Water-Related Scientific Activities of the U.S. Geological Survey in Nevada, Fiscal Years 1991-92

Compiled by M. Teresa Foglesong

U.S. GEOLOGICAL SURVEY

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U.S. DEPARTMENT OF THE INTERIOR

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MESSAGE FROM THE NEVADA DISTRICT CHIEF

The shortage of water available to support economic development in Nevada has been chronic throughout the State's history. The U.S. Geological Survey began collecting water-resources data in northwestern Nevada in 1890. The population of the State has grown rapidly since the 1950's. This has caused an increasing need for more detailed and sophisticated techniques for resource assessment and for systematic collection of basic hydrologic information. This information is used to further define and quantify the geographic distribution of ground and surface waters, and to demonstrate how those water supplies vary in quantity and quality.

The maturing science of hydrology and the development of sophisticated techniques for resource assessment have grown concurrently with the State's population, economic development, and water use. The Nevada District has been cooperating with several Federal, State, and local water-management agencies in the use of state-of-the-art techniques to better define Nevada's water resources. Thus, District studies now include routine use of remote-sensing, real-time data transmission, comprehensive relational data bases, and multidimensional digital models. Virtually all data collected by the District are compatible with geographic information systems that rapidly are becoming the universal language of resource planners and managers. New techniques to directly produce film separates for printing text, illustrations, and maps are cutting months to years from the publication process for scientific reports. These techniques also improve the editorial and presentation quality of reports. Increasingly, study results are available as digital data sets in addition to printed reports.

Along with technological changes, human resources have evolved in the field of hydrology. As recently as the 1960's, the Geological Survey was the major source of training for hydrologists; today, several fine academic institutions, including the University of Nevada System, are graduating many competent water-resources professionals. Nevada District studies have benefited from the increased availability of trained hydrologists and earth scientists with advanced degrees. The scientific scope of the District's activities has diversified. It now includes interdisciplinary research in development of new mathematical models and fundamental investigations of water movement, such as recharge to the unsaturated zone and water consumption by native vegetation. However, increase in research activities has not been at the expense of basic long-term data networks. Since 1985, the Nevada District has been expanding basic-data networks throughout the State to better provide information on water supply and use to Federal, State, and local agencies, as well as the public. The District also has been actively assisting State agencies in developing and applying new computer technology to efficiently provide the public with timely information on water allocation and use.

Nevada is a State noted for paradoxes. It is the most arid and one of the least densely populated States in the Nation. But, most recent census data show that Nevada is also the State with the fastest growing population and is the fourth most urban State, with 88 percent of the population living in communities of 2,500 or more. In 1992, northern Nevada residents experienced the sixth consecutive year of drought. The major water issues in the State are the need for more accurate assessment of surface- and ground-water resources and of the effects of increased water use (and reuse) on the quality of those resources.

Nevada District activities related to these issues include (1) development of data networks and river-management models for the Truckee River and Carson River systems; (2) assessment of the effects of large-scale, open-pit mines on water resources in the Humboldt River basin; (3) evaluation of potential effects on local basins of water export to Las Vegas Valley; (4) assessment of ground-water availability and resultant management in areas targeted for, or affected by, urban development; (5) investigation of effects of agricultural irrigation on the quality and quantity of water supply to wetlands and wildlife areas; and (6) assessment of the potential long-term hydrologic effects of nuclear-weapons testing and nuclear-waste storage in southern Nevada.

This biennial activities report summarizes the growth in scope and complexity of the District's programs and projects during fiscal years 1991 and 1992. It is intended to serve as a wide overview of District operations and to provide information to guide further inquiries about specific projects and activities. I encourage readers to contact me or my staff regarding any questions or comments about the Nevada District activities.

Jon O. Nowlin
Nevada District Chief
U.S. Geological Survey
Water Resources Division

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FIGURES

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CONVERSION FACTORS AND DEFINITIONS

Multiply	By	To obtain
acre	4,047	square meter
acre-foot (acre-ft)	1,233	cubic meter
acre-foot per year (acre-ft/yr)	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 comprise 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 1991 began October 1, 1990, and ended September 30, 1991).

Water-Related Scientific Activities of the U.S. Geological Survey in Nevada, Fiscal Years 1991-92

Compiled by M. Teresa Foglesong

INTRODUCTION

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, 1990, to September 30, 1992. The organizational structure, District funding, and technical resources of the Nevada District, as well as water conditions throughout the State and some major water issues of the State during the past two fiscal years, are described herein.

The Nevada District program consisted of 43 projects during the past two 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 and publications to aid the reader in locating other Geological Survey products, is 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 groundwater 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) 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 lo-cal agencies, uses a variety of investigative and interpretive techniques to collect and transfer hy-drologic 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 hydrol ogy 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.

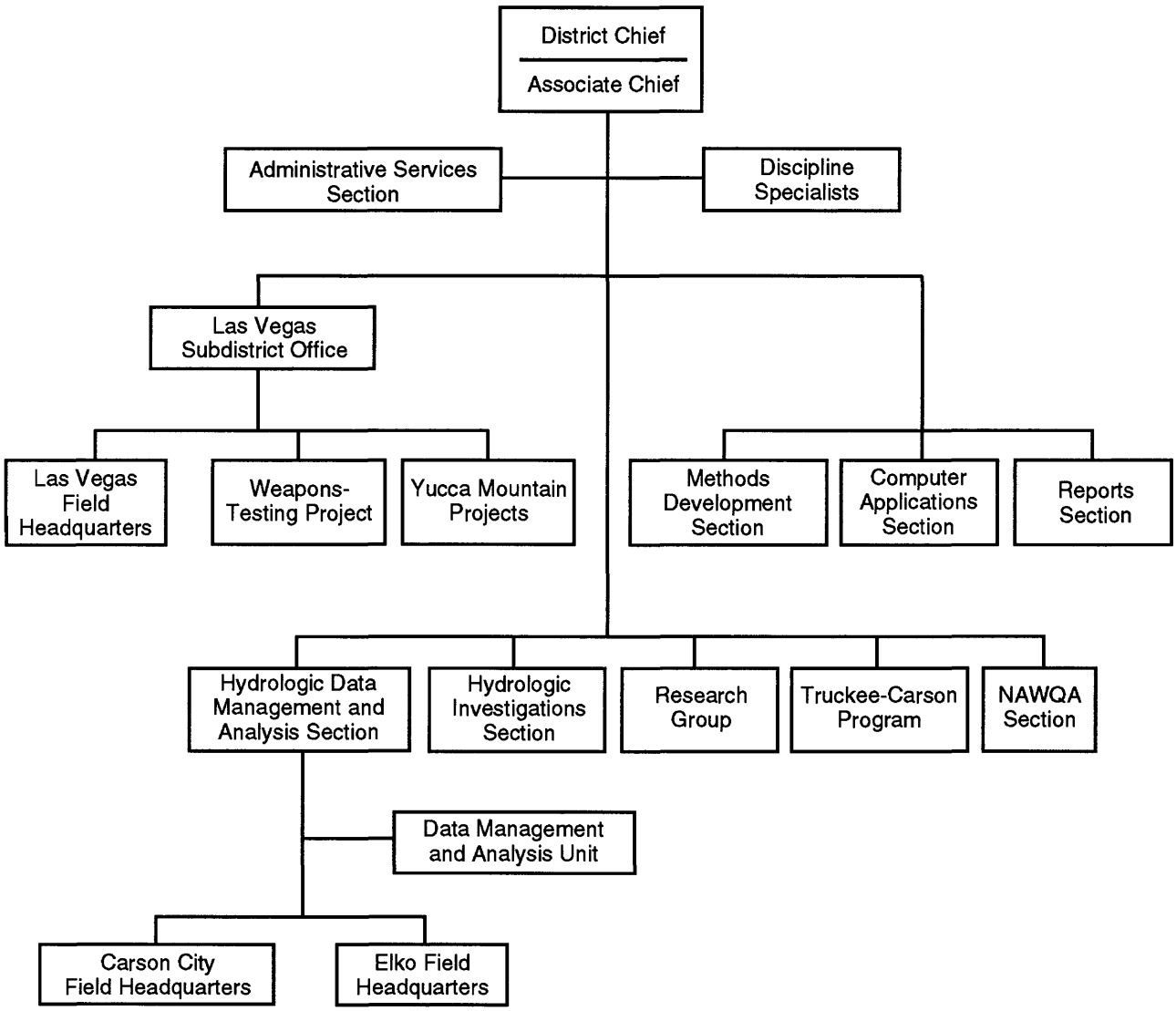


FIGURE 1.--Nevada District organizational structure. Abbreviation: NAWQA, National Water-Quality Assessment.

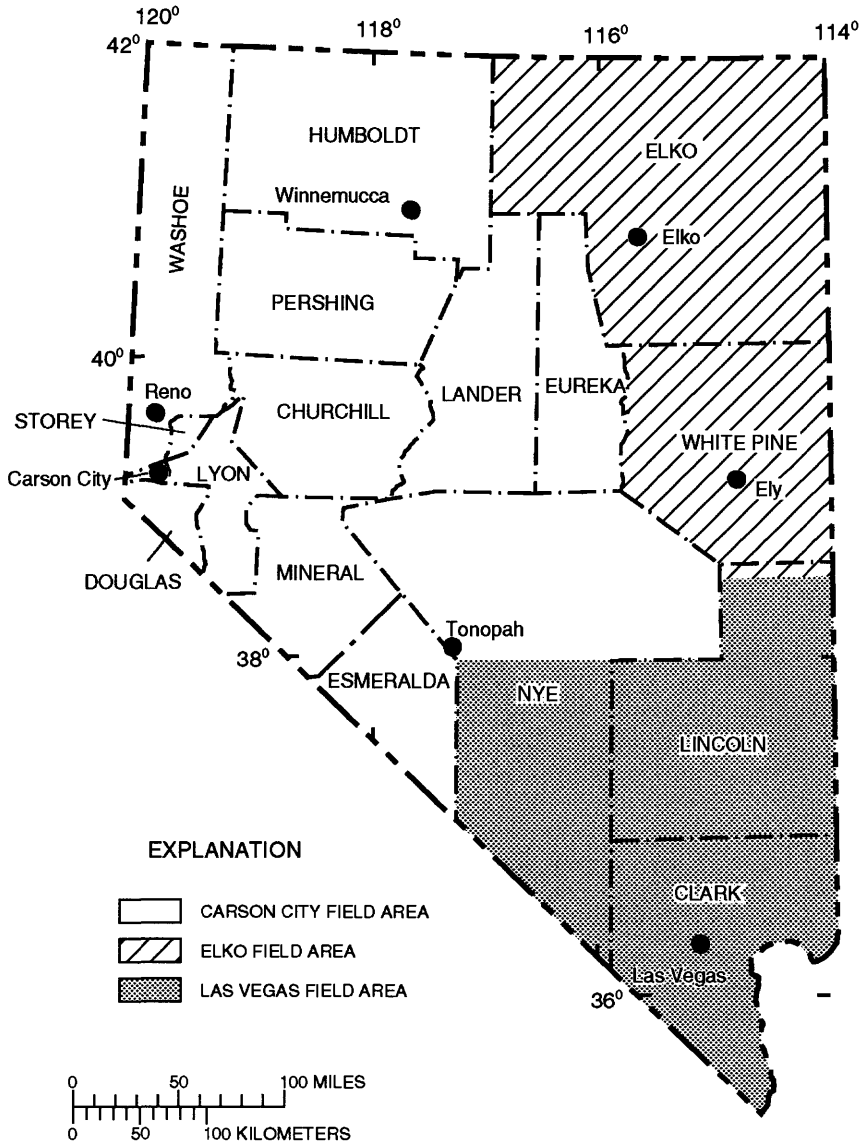


FIGURE 2.--General geographic areas of responsibility for basic-data collection by Nevada District Field Offices.

NEVADA DISTRICT, WRD

Organization

The Nevada District is responsible for water-related U.S. Geological Survey activities in Nevada. The Nevada District has a staff of about 150 employees, most of whom are in the District Office in Carson City; about 35 are in the Subdistrict Office in Las Vegas; and 3 are in the Field Office in Elko. These staffing figures represent more than a 150-percent increase from levels of 7 years ago 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 of each office is shown in figure 2.

During February 1992, the Las Vegas Subdistrict Office moved into a new building at 6770 South Paradise Road. During April 1992, the Carson City District Office moved into a new 22,000-square-foot office facility at 333 West Nye Lane. The Carson City Field Office and Beatty project personnel moved during July 1992 into the last phase of the new USGS District office, an 8,000-square-foot building housing offices, laboratory facilities, and a warehouse.

Addresses and phone numbers of the three WRD 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 1991 and 1992 are listed in table 1 and shown in figure 3. Total funds increased from $7.9 million in fiscal year 1991 to $10.1 million in fiscal year 1992. Cooperating agencies active during the period 1991-92 are listed in tables 2 and 3.

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. 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).

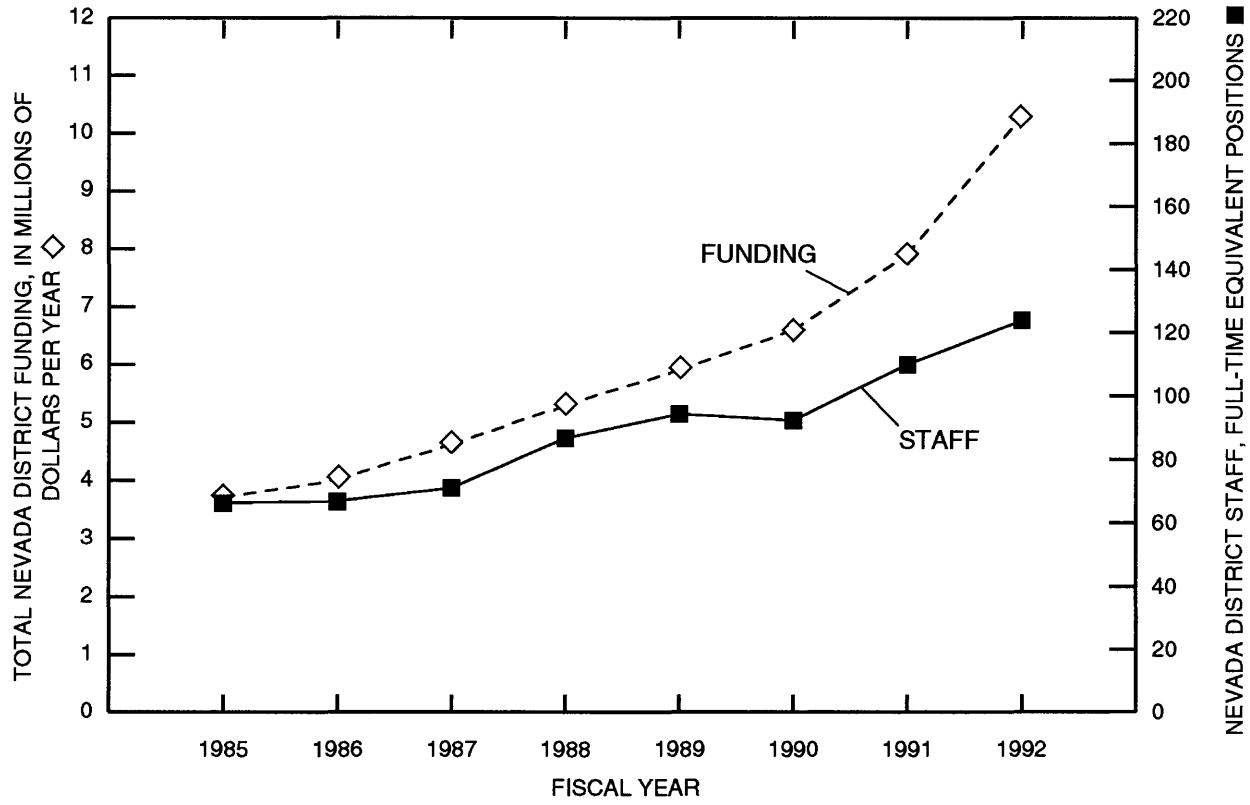
The staff is well educated. In fiscal year 1992, about 69 percent of the total staff had college degrees, including four Ph.D.'s. About 5 percent of the support staff (administration, computer, and reports sections) had college degrees. Technical skills of the District staff reflect the broad interdisciplinary nature of the Nevada program.

Table 1. Nevada District budget, fiscal years 1991-93 (in thousands of dollars; OFA, other Federal agencies)

	Fiscal year		
	1991	1992	1993[a]
Federal Program	$1,847	$3,439	$3,460
OFA Reimbursable Program	2,110	2,827	2,960
Cooperative Program			
Federal share	1,828	1,761	2,160
State and local share	2,147	2,090	1,790
TOTAL FUNDING	$7,932	$10,117	$10,370

[a] Projected.

A. Trend in total funds and staff, fiscal years 1985-92.



B. Funding from major types of programs, fiscal years 1991-92.

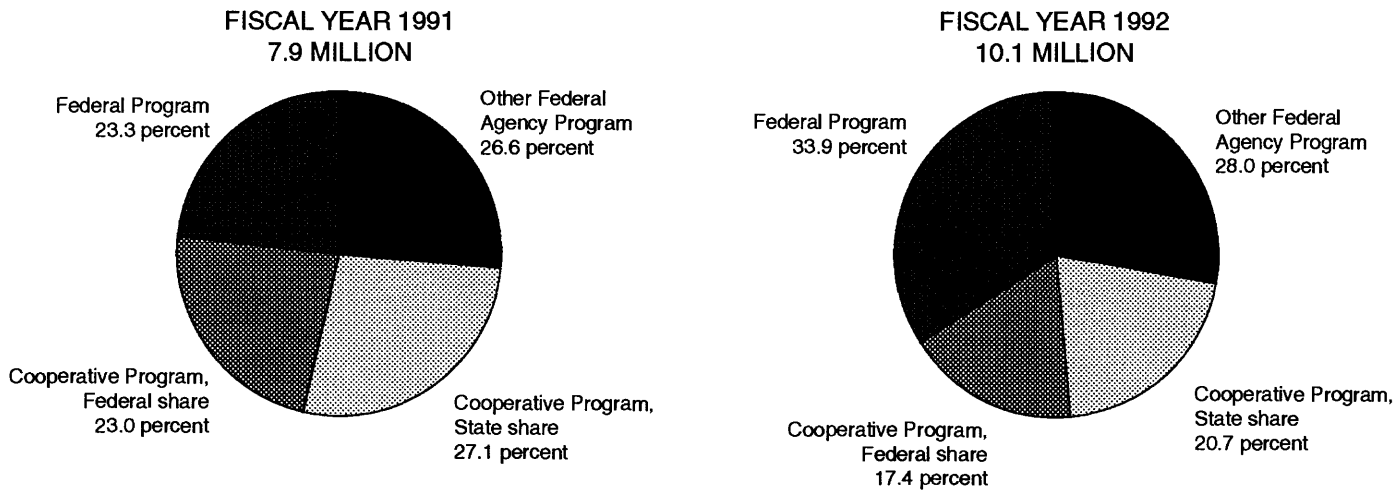


FIGURE 3.--Growth of Nevada District program and staff, and distribution of funding.

Table 2. Cooperating State and local agencies

State agencies
California Department of Water Resources
Nevada Bureau of Mines and Geology
Nevada Department of Conservation
and Natural Resources
Division of Environmental Protection
Division of Water Resources
Nevada Department of Transportation
Nevada Department of Wildlife
Carson Water Subconservancy District
Local agencies
Carson City Public Works Department
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
Elko County
Las Vegas Valley Water District
Regional Water Planning and Advisory Board-Reno-Sparks and Washoe County
South Tahoe Public Utility District
Summit Lake Paiute Tribe
Tahoe Regional Planning Agency
Truckee-Carson Irrigation District
Walker River Irrigation District
Washoe County
Department of Public Works
Department of Comprehensive Planning

Table 3. Cooperating Federal agencies

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

Computer Facilities

The Nevada District operates a multi-platform system of computers in all three offices networked with a Prime computer in the District office to maintain computerized data bases; process graphic information; model hydrologic systems; analyze remote-sensing imagery; develop geographic information systems (GIS); and perform word processing, computer graphics, mathematical processing, and other functions. This system is a node in the Distributed Information System (DIS-I) of the Water Resources Division, which links the USGS headquarters in Reston, Va., with WRD offices across the Nation (figure 4A). Dedicated communication lines link Nevada Field Offices in Elko and Las Vegas, and offices of some cooperators, to the District Office in Carson City (figure 4B). The computer system supports more than 100 simultaneous-user processes. Peripheral hardware has more than 5 gigabytes (5,000,000,000 bytes) of networked, online, high-speed disk storage; more than 80 user terminals; personal computers; large- and small-scale plotters; large- and small-scale digitizers; mechanical, color, and laser printers; flood-alert and real-time data networks; and mechanical, electronic, and digital-data recorders.

Early in 1991, the Geological Survey began developing the second-generation National Distributed Information System (DIS-II), which is based on Data General Aviion 32-bit fileservers and graphic workstations in local area network (LAN) and wide area network (WAN) configurations. Transition from the central Prime computer in the Carson City Offices 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 take place over a 3- to 4-year period. LAN's were installed in Carson City and Las Vegas in 1992, and the offices were tied into a WAN with the Nevada Department of Data Processing, to share existing State telecommunications lines (figure 4B). The District will be linked to the National USGS network by upgraded telecommunication lines providing access to the international network INTERNET. By the end of fiscal year 1992, the District system included a Prime 6350, Aviion 6220 fileserver, 16 workstations, 48 personal computers, and 3 Macintosh computers (for report illustrations and maps). New networks have been defined and developed so all Divisions of the Geological Survey, other Bureaus of the Department of the Interior, and State agencies can connect with and use the workstation technology.

