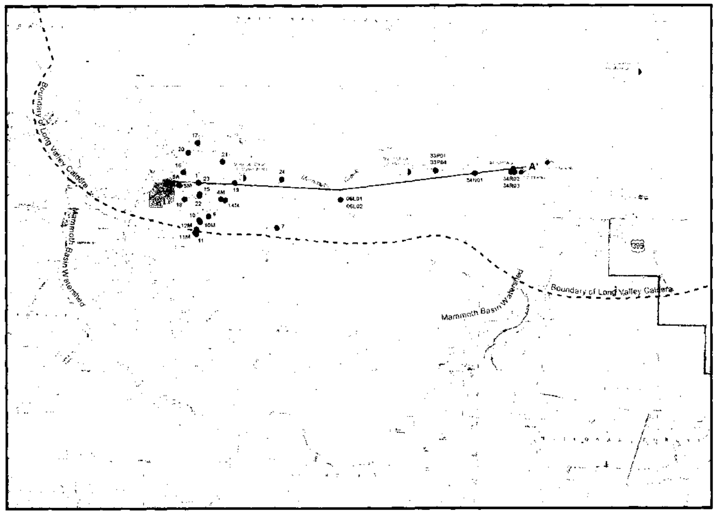
TASK ORDER NUMBER 3

Investigation of Groundwater Production Impacts On Surface Water Discharge and Spring Flow

Final Report



Prepared for:

Mammoth Community Water District

Date:

November 2003

Prepared by:

WE WILDERMUTH ENVIRONMENTAL, INC.
23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wild-environment.com

TASK ORDER NUMBER 3

INVESTIGATION OF GROUNDWATER PRODUCTION IMPACTS ON SURFACE WATER DISCHARGE AND SPRING FLOW

Final Report

Prepared for the
Mammoth Community Water District

November 2003

Wildermuth Environmental, Inc.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

This report describes an analysis of the basic hydrology of the Mammoth Basin area in the vicinity of Mammoth Community Water District (MCWD), the historical impacts of MCWD groundwater pumping on nearby surface water resources, and potential impacts of future MCWD groundwater pumping on these resources.

1.1 SCOPE OF WORK

Wildermuth Environmental Inc. was retained by the MCWD to conduct an investigation to estimate the impacts of historical and future MCWD production on spring discharge in the Valentine Reserve and the Hot Creek headwater springs area. The scope of work from WEI contract is listed below.

Task 1 Collect, Compile, and Review Data and Reports

Task 1 includes information collection, coordination, and definitional subtasks.

Task 1-1 Collect and Review Reports and New Information since the Completion of the Snowcreek Report. WEI staff will work with MCWD staff to identify new reports and information and WEI will review these documents.

Task 1-2 Collect Data from the LADWP, MCWD, USGS, and others. The types of data collected in this task include groundwater production and associated water quality data (sources MCWD and Snowcreek); recycled water production, discharge and associated water quality data (source MCWD); surface water discharge and associated water quality data (sources LADWP, MCWD, and USGS); and precipitation data and snow pack accumulation data (sources MCWD and others).

Task 1-3 Update MCWD Water Supply Plan Alternatives. MCWD will provide alternative future water supply plans to WEI for use in subsequent tasks.

Task 1-4 Field Reconnaissance. MCWD staff and WEI staff will visit Valentine Reserve to determine if there is adequate discharge monitoring sites in the Preserve, and to determine the effort required to activate and use these or new monitoring sites. Other sites may be visited based on Tasks 1-1 through Tasks 1-3.

Task 2 Update Analysis of Impacts to Surface Water Discharge

Task 2-1 Update Descriptions of Geologic and Hydrologic Conditions.

The efforts included in this subtask are:

- Processing and reviewing surface water discharge and chemistry data.
- Developing charts, tables, and maps to describe the hydrology and chemistry of surface water discharges.
- Updating the geologic and hydrologic descriptions of the Mammoth Basin area that are contained in the previous Snowcreek Report.

Task 2-2 Update Impact Analysis for AB, CD, and H-series Springs, and Other Surface Water Discharge Points Downgradient of MCWD wells. The impact analysis that was done in the Snowcreek report will be updated based on new data and the water supply plans provided by MCWD.

Task 2-3 Develop a New Impact Analysis for the Springs in the Valentine Reserve. Based on discussions with MCWD staff, WEI believes that there may not be enough information on the hydrogeology of the groundwater flow system that supports the springs in the Valentine Reserve to enable a direct analysis of impacts of MCWD groundwater production on Valentine Reserve spring discharge. WEI proposes to develop alternative impact scenarios and associated monitoring programs that could be used to determine if MCWD production could materially impact spring discharge and estimate the magnitude of this impact.

Task 3 Prepare Updated Report

Task 3-1 Prepare Draft Report. WEI will prepare a draft report for review by MCWD.

Task 3-2 Prepare Final Report. WEI will prepare a final report based on MCWD comments on the draft report.

1.2 Report Organization

This report consists of six sections and include

- Section 1 Introduction
- Section 2 Executive Summary – *provides a concise description of the findings of this investigation*
- Section 3 Mammoth Basin Geologic and Hydrologic Setting – *provides a quantitative description of the geologic and hydrologic conditions in the area*
- Section 4 Future Water Demands and Supplies – *provides a description of future water demands and water supply plan for the MCWD service area based on the MCWD 2000 Urban Water Management Plan and variants of the UWMP*
- Section 5 Impact of New Groundwater Production on Hot Creek Headsprings – *provides an analysis of future impacts at the Valentine Reserve and the Hot Creek headwater springs*
- Section 6 References

2. EXECUTIVE SUMMARY

This report describes the geologic and hydrologic setting of the groundwater resources available to and used by the MCWD (Section 3.1 to 3.3).

The analysis presented herein demonstrates, through readily available data and conventional methods of analysis, that historical groundwater production by MCWD and the Snowcreek golf courses has not impacted the springs that discharge to Hot Creek or the Valentine Reserve (Section 3-4 and 3-5, Figure 3-10).

Increases in groundwater production, necessary to meet future water demands, will not significantly impact the springs that discharge to Hot Creek (Section 3.4, Sections 4 and 5).

Analysis of piezometric level data at MCWD wells suggests that a groundwater barrier exists between the Valentine Reserve and the deep production wells operated by MCWD and Snowcreek. Piezometric variations caused by production at the MCWD and Snowcreek production wells do cross this barrier. In fact, the shallow and deep piezometric levels west of this barrier (as measured at MCWD wells 5M and 5A) and adjacent to the Valentine Reserve are at or near the ground surface. From these observations it was concluded that historic production at MCWD and Snowcreek wells has not influenced spring discharge at the Valentine Reserve, and future production at MCWD and Snowcreek wells will not influence spring flow at the Valentine Reserve (Section 3.5, Figures 3-4, 3-5, and 3-6).

Analysis of discharge data for Mammoth Creek at Old 395 shows that there has been no detectable decrease in discharge due to MCWD or Snowcreek groundwater production (Section 3.4, Figure 3-10).

3. MAMMOTH BASIN GEOLOGIC AND HYDROLOGIC SETTING

3.1 Study Area

The general study area, shown in Figure 3-1, is located on the eastern flank of the Sierra Nevada Mountain Range; approximately 30 miles north of the community of Bishop and almost directly west of Lake Crowley. This area encompasses a total of about 175 square miles. This area consists of some 155 square miles that lies within and forms the Long Valley Caldera and some 20 square miles that are south and outside the caldera boundary. Of primary interest to this study is the watershed area of Mammoth Creek and Hot Creek (Mammoth Basin watershed), which extends 13 miles eastward from Mammoth Mountain to a surface flow gaging station on lower Hot Creek. This area is shown in Plate 1 and in Figure 3-4. The watershed area of the Mammoth Basin is about 71 square miles and has maximum west-east and north-south dimensions of 13 and 9 miles respectively. Plate 1 shows the locations of wells, springs and, other important features.

The Mammoth Basin watershed occupies a topographically diverse area on the eastern flank of the Sierra Nevada Mountain Range. Surface elevations range from about 12,500 ft-msl at Bloody Mountain in the southern part of the Basin to about 6,900 ft-msl at the far eastern extreme of the Basin. Surface topography ranges from flat to undulating in the Mammoth Valley to sharp and craggy in the western mountainous elevations. The topography may be characterized as an alpine glaciated surface superimposed on an extrusive volcanic terrain.

3.2 Precipitation and Climatic Variability

Studies by the California Department of Water Resources (DWR, 1973) indicated that about 85 percent of all precipitation in the study area occurs during the period of October 1 through April 1. Average annual precipitation ranges from about 60 inches in the western mountainous area to about 10 inches in the extreme eastern part of the Basin. Precipitation occurs as snow and rain (DWR, 1973). Table 3-1 lists the annual precipitation totals at the Lake Mary Store station and the water content from the April snow survey. The Lake Mary Store precipitation data and April snow survey data are collected by the Los Angeles Department of Water and Power (LADWP). Precipitation records at Lake Mary Store started in 1948 and run through 1995. Annual precipitation at Lake Mary Store averages about 28 inches per year and ranges from a high of about 56 inches per year to a low of about 17 inches per year. The April snow survey records start in 1943 and run to the present. The average snow water content from the April snow surveys is about 43 inches per year and ranges from a high of about 87 inches per year to a low of about 12 inches per year.

Figure 3-2 is a plot of the cumulative departure from the mean the April snow survey. The cumulative departure from the mean (CDFM) plot is useful in characterizing wet and dry climatic periods. Negative sloped line segments indicate periods below the mean precipitation, whereas positively sloped line segments indicate periods of mean precipitation. For example, the period from 1978 to 1986 was a wet period and the period from 1987 to 1994 was a dry period. Review of the entire record for the Lake Mary Store data and the April snow survey data indicates that the 1978 to 1986 period was the wettest period in the 50-year precipitation record; the following period, the 1987 to 1994 dry period, was the most severe drought in the April snow survey record. In fact, when applied to the LADWP/USGS stream flow history for Mammoth Creek at Old 395, the CDFM approach indicates that the 1978 to 1986 period was the wettest period in the last 63 years and that the 1987 to 1994 dry period was the most severe drought period (in terms of magnitude and length) in the last 63 years. Stream discharge data will be characterized later in this section.

3.3 Geology and Hydrogeology of the Mammoth Basin Area

The Mammoth Basin watershed straddles the southern boundary of the Long Valley Caldera. Figure 3-3 depicts the general surface geology in the project area. Approximately one half of the Basin lies inside the down-dropped caldera feature and one half is south of and outside the caldera. Mammoth Basin is generally formed by elevated areas on the north and west that are comprised largely of Tertiary extrusive igneous rocks; a central trough filled with Quaternary alluvial, glacial, and volcanic deposits; and an abrupt southern flank of Pre-Tertiary igneous intrusive and metamorphic rocks. The central trough area opens and drains east to the Owens River and Lake Crowley. Quaternary lake deposits occur sporadically within the eastern portion of the Basin. Numerous faults occur in the extrusive igneous rocks along the northern flank of the Basin, while few faults have been mapped in the central and southern parts of the Basin.

3.3.1 Rock Formation Water Bearing Characteristics

Previous studies have indicated more than 20 geologic rock units are present in the project area. For hydrogeologic purposes these rock units can be grouped into five general formation categories. The relative water bearing characteristics of the exposed and underlying rock formations in Mammoth Basin are described herein from youngest to oldest in age.

Quaternary Alluvial Deposits (Qad) - This formation is comprised of detritus derived from all other rock formations in the project area. Such deposits are comprised of clay, silt, sand, cobbles and boulders that are generally unconsolidated and range in thickness from a thin wedge to an estimated 60 feet (DWR, 1973). These alluvial deposits range in permeability from low to moderate, and do not constitute large groundwater reservoirs because of their limited thickness and areal occurrence.

Quaternary Lake Deposits (Ql) - These lake sediments were deposited during the upper Pleistocene epoch in a large regional lake that was created by the damming of the upper Owens River Valley by volcanic and glacial rock materials. The lake deposits are most frequently comprised of unconsolidated fine grained sediments that are of low permeability and produce only small-to-moderate quantities of water. Depths of these deposits range to over 200 feet regionally. However, in the Mammoth Basin, depths appear to reach only to a few tens of feet in localized areas and therefore do not appear to constitute significant aquifers.

Quaternary Glacial Deposits (Qg) - During the Quaternary (Pleistocene) epoch, alpine glaciation was active throughout a large area of the Sierra Nevada Ranges. Remnants of this glaciation continue to persist today in some of the higher mountainous elevations. Within the project area, features related to glaciation and glacial deposition are present, for the most part, in the southern and central sectors of Mammoth Basin. The glacial deposits are slightly to moderately consolidated, consist of clay to boulder size fragments and locally provide groundwater to wells. Such materials were deposited at several glacial and inter-glacial intervals throughout the Pleistocene epoch and vary in thickness from a few feet to more than 100 feet.

Quaternary through Tertiary Igneous Rocks (Vb), (Vr) - These rock formations consist of lava flows, breccias and tuffs inter-bedded with glacial debris. Types of rock include basalt, rhyolite, latite and andesite. These formations occur mainly in the northern and western parts of the Basin and largely within the southern part of the Long Valley Caldera. Secondary porosity in these volcanic rocks along with the inter-bedded glacial sediments produce significant aquifers in the central part of the Mammoth Basin. These rocks range in depth to more than 3,000 feet.

Pre-Tertiary Rocks (pT) - This complex of rocks includes Paleozoic metasediments, Mesozoic metavolcanics and Cretaceous intrusive rocks. The rocks contained within this complex include a wide variety of igneous and metamorphic types which occur exclusively in the southern part of the Mammoth Basin. Groundwater in the Pre-Tertiary rocks is generally associated with the secondary porosity of faults, joint systems, and crush and fracture zones. The quantity of groundwater yielded from these rocks in the Mammoth Basin vicinity is usually small. The Pre-Tertiary rocks are the basement complex of the Sierra Nevada.

3.3.2 The Mammoth Basin Groundwater Systems

Underlying the Mammoth Basin is a groundwater regime that does not correspond to the boundaries of the surface drainage systems. Previous studies in the project vicinity have implied that the Mammoth Basin groundwater regime is a part of the Long Valley Caldera groundwater system. It is doubtful, however, that a single system prevails throughout the caldera and/or the Mammoth Basin considering the complex geology, hydrology, and hydrogeology of the area. It is also apparent from earlier studies that two, and perhaps more, groundwater systems are present.

