Water-Related Scientific Activities of the U.S. Geological Survey in Nevada, Fiscal Years 1993-94

Compiled by M. Teresa Foglesong

U.S. GEOLOGICAL SURVEY

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CONVERSION FACTORS AND DEFINITIONS

Multiply	By	To obtain
acre	4,047	square meter
acre-foot	1,233	cubic meter
acre-foot per year	0.001233	cubic hectometer per year
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot (ft)	0.3048	meter
inch (in.)	25.40	millimeter
mile (mi)	1.609	kilometer
square foot (ft^2)	0.0929	square meter
square mile (mi^2)	2.590	square kilometer

Fiscal Year and Water Year: Both constitute the 12-month period from October 1 through September 30, and are designated by the year in which the period ends (for example, fiscal year 1993 began October 1, 1992, and ended September 30, 1993).

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INTRODUCTION

The U.S. Geological Survey has been collecting water-resources data in Nevada since the 1880's. This report contains an overview of the progress of water-related scientific activities in Nevada by the Water Resources Division of the U.S. Geological Survey, from October 1, 1992, to September 30, 1994. The organizational structure, funding, and technical resources of the Nevada District, as well as water conditions throughout the State and some major water issues in the State during the past 2 fiscal years, are described herein.

The Nevada District program consisted of 37 projects during the past 2 fiscal years. A description of each project is given in the main body of the report. A list of publications produced by the Nevada District staff and a list of sources of information to aid the reader in locating other Geological Survey products are included at the end of the report.

ORIGIN OF THE U.S. GEOLOGICAL SURVEY

The U.S. Geological Survey (USGS) was established by an act of Congress on March 3, 1879, to provide a permanent Federal agency to conduct the systematic and scientific "classification of the public lands, and examination of the geological structure, mineral resources, and products of national domain." An integral part of that original mission is to publish and distribute the earth-science information needed to understand, plan the use of, and manage the Nation's energy, land, mineral, and water resources.

Since 1879, the research and fact-finding role of USGS has grown and been modified to meet the changing needs of the Nation it serves. As part of that evolution, USGS has become the map-making agency for the Federal Government, the primary source of data on surface- and ground-water resources of the Nation, and the employer of the largest number of professional earth scientists. Today's programs serve a diversity of needs and users.

BASIC MISSION AND PROGRAM OF THE WATER RESOURCES DIVISION

The mission of the Water Resources Division (WRD) of the USGS is to provide the hydrologic information and understanding needed to manage the Nation's water resources to benefit the people of the United States. To accomplish this mission, WRD, in cooperation with Federal, State, and local agencies, uses a variety of investigative and interpretive techniques to collect and transfer hydrologic information to the water-resources community and the public. WRD undertakes this mission by applying objective scientific methods and maintaining an unbiased stance in the midst of often highly controversial political issues.

Programs sponsored by WRD in Nevada include:

- Data collection to aid in evaluating the quantity, quality, distribution, and use of water resources in Nevada;
- Analytical and interpretive water-resources appraisals to describe the occurrence, quality, and availability of surface and ground water in Nevada;
- Basic and problem-oriented research in hydraulics, hydrology, and related fields of science and engineering;
- Scientific and technical assistance in hydrology to other Federal, State, and local agencies; and

- Public distribution of water-resources data and results of water-resources investigations through reports, maps, computerized information services, and other forms of release.

NEVADA DISTRICT, WRD

History

In 1889, U.S. Geological Survey personnel began measuring the flow of Nevada streams, starting with the Truckee River Basin. In 1913, the USGS and the Nevada State Engineer initiated a cooperative program to support the stream-gaging activities; more than eight decades later, that program is still in place. A ground-water program, also in cooperation with the State Engineer, began almost 50 years ago in 1945; it, too, is still in place. This information and additional historical perspective regarding the USGS presence in Nevada are provided by Shamberger (1991, p. 59-74).[1] Table 1, an update of the USGS chronology presented by Shamberger (1991, p. 93), lists the Geological Survey officials who have been in charge of water-resources investigations and data collection in the State since 1913.

Organization

The Nevada District currently is responsible for water-related U.S. Geological Survey activities in Nevada. The Nevada District has about 150 employees, most of whom are in the Carson City District Office; about 40 are in the Las Vegas Subdistrict Office; and 4 are in the Elko Field Office. These staffing figures represent more than a 200-percent increase from levels of 9 years ago (1985) and reflect an increasing interest in state water-resource issues. Organization of the Nevada District is shown in figure 1. Basic data on water resources in Nevada are collected throughout the State by personnel from the three offices. The area of responsibility for each office is shown in figure 2.

[1] Hugh A. Shamberger was Nevada State Engineer from 1951 to 1957, Director of the newly created Nevada Department of Conservation and Natural Resources from 1957 to 1965, and a senior Hydrologist with the USGS from 1968 to 1984.

Addresses and phone numbers of the three District offices in Nevada are listed below; inquiries regarding projects described in this report should be directed to the Public Information Assistant in the Nevada District Office in Carson City.

Nevada District Office
333 W. Nye Lane, Rm 203
Carson City, Nevada 89706-0866
(702) 887-7600

Las Vegas Subdistrict Office
6770 S. Paradise Rd.
Las Vegas, Nevada 89119-3721
(702) 897-4000

Elko Field Office
P.O. Box 1044
Elko, Nevada 89803-1044
(702) 738-5322

Funding and Cooperating Agencies

Programs of the Water Resources Division in Nevada are funded as follows:

1. Federal Program—funding is appropriated directly to USGS by the U.S. Congress for projects of National interest;

2. Cooperative Program—funding is shared by USGS and interested State or local agencies; and

3. Other Federal Agencies (OFA) Program—funding is supplied by Federal agencies requesting technical assistance from USGS.

Total funds and sources of those funds for fiscal years 1993 and 1994 are listed in table 2 and shown in figure 3. Total funds increased from $10.5 million in fiscal year 1993 to $10.8 million in fiscal year 1994. Cooperating agencies active during 1993-94 are listed in tables 3 and 4.

Technical Resources

District Staff

The most important factor for continuing growth in the Nevada District of high-quality data networks, hydrologic appraisals, and related research has been the dedication and technical excellence of the District staff.

Table 1. U.S. Geological Survey officials in charge of Water Resources Division activities in Nevada, 1913-94 (modified from Shamberger, 1991, p. 93)

SURFACE WATER BRANCH PERSONNEL, 1913-62

District office	District Engineer	Period	Engineer in charge	Remarks
Salt Lake City, Utah, for Utah and Nevada	E.A. Porter	1913-16		
	C.C. Jacob	1916-17		
	A.B. Purton	1917-42		
	M.J. Wilson	1942-47		
		1947-51	L.R. Sawyer	During 1947, a Surface Water Branch field office was established in Carson City to operate the cooperative stream-gaging program in Nevada.
		1951-59	C.H. Carstens	
		1960-61	L.J. Snell	
Carson City, Nev.	E.E. Harris	1961-62		

GROUND WATER BRANCH DISTRICT OFFICE, 1945-62

District office	District Engineer	Period	Remarks
Carson City, Nev.	T.W. Robinson	1945-50	A cooperative ground-water study involving Las Vegas and Pahrump Valleys was started July 1, 1944, with G.B. Maxey, Associate Geologist, in charge under general supervision of P.E. Dennis, District Geologist, Salt Lake City, Utah. On July 1, 1945, a statewide Ground Water District Office was established in Carson City.
	O.J. Loeltz	1950-62	

WATER RESOURCES DIVISION DISTRICT OFFICE, 1962-PRESENT (1994)

District office	District Chief	Period	Office Chief	Remarks
Carson City, Nev.	G.F.Worts, Jr.	1962-74		In 1962, the USGS began consolidating field activities of the Water Resources Division surface-water, ground-water, and water-quality branches into single multidisciplinary offices. The first consolidated District office in the Nation was established in Carson City on July 1, with all Division programs under general supervision of Nevada District Chief.
	J.P. Monis	1974-77		
	F.T. Hidaka	1977-79		
	T.J. Durbin	1979-81		
	Terry Katzer	1981-82		
Boise, Idaho	E.F. Hubbard, Jr.	1982-85	Terry Katzer	Idaho and Nevada District Offices merged into one District in August 1982, with District Chief and Idaho Office Chief in Boise, and Nevada Office Chief in Carson City.
		1985-86	Otto Moosburner	Acting Nevada Office Chief.
		1986-87	W.J. Carswell, Jr.	
Carson City, Nev.	W.J. Carswell, Jr.	1987-91		Idaho-Nevada District demerged into separate districts in October 1987, with Nevada District Chief in Carson City.
	J.O. Nowlin	1991-		

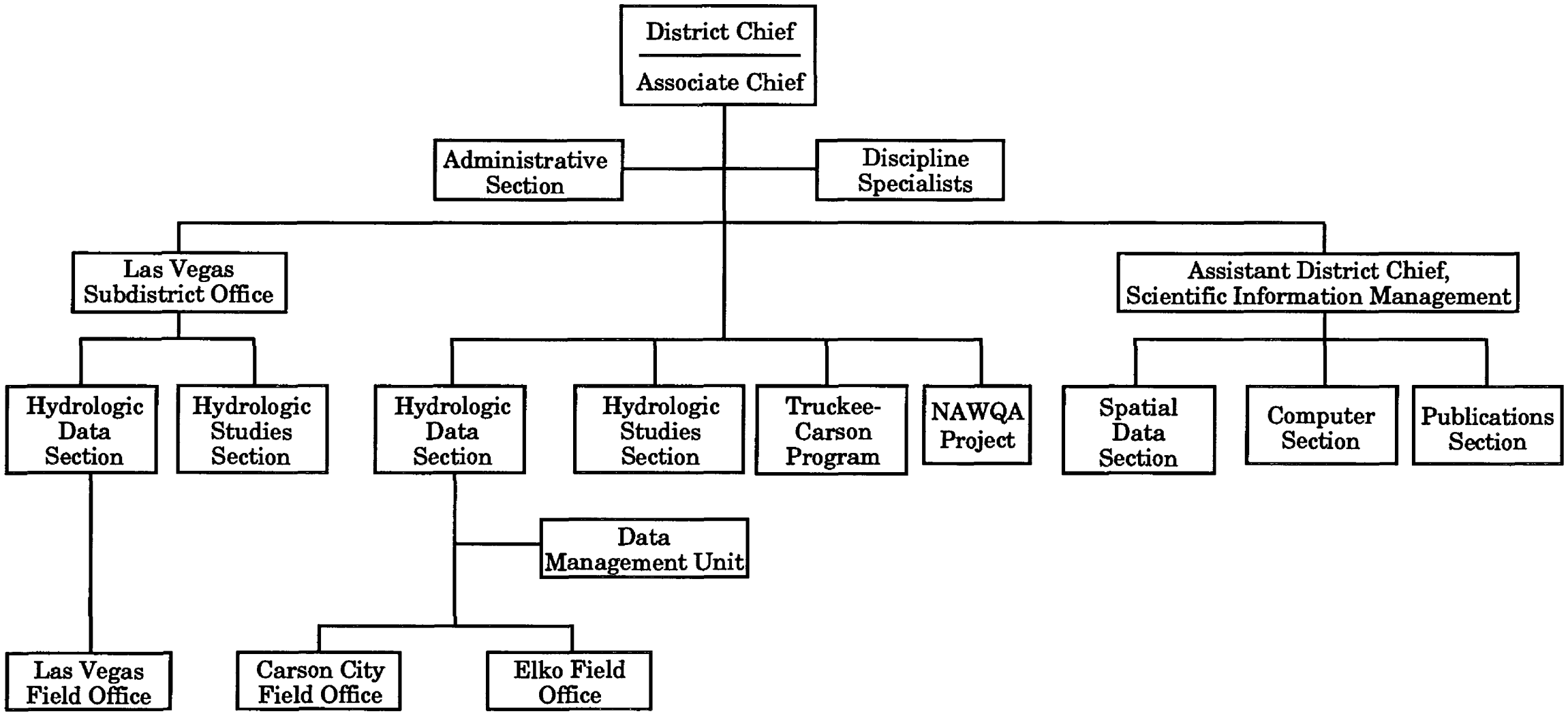


Figure 1. Nevada District organizational structure as of March 1994.

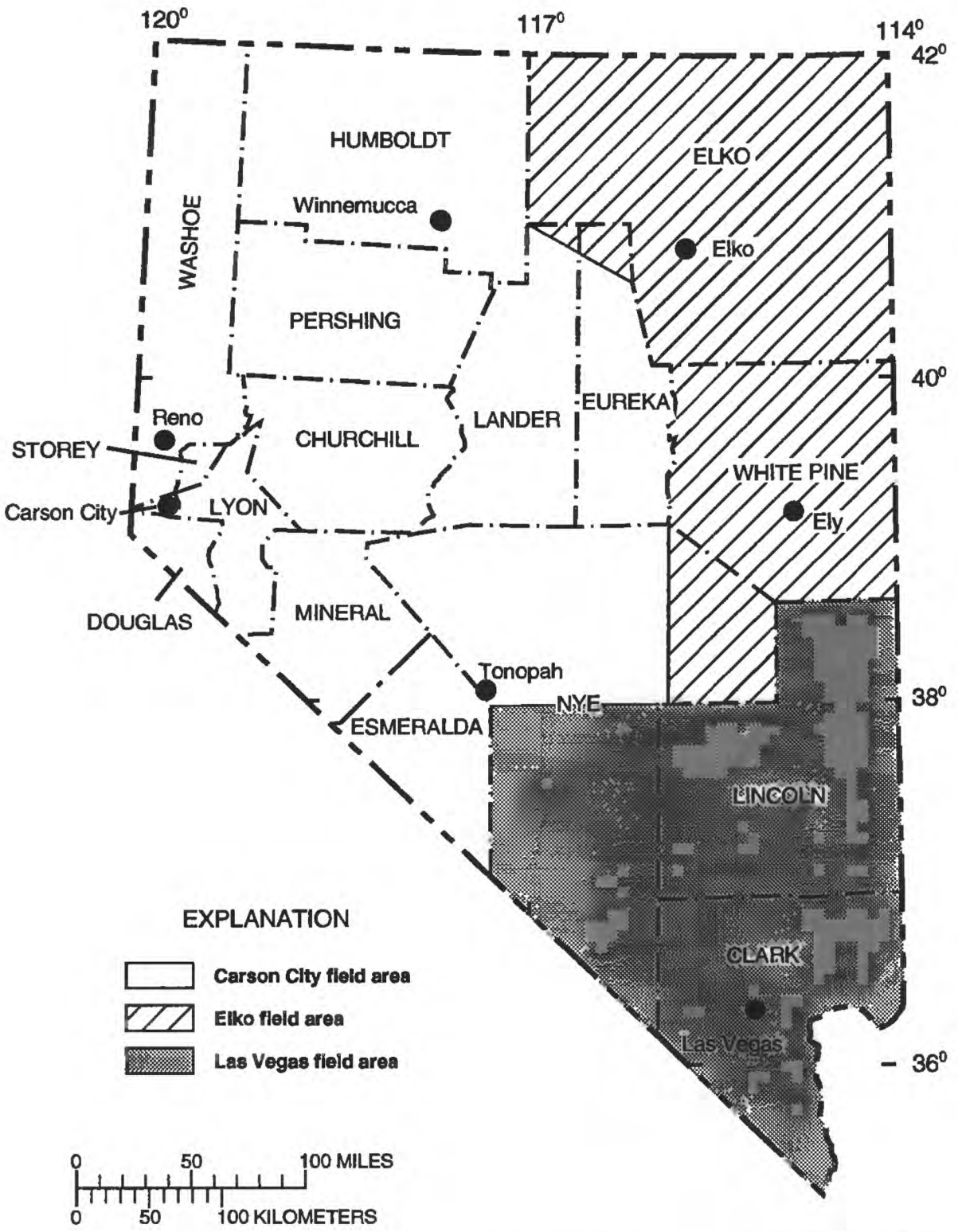


Figure 2. General geographic areas of responsibility for basic-data collection by Nevada District field offices.

The staff has grown in response to the growth in program (figure 3A). In figure 3A, the number of full-time equivalent positions for a given year equals the total number of hours worked during that year by all Nevada District staff members, both full-time and part-time, divided by 2,080 hours (the total number of full-time working hours per year).

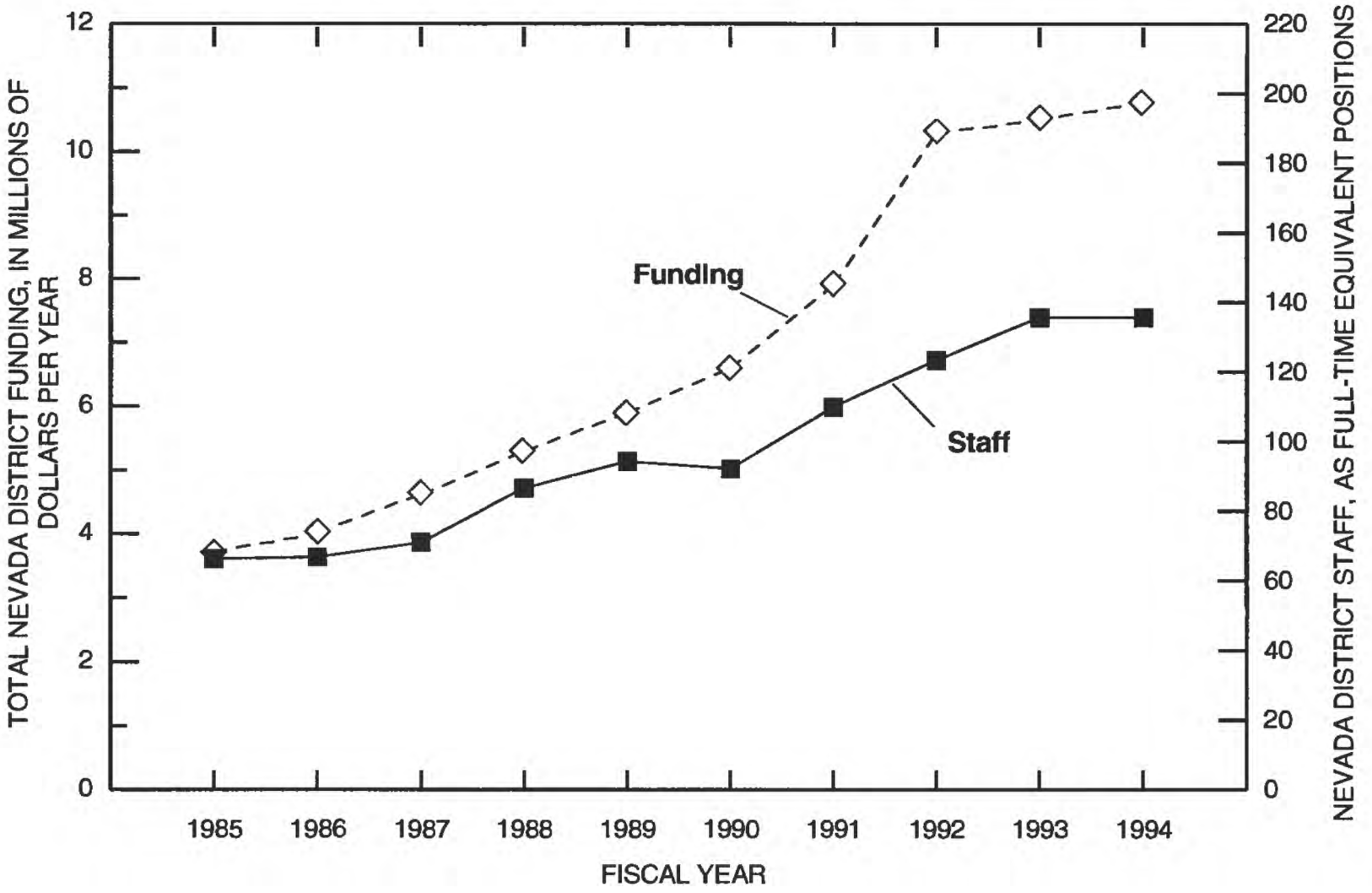
The staff is well educated. In fiscal year 1994, about 73 percent of the total staff had college degrees, including four doctorates. About 42 percent of the support staff (administration, computer, and publications sections) had college degrees. Technical skills of the District staff reflect the broad interdisciplinary nature of the Nevada program.

Table 2. Nevada District budget, fiscal years 1993-94

[In thousands of dollars; OFA, other Federal agencies]

	Fiscal year	
	1993	**1994**
Federal Program	3,539	3,458
OFA Reimbursable Program	3,077	3,049
Cooperative Program		
Federal share	1, 788	1,886
State and local share	2,157	2,395
TOTAL FUNDING	10,561	10,788

A. Trend in total funding and staff, fiscal years 1985-94.



B. Funding from major types of programs, fiscal years 1993-94

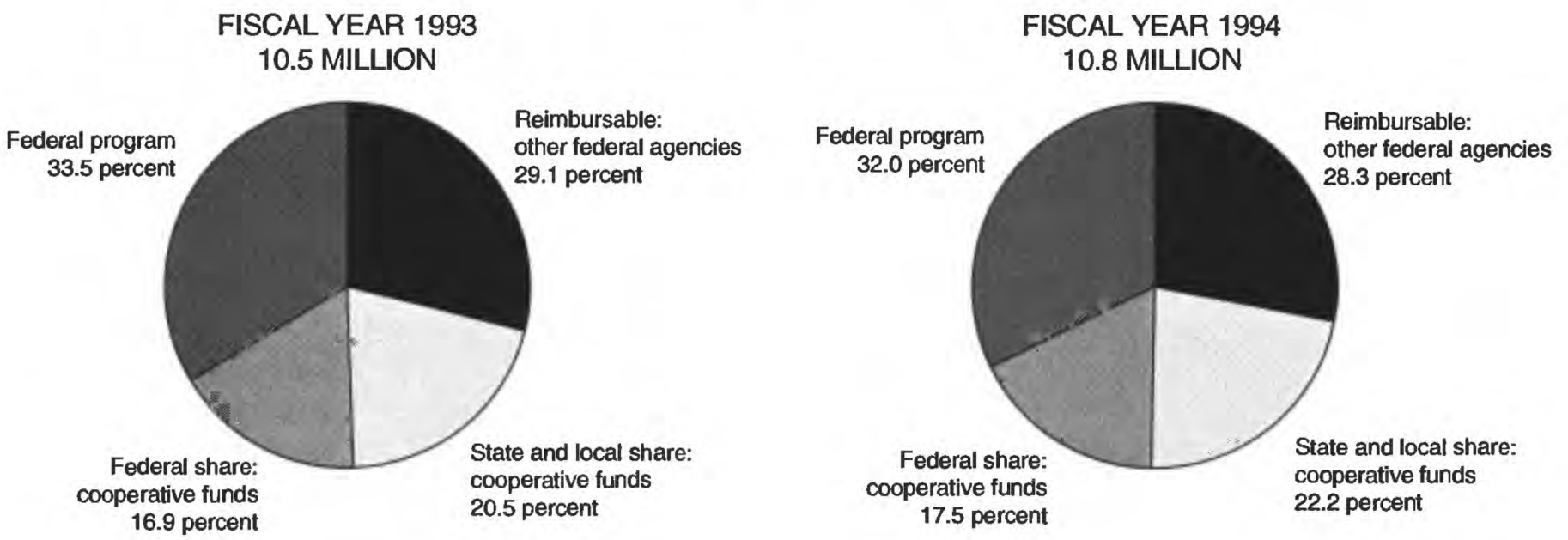


Figure 3. Growth of Nevada District program and staff, and distribution of funding.

Table 3. Cooperating State and local agencies

State agencies
Nevada Bureau of Mines and Geology
Nevada Department of Conservation and Natural Resources
Division of Environmental Protection
Division of Water Resources
Division of Wildlife
Nevada Department of Transportation
University of Nevada-Reno
Local agencies
Carson City
Public Works Department
Carson-Truckee Water Conservancy District
Carson Water Subconservancy District
Churchill County
City of Henderson
City of Las Vegas
City of Reno
City of Sparks
Clark County Regional Flood Control District
Clark County Sanitation District
Douglas County
Duck Valley Reservation Shoshone-Paiute Tribes
Las Vegas Valley Water District
Pyramid Lake Paiute Tribe
Southern Nevada Water Authority
Summit Lake Paiute Tribe
Tahoe Regional Planning Agency
Truckee-Carson Irrigation District
Walker River Irrigation District
Walker River Paiute Tribe
Washoe County
Department of Comprehensive Planning
Department of Public Works

Table 4. Contributing Federal agencies

Army Corps of Engineers
Board of Water Commissioners
Department of Defense
Department of Energy
Department of the Interior
Bureau of Indian Affairs
Bureau of Land Management
Bureau of Reclamation
Fish and Wildlife Service
National Park Service
Office of the Secretary
Federal Emergency Management Agency
Federal Water Master
Nuclear Regulatory Commission

Computer Facilities

The USGS has rapidly expanding requirements for computing, including data-base management, scientific interpretation and simulation, electronic report processing, administrative processing, and geographic information systems. To meet these needs, the Nevada District operates in a distributed computer environment, which is called the Distributed Information System (DIS-II). DIS-II consists of a network of advanced Unix workstations, appropriate software, and local area networks (LAN) for office telecommunications. Each workstation is a fast and powerful desktop computer with a high-resolution graphic monitor and enough software, hardware, and peripheral devices to allow a worker to perform most advanced tasks at the individual station. The LAN is an office-based telecommunications network that connects many computers and other devices to each other. Shared devices such as file servers and printers, are accessed through the LAN also.

Early in 1991, the Nevada District began developing the distributed computer environment, which is based on Data General AViiON fileservers and graphic workstations in local area networks (LAN) and wide area network (WAN) configurations. Transition from the central Prime computer in the District Office to a distributed system of workstations linked by a high-speed LAN within each of the three offices, and linked by a WAN between the Nevada offices will be fully implemented in early 1995.

The three Nevada District LAN's are hubs in the Distributed Information System (DIS-II) of the WRD, which links the USGS headquarters in Reston, Va., with WRD offices across the Nation (figure 4A). This WAN connection provides access to the international network INTERNET.

The Nevada District offices in Carson City and Las Vegas are connected through a WAN with the Nevada Department of Data Processing, to share existing State telecommunications lines (figure 4B). A dedicated communication line links the Nevada Field Office in Elko to the District Office in Carson City.

By the end of 1993, the Nevada District had the main hub of the distributed computer environment implemented (figure 4C). At the end of 1994, the Carson City Office has 1 Data General AViiON 9500 fileserver, 1 Data General AViiON 6220 fileserver, 4 Data General AViiON 530 workstations, and 14 Data General AViiON 300 workstations driving workgroup

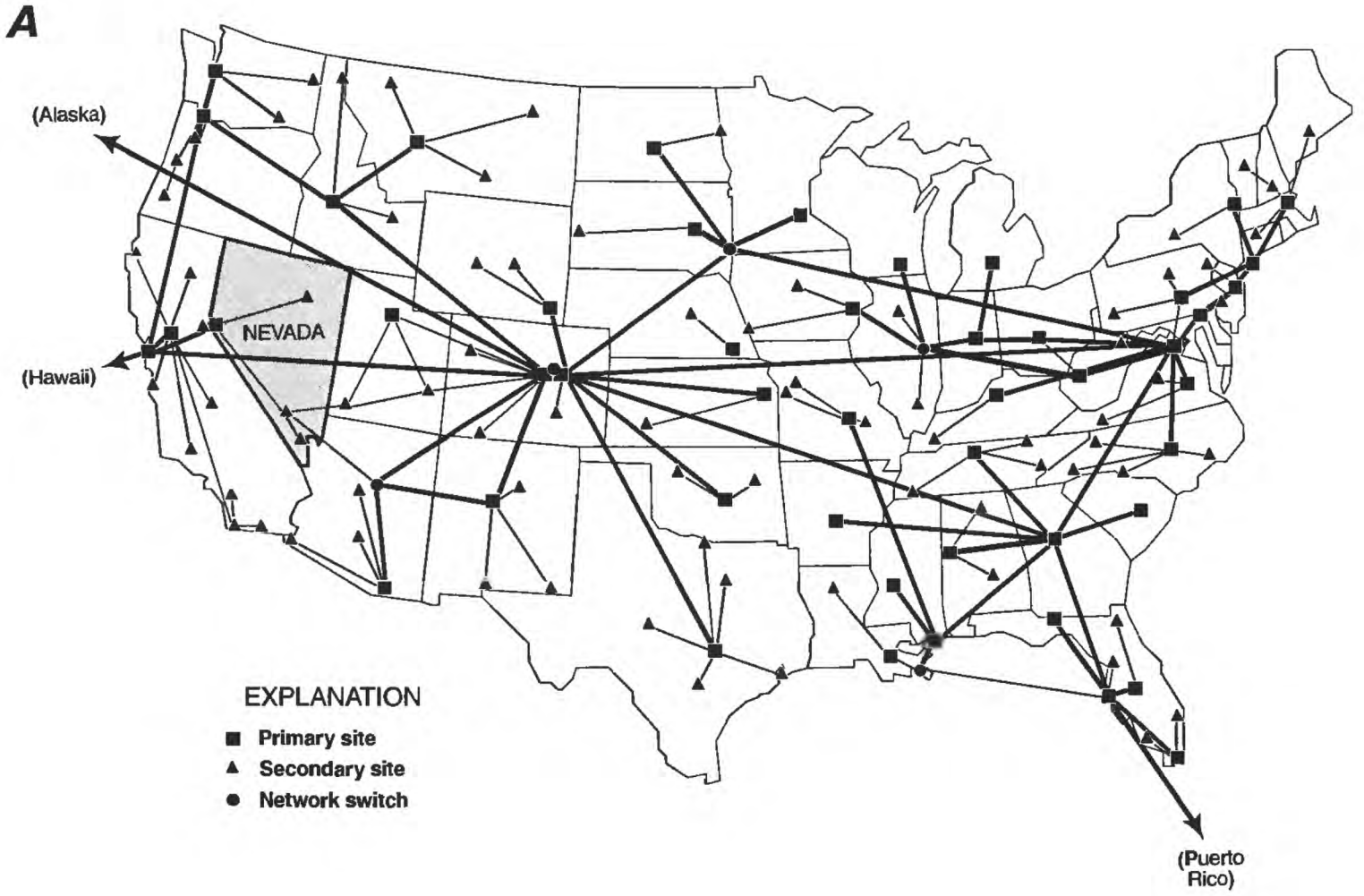


Figure 4. National Distributed-Information System network of the Water Resources Division *(A)*, wide-area network of the Nevada District *(B)*, and local-area network of the Nevada District *(C)* as of 1994. Abbreviations: NDWR, Nevada Division of Water Resources; WRD, Water Resources Division.

C

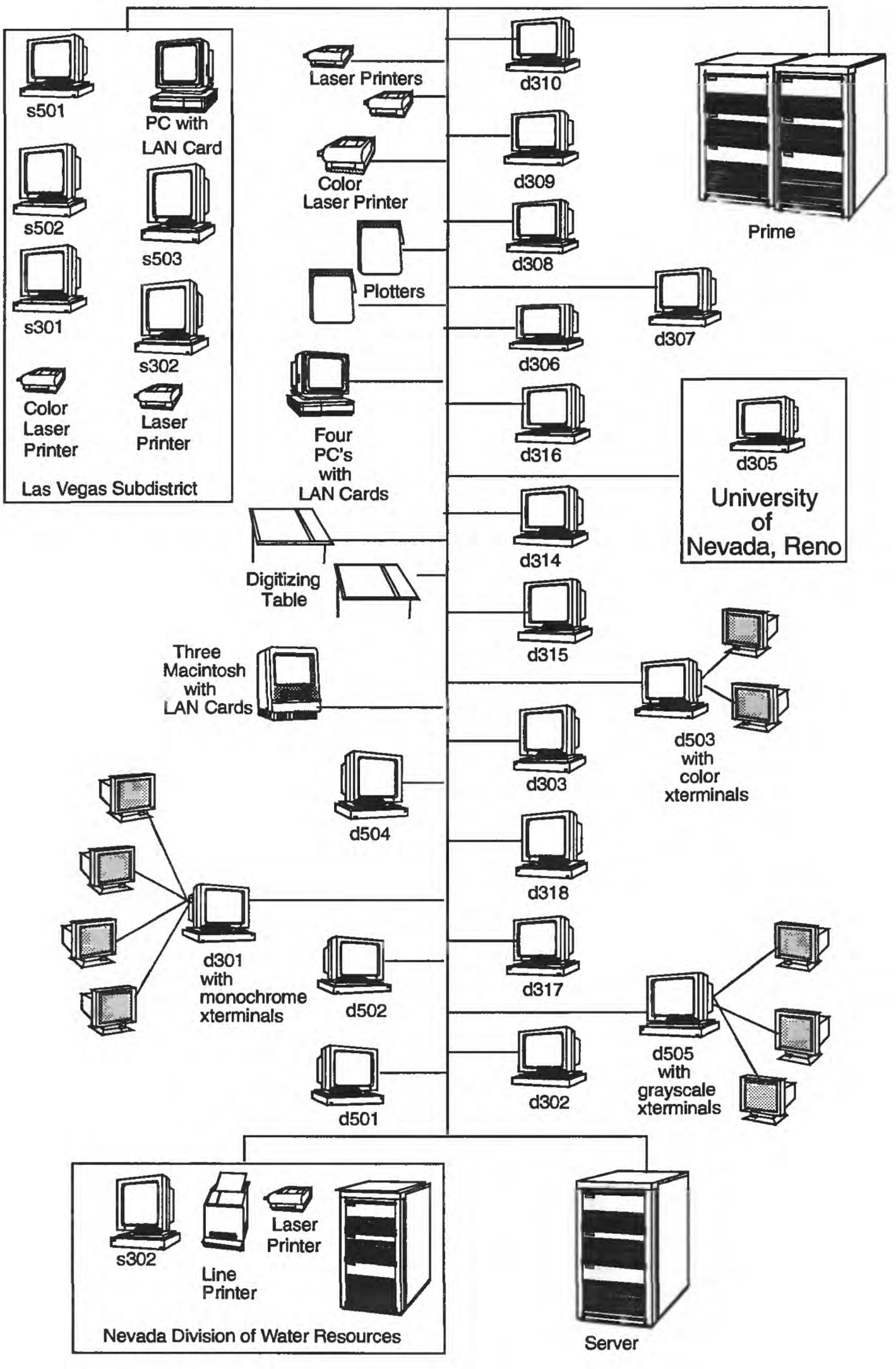


Figure 4. Continued.

clusters of MS/DOS and Macintosh computers running X-windows emulation software, X-terminals, and associated peripheral equipment. Peripherals include cd-rom technology, floppy disk technology, tape drives, scanners, laser printers, and color plotters. The Las Vegas Office has a Data General AViiON 9500 file-server, four Data General AViiON 530 workstations, and three Data General AViion 300 workstations driving workgroup clusters of MS/DOS computers running X-windows emulation software, X-terminals, and associated peripherals. By early 1995, both Carson City and Elko Field Offices will have a Data AViiON 530 workstation installed, driving a workgroup cluster of X-terminals and associated peripheral equipment.