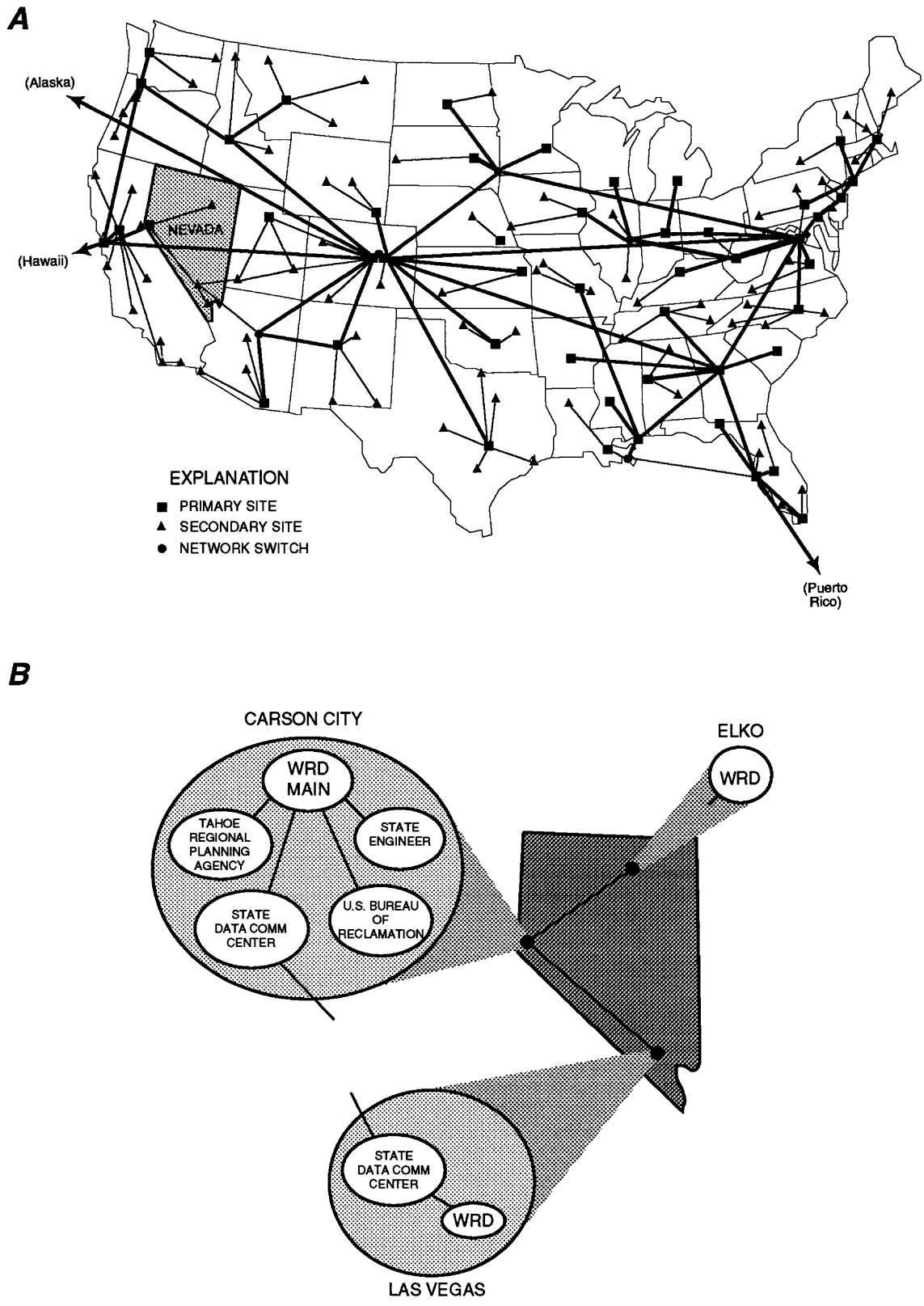


FIGURE 4.-- National Distributed-Information-System network of the Water Resources Division (WRD) *(A)* and wide area network of the Nevada District *(B)*.

Data-Base Management

The primary storage function of the Nevada District computer system is to maintain the National Water-Information System (NWIS) data bases. NWIS includes 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. Information collected as part of basic-data programs and interpretive studies is stored in NWIS data bases at all WRD District offices. Data are nationally aggregated in the National Water-Storage and Retrieval data base (WATSTORE), which is maintained on a large mainframe computer at USGS headquarters in Reston, Va.

The Nevada District has been encouraging State and local agencies to develop and integrate hydrologic information systems. The most recent major effort began in fiscal year 1991 as a cooperative program between USGS and Nevada Division of Water Resources (NDWR) to build a common environment for automation of hydrologic data using DIS-II technology. The first effort has been to develop a Nevada Water Permit File for efficient processing and storage of point-of-diversion and point-of-use data on surface- and ground-water withdrawals. The Water Permit File became operational on a fileserver in February 1992, and is operated and maintained by NDWR staff. Future phases of the program will integrate the State drillers' log files into the common system and provide GIS coverages. The resultant hydrologic information system is intended to provide a multi-agency, multi-user, common data base. This will save money through more efficient data capture and processing and provide more consistent information for resources assessment and management.

The Nevada District also is cooperating with the Nevada Division of Environmental Protection (NDEP) and the U.S. Environmental Protection Agency (USEPA) to develop interagency software for efficient capture and quality assurance of water-quality data from major laboratories in the State. Software has been developed using available spreadsheet formats to capture data from local laboratory data systems, process the data, screen for apparent errors, and create data sets compatible with USGS NWIS and USEPA STORET systems. Quality-assurance programs of NWIS are used by NDEP to screen the analytical data for potential errors prior to downloading to STORET. The USEPA is evaluating the system for potential National distribution and initial District applications are integrating data from State and local monitoring networks.

Geophysical Data Collection

The Nevada District uses surface- and borehole-geophysical methods to investigate hydrologic problems. Various surface-geophysical instrumentation, 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 (electromagneto-tellurics, 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, 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 Wildlife Management Area. Hourly well-water levels are monitored electronically 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 20 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 U.S. Geological Survey 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 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 Committee, Mackay School of Mines Advisory Board, Nevada Nonpoint-Source Pollution Task Force, USDOE Nevada Operations Office Environmental Action Committee, 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, and Truckee River Water-Quality Strategy 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, and Radiochemical Advisory Committee. In addition, Nevada District staff teach National USGS training courses.

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 have participated in several 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 position of Nevada District Public Information Assistant (PIA) was established in Carson City in late 1990. The 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 1 inch of annual runoff. 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 southeast 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.

Drought conditions continued in Nevada for the fifth consecutive year in water year 1991 (October 1, 1990, through September 30, 1991). Flows in the major streams ranged from 30 to 60 percent of average in the Sierra Nevada and from 20 to 40 percent along the Humboldt River. Colorado River below Hoover Dam flowed at 88 percent of its long-term average.

In water year 1992, drought conditions intensified in northern Nevada. Flow in the major streams generally ranged from 20 to 40 percent of long-term average. Precipitation during February and March 1992 greatly exceeded average annual precipitation at most locations in southern Nevada, but no significant flooding occurred.

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, and lowest during high streamflow due to dilution by precipitation or snowmelt runoff. Surface-water quality declines significantly near the downstream ends of internal drainages because of the concentrating effects of evaporation.

Surface-water quality did not change significantly in most streams during 1991-92; however, data from a few areas are worthy of note. High mercury concentrations in surficial soil and bottom sediments of the lower Carson River drainage system, the result of 19th-century ore-milling operations associated with the Comstock Lode, have caused recent environmental concern. Continued urbanization in the Las Vegas metropolitan area has accelerated sediment erosion and increased sediment transport in Las Vegas Wash because of increased discharge from wastewater effluent and urban runoff.

Ground Water

Development of ground-water supplies in Nevada continued at increasing rates during water years 1991-92. Drillers' logs of 4,376 wells were submitted to the State Engineer's office; 1,869 were for wells drilled in water year 1991 and 2,507 were for wells drilled in water year 1992. The number of logs submitted in 1992 was the highest of any years on record. Of the 4,376 logs submitted during the 2-year period, about two-thirds were of wells drilled for domestic use; the remainder were of wells drilled for exploration, industrial and public supply, and irrigation use.

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 1992, was still minor compared to 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.

Ground-water levels fluctuate in the short and long term in response to seasonal and 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

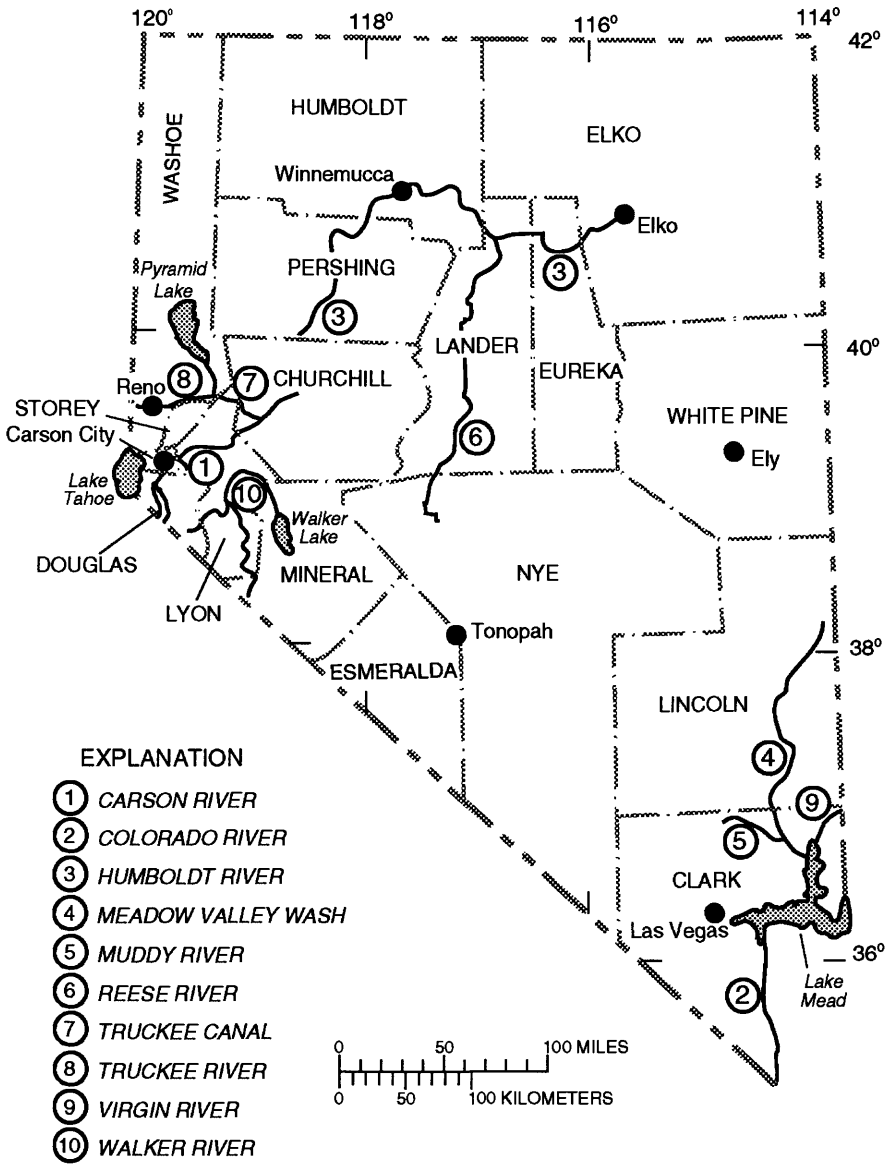


FIGURE 5.--Principal streams and lakes in Nevada.

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 significantly declined during the second half of the 1980's and early 1990's as a result of six consecutive drought years. In developed basins, water levels fluctuate during heavy pumping in summer. This is in addition to a long-term decline in water levels caused by pumping ground water from storage.

Drought

Water years 1991 and 1992 marked the fifth and sixth consecutive years of severe drought in northern Nevada. Cumulative flow in Sierra Nevada rivers and in the Humboldt River for the period 1987-92 was less than cumulative flow in those rivers during the historic drought of 1929-34. The level of Lake Tahoe has been below the rim since September 1990, the longest such period since records began in 1900. The lake level dropped to about 2 feet below the rim during autumn 1992, also the lowest level since 1900. Figure 6 shows flow in the Carson and Humboldt Rivers in 1991-92 compared to the long-term average.

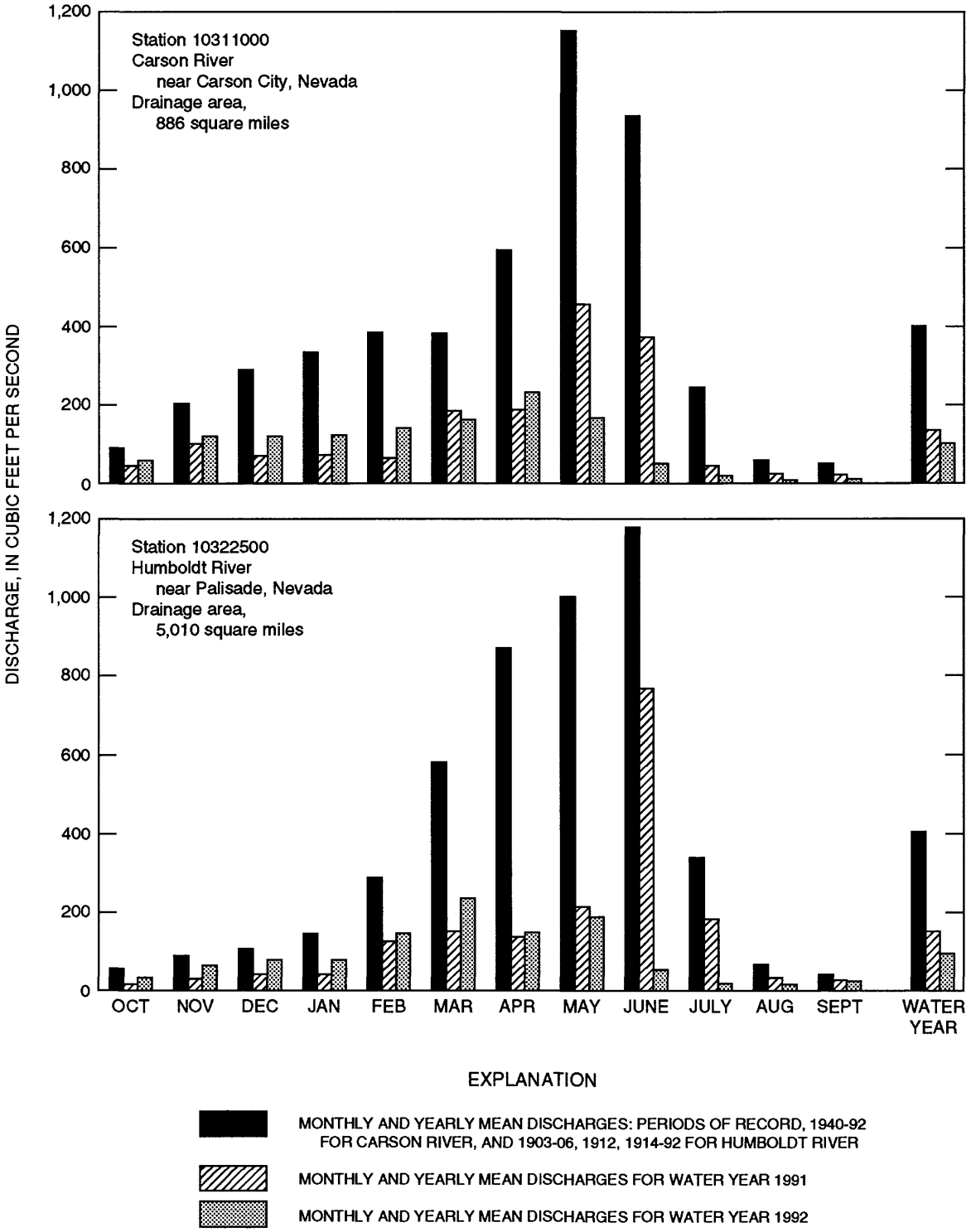


FIGURE 6.--Comparison of discharge during water years 1991-92 with long-term average discharge at two representative gaging stations.

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.

MAJOR WATER ISSUES IN NEVADA

Urban Water Use

The population in Nevada increased by more than 63 percent in the 1970's, and by 55 percent in the 1980's (see figure 7). The population of Nevada in 1992 was about 1.3 million, according to the State Demographer's Office at the University of Nevada, Reno. The major growth centers in Nevada are Las Vegas Valley and vicinity in the southeast; Reno-Sparks, Carson City, and Minden-Gardnerville 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 about 12 people per square mile. However, more than 88 percent of the population lives in communities of 2,500 people or more, according to the U.S. Bureau of Census. Population growth around these urban centers makes Nevada the fourth most urban State in the Nation.

The Truckee River, which flows from Lake Tahoe through the Reno-Sparks metropolitan area to

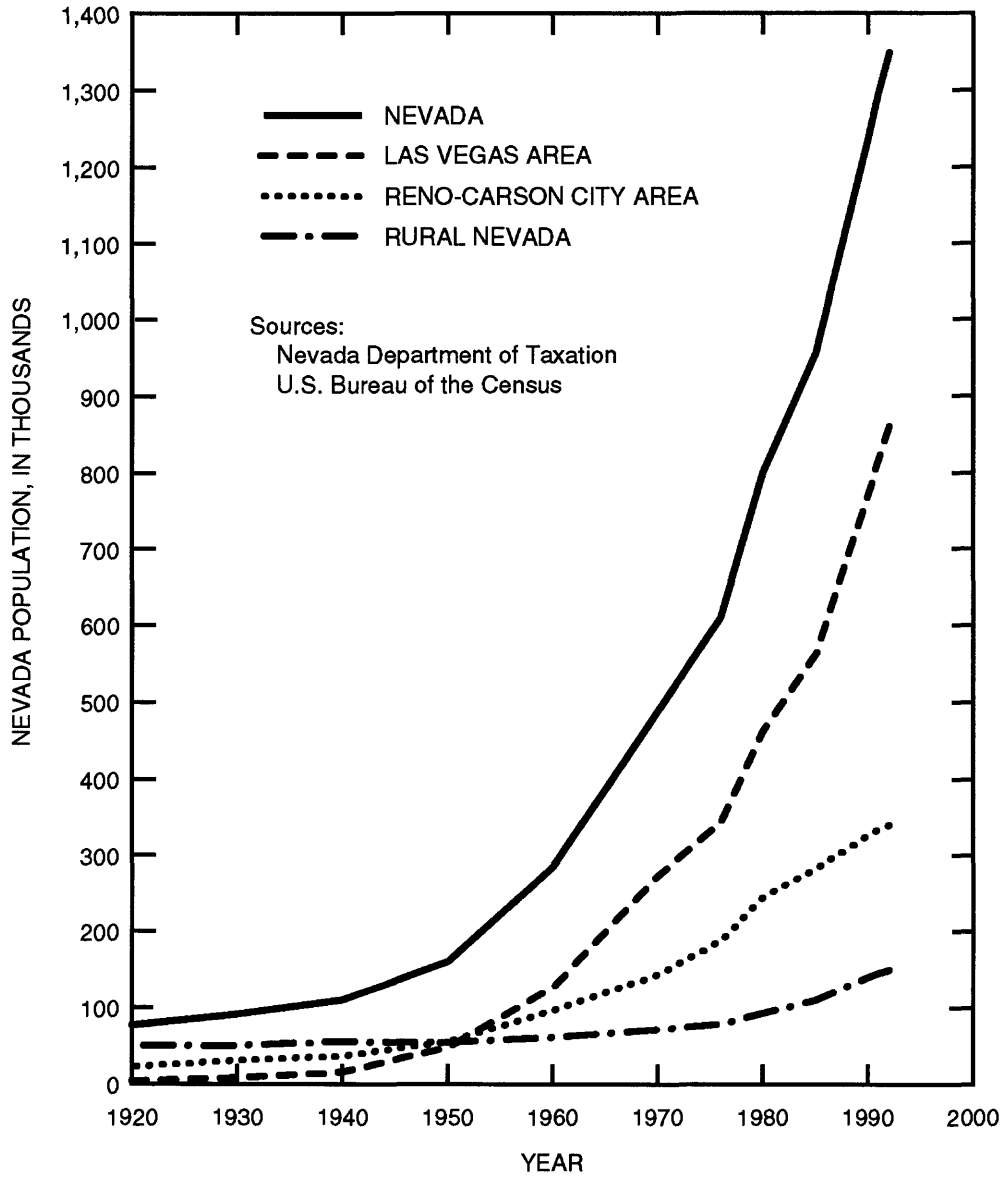


FIGURE 7.--Nevada population trends, 1920-92.

Pyramid Lake, is the major source of water for the Reno-Sparks area. Water rights for the Truckee River are entirely allocated, water-use restrictions have been imposed in the metropolitan area for the past five summers, and few local resources are left to support the continuing population growth. This has prompted the search for ground-water sources in an ever-widening region of northwestern Nevada. Although the water level of Lake Tahoe has remained below its natural rim since September 16, 1990, it has not been necessary to pump water from the lake to meet downstream needs.