Boundaries of the groundwater basin have not been specifically defined because of the complex hydrogeologic nature of the Mammoth Basin watershed. However, most water wells are located within the low-lying, central portions of the watershed.

Figure 3-4 shows the location of MCWD and USGS wells as well as a map view delineation of cross-section A-A'. This cross section passes through the MCWD production well field and parallels Mammoth Creek. Cross section A-A' originates approximately at MCWD well 5 and extends eastward to the Hot Creek Fish Hatchery. Figure 3-5 shows cross-section A-A' in profile view, which depicts the piezometric profiles of the groundwater systems for the summers of 1993 and 1998. Ground surface elevations were obtained from published topographic maps. Piezometric level and well construction data were obtained from MCWD and the USGS. Production and monitoring wells are shown in their actual or relative locations along the section line. Two distinct aquifer systems exist in the area where MCWD produces groundwater:

- a deep system that is highly responsive to MCWD groundwater production and responds slowly to recharge
- a shallow system that is not impacted by MCWD groundwater production and responds rapidly to recharge

The shallow system is defined herein as the glacial till and alluvium that overlies the Basin and is generally less than 100 feet in depth. The deep system consists of the fractured basalts and other water yielding rock that underlies the shallow system. All of MCWD production wells terminate well within the deep system.

Figure 3-6 shows the recent time history for several of the wells shown in Figure 3-4 and includes wells perforated in the shallow system; shallow system wells are depicted by dashed lines and deep system wells depicted by solid lines. The color scheme denotes shallow and deep system pairings where the piezometric level for wells perforated in the deep system are comparable to piezometric wells in the shallow system. The shallow monitoring wells located in the MCWD production well area have piezometric levels that are less than 50 feet below the ground surface. The shallow system piezometric level variations within the year are generally less than ten feet and follow the snow melt pattern with increasing levels in late spring and early summer and mild decreases thereafter until the next snow melt. In contrast, the piezometric levels for the MCWD deep monitoring and production wells are typically more than 150 feet below the ground surface—one notable exception is well 5A. The deep system piezometric level variations within the year can be as large 50 to 75 feet due to production stresses. The seasonal response to snow melt in the deep system appears dwarfed by production stresses.

The piezometric level time histories at all MCWD and USGS wells, where data is recorded, are plotted in Plate 2. The hydraulic impact of MCWD groundwater production does not appear to extend east of MCWD well 24 to the springs at the Hot Creek Fish Hatchery, nor does it appear to affect the piezometric levels in monitoring wells that are perforated in the shallow system and located in the same area as MCWD production wells (see also *Annual Report on Results of Mammoth Community Water District Groundwater Monitoring Program for October 2001 – September 2002*, Kenneth Schmidt and Associates, 2002). The deep system generally shows progressive drawdown from the summer to mid fall and generally recovers during the rest of the year. There was a period of progressive drawdown in the deep system from 1990 through 1995. This drawdown corresponded to a drought period wherein groundwater production was increased to replace dwindling surface supplies.

DWR (DWR, 1973) divided the Mammoth Groundwater Basin into eastern and western areas. The dividing point used by DWR is located near the Los Angeles YMCA Camp along the northern boundary of Section 7, T4S/R28E. For the purposes of this investigation, the Basin was divided into eastern and western areas. The western basin area was established as the area from the Mammoth Creek watershed tributary to the Mammoth Creek at Old 395 stream gage. The eastern basin area was established as the remaining part of the watershed from the Mammoth Creek at Old 395 stream gage to the Hot Creek at the Flume stream gage. Based on our review of the available groundwater production data, piezometric level data from wells, and surface discharge measurements it appears that the groundwater development activities in the western basin area have not significantly impacted the water resources in the eastern basin area.

The western basin area has a drainage area of about 34.5 square miles. Of these 34.5 square miles, approximately 14.4 square miles overlie areas where either groundwater is currently produced or could be potentially produced. Numerous production and monitoring wells have been constructed in this area by MCWD. These wells were drilled to depths of more than 700 feet. Geothermal groundwater is extracted and re-injected in the vicinity of Casa Diablo. The operations of the Casa Diablo facilities are in the extreme eastern part of this area and appear outside the hydraulic influence of the MCWD wells that are located about three miles west of the Casa Diablo facilities. Lithologic logs of wells indicate that inter-bedded alluvium, glacial till, and various types of extrusive volcanic rocks comprise the western basin area aquifers. Based on piezometric level and pumping records of the MCWD, the deep aquifer system is confined to semi-confined. The highly variable nature of the subsurface lithology and the complex stratigraphic and structural conditions result in a complex aquifer system. Groundwater recharge to the Basin is derived from the deep percolation of precipitation and applied water and the infiltration along Mammoth Creek and other tributaries. The causes of groundwater discharge from the western basin area are groundwater production from MCWD and Snowcreek wells, subsurface outflow to the eastern area, and evapotranspiration.

The eastern basin area has a drainage area of about 33.8 square miles. The most significant streams in the eastern area are Mammoth Creek, Laurel Creek, and Hot Creek. Several production wells and test wells have been constructed within the eastern basin area. Borehole logs for these wells indicate that the subsurface lithology is similar to that found in western basin area; i.e., inter-bedded alluvium, glacial till, volcanic extrusives, and agglomerates. The aquifers in the eastern basin area are as complex, or more so, than those in western basin area in that they also contain substantial geothermal resources. Recharge to the eastern basin area is derived from deep percolation of precipitation, infiltration along stream courses, recharge of recycled water at Laurel Pond, and subsurface inflows from the south, west, and north. The seasonal presence of marshes and shallow groundwater over a large area of the valley surface suggests that this area, under normal conditions, is refilled completely in most years. The USGS has several monitoring wells in eastern basin area, as shown in Plate 1. Piezometric level hydrographs for these wells are shown in Plate 2 (green hydrographs). Piezometric levels in the eastern basin area change slightly over time in response to climatic variability and do not appear to be influenced by the large piezometric variations in the deep system in the western basin area that is utilized by MCWD.

A number of springs issue from the surface in the eastern basin area. Among these springs, perhaps the most significant are the springs in the vicinity of the Hot Creek Fish Hatchery that are designated AB, CD, H1, and H23 (see Figure 3-4 and Plate 1). These springs comprise the headwaters of Hot Creek. The USGS (USGS, 1987) conducted a detailed analysis of the springs in the eastern basin area and continues to collect data that may be relevant to Long Valley Caldera seismic activity and hydrologic conditions.

3.3.3 Groundwater Development in the Mammoth Basin

Except for possible activities of Native Americans, development of groundwater in the Mammoth area did not commence until the late 1800s. This limited early development included the construction of shallow hand-dug wells and the improvement of cool and hot springs. Many of these springs continue to yield water for various uses. Recent groundwater production began in 1979 with the completion of MCWD well 1 and related pipelines and storage tanks. This well was tested to produce at a rate of 512 gallons per minute (gpm) with a specific capacity of 9.4 gallons per minute per foot of drawdown (gpm/ft). Two other wells, 2 and 3, constructed in the same year, but were poor producers and not outfitted with pumps. Well 6 and well 10, completed in 1988, penetrating fractured basalts to depths of about 700 feet. Seven wells have been added to the MCWD system since the construction of well 1. Table 3-2 lists construction information on production and monitor wells constructed by the MCWD. The recent annual groundwater production history is listed in Table 3-3. MCWD groundwater production increased from 48 acre-ft/yr in calendar year 1983 to 2,683 acre-ft/yr in 2002 and averaged at about 1,100 acre-ft/yr during this period. A few private wells also produce from the Mammoth Basin; the most significant is the Snowcreek Golf Course well. The Snowcreek well produces about 100 acre-ft/yr and ranges from a low of about 30 acre-ft/yr to about maximum of about 165 acre-ft/yr. There are plans to expand Snowcreek from a 9-hole to an 18-hole course sometime in the future. Table 3-4 shows the monthly production pattern for MCWD. About 60 percent of the annual groundwater production occurs during the June through September period and about 5 percent occurs in each of the remaining months of the year.

3.3.4 Groundwater Storage

The DWR estimated the available groundwater storage in the Mammoth Groundwater Basin to be about 57,000 acre-ft (DWR, 1973). The DWR storage estimate used piezometric level data from only a few wells and is based on the assumption that useful groundwater occurs only in unconsolidated sediments with a specific yield ranging from 7 to 10 percent. Since the DWR completed its study, MCWD has constructed several successful production wells into the fractured basalts that underlie the unconsolidated sediments. Useful groundwater storage extends to the basalts that underlie the unconsolidated sediments. For this study, we estimated the useful groundwater storage tributary to the AB and CD headsprings area. The useful groundwater storage tributary to the AB and CD headsprings is defined herein as the groundwater in storage that could flow by gravity towards the AB and CD headwater springs and consists of all drain-able groundwater up-gradient of the headwater springs. The Mammoth Basin up-gradient of the AB and CD headsprings is about 65.9 square miles. For storage analysis, this area can be divided into three areas:

- Mammoth Valley area from the fish hatchery westward about 7 miles and averaging about 1.5 miles wide;
- the area defined as the difference between the Mammoth Groundwater Basin as shown in Plate 1, and the Mammoth Valley area described above; and
- the area defined by the difference between the Mammoth Basin watershed area up gradient of the AB and CD headsprings, and the Mammoth Groundwater Basin.

The Mammoth Valley area is about 10.5 square miles. The aquifer in this area consists of relatively thin deposits of alluvium and glacial till underlain by layers of various types of volcanic rocks to depths of more than 700 feet in the western part of the Mammoth Valley area. The surface elevation at the AB and CD headsprings is about 7,075 ft-msl. The average saturated thickness in this area is about 250 feet. The specific yield of the aquifer materials in this area is estimated to be about 6 percent. The useful groundwater storage in this area is about 101,000 acre-ft. The remaining part of the groundwater basin area is irregular in shape and does not lend itself to the analysis described above due to a lack of lithologic data and piezometric level data. The area of the remaining part of the groundwater basin area is about 9.5 square miles. Assuming an average saturated thickness of 100 feet and a specific yield of 4 percent the useful groundwater storage in this area is estimated to be about 24,000 acre-ft. The total storage in the Mammoth groundwater basin area tributary to the AB and CD springs is about 125,000 acre-ft.

The Mammoth Basin drainage area outside the Mammoth Groundwater Basin is about 45.9 square miles and consists of fractured rock. Assuming an average saturated thickness of 250 feet and specific yield of

2 percent, the useful storage is estimated to be about 147,000 acre-ft. Therefore, the total useful groundwater storage tributary to the AB and CD headsprings is estimated to be about 272,000 acre-ft.

3.3.5 Surface Water Discharge and Spring Discharge Characterization

Mammoth Creek and Hot Creek are the major streams that drain the Mammoth Creek watershed. Mammoth Creek drains the western part of the Mammoth Basin flowing in a generally easterly direction past Highway 395 (see Plate 1). Mammoth Creek combines with Hot Creek near the Hot Creek Fish Hatchery. Hot Creek leaves the Basin near Cashbaugh Ranch at the eastern end of the Basin and continues about three miles northeast to a confluence with the Owens River. Surface flows have been measured at seven gaging stations within the Basin. These stations are listed below.

Station Name	Drainage Area (square miles)
Mammoth Creek above Bodle Ditch	2.8
Mammoth Creek below Twin Lakes	8.3
Laurel Creek at base of mountain	5.6
Sherwin Creek at base of mountain	4.7
Mammoth Creek at Old Highway 395	34.5
Hot Creek at the Flume	68.3

The locations of these stations are shown in Plate 1. Mammoth Creek at Old 395 and Hot Creek at the Flume are long-period stations with daily flow records of 50 years or longer. The USGS and others have measured spring discharge from AB, CD and H23 springs since about 1985. Table 3-5 lists the monthly and annual discharges for Mammoth Creek at Old 395 for the period from 1951 through early 2003. Table 3-6 lists the monthly and annual discharges for AB, CD, and H23 springs for the period of 1985 through early 2003. Table 3-7 lists the monthly and annual discharges for Hot Creek at the Flume for the period from 1951 through early 2003.

Figure 3-7 shows the average monthly distribution of discharge for Mammoth Creek at Old 395 and for Hot Creek at the Flume. Discharge in Mammoth Creek upstream of the AB, CD, and H23 headsprings is seasonal with just over 70 percent of the annual flow occurring in the May through August period. Most of the discharge during this period comes from snow melt. Average annual discharge for the Mammoth Creek at Old 395 is about 16,400 acre-ft/yr and has ranged from a low of about 3,200 acre-ft/yr to a high of about 45,800 acre-ft/yr.

Downstream at the Hot Creek at the Flume gaging station, about 46 percent of the annual discharge occurs during the May to August snowmelt period. In contrast to the upstream Mammoth Creek at Old 395 gaging station, Hot Creek has a significant base flow component fed in part by discharges from the AB, CD, and H23 headsprings. Average annual discharge for Hot Creek at the Flume averages about 42,700 acre-ft/yr and has ranged from a low of about 25,400 acre-ft/yr to a high of about 72,100 acre-ft/yr.

Figure 3-8 is a graphical comparison of the water content from the April snow surveys and the annual runoff for Mammoth Creek at Old 395 and Hot Creek at the Flume. The trend lines for annual discharge versus April snow survey is also plotted in Figure 3-8. The observed annual discharge for Hot Creek at the Flume is more scattered about its trend line than the observed annual discharges for Mammoth Creek at Old 395. The coefficients of determination for the trend are 0.66 and 0.77 for Hot Creek at flume and Mammoth Creek at Old 395, respectively. The coefficient of determination is the fraction of the variance in discharge that can be explained by the variance in April snow surveys. The difference in the coefficients of determinations is due to Hot Creek having a significant groundwater component that can sustain Hot Creek surface discharges in years with low precipitation, that is, Hot Creek discharge is less sensitive to annual variations in snowfall than Mammoth Creek.