Data-Base Management

The primary hydrologic data storage mechanisms for the Nevada District computer system are the National Water-Information System (NWIS) data bases. NWIS is comprised currently of several subsidiary data bases: Automated Data Processing System (ADAPS), supporting continuous (hourly or more frequent) surface-water, ground-water, and water-quality data; Ground-Water Site Inventory (GWSI), supporting water-level, well construction, and location data; Water-Quality Data (QWDATA), supporting physical, chemical, biological, and sediment data; and Water Use (WUSE), supporting site-specific and aggregated water-use data. A new NWIS, NWIS-II, is currently under development. NWIS-II will merge the different data bases from the present system to provide an integrated approach to storing, retrieving, and interpreting hydrologic data and ancillary information. The first release of the NWIS-II data base (which will contain instantaneous data values) and associated software is expected during 1995. A follow-up release of NWIS-II will provide the capability to store, retrieve, and manipulate time-series and water-use data. Information collected as part of the basic data programs and interpretive studies is stored in the NWIS by all WRD District offices. Data are Nationally aggregated in the National Water-Storage and Retrieval (WATSTORE) data base, which is maintained on a large mainframe computer at USGS Headquarters in Reston, Va.

The stress of exponential urban growth in Nevada on current and potential water supplies and resultant effects on hydrologic environments has generated an unprecedented need for, and resultant volume of, water-resources data and information. In cooperation with the Nevada Division of Environmental Protection (NDEP), Nevada Consumer Health Protection Service, and the U.S. Environmental Protection Agency (USEPA), the Nevada District continued the lead role in development of automated systems for capturing ground-water data from laboratories of several State and local agencies. The Nevada Water Permit File, developed by the Nevada District for the Nevada Division of Water Resources, was expanded in 1994 to include GIS-automated spatial data for drillers' logs, water permits, and water use. District management met with the NDEP and USEPA, Region IX, during 1994 to outline plans to integrate multiple agency data bases, including a proposed pilot effort for automatic transfer of ground-water data from USGS NWIS-I and NWIS-II to USEPA STORET.

Geophysical Data Collection

The Nevada District uses surface- and borehole-geophysical methods to investigate hydrologic problems. Several surface-geophysical instruments, computer software to process the data, and geophysical data bases, are maintained within the District. Instrumentation includes two seismographs, two gravimeters, a magnetometer, and an electrical-resistivity array. In addition, many types of geophysical methods and instrumentation are available elsewhere within USGS for District use: surface methods (electromagnetotellurics, very low frequency, resistivity, ground-penetrating radar, and marine seismic); airborne methods (radiometrics, magnetics, and side-looking radar); and borehole methods (short- and long-normal resistivity, acoustic velocity, neutron, gamma density, natural gamma, temperature, flowmeter, televiewer, radar, and gravity).

Water-Quality Analysis

Water-quality investigations are another important part of Nevada District operations. The District maintains mobile field laboratories with instrumentation for onsite measurement of pH, alkalinity, specific conductance, temperature, and dissolved oxygen, and onsite processing of water samples for analysis in the laboratory. Mobile and inhouse laboratory facilities are maintained for sample preparation and storage, reagent preparation, and instrument calibration and repair. The USGS National Water-Quality Laboratory in Arvada, Colo., which does production analyses and research, is

used for detailed chemical analyses of water, sediment, and tissue of aquatic biota. Additional analytical support is provided by cooperators and contract laboratories for some specific projects.

Electronic Data Collection

Many studies undertaken by the Nevada District now involve some form of direct electronic data acquisition. Electronic field monitors and data loggers are used for continuous, fixed-interval, and event monitoring or sampling in areas where frequent site visits are not practical. Electronic recording of water-quality data, water levels in wells and streams, and climatologic data related to evapotranspiration are the most common applications.

Field monitors are used to record water-quality characteristics—pH, specific conductance, temperature, and dissolved oxygen—in studies such as those at the Stillwater National Refuge and Carson Lake. Hourly water levels are monitored electronically in some wells in the eastern part of the State and at the Nevada Test Site to determine aquifer response to earth-tide fluctuations. Two systems are used for remote transmission of data. Data-collection platforms send data to geosynchronous satellites that relay the data through the DIS computer network to the District data bases. Direct line-of-sight radio telemetry also is in use, such as in the Clark County Flood-Alert System, which provides real-time monitoring of precipitation and streamflow at 26 sites. Additionally, the District uses electronic instrumentation and other techniques for direct determination of bare-soil evaporation and plant transpiration.

Other Nevada District Activities

As part of its responsibility to provide water-resources information to the public, the Nevada District staff participates in several activities in addition to data collection and hydrologic investigations.

Committee Involvement. —Members of the Nevada District staff serve on a variety of local and National committees and advisory boards. Recent examples include the Carson River Mercury Superfund Site Technical Advisory Committee, Clark County Comprehensive Planning Committee, Desert Research Institute Advisory Council on Water Resources Research, Governor's Drought Review and Reporting Committee, Governor's Technical Advisory Committee for the Carson River, Lake Tahoe Basin Erosion Control Technical Advisory Committee, Lake Tahoe Interagency Monitoring Program Technical Advisory Committee, Mackay School of Mines Advisory Board, Nevada Nonpoint-Source Pollution Task Force, Nevada Division of Environmental Protection Ground-Water Technical Task Force, Nevada State GIS Advisory Board, Nevada State Mapping Advisory Committee, Nevada Water Resources Association Planning Committee, Southern Nevada Federal Executive Association, Truckee River Operating Agreement Committee, Truckee River Water-Quality Monitoring Technical Advisory Committee, Truckee River Water-Quality Strategy Committee, University of Nevada-Reno Hydrology Program Advisory Committee, Vadose Zone Technical Liaison with State of California, and Virgin River Interior Coordinating Committee.

National involvement includes committees for preparing NWIS-II functional specifications, workgroups for administrative and water-quality data systems, the USGS Optical Storage Special Interest Group, the Subsidence Special Interest Group, Radiochemical Advisory Committee, Department of the Interior (DOI) Bureaus Technical Representative, DOI Devils Hole Work Group, U.S. Fish and Wildlife Service Water Rights Acquisition Program, U.S. Department of Agriculture (USDA) Erosion Control Group, USDA Small Business Innovation Research Program of National Research Initiative Competitive Grants Office, DIS-II Planning and Implementation Committee, USGS Western Region Overhead Policy Advisory Committee, USGS Western Region Office of Ground Water Borehole Geophysics Advisory Group, Sedimentation Subcommittee of the Interagency Committee on Water Data, USDOE Environmental Restoration Program Executive Advisory Group, USDOE Hydrologic Resources Management Program, USDOE Nevada Operations Office Environmental Action Committee, and USGS Western Region Technicians Advisory Committee. In addition, Nevada District staff teach National USGS training courses, and serve as Ad Hoc technical reviewers for journals such as the Geological Society of America, American Society of Agronomy, and Soil Science Society of America.

Environmental Impact Statements.—With increasing frequency, Federal, State, and local cooperators are requesting District staff reviews of environmental impact statements to verify the interpretation of hydrologic data presented in the statements.

Education.—The Nevada District actively participates in the educational community. Presentations on basic hydrology and general earth-science issues are given at local elementary and high schools; formal classes on hydrologic techniques are prepared for local universities; and students from universities, junior colleges, and high schools are employed in work-study programs in the Survey. Members of the Nevada District staff also serve as instructors for hydrology and earth-science courses in the University of Nevada system and participate in career and job fairs sponsored by high schools and universities.

Public Information and Outreach.—The Nevada District is a focal point for the public regarding map and earth-science questions. Staff members answer questions on regional hydrology and geology, basic scientific ideas, USGS publications, and related items. Each year, the Nevada District is represented at the Nevada Water Conference, which is sponsored by the Nevada Water Resources Association. The Public Information Assistant (PIA) compiles information in response to public requests for data and published information. The PIA may be contacted at (702) 887-7649.

WATER CONDITIONS IN NEVADA

Surface Water

Surface-water resources are sparse in Nevada because of the semiarid to arid climate. Typically, as much as 75 percent of Nevada's precipitation falls during the winter months. Only the highest mountains produce, on the average, more than 10 inches of annual runoff (Moosburner, 1986, p. 323). The three principal mountain sources of runoff are the Sierra Nevada, near the western boundary of the State, and the Ruby and Jarbidge Mountains, in the northeast.

Nevada has no large rivers. The largest streams in the State are the Humboldt River, which drains the Ruby and Jarbidge Mountains; the Truckee, Carson, and Walker Rivers, which drain parts of the Sierra Nevada in California and Nevada; and the Muddy and Virgin Rivers, which flow into the Colorado River in the southeastern part of the State (figure 5). Many of these rivers are controlled by dams, reservoirs, and diversions. Of the mentioned rivers, only the Humboldt and Muddy Rivers begin and end within Nevada.

In water year 1993, above-average precipitation and runoff provided some relief from the previous 6 years of drought in northern Nevada and parts of the Great Basin including the lower Colorado River Basin. Flow in the major streams generally ranged from 80 to 140 percent of long-term average. Flows in the major streams ranged from 50 to 60 percent of average in the Sierra Nevada and from 30 to 40 percent along the Humboldt River. Flow at Colorado River below Hoover Dam was at 70 percent of its long-term average (1935-93). Long-term drought conditions continued in most of Nevada in water year 1994.

Surface-Water Quality

The quality of surface water in Nevada differs from place to place and season to season. Concentrations of dissolved solids are commonly higher in the southern part of the state than in the northern part, and are dependent to a large extent on water discharge. Concentrations usually are highest during low streamflow, due to the dominance of ground-water contributions, and are lowest during high streamflow, due to dilution by precipitation or snowmelt runoff. Surface-water quality declines near the downstream ends of internal drainages because of the concentrating effects of evaporation.

During water years 1993-94, two northern Nevada stream-gaging stations (Carson River near Fort Churchill and Truckee River near Nixon) had mean dissolved-solids concentrations at 85 percent and 139 percent, respectively, of the long-term mean (1966-94). During these water years, discharges at those stations were 28 percent and 39 percent, respectively, of the long-term mean (1958-94). During 1993-94, a southern Nevada stream-gaging station (Virgin River at Littlefield) had a mean dissolved-solids concentration at 95 percent of the mean for the period of record (1949-94); discharge at that station was 79 percent of the long-term mean (1930-94).

During water year 1994, the Colorado River below Hoover Dam station had a mean concentration of dissolved solids that was 99 percent of the mean for the period of record (1946-94). Annual discharge was 95 percent of the mean for the period of record. The downward trend in concentration during 1983-85 for the station was probably the result of dilution by 5 consecutive years of greater-than-average inflow to Lake Mead. During 1988-93, in contrast, the concentration has increased, presumably because the amount of runoff from the upper basin has been less than the long-term mean.

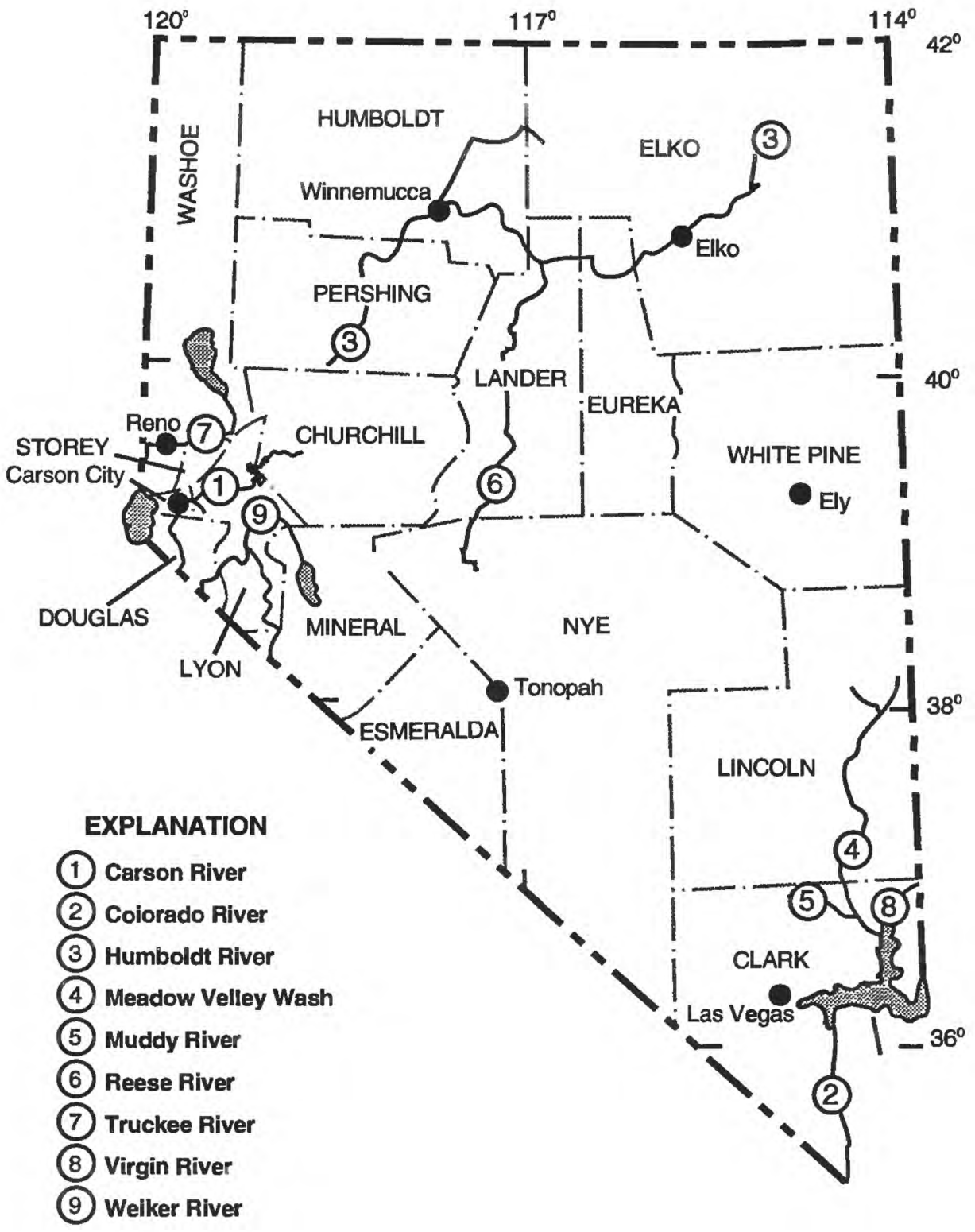


Figure 5. Principal streams and lakes in Nevada.

Ground Water

The State's ground-water supplies continued to be heavily stressed during 1993-94. However, the severity of effects differed from basin to basin. Pumpage from deep wells in thick basin-fill aquifers generally caused slight to moderate water-level declines. Ground water was pumped at greater-than-average rates along segments of the Humboldt, Truckee, Carson, and Walker Rivers to supplement upstream storage of surface supplies. In the Truckee Meadows, water was pumped at more than twice the normal rate to augment public supplies for Reno and Sparks owing to minimal upstream storage. Most supplemental pumping was for irrigation, resulting in significant local declines in water levels. During 1993, heavy pumping in Mason and Smith Valleys (in the Walker River Basin) caused continued water-level declines in excess of 40 feet, despite above-average precipitation and runoff in 1993. Several years of above-average runoff may be required to offset the cumulative effects of sustained pumping during 1987-94 (J.R. Harrill, U.S. Geological Survey, oral commun., 1995)—a drought during which precipitation was less than

average for all years except 1993. A record number of new wells were drilled during 1993-94. The total of 3,033 wells drilled in 1993 supersedes the previous record of 2,057 wells drilled in 1992. The increase continued during 1994, with 3,384 wells drilled, probably due to a combination of continued population growth and the continuing drought.

As in previous years, most wells were drilled in unconsolidated deposits of sand, gravel, silt, and clay that partly fill the many basins in Nevada. Most ground-water development is in these basins, where water is readily obtained from unconsolidated deposits at shallow depth and well yields are more predictable than in the mountains. Consolidated igneous, metamorphic, and sedimentary rocks underlie the basins and crop out in adjacent mountains. Some consolidated rocks, particularly those that are fractured, can yield substantial quantities of water. Development of water supplies from consolidated-rock aquifers became more common during the 1980's, but as of 1994, was still minor compared with development in the unconsolidated basin-fill aquifers. A trend that became more apparent in 1992 is increased withdrawals of water from consolidated-rock aquifers for dewatering mines. In 1992, a total of about 170,000 acre-feet was pumped to dewater open-pit mines in northern Nevada. By 1994, the rate had increased to more than 200,000 acre-feet per year (based on files of the Nevada State Engineer, 1994).

Ground-water levels fluctuate in response to seasonal and longer term climatic changes in recharge and discharge. Water levels generally rise during late winter and early spring in response to runoff from snowmelt in the mountains. Significant recharge takes place locally as a result of agricultural irrigation. Artificial recharge is practiced near urbanized areas with increasing frequency. Water levels generally decline during the summer, autumn, and early winter, when recharge is small and discharge by evapotranspiration and pumping is large. Long-term climatic changes also can affect water-level trends over a period of years. Water levels in many wells in the State declined during the late 1970's as a result of two consecutive drought years, rose during the first half of the 1980's as a result of several consecutive wet years, and declined during the second half of the 1980's and early 1990's as a result of drought years.

Drought

Water year 1994 marked the eighth year of continuing drought in northern Nevada. Although above-average precipitation was recorded during 1993 with the third heaviest snowpack of record, the winter of 1993-94 produced only 28 to 65 percent of the normal water content in the mountain snowpacks of principal river basins in northern Nevada (Soil Conservation Service, 1994). Figure 6 shows flow in the Carson and Humboldt Rivers in 1993-94 compared to the long-term average.

Lake Tahoe, which drains to the Truckee River, rose above its natural rim on May 26, 1993; the lake had been below the rim since September 16, 1990—the longest period of no outflow from the Lake since records began in 1900. On September 16, 1993, the water level again fell below its rim.

Runoff from the above-average 1992-93 snowpack enabled the Cui-ui, an endangered sucker-like fish found in Pyramid Lake, to swim up the Truckee River to spawn for the first time since 1986. Flow from released storage in the upper Truckee River allowed another spawning run in April and May 1994; however, reservoir supplies were severely depleted. Since 1909, the water level in Pyramid Lake has declined 73 feet (figure 7), which is equivalent to a 30 percent reduction in lake volume.

Fish in Walker Lake, the terminus of the Walker River, may die in less than 5 years (when the water-surface altitude reaches 3,940 feet) unless the lake receives large amounts of fresh-water inflow to reduce salinity (Mike Sevon, Nevada Department of Wildlife, written commun., 1994). Since 1908, the water level in Walker Lake has declined 132 feet, which is equivalent to a 75-percent reduction in volume. The lake-surface altitude has dropped about 30 feet since the onset of the drought in northern Nevada. Irrigation diversions and infiltration deplete virtually all the flows upstream from Walker Lake. The water-surface altitude of Walker Lake has declined about 140 feet since 1882 (figure 7).

Low streamflows and low storage in reservoirs have affected irrigated agriculture greatly throughout the drought period. In the last several years, municipal uses of water, such as lawn and golf-course watering, have been drastically curtailed in the Reno-Sparks area. Concerns have emerged about the available supply for municipal and domestic water uses, should the drought continue.

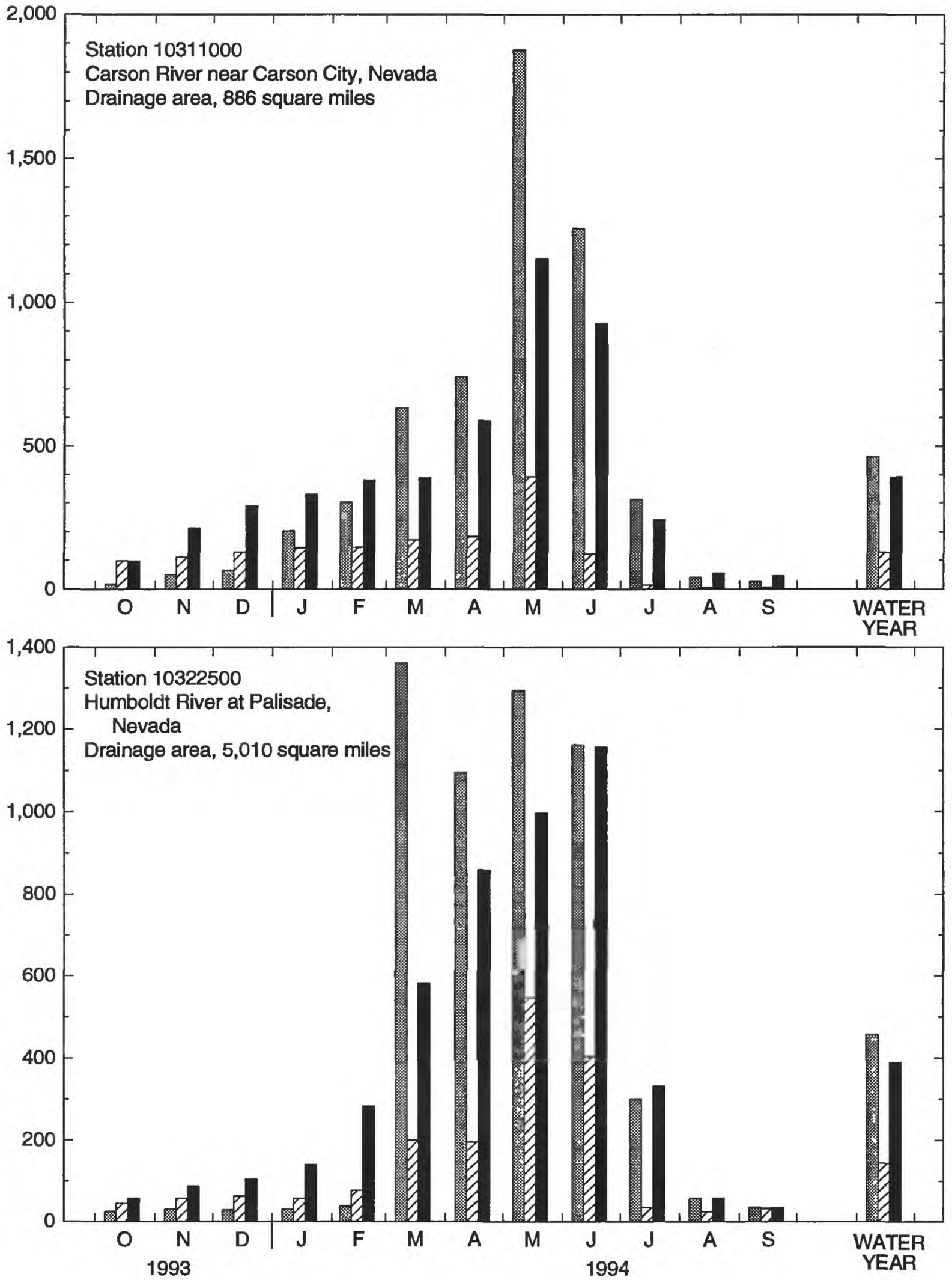


Figure 6. Discharges during water years 1993-94 with the long-term mean discharge at two representative gaging stations.

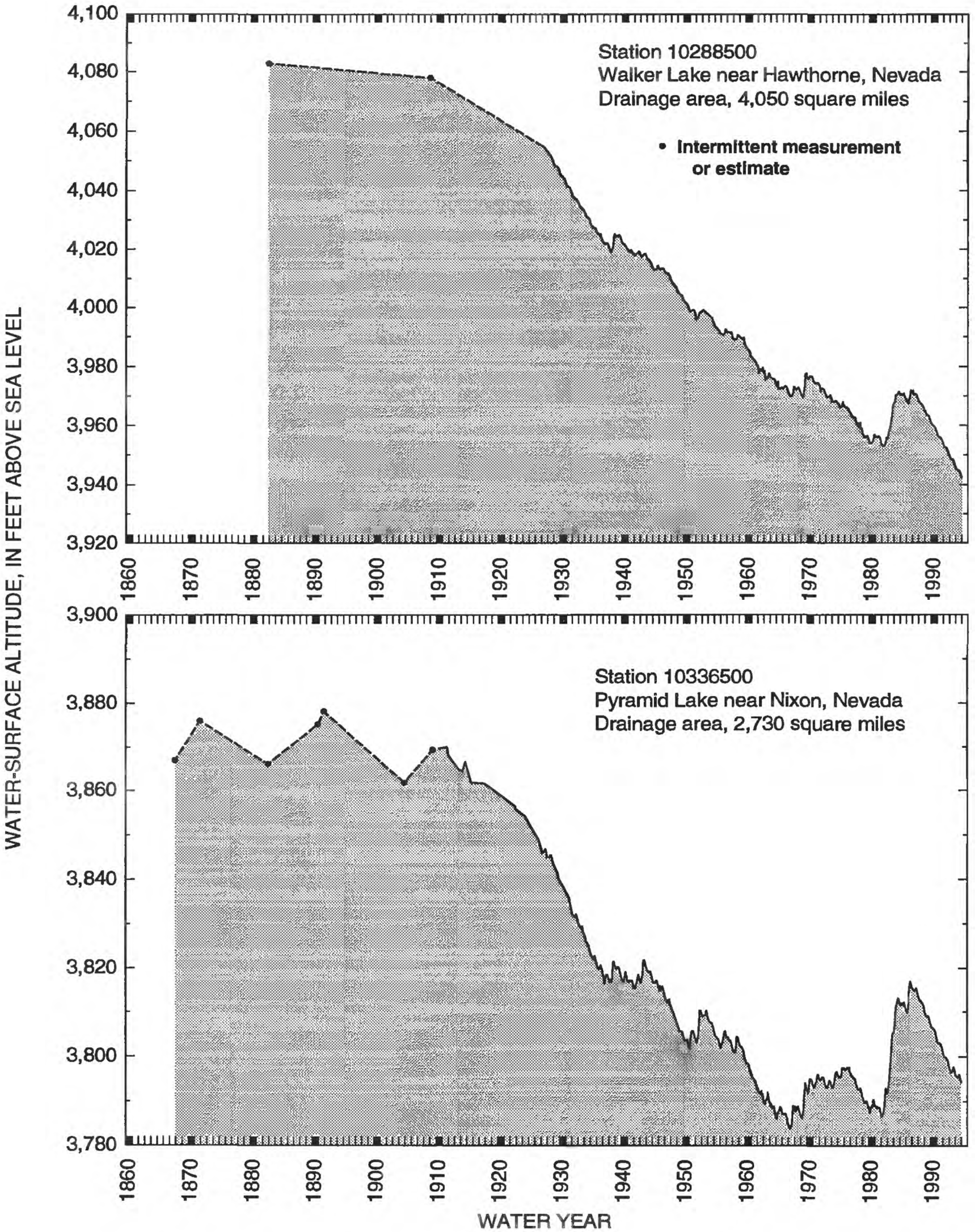


Figure 7. Water-surface altitude at Walker and Pyramid Lakes.

MAJOR WATER ISSUES IN NEVADA

Urban Water Use

Nevada leads the Nation in rate of population growth. The population in Nevada increased by more than 63 percent in the 1970's, and by 55 percent in the 1980's (see figure 8). The population of Nevada in 1994 was about 1.4 million (figure 8), according to the Nevada State Demographer (written commun., 1994). The major growth centers in Nevada are Las Vegas Valley and vicinity in the southeast; Reno, Sparks, Carson City and vicinity in the northwest; and Elko and vicinity in the northeast. Many people think of Nevada as a rural State because it has an average population density of only 12 people per square mile. However, more than 88 percent of the population lives in communities of 2,500 people or more. Population growth around these urban centers makes Nevada the fourth most urban State in the Nation (Robert Speaker, U.S. Department of Commerce, written commun., 1991).

Nevada also is the most arid State in the Nation. The arid Nevada valleys, still home to the West's largest wild horse populations, are increasingly targeted as sources of water for the rapidly expanding urban oases of the Reno-Sparks area in northwestern Nevada and Las Vegas in southeastern Nevada. Concurrent with the continuing strong growth of the gaming/tourism industry in the urban areas, the rapidly expanding large-scale open-pit gold mines of northern and northeastern Nevada were the largest producers of gold and silver in North America in 1994 (Susan Skorupa, Reno Gazette-Journal, 1995).

A trend is emerging in the development boom in southern Nevada as new mega-hotels now emphasize family tourism as much as, or more than, gaming. During the last 6 months of 1993, more than 12,000 new hotel rooms opened in Las Vegas. By early 1994, it was again virtually impossible to find an empty hotel room in the city during major convention or holiday weekends, and the flux of tourists passing through the Las Vegas airport continued to exceed 1 million per month (McCarran International Airport, oral commun., 1994). To continue growing, southern Nevada needs to obtain additional water supplies to augment the current water sources from the basin-fill aquifer and the Colorado River.

The effects of Nevada's rapid growth in population are concentrated in relatively small areas in southern Nevada (including Las Vegas Valley), the western parts of the Truckee and Carson River Basins in northwestern Nevada, and, to a lesser extent, the Elko area in the northeastern part of the State. In northern Nevada, water for this new growth is being developed from the conversion of agricultural water rights and water supplies. Rapid urbanization has the potential to effect the quality, as well as the quantity, of available water in areas that include the Lake Tahoe Basin, the Truckee, Carson, and Humboldt River Basins, and Las Vegas Valley. Currently, increasing nitrate concentrations in ground water are an important issue in urban areas of northern and southern Nevada. In some areas, the use of individual septic tanks for sewage disposal has been prohibited due to nitrate concentrations in ground water approaching or exceeding State and Federal standards. Other issues of concern to urbanizing areas include the presence of synthetic organic compounds in shallow ground water and potential trends in increasing dissolved-solids concentrations due to surficial recharge from agricultural, landscape, and recreational (golf course) irrigation.

The reuse of treated wastewater is increasing due to more stringent discharge requirements and the lack of inexpensive water. In 1994, about 15,000 acre-feet of wastewater was reused, about 9 percent of the total treated wastewater. Douglas County (at about 100 percent) and Carson City (at about 65 percent) are the leading counties in the State reusing treated wastewater. Current uses for treated wastewater are agricultural irrigation, golf course irrigation, power plant cooling water, wetlands, and dust control (Naomi Duerr, Nevada Division of Water Planning, oral commun., 1994).