Las Vegas Valley has two sources of water supply: Lake Mead and the basin-fill aquifer beneath Las Vegas Valley. Water levels in the basin-fill aquifer near heavily pumped wells have declined 10-15 feet since 1985, with seasonal fluctuations of about 30 feet. Colorado River water is fully allocated, with about 300,000 acre-feet per year set aside for Las Vegas, Nev. Currently, this allocation is not fully used; however, population growth and the associated demand for water are expected to exceed this allocation within the next decade. To obtain additional supplies, the Las Vegas Valley Water District (LVVWD) filed applications in 1989 to withdraw 864,000 acre-feet of ground water from 26 basins in Lincoln, Nye, and White Pine Counties and 70,000 acre-feet of surface water from the Virgin River in Clark County for use in Las Vegas Valley. However, current (mid-1992) plans propose pumping only about 181,000 acre-feet per year from 21 basins. If granted, the importation of water to Las Vegas would require an estimated $1.5 billion to build the required system of wells and pipelines. The rural counties oppose the Water District's application. The application filings also have caused concern for four Department of the Interior agencies (U.S. Bureau of Indian Affairs, U.S. Bureau of Land Management, National Park Service, and U.S. Fish and Wildlife Service). About 60 threatened or endangered plant and wildlife species are found in the area and could be affected by the transfer of water.

Urbanized areas of Nevada occupy a small percentage of the total area of the State. All urbanized areas will depend increasingly upon importation of water from, and ultimate exportation of wastes to, surrounding valleys. Concurrent with the recent population boom in urban areas has been the resurrection of the Nevada gold and silver industry. The largest scale mining development to date has been in the Humboldt River basin, which also has been considered as a potential source of additional water for northwestern Nevada. Conceptually, the needs of the mines to dispose of "waste" water from regional-scale dewatering operations could coincide with urban needs for more imported water. However, the resultant water-development projects could have significant long-term effects on water budgets and water quality in many rural valleys in and near the Humboldt River basin. In 1992, the total pumpage of ground-water for mine dewatering in the Humboldt River basin exceeded the combined annual flows of the Humboldt, Truckee, Carson, and Walker Rivers.

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. Owing to the continuing drought, surface-water allocations within irrigation districts were reduced, as was the amount of water delivered to water-right holders. In the Truckee-Carson Irrigation District (TCID), which includes the Newlands Project near Fallon, water allocations for 1992 were 28 percent of normal (M. Lipnicki, TCID, oral commun., 1992). In the Pershing County Water District, water allocations were 10 percent of normal (Sacramento Bee, July 27, 1992). In the Truckee Meadows, the Federal Water Master stopped the delivery of water to irrigation ditches on June 8, 1992; this was the earliest date that water deliveries were shut off. During normal water years, the irrigation ditches run until October 1 (Reno Gazette-Journal, June 4, 1992). The Governor declared 14 of Nevada's 17 counties as agricultural drought disaster areas.

As Nevada communities reach the maximum amount of water they can withdraw through their current water rights, the largest amount of water available to them is through the purchase or leasing of agricultural water rights. However, irrigation districts and farmers are reluctant to support long-term leasing of agricultural rights for urban use because they do not want to see the abandonment of their agrarian lifestyle that this change in use would cause.

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, the Fallon Paiute-Shoshone Tribal Settlement Act of 1990, and the Truckee-Carson-Pyramid Lake Water Rights Settlement Act, were signed into law in November 1990. Section 205 of the 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.

Water allocation in the Truckee and Carson Rivers is managed under several Federal Court decrees by an "interim" (since the mid 1930's) Federal Water Master. Major reservoirs and diversions on the Truckee and lower Carson Rivers are U.S. Bureau of Reclamation (USBR) projects. Most are operated under contract by TCID.

The USGS operates 54 streamflow-gaging stations and 26 water-quality monitoring stations in the Truckee River and Carson River basins as of September 30, 1992. The Truckee-Carson River-Quality Assessment Program of the 1970's and 1980's developed a calibrated daily nutrient and oxygen model for the Truckee River to address some of the water-quality issues. This work indicated that a daily or hourly streamflow model would be required before more detailed water-quality models could be developed. The new Truckee and Carson Rivers project will adapt, develop, and calibrate streamflow and selected water-quality models for the Truckee River and Carson River basins to assist water-resources planning and management required to implement the many provisions of Public Law 101-618.

Pyramid Lake Requirements

In response to the Pyramid Lake Indian Tribe and U.S. Fish and Wildlife Service (USFWS) legal challenges, USBR adopted a new set of Operating Criteria and Practices in 1988 for TCID Truckee River diversions. The result will significantly reduce streamflow diversion to the Newlands Irrigation Project at Fallon in favor of increased flows to Pyramid Lake. The environmental effects of the changes in water allocation within, and between, the two river basins (Truckee and Carson) will be addressed as part of the requirements of Public Law 101-618.

Irrigation-Induced Contamination at Stillwater Wildlife Management Area

Stillwater Wildlife Management Area (WMA) is one of four western hemisphere shore-bird reserves. Irrigation drainage from the Newlands Irrigation Project, which contains elevated concentrations of dissolved solids and potentially toxic trace elements, is the principal source of water to the Stillwater WMA. In a physical environment having some similarities to the Kesterson area in California, contaminants that may cause adverse biological effects for fish and wildlife include arsenic, boron, mercury, and selenium.

The water-supply and water-quality issues are complicated by legal and environmental pressures on the USBR to reduce diversions from the Truckee River to the Newlands Irrigation Project, potentially resulting in greatly reduced inflows to Stillwater WMA. Among the solutions provided in Public Law 101-618 is the allocation of at least $9 million in Federal funds, to be matched by State funds, for the purchase of agricultural water rights to guarantee a secure water supply to Stillwater WMA. About 3,600 acre-feet of irrigation water rights were purchased for Stillwater WMA during 1991-92 by USFWS and conservation groups, bringing the total water rights purchased--including Carson Lake--to about 8,300 acre-feet. This redistribution of significant amounts of water in the Fallon area may have long-term effects on water levels and water quality in the local shallow aquifers currently used for domestic water supplies. USGS is providing information on the hydrogeologic framework of the Carson Desert to USBR and information on the shallow ground-water flow paths to USFWS to aid in developing water-rights transfer strategies.

National Water-Quality Assessment Program

Owing 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 one area for a pilot NAWQA ground-water study. 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 water resources, and to provide a scientific understanding of the primary natural and human factors that affect water quality. The Nevada Basin and Range NAWQA, which includes the Truckee River and Carson River basins and Las Vegas Valley, is 1 of 20 initial full-scale studies started in FY 1991.

Weapons-Testing 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.

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 Water Resources Division in Nevada assists the 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.

Other Nevada District Projects

The Nevada District is involved in four other projects that address water-resources issues and are worthy of note. A project (NV158) began in 1990 to define the potential effects of possible global climate change on the water resources of the North Fork American River and Carson River basins and to develop analytical tools to assess effects of climate change on small-basin water resources. This project is improving the science of watershed modeling by using remote-sensing techniques and geographic information systems to design and calibrate watershed models for the two basins.

An evapotranspiration (ET) project (NV156) began in the Smoke Creek Desert of northwestern Nevada and in the Thousand Springs area of northeastern Nevada. This project is measuring the areal variability of ET from native vegetation assemblages by monitoring water-vapor discharge during two growing seasons. ET-landcover relations are being used to quantify total ET as a water-budget component in the study areas. The study of two contrasting basins is expected to provide a better test of the theory, contrasting methods, and transferability of the study to other areas.

Another project (NV175) was started to improve the reconnaissance estimates of ET in Railroad Valley. The relation between measured ET and depth to water along a transect, with variations in measured plant transpiration, will be studied.

Land subsidence and fissures due to groundwater withdrawals continue to be a major concern in Las Vegas Valley. USGS began a project (NV169) to develop a new three-dimensional granular-velocity model to help determine where fissures may most likely occur, and to provide information as to their potential magnitude.

PROJECTS FUNDED IN FISCAL YEARS 1991-92

Surface-Water Data Network *(Project 001)*

Location: Statewide in Nevada and eastern California.

Project Chief: Richard D. Hayes.

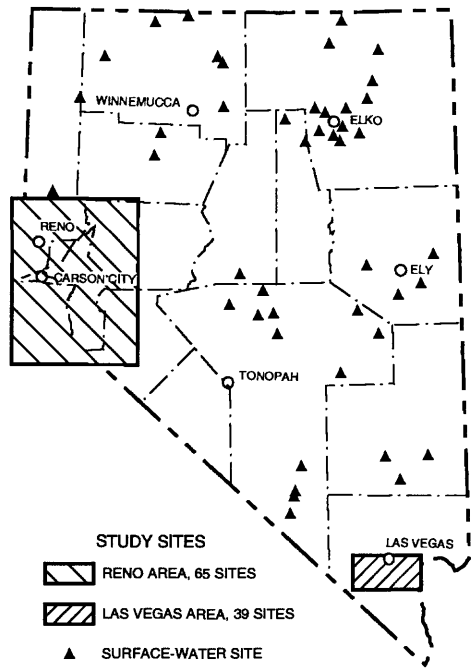
Period of Project: Continuous since 1894.

Cooperating Agencies: Carson City Public Works Department, 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 Department of Wildlife, South Tahoe Public Utility District, Summit Lake Paiute Tribe, Truckee-Carson Irrigation District, U.S. Army Corps of Engineers, U.S. Board of Water Commissioners, U.S. Bureau of Land Management, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, Walker River Irrigation District, 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 1991-92: Continuous streamflow monitoring at year-round and irrigation-season stations continued throughout 1991-92. The number of year-round sites and irrigation-season sites increased in 1991 and 1992. 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 1993: 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 1991-92:

Blackstun, D.E., 1991, Development of a real-time detection system for flood hazards in Clark County, Nevada [abs.]: American Water Resources Association, Symposium on Urban Hydrology and Drainage Issues, Denver, Colo., November 1990.

Bostic, R., Hitch, D. Van Gordon, L., and Swanson, R., 1991, Water resources data, Nevada, water year 1990: U.S. Geological Survey Water-Data Report NV-90-1, 358 p.

Garcia, K.T., Gortsema, G.C., Pennington, R.N., and Preissler, A.M., 1992, Water resources data, Nevada, water year 1991: U.S. Geological Survey Water-Data Report NV-91-1, 481 p.

Ground-Water Data Network (*Project 002*)

Location: Statewide.

Project Chief: Richard D. Hayes.

Period of Project: Continuous since 1945.

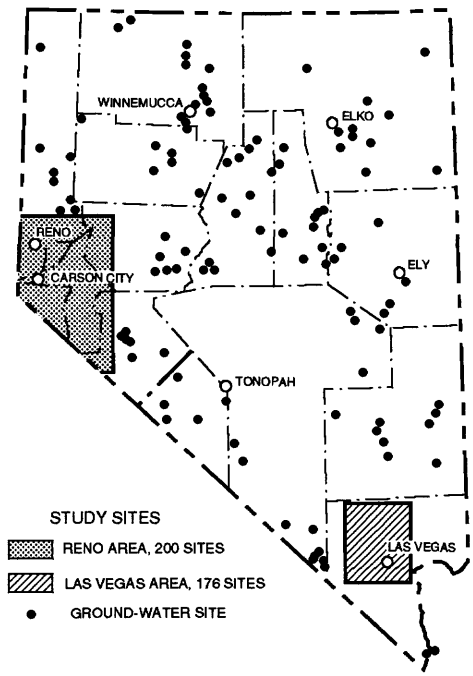
Cooperating Agencies: Carson City Public Works Department, Douglas County, Las Vegas Valley Water District, Nevada Bureau of Mines and Geology, Nevada Division of Water Resources, and Washoe County.

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 impact 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, as local land use changes, and as other needs arise.

Progress and Significant Results, Fiscal Years 1991-92: 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. The Nevada State Engineer was supplied with color graphs for the State and by county for calendar year 1991 showing the number of wells drilled and proposed use. An additional 50 sites were funded and added to assist Washoe County in collecting water-level information in Spanish Springs Valley.



Plans for Fiscal Year 1993: Ground-water data collection, computation, and compilation will continue. The Nevada State Engineer will be supplied with color graphs by county for calendar year 1992 showing the number of wells drilled and proposed use. The annual water-data report will be compiled and submitted for approval and publication.

Publications, Fiscal Years 1991-92:

Bostic, R., Hitch, D., Van Gordon, L., and Swanson, R., 1991, Water resources data, Nevada, water year 1990: U.S. Geological Survey Water-Data Report NV-90-1, 358 p.

Burbey, T.J., 1991, Water-level and pumpage data for Las Vegas Valley, Clark County, Nevada, 1986-90: U.S. Geological Survey Open-File Report 91-496, 122 p.

Garcia, K.T., Gortsema, G.C., Pennington, R.N., and Preissler, A.M., 1992, Water resources data, Nevada, water year 1991: U.S. Geological Survey Water-Data Report NV-91-1, 481 p.

Wood, D.B., 1991, Water-level changes associated with ground-water withdrawals and surface water imports, Las Vegas Valley, Nevada, 1981-83: Nevada Division of Water Resources, Information Report 32, 75 p.

-----1991, Water-level changes associated with ground-water withdrawals and surface-water imports, Las Vegas Valley, Nevada, 1983-85: Nevada Division of Water Resources, Information Report 33, 70 p.

Water-Quality Data Network (*Project 003*)

Location: Statewide and eastern California.

Project Chief: Richard D. Hayes.

Period of Project: Continuous since 1939.

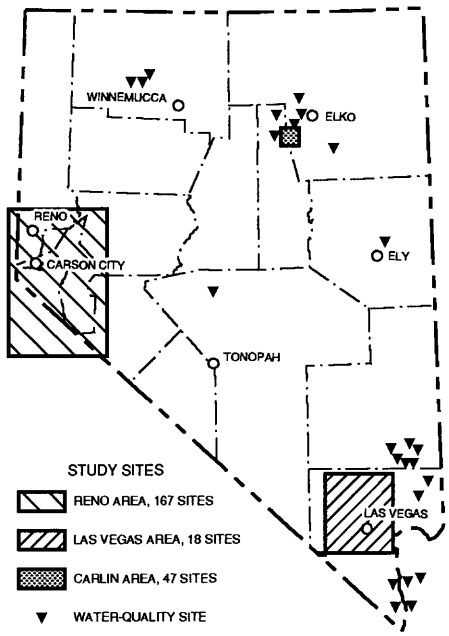
Cooperating Agencies: Carson City Public Works Department, City of Las Vegas, Douglas County, Nevada Department of Wildlife, Nevada Division of Environmental Protection, Nevada Division of Water Resources, U.S. Bureau of Land Management, and U.S. Fish and Wildlife Service.

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-term 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 1991-92: Sampling increased from 131 active sites in water year 1991 to 232 active sites in water year 1992. Data collection and analysis continued using improved statistical techniques. All data were processed and stored in the National Water-Information System computer data base. 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 1993: Data collection and analysis will continue. The annual water-data report will be compiled and submitted for approval and publication.

Publications, Fiscal Years 1991-92:

Bostic, R., Hitch, D., Van Gordon, L., and Swanson, R., 1991, Water resources data, Nevada, water year 1990: U.S. Geological Survey Water-Data Report NV-90-1, 358 p.

Garcia, K.T., Gortsema, G.C., Pennington, R.N., and Preissler, A.M., 1992, Water resources data, Nevada, water year 1991: U.S. Geological Survey Water-Data Report NV-91-1, 481 p.

Garcia, K.T., and Jacoboni, J.M. 1991, Data on ground-water quality in the Winnemucca District of the U.S. Bureau of Land Management, northwestern Nevada, 1934-87: U.S. Geological Survey Open-File Report 89-424, 150 p.

Sediment Stations *(Project 004)*

Location: Southern Nevada.

Project Chief: Richard D. Hayes.

Period of Project: Continuous since 1992.

Cooperating Agency: Las Vegas Valley Water District.

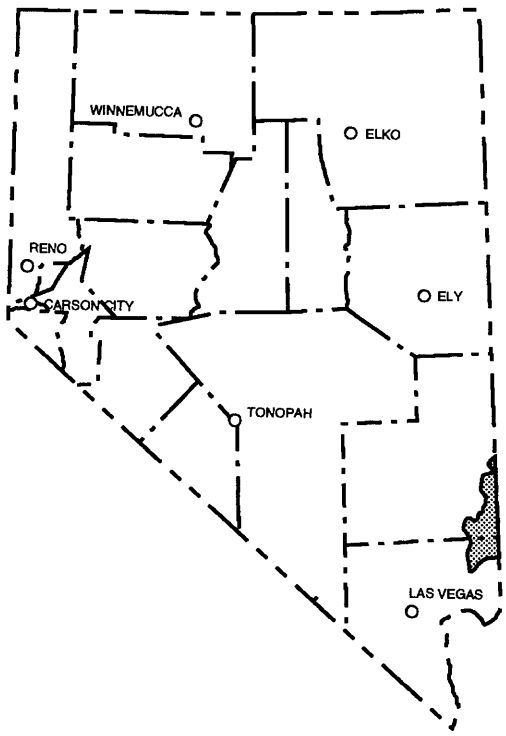
Problem: Sediment data are needed for purposes of surveillance, planning, design, hazard warning, operation, and management in water-related fields such as water supply, hydroelectric power, flood control, irrigation, bridge and culvert design, wildlife management, pollution abatement, flood-plain management, and water-resource development. It is necessary to maintain these data 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 Results, Fiscal Year 1992: Gaging and sediment-monitoring equipment were installed and data collection began.

Plans for Fiscal Year 1993: Data collection, computation, and compilation will continue. The 1992 sediment data will be prepared for inclusion in the annual water-data report.



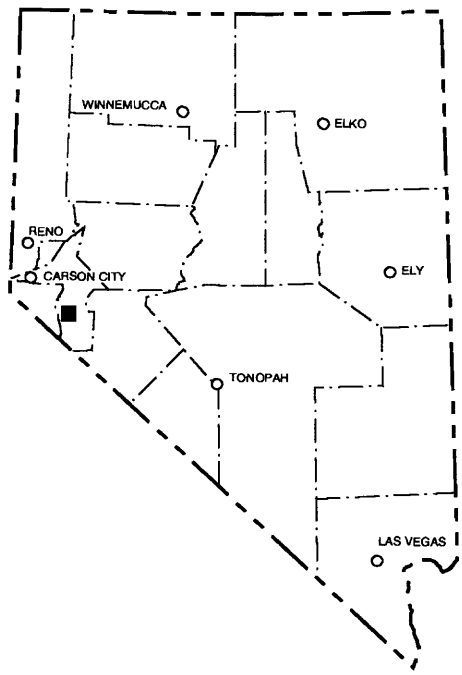
National Trends Network for Monitoring Atmospheric Deposition *(Project 005)*

Location: Smith Valley in western Nevada.

Project Chief: Richard D. Hayes.

Period of Project: Continuous since 1985.

Supporting 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: A single atmospheric-deposition sampler is being operated in Smith Valley, Nev. The sampler is checked weekly and samples are collected and analyzed for pH and specific conductance when sufficient precipitation occurs.

Progress and Significant Results, Fiscal Years 1991-92: Only 48 samples contained adequate quantities of precipitation for field determination of pH and specific conductance in 1991-92. 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 1993: Sample collection and compilation of data from the Smith Valley site will continue.

Flood-Insurance Studies (*Project 006*)

Location: Northern Nevada.

Project Chief: Rhea P. Williams.

Period of Project: Continuous since 1985.

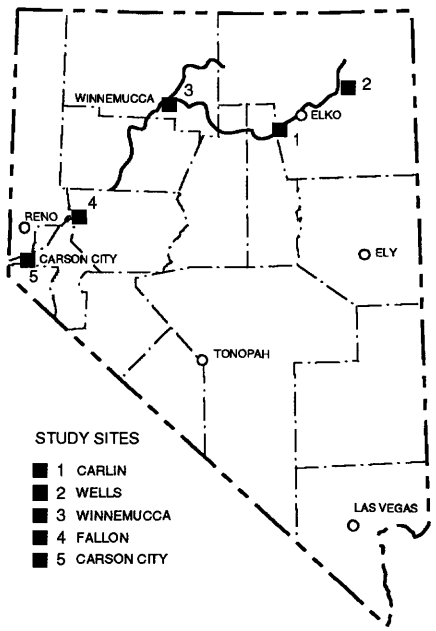
Supporting Other Federal Agency: Federal Emergency Management Agency.

Problem: Flooding in arid regions can be devastating because most rain occurs in the spring, when rain-on-snow events are 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 the information and 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 estimated from long-term measurements of river stages and from discharge to regional flood-frequency analyses. River slopes, channel and flood-plain dimensions, drainage networks, and runoff 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 1991-92: Data collection and analysis were completed for the Carson City, Douglas County, and Fallon studies. Results of the Carson City study were published by FEMA in a flood insurance-rate map. Data collection and analysis for the Tonopah area continued. The Fallon study is in review.



Plans for Fiscal Year 1993: Flood data for northern Washoe County will be collected. Compilation of the Tonopah data will be completed and the results will be published by FEMA.

Water Use in Nevada *(Project 007)*

Location: Statewide.

Project Chief: E. James Crompton.

Period of Project: Intermittent since 1978.

Cooperating Agencies: Nevada Division of Water Resources and U.S. Bureau of Reclamation.