Figure 3-9 shows the monthly distribution of discharge for the AB, CD, and H23 headsprings located at the fish hatchery. Daily discharge data for these springs are plotted in Plate 3 for their period of record along with the daily discharge data for Mammoth Creek at Old 395 and Hot Creek at the Flume. Comparable data does not exist for the H1 spring. The AB spring discharge shows a definitive seasonal pattern that consists of two components—a seasonal component that responds rapidly to the magnitude and timing of snow melt runoff (as observed in the Mammoth Creek at Old 395 record) and a more steady base flow component that responds to changes in long term groundwater storage and climatic cycles. Analysis of the daily discharge data for the AB spring and Mammoth Creek indicates that the peak discharge from the AB spring lags behind the Mammoth Creek peak discharge by one to two months; moreover, the AB seasonal component has a recession period of about five to six months where the Mammoth Creek recession period usually lasts two to three months. This can clearly be seen in Plate 3 by comparing the daily flow hydrograph for the AB headspring and Mammoth Creek at Old 395. In contrast, the CD and H23 springs show only a slight seasonal component with most of the discharge variation coming from changes in long term groundwater storage and climatic cycles. The recorded discharge history for the springs was heavily influenced by the 1987 through 1995 drought period and therefore estimates of average annual discharges based on the available history are probably low. The average annual discharge for the AB, CD, and H23 springs for the existing records are 5,100 acre-ft/yr, 6,100 acre-ft/yr, and 2,500 acre-ft/yr, respectively.

Table 3-7 lists the annual discharge of Hot Creek at the Flume, the associated base flow and storm flow components, and the annual flows for the AB, CD, and H23 headsprings. The total flow at Hot Creek at the Flume was divided into base flow and storm flow components through a detailed analysis of daily flow data for the period ranging from October 1950 to June 2003. Base flow is numerically equal to the total flow minus surface runoff and is comprised of spring flow and other groundwater that discharge to Hot Creek. In this investigation, base flow was estimated as the average of the daily discharge of October 15 and February 15 of the same water year. The base flow estimated for the discharge at the Hot Creek at the Flume gage averages at about 27,000 acre-ft/yr and ranges from a low of 16,000 acre-ft/yr to a high of about 42,000 acre-ft/yr. The average fraction of the base flow at the Hot Creek gage contributed by the AB, CD, and H23 springs during the 1986 to 1995 period is estimated at 18 percent, 23 percent, and 9 percent, respectively—50 percent of the base flow estimated at the gage.

3.4 Relationship Between Historical Groundwater Production and Surface Water Discharge

Prior investigations (USFS, 1990) presumed that groundwater production in the western part of the Mammoth Basin would cause a comparable reduction in spring flow at the headwater springs. The presumption of this impact is based on the assumption that groundwater storage is small and that all groundwater eventually leaves the basin as surface flow in Hot Creek. If these assumptions were true then stream discharge changes caused by MCWD groundwater production would be observable.

The MCWD well field is located about seven miles west and hydraulically up-gradient of the headsprings. Piezometric elevations in the vicinity of the significant groundwater production range from about 7,600 to 7,800 ft-msl. The groundwater elevation in the vicinity of the AB and CD headwater springs is about 7,075 ft-msl. A necessary condition for the groundwater production in the west Mammoth Basin area to influence the springs would be a change in the hydraulic gradient from the groundwater production area in the west extending continuously to the headsprings. Figure 3-5 shows a groundwater profile extending from the MCWD groundwater production area in the western part of the Mammoth groundwater basin and through the AB and CD headspring area. Plate 2 shows the piezometric level histories at wells extending from the MCWD groundwater production area in the west through the headspring area. The drop in piezometric level in the groundwater production area due to pumping can be clearly seen in Plate 2 (pink hydrographs) to range between 40 to 60 feet during the period 1987 to 1995. Storage depletion during part of the drought can be seen in MCWD well hydrographs in the far western end of the groundwater basin. Some down-gradient monitoring wells with ambient groundwater elevations above

7,400 ft-msl show slight piezometric level declines during the drought and may have been influenced by the accumulated up-gradient groundwater production during the drought. Groundwater elevations and the gradient below groundwater elevation 7,300 ft-msl show no significant changes due to drought or up-gradient groundwater production. Review of piezometric level data in Figure 3-5 and Plate 2 shows that aquifer stresses originating in the western part of the Mammoth Basin from groundwater production did not extend to the area of the headsprings where piezometric levels are about elevation 7,075 ft-msl.

The discharge records for Mammoth Creek at Old 395 and Hot Creek at the Flume were studied to see if groundwater production in the western part of the Mammoth Basin could have impacted the discharge in Mammoth Creek and spring discharge to Hot Creek. Double mass curves were developed for these stream discharge gaging stations. Double mass curves are plots of cumulative mass or flow at one station versus a similar cumulative term for another nearby station. Double mass curves are used to determine if significant changes have occurred at precipitation and stream discharge gages due to such activities as relocation of gages or construction of stream diversions. Changes in discharge due to drought or wet periods are filtered out in double mass curve analysis. Each point on the curve corresponds to a point in time. If data on the plot occurs after a change in the flow regime then the trend represented by the later data will diverge from the trend described by the data representing the period prior to a change. Figure 3-10 contains double mass curve plots for the Mammoth Creek at Old 395 gage versus April snow survey, and the Hot Creek at the Flume gage versus the same index. Review of the Mammoth Creek plot shows a fairly straight line with no divergence. Groundwater production has not impacted the surface discharge measured at this location. The Hot Creek plot shows no significant divergence. If groundwater pumping was depleting spring discharge, the divergence would have been down to the right; thus indicating the accumulation of stream discharge at a lesser rate than before significant groundwater production occurred. The lack of downward divergence at the Hot Creek gage indicates that there has been no observed depletion of spring flows as a result of past groundwater pumping.

There is a significant amount of recent piezometric level data in the area between the MCWD groundwater production area in the western part of the Mammoth Basin and the AB and CD headwater springs. Review of the piezometric level data in Figure 3-6 and Plate 2 shows that the changes in hydraulic gradient caused by groundwater production area in the western part of the Mammoth Basin did not extend to the area of the headsprings. Review of the double mass curve for Hot Creek indicates that there has been no observed depletion of the aggregate spring discharge measured at the Hot Creek at the Flume gage. From these two observations we conclude that historic groundwater production in western part of the Mammoth Basin has not noticeably impacted the discharge at the AB and CD headspring.

The Mammoth Basin is hydrologically more complex than described by the simple conceptual model developed by the DWR in 1973. The DWR conceptual model of the Mammoth Basin was based on very simplistic assumptions, the most significant being that the yield of the Basin is directly equatable to average annual basin precipitation minus average consumptive use. Runoff, recharge, and evapotranspiration processes are non linear with respect to precipitation—translated, average precipitation is not equatable to yield. The yield of the Mammoth groundwater basin can only be determined by studying hydrologic process over a historically-representative range of precipitation. The DWR estimated useful groundwater storage to be about 57,000 acre-ft based on groundwater stored only in unconsolidated deposits. In the 1980's MCWD developed production wells in fractured basalts which demonstrated that the useful storage includes fractured rocks that underlie and are adjacent to the unconsolidated deposits. The useful groundwater storage up-gradient and tributary to the AB and CD headsprings is estimated to be about 270,000 acre-ft.

The lack of noticeable spring flow and stream flow depletions is likely resultant of:

- structural complexity of the groundwater systems;
- the yield being significantly larger than the MCWD groundwater productions and AB and CD headspring discharges; and

- the large amount of groundwater storage relative to MCWD groundwater production and spring discharge.

3.5 Relationship Between Historic Groundwater Production and Discharge at Valentine Reserve Springs

Figure 3-4 shows the location of the Valentine reserve spring area , the location of MCWD production and monitoring wells, and the location of cross section A-A'. There is very little discharge data for the springs on the Reserve. The data that does exist is limited to short periods of time. For example, the period ranging from 1993 to the present does not include the entire spring discharge at the Reserve. Therefore, it is not possible to use the methods described above to estimate MCWD production impacts on the springs at the Reserve.

Careful review of well location and piezometric level data does show that the variations in the piezometric levels in the deep system caused by MCWD and Snowcreek production do not migrate west of MCWD deep monitoring well 5A and shallow monitoring well 5M. This can be seen in cross section A-A' (Figure 3-5) and in the piezometric level data plotted in Figure 3-6. Piezometric levels in Wells 5A and 5M do not respond to the variations the piezometric levels at deep production wells east of 5A and 5M. This suggests that a competent groundwater barrier exists east of wells 5A and 5M and that the piezometric level drawdown at the MCWD and Snowcreek production wells has not and will not impact the springs on the Valentine Reserve. Schmidt (2002) has compared some recent Valentine Reserve spring discharge data for 2001 to MCWD production and has also concluded that there is no relationship between MCWD production and spring discharge at the Valentine Reserve.

Table 3-1
Hydrologic Indices for the Mammoth Area

Water Year	April 1 Snow Surveys (inches)	Precip at Lake Mary Stores (inches)	Mammoth Creek at Old 395 (acre-ft)	Hot Creek at the Flume (acre-ft)
1933			9,860	
1934			6,136	
1935			13,650	
1936			14,125	
1937			18,069	
1938			32,544	
1939			10,193	
1940			15,628	
1941			21,655	
1942			23,873	
1943	54.70		19,990	
1944	34.30		12,314	
1945	57.30		20,914	
1946	46.20		16,806	
1947	34.50		11,210	
1948	25.30	25.93	9,982	
1949	41.30	23.54	9,461	
1950	37.90	24.05	9,812	
1951	33.60	36.44	15,741	36,915
1952	73.70	37.50	22,986	51,491
1953	32.30	28.35	11,574	38,958
1954	41.60	27.60	10,449	36,180
1955	35.20	24.12	9,561	33,860
1956	58.40	41.50	25,935	52,246
1957	34.20	30.75	16,411	43,855
1958	59.50	29.65	23,128	50,971
1959	30.80	22.00	8,261	35,454
1960	24.30	22.05	5,264	29,221
1961	25.60	20.00	3,487	25,437
1962	55.40	35.65	15,356	39,080
1963	31.40	33.75	18,965	45,759
1964	24.20	21.69	9,114	33,531
1965	48.00	33.60	20,877	45,942
1966	38.50	24.90	12,159	38,482
1967	58.50	39.50	30,780	59,016
1968	26.50	22.25	9,724	38,314
1969	86.50	44.30	36,702	72,128
1970	34.10	24.65	16,453	49,658
1971	42.00	22.65	12,773	41,322
1972	26.90	21.10	9,034	34,429
1973	60.20	32.15	18,041	47,743
1974	57.40	31.95	20,823	48,326
1975	48.50	26.50	17,468	
1976	24.60	19.68	7,388	
1977	12.30	17.28	3,151	
1978	70.60	36.18	24,617	
1979	37.30	30.61	17,246	
1980	65.70	37.37	27,877	
1981	36.10	20.11	9,566	
1982	61.00	42.58	21,447	
1983	83.70	55.90	45,813	
1984	44.50	29.90	24,078	60,694
1985	49.40	22.88	12,102	45,766
1986	79.60	29.57	28,700	62,002
1987	22.80	19.94	8,111	40,570
1988	30.70	19.46	5,972	33,457
1989	35.40	22.58	5,848	31,341
1990	29.80	19.30	5,073	27,910
1991	27.70	20.00	6,917	29,273
1992	25.70	20.40	5,859	27,251
1993	55.30	32.60	17,450	40,436
1994	21.30	17.55	7,486	30,055
1995	68.10	44.60	33,224	57,279
1996	41.80		24,953	53,883
1997	54.50		22,534	52,037
1998	54.90		26,759	57,102
1999	34.10		16,915	47,407
2000	36.50		13,615	41,010
2001	25.40		10,578	37,510
2002	34.90		9,871	32,583
Average	43.04	28.47	16,006	42,695
Max	86.50	55.90	45,813	72,128
Min	12.30	17.28	3,151	25,437

Table 3-2
Construction Data for MCWD Production and Monitoring Wells

Well Number	Year Drilled	Drilled Depth (feet)	Cased Depth (feet)	Perforated or Open Interval (feet)	Annular Seal (feet)	Aquifer System[4]
MCWD Production Wells						
1	1976	382	370	200-370	0-90	Deep
6	1987	670	670	146-670	0-52	Deep
10	1987	700	700	136-700	0-52	Deep
15	1992	720	407	407-720	0-135	Deep
16[1]	1992	710	715	420-470; 500-680	0-60	Deep
17[1]	1992	710	513	400-710	0-60	Deep
18[1]	1992	710	480	90-150; 240-470	0-60	Deep
20[1]	1992	710	420	420-710	0-60	Deep
MCWD Monitoring Wells						
4M	1984	89	89	69-89	0-50	Shallow
5A[2]	1982	357	357	112-357	0-112	Deep
5M	1993	80	80	20-75	0-20	Shallow
7	1987	480	480	290-480	0-50	Deep
10M	1988	27	27	7-27	0-5	Shallow
11	1988	600	600	170-360	0-50	Deep
11M	1988	43	43	5-43	0-5	Shallow
12M	1988	27	27	7-27	0-5	Shallow
14M	1988	520	501	100-310	0-100	Deep
19	1992	700	344	200-700	0-140	Deep
21[3]	1992	640	157	157-640	70-157	Deep
22	1992	85	85	55-85	0-25	Shallow
23	1992	65	65	30-65	0-25	Shallow
24	1993	450	430	300-450	0-20	Deep

1 -- In June 1994, wells numbered 16, 17, 18, and 20 were modified in preparation for production use.

2 -- In August 1993, well number 5 was modified, so as to be sealed off opposite the glacial till and be perforated only opposite the volcanic rock, and re-designated well number 5A.

3 -- In July 1997, an annular seal was placed in well number 21. Before the placement of the seal, the cased depth was 145 feet and the open interval ranged from 145 to 640 feet. The values listed in the table above represent this well with the annular seal in place.

4 -- The shallow system consists of surficial glacial tilland other alluvium that covers the fractured basalts. The shallow system is typically less than 100 feet thick.