Agricultural Water Use

Irrigation is the largest use of water in Nevada. In 1990, this use accounted for about 84 percent of all offstream withdrawals. In Nevada, irrigated crops include alfalfa seed, alfalfa, and other hay; winter and spring wheat; and potatoes and other vegetables. Of these, hay is the leading crop grown in Nevada. In 1993, 505,000 acres of hay were planted, and 7,700 acres of the number-two crop, potatoes, were planted (Nevada Appeal, 1993). Harvested croplands account for about 65 percent of all irrigated lands, and the remaining 35 percent was for irrigated pasture in 1987 (Nevada Agricultural Statistics Service, 1989, p. 6). In 1993, streamflows were adequate to meet most diversion requests;

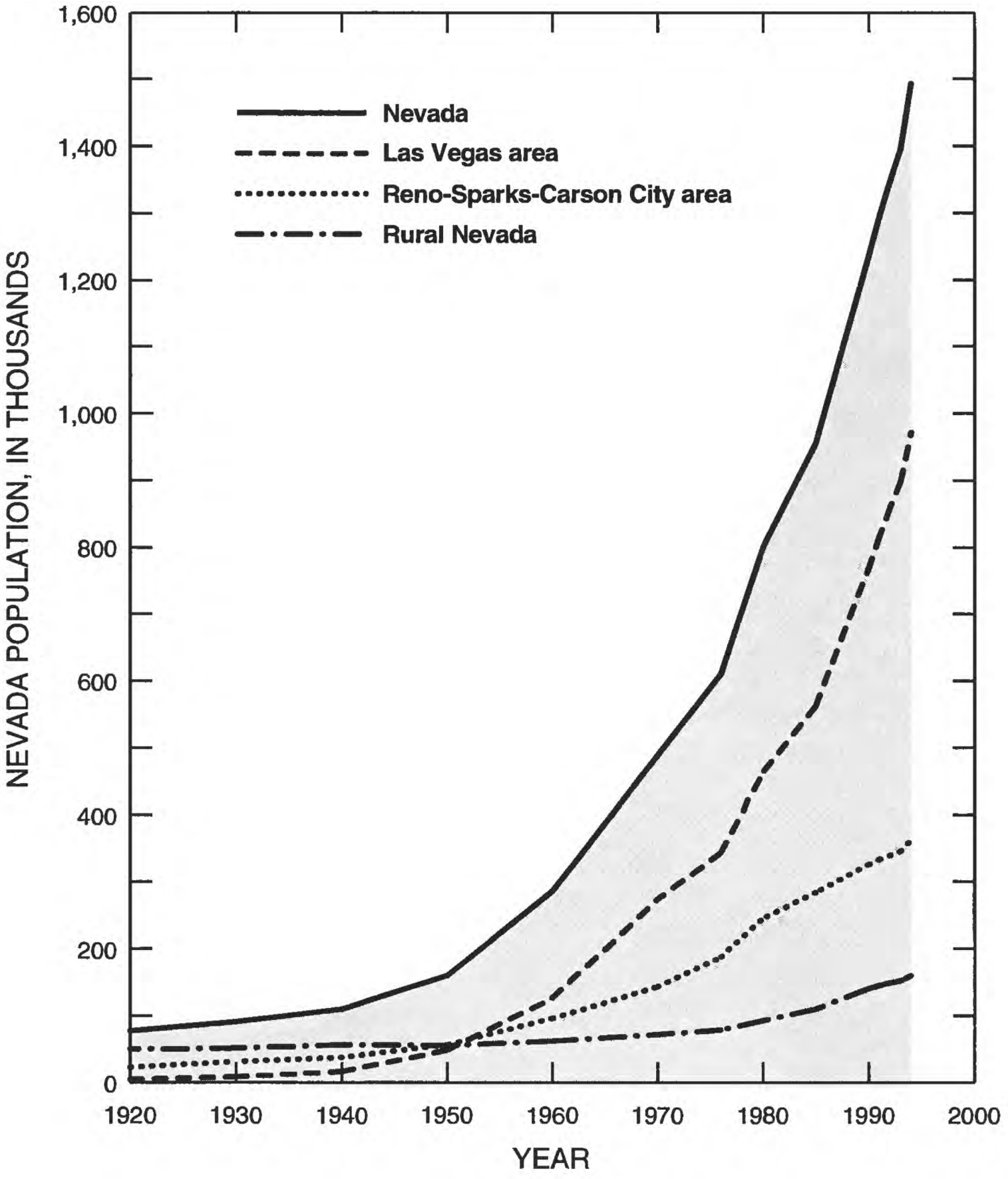


Figure 8. Nevada population trends, 1920-94. Sources: Nevada Department of Taxation; U.S. Bureau of the Census.

however, low ground-water levels caused higher conveyance losses, resulting in less water than normal reaching the fields. In the Truckee-Carson Irrigation District near Fallon, only 56 percent of the diverted water reached farmers' fields. Normally, 68 percent reaches the fields (Reno Gazette-Journal, 1993).

When growing Nevada communities withdraw the maximum amount of water available through their current water rights, the largest alternative supply is from the purchase or lease of agricultural rights, resulting in increased pressure on agricultural water-right holders to sell their rights to other users. However, agricultural users are reluctant to support long-term leasing of their water rights for urban use, for fear of losing their agrarian lifestyle. In 1994, less-than-normal streamflows in the Truckee River caused the Federal Water Master to restrict withdrawals starting on June 8. This resulted in irrigation ditches being cut off and the water supplier for Reno using its drought reserves (Reno Gazette-Journal, 1994).

Water Allocation in Truckee River and Carson River Basins

Agencies have been in litigation since the late 1800's over allocation of surface water in the Truckee River and Carson River Basins of Nevada and California. Basic issues involve division of the resources between the States, and competing demands in Nevada among (1) urban use in the growing Reno-Sparks area (mid-Truckee River); (2) Indian and endangered-species fishery requirements at Pyramid Lake (terminus of Truckee River); and (3) irrigation, fish, and waterfowl needs in Fallon and the Stillwater Wildlife Management Area (lower Carson River). Public Law 101-618, containing the Fallon Paiute-Shoshone Tribal Settlement Act and the Truckee-Carson-Pyramid Lake Water Rights Settlement Act (Jones and others, 1991, p. 99-117), was signed into law in November 1990. Section 205 of the Truckee-Carson-Pyramid Lake Act requires negotiation and implementation of an interagency operating agreement and operating plan for the Truckee River. The Act specifies that final ratification of the operating agreement and plan be in place by November 1997.

USGS assistance to Department of the Interior agencies in implementation of Public Law 101-618 increased in scope and scale during 1993-94. The Nevada District Truckee-Carson Program initiated upgrades of data networks to support the development of river flow models and real-time data networks for river operations. Initial activities in development of the Truckee-Carson River-systems model include preliminary calibration of flow-routing models for the Carson and Truckee Rivers and implementation of a graphical user interface for generating and displaying the results of simulations of alternative scenarios for river operations. Other Nevada District projects have published ground-water assessments of the Newlands Irrigation Project and Stillwater Wildlife Management Area to meet Bureau of Reclamation and U.S. Fish and Wildlife Service obligations under Public Law 101-618 for preliminary reports to Congress.

National Water-Quality Assessment Program

Due to the lack of long-term, consistent information that could be used to assess the quality of water resources of the Nation, the USGS implemented a pilot National Water-Quality Assessment (NAWQA) program in 1986 to develop, test, and refine assessment methods. The Carson River Basin was selected as a pilot study area. An interim review of the pilot program by the National Academy of Sciences in 1989 determined that implementation of a full-scale NAWQA program is in the best interest of the Nation, and that USGS is well qualified to establish and implement such a program. In 1991, USGS began a full-scale NAWQA program to describe the status of and trends in the quality of the Nation's surface- and ground-water resources, and to provide a scientific understanding of the primary natural and human factors that affect water quality. The Nevada Basin and Range study unit, which includes the Carson and Truckee River Basins and Las Vegas Valley, is 1 of 60 proposed NAWQA units that will be investigated throughout the Nation. The Nevada Basin and Range study is focusing on comparing and contrasting the effects of urban and agricultural land and water use on water quality.

Hydrology at Nevada Test Site

The Nevada District provides support to the U.S. Department of Energy (USDOE) by studying the hydrologic effects of weapons testing at the Nevada Test Site (NTS). Nuclear weapons have been tested at NTS since the early 1950's. The site was chosen because of its remote location, government ownership, and interior drainage system (Great Basin). Long-term studies of basin-and-range hydrology have identified regional aquifers that may allow radionuclides introduced into the subsurface environment to migrate beyond the NTS boundary. Studies are continuing that will determine the potential for radionuclides to be transported within these aquifers and that will assist USDOE in minimizing the effects of testing on the subsurface environment.

Other hydrologic research activities at NTS include investigations using geophysics and radioactive isotopes. Downhole radar shows promise to determine the location and magnitude of formation fractures controlling ground-water movement; flow velocity also may be determined using this geophysical technique. In other areas in and around NTS, a determination of the direction and rate of ground-water flow may be addressed using isotopes of strontium and uranium.

The Hydrologic Resources Management Program is applying state-of-the-art electronic pressure tranducers to record minute (0.002-foot) changes in water level in deep (more than 2,000-foot) wells at NTS. Sophisticated programs for reduction of time-series data have been applied to filter out barometric and earth-tide effects on subtle water-level fluctuations. This has allowed the processing of complex data-logger information to provide hydrographs that are being used to develop quantitative estimates of aquifer characteristics.

Potential Nuclear-Waste Repository at Yucca Mountain

In December 1987, the U.S. Congress identified Yucca Mountain, near the Nevada Test Site, as a potential location for the Nation's first high-level nuclear-waste repository. The potential repository is to be completed by 2010 and would be expected to contain nuclear waste for at least 10,000 years.

The WRD in Nevada assists the USGS Yucca Mountain Project Branch by studying the paleohydrology and flooding possibilities in the Yucca Mountain area. The District also operates monitoring networks to collect data in support of individual studies of unsaturated and saturated ground-water flow as part of the Yucca Mountain project.

Interbasin Water Transfers

The pursuit of interbasin transfers of surface water still continues in southern Nevada as a short-term solution to the water-supply problems in Las Vegas. Applications were filed for more than 180,000 acre-feet per year of ground water from valleys overlying the carbonate-rock province of eastern Nevada (D.H. Schaefer, U.S. Geological Survey, written commun., 1995) as a long-term solution to support southern Nevada populations in the 21st century. The Nevada District continues to provide objective data and resource assessments to serve public interests in southern Nevada water issues. The Carbonate-Rock Aquifer program provides technical assessments to Interior agencies on potential environmental effects of the Las Vegas Valley Water District water-transfer applications, and a cooperative effort with the Nevada Division of Water Resources will extend hydrologic-monitoring networks throughout the carbonate-rock province and will examine the hydrologic budget of Railroad Valley. This valley could be the most likely target for initial development of wells to supply water for interbasin transfer to Las Vegas. Other southern Nevada projects will continue a detailed analysis of natural ground-water discharge by evapotranspiration in Railroad Valley; continue research into developing a more general regional equation for estimation of evapotranspiration consumption of ground water by typical Great Basin plant communities; document the processes controlling sediment transport and channel geometry in the reach of the Virgin River targeted for surface-water diversions; and use GIS technology to integrate USGS NWIS and USGS-developed State water permit and pumpage data bases for Pahrump Valley.

In northwestern Nevada, growth in the Reno-Sparks area continues to stress available surface- and ground-water supplies and increases interest in plans for interbasin transfer of ground water. Area residents are beginning to question long-term effects of continued development and are requesting information on the availability of water resources. An environmental impact statement on the Truckee Meadows project to look at effects of importing ground water from Honey Lake Valley to the Reno-Sparks area (a distance of about 45 miles) was put on hold in late 1993 pending resolution of questions on the effect on wetlands, Indian water rights, and the potential of withdrawals to affect transport of contaminants at the Sierra Army Depot in Honey Lake Valley. During fiscal years 1993-94, the Nevada District continued to provide technical assistance to the Bureau of Land Management in the use of the USGS Honey Lake Valley ground-water flow model to prepare an environmental impact statement on the Truckee Meadows project. Southeast of Honey Lake Valley, a cooperative project with Washoe County is assessing the ground-water resources of Spanish Springs Valley, a potential recipient of Honey Lake Valley water to sustain future expansion of the City of Sparks incorporated area.

Hydrologic Effects Of Mining Activity

Ground-water levels in the vicinity of northern Nevada mine pits have declined dramatically. Attempts to dispose of the water pumped from the mines by ground-water recharge have created many new springs. A cooperative project with the Nevada Division of Water Resources completed an initial evaluation of the regional effects of mining on water resources along the Carlin Trend north of the Humboldt River. A new project began in 1993 to provide the Bureau of Land Management with a reconnaissance-level assessment of the effects of mining on hydrology throughout the Humboldt River Basin. The Nevada District will take a lead role in the hydrologic part of this regional assessment, including water-quality aspects.

Issue-Related Research

The existing water resources cannot easily accommodate urban and economic development in Nevada, and that focuses most USGS customer interest on issues such as data networks, resource assessment, delineation of water yields, documentation of water use, and information-management systems. However, many aspects of meeting urgent public need for hydrologic information also provide opportunities for applied research on fundamental processes.

"Simple" water budgets for arid ground-water basins require measurements and estimations of water balances for processes that are far from well understood. A research project in the Nevada District is refining instruments and models for estimation of ground-water evapotranspiration by phreatophytes, the major source of water discharge in many undeveloped valleys.

The need to refine techniques for estimating ground-water recharge led to funding of another research project that will focus on the effect of temperature on infiltration through the unsaturated zone beneath small streams and ditches on alluvial fans. Increased requirements to assess and manage complex hydrologic basins has placed new emphasis on more complex models to simulate interactions between streams and aquifers.

Currently, ground-water modules of river-system models do not provide realistic simulations of aquifer development. Proposed future collaborations between research staff in the Nevada District and researchers at the U.S. Army Corps of Engineers Hydrologic Engineering Center (HEC) would explore linking of USGS and HEC models to address some of these issues.

Another aspect of arid-lands hydrology that is not understood sufficiently to meet current real-world management needs is land subsidence due to ground-water pumpage. A continuing Nevada District project involves basic research on new algorithms for defining total aquifer displacement (solids and fluids) due to pumpage, and is installing state-of-the-art instrumentation in Las Vegas Valley for direct field measurement of both vertical and horizontal land displacement.

REFERENCES CITED

Jones, Jeanine, Maxwell, S.R., and Hayward, Patricia, 1991, Truckee River atlas: California Department of Water Resources, 128 p.

Moosburner, Otto, 1986, Nevada surface-water resources, *in* Moody, D.W., Chase, E.B., and Aronson, D.A., comps., National water summary 1985—Hydrologic events and surface-water resources: U.S. Geological Survey Water-Supply Paper 2300, p. 323-328.

Nevada Agricultural Statistics Service, comp., 1989, Nevada agricultural statistics, 1989: Reno, 44 p.

Nevada Appeal, 1993, After 6 years of drought, farms begin to green: Carson City, Nevada Appeal, September 7, p. A1.

Reno Gazette-Journal, 1993, Farmers to run dry: Reno, Nev., August 28, p. 1A.

———1994, Ditches shut down earlier than expected: Reno, Nev., June 11, p. 1A.

Shamberger, H.A., 1991, Evolution of Nevada's water laws, as related to the development and evaluation of the State's water resources, from 1866 to about 1960: Nevada Division of Water Resources, Bulletin 46, 100 p.

Skorupa, Susan, 1995, Nevada mines set record: Reno, Nev., Reno Gazette-Journal, p. 4C.

Soil Conservation Service, 1994, Nevada basin outlook report, May 1, 1994: Soil Conservation Service report, unpaginated.


U.S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PROJECTS FUNDED IN FISCAL YEARS 1993-94

(page 25 follows)

Surface-Water Data Network *(Project 001)*

Location: Statewide and eastern California.

Project Chief: Stephen E. Hammond.

Period of Project: Continuous since 1894.

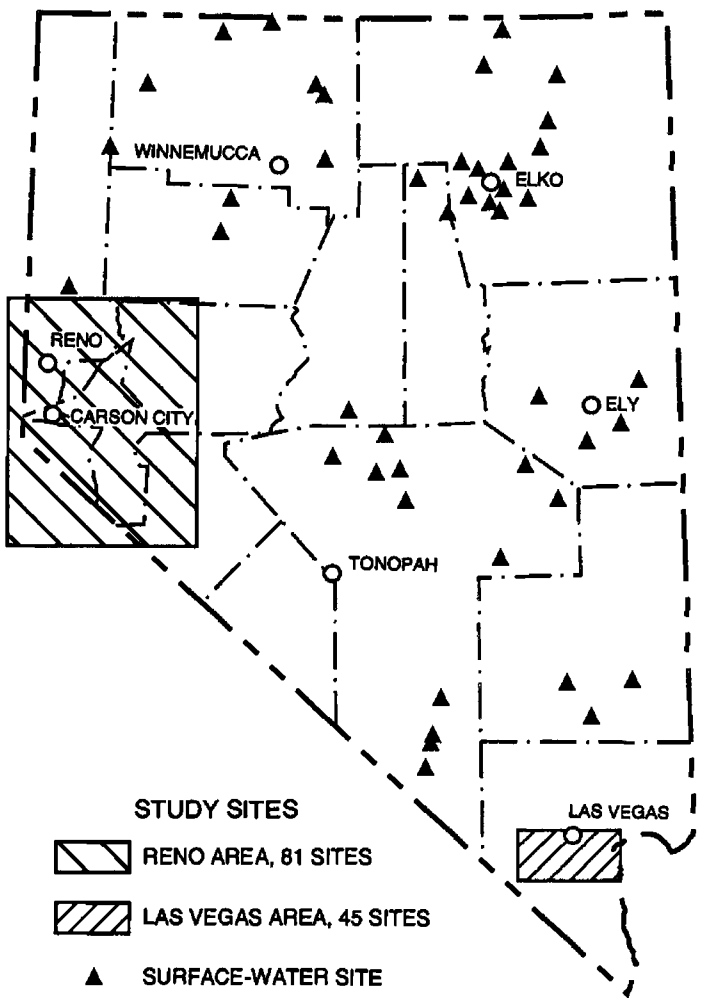
Cooperating and Supporting Federal Agencies: Bureau of Land Management, Bureau of Reclamation, Carson City Public Works Department, Carson-Truckee Water Conservancy District, Carson Water Subconservancy District, City of Henderson, City of Las Vegas, City of Reno, City of Sparks, Clark County Regional Flood Control District, Clark County Sanitation District, Douglas County, Duck Valley Reservation Shoshone-Paiute Tribes, Federal Water Master, Las Vegas Valley Water District, National Park Service, Nevada Department of Conservation and Natural Resources, Nevada Division of Water Resources, Nevada Division of Wildlife, Pyramid Lake Paiute Tribe, Summit Lake Paiute Tribe, Truckee-Carson Irrigation District, U.S. Army Corps of Engineers, U.S. Board of Water Commissioners, U.S. Fish and Wildlife Service, Walker River Irrigation District, Walker River Paiute Tribe, Washoe County Department of Comprehensive Planning, and Washoe County Department of Public Works.

Problem: Surface-water runoff is highly variable, both areally and seasonally, throughout the State. Information is needed for surveillance, planning, design, hazard warning, and management. These data are particularly relevant to water-related fields such as water supply, hydroelectric power, flood control, irrigation, bridge and culvert design, wildlife management, pollution abatement, flood-plain management, and water-resources development. An appropriate data base is necessary to support such ongoing needs.

Objectives: Data will be collected for (1) assessment of water resources, (2) operation of reservoirs and industries, (3) waste disposal and pollution control operations, (4) water-quality estimations, (5) compact and legal requirements, (6) analysis of short-term variability and long-term trends for forecasting, and (7) research.

Approach: The stage (level) and discharge of lakes and streams are measured at a network of surface-water stations and sites using standard USGS methods. Data-collection intervals are determined according to the principal purpose of each site.

Progress and Significant Results, Fiscal Years 1993-94: Continuous streamflow monitoring at year-round and irrigation-season stations continued throughout 1993-94. The number of year-round sites and irrigation-season sites increased in 1993 and 1994. In addition, stage measurements were made at several lakes and reservoirs. All data were processed and stored in the National Water-Information System computer data base. The annual water-data reports were published.



Plans for Fiscal Year 1995: Statewide surface-water data collection, computation, and compilation will continue. Field surveys and computations for indirect measurements of flow where gages have not yet been located will be made as needed. The annual water-data report will be compiled and submitted for approval and publication.

Publications, Fiscal Years 1993-94:

Emett, D.C., Hutchinson, D.D., Jonson, N.A., and O'Hair, K.L., 1994, Water resources data, Nevada, water year 1993: U.S. Geological Survey Water-Data Report NV-93-1, 596 p.

Glancy, P.A., and Williams, R.P., 1994, Problems with indirect determinations of peak streamflows in steep, desert stream channels, *in* Cotroneo, G.V., and Rumer, R.R., eds., Hydraulic engineering '94: American Society of Civil Engineers Conference, Buffalo, N.Y., August 1994, Proceedings, v. 1, p. 635-639.

Hess, D.L., Mello, K.A., Sexton, R.J., and Young, R.L., 1993, Water resources data, Nevada, water year 1992: U.S. Geological Survey Water-Data Report NV-92-1, 511 p.

Ground-Water Data Network *(Project 002)*

Location: Statewide.

Project Chief: Stephen E. Hammond.

Period of Project: Continuous since 1945.

Cooperating Agencies: Carson City Public Works Department, Churchill County, Douglas County, Las Vegas Valley Water District, Nevada Bureau of Mines and Geology, and Nevada Division of Water Resources.

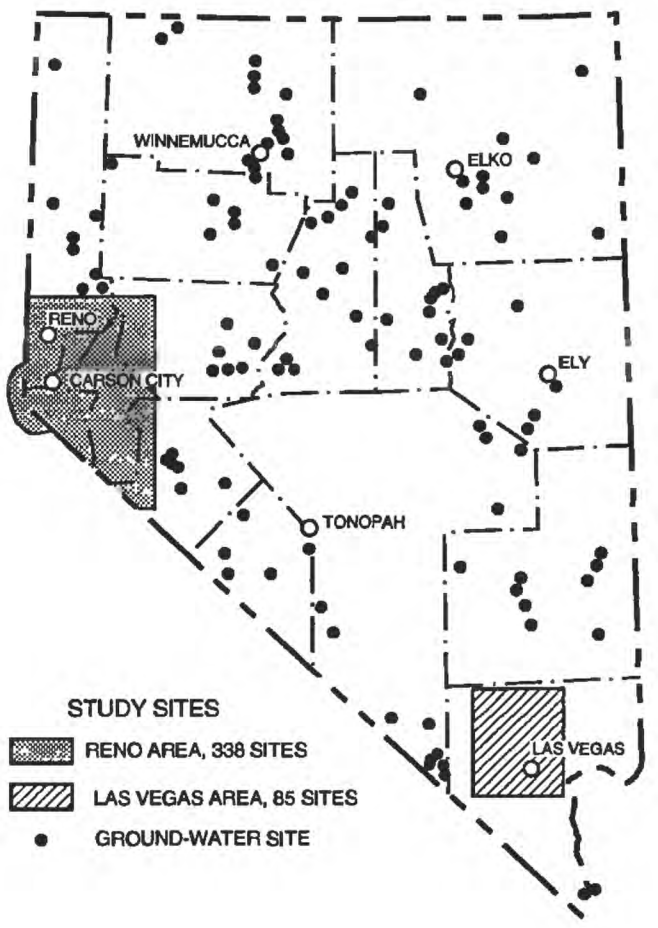
Problem: The long-term response of regional aquifers throughout the State to natural climatic variations and induced stresses is largely unknown. Proper planning and management of State water resources require long-term information so that trends can be defined, problems discovered, and corrective actions taken. Measurements of recharge to and discharge from ground-water systems provide a data base from which to evaluate the effects of management and development, and assist in determining future supplies.

Objectives: Long-term records will provide information to identify trends in ground-water levels in response to natural climatic variations and induced stresses within the State. The data are used by National, State, and local planners to (1) assess the ground-water resource, (2) estimate future conditions, (3) detect and define pollution and supply problems, and (4) provide information for management of the resource.

Approach: A regionally representative network of wells is maintained to allow measurement of water levels in most aquifers within the State. The wells are situated, if possible, away from areas of direct human effect such as residential, agricultural, or industrial areas. Measurements are made at approximately the same times each year to reduce seasonal effects. New wells are added to the network as old wells are destroyed, local land use changes, and other needs arise.

Progress and Significant Results, Fiscal Years 1993-94: Ground-water data collection, computation, and compilation continued. Basic records were verified for depth-to-water in wells and discharge from springs at sites included on the routine statewide network. All data were processed and stored in the National Water-Information System computer data base. The annual water-data reports were published.

Plans for Fiscal Year 1995: Ground-water data collection, computation, and compilation will continue. The annual water-data report will be compiled and submitted for approval and publication.



Publications, Fiscal Years 1993-94:

Burbey, T.J., in press, Pumpage and water-level change in the principal aquifer system of Las Vegas Valley, Nevada, 1980-90: Nevada Division of Water Resources, Information Report 34.

Emett, D.C., Hutchinson, D.D., Jonson, N.A., and O'Hair, K.L., 1994, Water resources data, Nevada, water year 1993: U.S. Geological Survey Water-Data Report NV-93-1, 596 p.

Hess, D.L., Mello, K.A., Sexton, R.J., and Young. R.J., 1993, Water resources data, Nevada, water year 1992: U.S. Geological Survey Water-Data Report NV-92-1, 511 p.

Water-Quality Data Network *(Project 003)*

Location: Statewide and eastern California.

Project Chief: Stephen E. Hammond.

Period of Project: Continuous since 1939.

Cooperating and Supporting Federal Agencies: Bureau of Land Management, Carson City Public Works Department, Douglas County, Nevada Bureau of Mines and Geology, Nevada Division of Environmental Protection, Nevada Division of Water Resources, Nevada Division of Wildlife, and U.S. Fish and Wildlife Service.

Problem: The physical, chemical, and biological quality of surface water is highly variable and must be monitored to identify local influences, seasonal trends, and long-term trends. Long-term records of standardized water-quality data provide information for management and planning.

Objectives: Analysis of the data will allow identification of short- and long-term trends, provide early warning of developing water-quality problems, and provide information for Federal management of interstate waters.

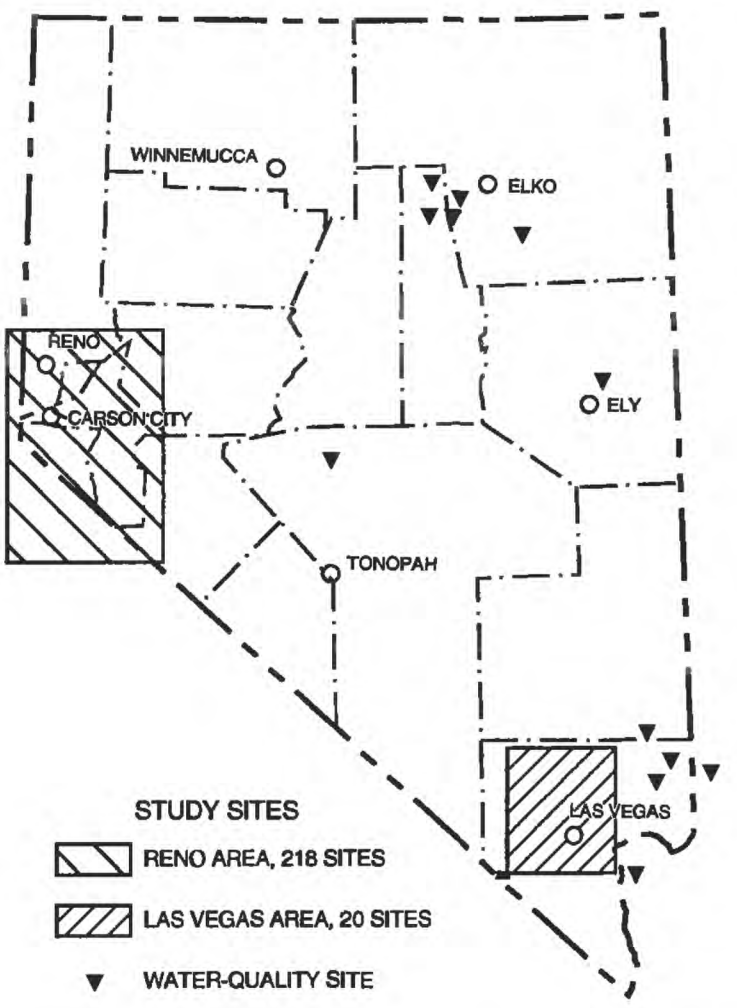
Approach: A network of water-quality sites for surface water and ground water has been established to provide information about physical, chemical, and biological characteristics. Standard USGS methods of water-sample collection, preservation, and analysis are used.

Progress and Significant Results, Fiscal Years 1993-94: Sampling increased from 195 active sites in water year 1993 to 250 active sites in water year 1994. Data collection and analysis continued using improved statistical techniques. All data were processed and stored in the National Water-Information System computer data base. Some station descriptions were updated. New personnel were trained to collect and review water-quality data. The USGS, in cooperation with the Nevada Division of Environmental Protection, developed interagency software for efficient capture and quality assurance of water-quality data obtained from selected major laboratories in the State. The annual water-data reports were published.

Plans for Fiscal Year 1995: Data collection and analysis will continue. The annual water-data report will be compiled and submitted for approval and publication.

Publications, Fiscal Years 1993-94:

Emett, D.C., Hutchinson, D.D., Jonson, N.A., and O'Hair, K.L., 1994, Water resources data, Nevada, water year 1993: U.S. Geological Survey Water-Data Report NV-93-1, 596 p.



Gortsema, G.C., 1993, Selected data on water quantity and quality at four sites on streams draining public lands, Colorado River Basin, southeastern Nevada, October 1988-September 1991: U.S. Geological Survey Open-File Report 93-439, 31 p.

Hess, D.L., Mello, K.A., Sexton, R.J., and Young, R.L., 1993, Water resources data, Nevada, water year 1992: U.S. Geological Survey Water-Data Report NV-92-1, 511 p.

Sediment Data Stations *(Project 004)*

Location: Virgin River Basin, Nev.

Project Chief: Stephen E. Hammond.

Period of Project: Continuous since 1992.

Cooperating Agency: Las Vegas Valley Water District.

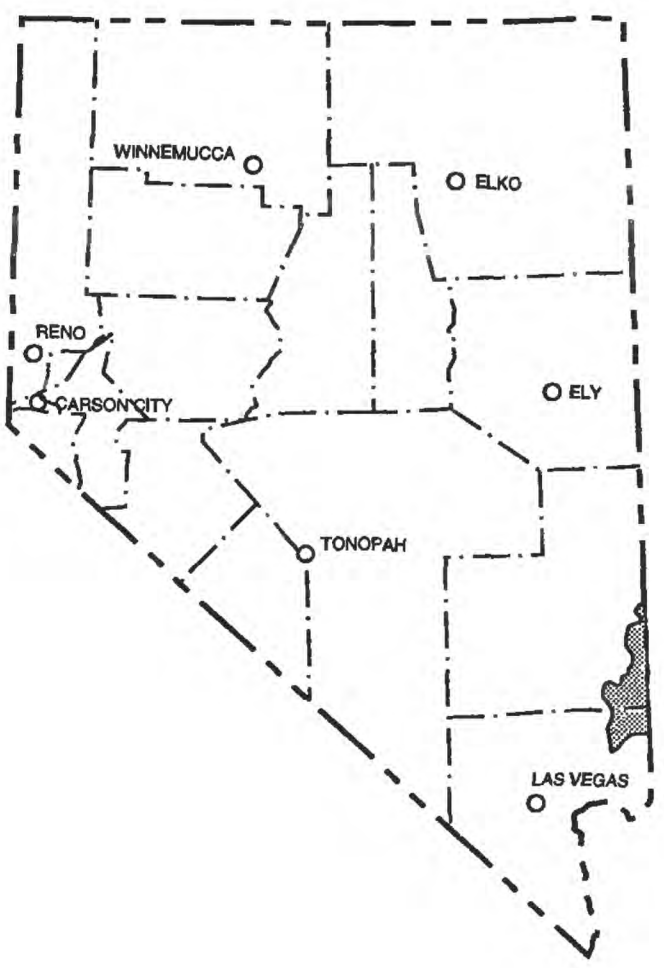
Probiem: Sediment data are needed for purposes of surveillance, planning, design, hazard warning, operation, and management in water-related fields such as water supply, hydroelectric power, flood control, irrigation, bridge and culvert design, wildlife management, pollution abatement, flood-plain management, and water-resource development. These data need to be maintained in an appropriate data base.

Objective: A network of sediment stations will be maintained to collect sediment data for various uses such as assessment of water resources; operation of reservoirs and industries; design of waste-disposal systems and pollution controls; collection of discharge data to accompany water-quality measurements, compact and legal requirements; and research or special studies.

Approach: Sediment data will be collected using standard USGS methods.

Progress and Significant Resuits, Fiscai Years 1993-94: Data collection, computation, and compilation continued.

Pians for Fiscai Year 1995: Data collection, computation, and compilation will continue. The annual water-data report will be compiled and submitted for approval and publication.



Nationai Trends Network for Monitoring Atmospheric Deposition *(Project 005)*

Location: Smith Valley and Saval Ranch, Nev.

Project Chief: Stephen E. Hammond.

Perlod of Project: Continuous since 1985.

Supportlng USGS Program: National Atmospheric Deposition Program.

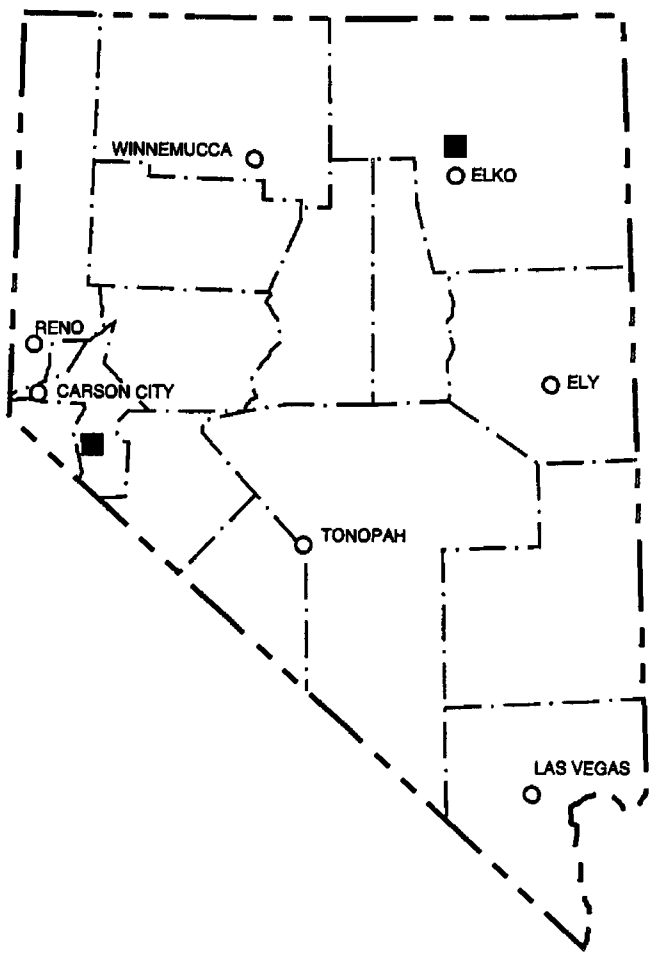
Problem: Acid precipitation has caused adverse ecological and economic consequences in the eastern United States. In the western United States, the chemical composition and variability of wet atmospheric deposition is largely unknown due to a lack of quantitative data. However, industrial and vehicular emissions, which are known to cause acid precipitation in the east, are found also in the west.