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 this resource. In addition to obtaining water-use data, methods need to be developed for improving collection of the data. More efficient ways of storing and retrieving the 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 State's water resources. Water-use 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 aggregated 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: (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 1991-92: Collection and compilation of water-use data in Nevada during 1991 and 1992 continued according to National guidelines. A computerized data base of water-rights permits was developed that allows 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. An agreement on collection of water-use data was made with the Nevada Division of Water Planning. Water-use information was published in the 1990 and 1991 annual water-data reports.

Plans for Fiscal Year 1993: The 1985 water-use report will be submitted for approval and publication. A template will be developed for a series of annual reports that will present trends in water use, streamflow, and water levels. Water-use programs with other State and regional agencies also will be developed.

Publications, Fiscal Years 1991-92:

Bostic, R., Hitch, D., Van Gordon, L., and Swanson, R., 1991, Water resources data, Nevada, water year 1990: U.S. Geological Survey Water-Data Report NV-90-1, 358 p.

Garcia, K.T., Gortsema, G.C., Pennington, R.N., and Preissler, A.M., 1992, Water resources data, Nevada, water year 1991: U.S. Geological Survey Water-Data Report NV-91-1, 481 p.

Flood Investigations of Nevada Streams *(Project 036)*

Location: Statewide.

Project Chief: Rhea P. Williams.

Period of Project: Continuous since 1961.

Cooperating Agency: Nevada Department of Transportation.

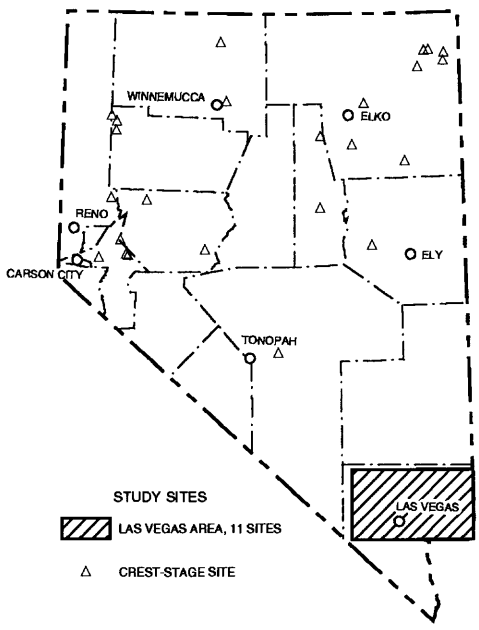
Problem: The design of hydraulic structures within stream channels depends on accurate estimations of flood frequency and related debris-flow magnitude. Flood-recurrence intervals generally cannot be estimated based on channel characteristics alone; long-term records of peak-flow measurements also are 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. The sites are visited periodically to verify flood records, maintain equipment, and make indirect measurements. Each crest-stage site is monitored for at least 10-15 years to provide data showing flood frequency and magnitude.

Progress and Significant Results, Fiscal Years 1991-92: Peak-streamflow data were collected at 30 sites. Peak-flow data for the 1990 and 1991 water years were included in the annual water-data reports. Data collection and investigations of mud- and debris-flow areas continued.

Plans for Fiscal Year 1993: Data collection and investigation of mud- and debris-flow areas will continue. The flood-frequency report will be submitted for approval and publication. Data will be prepared for inclusion in the 1992 annual water-data report.



Publications, Fiscal Years 1991-92:

Bostic, R., Hitch, D., Van Gordon, L., and Swanson, R., 1991, Water resources data, Nevada, water year 1990: U.S. Geological Survey Water-Data Report NV-90-1, 358 p.

Garcia, K.T., Gortsema, G.C., Pennington, R.N., and Preissler, A.M., 1992, Water resources data, Nevada, water year 1991: U.S. Geological Survey Water-Data Report NV-91-1, 481 p.

Environmental Hydrologic Studies (*Project 056*)

Location: Western and southern Nevada.

Project Chief: Patrick A. Glancy.

Period of Project: Continuous since 1973, encompassing individual short-term studies.

Cooperating Agency: Nevada Bureau of Mines and Geology.

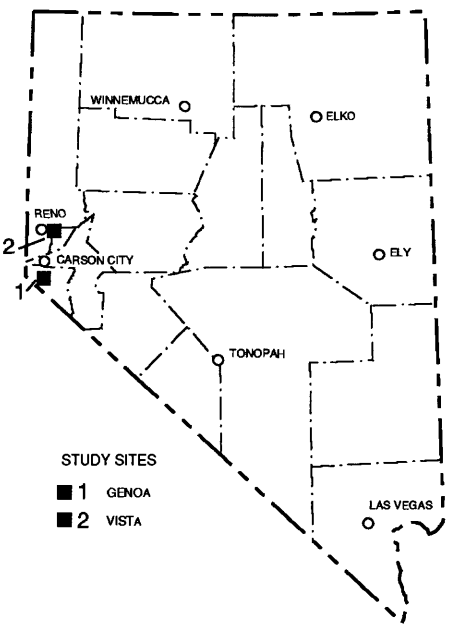
Problem: Nevada is an area of striking contrasts in landscapes, geohydrologic conditions, and land and water use, resulting in a variety of geologic and hydrologic hazards. Assessments are needed to (1) assist planners, developers, and water users in avoiding adverse consequences of hazards; and (2) develop new techniques for predicting and evaluating environmental, geologic, and hydrologic hazards.

Objectives: Individual problem-oriented studies are made in different parts of the State to address specific environmental issues. During fiscal years 1991-92, such studies included: (1) map areas subject to flooding and related fluvial hazards, (2) characterize areas of shallow ground water, (3) develop techniques for sampling volatile organic constituents in water, (4) determine distribution of radon in water-supply wells and springs, and (5) transfer techniques to cooperative agencies.

Approach: Information is obtained from published reports and original field work, such as mapping of flood-prone areas, evaluating fluvial-debris movement, collecting data on water levels and well yields, sampling water from wells and springs, and analyzing results.

Progress and Significant Results, Fiscal Years 1991-92: Reports on general hydrogeology and on flood and related debris-flow hazards for the Genoa area and the general hydrogeology for the Vista topographic quadrangle were published. A report on wellhead protection was prepared for review. Reports on radon in Carson Valley and radionuclide data were published.

Plans for Fiscal Year 1993: The reports on Ophir Creek and wellhead protection will be submitted for approval and publication.



Publications, Fiscal Years 1991-92:

Lico, M.S., 1992, Data for radon-222 and other radionuclides in ground water, Nevada, 1986-89: U.S. Geological Survey Open-File Report 91-488, 17 p.

Lico, M.S., and Rowe, T.G., 1991, Radon in ground water of Carson Valley, west-central Nevada, *in* Gunderson, L.C.S., and Wanty, R.B., eds., Field studies of radon in rocks, soils, and water: U.S. Geological Survey Bulletin 1971, p. 279-288.

Maurer, D.K., 1992, Hydrogeology of the Genoa quadrangle [Nevada]: Nevada Bureau of Mines and Geology Urban Map Series, Genoa Folio, Map 1Cf, scale 1:24,000.

Maurer, D.K., and Moffat, R.L., 1992, General hydrogeology of the Vista quadrangle [Nevada]: Nevada Bureau of Mines and Geology Urban Map Series, Vista Folio, Map 4Hf, scale 1:24,000.

-----1992, Flood and related debris-flow hazards, Genoa quadrangle [Nevada]: Nevada Bureau of Mines and Geology Urban Map Series, Genoa Folio, Map 1Cl, scale 1:24,000.

Meyer, D.F., and Berger, D.L., 1992, Flood and related debris hazards in the Genoa quadrangle, west-central Nevada: Nevada Bureau of Mines and Geology Open-File Report 92-2, 22 p.

Beatty Disposal-Site Investigation (*Project 072*)

Location: Amargosa Desert near Beatty, Nev.

Project Chief: Brian J. Andraski.

Period of Project: Continuous since 1976.

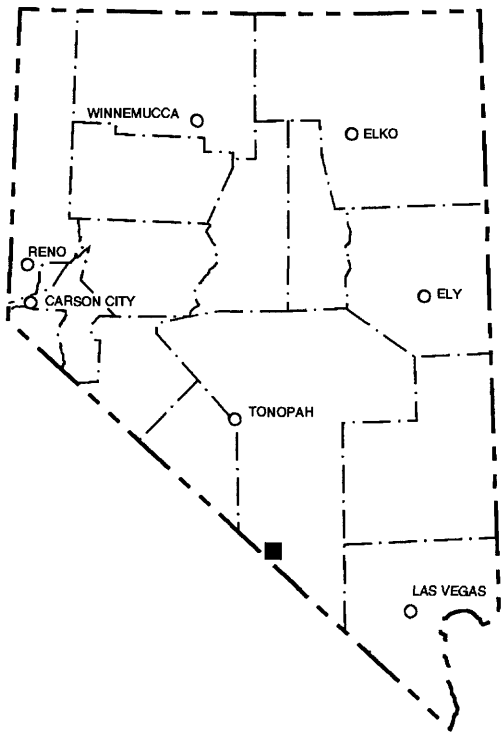
Supporting USGS program: Low-Level Nuclear Waste Hydrology Program

Problem: Solid, 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 rate of migration of radioactive solutes cannot be determined for present climatic conditions.

Objectives: Mechanisms and soil properties will be defined for controlling rates and directions of moisture movement (both 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 solid, 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. The amount of water and the potential for movement are being measured in undisturbed soil and in experimental trenches containing simulated waste. Physical properties, such as permeability and grain-size distribution, of the undisturbed-soil profile and experimental 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 trenches are being monitored.

Progress and Significant Results, Fiscal Years 1991-92: The field-data collection phase of the 5-year (September 1987-September 1992) experimental trench study was completed. 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. The installation of 33 psychrometers at the shaft was completed and the automated monitoring system was upgraded. Preliminary studies that better define bare-soil-evaporation rates from experimental trench covers were begun. Results from these studies indicate that the natural system (climate, soil, and vegetation) impedes water permeation at depth. 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. Presentations were made at the Soil Science Society of America and American Society of Agronomy joint annual meetings in San Antonio and Denver during October 1990 and 1991, respectively, and at the Vadose Zone Conference in Tucson during April 1991. Several reports were published.



Plans for Fiscal Year 1993: Preliminary analysis and final compilation of all experimental trench data will be completed. Physical properties of undisturbed soil and trench backfill will be analyzed. Collection and evaluation of basic weather data will continue and will be used to improve estimates of evapotranspiration and bare-soil evaporation rates.

Publications, Fiscal Years 1991-92:

Andraski, B.J., 1990, Rubber-balloon and drive-core sampling for determining bulk density of alluvial desert soil [abs.]: Agronomy Abstracts, American Society of Agronomy, 1990 Annual Meetings, San Antonio, Texas, October 1990, p. 208.

-----1991, Balloon and core sampling for determining bulk density of alluvial desert soil: Soil Science Society of America Journal, v. 55, p. 1188-1190.

-----1991, Soil-water regime at a low-level radioactive waste site, Amargosa Desert, Nevada [abs.]: Characterization of Transport Phenomena in the Vadose Zone, A Workshop Sponsored by Soil Science Society of America and American Geophysical Union, Tucson, University of Arizona, April 1991, Proceedings, p. 2-3.

-----1991, Vegetation and land-disturbance effects on recharge potential, Amargosa Desert, Nevada [abs.]: Agronomy Abstracts, American Society of Agronomy, 1991 Annual Meetings, Denver, Colo., October 1991, p. 212.

-----1992, Water movement through soil at a low-level radioactive-waste site in the Amargosa Desert: U.S. Geological Survey Yearbook Fiscal Year 1991, p. 73-75.

Andraski, B.J., Fischer, J.M., and Prudic, D.E., 1991, Beatty, Nevada, *in* Trask, N.J., and Stevens, P.R., U.S. Geological Survey Research in radioactive waste disposal--fiscal years 1986-90: U.S. Geological Survey Water-Resources Investigations Report 91-4084, p. 34-40.

Brown, R.G., and Nichols, W.D., 1990, Selected meteorological data for an arid climate over bare soil near Beatty, Nye County, Nevada, November 1977 through May 1980: U.S. Geological Survey Open-File Report 90-195, 48 p.

Fischer, J.M., 1990, Geohydrology of the near-surface unsaturated zone adjacent to the disposal site for low-level radioactive waste near Beatty, Nevada, *in* Bedinger, M.S., and Stevens, P.R., eds., Safe disposal of radionuclides in low-level radioactive-waste repository sites--Low-level radioactive-waste disposal workshop, U.S. Geological Survey, July 11-16, 1987, Big Bear Lake, Calif., Proceedings: U.S. Geological Survey Circular 1036, p. 57-61.

-----1992, Sediment properties and water movement through shallow unsaturated alluvium at an arid site for disposal of low-level radioactive waste near Beatty, Nye County, Nevada: U.S. Geological Survey Water-Resources Investigations Report 92-4032, 48 p.

Gee, G.W., Wierenga, P.J., Andraski, B.J., Young, M.H., Fayer, M.J., and Rockhold, M.L., (in press), Variations in water balance and recharge at three western desert sites: Journal of the Soil Science Society of America article.

Prudic, D.E., and Dennehy, K.F., 1990, Topic I--Induced changes in hydrology at low-level radioactive-waste repository sites, *in* Bedinger, M.S., and Stevens, P.R., eds., Safe disposal of radionuclides in low-level radioactive-waste repository sites--Low-level radioactive-waste disposal workshop, U.S. Geological Survey, July 11-16, 1987, Big Bear Lake, Calif., Proceedings: U.S. Geological Survey Circular 1036, p. 2-4.

Wood, J.L., and Andraski, B.J., (in press), 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.

Wood, J.L., and Fischer, J.M., 1991, Selected meteorological data for an arid site near Beatty, Nye County, Nevada, calendar year 1986: U.S. Geological Survey Open-File Report 91-189, 27 p.

-----1992, Selected meteorological data for an arid site near Beatty, Nye County, Nevada, calendar year 1987: U.S. Geological Survey Open-File Report 92-59, 27 p.

Wood, J.L., Hill, K.J., and Andraski, B.J., 1992, Selected meteorological data for an arid site near Beatty, Nye County, Nevada, calendar year 1988: U.S. Geological Survey Open-File Report 92-61, 27 p.

Regional Analysis of Aquifer Systems in Great Basin (*Project 091*)

Location: Nevada, western Utah, and parts of adjacent states.

Project Chief: James R. Harrill.

Period of Project: 1980-91.

Supporting USGS Program: Regional-Aquifer System Analysis.

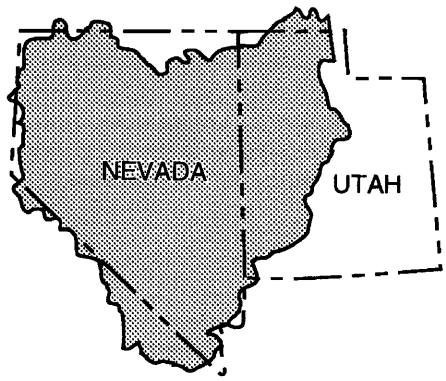
Problem: The Great Basin contains an extensive regional ground-water system of about 200 valley-fill aquifers which, in some places, are underlain and interconnected by permeable, consolidated rock. This system was included in a National program of Regional Aquifer-System Analysis (RASA). The Great Basin area of Nevada and Utah is experiencing increasing demands for water. Demand in many areas has reached the point where careful management is needed to meet anticipated future needs. This study provided understanding of the system at a regional scale, which is essential for wise management of the resource.

Objectives: The general objectives were to (1) describe, both hydraulically and geochemically, the present ground-water system and the ground-water system as it existed before development; (2) analyze the changes that led to the present condition of the system; (3) tie together, in a regional analysis, the results of prior studies dealing with individual segments of the system; and (4) provide predictive capabilities through which the effects of further ground-water development can be estimated.

Approach: Widespread hydrologic problems and areas typical of the Great Basin were identified, a detailed study was made, and results were regionalized and incorporated into an overall analysis of the Great Basin. The initial effort was concentrated in two general directions: (1) a description and regional analysis of aquifers and (2) a series of detailed studies to produce information that would have transfer value to similar areas. The final effort of the RASA project will draw results together into a comprehensive regional analysis.

Progress and Significant Results, Fiscal Years 1991-92: Several reports were approved for publication and currently are in press.

Plans for Fiscal Year 1993: Reports will be published. The summary report will be submitted for approval and publication.



Publications, Fiscal Years 1991-92:

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

Carman, R.L., (in press), 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.

Harrill, J.R., and Preissler, A.M., (in press), 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.

Harrill, J.R., Welch, A.H., and Preissler, A.M., 1992, Hydrogeochemical evidence for subsurface inflow to Stagecoach Valley, Lyon County, Nevada, *in* Subitzky, Seymour, ed., Selected papers in the hydrologic sciences, 1988-92: U.S. Geological Survey Water-Supply Paper 2340, p. 179-193.

Hines, L.B., 1992, Quantification of natural ground-water evapotranspiration in Smith Creek Valley, Lander County, Nevada, *in* Subitzky, Seymour, ed., Selected papers in the hydrologic sciences, 1988-92: U.S. Geological Survey Water-Supply Paper 2340, p. 9-20.

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.

Investigations of Flood-Hazard Potential at Nevada Test Site *(Project 105)*

Location: Yucca Mountain, Nevada Test Site.

Project Chief: Patrick A. Glancy.

Period of Project: Continuous since 1981.

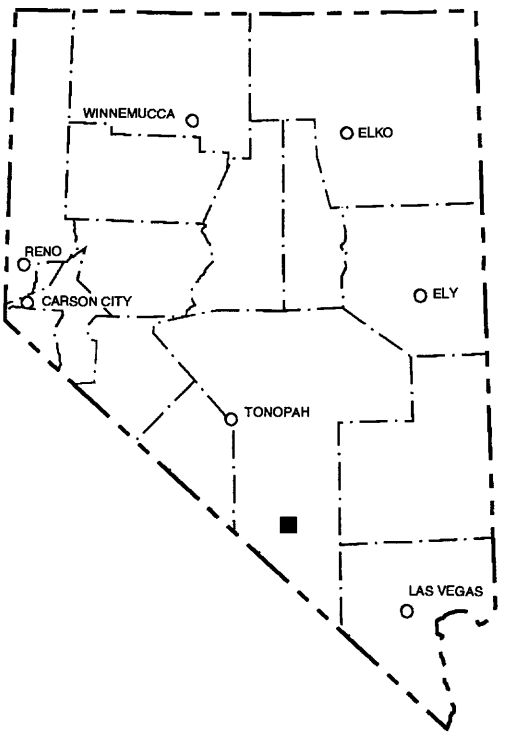
Supporting Other Federal Agencies: U.S. Bureau of Reclamation and U.S. Department of Energy.

Problem: Yucca Mountain is being considered as a potential storage site for high-level radioactive waste. Flooding and associated sediment movement are continual natural hazards at Yucca Mountain and at the Nevada Test Site. Engineering designs for all types of waste-storage facilities, including critically sensitive ones, require that the hazards be defined. Current flood-prediction capability is inhibited by an inadequate understanding of the natural processes involved, shortages of hydrologic data, and inadequate technology to interpret the data.

Objectives: This study is intended to increase knowledge and understanding of flood processes at Yucca Mountain by (1) adding needed data on precipitation, runoff, and debris transport to the data base to enhance predictive capability; (2) expanding the data base of high-flow events; and (3) collecting information on prehistoric floods. The data also are intended to be of use to other hydrologic studies.

Approach: A two-pronged approach that will improve the data base is planned. (1) An ongoing hydrologic data-collection program to investigate storms and runoff will be the main focus of the study; this will include collection of precipitation and streamflow data. (2) Paleohydrologic-data collection and interpretation techniques will be applied to determine those that are workable, and new techniques will be devised as necessary.

Progress and Significant Results, Fiscal Years 1991-92: The Yucca Mountain Project stop-work order was lifted, and routine data collection was authorized and continued. Fiscal year 1991 was a mild runoff year in southern Nevada. Most technical activity focused on collection, analysis, and interpretation of data from fiscal year 1990 flooding, which was frequent and widespread. All fiscal year 1990 data were reviewed, documented, and archived according



to rigid quality assurance criteria. The study plans for the Surface-Water Monitoring and Site Flood and Debris Hazards project study were completed and submitted for approval by the U.S. Department of Energy. The regional paleoflood reconnaissance began. The U.S. Bureau of Reclamation study on probable maximum flood peaks for the Yucca Mountain site was completed. Extensive runoff related to the El Nino climatic influence occurred in southern Nevada during late winter and early spring of 1992; however, little runoff occurred at Yucca Mountain. Summer thunderstorm activity was moderate throughout Nevada. Flooding related to thunderstorms caused damage in Hawthorne, Nev., in July 1992. Atmospheric instability that resulted in this flooding was related to the dying phase of tropical storm Darby.

Plans for Fiscal Year 1993: Routine data collection and studies on flooding and debris flows will continue.

Publication, Fiscal Years 1991-92:

Glancy, P.A., (in press), 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.

Carbonate-Rock Aquifers System *(Project 127)*

Location: Southeastern Nevada.

Project Chief: Donald H. Schaefer.

Period of Project: Continuous since 1991.