Table 3-3
Water Production by MCWD and Snowcreek
(acre-ft/yr)

Year	---------- MCWD Production ----------			Snowcreek	Total
	Surface Water	Groundwater	Total	Groundwater Production	Groundwater Production
1983	2,221	48	2,269		48
1984	2,450	157	2,607		157
1985	2,196	313	2,509		313
1986	2,164	264	2,428		264
1987	1,537	563	2,100		563
1988	1,605	595	2,200		595
1989	1,780	958	2,738		958
1990	1,485	1,142	2,627		1,142
1991	1,048	1,364	2,412	27	1,391
1992	804	2,385	3,189	100	2,486
1993	1,653	1,714	3,367	37	1,750
1994	1,364	1,412	2,776	155	1,567
1995	1,726	1,133	2,859	165	1,298
1996	2,024	1,012	3,036	97	1,109
1997	2,161	983	3,144	108	1,091
1998	2,042	874	2,916		874
1999	2,008	1,080	3,088	71	1,151
2000	1,972	1,304	3,276	70	1,374
2001	1,409	2,333	3,742	35	2,368
2002	1,327	2,723	4,050	40	2,763
Average	1,749	1,118	2,867	82	1,163
Max	2,450	2,723	4,050	165	2,763
Min	804	48	2,100	27	48

Source: MCWD Summary.xls

Table 3-4
Monthly and Annual Groundwater Production by the Mammoth Community Water District
(acre-ft)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1983	3.1	0.1	3.6	0.1	0.0	6.0	26.2	2.2	0.8	0.0	0.1	6.1	48.2
1984	6.6	0.0	10.6	0.0	10.5	22.1	55.1	4.9	19.4	0.0	2.3	25.2	156.6
1985	21.8	5.6	19.6	13.4	35.5	25.9	39.1	61.7	38.0	17.9	13.2	21.6	313.2
1986	14.2	11.3	9.9	2.7	17.7	29.8	42.1	66.4	10.2	0.0	28.4	31.8	264.3
1987	39.7	27.9	39.6	41.4	44.0	68.1	78.6	69.9	56.9	22.7	27.4	46.7	562.9
1988	47.0	54.2	58.2	23.9	39.8	58.2	48.6	51.4	53.8	28.9	58.9	71.9	594.9
1989	88.3	71.1	82.9	6.2	9.1	23.8	192.5	169.5	138.3	46.4	57.3	72.6	958.0
1990	51.0	55.8	37.9	72.3	42.9	118.4	141.0	180.5	192.3	95.9	70.9	83.7	1,142.5
1991	171.4	132.5	0.0	98.4	94.7	47.0	119.9	180.0	177.9	98.7	163.1	80.5	1,363.9
1992	80.0	120.8	111.4	147.4	76.1	160.0	297.3	413.3	309.2	260.9	157.9	250.8	2,385.1
1993	191.5	232.0	114.9	130.7	88.9	224.1	240.3	238.4	181.8	45.9	1.5	23.7	1,713.7
1994	76.0	30.2	82.6	64.7	90.1	124.4	244.3	316.9	198.1	50.9	34.5	99.5	1,412.3
1995	114.4	98.5	108.2	100.6	61.3	58.2	140.4	238.6	132.0	18.4	12.3	50.2	1,133.3
1996	37.3	39.3	34.2	14.1	32.4	117.2	180.5	229.1	161.6	83.8	23.2	59.1	1,011.9
1997	45.1	38.9	36.9	35.0	54.2	88.3	202.8	241.1	142.5	42.1	14.6	41.6	983.1
1998	26.8	25.3	30.4	19.9	6.2	68.4	232.6	246.2	116.8	44.8	17.5	39.1	873.9
1999	37.9	17.0	17.2	17.4	57.5	174.7	247.6	230.0	155.3	75.9	11.7	37.6	1,079.7
2000	48.6	23.2	28.6	16.5	99.8	221.8	312.4	280.3	171.6	42.8	11.3	47.1	1,304.2
2001	66.2	78.1	62.3	53.0	154.7	254.5	270.1	486.8	417.0	241.9	130.0	118.4	2,333.2
2002	147.3	171.7	238.3	179.3	135.5	297.2	327.3	413.9	341.7	218.3	129.2	122.8	2,722.7
AVG	65.7	61.7	56.4	51.8	57.5	109.4	171.9	206.1	150.8	71.8	48.3	66.5	1,117.9
MIN	3.1	0.0	0.0	0.0	0.0	6.0	26.2	2.2	0.8	0.0	0.1	6.1	48.2
MAX	65.7	61.7	56.4	51.8	57.5	109.4	171.9	206.1	150.8	71.8	48.3	66.5	1,117.9
Fraction of Annual Production	6%	6%	5%	5%	5%	10%	15%	18%	13%	6%	4%	6%	100%

Note: Includes all pumpage from wells for pump testing, golf course water, and for use by community.

Table 3-5
Monthly Distribution of Discharge for Mammoth Creek at Old 395

(acre-ft)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1950-1951	250	1,660	2,160	770	575	505	743	2,355	3,399	1,854	994	475	15,740
1951-1952	437	340	646	607	480	372	708	3,788	6,158	5,724	2,579	1,147	22,986
1952-1953	748	423	536	651	354	410	821	1,021	2,979	2,725	616	289	11,573
1953-1954	307	295	251	212	278	521	1,088	3,123	2,500	1,221	391	261	10,448
1954-1955	144	336	294	323	223	271	497	1,217	4,239	1,355	462	198	9,559
1955-1956	281	274	1,556	808	446	440	944	3,324	8,526	5,872	2,279	1,186	25,936
1956-1957	1,024	765	577	565	569	532	700	1,642	6,343	2,471	807	415	16,410
1957-1958	475	382	389	309	341	439	853	4,662	6,959	4,634	2,419	1,265	23,127
1958-1959	644	522	429	439	371	502	828	1,447	1,900	586	226	366	8,260
1959-1960	348	222	241	356	369	412	598	864	1,371	302	95	87	5,265
1960-1961	136	144	179	188	145	220	192	604	970	332	201	175	3,486
1961-1962	138	148	227	231	357	349	1,094	2,092	5,548	3,358	1,209	605	15,356
1962-1963	542	393	426	336	1,048	422	590	2,187	6,232	4,333	1,581	874	18,964
1963-1964	639	853	636	425	308	471	600	1,492	2,271	723	408	286	9,112
1964-1965	154	347	1,317	937	348	521	836	2,025	5,118	4,438	3,367	1,469	20,877
1965-1966	842	777	587	555	472	566	1,015	3,230	2,321	990	459	345	12,159
1966-1967	340	303	857	469	475	610	519	3,232	8,411	10,195	3,387	1,983	30,781
1967-1968	1,124	818	592	598	599	531	568	1,640	1,993	753	376	131	9,723
1968-1969	232	368	323	277	106	246	982	8,572	11,634	8,806	3,691	1,466	36,703
1969-1970	1,367	879	697	880	665	779	909	2,548	4,342	2,151	751	485	16,453
1970-1971	453	590	519	425	333	496	593	1,811	4,300	2,099	751	403	12,773
1971-1972	494	516	418	416	296	399	586	1,584	2,768	702	190	664	9,033
1972-1973	519	361	453	430	514	340	518	4,798	6,306	2,314	996	491	18,040
1973-1974	522	1,049	562	593	395	526	801	4,346	7,104	3,006	1,313	606	20,823
1974-1975	516	336	362	366	392	340	477	2,700	7,110	3,118	1,058	694	17,469
1975-1976	1,017	572	460	400	395	468	419	1,805	927	382	326	215	7,386
1976-1977	272	195	127	139	220	225	261	299	904	287	117	107	3,153
1977-1978	83	77	64	68	46	169	423	3,019	8,894	6,287	2,769	2,719	24,618
1978-1979	1,138	768	457	727	537	606	1,047	4,063	4,366	1,948	947	642	17,246
1979-1980	421	352	312	782	517	463	969	3,770	8,173	7,892	2,918	1,308	27,877
1980-1981	810	469	372	380	392	361	648	2,145	2,679	750	301	259	9,566
1981-1982	393	483	414	155	346	297	1,553	4,978	7,983	6,933	3,447	3,109	30,091
1982-1983	2,553	1,999	1,318	857	755	782	668	4,475	13,277	11,024	5,554	2,551	45,813
1983-1984	1,813	1,466	1,162	1,218	631	758	1,093	4,828	5,178	3,496	1,640	795	24,078
1984-1985	1,211	736	618	446	378	343	999	2,722	2,853	988	420	388	12,102
1985-1986	352	341	413	367	392	967	1,668	5,582	10,659	4,839	1,998	1,122	28,700
1986-1987	1,244	555	494	442	337	390	427	1,888	1,330	549	262	193	8,111
1987-1988	219	345	276	422	297	306	454	1,038	1,306	812	302	195	5,972
1988-1989	188	172	203	271	203	385	589	1,376	1,417	497	294	253	5,848
1989-1990	292	341	218	260	225	245	423	845	1,065	560	385	214	5,073
1990-1991	156	195	112	81	98	262	259	592	3,050	1,291	480	341	6,917
1991-1992	319	417	307	234	226	167	336	1,541	1,046	621	370	275	5,859
1992-1993	235	272	135	172	198	348	616	3,418	5,555	4,132	1,559	810	17,450
1993-1994	544	445	433	362	350	345	489	1,541	1,828	548	313	288	7,486
1994-1995	354	326	409	436	394	585	892	2,773	8,224	11,412	5,199	2,220	33,224
1995-1996	1,303	807	821	702	867	791	1,413	5,521	6,596	3,501	1,722	909	24,953
1996-1997	673	948	710	2,507	693	823	1,454	4,843	5,005	2,490	1,414	974	22,534
1997-1998	658	588	512	619	522	636	703	1,416	6,611	9,119	3,554	1,821	26,759
1998-1999	1,043	942	672	633	558	560	708	2,892	4,911	2,286	1,045	665	16,915
1999-2000	502	494	309	451	474	470	782	3,566	3,871	1,364	827	505	13,615
2000-2001	527	416	418	380	362	462	590	3,727	1,945	909	488	354	10,578
2001-2002	338	390	441	347	312	386	777	1,855	2,972	1,109	534	410	9,871
2002-2003	362	639	374	384	308	424	557						
Average	598	544	524	498	406	457	741	2,747	4,681	3,079	1,342	769	16,401
Stan Dev	469	372	379	365	188	173	319	1,616	2,997	2,997	1,325	711	9,461
Coef of Var	78%	68%	72%	73%	46%	38%	43%	59%	64%	97%	99%	92%	58%
Max	2,553	1,999	2,160	2,507	1,048	967	1,668	8,572	13,277	11,412	5,554	3,109	45,813
Min	83	77	64	68	46	167	192	299	904	287	95	87	3,153
% of Annual	3.6%	3.3%	3.2%	3.0%	2.5%	2.8%	4.5%	16.7%	28.5%	18.8%	8.2%	4.7%	100.0%

Table 3-6
Spring Discharge in the Hot Creek Fish Hatchery Area
(acre-ft)

Years	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
						AB Spring							
1985							516	583	684	700	626	574	
1986	552	519	516	528	470	574	641	715	810	911	829	703	7,767
1987	669	580	559	525	448	497	479	522	531	525	503	442	6,279
1988	430	399	393	374	347	368	350	359	433	436	399	341	4,628
1989													
1990													
1991		193	190	203	184	209	196	203	344	402	381	301	
1992	252	224	203	187	163	172	169	196	279	230	193	178	2,446
1993	157	132	132	163	172	178	273	322	463	562	562	473	3,588
1994	390	313	264	233	172	206	175	221	365	344	227	175	3,084
1995	166	147	147	175	144	196	322	424	580	789	862	770	4,723
1996	632	543	470	436	393	420	414	571	610	690	656	601	6,436
1997	557	476	447	518	476	490	459	547	587	663	634	572	6,426
1998	553	476	484	510	441	493	509	546	587	788	841	808	7,036
1999	733	620	587	550	461	462	426	457	601	685	702	605	6,889
2000	550	464	434	416	397	413	422	508	564	612	603	482	5,865
2001	444	390	392	380	324	345	315	408	489	498	451	363	4,799
2002	312	273	264	261	226	265	226	293	393	446	369	299	3,627
2003	273	254	237	229	187	209	189	219	250				
Average	445	375	357	355	313	344	358	417	504	580	552	480	5,081
Max	733	620	587	550	476	574	641	715	810	911	862	808	7,767
Min	157	132	132	163	144	172	169	196	250	230	193	175	2,446
% of Annual	8.8%	7.4%	7.0%	7.0%	6.2%	6.8%	7.0%	8.2%	9.9%	11.4%	10.9%	9.5%	100%
						CD Spring							
1988													
1989		424	494	506	460	506	534	503	503	577	565	470	
1990	396	365	479	513	411	537	488	470	482	531	494	473	5,638
1991	552	540	525	485	460	497	454	439	509	583	651	574	6,270
1992	485	439	457	460	433	470	445	448	470	485	460	420	5,472
1993	436	399	414	433	405	509	525	519	568	746	660	644	6,257
1994	617	485	500	516	448	476	457	466	543	565	519	473	6,064
1995	454	362	368	356	316	374	408	491	559	678	675	657	5,699
1996	626	549	531	506	457	482	466	548	581	602	642	585	6,576
1997	562	515	509	516	472	521	490	503	518	546	568	550	6,270
1998	524	500	514	516	472	532	494	541	551	709	736	693	6,782
1999	642	590	573	534	472	500	485	502	554	626	628	590	6,696
2000	595	544	522	487	448	473	471	506	538	571	558	525	6,238
2001	509	459	464	456	416	470	492	564	604	603	586	535	6,158
2002	502	466	480	497	447	479	441	477	545	585	537	490	5,946
2003	486	460	465	465	402	448	433	454	312				
Average	528	473	486	483	435	485	472	495	522	600	591	548	6,120
Max	642	590	573	534	472	537	534	564	604	746	736	693	6,576
Min	396	362	368	356	316	374	408	439	312	485	460	420	5,472
% of Annual	8.6%	7.7%	7.9%	7.9%	7.1%	7.9%	7.7%	8.1%	8.5%	9.8%	9.7%	9.0%	100%
						H23 Spring							
1987				218	206	224	218	224	224	230	227	215	
1988	209	203	203	206	193	215	203	209	206	218	218	196	2,477
1989	199	190	193	187	153	178	184	184	187	206	203	190	2,256
1990	193	184	184	181	160	181	169	184	184	190	193	203	2,207
1991	209	199	206	196	184	184	178	181	181	209	221	187	2,335
1992	166	160	169	160	157	166	163	172	181	181	175	153	2,001
1993	169	166	172	178	163	184	193	221	230	249	255	233	2,412
1994	221	215	190	184	172	196	187	252	242	246	236	233	2,575
1995	227	181	190	187	169	196	187	193	212	246	249	246	2,483
1996	242	215	230	221	224	227	196	231	226	241	262	243	2,759
1997	234	213	208	218	210	233	210	204	222	209	231	229	2,621
1998	222	208	203	212	190	220	220	226	213	239	272	267	2,692
1999	277	251	249	246	198	226	213	205	234	253	273	242	2,867
2000	241	242	216	209	207	217	218	213	207	237	229	212	2,648
2001	227	213	209	217	192	224	209	194	229	*248*	245	235	2,642
2002	219	211	204	192	175	184	169	195	223	246	240	205	2,463
2003	193	188	192	203	153	184	137	175	106				
Average	216	202	201	201	183	202	191	204	206	228	233	218	2,485
Max	277	251	249	246	224	233	220	252	242	253	273	267	2,759
Min	166	160	169	160	153	166	137	172	106	181	175	153	2,001
% of Annual	8.7%	8.1%	8.1%	8.1%	7.3%	8.1%	7.7%	8.2%	8.3%	9.2%	9.4%	8.8%	100%