Objectives: Precipitation data will be characterized to determine variations and trends as part of a Nationwide program to quantify the chemical properties of wet atmospheric deposition.

Approach: Two atmospheric-deposition samplers are being operated, one in Smith Valley, Nev., and one at Saval Ranch, Nev. The samplers are checked weekly and samples are collected and analyzed for pH and specific conductance when sufficient precipitation occurs.

Progress and Significant Results, Fiscal Years 1993-94: Twenty-four samples contained adequate quantities of precipitation for field determination of pH and specific conductance in 1993-94. An interstate comparison study was made by the National Atmospheric Deposition Program and the National Trends Network. The data were published in the annual data summaries of the National Atmospheric Deposition Program.

Plans for Fiscal Year 1995: Sample collection and compilation of data from the Smith Valley and the Saval Ranch sites will continue.



Flood-Insurance Studies *(Project 006)*

Location: Northern Nevada.

Project Chief: Stephen E. Hammond.

Period of Project: Continuous since 1985.

Supporting Federal Agency: Federal Emergency Management Agency.

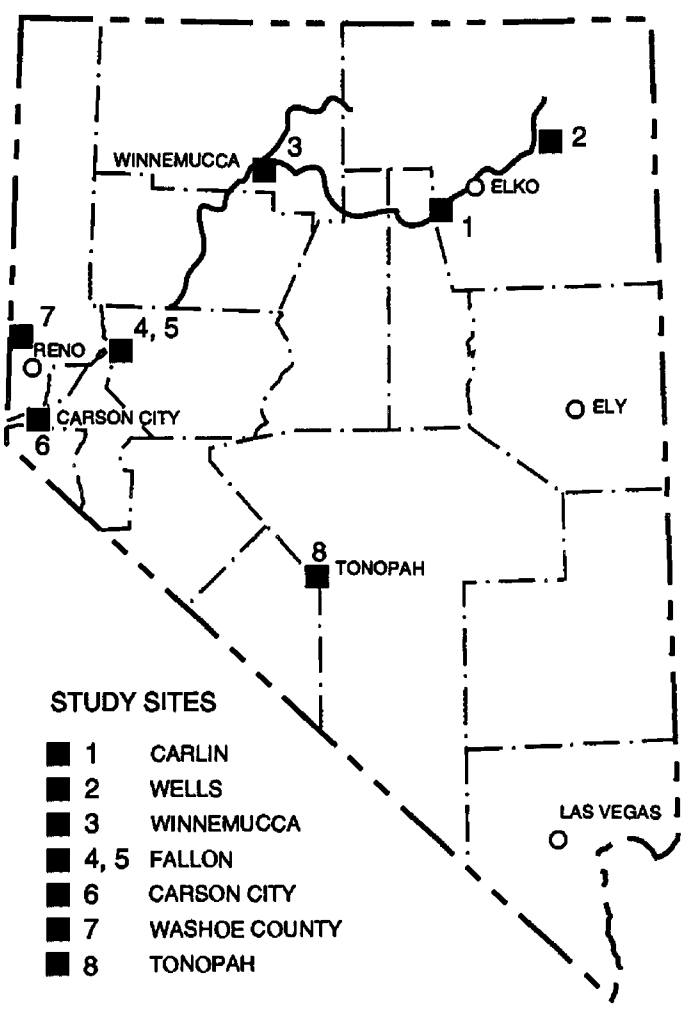
Problem: Flooding in arid regions can be devastating because most rain occurs in the spring, when rain on snow is likely, and sparse vegetation and compacted desert soils allow little infiltration of rainfall and snowmelt. Excessive overland flow is also a consequence of locally intense thunderstorms. The National Flood Insurance Act of 1968 provides that the Federal Emergency Management Agency (FEMA) operates a flood-insurance program through the Federal Flood Insurance Administration. FEMA needs information from flood studies in selected areas to determine appropriate flood-insurance premiums.

Objectives: Efficient procedures will be developed to obtain information at the accuracy required by FEMA on flood frequency and inundated areas, and to determine 100-year-flood-plain boundaries.

Approach: Precipitation, river-stage, and discharge measurements collected as part of the surface-water data network are used. Flood frequencies are determined from long-term measurements of discharge or regional flood-frequency analyses. River slopes, channel and flood-plain dimensions, drainage areas, and other characteristics of drainage basins are estimated from maps, where possible, or measured directly. Areas of potential inundation are estimated using ground surveys, photogrammetry, and other available data in conjunction with flood-frequency estimates, hydraulic analysis, and, as appropriate, drainage-basin models.

Progress and Significant Results, Fiscal Years 1993-94: Data collection was completed for the Washoe County area and the City of Tonopah using aerial photography. Analysis of the data began. Flood data collected at sites along the Carson River near the Carson City-Douglas County line were published by FEMA in 1994.

Plans for Fiscal Year 1995: Analysis of the flood data for western Washoe County area and the City of Tonopah will be completed and results submitted for publication by FEMA. A new study in the Fallon area will begin in late 1994.



Water Use in Nevada *(Project 007)*

Location: Statewide.

Project Chief: E. James Crompton.

Period of Project: Intermittent since 1978.

Cooperating Agency: Nevada Division of Water Resources.

Problem: Nevada is the driest State in the Nation, and it also has the fastest growing population. Water-use data are critically needed for the planning and management of the State's water resources. In addition to obtaining water-use data, methods need to be developed for improving data collection. More efficient ways of storing and retrieving data, to be compatible with other computer data bases, also need to be developed.

Objectives: Water-use information will be made available for the best utilization and management of the resource. The data will be collected, stored, and distributed to complement the available water-quantity and water-quality information. The data-storage system is designed to handle site-specific and aggregate water-use data to meet the needs of local users, State agencies, USGS, and other Federal agencies.

Approach: Information is to be compiled based on the smallest unit feasible, usually individual points of diversion or withdrawal. Three major advantages of using this approach are that (1) more sources of reliable information are available at smaller scales, (2) compilations detailed enough to provide specific information about small areas are in demand at a local level, and (3) larger scale requirements may be satisfied by summing the small-scale information.

Progress and Significant Results, Fiscal Years 1993-94: Collection and compilation of water-use data in Nevada during 1993 and 1994 continued in accordance with National guidelines. Enhancements were made to the computerized data base of water-rights permits developed to allow USGS and the Nevada Division of Water Resources to share data bases on a wide-area network. The data base has capabilities for quality control and quality assurance that ensure accuracy of the data. Conversion of the well drillers' log file to a data base compatible with the permit file was completed and is being used. A method is being developed to make the water-use data base compatible with the permit file. An associated project created and tested a data base for the storage of spatial water-rights data. Water-use information was published in the 1993 and 1994 annual water-data reports. Presentations on the Pahrump spatial data base were given at the Nevada Water Resources Association annual conference in March 1994 and at the Environmental Systems Research Institute annual conference in May 1994.

Plans for Fiscal Year 1995: The final phase of the data base for the storage of spatial water- rights data will be completed. Water-use programs with other State and regional agencies will be developed. Water-use information will be compiled and published in the annual water-data report.

Publications, Fiscal Years 1993-94:

Emett, D.C., Hutchinson, D.D., Jonson, N.A., and O'Hair, K.L., 1994, Water resources data, Nevada, water year 1993: U.S. Geological Survey Water-Data Report NV-93-1, 596 p.

Hess, D.L., Mello, K.A., Sexton, R.J., and Young, R.L., 1993, Water resources data, Nevada, water year 1992: U.S. Geological Survey Water-Data Report NV-92-1, 511 p.

Peltz, L.A., Hickenbottom, K.W., Dillon, M.J., and Taylor, Tracy, 1994, Development of a spatial data base for water-right information in Pahrump Valley, Nevada: 14th Annual User Conference, Environmental Systems Research Institute, Palm Springs, Calif., May 1994, Proceedings (CD-ROM), p. 253-256.

Peltz, L.A., Hickenbottom, K.W., Taylor, T.W., and Dillon, M.J., 1994, Spatial data base for water-right information—Pilot study in Pahrump Valley, Nevada [abs.]: Nevada Water Conference, Nevada Water Resources Association, Las Vegas, March 1994, Abstracts of Technical Papers and Posters, p. 38.

Flood Investigations of Nevada Streams
(Project 036)

Location: Statewide.

Project Chief: Stephen E. Hammond.

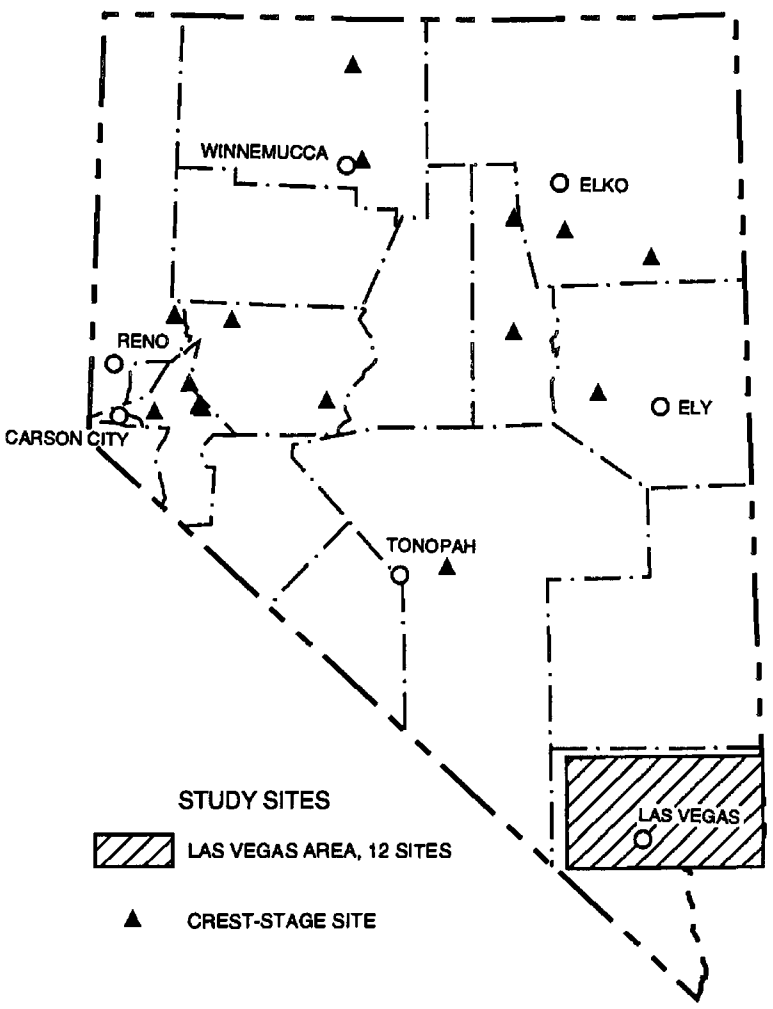
Period of Project: Continuous since 1961.

Cooperating and Supporting Federal Agencies: Nevada Department of Transportation and U.S. Army Corps of Engineers.

Problem: The design of hydraulic structures within stream channels depends on accurate estimations of flood frequency and related debris-flow magnitude. Flood-recurrence intervals generally cannot be estimated on the basis of channel characteristics alone; long-term records of peak-flow measurements also are necessary. The Nevada Department of Transportation needs flood data to assist in the design of hydraulic structures for highways.

Objectives: The frequency and magnitude of floods of Nevada streams are appraised and data are provided for use in the design of highways and hydraulic structures.

Approach: Crest-stage gages to measure peak-streamflow stages have been installed, and are being maintained and operated. Sites are visited periodically to obtain flood records, maintain equipment, and make indirect measurements. Each crest-stage site is monitored for at least 10-15 years to provide data defining flood frequency and magnitude.



Progress and Significant Results, Fiscal Years 1993-94: Peak-streamflow data were collected at 27 sites. Peak-flow data for the 1992 and 1993 water years were published in the annual water-data reports. Data collection and investigations of mud- and debris-flow areas continued.

Plans for Fiscal Year 1995: Data collection and investigation of mud- and debris-flow areas will continue. Peak-flow data will be published in the annual water data report. The flood-frequency report will be submitted for approval.

Publications, Fiscal Years 1993-94:

Emett, D.C., Hutchinson, D.D., Jonson, N.A., and O'Hair, K.L., 1994, Water resources data, Nevada, water year 1993: U.S. Geological Survey Water-Data Report NV-93-1, 596 p.

Hess, D.L., Mello, K.A., Sexton, R.J., and Young, R.L., 1993, Water resources data, Nevada, water year 1992: U.S. Geological Survey Water-Data Report NV-92-1, 511 p.

Beatty Disposai-Site investigation *(Project 072)*

Location: Amargosa Desert near Beatty, Nev.

Project Chief: Brian J. Andraski.

Period of Project: Continuous since 1976.

Supporting Federal Agency and USGS program: Nuclear Regulatory Commission and Low-Level Nuclear Waste Hydrology Program.

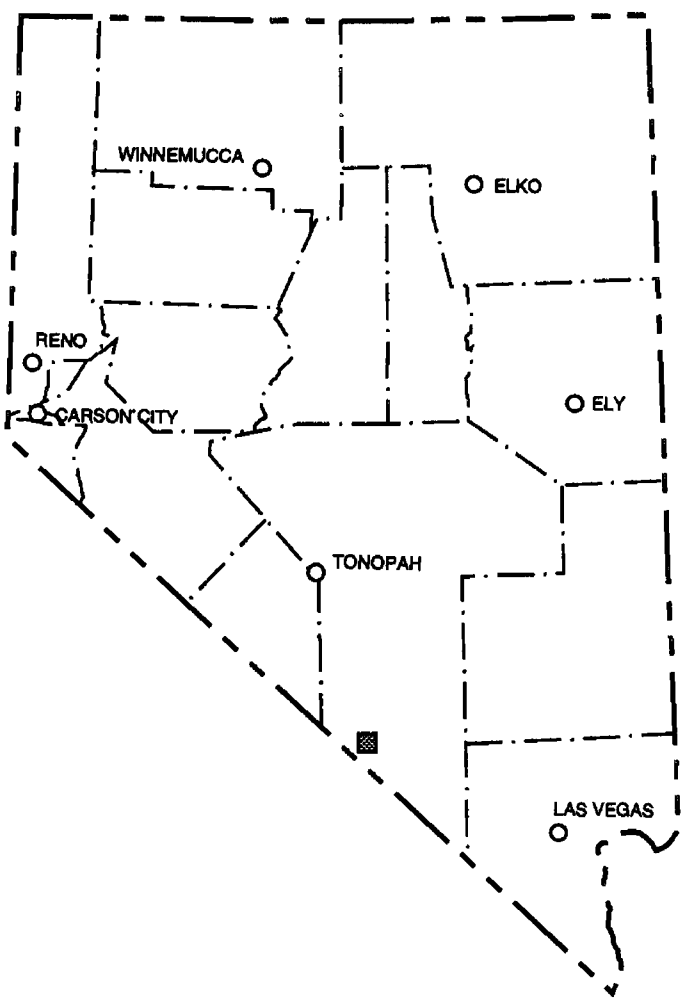
Problem: Low-level radioactive waste has been buried at a site near Beatty, Nev., since 1962. Processes affecting the movement of water in the dry sediments are not understood. Therefore, the rates of potential migration of radioactive solutes cannot be estimated for present climatic conditions.

Objectives: Mechanisms and soil properties will be defined for controlling rates and directions of moisture movement (as liquid and vapor) through unsaturated soil under disturbed and undisturbed conditions. Methods for measuring properties of and water movement in dry alluvial soils will be developed. Rates of trench subsidence and erosion over time will be determined. The results of these studies will be used to (1) evaluate the geohydrologic suitability of the existing site for waste containment and (2) contribute information for the development of guidelines and criteria for selection and establishment of future burial sites for low-level radioactive waste.

Approach: Soil moisture and temperature are measured at an undisturbed site and at a disturbed test-trench site. Meteorological conditions are being monitored. Physical properties, such as permeability and grain-size distribution, of the undisturbed-soil profile and test-trench backfill are being characterized through laboratory analysis. The vertical variability of these properties is being evaluated by statistical analysis. Erosion and subsidence of the test trenches are being monitored.

Progress and Significant Results, Fiscal Years 1993-94: Monitoring of long-term soil moisture, erosion, and subsidence continued. Laboratory analyses to characterize the physical properties and vertical variability of the undisturbed soil profile and trench backfill were completed. Evaluation of field and laboratory data continued. Direct measurement of daily evapotranspiration (ET) compared favorably with water depletion calculations. Results from these studies indicate that the natural system (climate, stratified soils, vegetation) effectively reduces the potential for deep percolation of infiltrated water. The construction of burial trenches and removal of native vegetation, however, significantly alters the natural environment of the site and increases the potential for water to percolate toward the buried waste. Erosion and subsidence of trenches decreased with time. Drum placement (random versus stacked) had little effect on post-construction subsidence. Reports were published and presentations on the study results were made at several meetings.

Plans for Fiscal Year 1995: Final compilation and analysis of long-term field and laboratory data will be completed. Collection and evaluation of basic weather, soil moisture, erosion, and subsidence data will continue. Results will be used to improve the understanding of processes affecting waste isolation at the Beatty site. Reports will be submitted for approval and publication.



Publications, Fiscal Years 1993-94:

Andraski, B.J., in press, Disturbance effects on soil properties and water balance at a low-level radioactive waste site, Amargosa Desert, Nevada [abs.]: 86th Annual Meeting, American Society of Agronomy, Seattle, November 1994, Agronomy Abstracts, v. 86, p. 227.

———in press, Simulated trench studies near Beatty, Nevada—Initial results and implications *in* Conference on Disposal of Low-Level Radioactive Waste, Reston, Va., May 1993: U.S. Geological Survey Water-Resources Investigations Report 95-4015.

Gee, G.W., Wierenga, P.J., Andraski, B.J., Young, M.H., Fayer, M.J., and Rockhold, M.L., 1994, Variations in water balance and recharge potential at three western desert sites: Soil Science Society of America Journal, v. 58, no. 1, p. 63-72.

Wood, J.L., and Andraski, B.J., 1992, Selected meteorological data for an arid site near Beatty, Nye County, Nevada, calendar year 1989: U.S. Geological Survey Open-File Report 92-484, 27 p.

———in press, Selected meteorological data for an arid site near Beatty, Nye County, Nevada, calendar years 1990 and 1991: U.S. Geological Survey Open-File Report 94-489.

Carbonate-Rock Aquifer System
(Project 127)

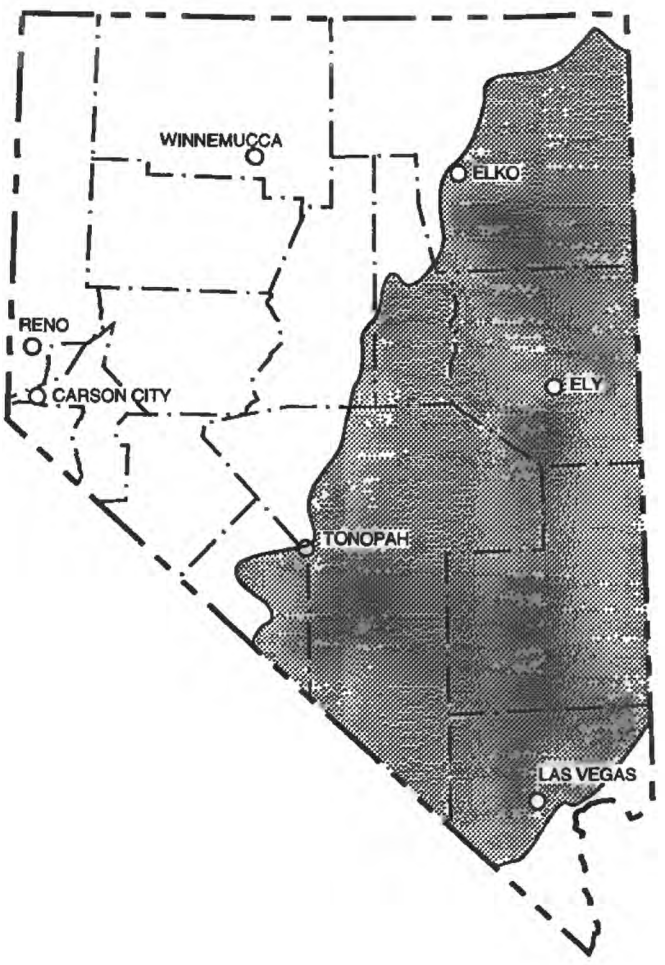
Location: Eastern and southern Nevada.

Project Chief: Donald H. Schaefer.

Period of Project: Continuous since 1991.

Supporting Federal Agencies: Bureau of Indian Affairs (BIA), Bureau of Land Management (BLM), National Park Service (NPS), and U.S. Fish and Wildlife Service (USFWS).

Problem: The Department of the Interior has major concerns about applications filed by the Las Vegas Valley Water District (LVVWD) to appropriate 181,000 acre-feet per year of ground water in 17 hydrographic areas in eastern and southern Nevada, generally to the north of Las Vegas and underlain by carbonate-rock aquifers. The LVVWD also has filed for 60,000 acre-feet per year of surface water from the Virgin River. Approximately 60 threatened or endangered plant and wildlife species are found in the carbonate-rock area and could be affected negatively. USGS has been asked to provide technical support and assistance to the four protestants—BIA, BLM, NPS, and USFWS—to prepare for and participate in proceedings before the Nevada State Engineer concerning water-right applications by LVVWD. NPS is the lead coordinating agency for this effort.



Objectives: Technical support and assistance will be provided to the protestants. The diversions proposed by LVVWD were simulated using a regional model to determine the effects on the ground-water systems for steady-state conditions.

Approach: The existing USGS computer model of the carbonate-rock province will be used to make a series of simulations on pumpage proposed by LVVWD. The simulations will be analyzed and results summarized in a brief report. Hydrologic expertise will be provided at meetings, briefings, and hearings, as requested.

Progress and Significant Results, Fiscal Years 1993-94: Analysis of the model simulations continued, and a report describing these results was completed and reviewed. Hydrologists attended hearings and meetings to provide expertise.

Plans for Fiscal Year 1995: The model-simulation report will be submitted for approval and publication. Technical assistance and support materials will be provided at public hearings and meetings.

Nevada Carbonate-Rock Aquifers
(Project 128)

Location: Eastern and southern Nevada.

Project Chief: Donald H. Schaefer.

Period of Project: Continuous since 1984.

Cooperating Agency: Las Vegas Valley Water District.

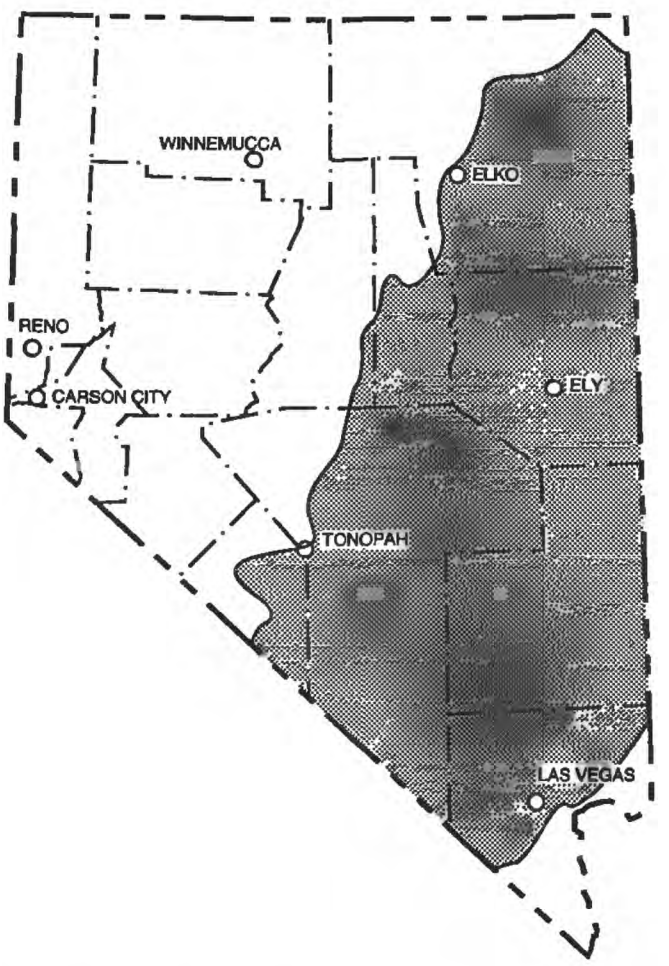
Problem: Demand for water in Las Vegas and smaller towns in eastern and southern Nevada is growing and additional supplies may be needed from ground-water sources outside the local basins. Previous assessments of the water resources of eastern Nevada indicate that the carbonate-rock aquifers are a potential ground-water source, but insufficient data are available upon which to base a decision for the location of major supply wells. The location of wells needs to be based on adequate data and sound hydrologic reasoning because of the high cost of developing wells in the carbonate-rock aquifers. Testing and monitoring of selected wells are needed to ensure continued availability of water supplies.

Objectives: The carbonate aquifers of eastern Nevada are being studied to determine the location of units with high transmissivity, high storage capacity, and good water quality, and, where possible, the cause of the high transmissivities. Areas with potential for siting of high-production wells may be selected for test drilling and evaluation.

Approach: Initial studies focused on the southern part of the carbonate-rock province; later phases were aimed at the central and northern parts of the carbonate-rock province. Detailed hydrological, chemical, and geological analyses of springs and wells already available were used to gain understanding of the carbonate-rock hydrology and to site other test wells. Test wells drilled by USGS and Bureau of Reclamation were used to determine aquifer properties. Areal studies, including remote-sensing, geological, geophysical, geochemical, and meteorological surveys were used with the well-test data to define areas in which high-production wells may be sited.

Progress and Significant Results, Fiscal Years 1993-94: Routine data collection and ground-water monitoring continued. Several reports were published. Several wells were replaced and additional recorders were installed in the wells. A data report was drafted and submitted for review. A presentation on carbon-14 dating of ground water in carbonate-rock aquifers in southern Nevada was presented at the Geological Society of America meeting in 1993.

Plans for Fiscal Year 1995: Routine data collection and ground-water monitoring will continue. The data report will be submitted for approval and publication.



Publications, Fiscal Years 1993-94:

Berger, D.L., 1992, Lithologic properties of carbonate-rock aquifers at five test wells in the Coyote Spring Valley area, southern Nevada, as determined from geophysical logs: U.S. Geological Survey Water-Resources Investigations Report 91-4167, 27 p.

Dettinger, M.D., Schmidt, D.L., Harrill, J.R., and Hess, J.W., in press, Distribution of carbonate-rock aquifers and the potential for their development, southern Nevada and parts of Arizona, California, and Utah: U.S. Geological Survey Water-Resources Investigations Report 91-4146.

Johnson, M.J., 1993, Micrometeorological measurements at Ash Meadows and Corn Creek Springs, Nye and Clark Counties, Nevada, 1986-87: U.S. Geological Survey Open-File Report 92-650, 41 p., 3 diskettes.

———in press, Ground-water discharge by evapotranspiration in a desert environment of southern Nevada, 1987: U.S. Geological Survey Water-Resources Investigations Report 94-4124, 20 p.

Schaefer, D.H., 1993, Hydrologic implications of measured changes in gravity during pumping at a carbonate-rock well near Moapa, Clark County, Nevada: U.S. Geological Survey Water-Resources Investigations Report 93-4095, 11 p.

Thomas, J.M., 1993, Carbon-14 dating of ground water in carbonate-rock aquifers of Southern Nevada—A complex problem [abs.]: Geological Society of America, Abstracts with Programs, v. 25. no 6, p. 90.

Nevada Test Site Hydrology *(Project 130)*

Location: Southern Nye County, Nev.

Project Chief: Douglas A. Trudeau, 1991-93; and Gary M. Russell, 1993-94.

Period of Project: Continuous since 1985.

Supporting Federal Agency: U.S. Department of Energy.

Problem: Underground nuclear-weapons testing at the Nevada Test Site (NTS) creates the potential for long-term contamination of ground-water supplies by radionuclides. Also, the location and design of test holes require hydrologic information.

Objectives: The regional ground-water flow system underlying NTS will be characterized. The potential for radionuclide migration related to underground nuclear-weapons testing will be investigated and other hydrologic expertise will be provided in support of the U.S. Department of Energy, Hydrologic Resources Management Program.

Approach: Several studies will be proposed, designed, and developed to obtain data necessary to meet the objectives. A network of test holes and wells was established to collect hydrogeologic data at NTS and vicinity. Geologic and hydrologic information is being processed in a geographic information system. Data are stored in computerized USGS data bases.

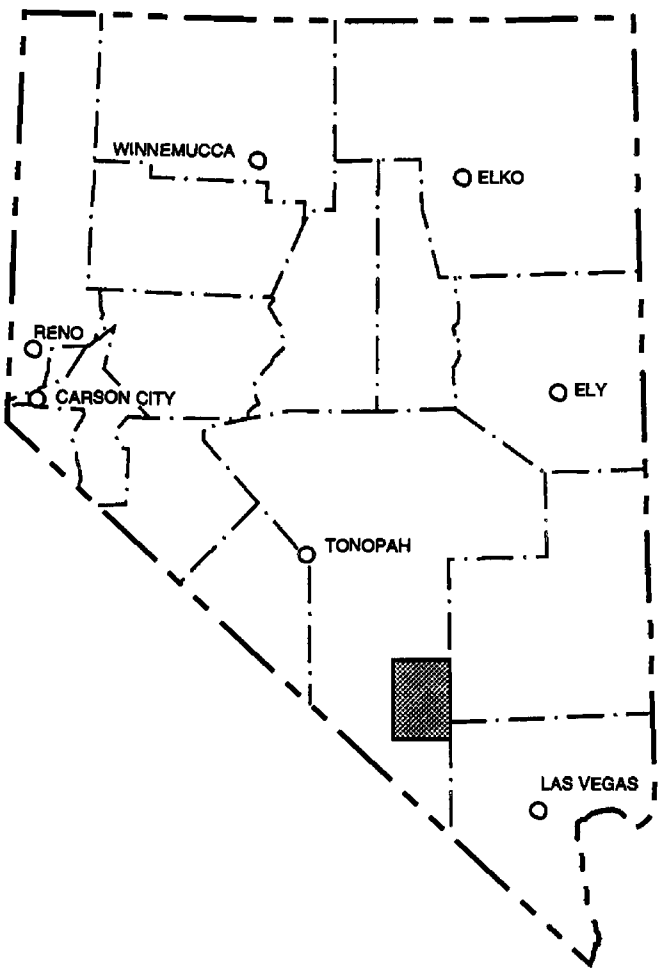
Progress and Significant Results, Fiscal Years 1993-94: Hydrologic expertise and technical support were provided to the Hydrologic Resources Management Program at NTS. A study began on the determination of hydraulic properties at the NTS and vicinity using analysis of frequency responses of water levels to earth tides, atmospheric loading, and seismic events. Routine data collection, computation, and compilations continued. Reports containing ground-water data collected for water years 1990-93 were submitted for approval. The Yucca Flat water-level map was prepared for submittal and approval. Presentations were given at several meetings and symposia.

Plans for Fiscal Year 1995: Data-collection activities will continue. Reports will be submitted for approval and publication.

Publications, Fiscal Years 1993-94:

Carman, R.L., in press, Meteorological data for four sites at surface-disruption features in Yucca Flat, Nevada Test Site, Nye County, Nevada, 1985-86: U.S. Geological Survey Open-File Report 94-491, 43 p.

Hale, G.S., and Trudeau, D.A., 1993, Ground-water levels from well and test-hole data, Yucca Flat, Nevada Test Site, Nye County, Nevada, 1959-91 [abs.]: 7th Symposium on Containment of Underground Nuclear Explosions, Kent, Wash., September 1993, Abstracts (CONF-9309103-ABS), p. 39.



Hawkins, W.L., Trudeau, D.A., and Drellack, S.L., 1993, Hydrogeologic investigations at the Nevada Test Site, *in* Eckstein, Yoram, and Zaporozed, Alexander, eds., Industrial and agricultural impacts on the hydrologic environment: Second USA/CIS Joint Conference on Environmental Hydrology and Hydrogeology, Water Environment Federation, American Institute of Hydrology, Proceedings, 18 p.

Scott, W.B., and Morgan, C.O., 1992, Hydrologic activities of the U.S. Geological Survey in support of the radionuclide migration program, Nevada Test Site, Nye County, Nevada, fiscal year 1986, *in* Jones, M.A., comp., Hydrology/Radionuclide Migration Program and related research activities, FY 1986 progress report (October 1, 1985-September 30, 1986): U.S. Department of Energy, DOE/NV-354, UC-700, p. 177-186.

Unger, R.W., in press, Evaluation of digital pressure sensors used to measure water levels at the Nevada Test Site, Nye County, Nevada [abs.]: U.S. Geological Survey Hydrologic Instrument Facility and Office of Ground Water Joint Workshop on Submersible Pressure Transducers, Lakewood, Colo., June 1994, Proceedings.

Wood, D.B., 1992, Ground-water data collected at the Nevada Test Site and vicinity, Nye County, Nevada, water years 1988-89: U.S. Geological Survey Open-File Report 92-130, 50 p.

Geographic Information System for Lake Tahoe Basin *(Project 146)*

Location: Lake Tahoe Basin, Nevada and California.