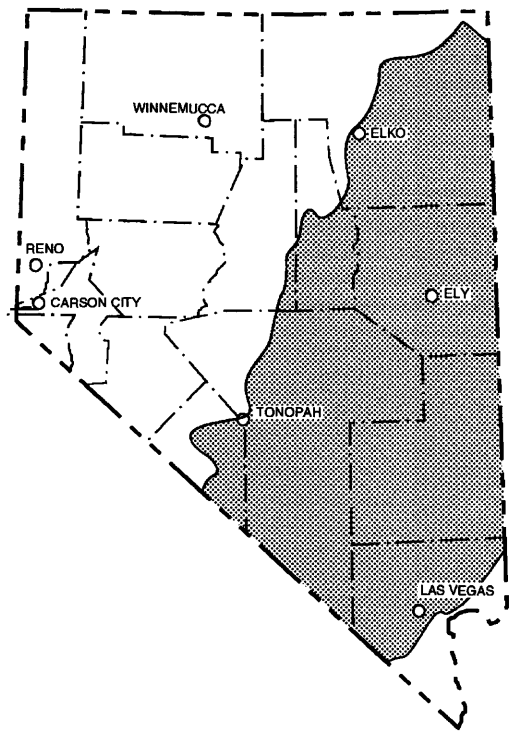
Supporting Other Federal Agencies: National Park Service (NPS), U.S. Bureau of Indian Affairs (USBIA), U.S. Bureau of Land Management (USBLM), and U.S. Fish and Wildlife Service (USFWS).

Problem: The Department of the Interior has major concerns about applications filed by the Las Vegas Valley Water District (LVVWD) to appropriate 804,000 acre-feet per year of ground water in 26 hydrographic areas in eastern 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--NPS, USBIA, USBLM, 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 will be simulated using a regional model developed for the RASA project (NV091) to determine the effects on the ground-water systems at 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 1991-92: The computer model was used to simulate several hypothetical pumping scenarios in the carbonate-rock province; analysis of the results began. Hydrologists attended hearings and meetings to provide expertise.



Plans for Fiscal Year 1993: Analysis of the model simulations will continue. Technical assistance and support materials will be provided at public hearings and meetings.

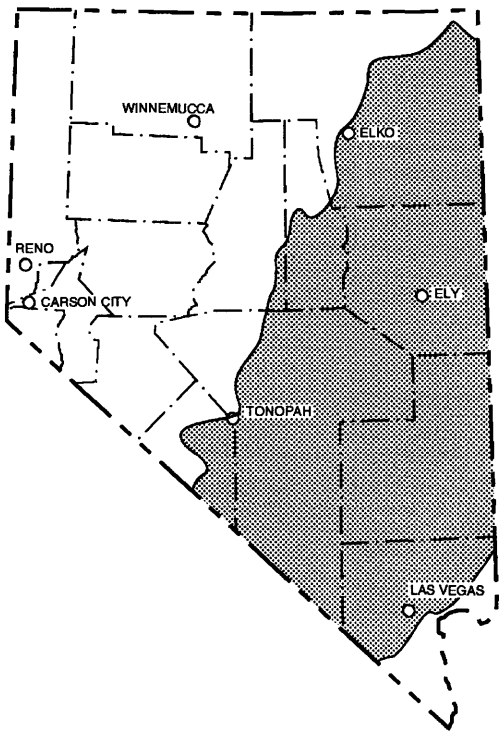
Nevada Carbonate-Rock Aquifers (*Project 128*)

Location: Southeastern 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 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 will be 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 will 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 U.S. 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 1991-92: The planners' guide report was published. A report on the lithologic properties of carbonate-rock aquifers in Coyote Valley was approved and is in press. The summary report was approved for publication and is in press. The Phase I monitoring program was reactivated and measurements were made in central and southern Nevada. Phase II began in fiscal year 1991 as a ground-water monitoring program for the Las Vegas Valley Water District.

Plans for Fiscal Year 1993: The reports will be completed, reviewed, and submitted for approval and publication. Routine data collection and ground-water monitoring will continue.

Publications, Fiscal Years 1991-92:

Berger, D.L., (in press), 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.

Dettinger, M.D., 1992, Geohydrology of areas being considered for exploratory drilling and development of the carbonate-rock aquifers in southern Nevada--Preliminary assessment: U.S. Geological Survey Water-Resources Investigations Report 90-4077, 35 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., (in press), 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.

Schaefer, D.H., Morris, T.M., and Dettinger, M.D., 1992, Hydrogeologic and geophysical data for selected wells and springs in the Sheep Range area, Clark and Lincoln Counties, Nevada: U.S. Geological Survey Open-File Report 89-425, 26 p.

Thomas, J.M., Lyles, B.F., and Carpenter, L.A., 1991, Chemical and isotopic data for water from wells, springs, and streams in carbonate-rock terrane of southern and eastern Nevada and southeastern California, 1985-88: U.S. Geological Survey Open-File Report 89-422, 24 p.

Nevada Test Site, Weapons Hydrology *(Project 130)*

Location: Southern Nye County, Nev.

Project Chief: William B. Scott, 1985-91; and Douglas A. Trudeau, 1991-92.

Period of Project: Continuous since 1985.

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

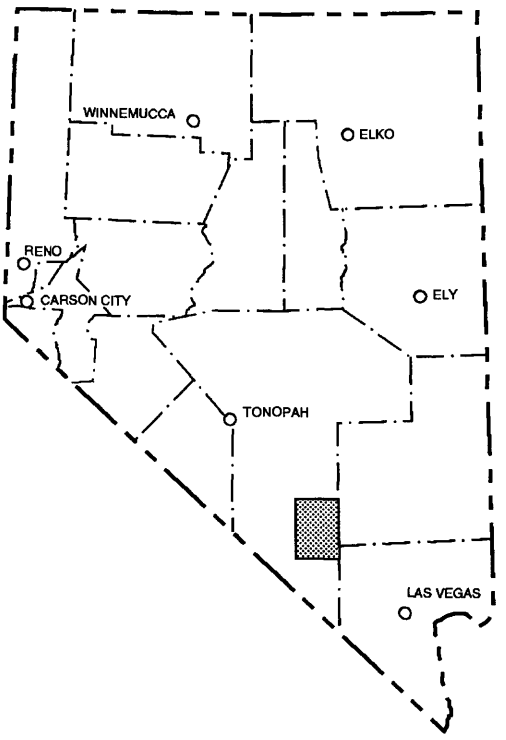
Problem: Underground nuclear-weapons testing at the Nevada Test Site (NTS) creates the potential for long-term contamination of ground-water supplies by radionuclides. Also, the location and design of underground nuclear-test sites require hydrologic information.

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 (USDOE), Hydrology/Radionuclide Migration 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 and in the vicinity of NTS. 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 1991-92: Continued to provide hydrologic expertise and technical support to the Weapons Testing Program at NTS. Another test hole proposed as part of the Hydrology/Radionuclide Migration Program was drilled and tested. Data-collection activities continued. A formal plan for quality assurance was developed and is awaiting implementation. USGS also assisted USDOE in developing and implementing a ground-water protection policy for underground nuclear tests. The ground-water data report for water years 1988-89 was approved and currently is in press. The first drafts of the Yucca Flat and Pahute Mesa water-level maps were completed. Ground-water data collected in 1990-91 at the NTS were compiled for review.

Plans for Fiscal Year 1993: Continue data-collection activities. Complete Yucca Flat and Pahute Mesa water-level maps. The 1990-91 ground-water data report will be submitted for approval and publication.



Publications, Fiscal Years 1991-92:

Arteaga, F.E., Savard, C.S., Johnson, M.E., and Stone, J.C., 1991, Hydrogeologic data from selected wells and test holes in and adjacent to the Nevada Test Site, Nye County, Nevada: U.S. Geological Survey Open-File Report 87-536, 23 p.

Cole, J.C., Sawyer, D.A., Laczniak, R.J., and Trudeau, D.A., 1991, The hydrogeologic view of containment [abs.]: Sixth Symposium on Containment of Underground Nuclear Explosions, Lawrence Livermore National Laboratory CONF-9109114, p. 175.

Scott, W.B., and Morgan, C.O., (in press), Hydrologic activities of the U.S. Geological Survey in support of the radionuclide migration program, Nevada Test Site, Nye County, Nevada, fiscal year 1986: U.S. Department of Energy Summary Report for 1986.

Wood, D.B., (in press), 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.

Ground-Water Quality in Carson River Basin *(Project 142)*

Location: Western Nevada and eastern California.

Project Chief: Alan H. Welch.

Period of Project: 1986-91.

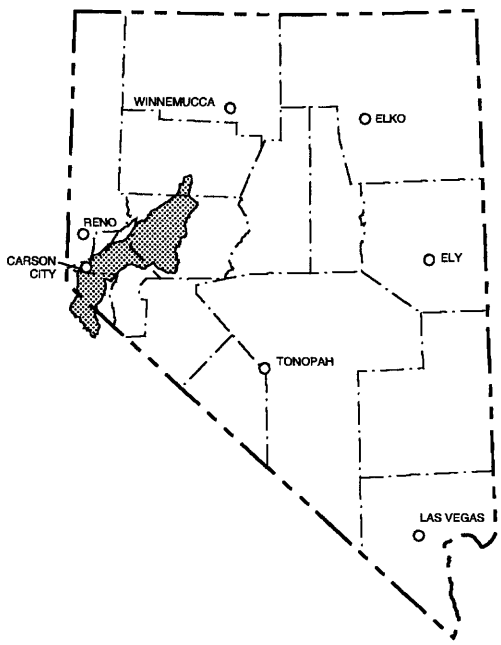
Supporting USGS Program: National Water-Quality Assessment Program.

Problem: Natural and man-induced contamination of aquifer systems is controlled largely by geology, hydrology, water withdrawals, and land use. Areas with hydrologic and geologic diversity, such as the Carson River basin, are most likely to show the largest effects. Studies in these areas should produce results with high transfer value to other areas.

Objectives: This pilot National Water-Quality Assessment (NAWQA) program (a ground-water project) was designed to (1) determine the occurrence and areal distribution of selected trace elements, manmade organic compounds, and other chemical substances that affect the uses of ground water and that are widespread within the study area; (2) identify and describe zones that are known or likely to have specific water-quality problems; (3) identify and describe zones that, in relation to land use and geologic and hydrologic conditions, are susceptible to future degradation with respect to specific substances; and (4) explore relations of different types of degraded ground-water quality to land use, hydrology, and other pertinent factors.

Approach: Existing data on ground-water quality were inventoried and statistically summarized. On the basis of this initial analysis, a program was designed and implemented to collect additional data to more completely describe the quality of the aquifers with respect to water use. The data were used to define the relations of observed water quality to geohydrologic and land-use factors.

Progress and Significant Results, Fiscal Years 1991-92: Work continued on reports. A report on the hydrology of Churchill and Dayton Valleys was published. Articles on ground-water quality in the Carson City urban area and on radionuclides in the Carson River basin were approved and submitted to the respective journals.



Plans for Fiscal Year 1993: Reports will be prepared for publication.

Publications, Fiscal Years 1991-92:

Hamilton, P.A., Welch, A.H., Christenson, S.C., and Alley, W.M., (in press), Uses and limitations of existing ground-water quality data, *in* Alley, W.M., ed., Regional ground-water quality: New York, Van Nostrand Reinhold, Chapter 19.

Schaefer, D.H., and Whitney, Rita, 1992, Geologic framework and ground-water conditions in basin-fill aquifers of the Dayton Valley and Churchill Valley hydrographic areas, western Nevada: U.S. Geological Survey Water-Resources Investigations Report 91-4072, 12 p.

Thomas, J.M., Welch, A.H., Lico, M.S., Hughes, J.L., and Whitney, Rita, (in press), Radionuclides in groundwater of the Carson River basin, western Nevada and eastern California: Applied Geochemistry article.

Relations Between Soil and Ground-Water Chemistry in Carson River Basin
(Project 145)

Location: Northwestern Nevada and eastern California.

Project Chief: Elizabeth A. Frick (transferred to Georgia District).

Period of Project: 1987-91.

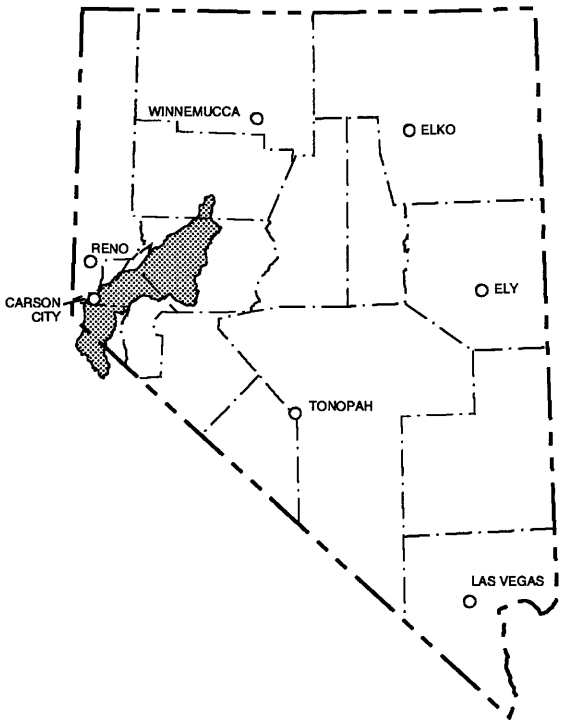
Supporting USGS Program: National Water-Quality Assessment Program

Problem: Within the Carson River basin, environmentally significant concentrations of elements such as arsenic, selenium, molybdenum, boron, lithium, and uranium are present in the unsaturated zone of some, if not most, basin-fill aquifers. Few historical data are available on the areal and vertical distribution of trace elements in the soils and aquifers of the Carson River basin; however, two other projects are collecting water- and soil-chemistry data (see projects 142 and 148). A computerized geographic information system (GIS) is needed to analyze relations between the geochemistry of soils and shallow-aquifer material and the geochemistry of underlying shallow ground water.

Objectives: The objectives of this project were to (1) develop a GIS to store, manage, and integrate data on the areal distribution of selected trace inorganic constituents in soils, shallow-aquifer materials, and ground water; related bedrock geology; and hydrologic factors in the Carson River basin; (2) use GIS and other software to analyze, present, and relate data; and (3) analyze and interpret relations between the geochemistry of soils and rocks and the quality of ground water in the Carson River basin.

Approach: A GIS was developed for the Carson River basin using computer software to store, manage, and integrate the data. Data on geology, soil and water chemistry, and land use were compiled and put in digital form. The GIS and related data bases were used to test hypotheses relating areal and vertical patterns in trace-element geochemistry of soils, and ground-water quality, to geology and land use.

Progress and Significant Results, Fiscal Years 1991-92: Work continued on the GIS report on Carson River geochemistry.



Plans for Fiscal Year 1993: Report will be submitted for approval and publication.

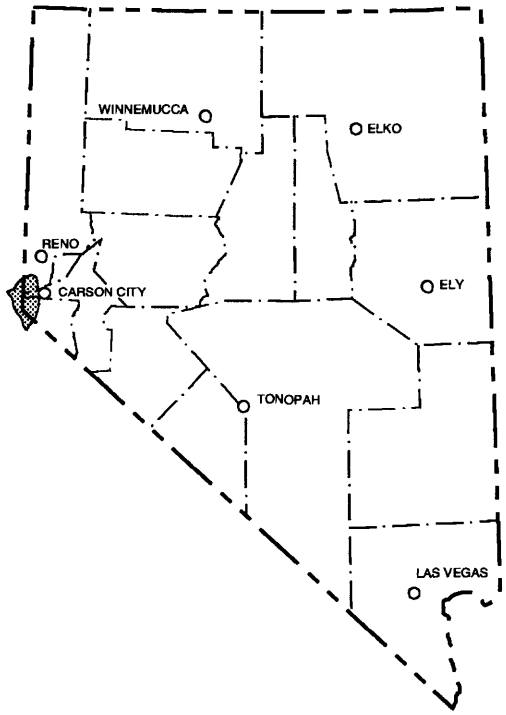
Geographic Information System for Lake Tahoe Basin *(Project 146)*

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 varying 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 will be developed. The data base, the Tahoe Environmental Geographic Information System (TEGIS), can be used for exchange of water-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: Initially, a pilot GIS data base was created for the Washoe County part of the Lake Tahoe Basin (31 square miles) using manual and automated digitizing. 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, (4) complete thematic mapping and integrate and automate the maps, (5) demonstrate GIS, and (6) develop computer software to allow simultaneous multiuser access. Cartographic and thematic data in TEGIS includes five major classes of information: permit information, assessor data, land-transfer data, natural-resource data, and monitoring data. The GIS will be expanded to other parts of the basin.

Progress and Significant Results, Fiscal Years 1991-92: Maps of GIS coverages for natural-resource layers (soils, geology, riparian, vegetation watersheds, land-use capability, and monitoring sites) were completed and prepared for USGS review. A poster session on GIS layers in the Lake Tahoe Basin was presented at the 11th Annual Environmental Systems Research Institute Conference in May 1991. Work continued on a documentation report on the development of a spatial data base for the Lake Tahoe Basin in Nevada and California.

Plans for Fiscal Year 1993: Documentation and map reports will be submitted for approval and publication.

Publications, Fiscal Years 1991-92:

Cartier, K.D., 1991, TEGIS GIS layers, Lake Tahoe Basin [Nevada-California]: 11th Annual Environmental Systems Research Institute User Conference, Palm Springs, Calif., May 1991, poster-session display.

Cartier, K.D., Peltz, L.A., and Long, K.F., 1992, Tahoe Environmental Geographic Information System, Lake Tahoe Basin, California and Nevada [abs.]: American Institute of Professional Geologists, Program with Abstracts, Lake Tahoe, September 1992, p. 11.

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.

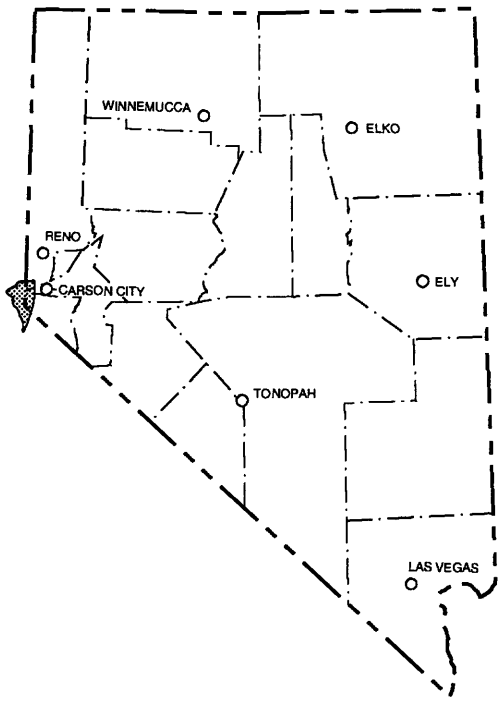
Cooperating Agency: Tahoe Regional Planning Agency.

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 is to (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 sites will be expanded to better define the nutrient and sediment input to Lake Tahoe from tributary streams. More sites will be added to 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 1991-92: 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. The network was expanded to 11 nonrecording sampling sites during spring 1991 runoff and rainfall events. Data collected during 1990 and 1991 were included in the annual water-data reports.



Plans for Fiscal Year 1993: Network operation will continue and work will continue on a report to compare different methods for calculating nutrient and sediment loads. The 1992 data will be compiled for inclusion in the annual water-data report.

Publications, Fiscal Years 1991-92:

Bostic, R., Hitch, D., Van Gordon, L., and Swanson, R., 1991, Water resources data, Nevada, water year 1990: U.S. Geological Survey Water-Data Report NV-90-1, 358 p.

Garcia, K.T., Gortsema, G.C., Pennington, R.N., and Preissler, A.M., 1992, Water resources data, Nevada, water year 1991: U.S. Geological Survey Water-Data Report NV-91-1, 481 p.

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

Location: Churchill and Pershing Counties, Nev.

Project Chief: Michael S. Lico.

Period of Project: 1987-91.

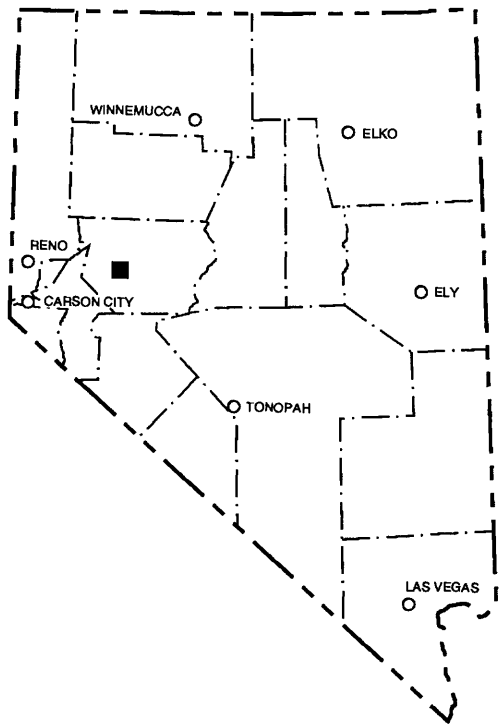
Supporting USGS Program: Department of the Interior National Irrigation Water Quality Program.

Problem: The Stillwater Wildlife Management Area (SWMA), the largest wetland in Nevada and an important sanctuary for migratory waterfowl and other waterfowl is maintained mostly by irrigation-return flow draining from fields in the Fallon area. Elevated concentrations of potentially toxic trace elements have been found in this drain water. The geochemical processes controlling the mobilization, transport, and fate of these trace elements need to be determined.

