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INTRODUCTION

In 1991, the U.S. Geological Survey (USGS) began a full-scale National Water-Quality Assessment (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 NAWQA program consists of 60 of the Nation's most important river basins and aquifer systems, referred to as study units. These study units represent a large part of the Nation's water use and population served by public supplies. In 1991, the Nevada Basin and Range (NVBR) was among the first 20 NAWQA study units selected for investigation under the full-scale implementation plan. The NVBR NAWQA study unit consists of three drainage basins, the Las Vegas Valley area in southeast Nevada, and the Carson and Truckee River Basins in northwest Nevada and northeast California (see inset map, fig. 4). NAWQA studies will provide nationally consistent information that can be integrated to describe the quality of the Nation's water resources, define the conditions and trends in water quality, and identify, describe, and explain the major factors that affect observed water-quality conditions and trends.

As part of the NVBR NAWQA program, a network of 32 monitoring wells (fig. 4) was established to evaluate the effects of urban land use on shallow ground-water quality in the Las Vegas urban area. The network consists of wells completed just below the water table. Water sampled from these wells is the ground water most likely to show contamination from sources at the land surface (Squillace and others, 1995, p. 3). These wells are not used for drinking-water supplies.

Most of the network wells penetrate shallow aquifers similar to those described by Harrill (1976, p. 26), which are supplemented or developed from secondary recharge attributed to excess landscape irrigation. Increasing use of water for landscape irrigation, and ground-water withdrawals for public-water supplies from the deeper principal aquifers, have created the potential for poor-quality shallow ground water (exceeds drinking water standards for one or more constituents) to move downward and contaminate the principal aquifers (Dettinger, 1987, p. 49).

Purpose and Scope

This report presents water-quality and ancillary data for shallow ground-water samples collected in the Las Vegas urban area during August 1993. The ground-water samples were collected by NVBR NAWQA project personnel for use in assessing the effects of urban land use on ground-water quality. The sampling network consisted of 32 monitoring wells; 25 are existing monitoring wells maintained by the Las Vegas Valley Water District or the U.S. Geological Survey and the remaining 7 wells were installed as part of the NVBR NAWQA project. Climate, hydrology, population, land use, and water use of the Las Vegas Valley also are described herein.

Acknowledgments

The authors acknowledge entities and individuals who participated in selecting, installing, and sampling network wells, and in the chemical analyses of water-quality samples. The Las Vegas Valley Water District, represented by Erin Cole, assisted in locating sites for installing monitoring wells and provided access to shallow ground-water monitoring wells. The City of Las Vegas and Clark County Parks and Recreation gave permission for installing monitoring wells on properties that they administer. The USGS Corrosion by Wet Precipitation research group, led by Michael Reddy with assistance from Scott Charlton and Charmaine Gunther, collected and analyzed ground-water samples for major, minor, and trace inorganic constituents. Glenda Brown of the USGS National Water Quality Laboratory assisted in the collection of ground-water samples. USGS Nevada District personnel Robert Pennington, Ronald Collins, Armando Robledo, and Arthur Johnson assisted in the installation and sampling of monitor wells.

Geographic Setting

The Las Vegas Valley area encompasses 1,640 mi^2 in southeastern Nevada. Altitudes range from about 11,900 ft above sea level in the Spring Mountains in the west to about 1,200 ft where Las Vegas Wash enters Lake Mead. The valley trends northwest to southeast and is approximately 50 mi long and 30 mi wide.

The climate of the Las Vegas Valley area varies from subhumid continental at higher altitudes in the Spring Mountains, where average annual precipitation exceeds 20 in., to low-latitude desert at lower altitudes, including the Las Vegas urban area where average annual precipitation is about 4 in. (Speck, 1985, p. 3). Most rain falls during December through March. Summer thunderstorms of short duration and high intensity can cause local flooding and erosion. Intense rain storms are possible in any season and can produce torrents of water and debris.

In Las Vegas for 1981-91, the average monthly summer temperature maximum was 102°F and the minimum was 70°F, and the average monthly winter temperature maximum was 59°F and the minimum was 33°F. The frost-free period averages about 240 days in the valley (data from National Climatic Center, 1982-92).

Hydrologic Setting

The NVBR NAWQA Las Vegas Valley area includes the Las Vegas Valley Hydrographic Area and part of the Black Mountains Hydrographic Area[1]. Major aquifers in the Las Vegas Valley area are within a 550-mi^2 area of basin-fill deposits that are thousands of feet thick and consist primarily of unconsolidated sediments (Harrill, 1976, p. 7). Most ground water flows from recharge areas in the Spring Mountains, in the northwest part of the valley, to the southeast through Las Vegas Valley (Loeltz, 1963, p. Q5).

Descriptions of aquifers in the Las Vegas Valley are based on reports by Maxey and Jameson (1948), Malmberg (1965), Harrill (1976), Dettinger (1987), and Morgan and Dettinger (1996). In the valley, four aquifer zones have been described: (1) shallow (perched) aquifers, (2) near-surface aquifers, (3) principal aquifers, and (4) deep aquifers. Confined and unconfined conditions are present locally in all aquifers.