Project Chief: Kenn D. Cartier.

Period of Project: Continuous since 1987.

Cooperating Agency: Tahoe Regional Planning Agency.

Problem: Resource assessment, land and resource management, and basic research relating to hydrology in the Lake Tahoe Basin have been hampered by the lack of a common, basin-wide geographic data base. Data collected for diverse purposes at several scales are stored by individual agencies with different reporting conventions and standards. Previously, a great deal of effort was expended to reduce duplication in monitoring efforts and to cross-reference data sources for the basin. Existing data need to be recompiled at uniform scales (1:6,000 and 1:24,000) and automated into a consistent geographic information system (GIS).

Objectives: A geographic data base of natural-resource and manmade features was developed. The data base, the Tahoe Environmental Geographic Information System (TEGIS), can be used for exchange of natural-resource data between the USGS and other agencies, particularly the Tahoe Regional Planning Agency (TRPA). TRPA will use TEGIS to manage, analyze, and display data in support of land- and water-resource management.

Approach: The major steps in completing the pilot project were to (1) define needs and objectives, (2) design a data base, (3) compile and inventory data, and (4) complete thematic mapping. Cartographic and thematic data in TEGIS includes three major classes of information: permit information, natural-resource data, and monitoring data.

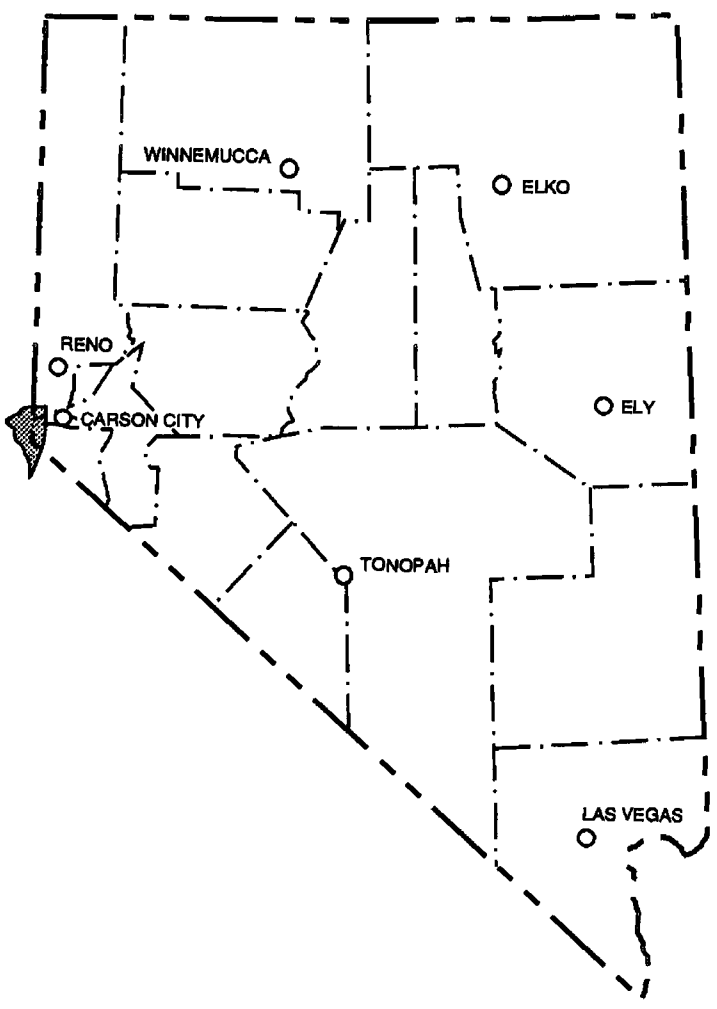
Progress and Significant Results, Fiscal Years 1993-94: All digital GIS data layers were completed. The documentation report was published. Map reports were submitted for review.

Plans for Fiscal Year 1995: Map reports will be submitted for approval and publication.

Publications, Fiscal Years 1993-94:

Cartier, K.D., Peltz, L.A., and Smith, J.L., 1994, Development and documentation of spatial data bases for the Lake Tahoe Basin, California and Nevada: U.S. Geological Survey Water-Resources Investigations Report 93-4182, 65 p.

Peltz, L.A., in press, Slope and aspect classifications of Lake Tahoe Basin, California and Nevada: U.S. Geological Survey Open-File Report 94-105, 1 sheet.



Stream Monitoring in Lake Tahoe Basin
(Project 147)

Location: Lake Tahoe Basin, Nevada and California.

Project Chief: Timothy G. Rowe.

Period of Project: Continuous since 1987.

Cooperating Agency: Tahoe Regional Planning Agency.

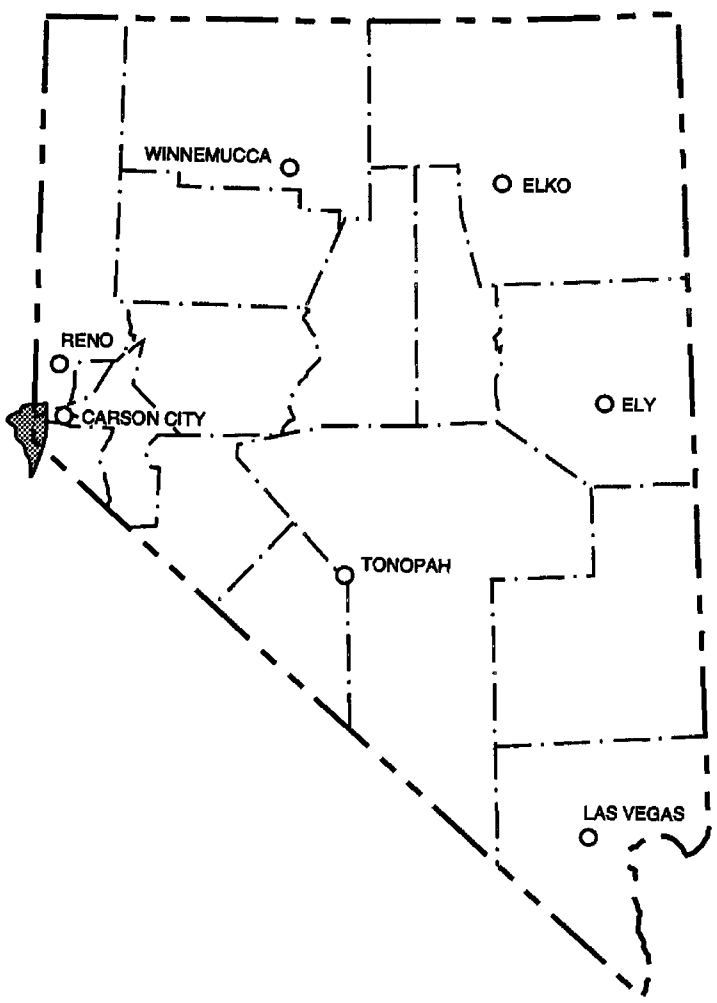
Problem: Deteriorating water quality in Lake Tahoe prompted the initiation of environmental programs in the basin. Water-quality data, especially nutrient data, on streams tributary to Lake Tahoe are needed to document the local and regional effectiveness of environmental programs and to assure compliance with the State water-quality management plan.

Objectives: This study will (1) provide a long-term data base of streamflow and of sediment and nutrient loadings from major streams tributary to Lake Tahoe, (2) determine the sources of streamflow and of sediment and nutrient loads, (3) describe the mechanisms by which sediment and nutrient loads are transported to and by streams, (4) develop methods of estimating total streamflow and nutrient and sediment loads transported by streams to Lake Tahoe, and (5) support assessment of the effects of land use and development in the Lake Tahoe Basin on the measured tributary loads.

Approach: The existing network of 31 sites will be maintained to better define the nutrient and sediment input to Lake Tahoe from tributary streams. The sites are part of the Lake Tahoe Interagency Monitoring Program network. Water-quality analyses are done by the Tahoe Research Group, University of California at Davis.

Progress and Significant Results, Fiscal Years 1993-94: The stream-monitoring network continued to provide data needed to develop estimates of annual streamflow and loads of sediment and nutrients contributed to Lake Tahoe by Nevada tributaries. Continuous-record streamflow gaging stations were operated and maintained; water samples were collected and analyzed for concentrations of suspended sediment, iron, and nitrogen and phosphorous species. An additional five streamflow sites in California were added to the monitoring network. Data were collected, compiled, and computed for publication in the annual water-data reports. A poster was presented at the Nevada Water Resources Association (NWRA) annual conference in February 1993 and an oral presentation was made at the NWRA annual conference in March 1994.

Plans for Fiscal Year 1995: Network operation will continue and reports will be submitted for review. The 1994 data will be published in the annual water-data report.



Publications, Fiscal Years 1993-94:

Emett, D.C., Hutchinson, D.D., Jonson, N.A., and O'Hair, K.L., 1994, Water resources data, Nevada, water year 1993: U.S. Geological Survey Water-Data Report NV-93-1, 596 p.

Hess, D.L., Mello, K.A., Sexton, R.J., and Young, R.L., 1993, Water resources data, Nevada, water year 1992: U.S. Geological Survey Water-Data Report NV-92-1, 511 p.

Rowe, T.G., 1993, Streamflow, sediment, and nutrient data for two streams in the Incline Village area of the Lake Tahoe Basin, Nevada, during water years 1988-92 [abs.]: Nevada Water Conference, Nevada Water Resources Association, Reno, February 1993, Abstracts of Presented Papers and Posters, p. 26.

———1994, Streamflow and water quality during drought and non-drought years at Incline Creek, a tributary to Lake Tahoe, Nevada, 1988-93 [abs.]: Nevada Water Conference, Nevada Water Resources Association, Las Vegas, March 1994, Abstracts of Technical Papers and Posters, p. 10.

Irrigation Drainage in and near Stillwater Wildlife Management Area *(Project 148)*

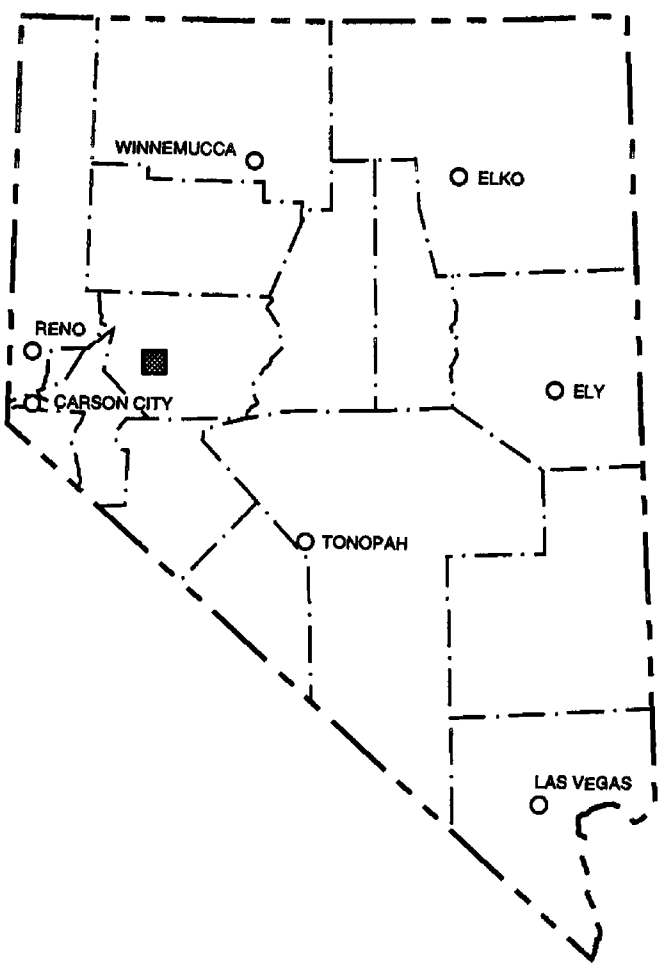
Location: Churchill and Pershing Counties, Nev.

Project Chief: Ray J. Hoffman.

Period of Project: Continuous since 1986.

Supporting USGS Program: Department of the Interior National Irrigation Water-Quality Program.

Problem: The Stillwater National Wildlife Refuge (SNWR) and nearby Carson Lake contain the largest marsh in Nevada, and are important sanctuaries for migratory and other waterfowl. The marsh is maintained mostly by irrigation-return flow drained from agricultural fields in the Fallon area. Elevated concentrations of potentially toxic trace elements have been found in the drain water, bottom sediment, and biota and this is a major concern for the Department of the Interior. The geochemical processes controlling the mobilization, transport, and fate of these trace elements and their effects on migratory waterfowl were studied in Phase 3 of the project. The USGS has been asked to continue to provide technical support and assistance to the Department of the Interior as part of Phase 4 of the project. Phase 4 involves the planning for remediation.



Objectives: The objectives are to monitor and collect surface-water data in the SNWR and Carson Lake for mitigation and possible clean-up purposes. Technical expertise and support will be provided to the Bureau of Reclamation.

Approach: Year-round measurements of drainflow, specific conductance, and water temperature will be made in several drain inputs to the SNWR and Carson Lake. Monthly samples for the analyses of major ions and selected trace elements will be collected during the irrigation season. These data will be collected in conjunction with the collateral U.S. Fish and Wildlife Service biomonitoring program.

Progress and Significant Results, Fiscal Years 1993-94: Work continued on reports and data-collection activities. A report on the effects on biota in the Stillwater and Fernley Wildlife Management Areas and other nearby wetlands was published in 1993 and a report summarizing the results of the detailed studies (Phase 3) was published in 1994.

Plans for Fiscal Year 1995: Routine data-collection activities and monitoring will continue. Technical assistance and support materials will be provided at meetings.

Publications, Fiscal Years 1993-94:

Hallock, R.J., and Hallock, L.L., eds., 1993, Detailed study of irrigation drainage in and near wildlife management areas, west-central Nevada, 1987-90—Part B. Effect on biota in Stillwater and Fernley Wildlife Management Areas and other nearby wetlands: U.S. Geological Survey Water-Resources Investigations Report 92-4042B, 84 p.

Hoffman, R.J., 1994, Detailed study of irrigation drainage in and near Wildlife Management Areas, west-central Nevada 1987-90—Part C. Summary of irrigation drainage effects on water quality, bottom sediment, and biota: U.S. Geological Survey Water-Resources Investigations Report 92-4024C, 32 p.

Ground-Water Conditions, Desert Valley
(Project 152)

Location: Northwestern Nevada.

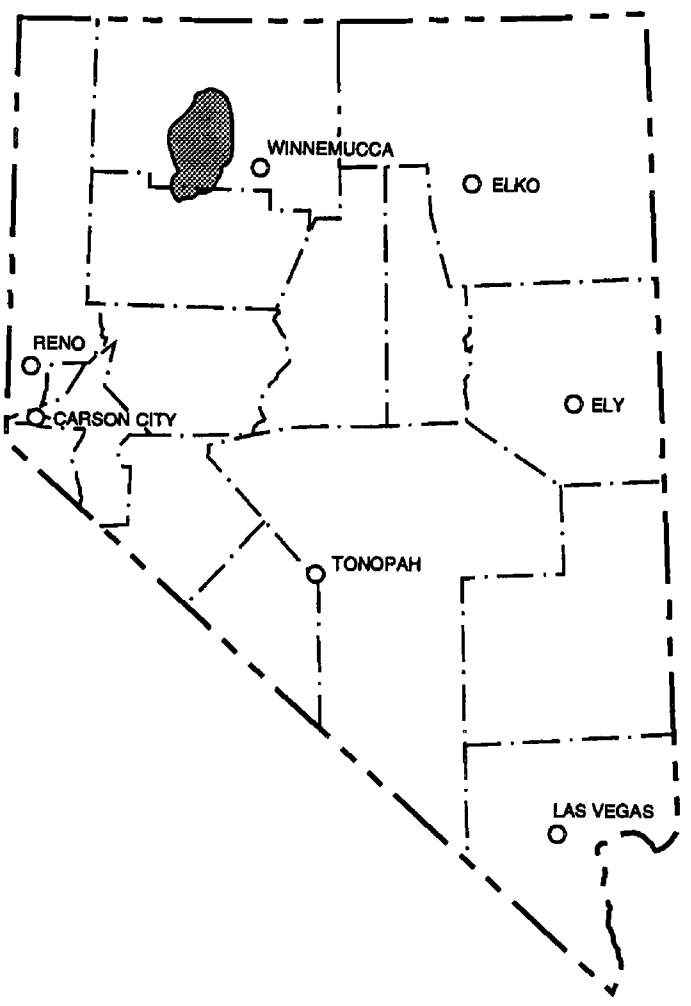
Project Chief: David L. Berger.

Period of Project: 1989-93.

Cooperating Agency: Nevada Division of Water Resources.

Problem: A ground-water overdraft has been caused in northern Desert Valley by the dewatering of an open-pit mine. Before dewatering of the mine, annual ground-water withdrawals for irrigation in the valley were approximately equal to the estimated average annual recharge. Current hydrologic conditions need to be documented before effects of increased ground-water withdrawals can be evaluated. The ground-water budget of the area needs to be evaluated with respect to information collected since 1962 (last major reconnaissance of the area), then revised if necessary.

Objectives: The investigation provided hydrologic data and interpretation to (1) document current hydrologic conditions in Desert Valley, (2) determine hydrologic changes since the predevelopment conditions of 1962, (3) re-evaluate the ground-water budget based on hydrologic information available since 1962, and (4) evaluate the potential for long-term hydrologic effects of current ground-water withdrawals.



Approach: Available hydrologic data were compiled, and wells, springs, and streams were inventoried. Water-quality samples were collected and ground-water withdrawal records were compiled. Predevelopment hydrologic conditions were estimated by comparing 1962 data with current conditions (1991). The water budget was re-evaluated and revised on the basis of results from evapotranspiration studies, geophysical studies made to determine the potential for subsurface flow, evaluation of recharge potential in sand-dune areas, and determination of ground-water interaction with the Quinn River. Long-term effects of ground-water withdrawals were evaluated by developing a mathematical flow model to simulate current and potential ground-water conditions.

Progress and Significant Results, Fiscal Years 1993-94: A journal article was published in Water Resources Bulletin. Routine data-collection activities continued. The final report was submitted for approval.

Plans for Fiscal Year 1995: The final report will be published.

Publications, Fiscal Years 1993-94:

Berger, D.L., 1992, Ground-water recharge through active sand dunes in northwestern Nevada: Water Resources Bulletin, v. 28, no. 5, p. 959-965.

Effect of Regional Ground-Water Flow on Oil Migration *(Project 160)*

Location: Great Basin (initial study site: in and near Railroad Valley, Nev.).

Project Chief: Donald H. Schaefer.

Period of Project: 1990-93.

Supporting USGS Program: National Research Program.

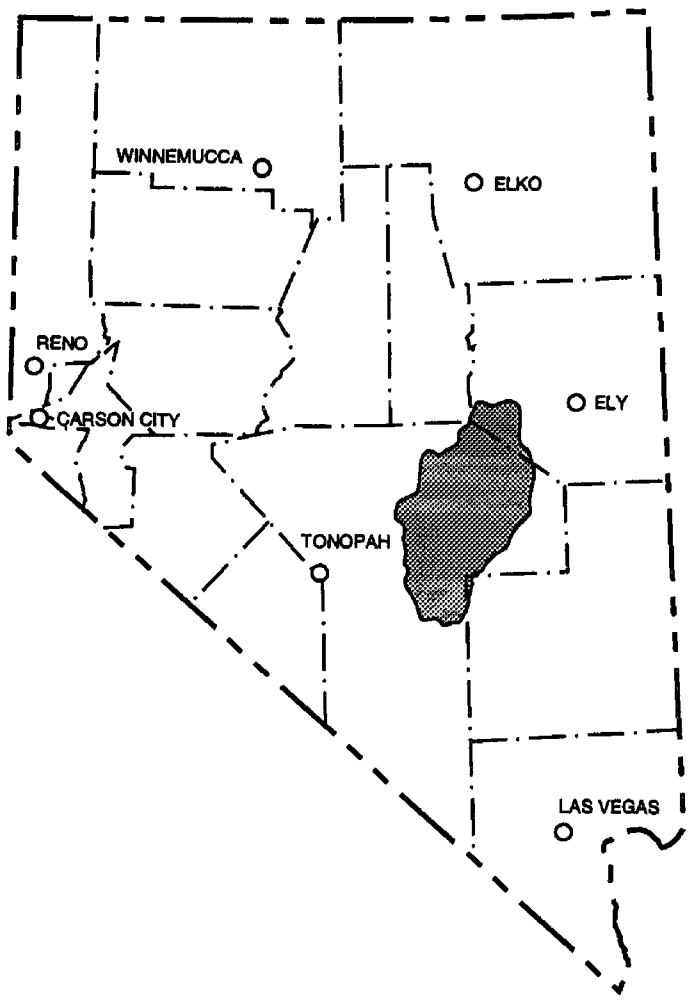
Problem: Recent studies suggest that regional flow of ground water may be a driving force for oil migration in certain areas. A conceptual model for a water-driven migration system suggests that ground water from recharge areas leaches soluble oil near deeply buried source rocks, transports the oil through regional aquifers, and deposits it in a structural or stratigraphic trap at the discharge end of the flow system. Little is known about whether this or other conceptual models can explain if regional flow of ground water is a driving force for oil migration.

Objectives: The study was made to determine if a relation exists between regional ground-water flow and the occurrence and movement of oil in the Great Basin. The study area for this project was the Great Basin region of eastern Nevada and western Utah; however, much of the initial work was concentrated in the Railroad Valley area of east-central Nevada. An understanding of the movement of oil in and adjacent to Railroad Valley, as related to regional ground-water flow, provided information usable in other areas of the Great Basin. A conceptual model of the Railroad Valley ground-water flow system was developed on the basis of the observations and analyses made during this study.

Approach: A literature search was made and existing data compiled, with an emphasis on Railroad Valley. The large amount of existing oil-well data and considerable oil exploration in this valley made it a good location to develop and test conceptual models. Any correlations between occurrence of oil and regional ground-water flow were determined.

Progress and Significant Results, Fiscal Years 1993-94: The hydrologic atlas was prepared to be submitted for approval.

Plans for Fiscal Year 1995: The hydrologic atlas will be submitted for approval and publication.



Surface-Water Runoff Monitoring, Yucca Mountain Area *(Project 161)*

Location: Southern Nye County, Nev.

Project Chief: David A. Beck.

Period of Project: Continuous since 1989.

Supporting Federal Agency: U.S. Department of Energy.

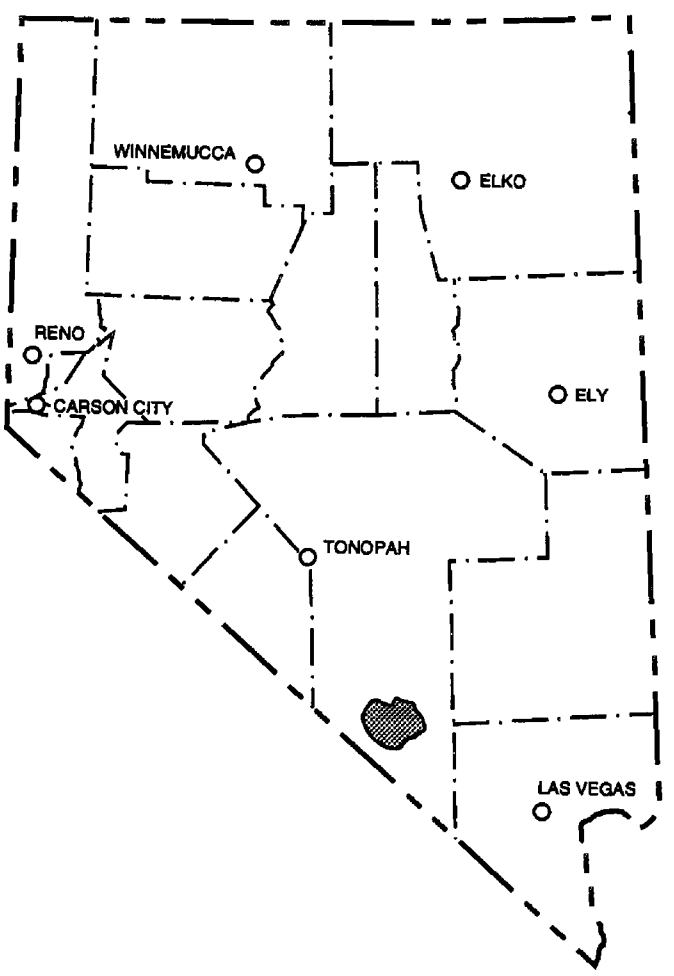
Problem: Yucca Mountain is being studied as a potential repository for high-level radioactive waste. Streamflow data are needed to help determine the relation between precipitation and runoff and between runoff and infiltration in the area.

Objectives: The study (1) uses streamflow data to describe the runoff characteristics of the area and assess the response of runoff to precipitation and (2) provides basic data and interpretation of surface-water runoff data to other investigations. The data are used in those studies to evaluate infiltration to the unsaturated zone and ground-water recharge at Yucca Mountain and surrounding areas.

Approach: Streamflow data from a dense network of recording and nonrecording gages on Yucca Mountain washes and a regional network peripheral to Yucca Mountain are collected and analyzed.

Progress and Significant Results, Fiscal Years 1993-94: Data collection continued and data were compiled and summarized. Rainfall activity during the months of December 1992 and January-February 1993 resulted in some of the highest peaks and volumes of runoff since 1984. Water samples were collected from several washes during runoff periods. Six additional continuous-recording stream gages were installed; one in the regional runoff network and five in the Yucca Mountain network. Reports on streamflow and precipitation data collected during water years 1983-85 and water years 1986-90 were published. Streamflow and precipitation data collected during water years 1991-93 were published in the annual water-data report.

Plans for Fiscal Year 1995: Routine data-collection activities and monitoring will continue. Streamflow and precipitation data collected during water year 1994 will be published in the annual water-data report. Additional continuous-recording streamflow gages will be installed pending the availability of funds.



Publications, Fiscal Years 1993-94:

Emett, D.C., Hutchinson, D.D., Jonson, N.A., and O'Hair, K.L., 1994, Water resources data, Nevada, water year 1993: U.S. Geological Survey Water-Data Report NV-93-1, 596 p.

Glancy, P.A., and Williams, R.P., 1994, Problems with direct determinations of peak streamflows in steep, desert stream channels, *in* Cotroneo, G.V., and Rumer, R.R., eds., Hydraulic Engineering '94: American Society of Civil Engineers Conference, Buffalo, N.Y., August 1994, Proceedings, v. 1, p. 635-639.

Kane, T.G., III, Baurer, D.J., and Martinez, C.M., 1994, Streamflow and selected precipitation data for Yucca Mountain region, southern Nevada and eastern California, water years 1986-90: U.S. Geological Survey Open-File Report 94-312, 118 p.

Pabst, M.E., Beck, D.A., Glancy, P.A., and Johnson, J.A., 1993, Streamflow and selected precipitation data for Yucca Mountain and vicinity, Nye County, Nevada, water years 1983-85: U.S. Geological Survey Open-File Report 93-438, 66 p.

Ground-Water Monitoring Program, Yucca Mountain Area *(Project 163)*

Location: Southern Nye County, Nev., and eastern California

Project Chief: Richard J. La Camera.

Period of Project: Continuous since 1989.

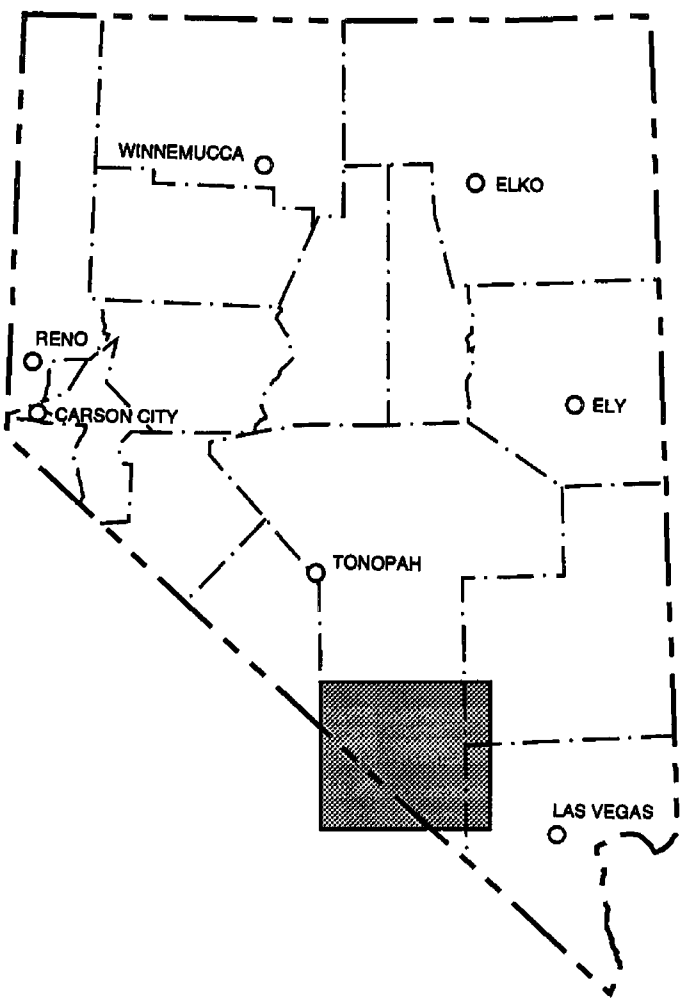
Supporting Federal Agency: U.S. Department of Energy (USDOE).

Problem: Yucca Mountain is being considered as a potential repository of high-level radioactive waste. Hydrologic, geologic, geochemical, and other investigations are needed to determine the suitability of the site for storage of waste. Possible adverse effects on ground-water quantity due to studies, construction, or operation of a potential repository must be identified. In order to identify adverse effects, the quantity and use of ground-water resources in the area require systematic monitoring. Available data and existing data-collection activities are inadequate to satisfactorily provide early detection of adverse effects on ground-water resources.

Objectives: The study monitors and characterizes the quantity and use of ground-water resources at and near Yucca Mountain to (1) document ground-water conditions; (2) detect changes in those conditions due to ongoing site investigations, other activities in the region, or natural variability; and (3) provide a basis for further hydrologic analyses to determine changes due to waste storage and related activities.

Approach: Data will be collected and compiled to characterize ground-water quantity and withdrawals. Water levels will be measured monthly at about 35 sites and springflows will be measured quarterly at about 6 sites to indicate changes in ground-water quantity in the region. Selected ground-water level and springflow data collected as part of other data-collection activities also will be compiled, evaluated, and supplemented to provide uniform monitoring. Pumpage amounts from wells will be compiled on the basis of records maintained by other agencies, organizations, and programs to estimate annual ground-water withdrawals in the region. Data collection and compilation will continue until site investigations are complete. A data base will be created that will be used to document baseline and changing conditions and to evaluate potential effects of site investigations.

Progress and Significant Results, Fiscal Years 1993-94: Routine data-collection activities and monitoring continued. Altitudes of reference points were verified by making land surveys. Electric tapes and pressure-sensor systems were calibrated. USDOE was provided with quarterly reports of



data collected and compiled at monitoring sites. Concurrence was given by USDOE on the format and content of annual monitoring reports. A report summarizing historical and current data for monitoring sites was completed and submitted for approval and publication. The summary of data for monitoring sites collected and compiled through 1992 was completed and published. Draft reports summarizing data at monitoring sites through 1993, and geohydrologic data collected at recently drilled monitoring well, JF-3, were prepared.

Plans for Fiscal Year 1995: Data-collection activities will continue. USDOE will be provided with quarterly updates of data collected and compiled at monitoring sites. The summary of data for monitoring sites through 1993 and geohydrologic data for monitoring well JF-3 will be submitted for approval and publication. A draft report for data collected and compiled through 1994 will be prepared.

Publications, Fiscal Years 1993-94:

La Camera, R.J., and Westenburg, C.L., 1994, Selected ground-water data for Yucca Mountain region, southern Nevada and eastern California, through December 1992: U.S. Geological Survey Open-File Report 94-54, 161 p.

Carlin Gold-Belt Hydrology *(Project 166)*

Location: Northeastern Nevada.

Project Chief: Russell W. Plume.

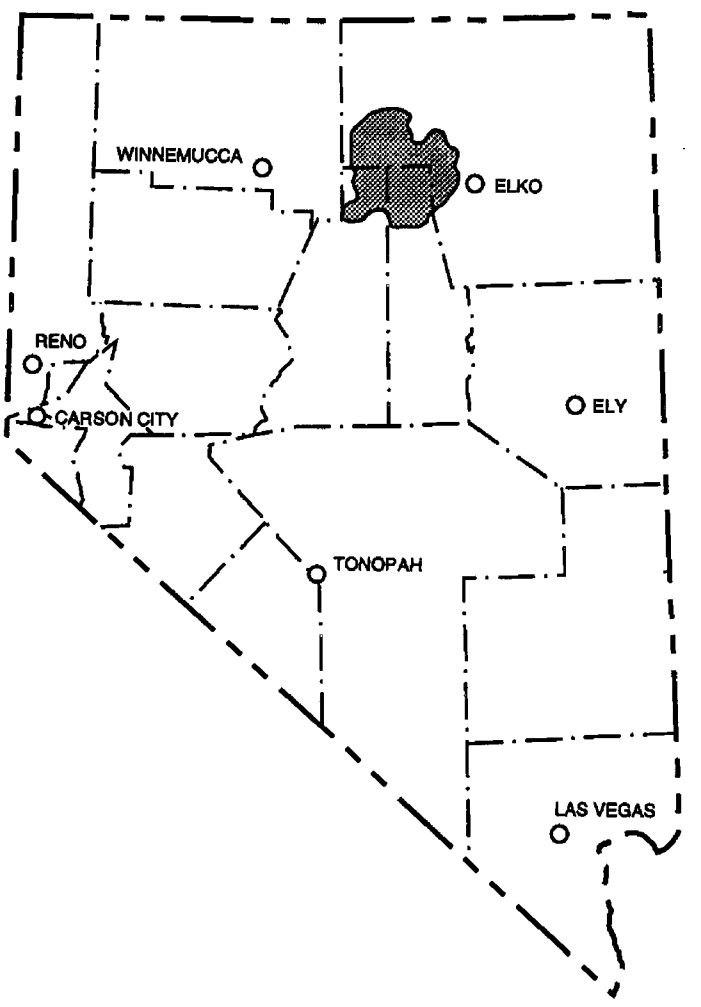
Period of Project: 1990-94.