Objectives: The objectives of this study were to (1) determine the occurrence, distribution, and geochemical processes that result in mobilization and transport of toxic constituents to SWMA, Fernley Wildlife Management Area (FWMA), and Humboldt Wildlife Management Area (HWMA); and (2) collect baseline water-quality and bottom-material data in areas where none existed.

Approach: Results of quarterly water-quality sampling at monitored sites were used to identify areas that contributed trace elements to SWMA and FWMA. Continuous monitoring of input drains provided data from areas that contribute large loads of trace and toxic materials. Water levels in wells were measured to determine ground-water flow directions, and more wells were installed along ground-water flow paths for detailed sampling. Ground-water seepage on lake bottoms was measured, and bottom sediments and cores characterized. Geochemical models were used to evaluate sediment-water interactions.

Progress and Significant Results, Fiscal Years 1991-92: Work continued on reports. A detailed report on water quality and a data report for the Stillwater, Fernley, and Humboldt Wildlife Management Areas were published. A summary of report results was presented to Congress in July 1992.



Plans for Fiscal Year 1993: Report on biology of the wildlife management areas will be submitted for approval and publication.

Publications, Fiscal Years 1991-92:

Lico, M.S., 1992, Detailed study of irrigation drainage in and near wildlife management areas, west-central Nevada, 1987-90--Part A, Water quality, sediment composition, and hydrogeochemical processes in Stillwater and Fernley Wildlife Management Areas: U.S. Geological Survey Water-Resources Investigations Report 92-4024A, 65 p.

Rowe, T.G., Lico, M.S., Hallock, R.J., Maest, A.S., and Hoffman, R.J., 1991, Physical, chemical, and biological data for detailed study of irrigation drainage in and near Stillwater, Fernley, and Humboldt Wildlife Management Areas, and Carson Lake, west-central Nevada, 1987-89: U.S. Geological Survey Open-File Report 91-185, 199 p.

Effects of Ground-Water Withdrawals in Maggie Creek Area *(Project 149)*

Location: Elko and Eureka Counties, Nev.

Project Chief: Russell W. Plume.

Period of Project: 1988-91.

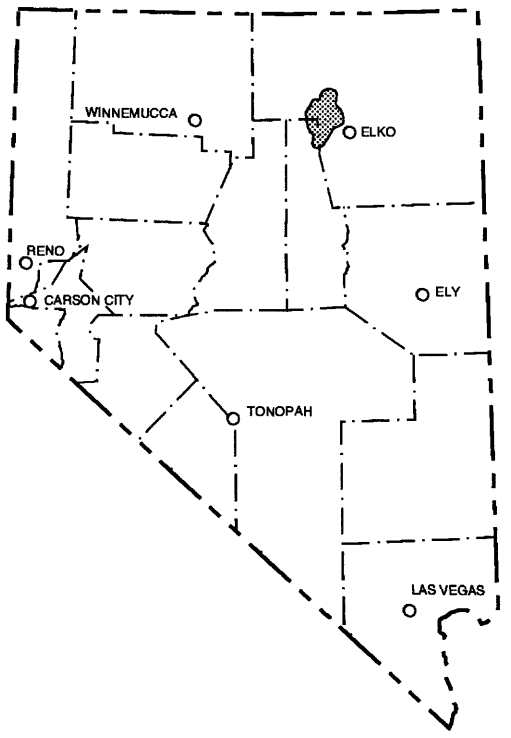
Cooperating Agency: Nevada Division of Water Resources.

Problem: The Maggie Creek area, including the town of Carlin, is an area of rapidly developing mining operations. In 1985, water consumption for mining and milling operations was less than 800 acre-feet per year. An estimated 5,650 acre-feet was used in 1988 and increased to more than 9,000 acre-feet in 1989. Mining and milling activities are expected to continue at 1989 levels for 10-20 years. Specific concerns are: (1) potential for reduction of flow at Carlin Springs, the main water source for the town; (2) potential for induced leakage from the channels of Maggie Creek and the Humboldt River, which could affect downstream water users; and (3) uncertainty regarding the long-term response of the ground-water system to sustained larger withdrawals.

Objectives: The study was to (1) document hydrologic conditions, including ground-water levels, water quality, surface flows, pumpage, and response to pumping; (2) update ground-water budgets; (3) evaluate the lower part of the basin to determine hydrologic characteristics, geometric boundaries, and interaction of the aquifers; (4) develop a conceptual model of the flow system in the lower part of the basin that is compatible with available geologic, hydrologic, geochemical, and geophysical information; (5) evaluate probable effects of pumping during the anticipated life of the mining operation; and (6) determine areas that, based on geologic and hydrologic information, have potential as artificial-recharge sites.

Approach: The project was initiated in late 1988 with a literature search and establishment of eight sites for measuring streamflow on Maggie Creek. Hydrologic, geologic, and geophysical data were collected and analyzed throughout fiscal years 1989-90.

Progress and Significant Results, Fiscal Years 1991-92: A report describing study results is being reviewed.



Plans for Fiscal Year 1993: Report will be submitted for approval and publication.

Ground-Water Appraisal of Smoke Creek Desert *(Project 150)*

Location: Washoe County, Nev., and Lassen County, Calif.

Project Chief: Douglas K. Maurer.

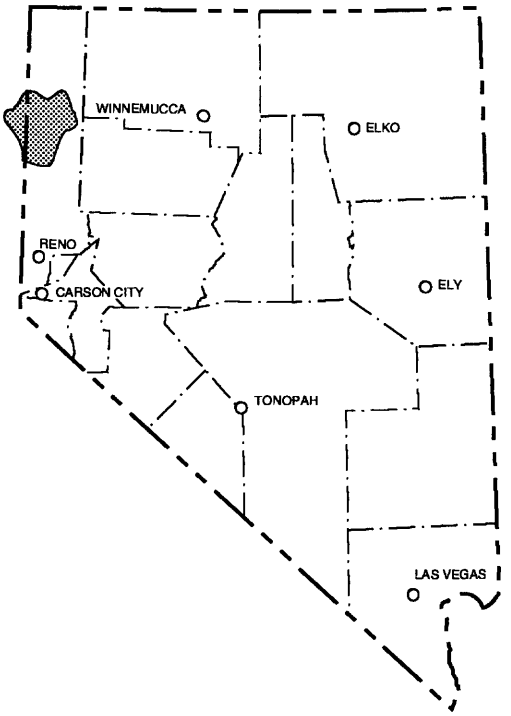
Period of Project: 1988-91.

Cooperating Agencies: California Department of Water Resources and Regional Water Planning (1988-90) and Advisory Board--Reno-Sparks and Washoe County (1988-91).

Problem: Smoke Creek Desert is being considered as a potential water source for the rapidly growing population of Reno, Sparks, and surrounding area. An estimated 13,000 acre-feet of water recharges the basin, but estimates of the amount and type of discharge are not as well defined. Much of the discharge may be by evapotranspiration from a large playa in the center of the basin--water that could be put to other uses. A more detailed assessment of the amount and quality of water available is needed. Hydrologic and geologic data are insufficient to support interpretive studies.

Objectives: This study collected data that were used to (1) reappraise the water budget, (2) define the boundaries and hydrologic properties of the principal aquifers, (3) determine the general quality of surface and ground water, and (4) develop a conceptual model of the hydrologic system to aid in understanding the occurrence and movement of ground water in Smoke Creek Desert.

Approach: The emphasis of this study was to collect data that related to recharge, discharge, water quality, and basin and aquifer geometry. Wells and springs were inventoried and a ground-water monitoring network established. Precipitation gages were installed and a streamflow network was established. A site for measurement of evapotranspiration from the playa was selected. Surface- and ground-water samples were collected for chemical analysis. Geophysical techniques were used to determine aquifer geometry.



Progress and Significant Results, Fiscal Years 1991-92: The geophysical survey was completed. Data collection continued and instruments to measure evapotranspiration were installed. Landsat imagery was used to prepare a map of phreatophyte distribution. A report summarizing the data and results was completed and reviewed.

Plans for Fiscal Year 1993: The report will be submitted for approval and publication.

Ground-Water Quality Monitoring, Lake Tahoe Basin *(Project 151)*

Location: Lake Tahoe Basin, Nevada and California.

Project Chief: Carl E. Thodal.

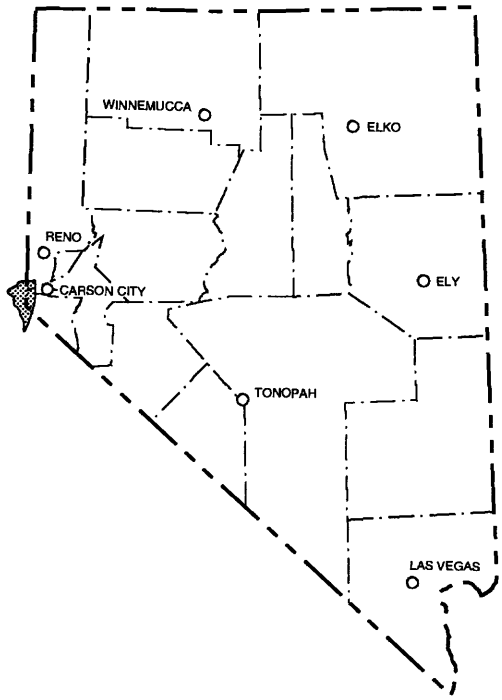
Period of Project: 1988-93.

Cooperating Agency: Tahoe Regional Planning Agency.

Problem: The clarity of water in Lake Tahoe has decreased during the last two decades as a result of increasing phytoplankton productivity attributed to nutrient loading. Nutrient-monitoring networks in the basin had been developed to determine nutrient loads from tributary streams and atmospheric deposition. Results from previous investigations indicate that nitrate-nitrogen and soluble phosphorus are transported into Lake Tahoe by ground water, either as base flow in tributary streams or as direct seepage into the lake. A well-designed ground-water monitoring network is needed to determine the role of ground water in the nutrient budget of Lake Tahoe.

Objectives: The 6-year investigation will (1) compile and evaluate historical ground-water flow and water-quality data for the Lake Tahoe Basin; (2) determine data needed to estimate loads and define sources of nutrients transported to the lake by ground water; and (3) design and begin operation of a network of wells in the basin to monitor ground-water levels and quality, with an emphasis on nutrients.

Approach: All available data on ground-water levels and water quality were compiled, and historical sampling sites were inventoried and field checked during the first year of study. Additional wells were sampled to augment the available data base. The monitoring network was designed and implemented, based on an evaluation of the historical data, during the second year of the study. Data on nutrient concentrations, water levels, on-site measurements, and chemical analyses of constituents will be collected to determine the sources and chemical evolution of ground water. Existing data and new data will be evaluated to determine which drainages may potentially contribute significant nutrient loads to the lake and to determine areas where additional data needs are greatest.



Progress and Significant Results, Fiscal Years 1991-92: Field measurements and water samples were collected quarterly to characterize seasonal variability. Report writing continued. Data were published in the 1991 annual water-data report.

Plans for Fiscal Year 1993: Reports will be submitted for approval and publication.

Publications, Fiscal Years 1991-92:

Garcia, K.T., Gortsema, G.C., Pennington, R.N., and Preissler, A.M., 1992, Water resources data, Nevada, water year 1991: U.S. Geological Survey Water-Data Report NV-91-1, 481 p.

Ground-Water Conditions, Desert Valley *(Project 152)*

Location: Northwestern Nevada.

Project Chief: David L. Berger.

Period of Project: 1989-93.

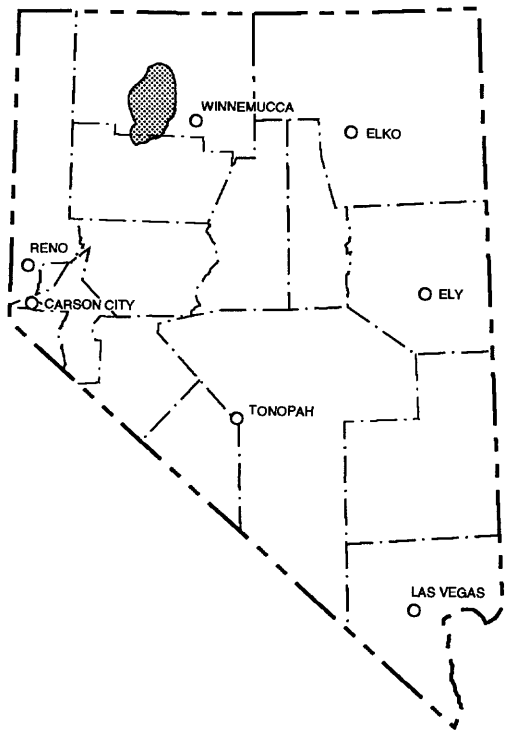
Cooperating Agency: Nevada Division of Water Resources.

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 will provide 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 will be compiled, and wells, springs, and streams will be inventoried. Water-quality samples will be collected and ground-water withdrawal records will be compiled. Predevelopment hydrologic conditions will be estimated by comparing 1962 data with current conditions. The water budget will be evaluated and revised based on 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 will be evaluated by developing a digital model to simulate current and potential ground-water conditions.

Progress and Significant Results, Fiscal Years 1991-92: Data on ground-water levels, precipitation, and miscellaneous discharge measurements were collected and tabulated. Geophysical surveys were completed, phreatophytes mapped, and observation wells drilled. Steady-state and transient simulations for the ground-water flow model were made. All work on other elements has been completed and the first draft of the final report is near completion. An article was approved and submitted to a journal. The results from a deep percolation model for estimating ground-water recharge from precipitation were presented at the 83rd annual meeting of the American Society of Agronomy.



Plans for Fiscal Year 1993: Report will be submitted for approval and publication.

Publications, Fiscal Years 1991-92:

Berger, D.L., (in press), Ground-water recharge through active sand dunes in northwestern Nevada: Water Resources Bulletin article.

Berger, D.L., and Andraski, B.J., 1991, Simulation of ground-water recharge through eolian deposits in an arid basin, northwestern Nevada [abs.]: Agronomy Abstracts, American Society of Agronomy, 1991 Annual Meetings, Denver, Colo., p. 214.

Evapotranspiration Variability in Native Vegetation *(Project 156)*

Location: Northeastern and northwestern Nevada.

Project Chief: Michael J. Johnson.

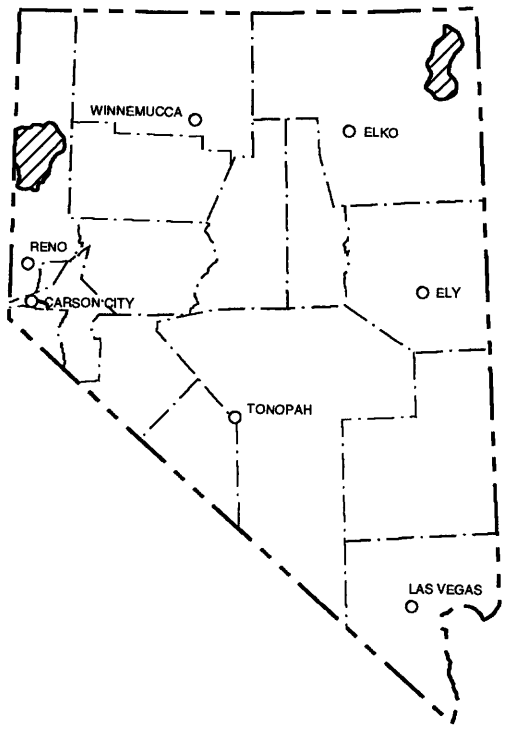
Period of Project: 1989-92.

Cooperating Agencies: Elko County, Nevada Division of Water Resources and Regional Water Planning and Advisory Board--Reno-Sparks and Washoe County.

Problem: The major discharge component of ground-water basins in Nevada, and in a large part of the western United States, is evapotranspiration (ET). In these basins, ET has not been quantified by making measurements, but commonly is estimated by empirical equations using available meteorological data or assumed ET rates for land cover in the basin. Such ET estimates can affect greatly the accuracy of water budgets upon which water allocations are based. Quantification of ET through direct measurements of water-vapor discharge is believed to hold the greatest promise for improving water-budget estimates. Little work has been done to physically measure ET from native vegetation in the Great Basin.

Objectives: The study (1) measured and defined the areal variability of ET from native vegetation, and (2) developed and used ET/land-cover relations, along with satellite imagery, to interpolate point measurements of ET over a selected basin to quantify the total ET component of the water-budget of the basin.

Approach: The Bowen-ratio method was used to solve the energy-balance equation and obtain the latent-heat flux. The eddy-correlation method also was used. Both are micrometeorological techniques requiring short-term monitoring to obtain data on water-vapor discharge. In the first year, point measurements of ET were made and interpolated to determine ET in the Toano Draw-Rock Springs Creek area of northeastern Nevada. Work also was done in other basins.



Progress and Significant Results, Fiscal Years 1991-92: Field data from Toano Draw were processed. ET and land-cover relations, used with vegetation-assemblage maps to interpolate point measurements of ET over the study area, were developed to quantify the total ET component in the water budget. Preparation began on a map report that will show generalized zones of ET and describe the total ET component of the water budget for the growing season. Micrometeorological equipment was installed in the Smoke Creek Desert of northwestern Nevada, data were collected and processed, equipment was removed, and point measurements were interpreted to obtain ET rates.

Plans for Fiscal Year 1993: Complete the map report and summarize the techniques and results of ET measurements in a journal article.

Paired-Basin Climate Change *(Project 158)*

Location: Sierra Nevada, Nevada and California.

Project Chief: Alex Pupacko.

Period of Project: 1990-93.

Supporting USGS Program: Global Change Hydrology Program.

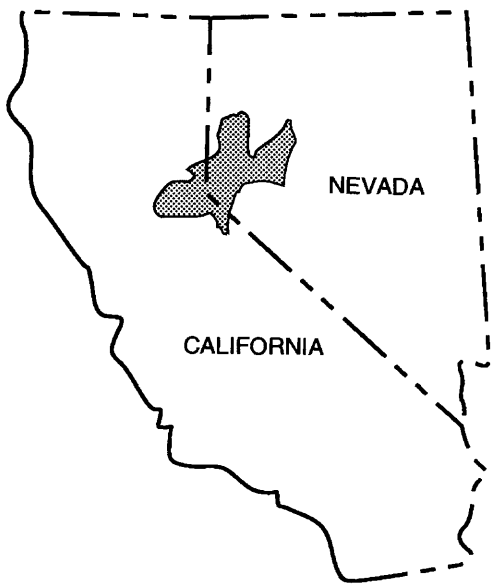
Problem: Changes in the current climatic regime could significantly affect the type, amount, and occurrence of precipitation and runoff in the American River, Carson River, and Truckee River basins and result in extensive changes in hydrologic processes and water management and use.

Objectives: The project will define the effects of possible climate change on the surface-water resources of the American River, Carson River, and Truckee River basins and develop analytical tools for interpreting those changes. The project complements a parallel investigation by the U.S. Bureau of Reclamation to study the possible effects of climate change on water supply and demand, system management, and operating criteria.

Approach: Current and future climate scenarios will be defined and developed, a data base to support watershed modeling of the three basins will be developed, and watershed processes for current and future climate scenarios will be modeled.

Progress and Significant Results, Fiscal Years 1991-92: Watershed models for the Carson River and American River basins were completed and linked to changed climate scenarios. Model output was analyzed and presented at the Pacific Climate Conference in April 1992.

Plans for Fiscal Year 1993: Presentations will be given at the American Water Resources Association meeting in November 1992 in Reno, Nev. Reports will be submitted for approval and publication.



Publications, Fiscal Years 1991-92:

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

Dettinger, M.D., and Ghil, M., 1991, Interannual and interdecadal variability of surface-air temperatures in the United States: 16th Annual National Oceanic and Atmospheric Administration Climate Diagnostics Workshop, Lake Arrowhead, Calif., Proceedings, November 1991, p. 209-214.

Dettinger, M.D., and Jeton, A.E., 1992, Simulated streamflow responses to climate change in the American and Carson Rivers of the Sierra Nevada, California and Nevada [abs.]: 9th Annual Pacific Climate Workshop (PACLIM), Asilomar, Calif., April 1992, p. 92

Jeton, A.E., 1991, Simulating watershed responses to climate in the Carson, American, and Truckee River basins, California and Nevada [abs.]: Abstracts on Climate Variability of the Eastern North Pacific and Western North America, 8th Annual PACLIM Workshop, Pacific Grove, Calif., March 1991, p. 13-14.

-----1992, Calibration of two Sierra Nevada watersheds and application of a geographic information system to model parameterization [abs.]: 9th Annual Pacific Climate Workshop (PACLIM), Asilomar, Calif., April 1992, p. 33.

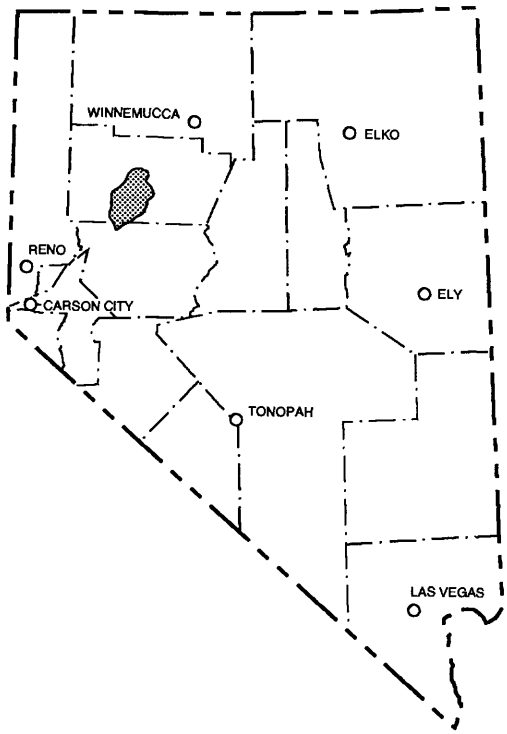
Pupacko, Alex, 1991, Potential effects of climate change on the surface-water resources of the Carson, American, and Truckee River basins--A study in progress [abs.]: Abstracts on Climate Variability of the Eastern North Pacific and Western North America, 8th Annual PACLIM Workshop, Pacific Grove, Calif., March 1991, p. 23-24.