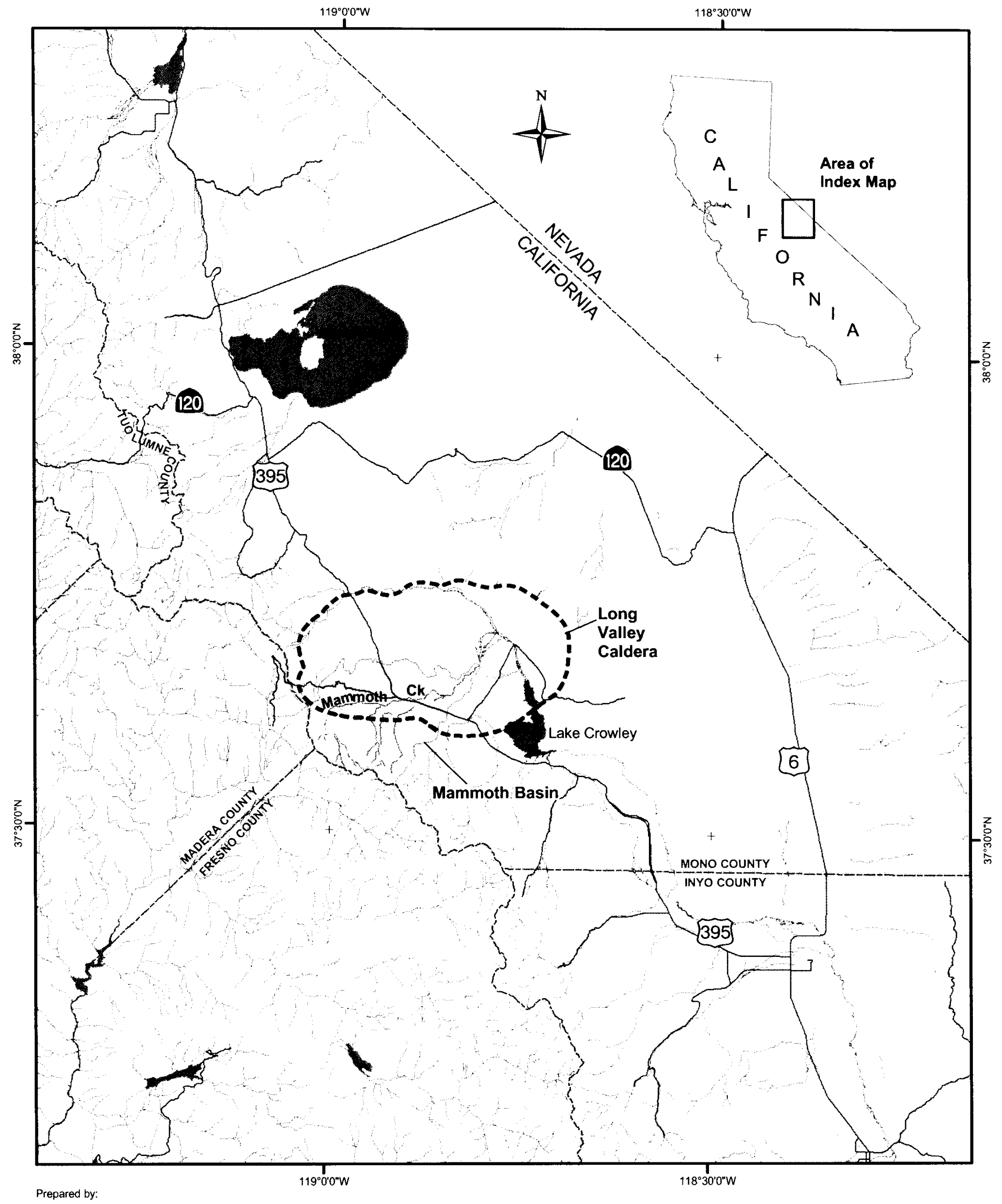
Table 3-7
Monthly Distribution of Discharge for Hot Creek at Flume

(acre-ft)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1950-1951	2,274	3,432	3,912	2,678	2,352	2,411	2,257	3,617	5,190	3,637	2,746	2,437	36,943
1951-1952	2,401	2,177	2,411	2,548	2,228	2,377	3,305	6,623	9,779	8,451	5,267	3,912	51,479
1952-1953	3,448	2,892	2,899	3,030	2,410	2,663	2,877	2,936	4,825	5,493	2,955	2,521	38,949
1953-1954	2,471	2,382	2,307	2,274	2,171	2,764	3,080	4,961	4,724	3,974	2,652	2,407	36,167
1954-1955	2,340	2,276	2,366	2,375	2,110	2,496	2,433	3,167	5,961	3,337	2,673	2,325	33,859
1955-1956	2,327	2,207	3,712	3,219	2,634	2,842	3,290	4,993	9,663	8,606	4,931	3,808	52,232
1956-1957	3,742	3,320	3,111	2,965	2,794	3,001	2,967	3,431	7,770	4,716	3,111	2,913	43,841
1957-1958	2,959	2,752	2,656	2,490	2,380	2,720	3,797	6,732	8,453	7,050	5,019	3,955	50,963
1958-1959	3,400	3,109	2,960	2,905	2,474	3,015	3,021	3,149	3,628	2,727	2,514	2,539	35,441
1959-1960	2,437	2,371	2,437	2,476	2,362	2,533	2,482	2,380	3,025	2,377	2,193	2,146	29,219
1960-1961	2,120	2,050	2,091	2,082	1,980	2,259	2,074	2,173	2,386	2,121	2,021	2,051	25,408
1961-1962	2,173	2,095	2,184	2,166	2,103	2,386	3,576	3,844	7,016	5,371	3,233	2,926	39,073
1962-1963	2,958	2,583	2,585	2,351	3,529	2,675	2,768	4,152	8,312	6,511	3,896	3,428	45,748
1963-1964	3,235	3,185	2,810	2,570	2,354	2,555	2,579	3,021	3,994	2,568	2,379	2,272	33,522
1964-1965	2,309	2,272	2,988	2,824	2,319	2,622	2,868	3,534	7,096	7,172	5,815	4,114	45,933
1965-1966	3,573	3,342	3,097	3,018	2,493	2,972	3,073	4,622	4,209	2,973	2,598	2,503	38,473
1966-1967	2,581	2,397	3,155	2,596	2,434	3,188	3,250	5,108	9,860	12,523	6,643	5,269	59,004
1967-1968	4,282	3,644	3,438	3,263	3,042	2,977	2,835	3,349	3,729	2,791	2,567	2,378	38,295
1968-1969	2,456	2,525	2,500	2,497	2,300	2,890	4,214	11,513	16,151	12,685	7,364	5,018	72,113
1969-1970	4,789	3,863	3,663	3,718	3,260	3,578	3,528	4,686	6,758	5,190	3,456	3,164	49,653
1970-1971	3,148	3,191	3,235	3,065	2,721	2,923	2,681	4,189	6,056	4,300	3,090	2,710	41,309
1971-1972	2,938	2,923	2,685	2,694	2,473	2,786	2,504	3,119	4,566	2,655	2,284	2,797	34,424
1972-1973	2,801	2,619	2,697	2,710	2,511	2,656	3,564	7,173	8,704	5,488	3,669	3,138	47,730
1973-1974	3,059	3,541	3,068	3,095	2,622	2,995	2,944	5,998	8,784	5,390	3,747	3,072	48,315
1974-1975	3,106	2,745	2,709	2,692	2,272	2,658	2,554						
1983-1984	5,568	5,009	4,811	4,343	3,893	3,899	3,736	6,905	7,644	6,403	4,688	3,795	60,694
1984-1985	4,002	3,930	3,893	3,617	3,125	3,387	3,710	4,910	5,205	3,724	3,207	3,056	45,766
1985-1986	3,091	3,040	3,262	3,306	3,337	4,654	4,662	8,067	10,199	8,275	5,610	4,499	62,002
1986-1987	4,551	3,708	3,456	3,282	2,976	3,294	2,856	4,008	3,706	3,155	2,899	2,679	40,570
1987-1988	2,602	2,637	2,703	2,820	2,655	2,802	2,637	3,020	3,441	3,006	2,669	2,465	33,457
1988-1989	2,526	2,542	2,384	2,399	2,271	2,566	2,483	3,329	3,329	2,625	2,499	2,388	31,341
1989-1990	2,378	2,346	2,284	2,306	2,118	2,417	2,185	2,437	2,649	2,358	2,374	2,058	27,910
1990-1991	2,015	2,005	1,945	1,969	1,858	2,239	2,384	2,358	4,156	3,099	2,731	2,514	29,273
1991-1992	2,316	2,237	2,094	2,086	1,995	2,150	2,106	2,931	2,647	2,473	2,203	2,013	27,251
1992-1993	2,060	1,991	1,818	1,963	1,814	2,409	2,967	4,710	7,032	6,476	3,982	3,214	40,436
1993-1994	2,937	2,600	2,499	2,378	2,102	2,318	2,249	3,072	3,250	2,520	2,191	1,939	30,055
1994-1995	1,955	1,929	2,090	2,213	2,048	2,731	3,197	4,648	9,487	13,161	8,305	5,515	57,279
1995-1996	4,158	3,429	3,550	3,216	3,157	3,266	3,591	6,948	8,469	6,024	4,474	3,601	53,883
1996-1997	3,236	3,442	3,274	5,824	3,230	3,395	3,552	6,542	7,073	5,015	3,958	3,496	52,037
1997-1998	3,248	3,022	3,068	3,234	2,824	3,389	3,393	3,833	8,162	11,313	6,605	5,011	57,102
1998-1999	4,200	3,841	3,446	3,367	3,093	3,177	3,088	4,823	6,865	4,769	3,639	3,099	47,407
1999-2000	3,016	2,925	2,758	2,887	2,760	2,840	2,731	5,150	5,901	3,823	3,308	2,911	41,010
2000-2001	2,901	2,699	2,723	2,649	2,425	2,955	2,764	5,193	4,067	3,258	2,871	2,643	37,148
2001-2002	2,516	2,445	2,516	2,425	2,201	2,467	2,673	3,145	4,275	2,915	2,625	2,378	32,581
2002-2003	2,431	2,863	2,586	2,691	2,338	2,627	2,479	3,437	5,977				
Average	3,001	2,856	2,863	2,828	2,546	2,843	2,977	4,499	6,231	5,174	3,667	3,095	42,681
Stan Dev	807	648	603	673	466	472	566	1,832	2,759	2,957	1,522	921	10,821
Coef of Var	27%	23%	21%	24%	18%	17%	19%	41%	44%	57%	42%	30%	25%
Max	5,568	5,009	4,811	5,824	3,893	4,654	4,662	11,513	16,151	13,161	8,305	5,515	72,113
Min	1,955	1,929	1,818	1,963	1,814	2,150	2,074	2,173	2,386	2,121	2,021	1,939	25,408
% of Annual	7.0%	6.7%	6.7%	6.6%	6.0%	6.7%	7.0%	10.5%	14.6%	12.1%	8.6%	7.3%	100.0%

Table 3-8
Flow Components for Hot Creek at Flume
(acre-ft/yr)

Year	Discharge at Hot Creek at Flume			Discharge at Springs		
	Total	Base[1]	Snowmelt and Storm Discharge	AB	CD	H23
1950 / 1951	36,943	23,161	13,781			
1951 / 1952	51,403	21,984	29,419			
1952 / 1953	38,948	29,060	9,888			
1953 / 1954	36,168	25,007	11,161			
1954 / 1955	33,859	25,260	8,599			
1955 / 1956	52,153	25,369	26,784			
1956 / 1957	43,840	15,851	27,989			
1957 / 1958	50,963	27,450	23,514			
1958 / 1959	35,443	30,576	4,867			
1959 / 1960	29,136	24,774	4,362			
1960 / 1961	25,407	22,365	3,041			
1961 / 1962	39,072	23,270	15,802			
1962 / 1963	45,749	28,409	17,340			
1963 / 1964	33,411	27,142	6,268			
1964 / 1965	45,933	26,853	19,080			
1965 / 1966	38,472	29,676	8,797			
1966 / 1967	59,003	26,624	32,379			
1967 / 1968	38,141	34,524	3,617			
1968 / 1969	72,114	27,577	44,537			
1969 / 1970	49,653	34,501	15,151			
1970 / 1971	41,308	30,508	10,801			
1971 / 1972	34,331	26,998	7,333			
1972 / 1973	47,732	26,527	21,205			
1973 / 1974	48,315	29,784	18,531			
1983 / 1984	60,495	42,066	18,429			
1984 / 1985	45,879	35,596	10,282			
1985 / 1986	64,501	33,791	30,710	7,767		
1986 / 1987	40,570	36,624	3,946	6,279		
1987 / 1988	33,374	28,409	4,965	4,628		2,477
1988 / 1989	31,341	26,744	4,597			2,256
1989 / 1990	27,911	24,609	3,302		5,638	2,207
1990 / 1991	29,273	22,632	6,641		6,270	2,335
1991 / 1992	27,171	22,691	4,480	2,446	5,472	2,001
1992 / 1993	40,437	22,712	17,726	3,588	6,257	2,412
1993 / 1994	30,054	25,405	4,649	3,084	6,064	2,575
1994 / 1995	57,279	21,346	35,933	4,723	5,699	2,483
1995 / 1996	53,884	30,978	22,906	6,436	6,576	2,759
1996 / 1997	52,038	31,702	20,336	6,426	6,270	2,621
1997 / 1998	57,102	30,327	26,775	7,036	6,782	2,692
1998 / 1999	47,408	34,851	12,557	6,889	6,696	2,867
1999 / 2000	41,010	29,350	11,661	5,865	6,238	2,648
2000 / 2001	37,150	27,468	9,682	4,799	6,158	2,642
2001 / 2002	32,583	25,079	7,503	3,627	5,946	2,463
Average (acre-ft/yr)	42,720	27,805	14,915	5,257	6,159	2,496
Min (acre-ft/yr)	25,407	15,851	3,041	2,446	5,472	2,001
Max (acre-ft/yr)	72,114	42,066	44,537	7,767	6,782	2,867
Coefficient of Variation	26%	18%	69%	31%	6%	9%
Average (cfs)	59.0	38.4	20.6	7.26	8.51	3.45
Min (cfs)	35.1	21.9	4.20	3.38	7.56	2.76
Max (cfs)	99.6	58.1	61.5	10.7	9.37	3.96
Standard Deviation (cfs)				2.57	0.47	0.26
Fraction of Total Spring Flow (1986 to 2002)				19%	22%	9%