Cooperating Agency: Nevada Division of Water Resources.

Problem: Demands for ground water to process ore are increasing along the Carlin trend in northeastern Nevada, where several large, open-pit gold mines are in different stages of operation and development. In addition, two open pits have extended below the water table, requiring withdrawal of large volumes of water. Mining activity in the area is anticipated to last 10-20 years. Potential long-term effects include water-level declines over large areas, changes in streamflow of the Humboldt River and its tributaries, and changes in ground- and surface-water quality. However, these potential effects cannot be assessed unless hydrologic conditions are documented. Hydrologic data needed to document these conditions are not available for most of the area. The problem also has been complicated by an extended drought that has affected water resources in the area. The causes (drought or mining) of future changes in water resources and potential long-term effects would be difficult to assess because of the lack of hydrologic data. Thus, documentation and monitoring of hydrologic conditions, and development of a better understanding of the regional and basin-level hydrogeologic framework along the Carlin trend are needed.

Objectives: The initial goal was to provide a reconnaissance of hydrologic conditions in basins along or adjacent to the Carlin trend north of the Humboldt River. Subsequent goals are to (1) use historic data and data collected during the initial reconnaissance to define the current hydrologic setting of the Carlin Trend area and (2) design and operate a hydrologic monitoring network that will provide data for evaluating effects of mining.

Approach: Existing hydrologic data were obtained and evaluated and an areal reconnaissance of the water resources was made. Streamflow and ground-water measurements were made and water-quality samples were collected at selected sites. Locations for five more stream-gaging stations were selected on the Humboldt River and its tributaries. The investigation was done in two overlapping phases. Phase I was directed toward defining the hydrologic setting. Data collection continued through fiscal year 1993. Phase II involved operation of the long-term hydrologic-monitoring network. Streamflow, ground-water levels, and water-quality data were collected from enough stations to monitor overall conditions in the area. Phase II continued through 1994 and then scaled down to a few observation stations until the hydrologic conditions stabilized.



Progress and Significant Results, Fiscal Years 1993-94: Low-level monitoring and data-collection activities continued and results were published in the annual water-data reports. A report detailing project findings was submitted for review.

Plans for Fiscal Year 1995: Low-level monitoring and data-collection activities will continue and results will be published in the annual water-data report. The project report will be submitted for approval and publication.

Publications, Fiscal Years 1993-94:

Emett, D.C., Hutchinson, D.D., Jonson, N.A., and O'Hair, K.L., 1994, Water resources data, Nevada, water year 1993: U.S. Geological Survey Water-Data Report NV-93-1, 596 p.

Hess, D.L., Mello, K.A., Sexton, R.J., and Young, R.L., 1993, Water resources data, Nevada, water year 1992: U.S. Geological Survey Water-Data Report NV-92-1, 511 p.

Nevada Basin and Range National Water-Quality Assessment *(Project 167)*

Location: Carson and Truckee River Basins, Nevada and California, and Las Vegas Valley, Nev.

Project Chief: Hugh E. Bevans.

Period of Project: Continuous since 1990.

Cooperating Agency and Supporting USGS Program: University of Nevada, Reno, and National Water-Quality Assessment Program.

Problem: Information about the quality of ground- and surface-water resources is needed on a consistent and continuing basis so that water-resource managers and the public will have a scientifically sound basis for evaluating resources, planning effective water-quality management programs, and predicting effects of land- and water-management practices.

Objectives: The Nevada Basin and Range is 1 of 60 proposed NAWQA study units distributed throughout the Nation that will be investigated to (1) provide a Nationally consistent description of current water-quality conditions; (2) define long-term trends in water quality; and (3) identify, describe, and explain, as possible, the major factors that affect observed water-quality conditions and trends.

Approach: The investigation will be made in 10-year cycles that include retrospective analysis of available water-quality data and ancillary information, intensive periods of data collection and analysis, and trend monitoring. During the retrospective phase, available water-quality and ancillary (land use, water use, and geologic) data from several sources will be compiled. Reports will be written that summarize and interpret available information on pesticides, nutrients, and suspended sediment. An intensive data-collection and analysis phase will be undertaken during the 3rd through 6th years of the study to develop a nationally consistent water-quality data base. During the 7th through 10th years of the study, report writing and low-level monitoring activities will continue. The 10-year project cycle is scheduled to begin again in the 11th year with a new retrospective phase.

Progress and Significant Results, Fiscal Years 1993-94: Intensive data-collection and investigation activities began in spring 1993. A network of 10 fixed-site surface-water stations was established on the Carson and Truckee Rivers and Las Vegas Wash to assess spatial and temporal variability in water quality. A network of 30 observation wells in Las Vegas Valley was established in autumn 1993, and 30 observation wells in the Reno-Sparks area were established in spring 1994. This network of 60 observation wells was established to evaluate the effects of urban land use on shallow ground-water quality. A network of 30 observation wells was established in the Carson Valley and Carson Desert areas in summer 1994 to evaluate the effects of agriculture. In the area of South Lake Tahoe, Calif., 14 public water-supply wells were sampled in spring 1994 for radon-222 and uranium activities. Intensive ecological assessments were

made at fixed-site stream-gaging stations in autumn 1993. Four of these sites, established to evaluate trends, were reassessed in autumn 1994. Assessments of changes in benthic invertebrates and algae in the Reno-Sparks area and Carson Valley agricultural area were made in autumn 1994. An environmental setting report and a retrospective report on pesticides, nutrients, and suspended sediment were submitted for review. Presentations were made at the 1994 Nevada Water Resources Association conference.

Plans for Fiscal Year 1995: Intensive surface-and ground-water data collection and investigation activities will continue. Reports will be submitted for approval and publication.

Publications, Fiscal Years 1993-94:

Kilroy, K.C., 1994, Pesticides in the Carson River, Truckee River, and Las Vegas Basins, Nevada and California, 1970-90 [abs.]: Nevada Water Conference, Nevada Water Resources Association, Las Vegas, March 1994, Abstracts of Technical Papers and Posters, p. 28.

Lawrence, S.J., 1994, Selected trace elements in bed sediment and tissues of four aquatic invertebrate species from the Truckee and Carson River Basins and Las Vegas Wash, Nevada and California, September 1992 [abs.]: Nevada Water Conference, Nevada Water Resources Association, Las Vegas, March 1994, Abstracts of Technical Papers and Posters, p. 44.

Lawrence, S.J., and Bevans, H.E., in press, Mercury in bottom sediment and aquatic invertebrates, Carson and Truckee River Basins, Nevada and California [abs.]: 15th Annual Meeting, Society of Environmental Toxicology and Chemistry, Denver, October 1994, Abstract Book, p. 19.

Granular Velocity Subsidence Model
(Project 169)

Location: Southeastern Nevada.

Project Chief: Thomas J. Burbey.

Period of Project: 1990-95.

Cooperating Agencies: Las Vegas Valley Water District and Nevada Division of Water Resources.

Probiem: Land subsidence and earth fissures due to groundwater withdrawal are ongoing problems in many urban and agricultural areas around the world. Current computer models have limited use because they are generally one dimensional in scope. Recently, a three-dimensional mathematical model was developed that accounts for vertical and horizontal granular displacement. Skeletal granular movement due to long-term overdraft of aquifers can cause earth fissures. A model that links the granular-velocity model and the groundwater flow model is needed to more adequately provide the data necessary to predict the location and magnitude of fissures.

Objectives: A three-dimensional granular-velocity model will be developed from recently established mathematical concepts and applied to Las Vegas Valley. Field data will be collected to validate and calibrate the new granular-velocity model.

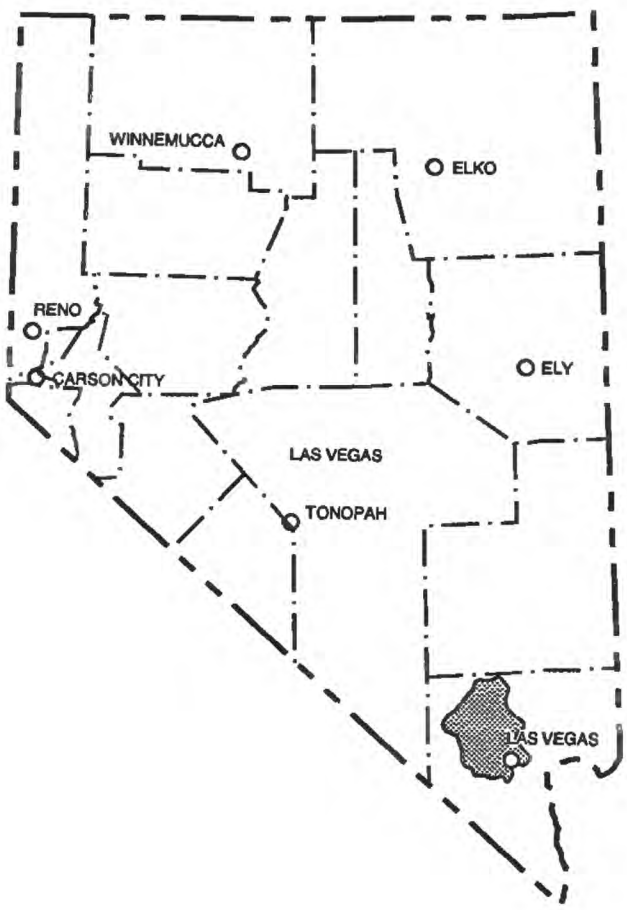
Approach: The granular-velocity model will be evaluated against existing analytic and numerical models and will then be used to evaluate vertical and horizontal movement in Las Vegas Valley. The granular-velocity model will use recently established mathematical concepts. An extensometer and instrumentation to monitor horizontal granular movement will be installed where subsidence and horizontal displacement are most active. A network will be developed to collect data necessary for the calibration of the newly developed granular-velocity model. Results of this model will be compared with results of other subsidence models.

Progress and Significant Resuits, Fiscai Years 1993-94: Data-collection activities began. The granular-velocity model was calibrated and numerical stability problems were evaluated. The extensometer and nested piezometer wells were installed, and instrumentation to monitor horizontal movement was implemented. A journal article was submitted for acceptance and publication.

Plans for Fiscai Year 1995: Data-collection activities will continue. Modeling activities and report writing will continue.

Pubiications, Fiscai Years 1993-94:

Burbey, T.J., 1993, Calculation of horizontal granular movement in confined aquifers [abs.]: Geological Society of America, Abstracts with Programs, v. 25, no. 6, p. 258.



Helm, D.C., 1994, Horizontal aquifer movement in a Theis-Thiem confined system: Water Resources Research, v. 30, no. 4, p. 953-964.

Environmental Restoration, Nevada Test Site
(Project 170)

Location: Southern Nye County, Nev.

Project Chief: Randell J. Laczniak.

Period of Project: Continuous since 1991.

Supporting Federal Agency: U.S. Department of Energy (USDOE).

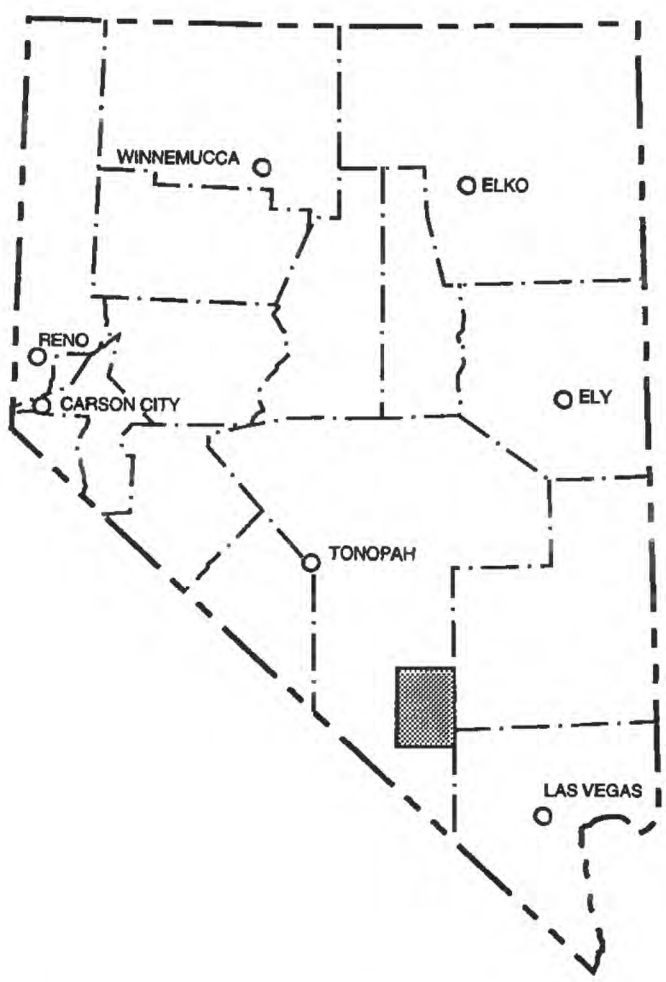
Problem: Underground testing of nuclear weapons at the Nevada Test Site (NTS) has created potential environmental hazards. USDOE is concerned about these hazards and is committed to comply with existing environmental laws and regulations. USDOE has begun an Environmental Restoration Program (ERP) to acquire information and provide the resources necessary to address environmental concerns at NTS. USDOE has requested USGS participation in this program.

Objectives: USGS provides hydrologic expertise and technical guidance to USDOE in support of ERP, primarily on activities related to characterization of the ground-water flow system. USGS develops and participates in special studies to address unresolved hydrologic issues at NTS, and provides regional synthesis and analysis of hydrologic information gathered through ERP activities. The USGS will provide the lead scientific role in activities to refine estimates of ground-water discharge from subbasins downgradient of NTS.

Approach: The USGS participates in program efforts to acquire hydrologic information at NTS and vicinity. Primary activities include the siting of drill holes, reviewing program control documents, developing and reviewing hydrologic testing and sampling plans, and collecting water-level and water-chemistry data from on- and off-site monitoring locations. Studies to refine ground-water discharge estimates from the major subbasins beneath NTS are being initiated. Participation on other hydrologic studies will be provided in response to USDOE requests.

Progress and Significant Results, Fiscal Years 1993-94: Hydrologic expertise and technical support were provided to USDOE. Water-level networks were maintained on- and off-site. Hydrologic data collected through program activities were provided monthly and published in the annual data report. A report describing the current conceptual understanding of ground-water flow at NTS was submitted for approval. A study re-evaluating ground-water discharge through a detailed quantification of evapotranspiration was initiated at Ash Meadows.

Plans for Fiscal Year 1995: Hydrologic support will continue to be provided to USDOE. The report describing the conceptual understanding of the ground-water flow at NTS



will be published. On- and off-site water-level networks will be maintained. The discharge study at Ash Meadows will be continued and a similar study will be started at Oasis Valley. Data will be published in the annual data report. Data on evapotranspiration rates and water-table fluctuations specific to Ash Meadows will be published.

Publications, Fiscal Years 1993-94:

Emett, D.C., Hutchinson, D.D., Jonson, N.A., and O'Hair, K.L., 1994, Water resources data, Nevada, water year 1993: U.S. Geological Survey Water-Data Report NV-93-1, 511 p.

Truckee-Carson Program, River Basin Modeling and Monitoring *(Project 171)*

Location: Truckee River and Carson River Basins, Nevada and California.

Project Chief: Larry R. Bohman.

Period of Project: Continuous since 1991.

Supporting USGS Program: Truckee-Carson Program.

Problem: Title II of Public Law 101-618, the Truckee-Carson-Pyramid Lake Water Rights Settlement Act of 1990, contains many explicit and implicit action requirements for Department of the Interior agencies, principally the Bureau of Reclamation, U.S. Fish and Wildlife Service, and Bureau of Indian Affairs. The U.S. Geological Survey has been asked to provide detailed water-resources data and analysis for the Truckee River and Carson River Basins of California and Nevada, including the Lake Tahoe Basin. Environmental assessments required by the Act not only will need collation and synthesis of existing data, but also models to assess causes and effects of alternative management and operational scenarios connected with river operations, water-rights transfers, and changes in irrigation practices.

Objectives: A Federal river-monitoring network will be designed and implemented to provide consistent, long-term data for water-resources management and planning. River-basin simulation models will be developed, tested, and applied as tools for water-resources management and planning. Technical support will be provided to the Department of the Interior as required under legislative mandates.

Approach: Existing networks and data of the Department of the Interior were reviewed. A data-base management system and a baseline Federal gaging-station network were designed and implemented to monitor streamflow, storage, and water quality. Appropriate modeling tools are being adapted or developed and calibrated to the Truckee River and Carson River Basins for use by several agencies. The resultant models will be used to review and revise the data networks. Technical support to the Department of the Interior for implementation of Public Law 101-618 is being provided. Staff will participate in technical workgroups and committees. In fiscal year 1995, studies on ground-water yield in California and parts of the Truckee River Basin will begin, if required.

Progress and Significant Results, Fiscal Years 1993-94: New gaging stations were established and existing stations were upgraded in support of the development of river flow models and real-time networks for river operations within the two basins. Continuous monitoring streamflow stations were established at 21 streamflow and 22 stream-temperature sites in the Truckee River Basin in fiscal year 1993. Seven continuous streamflow and 21 partial-record

gaging stations were established in the Carson River Basin in fiscal year 1994. Preliminary flow-routing models were constructed and tested for the main channels of the Truckee River between Lake Tahoe and Marble Bluff Dam and for the Carson River from Markleeville (East Fork) and Woodfords (West Fork) to just downstream of Lahontan Reservoir. A stream-temperature model was calibrated for the Truckee River to assist in fisheries management and as a necessary element to enhance future water-quality modeling efforts. A graphical user interface was implemented that will be used for generating and displaying the simulation results of alternative river operations scenarios. Technical and hydrologic support were provided to the Department of the Interior. Project personnel attended and participated in technical workgroups and committee meetings. Data collected in fiscal year 1993 were published in the annual water-data report. Development of a project geographic informations systems data base continued.

Plans for Fiscal Year 1995: Data-collection activities will continue. Technical and hydrologic support to the Department of the Interior will be provided. Development of hydraulic modeling activities will continue. Data will be published in the annual water-data report. Reports describing the two flow-routing models, the stream temperature model, and the results of dye-tracing studies along the Truckee River will be submitted for approval. Work also will begin to translate and code operation/allocation rules into the

modeling framework so that a fully functional policy analysis tool for basin managers can be developed. Precipitation-runoff models will be calibrated for several basins surrounding Lake Tahoe and along the Truckee River between Tahoe City, Calif., and Reno, Nev.

Publications, Fiscal Year 1993-94:

Bohman, L.R., 1994, The Truckee-Carson Program: U.S. Geological Survey Yearbook, Fiscal Year 1993, p. 55.

Emett, D.C., Hutchinson, D.D., Jonson, N.A., and O'Hair, K.L., 1994, Water resources data, Nevada, water year 1993: U.S. Geological Survey Water-Data Report NV-93-1, 596 p.

Reece, B.D., Liebermann, T.D., and Carman, R.L., 1994, Topographic-shading time series from digital elevation data for input to a stream-temperature model, Truckee River Basin, California and Nevada, *in* Lawson, C.A., and Bennett, P.C., comps., Scientific Visualization Workshop, Menlo Park, California, September 15-17, 1993, Abstracts: U.S. Geological Survey Open-File Report 94-134, p. 14-15.

Trionfante, J.V., and Peltz, L.A., 1994, Hydrologic features of the Truckee and Carson River Basins and adjacent areas, western Nevada and eastern California: U.S. Geological Survey Open-File Report 93-638, 1 sheet.

Beatty Deep Unsaturated Zone *(Project 172)*

Location: Amargosa Desert near Beatty, Nev.

Project Chief: David E. Prudic.

Period of Project: 1992-96.

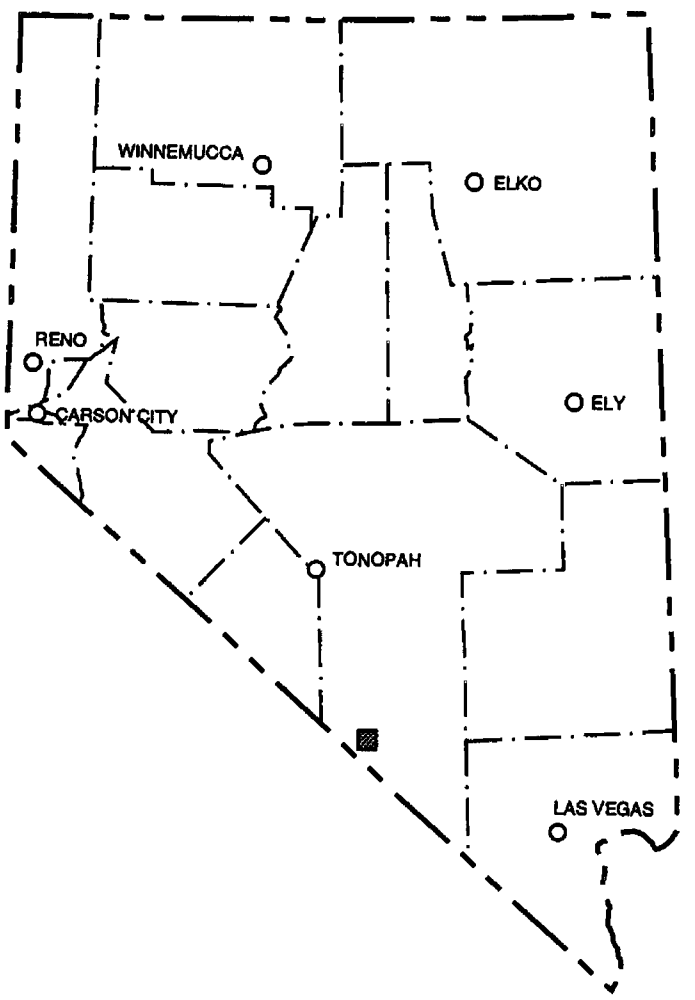
Supporting Federal Agency and USGS Program: Low-Level Nuclear Waste Hydrology Program and U.S. Nuclear Regulatory Commission.

Problem: Burial of low-level radioactive waste in thick, unsaturated zones in desert environments has been an accepted practice for many years. However, understanding and monitoring the movement of water and contaminants in such environments has proved difficult. Methods to measure water content and water potential have improved recently. Data collected indicate that water movement involves liquid and vapor flow. To better understand the potential for movement of contaminants at such sites, there is a need to understand the processes involved in multiphase fluid flow.

Objectives: The effects of normal seasonal heating of the upper several feet of soils on water movement during the summer months, followed by cooling in the winter months, will be studied. The effects of atmospheric changes on the movement of vapor flow will be evaluated. The direction of water flow below the zone of seasonal fluctuations in temperatures and water potentials will be determined. The hypothesis of upward vapor flow from a deep water table (300-370 feet below land surface) will be tested.

Approach: Soil-gas pressure changes caused by atmospheric pressure changes will be monitored to determine air permeability in unsaturated sediments and to determine the depth of atmospheric air circulation in the unsaturated zone. Soil-gas samples will be collected to determine the depth of atmospheric air circulation. Test holes will be drilled to determine moisture contents, water potentials, and temperatures in the deep unsaturated zone.

Progress and Significant Results, Fiscal Years 1993-94: Two test holes were drilled during fiscal year 1993. One was drilled to a depth of about 157 feet and instrumented with thermocouple psychrometers. The other was drilled to a depth of about 360 feet and instrumented with air piezometers. Analyses of core samples collected during drilling indicate moisture contents are generally higher below a depth of about 98 feet. Results from thermocouple psychrometers show water potential increases from a depth of about 40 to 157 feet, indicating water movement is upward in this interval. Similarly, temperature increases 2.2 degrees Celsius over the same depth interval, producing an increase in vapor density and indicating upward vapor flow as well. Soil-gas samples collected from the air piezometers were analyzed for carbon dioxide, carbon isotopes, and tritium. Partial pressures of carbon dioxide indicate that carbon dioxide is degassing from ground water and moving upward through the unsaturated zone.



Plans for Fiscal Year 1995: Data collected during 1992-94 will be analyzed. Reports will be written summarizing the results.

Publications, Fiscal Years 1993-94:

Prudic, D.E., 1994, Effects of temperatures at the arid disposal site for low-level radioactive wastes near Beatty, Nevada [abs.]: Geological Society of America, Abstracts with Programs, v. 26, no. 7, p. 143.

———1994, Estimates of percolation rates and ages of water in unsaturated sediments at two Mojave Desert sites, California-Nevada: U.S. Geological Survey Water-Resources Investigations Report 94-4160, 19 p.

———in press, Water-vapor movement through unsaturated alluvium in Amargosa Desert near Beatty, Nevada—Current understanding and continuing studies *in* Conference on Disposal of Low-Level Radioactive Waste, Reston, Va., May 1993: U.S. Geological Survey Water-Resources Investigations Report 95-4015.

Prudic, D.E., and Striegl, R.G., 1994, Water and carbon-dioxide movement through unsaturated alluvium near an arid disposal site for low-level radioactive waste, Beatty Nevada [abs.]: Eos, American Geophysical Union Transactions, v. 75, no. 16, p. 161.

Trask, N.J., Prudic, D.E., and Stevens, P.R., 1994, Hydrologic research programs of the U.S. Geological Survey relevant to low-level radioactive waste disposal [abs.]: Eos, American Geophysical Union Transactions, v. 75, no. 16, p. 160.

Ground-Water Conditions in and near Newlands Irrigation Project, Carson Desert *(Project 173)*

Location: West-central Nevada.

Project Chief: Douglas K. Maurer.

Period of Project: 1992-93.

Supporting Federal Agency: Bureau of Reclamation.

Problem: National legislation, court-decreed operating criteria, and agency directives have resulted in the reduction of agricultural water use in the Newlands Irrigation Project area near Fallon, Nev. The Bureau of Reclamation has been directed to increase delivery efficiency of agricultural water to 75 percent. The U.S. Fish and Wildlife Service has been directed to acquire water rights to maintain 25,000 acres of wetlands in the Carson Desert. Congress requested that both agencies report on effects of these changes on ground-water aquifers in the area by November 1993.

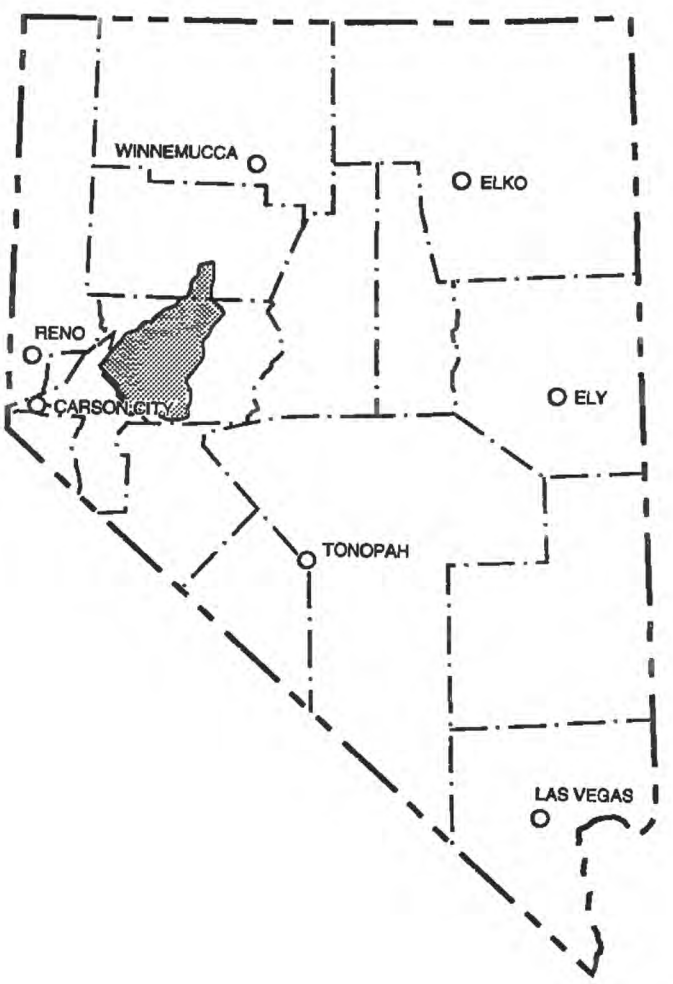
Objectives: Conceptual models of mechanisms for recharge to, and ground-water flow paths through, aquifers in the Carson Desert were developed. The potential effects of changing water use on yield and water quality in local aquifers used for domestic and public water supply were studied. Suggestions for additional study to improve understanding of existing water resources, movement of ground water, and potential effects of changes in water use were delineated.

Approach: Existing literature and data on the geohydrology of the Carson Desert were compiled and reviewed to develop conceptual models.

Progress and Significant Results, Fiscal Years 1993-94: The report summarizing results was published. Relict channels of the Carson River could be conduits for ground-water flow and recharge. Near-surface clay beds inhibit vertical ground-water flow near the center and eastern part of the basin, except where breached by relict channels. Conceptual models of the basin show that changes in water use in the western part of the basin probably would affect recharge to the sedimentary and basalt aquifers. Near the center of the basin, water-use changes could affect the shallow and basalt aquifers but might have less effect on the intermediate aquifer. In the eastern part of the basin, changes could affect the shallow aquifer, but would probably not affect the intermediate or basalt aquifers.

Publications, Fiscal Years 1993-94:

Maurer, D.K., Johnson, A.K., and Welch, A.H., 1994, Hydrogeology and potential effects of changes in water use, Carson Desert agricultural area, Churchill County, Nevada: U.S. Geological Survey Open-File Report 93-463, 101 p.



Ground-Water Levels and Directions of Movement in Newlands Irrigation Project
(Project 174)

Location: West-central Nevada.

Project Chief: Ralph L. Seiler.

Period of Project: 1992-93.

Supporting Federal Agency: U.S. Fish and Wildlife Service.

Problem: Application of irrigation water, leakage from canals, and storage of water within the Newlands Irrigation Project area has altered the natural ground-water system. Acquisition of water rights for Lahontan Valley wetlands pursuant to Public Law 101-618, section 206, will result in delivery of less water for irrigation to the area and less recharge to the shallow aquifer system. Information on the depth to water and ground-water flow directions is needed by planners to assess the hydrologic effects of the water-rights acquisition.

Objective: The depth to ground water, ground-water gradients, and ground-water flow directions in the shallow aquifer system were determined. A network for future ground-water monitoring was designed.

Approach: Existing wells were selected for the monitoring network and new wells were drilled as needed to expand the areal coverage. Water levels at selected wells were measured biweekly and synoptic measurements of wells were made before, during, and after the 1992 irrigation season. Altitudes of land surface at selected wells were determined by surveying techniques and tied into existing USGS benchmarks of known altitude.

Progress and Significant Results, Fiscal Years 1993-94: Data-collection activities were completed and the report summarizing the results was published.

Publications, Fiscal Years 1993-94:

Seiler, R.L., 1993, Water-level changes in the shallow aquifer near Fallon, Nevada [abs.]: Nevada Water Conference, Nevada Water Resources Association, Reno, February 1993, Abstracts of Presented Papers and Posters, p. 10.

Seiler, R.L., and Allander, K.K., 1993, Water-level changes and directions of ground-water flow in the shallow aquifer, Fallon area, Churchill County, Nevada: U.S. Geological Water-Resources Investigations Report 93-4118, 74 p.

Railroad Valley Evapotranspiration
(Project 175)

Location: Railroad Valley, Nev.

Project Chief: Michael J. Johnson.

Period of Project: 1992-95.

Cooperating Agencies: Las Vegas Valley Water District and Nevada Division of Water Resources.