Water-quality data presented in this report were collected from the shallow aquifers described by Harrill (1976, p. 26). These aquifers, which have developed from secondary recharge due to excess landscape irrigation, are described as about the upper 20-50 ft of saturated sediments where the water table is within about 20 ft of the land surface. Shallow ground water discharges (1) to Las Vegas Wash and its tributaries, (2) by evapotranspiration, and (3) possibly by downward percolation to deeper aquifers.

Ground water near the water table tends to have higher concentrations of dissolved solids than deeper ground water everywhere in the valley, with the exceptions of the northern and western edges of the valley where the chemistry of the water appears similar regardless of depth (Dettinger, 1987, p. 32). The quality of public water-supply sources in deep principal aquifers may be threatened by current hydrologic conditions that have created the potential for downward leakage of water from shallow aquifers. Declining water levels in principal aquifers, caused by withdrawals for public-water supplies, and the development of shallow aquifers, caused by excess landscape irrigation, have created a downward hydraulic gradient. Although clay layers, which dried and compacted following water-level declines in principal aquifers, impede the downward movement of poor-quality water from the shallow aquifers, the potential exists for degradation of water quality in principal aquifers. The principal aquifers are most susceptible to degradation by mixing with shallow water around the margins of the valley where confining layers are not present to impede downward movement and mixing (Dettinger, 1987, p. 18).

Population and Urbanization

The population of the Las Vegas Valley area was about 900,000 in 1993 (data from Nevada Department of Taxation). Population growth rates in the Las Vegas Valley area (fig. 1) averaged nearly 70 percent in the 1970's and nearly 65 percent in the 1980's (data from Nevada Department of Taxation and U.S. Bureau of the Census). Urban activities can affect the quality of water resources.

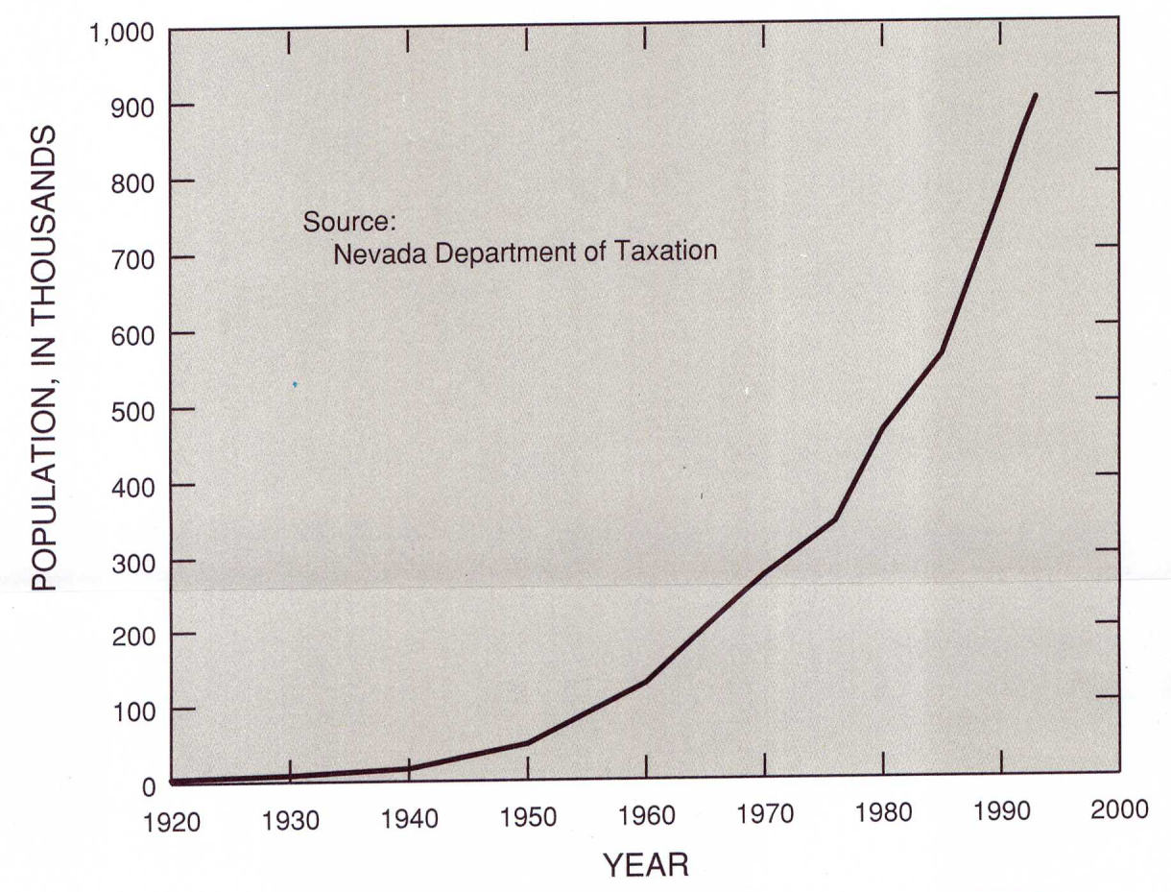

Figure 1.—Population trend in Las Vegas Valley area, 1920-93.