Prepared by:

WE WILDERMUTH ENVIRONMENTAL, INC.
23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wild-environment.com

Author: CKM
Date: 20031009
File: Figure_3-1.mxd

0 5 Miles

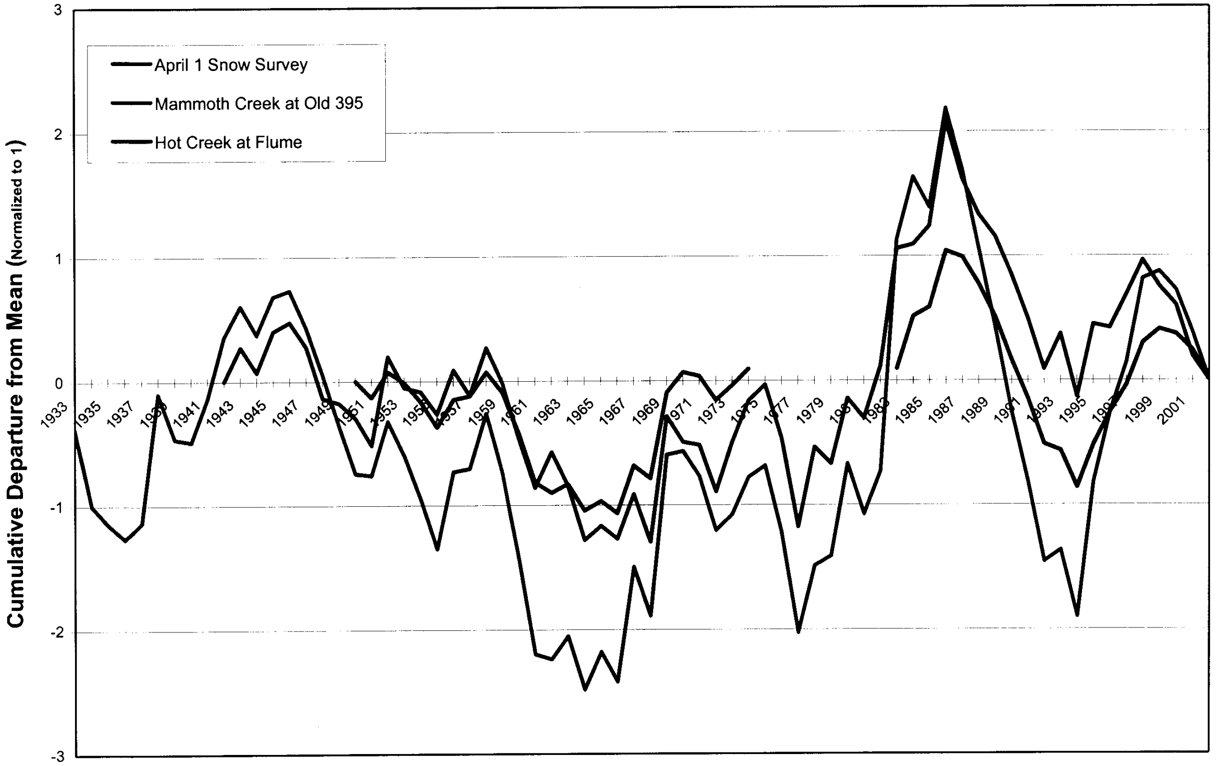
KM
0 5 10

Mammoth Community Water District

Study Area Location Map

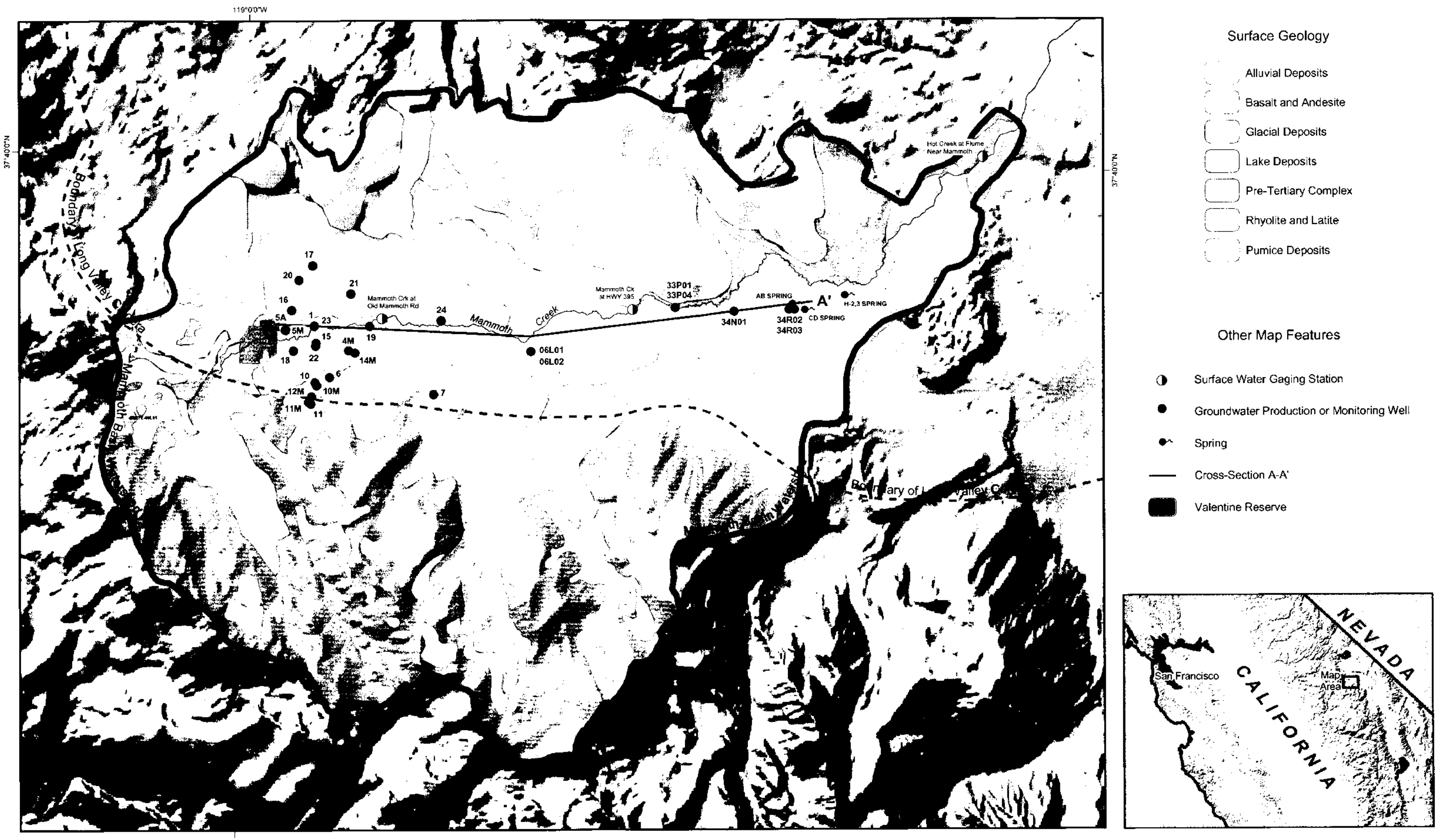
Figure 3-1

Figure 3-2
Cumulative Departure From Mean For Hydrologic Times Series in the Mammoth Basin



S:\Clients\Mammoth CWD\2002_03 Revised Yield_aka Snow Creek_ Report Project\20031009 Report\ -- 20031009 Accum Departure.xls -- Figure 3-2 MCWD
Created on 07/17/03
Printed on 11/17/2003

Wildermuth Environmental, Inc.



Produced by:

WE WILDERMUTH ENVIRONMENTAL, INC.

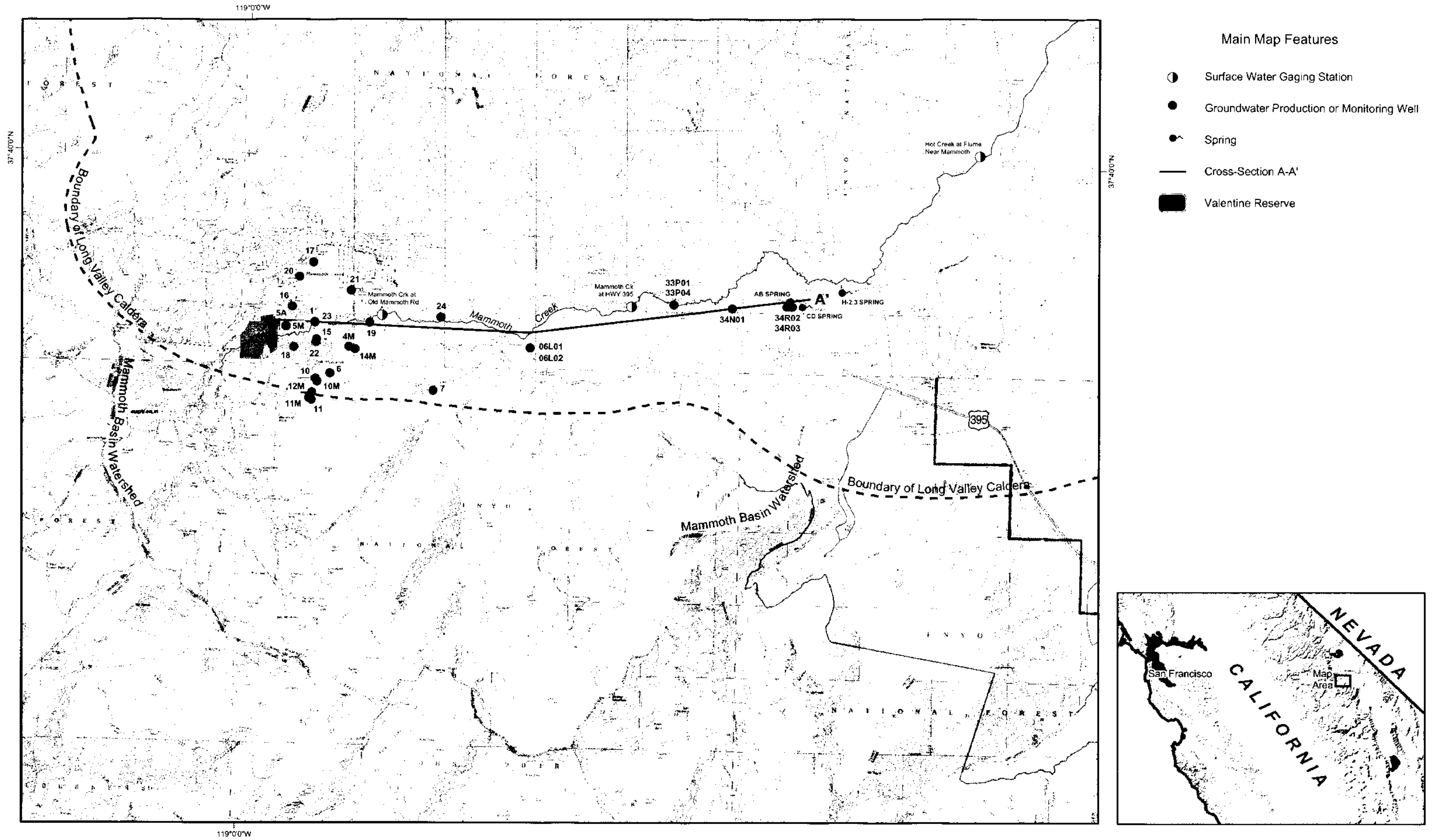
23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wild-environment.com

Author: AEM
Date: 20031009
File: Figure_3-3.mxd

Mammoth Community Water District
Revised Yield Report
Mammoth Basin Geology and Hydrologic Setting

Geology Map

Figure 3-3



Produced by:

WE WILDERMUTH ENVIRONMENTAL, INC.