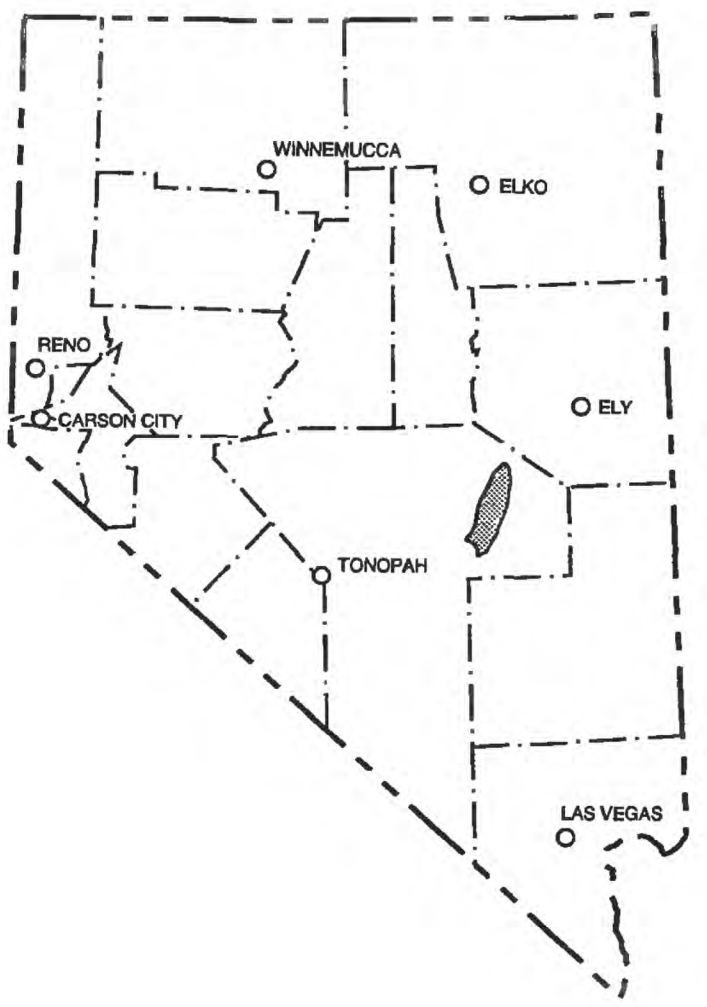
Problem: Increasing demands for water supplies in arid and semiarid regions require greater accuracy in defining regional water budgets. The accuracy of these budgets depends on measured or estimated values of each of the budget components. Evapotranspiration (ET) is the least known and understood component, and improved methods to estimate ET would increase the utility of the water budget for use by water managers to allocate the water resources. Field verification of existing estimates by extrapolating from point measurements to an entire basin is needed. Information obtained from Railroad Valley would have a high transfer value to similar areas in the Great Basin.

Objectives: Reconnaissance estimates using field measurements were evaluated. The relation between ET and depth to water at locations from the playa to the upper fringe of phreatophytes was determined and micrometeorological measurements of ET were correlated with plant transpiration in this area. The validity of proposed models that estimate ET was tested. A refined estimate of ground-water discharge for Railroad Valley using remotely sensed data, field measurements, and models was developed.

Approach: The energy-budget, Bowen-ratio, and eddy-correlation methods were used to determine point measurements of ET. Plant transpiration was measured. The models that estimate ET were tested. Landsat data were obtained from the Las Vegas Valley Water District to determine land-cover classification used to distribute ET rates for estimating ground-water discharge.

Progress and Significant Results, Fiscal Years 1993-94: Collection, processing, and evaluation of point measurements of ET, weather, and borehole water levels continued. Testing of ET models continued and the models were field verified. Report was submitted for review.

Plans for Fiscal Year 1995: Data collection and interpretation will continue. Report will be submitted for approval and publication.



Data Synthesis of Irrigation Drainage Areas
(Project 176)

Location: Western United States.

Project Chief: Ralph L. Seiler.

Period of Project: 1992-95.

Supporting USGS Program: Department of Interior National Irrigation Water-Quality Program.

Problem: Concern has increased during the last several years about the quality of irrigation drainage and its potential harmful effects on human health, fish, and wildlife. As a result, the National Irrigation Water-Quality Program was begun in October 1985 to identify the extent of irrigation-induced water-quality problems in the western states. Twenty-five reconnaissance investigations were made by interbureau study teams to determine whether irrigation drainage has caused harmful effects on human health, fish and wildlife, or other beneficial uses of water. Eight areas were subsequently selected for detailed investigation after reconnaissance investigations confirmed that irrigation drainage had caused significant harmful effects. Several reports on the results of the investigations have been published and several are in review for 25 areas in 14 States. A comprehensive evaluation of the data is needed to determine how climate, hydrology, geology, and other factors are linked to determine the extent and magnitude of irrigation water-quality problems.

Objectives: Most of the data collected for the reconnaissance and detailed investigations has been gathered into one data base. Multivariate statistics and pattern-recognition techniques are being used to identify how the hydrologic and geologic setting and geochemical and biological processes link with human activities to determine the magnitude and extent of contamination problems. As much as possible, capabilities will be developed to predict where irrigation drainage may result in water-quality problems.

Approach: A data base was created that combined water-quality data from USGS, Water Resources Division; sediment data from USGS, Geologic Division; and biologic data from U.S. Fish and Wildlife Service (USFWS). A study team including three scientists from USGS and one scientist from USFWS was formed. One USGS member was the team leader who coordinated the overall project and built the data base. The team members will work independently in their areas of expertise and will collaborate for the summary report.

Progress and Significant Results, Fiscal Years 1993-94: Data-base design was completed, data analysis and interpretation began, and an outline of the final report was prepared. A poster was presented at the American Water Resources Association conference in June 1994.

Plans for Fiscal Year 1995: Data analysis will be completed and draft reports will be written and submitted for review.

Publications, Fiscal Years 1993-94:

Seiler, R.L., 1994, Synthesis of data from the U.S. Department of the Interior irrigation drainage studies, western United States [abs.]: 1994 Annual Summer Symposium, American Water Resources Association, Jackson Hole, Wyo., June, Proceedings, p. 1167.

Installation Restoration Project, Nellis Air Force Base *(Project 178)*

Location: Southern Nevada.

Project Chief: Glenn S. Hale.

Period of Project: 1992-93.

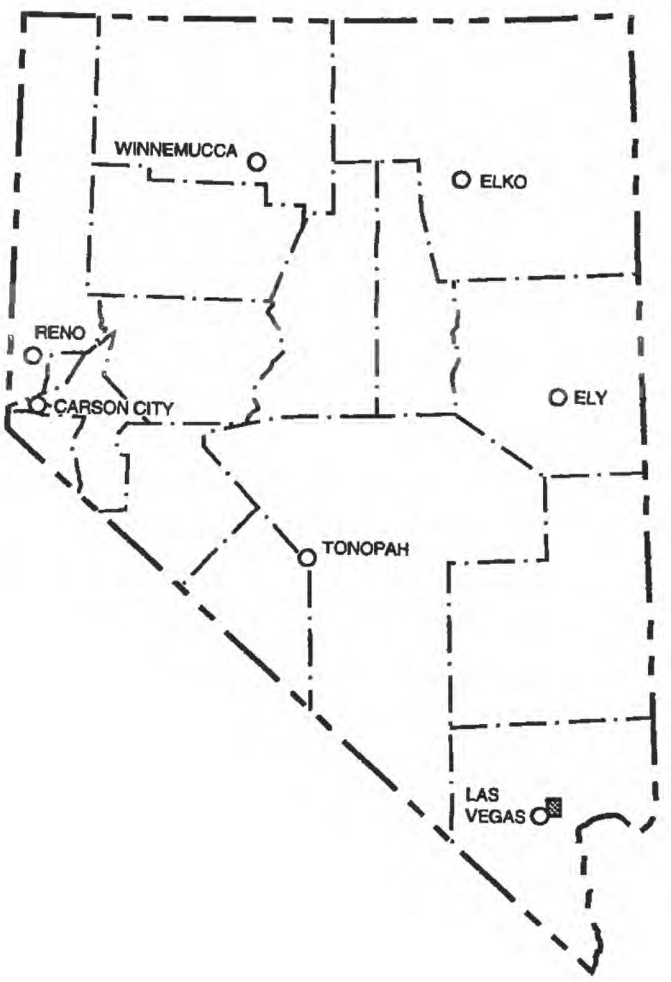
Supporting Federal Agency: Department of Defense.

Problem: Effluent from two evaporation/percolation ponds, used for the secondary treatment of sewage at Nellis Air Force Base, has percolated into the ground-water system beneath the site. The effluent may contain constituents that could adversely affect the environment, specifically the ground-water chemistry. A State of Nevada operating permit for the Imhoff Tank Wastewater Treatment System requires the installation of three monitoring wells and sampling of ground water to determine whether contamination is present.

Objective: The study was made to determine if effluent from the ponds had infiltrated through the subsurface soils and contaminated the ground water.

Approach: Three monitoring wells were installed at the site to serve as ground-water sampling and water-level measurement points.

Progress and Significant Results, Fiscal Year 1993: Three monitoring wells were installed. Funding was not continued; project ended.



Virgin River Geomorphic Study
(Project 179)

Location: Southern Nevada.

Project Chief: Marsha M. Hilmes.

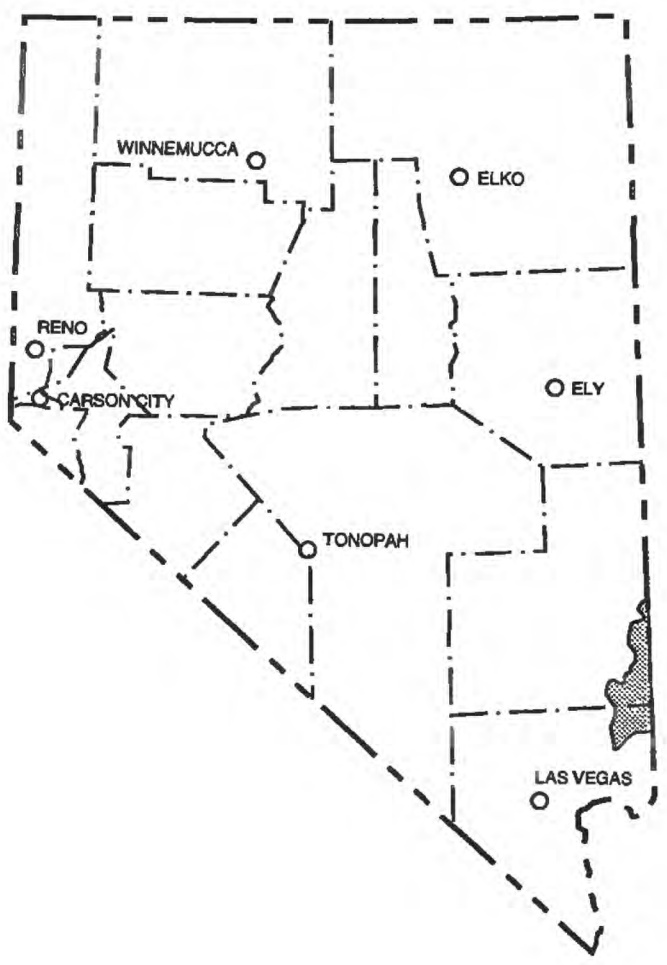
Period of Project: 1993-97.

Cooperating Agency: Southern Nevada Water Authority.

Problem: The Las Vegas Valley Water District has applied for an annual appropriation of approximately 70,000 acre-feet of water from the terminal reach of the Virgin River in Nevada. Current plans are to extract the water from Lake Mead if changes in the Colorado River Compact can be secured. A determination of the geomorphic stability of the Virgin River channel over time would be a useful tool in planning a diversion for any water-resource project. The geomorphology of the lower Virgin River has not been documented and the relation between geomorphic change and the cause of the change is not well understood.

Objective: An assessment will be made of the fluvial geomorphic characteristics, with specific reference to sediment-discharge relations and geomorphic change of the lower Virgin River between Littlefield, Ariz., and Lake Mead, Nev.

Approach: Discharge, suspended sediment, and bedload data will be collected, beginning in fiscal year 1993. Annual and seasonal sediment-discharge relations will be developed. Changes in planimetric form of the river will be quantified using aerial photographs and Landsat satellite images. Changes in channel geometry will be quantified using channel cross-section surveys.



Progress and Significant Results, Fiscal Years 1993-94: Data were collected, analyzed, and compiled for inclusion in the annual water-data report. Digitizing of aerial photography, processing of Landsat satellite images, and production of report illustrations began. Channel geometry was surveyed. Aerial photographs were taken on June 1, 1994.

Plans for Fiscal Year 1995: Routine data collection will continue. Data will be analyzed, compiled, and published in the annual water-data report. Aerial photography will be digitized. Planform and channel geometry characteristics will be measured. A geographic data base will be developed.

Publications, Fiscal Years 1993-94:

Emett, D.C., Hutchinson, D.D., Jonson, N.A., and O'Hair K.L., 1994, Water resources data, Nevada, water year 1993: U.S. Geological Survey Water-Data Report NV-93-1, 596 p.

Hilmes, M.M., 1994, Seasonal variation of suspended-sediment transport in the lower Virgin River, Arizona and Nevada [abs.]: Geological Society of America, Abstracts with Programs, v. 26, no. 7, p. A302.

Water Resources Evaluation of Spanish Springs Valley *(Project 180)*

Location: North of Reno-Sparks, Nev.

Project Chief: David L. Berger.

Period of Project: 1993-96.

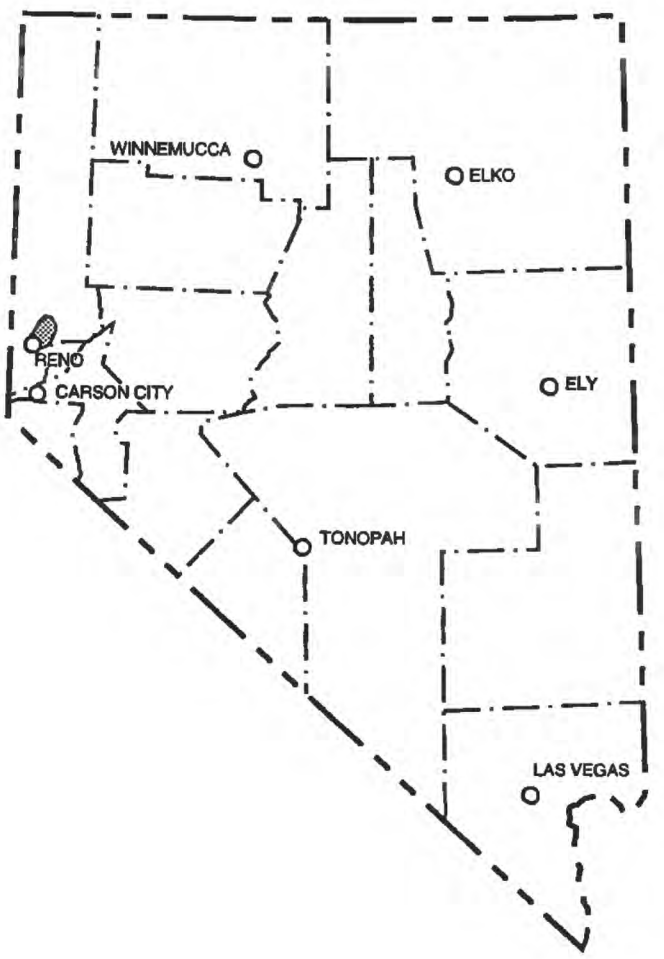
Cooperating Agency: Nevada Division of Water Resources.

Problem: Spanish Springs Valley, in northwest Nevada, is experiencing rapid population growth, and planners anticipate land-use changes from rural and agricultural to suburban designations. By 2007, residential development in Spanish Springs Valley is expected to increase substantially. For over a century, flow from the Truckee River has been diverted to Spanish Springs Valley by the Orr Ditch for agricultural use. An estimated 85 percent of the total annual ground-water recharge to the basin occurs as seepage losses from the Orr Ditch and associated irrigated lands. The effects on the sustained yield of the basin from the decrease or removal of irrigation seepage is unknown, but must be addressed to assist in proper planning and future management decisions.

Objectives: The project will evaluate and refine estimates of the water budget and sustained yield of the aquifer system in Spanish Springs Valley. A determination of the effects of changes in surface-water importation on the sustained yield of the basin also will be made.

Approach: Discharge measurements of all imported surface water and all return flow to the Truckee Meadows will be made. Precipitation gages will be established at several altitudes in the basin and measurements used to update the existing precipitation map. These data will be correlated with long-term precipitation data from nearby stations. Geophysical data will be collected and geophysical modeling programs will be used to define basin-fill thickness. A deep-percolation model and chloride-balance technique will be used to estimate ground-water recharge from precipitation within the basin. Water-level, geochemical, and isotopic data will be used to determine ground-water flow paths, sources, and mixing. Satellite imaging, aerial photography, and field mapping will be used to estimate areas of specific phreatophyte types and densities. A three-dimensional mathematical flow model of the aquifer system will be developed and used to evaluate the ground-water budget. The model will incorporate a stream-routing package for simulating interactions between surface and ground water and balances of inflow and outflow. Simulations will be made to evaluate the effects of decreased flows in Orr Ditch.

Progress and Significant Results, Fiscal Years 1993-94: Routine data-collection activities began and included collection of monthly ground-water levels at 70 wells, monthly precipitation at 7 gages, quarterly measurements at 3 bulk-precipitation storage gages, and continuous streamflow discharge measurements of the Orr Ditch (inflows) and North Truckee Drain (outflows). A series of seepage measurements were made along Orr Ditch to quantify the contribution of ground-water recharge from the current irrigation system. Ten observation wells and three shallow auger holes were drilled for inclusion in the monthly monitoring network. Geophysical logs were collected for 6 of the 10 wells. Geochemical sampling for chlorofluorocarbons, tritium, stable isotopes, and major ions was completed at 16 ground-water sites. Chemical analyses for chloride, bromide, phosphate, fluoride, sulfate, and nitrate concentrations in precipitation were made from five bulk-precipitation collection sites. A depth-to-bedrock contour map was developed. A preliminary relation between altitude and precipitation was developed. Work began on a three-dimensional flow model based on the conceptualization of the ground-water flow system in Spanish Springs Valley.



Plans for Fiscal Year 1995: Data-collection activities will continue at a reduced frequency. Installation of nested piezometer sites for sampling chlorofluorocarbons will be completed. Analysis of the results from the ground-water flow model will be made for steady-state and transient conditions. The final report will be prepared and submitted for review.

Publications, Fiscal Years 1993-94:

Emett, D.C., Hutchinson, D.D., Jonson, N.A., and O'Hair, K.L., 1994, Water resources data, Nevada, water year 1993: U.S. Geological Survey Water-Data Report NV-93-1, 596 p.

Humboldt Basin Mining Effects
(Project 182)

Location: North-central Nevada.

Project Chief: E. James Crompton.

Period of Project: 1993-94.

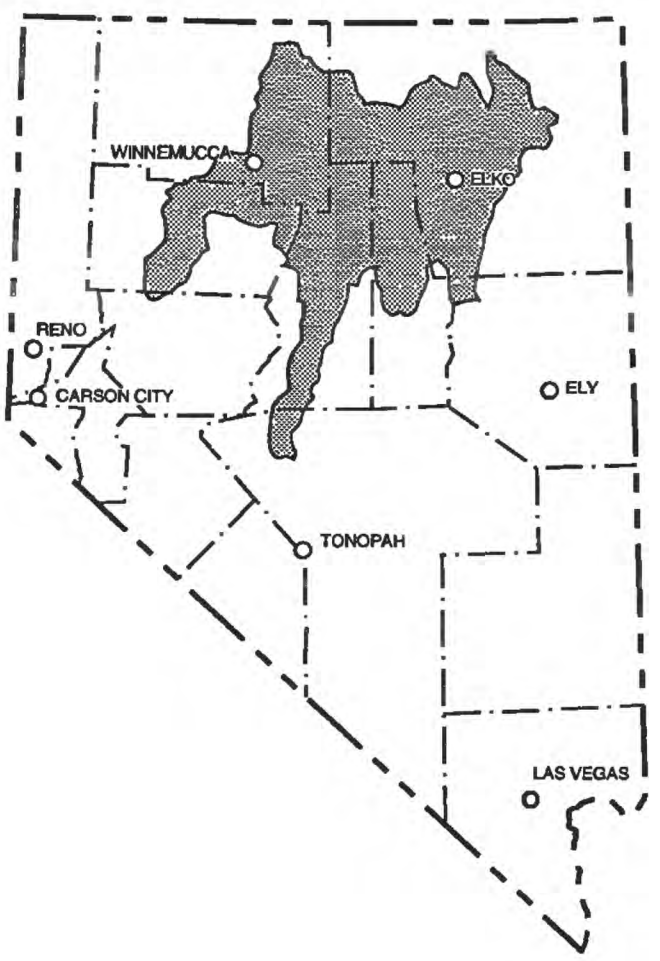
Supporting Federai Agency: Bureau of Land Management.

Problem: The Humboldt River Basin lies entirely within Nevada and encompasses about 16,800 square miles in the north-central part of the State. Historically, the principal water use in the basin has been irrigation from surface-water sources. Mining has become the second largest water use in the basin and the largest water use on public lands. With the major surface-water sources fully appropriated, ground water is becoming the principal source to meet the growing water needs in the basin. The effect of the large water withdrawals on the ground- and surface-water system locally and regionally (within the river basin) is not well known. The short- and long-term effects of mining on the water resources of the basin need to be delineated.

Objectives: A preliminary assessment was made of the potential effects of mining operations and associated water uses on short- and long-term local and regional water conditions within the Humboldt River Basin.

Approach: A 20-month study was done to compile and evaluate existing data, and to derive a semi-quantitative ranking of the estimated effects of mining operations on the water resources in hydrographic areas in the basin. Mines within the basin and less than 2 miles beyond the basin boundary were included in the study. A generalized rating system was developed and applied to seven water and water-related characteristics to rank potential effects in each hydrographic area.

Progress and Significant Results, Fiscal Years 1993-94: The project began in February 1993. Data compilation and analysis were completed. A map report was written and submitted for approval.



Estimating Regional Ground-Water Discharge by Evapotranspiration
(Project 184)

Location: Central Nevada.

Project Chief: William D. Nichols.

Period of Project: 1993-97.

Cooperating Agency: Nevada Division of Water Resources.

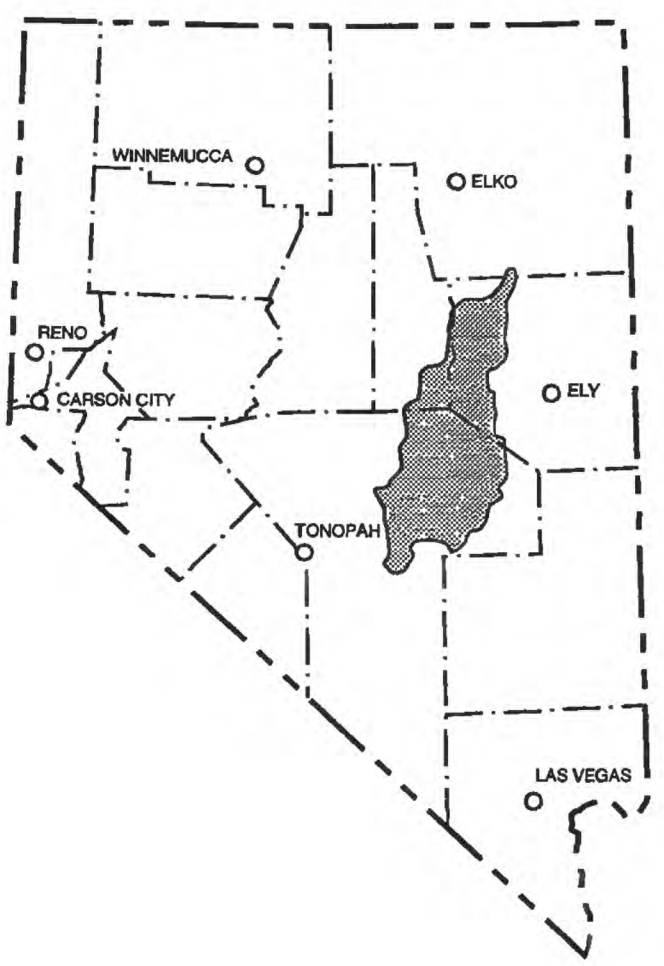
Problem: Understanding the water balance is fundamental to evaluating water resources. Among the terms of the water balance, evapotranspiration (ET) is the least known and least understood. In many arid and semiarid areas such as Nevada, ET includes large quantities of ground water, but few methods have been developed to measure or estimate this quantity. Developing and improving methods for estimating ET at regional scales will improve the reliability of estimated ground-water discharge and provide a framework for evaluating current empirical methods for estimating ground-water recharge. This, in turn, will lead to improved methods for estimating the total water balance on regional scales.

Objectives: The investigation will develop a generally applicable model for estimating ground-water discharge by ET in the central Great Basin. Regional-scale ground-water discharge by ET will be estimated for the eastern Great Basin.

Approach: Field investigations were begun at selected locations in the study area to measure energy budget and depth-to-water data. Plant type and density data will be gathered also. These data will be used in conjunction with Landsat satellite imagery to develop equations describing ground-water discharge by evapotranspiration.

Progress and Significant Results, Fiscal Years 1993-94: ET measurements were made in Railroad Valley and Little Fish Lake Valley. Transects were used to evaluate plant type and density for calibration of land-cover classifications using Landsat satellite imagery in both valleys. Depth-to-water measurements were made and the data were compiled.

Plans for Fiscal Year 1995: Measurements of ET will be made in the central Great Basin study area. Plant type and density will be determined for calibration of land-cover classifications using Landsat satellite imagery in the central Great Basin. More data for the study area will be collected and compiled. Preparation of a regional map of the depth to ground water will begin. The ground-water ET in relation to depth-to-water data for Railroad Valley will be combined and preparation of a comprehensive model using geographic information system techniques will begin.



Publications, Fiscal Years 1993-94:

Chehbouni, A., Nichols, W.D., Qi, J., Njoku, E.G., Kerr, Y.H, and Cabot, F., in press, On the use of radiative surface temperature to estimate sensible heat flux over sparse shrubs in Nevada: 6th International Symposium—Physical Measurements and Signatures in Remote Sensing, January 1994, Proceedings.

Nichols, W.D., in press, Groundwater discharge by phreatophyte shrubs in the Great Basin as related to depth to groundwater: Water Resources Research, v. 30, no. 12, p. 3265-3274.

Stewart, J.B., Kustas, W.P., Nichols, W.D., Moran, M.S., and deBruin, H.A.R., 1994, Sensible heat flux—Radiometric surface temperature relationship for eight semiarid areas: Journal of Applied Meteorology, v. 33, p. 1110-1117.

Intermittent Recharge in Eagle Valley
(Project 185)

Location: Eagle Valley, Nev.

Project Chief: David E. Prudic.

Period of Project: 1994-96.

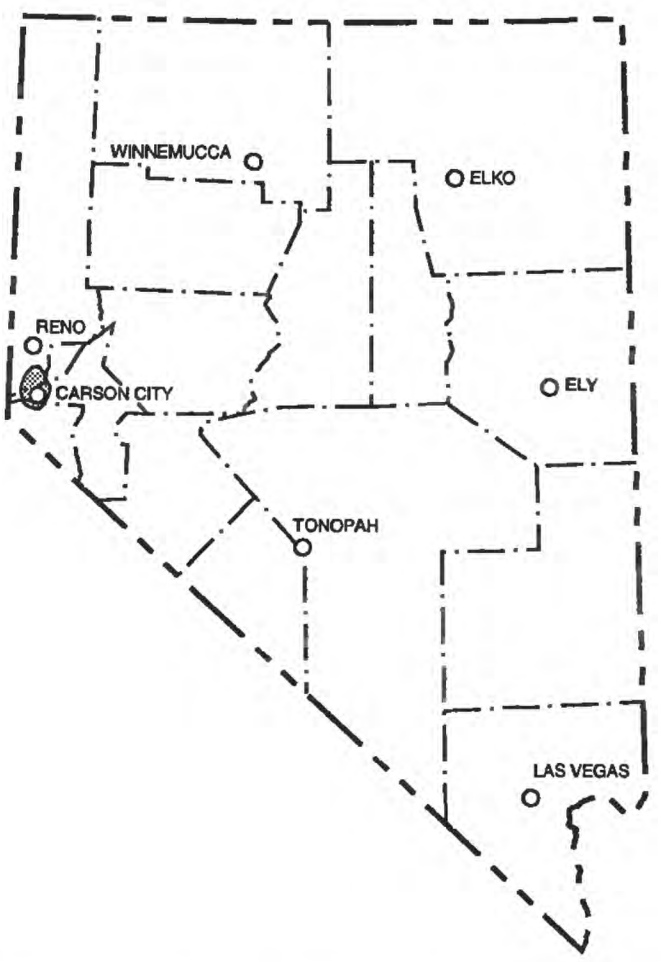
Cooperating Agency: Carson City Public Works Department.

Problem: Many basins in the western United States receive a large part of their ground-water recharge from intermittent surface-water flow. This recharge is typically from natural ephemeral streams, unlined irrigation ditches, and augmentation projects. Currently, ground-water flow models of the U.S. Geological Survey assume instantaneous recharge between surface water and ground water and do not include any of the processes of flow through an unsaturated zone that may delay or affect the quantity of recharge. Better numerical methods are needed to more accurately simulate flow between the land surface and aquifers separated by an unsaturated zone, because of increased concerns about pollution affecting ground water and because increased demands for ground water require more accurate estimates of recharge.

Objective: This project will develop new methods for estimating ground-water recharge from streams and from underflow beneath adjacent mountains. A better method will be developed for simulating percolation from a stream to the underlying ground-water table by way of an unsaturated zone.

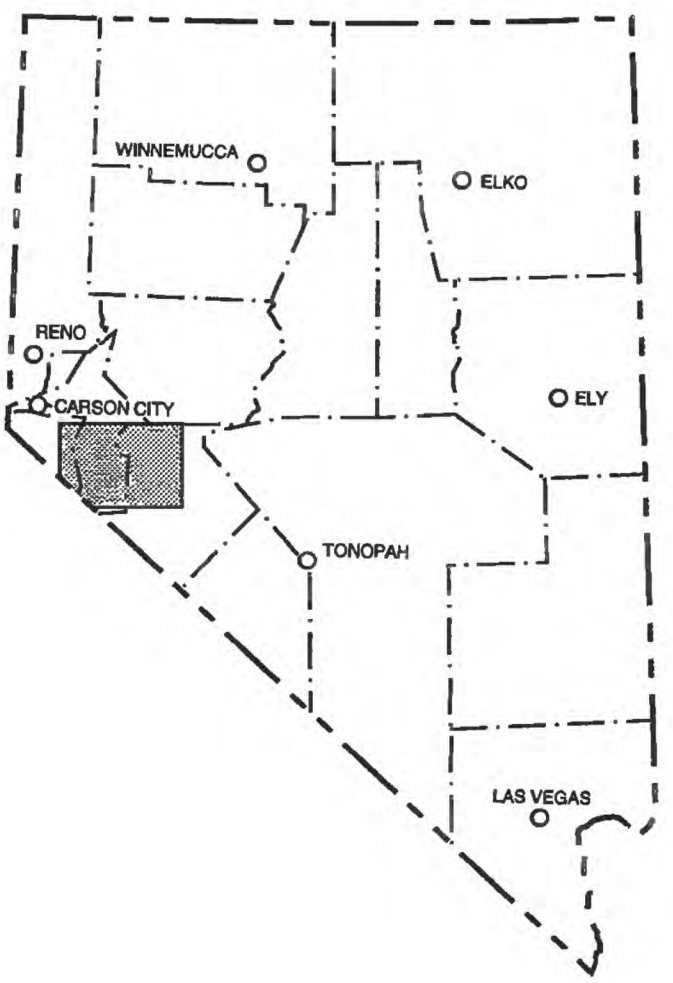
Approach: Recharge from intermittent streamflow in Vicee Canyon will be determined from transient temperature-depth profiles. The effect of temperature on stream infiltration will be measured and simulated with a variably saturated flow model modified to account for heat transport. Underflow beneath the major drainages entering the basin-fill aquifer will be determined by estimating thickness of fill beneath Vicee, Ash, and Kings Canyons using geophysical methods and by drilling three test holes in each canyon to determine aquifer properties and hydraulic gradients. A new stream package for the USGS modular finite-difference model will be written that will incorporate the effects of unsaturated flow between the streambed and the aquifer. Data collected in Vicee Canyon will be used to test the new program.

Progress and Significant Results, Fiscal Year 1994: Thermistors were placed beneath the channel of Vicee Canyon at two sites and neutron-access tubes were installed nearby. Flumes with transducers and thermistors were placed at three locations in the stream channel and a week-long experiment was completed in May. Surface resistivity and seismic surveys were done in June near the mouths of Vicee, Ash, and Kings Canyons. The geophysical surveys were made to estimate the depth to ground water and thickness of fill. Test holes were drilled at selected locations near the mouths of each canyon in August. Analyses of data collected in Vicee Canyon began.



Plans for Fiscal Year 1995: Data-collection and modeling activities will continue. Reports will be written and submitted for approval.

Walker River Assessment *(Project 186)*



Location: Walker River and Walker Lake area, Nevada and California.

Project Chief: James M. Thomas.

Period of Project: 1994-96.

Cooperating Agency: Walker River Paiute Tribe.

Problem: The lake-surface altitude of Walker Lake, a terminal desert lake near Hawthorne, Nev., has declined by 135 feet since 1882 when agricultural irrigation began in the basin. During the same period, the salinity has increased from approximately 2,500 to 12,500 milligrams per liter, disrupting the ecosystem because species vital to the food chain can no longer survive. The lake is an important migratory resting and feeding site for waterfowl, such as pelicans and loons, that depend on a reliable source of food during their stopover. The loss of the lake's trout fishery would affect the economy of the local communities. The upstream users are economically dependent upon availability of water-rights appropriations. The present rate of salt migration into Walker Lake from bottom sediments is unknown. An investigation is needed to estimate changes in Walker Lake salinity in response to evaporation and salt inputs from surface water, ground water, and lake-bottom sediment.

Objective: Changes in Walker Lake salinity will be estimated in response to evaporative water loss and the combined salt contribution from surface water, ground water, and lake-bottom sediments by estimating changes in lake salinity for different scenarios of river inflow and salt loading. The contributions of dissolved salts to Walker Lake from ground water and from lake-bottom sediments will not be monitored and therefore will be estimated.

Progress and Significant Resuits, Fiscai Year 1994: Historical data were compiled and analyzed to determine historical loading of dissolved solids. Data collection and interpretation began. Preparation of a report began.

Pians for Fiscal Year 1995: Routine data-collection activities will continue. The report will be submitted for review.

Bridge Scour *(Project 187)*

Location: Western Nevada.