-----1991, Preliminary investigation for characterization of drought and streamflow in the western Great Basin--Distinguishing climate change from natural variability, *in* Kirby, W.H., and Tan, W.Y., compilers, Proceedings of the United States-People's Republic of China Bilateral Symposium on Droughts and Arid-Region Hydrology, September 16-20, 1991, Tucson, Arizona: U.S. Geological Survey Open-File Report 91-244, p. 73-78.

-----1992, Potential effects of climate change on a windward and on a leeward drainage basin in the northern Sierra Nevada [abs.]: 9th Annual Pacific Climate Workshop (PACLIM), Asilomar, Calif., April 1992, p. 10.

-----(in press), Sensitivity of streamflow in Sierra Nevada Watersheds to climate change--a study on progress [abs.]: Proceedings of the USGS Global Change Research Program, Reston, Va.

Irrigation Drainage in Humboldt Wildlife Management Area *(Project 159)*



Location: Pershing and Humboldt Counties, Nev.

Project Chief: Ralph L. Seiler.

Period of Project: 1990-92.

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

Problem: During the past several years, concern has been increasing about the quality of irrigation drainage and its effect on human health, fish, and wildlife. The Humboldt Wildlife Management Area (HWMA) is an important feeding and resting area for migratory birds that use the Pacific flyway. It is maintained mostly by irrigation-return flow from fields in the Lovelock area. Elevated concentrations of potentially toxic trace elements have been found in the drain water and in birds using the HWMA.

Objectives: The HWMA will be studied to determine if irrigation drainage flowing into the area has caused or has potential to cause significant harmful effects on human health, fish, and wildlife, or to impair water use.

Approach: Reconnaissance sampling of surface and ground water at sites near HWMA was done during the pre-, mid-, and post-irrigation seasons. Water samples for inorganic chemical analysis were collected all three times; water samples for organic chemical analysis were collected only once, during the mid-irrigation season. Bottom sediment samples for inorganic and organic chemical analyses were collected once, during the post-irrigation season. Data were analyzed to determine what effect irrigation-return flows have on water quality in the HWMA.

Progress and Significant Results, Fiscal Years 1991-92: The final round of data collection was completed in November 1990. The data were analyzed and preliminary results presented to members of the National Academy of Sciences in March 1991. The report of findings has been written and reviewed.

Plans for Fiscal Year 1993: The report will be submitted for approval and publication.

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.

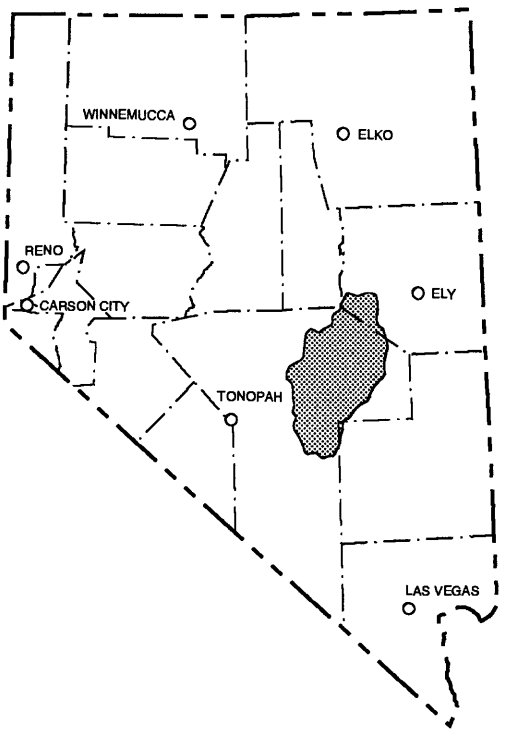
Period of Project: 1990-93.

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 possible conceptual model for a water-driven, oil-migration system describes that ground water from the recharge area leaches soluble oil near deeply buried source rocks, transports the oil through regional aquifers, and deposits it in a 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 will 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 is the Great Basin region of eastern Nevada and western Utah; however, much of the initial work will be 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, could provide information usable in other areas of the Great Basin. A conceptual model of the Railroad Valley ground-water flow system will be developed based on the observations and analyses made during this study.

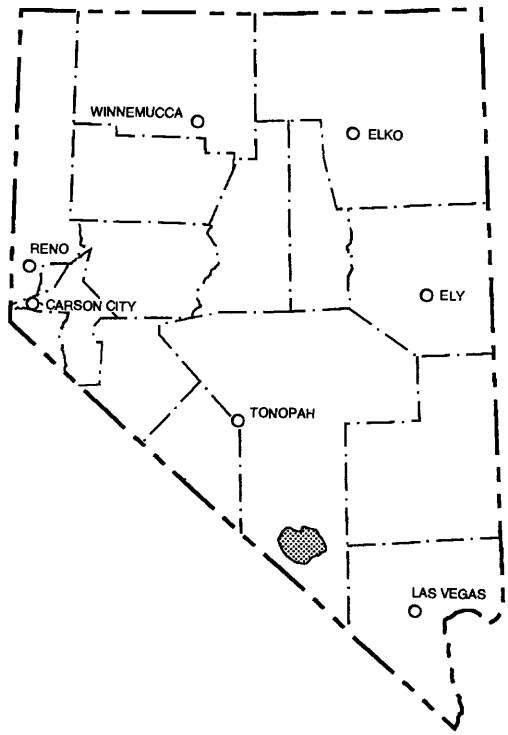
Approach: A literature search will be made and existing data compiled, with an emphasis on Railroad Valley. The large amount of existing oil-well data and considerable oil exploration in this valley make it a good location to develop and test conceptual models. Any correlations between occurrence of oil and regional ground-water flow will be determined. Based on the results, a recommendation regarding further study will be made. Wells will be sampled for organics, cross-sectional modeling, and possible test drilling.



Progress and Significant Results, Fiscal Years 1991-92: A comprehensive study plan was prepared. Initial modeling efforts in Railroad Valley were unsuccessful and the workplan was scaled back to document only current spatial relations of ground-water flow patterns to oil locations. A hydrologic atlas was prepared to show locations of oil fields and test wells with indications of oil as they relate to the regional ground-water flow system in the Great Basin.

Plans for Fiscal Year 1993: Work will continue on the hydrologic atlas; it 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 Other 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 will (1) use streamflow data to describe the runoff characteristics of the area and assess the response of runoff to precipitation and (2) provide basic data and interpretation of surface-water runoff data to other investigations. The data will be 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 will be collected and analyzed.

Progress and Significant Results, Fiscal Years 1991-92: Data collection continued. Data were compiled and summarized. Reconnaissance began for potential gaging sites in upper Fortymile Wash and in washes on Yucca Mountain. Streamflow gaging stations were installed and operation began at selected sites in upper Fortymile Wash, Yucca Mountain, and Amargosa Valley. The background-data report for water years 1983-85 was submitted for review.

Plans for Fiscal Year 1993: Operation of the existing continuous-recording and precipitation gages will continue. One new streamflow gaging station will be installed on Yucca Mountain along Pagany Wash near the proposed site of the repository. The data report for water years 1983-85 will be submitted for approval. Data will be compiled and summarized in other reports.

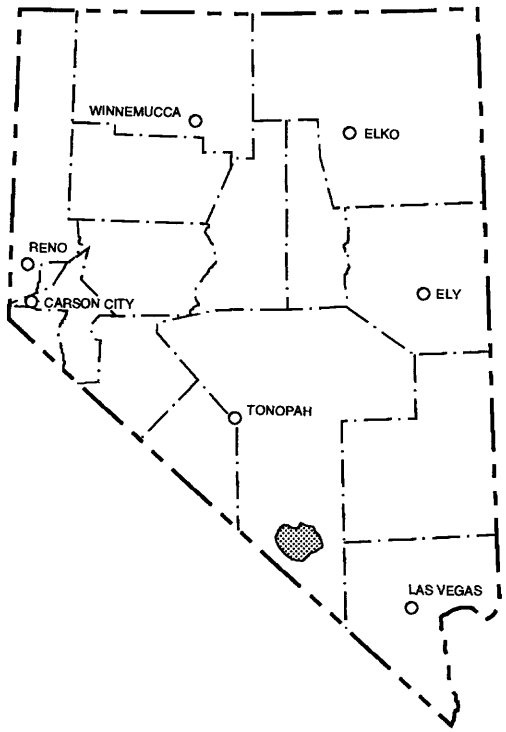
Transport of Debris by Severe Runoff, Yucca Mountain Area *(Project 162)*

Location: Southern Nye County, Nev.

Project Chief: Patrick A. Glancy, 1990-91; and Dennis Grasso, 1991-92.

Period of Project: 1989-95.

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



Problem: Flooding and associated sediment movement are significant hazards in arid and semiarid regions, yet infrequent precipitation has yielded a meager data base on which to estimate site-specific frequency of flooding or debris-transport processes. Yucca Mountain is being considered as a potential repository for high-level radioactive waste; therefore, debris movement caused by intensive runoff may present a significant hazard to surface facilities. Methods to predict debris-associated hazards are needed for rational placement and design of surface facilities at the potential repository. Predictions of long-term denudation rates are required for additional assessment.

Objectives: The study will (1) expand the debris-transport data base in southern Nevada and adjacent parts of California, Arizona, and Utah; and (2) improve predictive techniques to estimate debris transport at Yucca Mountain by developing both qualitative assessments and quantitative measures of the magnitude and frequency of intensive runoff and associated debris movement.

Approach: The data-collection program will investigate debris transport within a 185-mile radius of Yucca Mountain. Estimates and indirect measurements of peak flow at ungaged sites will be made. Debris transport will be documented to determine effects, or potential effects, of erosion, transport, and deposition, and the conditions and processes that determine them. Specifically, documentation will (1) map and analyze areas of erosion, transportation, and deposition using aerial photographs and other remote-sensing products, or topographic maps; (2) describe deposits to determine the mode of transport (debris flow, hyperconcentrated flow, or streamflow); (3) describe rock types to determine debris origin; (4) collect and analyze samples of deposits; (5) describe vegetation that may have interacted with the flows; and (6) document the meteorologic events that produced the runoff. From this data base, predictive capability for site-specific conditions at Yucca Mountain will be developed.

Progress and Significant Results, Fiscal Years 1991-92: Field investigation of the August 1990 Walker Lake storm and debris transport continued.

Plans for Fiscal Year 1993: Debris transport will be monitored as it occurs and the potential for severe debris transport at Yucca Mountain will be assessed.

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

Location: Southern Nye County, Nev.

Project Chief: Richard J. La Camera.

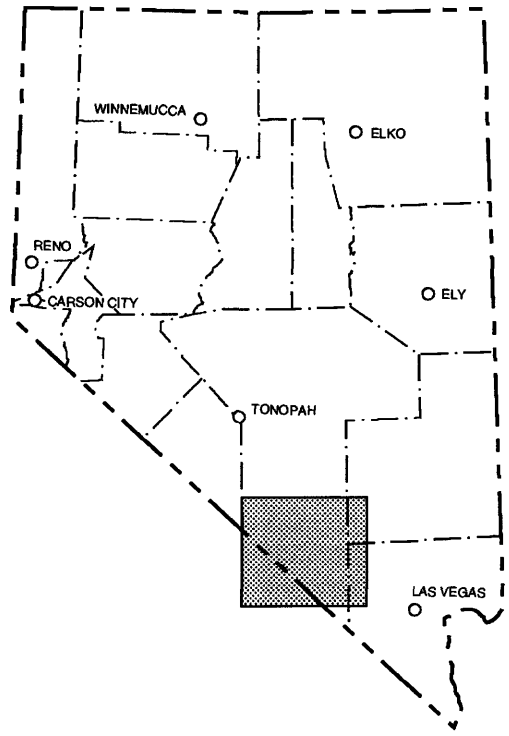
Period of Project: Continuous since 1989.

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

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 water resources in the area due to construction or operation of a potential repository must be identified. In order to identify adverse effects, the quantity and quality of ground-water resources in the area require systematic monitoring. Available data and current monitoring are inadequate to satisfactorily provide early detection of adverse effects on ground-water resources.

Objectives: The study will monitor and characterize ground-water resources at and near Yucca Mountain with respect to quantity and quality to (1) document baseline water-resource 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.

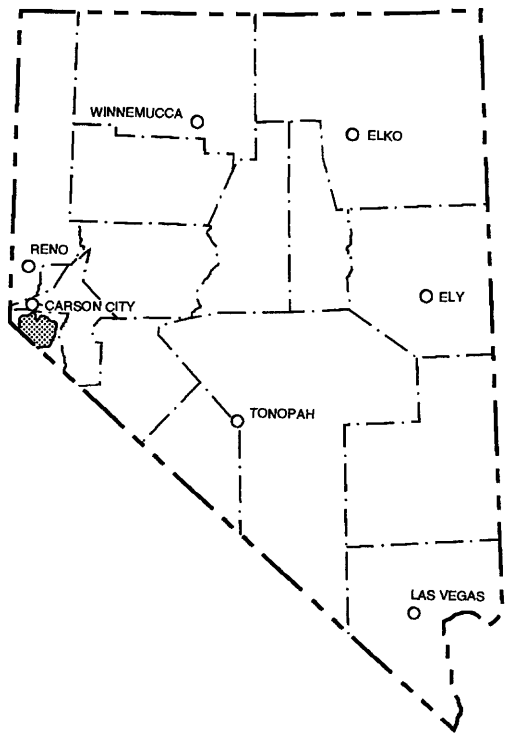
Approach: Data will be collected and compiled to characterize (1) water quantity, (2) water quality, and (3) water use. Water-quantity and water-quality monitoring networks will be designed on the basis of literature surveys and data compilations, measurements of discharge at selected springs and ephemeral streams, measurements of water levels at selected wells, and characterization of the chemical quality of ground and surface waters. Water quality at selected sites will be characterized with respect to drinking-water standards and the presence of inorganic, organic, and radioactive contaminants. This data base will be used to document baseline and changing conditions and to evaluate the effects of site investigations. Data from existing data collection will be used and supplemented as necessary to provide uniform monitoring. Data collection will continue until site investigations are complete.



Progress and Significant Results, Fiscal Years 1991-92: A document detailing a ground-water level and springflow-monitoring network, and methods for determining potential effects of ground-water withdrawals on water resources in Death Valley National Monument, was completed through consultations with the U.S. Department of Energy (USDOE) and the National Park Service. Testimony was presented during the Nevada State Engineer public hearings associated with issuance of a water-appropriation permit for site characterization. Quality-assurance (QA) requirements were fulfilled, including preparation of a QA grading package and technical procedures for measuring water discharge and quality. The process of obtaining land-access clearances to monitoring sites was completed. Routine collection of water-quantity and water-quality data continued. Contractors for USDOE were assisted with the design and test of a new monitoring well. Continuous-recording equipment for monitoring water levels was installed in two wells within the network. USDOE was provided with quarterly reports of data collected and compiled from the network sites.

Plans for Fiscal Year 1993: Data-collection activities will continue. USDOE will be provided with quarterly reports of data collected and compiled from the network sites. The summary of data for monitoring sites collected and compiled through fiscal year 1992 will be prepared and submitted for approval and publication.

Artificial-Recharge Evaluation, Douglas County (*Project 165*)



Location: West-central Nevada.

Project Chief: Douglas K. Maurer.

Period of Project: 1989-91.

Cooperating Agency: Douglas County.

Problem: Rapid population growth in Carson Valley, west-central Nevada, is causing changes from agricultural to urban land use, accompanied by changes in the distribution and use of water. Artificial recharge to the ground-water aquifers of the valley would provide dependable, off-channel storage for urban water use.

Objectives: The project evaluated and summarized available information about artificial recharge for the Douglas County part of Carson Valley. Specifically, the study (1) developed criteria to determine the relative potential for developing artificial-recharge sites in areas throughout the valley, (2) provided information needed to evaluate artificial recharge as a way to provide additional off-channel storage of surface water, and (3) delineated areas with potential for artificial recharge.

Approach: Existing literature was reviewed to obtain criteria for assessing the potential for artificial recharge. Data from USGS files and data bases; files of State, County, and other Federal agencies; and published reports were compiled, reviewed, and used to delineate areas with high potential for recharge.

Progress and Significant Results, Fiscal Years 1991-92: The report was completed and reviewed. A geographic information system was used to combine maps and geologic and hydrologic attributes for a final map showing areas with differing potential for artificial recharge.

Plans for Fiscal Year 1993: The maps will be submitted for approval and publication.

Carlin Gold-Belt Hydrology (*Project 166*)

Location: Northeastern Nevada.

Project Chief: Russell W. Plume.

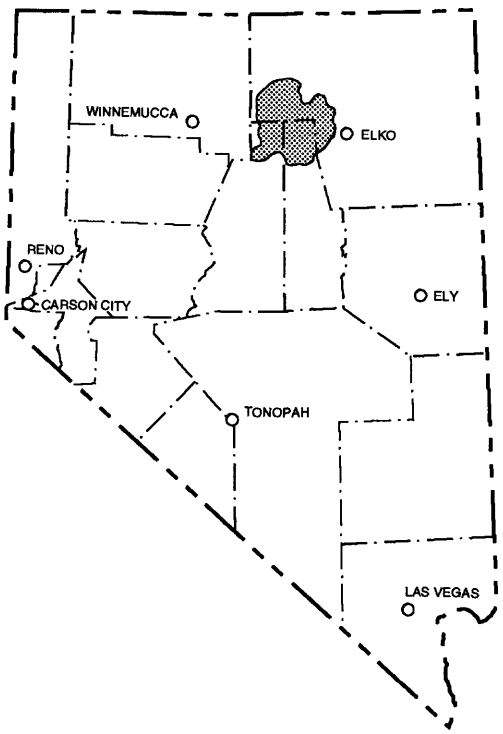
Period of Project: 1990-94.

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, some open pits will extend below the water table, requiring withdrawal of large volumes of water. The mining life of the area is anticipated to be 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 is complicated by a drought, now in its sixth year (1992), 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 several sites. Locations for four more streamflow gaging stations were selected on the Humboldt River and its tributaries. The investigation will continue in two phases that will overlap. The continuation of Phase I will be directed toward defining the hydrologic setting. Data collection will continue through fiscal year 1993. Phase II will involve operation of the long-term hydrologic-monitoring network. Streamflow, ground-water levels, and water-quality data will be collected from enough stations to monitor overall conditions in the area. Phase II will continue through 1994 and then scale down to a few observation stations until the hydrologic conditions stabilize.



Progress and Significant Results, Fiscal Years 1991-92: Water levels were measured at about 80 wells in November 1991 and at about 40 wells in March 1992. Miscellaneous streamflow measurements were made at about 40 sites along the Humboldt River and its tributaries. Continuous flow of the Humboldt River and its tributaries in and adjacent to the project area was monitored at eight gages. A precipitation gage was installed in the Tuscarora Mountains and a monitoring well was installed at Boulder Flat. Measurements of evapotranspiration rates began at sites along upper Maggie Creek and at Boulder Flat and phreatophyte mapping was completed.

Ground-water samples were collected at nine wells and two springs in January and September 1992 and analyzed for tritium, deuterium, oxygen-18, major cations and anions, nutrients, carbon-13, and carbon-14. A preliminary plan for long-term monitoring of streamflow, ground-water levels, and surface- and ground-water quality was prepared. Precipitation data from 14 sites were compiled for 1967-90 and a relation between precipitation and altitude was obtained. A presentation was given at the Society of Mining Engineers meeting in February 1992. A report detailing project findings was started. The lower Maggie Creek gage was deactivated due to operation and maintenance problems and two new gages were installed near the mouths of Maggie and Susie Creeks.

Plans for Fiscal Year 1993: Data collection will be reduced to a level necessary for long-term monitoring of hydrologic conditions. Data analysis and report preparation will continue. Data collected in the project area will be published in the 1992 annual water-data report.

Publications, Fiscal Years 1991-92:

Plume, R.W., and Stone, W.J., 1992, Hydrogeologic setting of the Carlin trend, northeastern Nevada: Society for Mining, Metallurgy, and Exploration, Inc., Preprint Number 92-27, 6 p.

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

Location: Western and southern Great Basin.

Project Chief: Hugh E. Bevans.

Period of Project: Continuous since 1990.