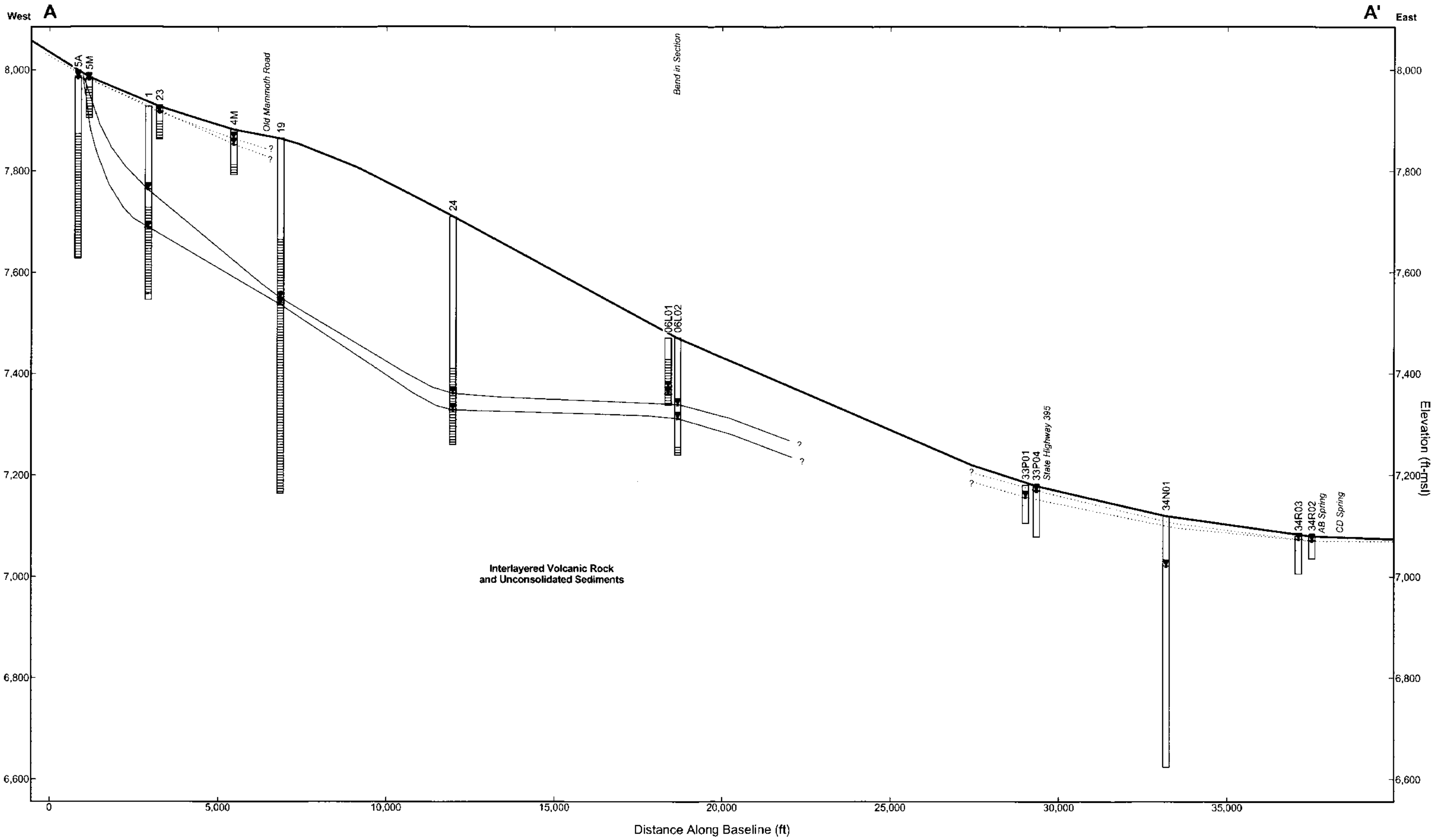
23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wild-environment.com

Author: AEM
Date: 20031009
File: Figure_3-4.mxd

Mammoth Community Water District
Revised Yield Report
Mammoth Basin Geology and Hydrologic Setting

Location of MCWD Wells and Cross-Section A-A'

Figure 3-4



Prepared by:

WE WILDERMUTH ENVIRONMENTAL, INC.
www.wild-environment.com

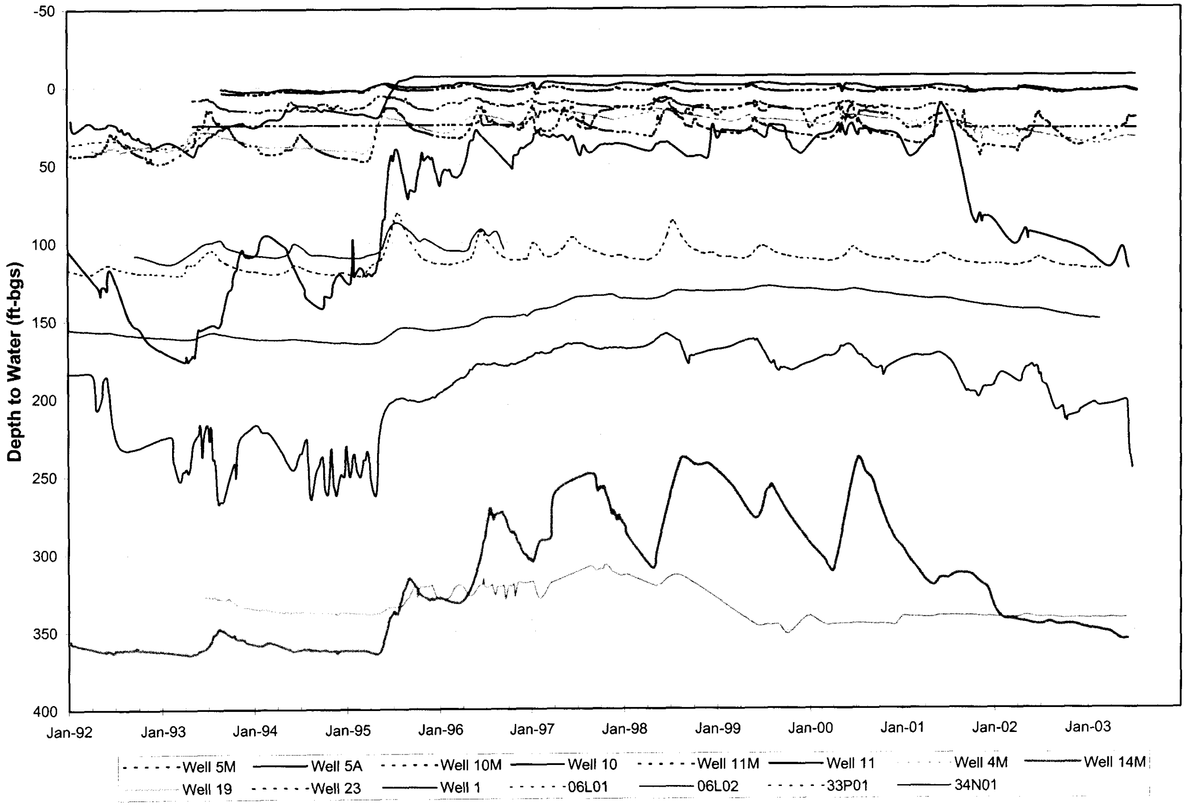
Vertical Scale: 1 = 180'
Horizontal Scale: 1 = 2700'
Vertical Exaggeration = 15:1

Mammoth Community Water District

Cross-Section A-A'
Groundwater Piezometric Profile

Figure 3-5

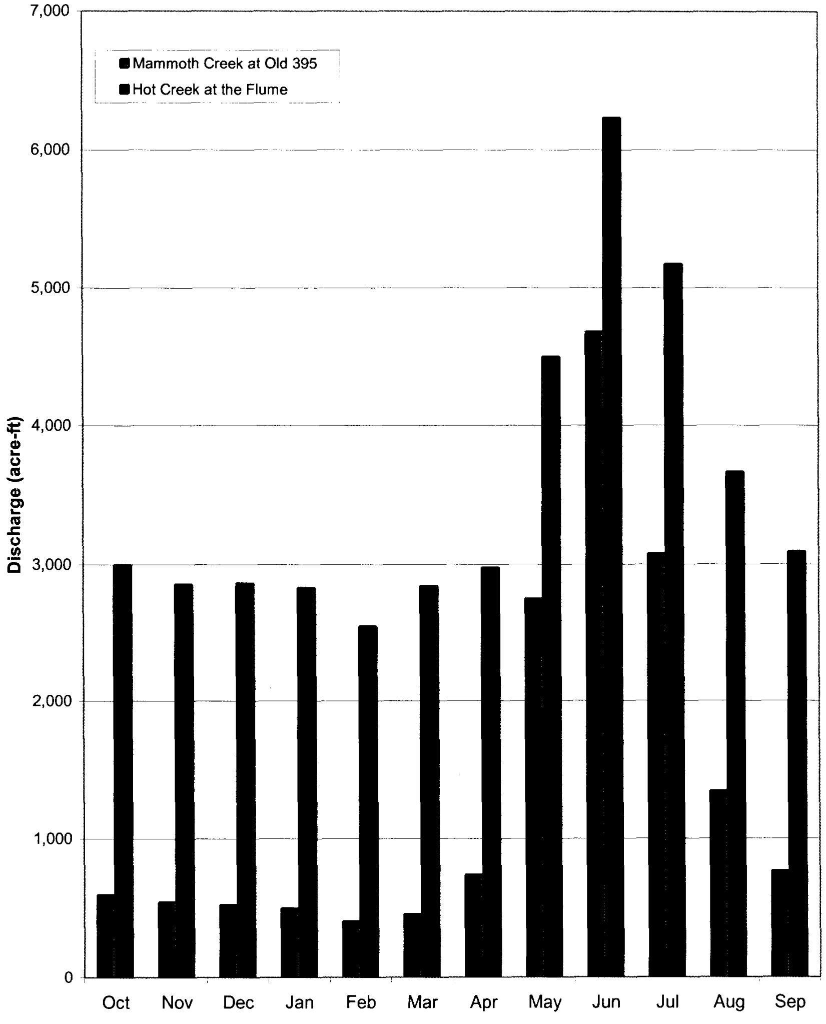
Figure 3-6
Water Level Time History for Deep and Shallow System Wells



S:\Clients\Mammoth CWD\2002_03 Revised Yield_aka Snow Creek_ Report Project\20031009 Report\ -- 20031009 Figure 3-6 WL_TimeHistories.xls -- Chart_DvS_92-03
Created on 10/08/03
Printed on 11/17/2003

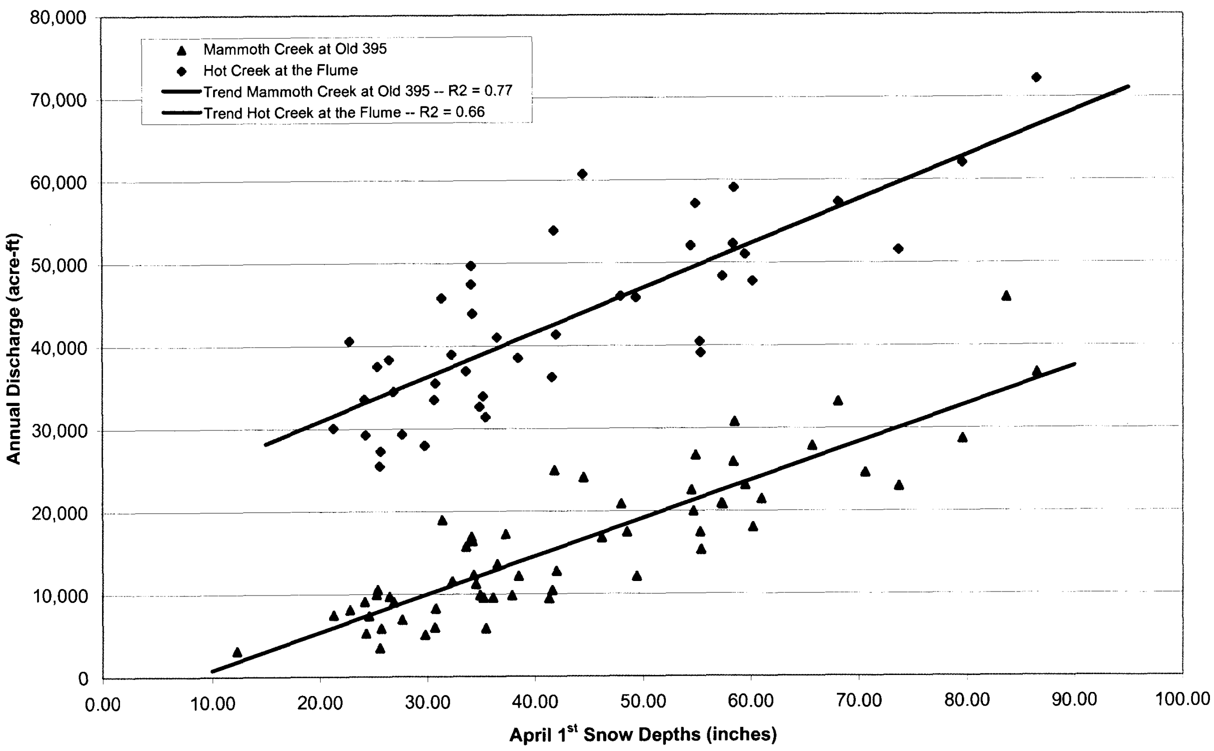
Wildermuth Environmental, Inc.

Figure 3-7 Monthly Distribution for Mammoth Creek at Old 395 and for Hot Creek at the Flume



S:\Clients\Mammoth CWD\2002_03 Revised Yleld_aka Snow Creek_ Report Project\20031009 Report\ -- 20030717 Basic Hydrology.xls --
Figure 3-7 Mon Qs Dist
Created on 07/17/03
Printed on 11/17/2003

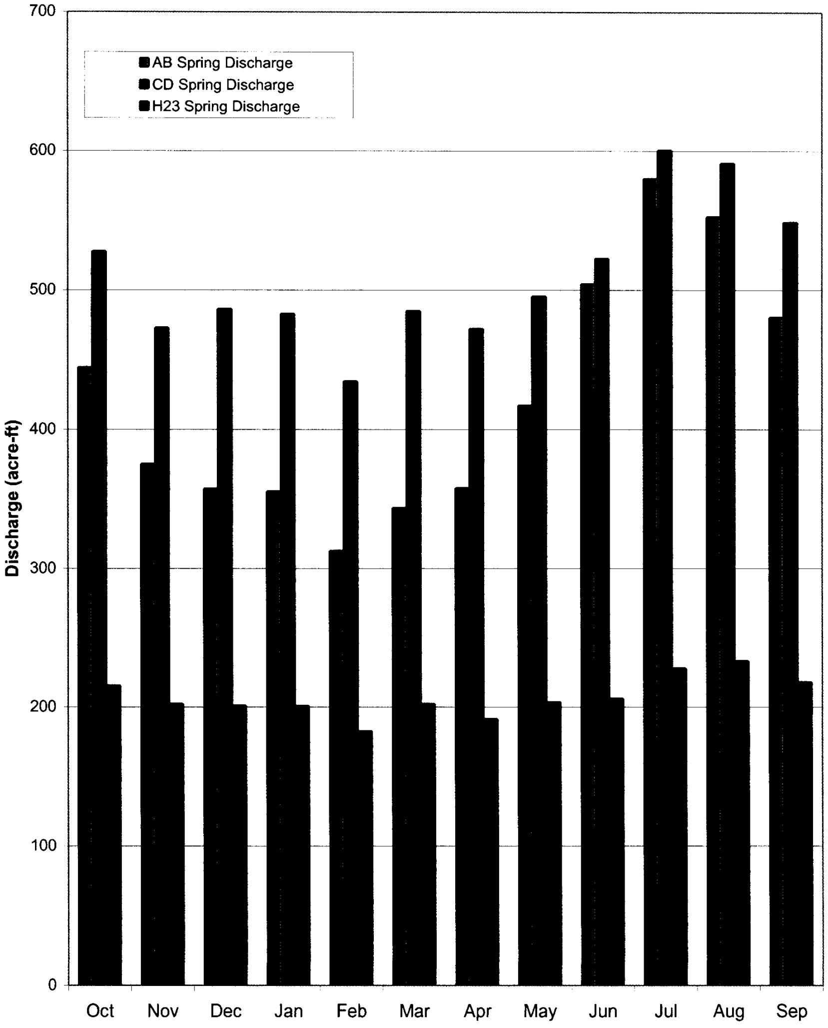
Figure 3-8 Comparison of Discharge in Mammoth Basin to the April 1st Snow Surveys



S:\Clients\Mammoth CWD\2002_03 Revised Yield_aka Snow Creek_ Report Project\20031009 Report\ -- 20031009 Accum Departure.xls -- Figure 3-8 april 1_regress tw
Created on 10/07/03
Printed on 11/17/2003

Wildermuth Environmental, Inc.