Project Chief: Rhea P. Williams.

Period of Project: 1994-96.

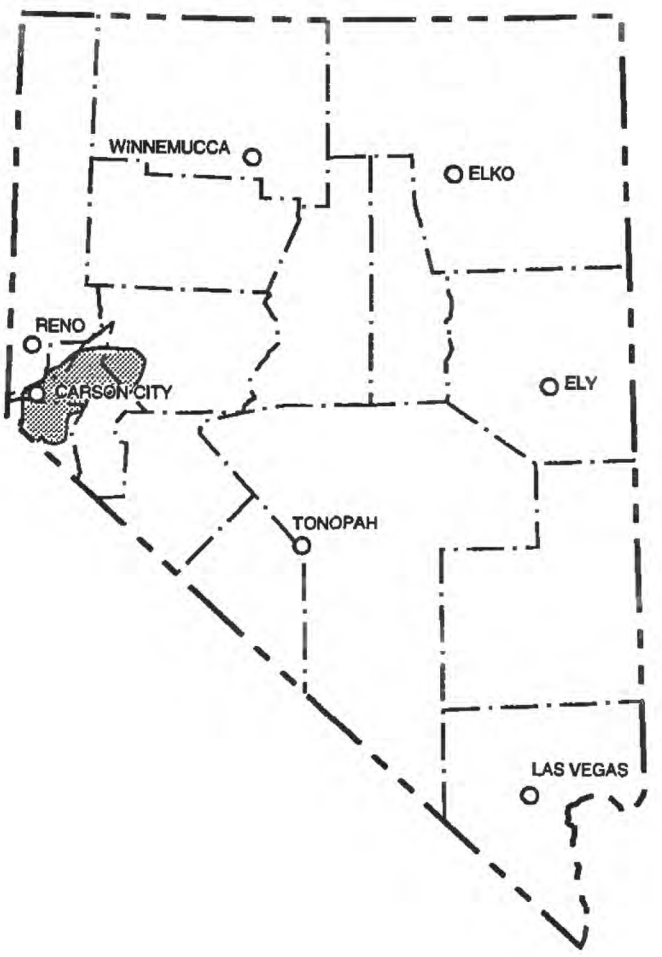
Cooperating Agency: Nevada Department of Transportation.

Problem: The most common cause of bridge failures is the scouring of bridge foundations during floods. Scour is a lowering of the streambed below a surveyed or an assumed datum. Scour depth is the depth of bed material eroded by discharge. In 1988, the Federal Highway Administration (FHWA) requested that all State highway agencies evaluate the bridges on the Federal Aid System for susceptibility to scour-related failure. A schedule has been proposed to have all over-water bridges evaluated for scour susceptibility within the next few years. The FHWA published Hydraulic Engineering Circulars HEC-18 and HEC-20 to provide guidance in evaluating scour potential. Through an initial screening process, the Nevada Department of Transportation (NDOT) has looked at more than 200 bridges; some, which appear susceptible to scour, need further evaluation. The USGS proposed a three-level program to assist NDOT in evaluating the potential for scour-related failure of bridges in Nevada on the basis of procedures in the FHWA circulars.

Objective: Assistance will be provided to NDOT for assessment and evaluation of scour depth at selected bridge sites using the guidelines in the Hydraulic Engineering circulars.

Approach: Field data will be collected to obtain cross sections, bridge geometry, and bed-material particle-size distribution for "scour susceptible" bridges identified by NDOT (Level 1). The data will be compiled in a geographic information system for future channel comparisons. A hydrologic assessment of the 100- and 500-year flood discharges for a bridge site will be made on the basis of existing flood-frequency reports. The "extreme" event under consideration for these analyses is a flood with a 500-year recurrence interval. Scour calculations will be made using site-collected data as required (Level 2). A hydraulic sediment-transport model may be needed. For critical scour sites and anticipated long-term geomorphic changes, work includes sediment-transport modeling for general and local scour predictions (Level 3). Site reports and conclusions of the analysis for each bridge site will be prepared.

Progress and Significant Results, Fiscal Year 1994: Level-1 analysis began in August 1994.



Plans for Fiscal Year 1995: Level-1 data will be collected and reviewed by USGS. After these analyses, those sites with a ranking of scour potential will be analyzed by the Level-2 program. If warranted by the results of Level-2 analyses, a comprehensive Level-3 fluvial model study will be considered.

WATER-RELATED PUBLICATIONS, NEVADA DISTRICT, FISCAL YEARS 1993-94

Andraski, B.J., in press, Disturbance effects on soil properties and water balance at a low-level radioactive waste site, Amargosa Desert, Nevada [abs.]: 86th Annual Meeting, American Society of Agronomy, Seattle, November 1994, Agronomy Abstracts, v. 86, p. 227.

———in press, Simulated trench studies near Beatty, Nevada—Initial results and implications *in* Conference on Disposal of Low-Level Radioactive Waste, Reston, Va., May 1993: U.S. Geological Survey Water-Resources Investigations Report 95-4015.

Andraski, B.J., and Lowery, Birl, 1992, Erosion effects on soil-water storage, plant water uptake, and corn growth: Soil Science Society of America Journal, v. 56, no. 6, p. 1911-1919.

August, M.H., Jacoboni, J.M., Jeton, A.E., Parker, R.S., Pupacko, Alex, Ruddy, B.C., Smith, J.L., and Redmond, K.T., 1992, Hydrologic and climatic data bases used to assess potential effects of climate change on water resources of American River, Carson River, and Truckee River Basins, California-Nevada, and of Gunnison River Basin, Colorado: U.S. Geological Survey Open-File Report 92-627, 72 p.

August, M.H., and Long, Kati, in press, Development of a data base to support the publication of the USGS Water Data report: Fifth Annual Conference, Nevada State GIS, Sparks, December 1994, Final Program, unpaginated.

August, M.H., and Ruddy, B.C., 1992, Hydrologic and climatic data bases used to assess the potential effects of climate change on the water resources of the American, Carson, and Truckee River Basins, California-Nevada, and of Gunnison River Basin, Colorado [abs.], *in* Herrmann, Raymond, ed., Managing water resources during global change: 28th Annual Conference, American Water Resources Association, Reno, Nev., November 1992, Abstracts, p. 57.

Berger, D.L., 1992, Ground-water recharge through active sand dunes in northwestern Nevada: Water Resources Bulletin, v. 28, no. 5, p. 959-965.

———1992, Lithologic properties of carbonate-rock aquifers at five test wells in the Coyote Spring Valley area, southern Nevada, as determined from geophysical logs: U.S. Geological Survey Water-Resources Investigations Report 91-4167, 27 p.

Bohman, L.R., 1994, The Truckee-Carson program: U.S. Geological Survey Yearbook, Fiscal Year 1993, p. 55.

Bunch, R.L., 1994, Bibliography of selected water-resources publications on Nevada by the U.S. Geological Survey, 1885 through 1993: U.S. Geological Survey Open-File Report 94-53, 38 p.

Burbey, T.J., 1993, Calculation of horizontal granular movement in confined aquifers [abs.]: Geological Society of America, Abstracts with Programs, v. 25, no. 6, p. 258.

———1993, Shallow ground water in the Whitney area, southeastern Las Vegas Valley, Clark County, Nevada, Part II, Assessment of a proposed strategy to reduce the contribution of salts to Las Vegas Wash: U.S. Geological Survey Water-Resources Investigations Report 92-4051, 58 p.

———in press, Pumpage and water-level change in the principal aquifer system of Las Vegas Valley, Nevada, 1980-90: Nevada Division of Water Resources, Information Report 34.

Carey, A.E., 1994, Documentation of model input and output values used for analyses of simulated development in Stagecoach Valley, Lyon and Storey Counties, Western Nevada: U.S. Geological Survey Open-File Report 92-630, 4 p., 1 diskette.

Carey, A.E., and Prudic, D.E., in press, Documentation of model input and output values for simulation of pumping effects in Paradise Valley, a basin tributary to the Humboldt River, Humboldt County, Nevada: U.S. Geological Survey Open-File Report 92-491, 1 diskette.

Carman, R.L., 1993, Measurement of evapotranspiration in phreatophyte areas, Smith Creek Valley and Carson Desert, west-central Nevada, 1983: U.S. Geological Survey Water-Resources Investigations Report 89-4118, 18 p.

———in press, Meteorological data for four sites at surface-disruption features in Yucca Flat, Nevada Test Site, Nye County, Nevada, 1985-86: U.S. Geological Survey Open-File Report 94-491, 43 p.

Cartier, K.D., Peltz, L.A., and Smith, J.L., 1994, Development and documentation of spatial data bases for the Lake Tahoe Basin, California and Nevada: U.S. Geological Survey Water-Resources Investigations Report 93-4182, 65 p.

Chehbouni, A., Nichols, W.D., Qi, J., Njoku, E.G., Kerr, Y.H., and Cabot, F., in press, On the use of radiative surface temperature to estimate sensible heat flux over sparse shrubs in Nevada: 6th International Symposium—Physical Measurements and Signatures in Remote Sensing, January 1994, Proceedings.

Dettinger, M.D., in press, Description of interdecadal variability of surface climate in the western SOWR study areas using singular spectrum analysis [abs.]: USGS Global Change Research Program, Reston, Va., March 1991, Proceedings.

———in press, Sensitivity of streamflow in Sierra Nevada watersheds to climate change—A study on progress [abs.]: USGS Global Change Research Program, Reston, Va., March 1991, Proceedings.

Dettinger, M.D., Schmidt, D.L., Harrill, J.R., and Hess, J.W., in press, Distribution of carbonate-rock aquifers and the potential for their development, southern Nevada and parts of Arizona, California, and Utah: U.S. Geological Survey Water-Resources Investigations Report 91-4146.

Emett, D.C., Hutchinson, D.D., Jonson, N.A., and O'Hair, K.L., 1994, Water resources data, Nevada, water year 1993: U.S. Geological Survey Water-Data Report NV-93-1, 596 p.

Foglesong, M.T., 1993, Water-related scientific activities of the U.S. Geological Survey in Nevada, fiscal years 1991-92: U.S. Geological Survey Open-File Report 93-97, 85 p.

Gee, G.W., Wierenga, P.J., Andraski, B.J., Young, M.H., Fayer, M.J., and Rockhold, M.L., 1994, Variations in water balance and recharge potential at three western desert sites: Soil Science Society of America Journal, v. 58, no. 1, p. 63-72.

Glancy, P.A., 1994, Evidence of prehistoric flooding and the potential for future extreme flooding at Coyote Wash, Yucca Mountain, Nevada: U.S. Geological Survey Open-File Report 92-458, 31 p.

Glancy, P.A., and Williams, R.P., 1994, Problems with indirect determinations of peak streamflows in steep, desert stream channels, *in* Cotroneo, G.V., and Rumer, R.R., eds., Hydraulic engineering '94: American Society of Civil Engineers Conference, Buffalo, N.Y., August 1994, Proceedings, v. 1, p. 635-639.

Gortsema, G.C., 1993, Selected data on water quantity and quality at four sites on streams draining public lands, Colorado River Basin, southeastern Nevada, October 1988-September 1991: U.S. Geological Survey Open-File Report 93-439, 31 p.

Hale, G.S., and Trudeau, D.A., 1993, Ground-water levels from well and test-hole data, Yucca Flat, Nevada Test Site, Nye County, Nevada, 1959-91 [abs.]: 7th Symposium on Containment of Underground Nuclear Explosions, Kent, Wash., September 1993, Abstracts (CONF-9309103-ABS), p. 39.

Hallock, R.J., and Hallock, L.L., eds., 1993, Detailed study of irrigation drainage in and near wildlife management areas, west-central Nevada, 1987-90—Part B. Effect on biota in Stillwater and Fernley Wildlife Management Areas and other nearby wetlands: U.S. Geological Survey Water-Resources Investigations Report 92-4042B, 84 p.

Hamilton, P.A., Welch, A.H., Christenson, S.C., and Alley, W.M., 1993, Uses and limitations of existing ground-water quality data, *in* Alley, W.M., ed., Regional ground-water quality: New York, Van Nostrand Reinhold, chap. 25, p. 613-622.

Handman, E.H., 1992, Hydrologic aspects of interbasin transport of ground water from Honey Lake Valley, Washoe County, Nevada [abs.], *in* Herrmann, Raymond, ed., Managing water resources during global change: 28th Annual Conference, American Water Resources Association, Reno, Nev., November 1992, Abstracts, p. 17.

Harrill, J.R., and Preissler, A.M., 1994, Ground-water flow and simulated effects of development in Stagecoach Valley, a small, partly drained basin in Lyon and Storey Counties, western Nevada: U.S. Geological Survey Professional Paper 1409-H, 74 p.

Hawkins, W.L., Trudeau, D.A., and Drellack, S.L., 1993, Hydrogeologic investigations at the Nevada Test Site, *in* Eckstein, Yoram, and Zaporozed, Alexander, eds., Industrial and agricultural impacts on the hydrologic environment: Second USA/CIS Joint Conference on Environmental Hydrology and Hydrogeology, Water Environment Federation, American Institute of Hydrology, Proceedings, 18 p.

Helm, D.C., 1994, Horizontal aquifer movement in a Theis-Thiem confined system: Water Resources Research, v. 30, no. 4, p. 953-964.

Hess, D.L., Mello, K.A., Sexton, R.J., and Young, R.L., 1993, Water resources data, Nevada, water year 1992: U.S. Geological Survey Water-Data Report NV-92-1, 511 p.

Hilmes, M.M., 1994, Seasonal variation of suspended-sediment transport in the lower Virgin River, Arizona and Nevada [abs.]: Geological Society of America, Abstracts with Programs, v. 26, no. 7, p. A302.

Hoffman, R.J., 1994, Detailed study of irrigation drainage in and near Wildlife Management Areas, west-central Nevada, 1987-90—Part C. Summary of irrigation drainage effects on water quality, bottom sediment, and biota: U.S. Geological Survey Water-Resources Investigations Report 92-4024C, 32 p.

Humes, K.S., Kustas, W.P., Moran, M.S., Nichols, W.D., and Weltz, M.A., 1994, Variability of emissivity and surface temperature over a sparsely vegetated surface: Water Resources Research, v. 30, no. 5, p. 1299-1310.

Jeton, A.J., 1992, Modeling the sensitivity of water-resources to climate change—A paired-basin analysis of two small watersheds in the Sierra Nevada, California-Nevada [abs.], *in* Herrman, Raymond, ed., Managing water resources during global change: 28th Annual Conference, American Water Resources Association, Reno, Nev., November 1992, Abstracts, p. 57.

Jeton, A.E., and Smith, J.L., 1993, Development of watershed models for two Sierra Nevada basins using a geographic information system: Geographic Information Systems and Water Resources, American Water Resources Association, Mobile, Ala., March 1993, Proceedings, p. 251-258.

———1993, Watershed modeling—Spatial partioning using GIS, *in* Burton, J.S., comp., Proceedings of the Federal Interagency Workshop on Hydrologic Modeling Demands for the 90's: U.S. Geological Survey Water-Resources Investigations Report 93-4018, p. 5-81—5-88.

Johnson, M.J., 1993, Micrometeorological measurements at Ash Meadows and Corn Creek Springs, Nye and Clark Counties, Nevada, 1986-87: U.S. Geological Survey Open-File Report 92-650, 41 p., 3 diskettes.

———in press, Ground-water discharge by evapotranspiration in a desert environment of southern Nevada, 1987: U.S. Geological Survey Water-Resources Investigations Report 94-4124, 20 p.

Kane, T.G., III, Bauer, D.J., and Martinez, C.M., 1994, Streamflow and selected precipitation data for Yucca Mountain Region, southern Nevada and eastern California, water years 1986-90: U.S. Geological Survey Open-File Report 94-312, 118 p.

Kelmelis, John, and Liebermann, T.D., 1994, Scientific management of the Upper Mississippi River Basin [abs.]: Urban and Regional Information Systems Association Annual Conference, Milwaukee, Wis., August 1994, Proceedings, p. 45.

Kilroy, K.C., 1994, Pesticides in the Carson River, Truckee River, and Las Vegas Basins, Nevada and California, 1970-90 [abs.]: Nevada Water Conference, Nevada Water Resources Association, Las Vegas, March 1994, Abstracts of Technical Papers and Posters, p. 28.

Kustas, W.P., Blanford, J.H., Stannard, D.I., Daughtry, C.S.T., Nichols, W.D., and Weltz, M.A., 1994, Local energy flux estimates for unstable conditions using variance data in semiarid rangelands: Water Resources Research, v. 30, no. 5, p. 1351-1362.

La Camera, R.J., and Westenburg, C.L., 1994, Selected ground-water data for Yucca Mountain region, southern Nevada and eastern California, through December 1992: U.S. Geological Survey Open-File Report 94-54, 161 p.

Lawrence, S.J., 1994, Selected trace elements in bed sediment and tissues of four aquatic invertebrate species from the Truckee and Carson River Basins and Las Vegas Wash, Nevada and California, September 1992 [abs.]: Nevada Water Conference, Nevada Water Resources Association, Las Vegas, March 1994, Abstracts of Technical Papers and Posters, p. 44.

Lawrence, S.J., and Bevans, H.E., in press, Mercury in bottom sediment and aquatic invertebrates, Carson and Truckee River Basins, Nevada and California [abs.]: 15th Annual Meeting, Society of Environmental Toxicology and Chemistry, Denver, October 1994, Abstract Book, p. 19.

Lico, M.S., in press, Nevada wetland resources, *in* National water summary on wetland resources—including hydrologic events of 1992-93: U.S. Geological Survey Water-Supply Paper 2425.

Lico, M.S., and Seiler, R.L., in press, Ground-water quality and geochemistry, Carson Desert, western Nevada: U.S. Geological Survey Open-File Report 94-31.

Liebermann, T.D., 1994, Use of a geographic information system for spatial data analysis, *in* Steile, K.S., comp., Computer-science, guest-lecture series at Langston University sponsored by the U.S. Geological Survey—Abstracts, 1992-93: U.S. Geological Survey Open-File Report 94-86, p. 3.

Liebermann, T.D., Stone, J.C., and Peltz, L.A., 1994, Comprehensive approach to the production of map illustrations by computer [abs.], *in* Balthrop, B.H., and Baker, E.G., comps., U.S. Geological Survey National Computer Technology Meeting, program and abstracts, New Orleans, Louisiana, April 10-15, 1994: U.S. Geological Survey Open-File Report 94-52, p. 25.

Long, Kati, and Peltz, L.A., in press, Water-related scientific activities of the spatial applications section, Nevada District, U.S. Geological Survey, 1994: Fifth Annual Conference, Nevada State GIS, Sparks, December 1994, Final Program, unpaginated.

Maurer, D.K., 1993, Hydrogeologic setting and hydrologic data of the Smoke Creek Desert Basin, Washoe County, Nevada, and Lassen County, California, water years 1988-90: U.S. Geological Survey Water-Resources Investigations Report 93-4043, 45 p.

Maurer, D.K., Johnson, A.K., and Welch, A.H., 1994, Hydrogeology and potential effects of changes in water use, Carson Desert agricultural area, Churchill County, Nevada: U.S. Geological Survey Open-File Report 93-463, 101 p.

Maurer, D.K., and Peltz, L.A., in press, Potential for, and possible effects of, artificial recharge in Carson Valley, Douglas County, Nevada: U.S. Geological Survey Water-Resources Investigations Report 94-4126, 4 sheets.

Moran, M.S., Kustas, W.P., Vidal, A., Stannard, D.I., Blanford, J.H., and Nichols, W.D., 1994, Use of ground-based remotely sensed data for surface energy balance evaluation of a semiarid rangeland: Water Resources Research, v. 30, no. 5, p. 1339-1350.

Morgan, D.S., and Dettinger, M.D., 1994, Ground-water conditions in Las Vegas Valley, Clark County, Nevada—Part II, Geohydrology and simulation of ground-water flow: U.S. Geological Survey Open-File Report 90-179, 151 p.

Nichols, W.D., 1992, The uncertainty of water budget estimates in the Great Basin, *in* Herrmann, Raymond, ed., Managing water resources during global change: 28th Annual Conference and Symposium, American Water Resources Association, Reno, Nev., November 1992, Proceedings, p. 309-317.

———1993, Estimating discharge of shallow groundwater by transpiration from greasewood in the northern Great Basin: Water Resources Research, v. 29, no. 8, p. 2771-2778.

———in press, Groundwater discharge by phreatophyte shrubs in the Great Basin as related to depth to groundwater: Water Resources Research, v. 30, no. 12, p. 3265-3274.

Pabst, M.E., Beck, D.A., Glancy, P.A., and Johnson, J.A., 1993, Streamflow and selected precipitation data for Yucca Mountain and vicinity, Nye County, Nevada, water years 1983-85: U.S. Geological Survey Open-File Report 93-438, 66 p.

Peltz, L.A., in press, Slope and aspect classifications of Lake Tahoe Basin, California and Nevada: U.S. Geological Survey Open-File Report 94-105, 1 sheet.

Peltz, L.A., Hickenbottom, K.W., Dillon, M.J., and Taylor, Tracy, 1994, Development of a spatial data base for water-right information in Pahrump Valley, Nevada: 14th Annual User Conference, Environmental Systems Research Institute, Palm Springs, Calif., May 1994, Proceedings (CD-ROM), p. 253-256.

Peltz, L.A., Hickenbottom, K.W., Taylor, T.W., and Dillon, M.J., 1994, Spatial data base for water-right information—Pilot study in Pahrump Valley, Nevada [abs.]: Nevada Water Conference, Nevada Water Resources Association, Las Vegas, March 1994, Abstracts of Technical Papers and Posters, p. 38.

Plume, R.W., in press, Hydrogeologic framework of the Great Basin Region of Nevada, Utah, and adjacent states: U.S. Geological Survey Professional Paper 1409-B.

Prudic, D.E., 1994, Effects of temperature at the arid disposal site for low-level radioactive wastes near Beatty, Nevada [abs.]: Geological Society of America, Abstracts with Programs, v. 26, no. 7, p. 143.

———1994, Estimates of percolation rates and ages of water in unsaturated sediments at two Mojave Desert sites, California-Nevada: U.S. Geological Survey Water-Resources Investigations Report 94-4160, 19 p.

———in press, Water-vapor movement through unsaturated alluvium in Amargosa Desert near Beatty, Nevada—Current understanding and continuing studies *in* Conference on Disposal of Low-Level Radioactive Waste, Reston, Va., May 1993: U.S. Geological Survey Water-Resources Investigations Report 95-4015

Prudic, D.E., Harrill, J.R., and Burbey, T.J., 1993, Conceptual evaluation of regional ground-water flow in the carbonate-rock province of the Great Basin, Nevada, Utah, and adjacent states: U.S. Geological Survey Open-File Report 93-170 (revision of Open-File Report 90-560), 103 p.

Prudic, D.E., and Herman, M.E., in press, Ground-water hydrology and simulated effects of development in Paradise Valley, a basin tributary to the Humboldt River in Humboldt County, Nevada: U.S. Geological Survey Professional Paper 1409-F.

Prudic, D.E., and Striegl, R.G., 1994, Water and carbon-dioxide movement through unsaturated alluvium near an arid disposal site for low-level radioactive waste, Beatty, Nevada [abs.]: Eos, American Geophysical Union Transactions, v. 75, no. 16, p. 161.

Pupacko, Alex, 1992, Streamflow variability in the Lake Tahoe Basin, California-Nevada [abs.], *in* Herrmann, Raymond, ed., Managing water resources during global change: 28th Annual Conference, American Water Resources Association, Reno, Nev., November 1992, Abstracts, p. 59.

———1993, Potential effects of climate change on the surface-water resources of the Carson, American, and Truckee River Basins [abs.], *in* Kelmelis, J.A., and Snow, Mitchell, eds., Proceedings of the U.S. Geological Survey global change research forum, Herndon, Virginia, March 18-20, 1991: U.S. Geological Survey Circular 1086, p. 107.

———1993, Variations in northern Sierra Nevada streamflow—Implications of climate change: Water Resources Bulletin, v. 29, no. 2, p. 283-290.

———in press, Sensitivity of streamflow in Sierra Nevada watersheds to climate change—a study in progress [abs.]: USGS Global Change Research Program, Reston, Va., March 1991, Proceedings.

Pupacko, Alex, Dettinger, M.D., Duell, L.F., Jeton, A.E., and Smith, J.L., 1992, Potential effects of climate change on surface-water resources of two high mountain watersheds in the western United States: Japan-U.S. Committee on Hydrology, Water Resources, and Global Climate Change, Proceedings, Tsukuba, Japan, February 1992, JUCHWR Publication No. 1, p. 275-286.

Reece, B.D., and Peltz, L.A., in press, Browsing the Internet World Wide Web—Discovering, retrieving, and displaying multimedia documents using mosaic: 5th Annual Conference, Nevada State GIS, Sparks, December 1994, Final Program, unpaginated.

Reece, B.D., Liebermann, T.D., and Carman, R.L., 1994, Topographic-shading time series from digital elevation data for input to a stream-temperature model, Truckee River Basin, California and Nevada, *in* Lawson, C.A., and Bennett, P.C., comps., Scientific visualization workshop, Menlo Park, California, September 15-17, 1993, abstracts: U.S. Geological Survey Open-File Report 94-134, p. 14-15.

Rockwell, G.L., 1993, Surface-water hydrology of Honey Lake Valley, Lassen County, California, and Washoe County, Nevada: U.S. Geological Survey Hydrologic Investigations Atlas HA-726, 2 sheets.

Rowe, T.G., 1993, Streamflow, sediment, and nutrient data for two streams in the Incline Village area of the Lake Tahoe Basin, Nevada, during water years 1988-92 [abs.]: Nevada Water Conference, Nevada Water Resources Association, Reno, February 1993, Abstracts of Presented Papers and Posters, p. 26.

———1994, Streamflow and water quality during drought and non-drought years at Incline Creek, a tributary to Lake Tahoe, Nevada, 1988-93 [abs.]: Nevada Water Conference, Nevada Water Resources Association, Las Vegas, March 1994, Abstracts of Technical Papers and Posters, p. 10.

Savard, C.S., and Crompton, E.J., 1993, Hydrologic data for east-central Nevada, water years 1982-88: U.S. Geological Survey Open-File Report 90-153, 128 p.

Schaefer, D.H., 1993, Documentation of model input and output values for simulation of regional ground-water flow, carbonate-rock province, Nevada, Utah, and adjacent states: U.S. Geological Survey Open-File Report 93-420 (revision of Open-File Report 91-479), 4 p., 1 diskette.

———1993, Hydrologic implications of measured changes in gravity during pumping at a carbonate-rock well near Moapa, Clark County, Nevada: U.S. Geological Survey Water-Resources Investigations Report 93-4095, 11 p.

Scott, W.B., and Morgan, C.O., 1992, Hydrologic activities of the U.S. Geological Survey in support of the radionuclide migration program, Nevada Test Site, Nye County, Nevada, fiscal year 1986, *in* Jones, M.A., comp., Hydrology/Radionuclide Migration Program and related research activities, FY 1986 progress report (October 1, 1985-September 30, 1986): U.S. Department of Energy, DOE/NV-354, UC-700, p. 177-186.

Seiler, R.L., 1993, Nevada stream water quality, *in* Paulson, R.W., Chase, E.B., Williams, J.S., and Moody, D.W., comps., Hydrologic events and stream water quality: U.S. Geological Survey Water-Supply Paper 2400, p. 379-385.

———1993, Water-level changes in the shallow aquifer near Fallon, Nevada [abs.]: Nevada Water Conference, Nevada Water Resources Association, Reno, February 1993, Abstracts of Presented Papers and Posters, p. 10.

———1994, Synthesis of data from the U.S. Department of the Interior irrigation drainage studies, western United States [abs.]: 1994 Annual Summer Symposium, American Water Resources Association, Jackson Hole, Wyo., June, Proceedings, p. 1167.

Seiler, R.L., and Allander, K.K., 1993, Water-level changes and directions of ground-water flow in the shallow aquifer, Fallon area, Churchill County, Nevada: U.S. Geological Survey Water-Resources Investigations Report 93-4118, 74 p.

Seiler, R.L., Ekechukwu, G.A., and Hallock, R.J., 1993, Reconnaissance investigation of water quality, bottom sediment, and biota associated with irrigation drainage in and near Humboldt Wildlife Management Area, Churchill and Pershing Counties, Nevada, 1990-91: U.S. Geological Survey Water-Resources Investigations Report 93-4072, 115 p.

Smith, J.L., 1992, Objective method for watershed characterization using a geographic information system and remotely sensed data [abs.], *in* Herrmann, Raymond, ed., Managing water resources during global climate change: 28th Annual Conference, American Water Resources Association, Reno, Nev., November 1992, Abstracts, p. 92.

———in press, Geographic information system of surveyed and photogrammetric measurements of cross-sectional elevation data, Virgin River, Nevada and Arizona: 5th Annual Conference, Nevada State GIS, Sparks, December 1994, Final Program, unpaginated.

Smith, J.L., and Reece, B.D., in press, Watershed characterization for precipitation runoff modeling system, North Fork American River and East Fork Carson River watersheds, California: U.S. Geological Survey Hydrologic Investigations Atlas HA-734, 1 sheet.

Stewart, J.B., Kustas, W.P., Nichols, W.D., Moran, M.S., and deBruin, H.A.R., 1994, Sensible heat flux—radiometric surface temperature relation for eight semiarid areas: Journal of Applied Meteorology, v. 33, p. 1110-1117.

Thodal, C.E., in press, Hydrogeologic setting and ground-water quality of areas tributary to Lake Tahoe in Douglas County and Carson City, Nevada, through 1987: U.S. Geological Survey Water-Resources Investigations Report 94-4079.

Thomas, J.M., 1993, Carbon-14 dating of ground water in carbonate-rock aquifers of southern Nevada—A complex problem [abs.]: Geological Society of America, Abstracts with Programs, v. 25, no. 6, p. 90.

Thomas, J.M., and Lawrence, S.J., in press, Ground-water quality and geochemistry in Dayton, Stagecoach, and Churchill Valleys, western Nevada: U.S. Geological Survey Open-File Report 93-356.

Thomas, J.M., and Welch, A.H., in press, Geochemistry and isotope hydrology of representative aquifers in the Great Basin Region of Nevada, Utah, and adjacent states: U.S. Geological Survey Professional Paper 1409-C.

Thomas, J.M., Welch, A.H., Lico, M.S., Hughes, J.L., and Whitney, Rita, 1993, Radionuclides in groundwater of the Carson River basin, western Nevada and eastern California, U.S.A.: Applied Geochemistry, v. 8, no 5, p. 447-471.

Trask, N.J., Prudic, D.E., and Stevens, P.R., 1994, Hydrologic research programs of the U.S. Geological Survey relevant to low-level radioactive waste disposal [abs.]: Eos, American Geophysical Union Transactions, v. 75, no. 16, p. 160.

Trionfante, J.V., and Peltz, L.A., 1994, Hydrologic features of the Truckee and Carson River Basins and adjacent areas, western Nevada and eastern California: U.S. Geological Survey Open-File Report 93-638, 1 sheet.

Unger, R.W., in press, Evaluation of digital pressure sensors used to measure water levels at the Nevada Test Site, Nye County, Nevada [abs.]: U.S. Geological Survey Hydrologic Instrument Facility and Office of Ground Water Joint Workshop on Submersible Pressure Transducers, Lakewood, Colo., June 1994, Proceedings.

Van Denburgh, A.S., Goerlitz, D.F., and Godsy, E.M., in press, Depletion of nitrogen-bearing explosives wastes in a shallow ground-water plume near Hawthorne, Nevada, *in* Morganwalp, D.W., and Aronson, D.A., eds., U.S. Geological Survey Toxic Substances Hydrology Program—Proceedings of the technical meeting, Colorado Springs, Colorado, September 20-24, 1993: U.S. Geological Survey Water-Resources Investigations Report 94-4015.

Welch, A.H., in press, Ground-water quality and geochemistry in Carson and Eagle Valleys, western Nevada and eastern California: U.S. Geological Survey Open-File Report 93-33.

Welch, A.H., Szabo, Zoltan, Parkhurst, D.L., Van Metre, P.C., and Mullin, A.H., 1993, A limitation of gross-beta activity in environmental studies of ground water [abs.]: 35th Rocky Mountain Conference on Analytical Chemistry, Society for Applied Spectroscopy and American Chemical Society, Denver, Colo., July 1993, Program and Abstracts, no. 314.

Welch, A.H., Szabo, Zoltan, Parkhurst, D.L., Van Metre, P.C., and Mullin, A.H., 1993, A limitation of gross-beta activity in studies of naturally occurring beta-emitting radionuclides in ground water [abs.]: Eos, American Geophysical Union Transactions, v. 74, no. 43, p. 298.

Westenburg, C.L., 1993, Water-resources data for the Devils Hole area, Nye County, Nevada, July 1978-September 1988: U.S. Geological Survey Open-File Report 90-381, 13 p.

Whitney, Rita, 1994, Data on ground-water quality in the Carson River Basin, western Nevada and eastern Califonia, 1987-90: U.S. Geological Survey Open-File Report 94-39, 182 p.

Wood, D.B., 1992, Ground-water data collected at the Nevada Test Site and vicinity, Nye County, Nevada, water years 1988-89: U.S. Geological Survey Open-File Report 92-130, 50 p.

Wood, J.L., and Andraski, B.J., 1992, Selected meteorological data for an arid site near Beatty, Nye County, Nevada, calendar year 1989: U.S. Geological Survey Open-File Report 92-484, 27 p.

———in press, Selected meteorological data for an arid site near Beatty, Nye County, Nevada, calendar years 1990 and 1991: U.S. Geological Survey Open-File Report 94-489.

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