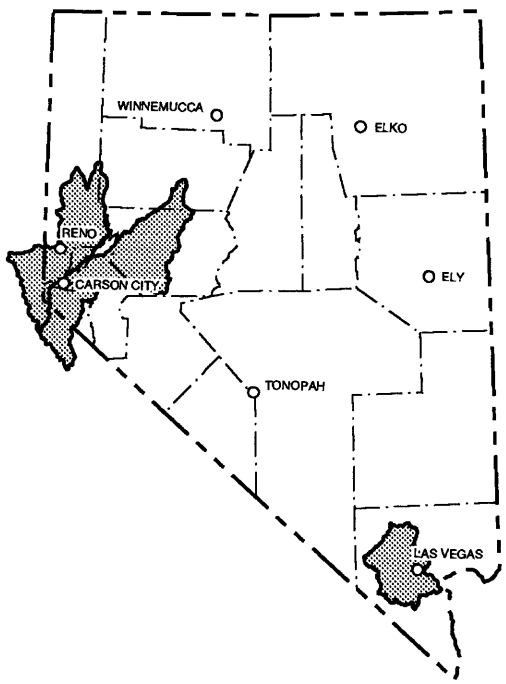
Supporting USGS Program: National Water-Quality Assessment Program

Problem: Information about the quality of ground- and surface-water resources for major Nevada urban areas 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, determining the effectiveness of water-quality management programs, and predicting effects of land- and water-management practices.

Objectives: The Nevada Basin and Range National Water-Quality Assessment is 1 of 20 initial study units in 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 of the investigation, water-quality and ancillary (land use, water use, and geologic) data from various sources will be compiled, evaluated, and entered in a computerized data base. Reconnaissance-level field investigations of water quality also will be made. An intensive data-collection and analysis phase will be undertaken for the 5th and 6th years of the study to develop a nationally consistent water-quality data base. During the 7th through 10th years of the study, a less intensive network for monitoring water-quality trends will be maintained. 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 1991-92: An open-file report describing the study objectives; physical, cultural, and hydrologic settings; and water-quality issues was published. The first draft of the project workplan for retrospective and reconnaissance activities was written and reviewed. Reconnaissance sampling of semivolatile organic compounds in ground and surface water in the Las Vegas area was completed. Aquatic biology field assessments were done in the Carson and Truckee Rivers and at the mouth of the Las Vegas Wash. A survey for occurrence of trace inorganic and organic elements in bed sediments and tissue of aquatic biota was made in the same area as the biology field assessments. Results of these investigations are being used to plan intensive studies.

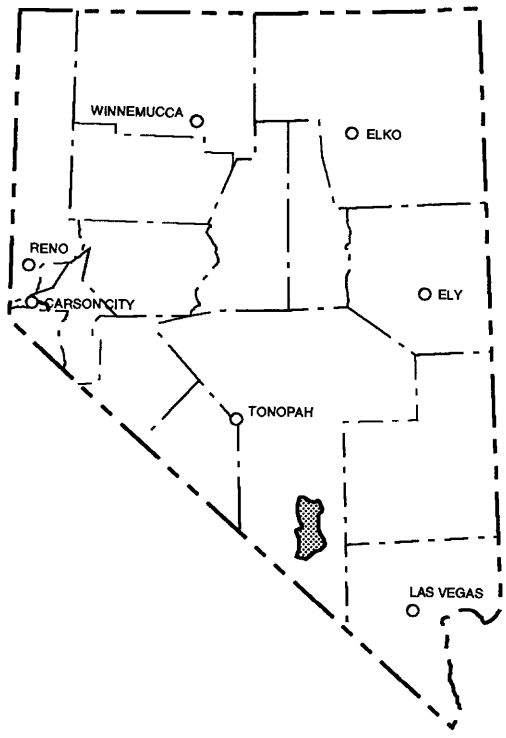


Plans for Fiscal Year 1993: The workplan for intensive surface-water and ground-water data collection and investigation activities will be completed and these activities will start in the spring of 1993.

Publications, Fiscal Year 1992:

Bevans, H.E., and Kilroy, K.C., 1991, National Water-Quality Assessment Program--Nevada Basin and Range: U.S. Geological Survey Open-File Report 91-154, 2 p. (Water Fact Sheet).

Future Surface-Water Hydrology, Yucca Mountain Area *(Project 168)*



Location: Southern Nye County, Nev.

Project Chief: Dennis Grasso.

Period of Project: 1990-97.

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

Problem: Yucca Mountain is being considered as a potential repository for high-level radioactive waste. A study is needed to characterize the effects of potential climate changes on the regional and local surface-water systems.

Objectives: The potential effects of future climatic conditions on the regional and local surface-water systems at Yucca Mountain will be assessed.

Approach: Precipitation-runoff models supported by the USGS will be evaluated, tested, and modified as needed to meet the project objectives. The model chosen will be calibrated using data related to past and present hydrologic conditions. The model will use paleoclimatic and analog-recharge data and the results compared with known or estimated hydrologic conditions. Several hydrologic simulations of future regional and local precipitation-runoff conditions will be used to evaluate possible consequences of future climatic change.

Progress and Significant Results, Fiscal Years 1991-92: Study plans for the project were prepared and reviewed by the U.S. Department of Energy.

Plans for Fiscal Year 1993: Study plan will be completed and various models will be tested.

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.

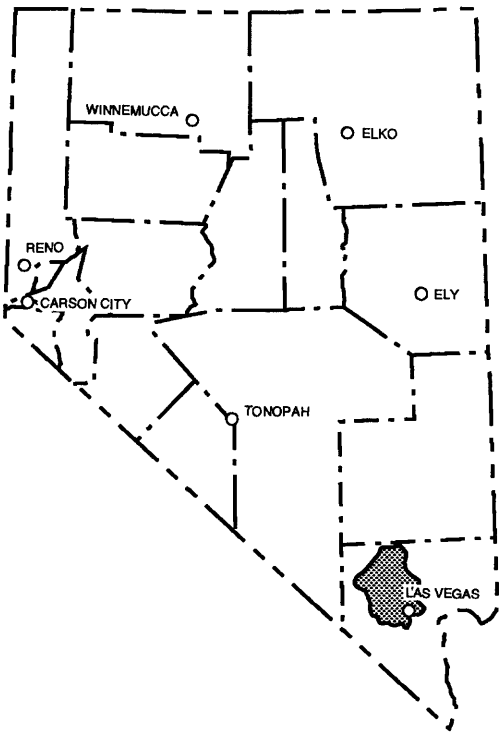
Problem: Land subsidence and earth fissures due to ground-water withdrawal are ongoing problems in many urban and agricultural areas around the world. Current computer models have limited use because they are generally one dimensional in scope. Recently, a three-dimensional mathematical model was developed that accounts for both vertical and horizontal granular displacement. Skeletal granular movement due to long-term overdraft of aquifers is responsible for causing earth fissures. A model that links the granular-velocity model and the ground-water 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: A ground-water flow model will be converted to a USGS granular-velocity model using available subsidence models. The granular-velocity model will use recently established mathematical concepts. An extensometer will be installed where subsidence is most active and 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 Results, Fiscal Years 1991-92: Extensive programming work on modeling activities was done during fiscal years 1991-92. The well design for the installation of the extensometer equipment was started and drilling began. Preparation of the reports began.

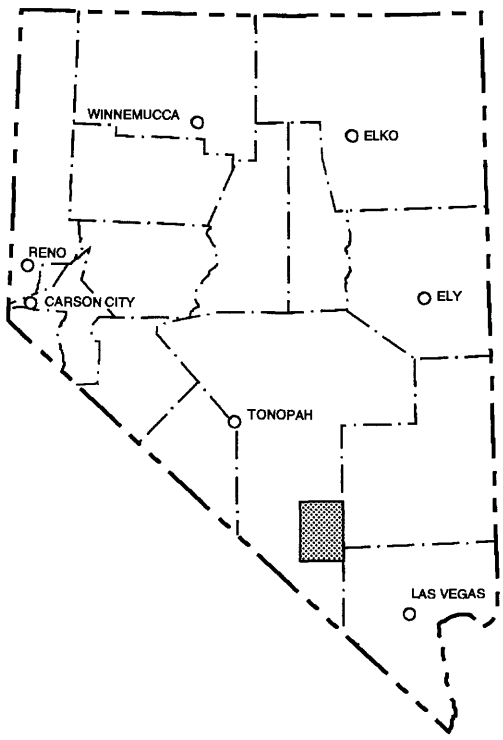
Plans for Fiscal Year 1993: Data-collection activities will begin. Modeling activities and report writing will continue.



Publication, Fiscal Year 1992:

Helm, D.C., (in press), Horizontal aquifer movement in a Theis-Thiem confined system: Water Resources Research journal article.

Environmental Restoration, Nevada Test Site *(Project 170)*



Location: Southern Nye County, Nev.

Project Chief: Randell J. Laczniak.

Period of Project: Continuous since 1991.

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

Problem: Underground testing of nuclear weapons at the Nevada Test Site (NTS) has created potential environmental hazards. The U.S. Department of Energy (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 will provide hydrologic expertise and technical guidance to USDOE in support of ERP, primarily on activities related to characterization of the ground-water flow system. USGS will develop and participate in special studies to address unresolved hydrologic issues at NTS, and will provide regional synthesis and analysis of hydrologic information gathered through ERP activities.

Approach: Sites for drilling monitoring wells will be chosen. Hydrologic testing procedures will be developed and reviewed. Hydrologic data from ERP monitoring wells will be collected and analyzed. Special studies to adequately characterize ground-water flow at NTS will be implemented.

Progress and Significant Results, Fiscal Years 1991-92: Project personnel assisted in planning for hydrologic testing in wells and prepared hydrologic assessments of several wells. A report that describes the current conceptual model of the hydrogeologic system at NTS was begun and submitted for review. Hydrologic expertise and technical support was provided to USDOE.

Plans for Fiscal Year 1993: Hydrologic expertise and technical support to USDOE will continue. The conceptual report will be submitted for approval and publication.

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

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

Project Chief: Larry Bohman.

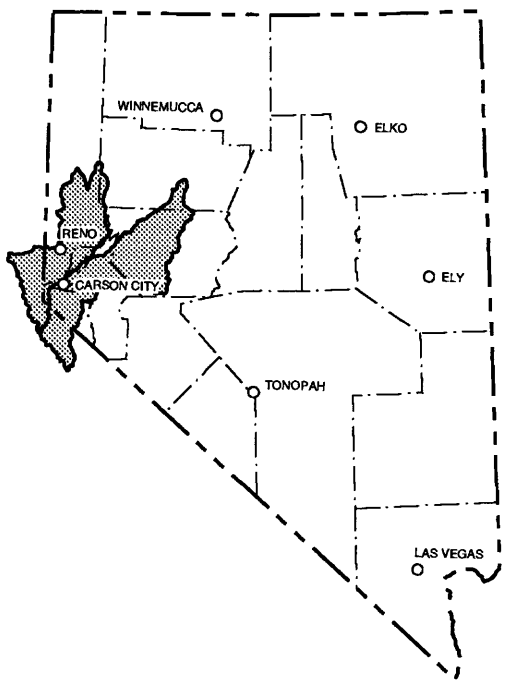
Period of Project: Continuous since 1991.

Supporting USGS Program: Truckee-Carson Program.

Problem: Title II of Public Law 101-618, the Water Settlement Act, contains many explicit and implicit action requirements for Department of the Interior agencies, principally the U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, and U.S. 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 will be reviewed. A baseline Federal network will be designed and implemented for river and lake or reservoir gages, water-quality monitoring networks, and data telemetry and data-base management systems. Appropriate modeling tools will be adapted or developed and calibrated to the Truckee River and Carson River basins for use by various 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 will be 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 1991-92: Existing water-data networks were reviewed. Instruments were purchased, some gages were installed, and data-collection activities at existing stations continued. Existing models were reviewed to begin development of appropriate modeling tools. Technical and hydrologic support was provided to the Department of the Interior. Project personnel attended and participated in technical workgroups and committee meetings. Data collected in fiscal year 1991 was published in the annual water-data report.

Plans for Fiscal Year 1993: 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 1992 annual water-data report.

Publications, Fiscal Years 1991-92:

Garcia, K.T., Gortsema, G.C., Pennington, R.N., and Preissler, A.M., 1992, Water resources data, Nevada, water year 1991: U.S. Geological Survey Water-Data Report NV-91-1, 481 p.

Beatty Deep Unsaturated Zone *(Project 172)*

Location: Amargosa Desert near Beatty, Nev.

Project Chief: David E. Prudic.

Period of Project: 1992-96.

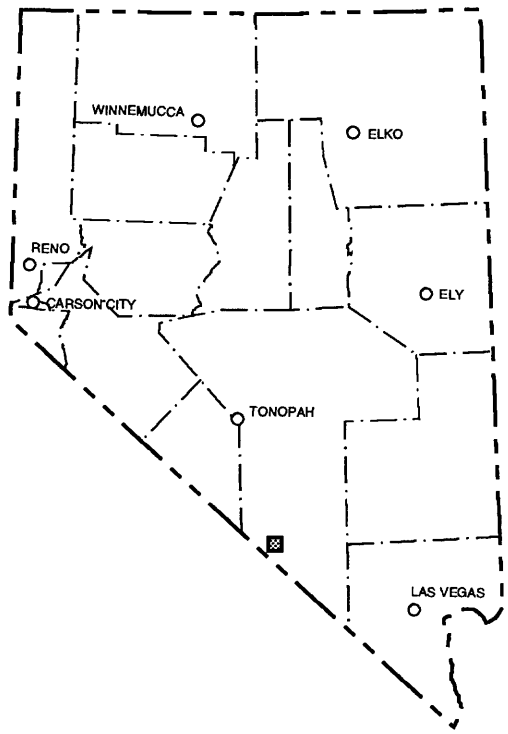
Supporting USGS Program: Low-Level Nuclear Waste Hydrology Program.

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 both 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 to 400 feet) will be tested.

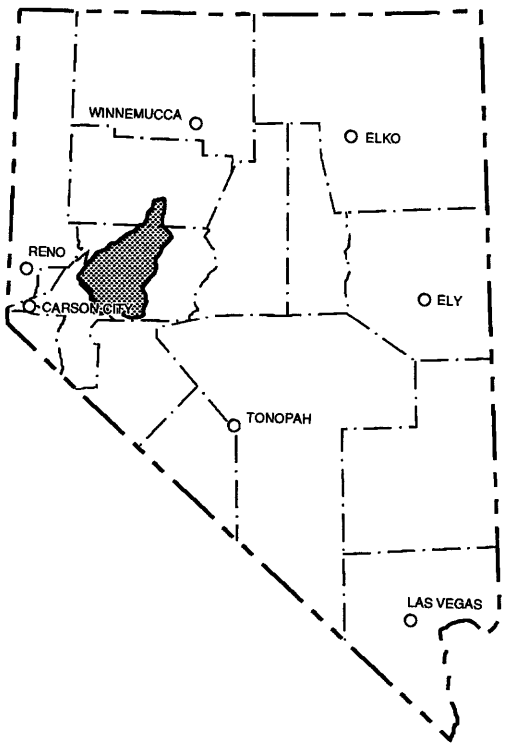
Approach: Soil-gas pressure changes caused by atmospheric pressure changes will be monitored to determine the permeability to air of the unsaturated sediments and to determine the depth of atmospheric air circulation in the unsaturated zone. Soil-gas samples will be collected to determine the depth of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

Progress and Significant Results, Fiscal Year 1992: Air-pressure measurements were collected. Soil-gas samples were collected to a depth of 100 feet. A method was designed to install thermocouple psychrometers in a borehole.



Plans for Fiscal Year 1993: Test-drilling for a thermocouple psychrometer test hole will begin. A test hole will be drilled and air piezometers will be installed. Air pressure measurements will be analyzed.

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 Other Federal Agency: U.S. 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 U.S. 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 Carson Desert. Congress has requested that both agencies report on effects of these changes on ground-water aquifers in the area by November 1993.

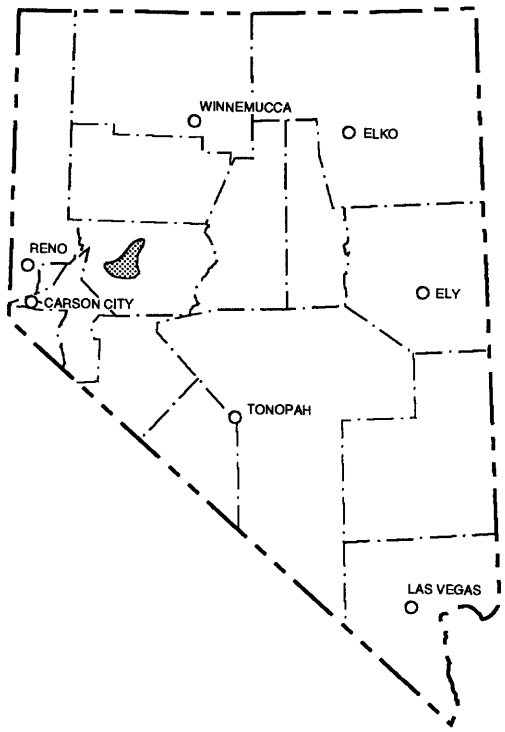
Objectives: A conceptual model of recharge mechanisms to, and ground-water flow paths through, aquifers in the Carson Desert will be developed. The potential effects of changing water use on yield and water quality in local aquifers used for domestic and public water supply will be studied. Data-collection networks will be designed, and methods to fill gaps in existing data will be recommended to refine the conceptual model.

Approach: Existing literature and data on the geohydrology of the Carson Desert will be compiled and reviewed and a conceptual model will be developed.

Progress and Significant Results, Fiscal Year 1992: The literature search was completed and development of the conceptual model began. Report writing began.

Plans for Fiscal Year 1993: The report will be submitted for approval and publication.

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 Other 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 will be determined. A network for future ground-water monitoring will be designed.

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

Progress and Significant Results, Fiscal Year 1992: More than 90 existing wells were selected and 9 new wells were drilled for the monitoring network. Data collection and report writing began. Ground-water levels in some wells rose between 2 and 4 feet after delivery of irrigation water began.

Plans for Fiscal Year 1993: Data-collection activities will continue. The report will be submitted for approval and publication.

Railroad Valley Evapotranspiration *(Project 175)*

Location: Railroad Valley, Nev.

Project Chief: Michael J. Johnson.

Period of Project: 1992-95.

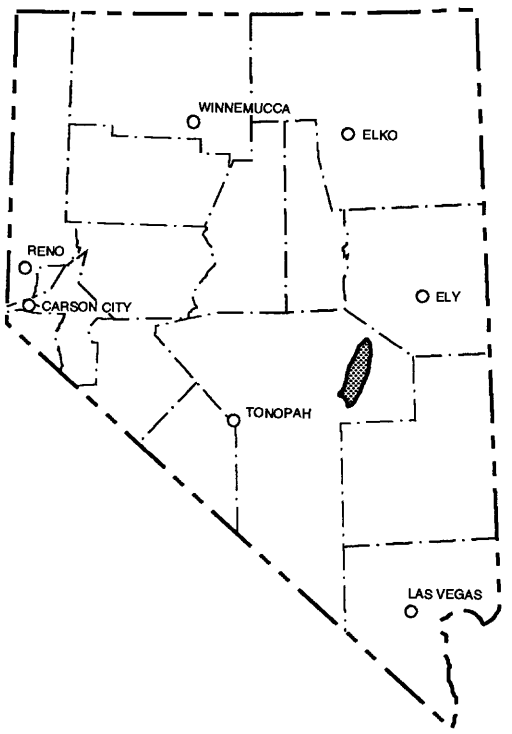
Cooperating Agencies: Las Vegas Valley Water District and Nevada Division of Water Resources.

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.

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

Approach: The energy-budget, Bowen-ratio, and eddy-correlation methods will be used to determine point measurements of ET. Plant transpiration will be measured. The models that estimate ET will be tested. Landsat data will be 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 Year 1992: The equipment required to measure ET was ordered or designed. Satellite imagery that shows vegetation was obtained. Landsat areal reconnaissance to locate transects was made.



Equipment was installed and data collection, initial processing, and analysis began.

Plans for Fiscal Year 1993: Data-collection and interpretation will continue.

Data Synthesis of Irrigation Drainage Areas *(Project 176)*

Location: Western United States.

Project Chief: Ralph L. Seiler.

Period of Project: 1992-94.

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. As part of the program, the Task Group on Irrigation Drainage was formed, including members of the U.S. Bureau of Indian Affairs, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service (USFWS), and the U.S. Geological Survey (USGS). The Task Group prepared a comprehensive plan for reviewing irrigation drainage concerns for the Department of the Interior, and identified 25 areas in 14 States that warranted reconnaissance-level investigations. The reconnaissance investigations were conducted by interbureau study teams, and seven areas were selected for detailed investigation. Several reports on the results of the investigations have been published and several are in review. A comprehensive evaluation of the data collected is needed to determine how climate, drainage, geology, and other factors may be linked to determine whether irrigation drainage in other areas of the western region of the United States will result in water-quality problems.

Objectives: The data collected for the reconnaissance and detailed investigations will be gathered into one data base. Multivariate statistics and pattern-recognition techniques will be 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. Capabilities will be developed as much as possible to estimate where irrigation drainage may result in water-quality problems.

Approach: A data base will be created that combines water-quality data from USGS, Water Resources Division; sediment data from USGS, Geologic Division; and biologic data from USFWS. A study team including three scientists from USGS and one scientist from USFWS will be formed. One USGS member will be the team leader who will coordinate the overall project and author/co-author reports summarizing the results of data syntheses. One USGS member will analyze chemical and mineralogic data and another USGS member will analyze the hydrologic and geologic data. The USFWS member and the team leader are biologists who will interpret the biologic data.

Progress and Significant Results, Fiscal Year 1992: A workplan was drafted by the study team. Preparation of the data base began.

Plans for Fiscal Year 1993: The data will be analyzed and the results will be interpreted.

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