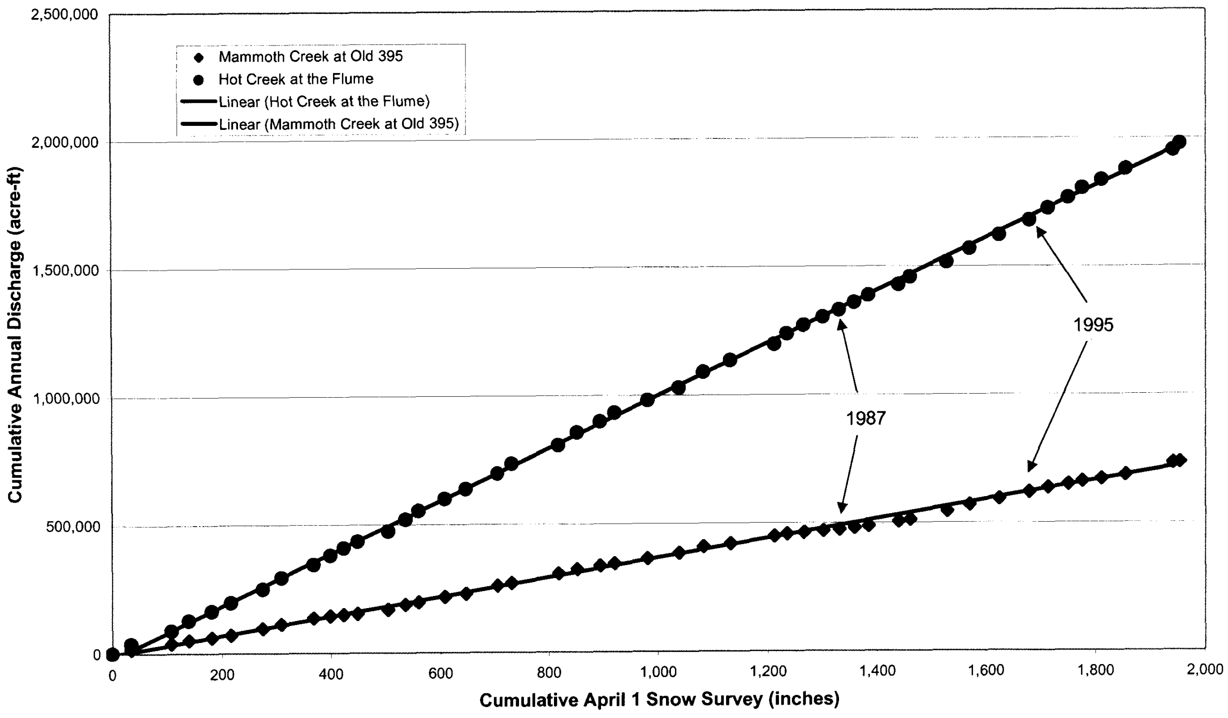
Figure 3-9 Monthly Distribution for Discharge for Springs at the Hot Creek Fish Hatchery



S:\Clients\Mammoth CWD\2002_03 Revised Yleld_aka Snow Creek_ Report Project\20031009 Report\ -- 20031004 Water Demands.xls --
Figure 3-9 Mon Qs Springs
Creatd on 07/17/03
Printed on 11/17/2003

Wildermuth Environmental, Inc.

Figure 3-10 Double Mass Curve for Mammoth Creek at Old 395 and Hot Creek at Flume Versus April 1 Snow Survey (1951 through 2002)



S:\Clients\Mammoth CWD\2002_03 Revised Yield_aka Snow Creek_ Report Project\20031009 Report\ -- 20031009 Accum Departure.xls -- Figure 3-10 MCWD
Created on 07/17/03
Printed on 11/17/2003

Wildermuth Environmental, Inc.

4. FUTURE WATER DEMANDS AND SUPPLIES

4.1 Current Demands and Water Supply Sources

Estimates of existing and future water demands in the Mammoth Basin are listed in Table 4-1. These estimates are based in part on published estimates from MCWD (2000 Urban Water Management Plan, MCWD, updated in October 2001) and other estimates for the Snowcreek Golf Course. Water supplies in the MCWD service area come from a combination of surface water diverted from Lake Mary and groundwater pumped within its service area. Table 3-4 lists monthly and annual amounts of water produced by MCWD from 1983 through 2002 and includes a groundwater production estimate by the Snowcreek golf course. Domestic use at the Casa Diablo geothermal plant is estimated at 0.35 acre-ft/yr.

4.2 Future Water Supply Scenarios

Three basic scenarios were developed to investigate the potential impacts of groundwater production in the Mammoth area for existing and ultimate build out assumed in 2020. The 2020 scenarios are distinguished by the inclusion or exclusion of the Dry Creek Project. The Dry Creek project is essentially an importation project to bring supplemental waters from outside of the Mammoth Basin to meet future water demands. Recycled water was not included as source of supply in these scenarios. The scenarios studied herein include:

- Existing Conditions – Existing surface and ground water sources and estimated year 2005 demands.
- 2020 Supply as per 2001 UWMP – Existing surface and ground water sources and the Dry Creek importation project with estimated 2020 demands.
- 2020 Supply as per 2001 UWMP without Dry Creek – Existing surface and ground water sources with estimated 2020 demands.

Snowcreek production was assumed to increase from about 100 acre-ft/yr to 200 acre-ft/yr with the expansion of the golf course from a 9-hole course to an 18-hole course.

Table 4-1 shows the estimated water demands and supply capacities for each scenario. Each scenario has a normal or average water supply condition and a three-year dry-period supply condition. With one exception there is an adequate buffer of surplus supply. The exception is the 2020 Supply as per *2001 UWMP without Dry Creek* scenario under a three-year dry-period water supply condition where supply equals demand.

Table 4-1
Water Demands and Supply Plan Alternatives
(acre-ft/yr)

Source	Existing Conditions[1]		2001 UWMP Future[1]		2001 UWMP Future without Dry Creek	
	Average	3-yr Dry Period	Average	3-yr Dry Period	Average	3-yr Dry Period
MCWD Surface Water Production Capacity[5]	2,530	1,200	2,760	1,200	2,760	1,200
MCWD Groundwater Production Capacity[5]	4,000	3,800	4,000	3,800	4,000	3,800
Snow Creek Groundwater Production	100	100	200	200	200	200
Dry-Creek Groundwater Production	0	0	1,500	1,250	0	0
Total Production Capacity	6,630	5,100	8,460	6,450	6,960	5,200
Existing Demand[2]	3,720	3,720				
Future Demand[3]			4,980	4,980	4,980	4,980
Surplus (Deficit)[4]	2,910	1,380	3,480	1,470	1,980	220

1 -- Source 2000 Urban Water Management Plan, Mammoth Community Water District, Updated 2001

2 -- Year 2005 estimated demand

3 -- Year 2020 estimated demand and assumed to be demand at build out

4 -- Difference between *Total Production Capacity* and either *Existing Demand* or *Future Demand*

5 -- The MCWD 2000 UWMP estimates the 3-yr dry-period capacities as 1,370 acre-ft/yr and 3,300 acre-ft/yr for surface and ground water respectively; values in this table were modified as suggested by Gary Sisson on 9-2-03 email.

5. IMPACT OF NEW GROUNDWATER PRODUCTION ON HOT CREEK HEADSPRINGS

5.1 Assumptions and Methodology

From the analysis of the data presented in Section 3, it was concluded that there has been no discernible impact on the Hot Creek spring discharges from historical groundwater production in the western part of the Mammoth Basin. The hydrologic and geologic complexities of the Basin preclude the development and use of groundwater flow modeling for impact analysis. A conservative approach was developed to estimate impacts of future/new groundwater production on the Hot Creek spring discharges. We assumed that all new groundwater production would impact the springs directly; with the impact allocated to the springs based on their relative contribution to the Hot Creek base flow. Groundwater production impacts would normally be buffered or attenuated due to groundwater storage–it was assumed herein that attenuation from storage is negligible. It was further assumed that the seasonal variation in groundwater production would not propagate through the groundwater basin to the springs. This assumption is reasonable due to the great distance between the production area and the headsprings (about 7 miles) as well as the observation that the historical production has not influenced the discharge at the springs

The results of this analytical approach are summarized in Table 5-1. New production, if positive, is assumed to deplete the springs with 19 percent allocated to the AB spring, 22 percent to the CD spring and 9 percent to the H23 spring. The remaining depletion is assumed to occur in aggregate at other springs tributary to Hot Creek. This is a "worst" case analysis in that spring flows are assumed to respond immediately and in direct proportion to new groundwater production.

5.2 Impacts on Spring Discharge

Table 5-1 contains the average spring discharge in the column titled "non drought" and the estimated lowest average annual discharge observed at the spring in the column titled "drought." The spring flow depletions, assumed to occur due to new groundwater production, were deducted from the flows for cumulative new groundwater production and MCWD-only production. New groundwater production is equal to estimated future groundwater production minus the average annual groundwater production through 2002, which is equal to 1,073 acre-ft/yr. That is, the impact of historical production is assumed to be imbedded in the historical spring discharge data.

The resulting impacts on spring discharge are listed in Table 5-1. The impacts vary with scenario and climatic assumptions; ranging from zero up to 0.8 cfs at the H23 spring (11 percent under drought conditions and about 2 percent under non-drought conditions). These impacts are conservative, much less than estimated herein, and more than likely immeasurable.

Table 5-1
Projected Worst-Case Impacts From Cumulative and Incremental Groundwater Water Production for the MCWD Service Area and Surrounding Areas on Spring Discharge

(cfs)

	Spring Flow		Fraction of Spring Flow Depletion Assigned to Spring	Flow in Springs					
				Existing Conditions[3]		2001 UWMP Future[3]		2001 UWMP Future without Dry Creek	
	Non-Drought	3-Yr Dry Period[4]		Non-Drought	3-Yr Dry Period	Non-Drought	3-Yr Dry Period	Non-Drought	3-Yr Dry Period
Cumulative New Groundwater Production[1] (acre-ft/yr)				17	1,347	1,047	2,607	1,047	2,607
New Snowcreek Production (acre-ft/yr)				0	0	100	100	100	100
AB Spring	7.3	3.4	19%						
Cumulative				*7.3*	*3.0*	*7.0*	*2.7*	*7.0*	*2.7*
MCWD-Only				*7.3*	*3.0*	*7.0*	*2.7*	*7.0*	*2.7*
CD Spring	8.5	7.6	22%						
Cumulative				*8.5*	*7.1*	*8.2*	*6.8*	*8.2*	*6.8*
MCWD-Only				*8.5*	*7.1*	*8.2*	*6.8*	*8.2*	*6.8*
H23 Spring	3.5	2.8	9%						
Cumulative				*3.4*	*2.6*	*3.3*	*2.4*	*3.3*	*2.4*
MCWD-Only				*3.4*	*2.6*	*3.3*	*2.5*	*3.3*	*2.5*
All Other Springs Below Hot Creek Fish Hatchery	19.2	8.2	50%						
Cumulative				*19.2*	*7.3*	*18.5*	*6.4*	*18.5*	*6.4*
MCWD-Only				*19.2*	*7.3*	*18.5*	*6.5*	*18.5*	*6.5*
Total All Springs[2]	38.4	21.9	100%						
Cumulative				19	20.0	37.0	18.3	37.0	18.3
MCWD-Only				19	20.0	37.1	18.4	37.1	18.4

1 -- Total production from Table 4-1 minus average production (1,073 acre-ft/yr) through 2002.

2 -- Base flow for Hot Creek at Flume from Table 3-8.

3 -- Source 2000 Urban Water Management Plan, Mammoth Community Water District, Updated 2001; base production is zero

4 -- Minimum observed discharge shown in Table 3-8

5-- Cumulative means all groundwater production in Mammoth Basin; MCWD-Only means MCWD only.

6. REFERENCES

Barnett Consultants, spring flow data in hardcopy format.

Beak Consultants, Incorporated, Brown Trout and Rainbow Trout Instream Flow Requirements in Mammoth Creek, California, draft report, September 1991.

Department of Water Resources (DWR), Mammoth Basin Water Resources Environmental Study, December 1973.

Kenneth Schmidt and Associates, Results of the Summer 1993 aquifer test, Mammoth County Water District Well No. 15, November 1993.

Kenneth Schmidt and Associates, Letter report regarding Potential Impacts of MCWD Well No. 11 Pumpage, March 27, 1991.

Kenneth Schmidt and Associates, Annual Report on Results of Mammoth Community Water District Groundwater Monitoring Program for October 1994 to September 1995, December 1995.

Leroy Crandall and Associates, Review of Available Information on Ground Water Conditions in Mammoth Valley, May 1991.

Los Angeles Department of Water and Power (LADWP), streamflow data in hardcopy and magnetic forms for Mammoth Creek at Old 395 and Hot Creek at Flume.

Mammoth Community Water District (MCWD), 2000 Urban Water Management Plan, Updated October 2001.

Mark J. Wildermuth, Water Resources Engineer, Hydrologic Impacts of the Snowcreek Golf Course Expansion of the AB and CD Headwater Springs, September 1996.

Triad Engineering Corporation, Watershed Analysis for Proposed Sherwin Ski Area, December 1985.

United States Department of Agriculture, Forest Service, Draft Environmental Impact Statement, Proposed Snowcreek golf Course Expansion Project, December 1995.

United States Geological Survey (USGS), Sources of Arsenic in Streams Tributary to lake Crowley, California, 1976.

United States Geological Survey (USGS), Hydrologic and Geochemical Monitoring in Long Valley Caldera, Mono County California, 1982 to 1984, Water-Resources Investigations Report 85-4183, 1985.

United States Geological Survey (USGS), Hydrologic and Geochemical Monitoring in Long Valley Caldera, Mono County California, 1985, Water-Resources Investigations Report 87-4090, 1987.

United States Geological Survey (USGS), Review of Mammoth Community Water District Reports and Data, circa February 1995.