Water and Land Use

Ground water was the main source of water for the area until 1971, when extensive importation of Colorado River water began. Water from Lake Mead on the Colorado River is provided for use in most of the valley by water-distribution systems in Las Vegas, North Las Vegas, and Henderson. Total water use for the Las Vegas Valley area in 1990 was about 317,000 acre-ft (James E. Crompton, U.S. Geological Survey, written commun., 1992). This included all self-supplied withdrawals and public-supply deliveries. Of the 317,000 acre-ft of water used, about 80 percent came from Lake Mead. Public-water supplies accounted for about 91 percent of the water used (fig. 2). Self-supplied water for commercial and domestic purposes was about 4 percent of the total. Self-supplied water for industrial and mining use was about 3 percent of the total. Self-supplied water for irrigation and agriculture was about 2 percent of the total.

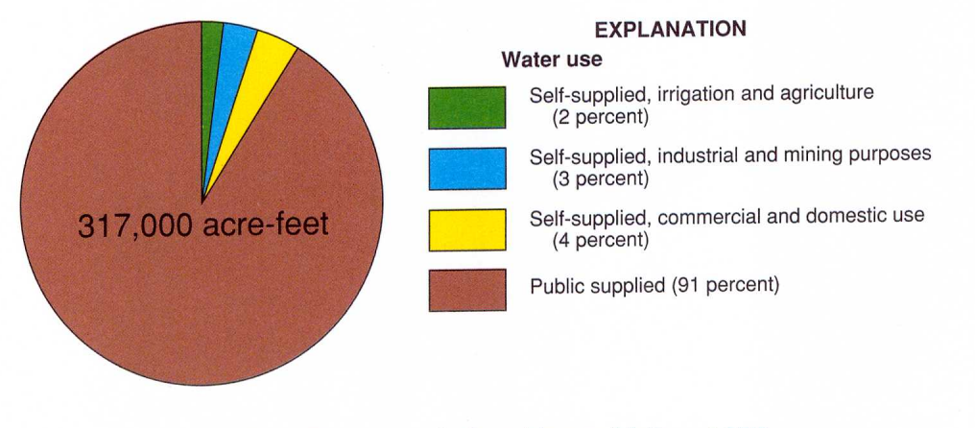

Figure 2.—Water use in Las Vegas Valley, 1990.

Land use in the Las Vegas Valley (fig. 3) was 79 percent range, 14 percent forest, 5 percent urban, 1 percent open water and wetlands, and 1 percent barren (U.S. Geological Survey, digital data, 1973-83, 1:25,000). Figure 4 shows the Las Vegas urban area further divided into commercial, residential, irrigated (includes parks and golf courses), industrial and utilities, lake and open water, and vacant and rural land uses (Las Vegas Valley Water District, digital data, provisional, 1993, 1:24,000).

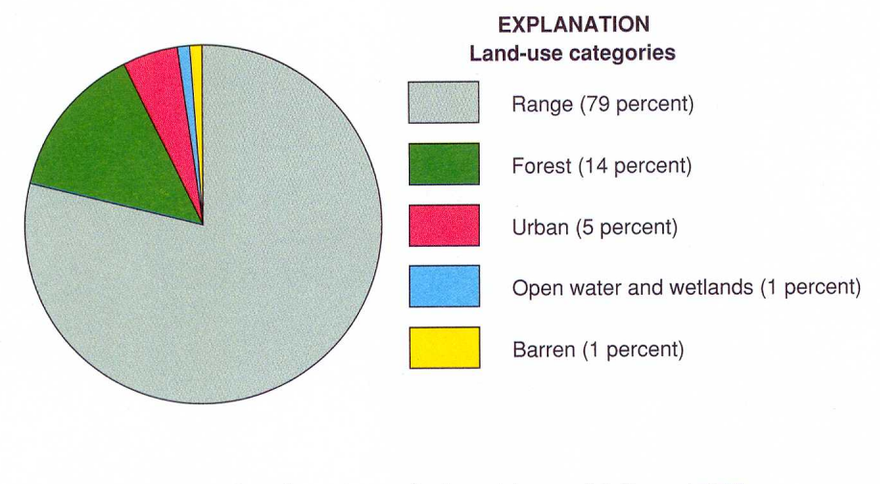

Figure 3.—Land use in Las Vegas Valley, 1990.

METHODS OF INVESTIGATION

Site Selection and Well-Installation Procedures

The 32 shallow monitoring wells sampled in the Las Vegas urban area are shown in figure 4. New wells at sites 4, 8, 10, 14, 20, 22, and 32 were installed and developed by NVBR NAWQA project personnel in August 1993. All new wells were installed according to NAWQA protocols (Hardy and others, 1989). These wells were drilled using continuous-flight augering techniques without the use of drilling fluids. To avoid contamination during drilling, the auger flights and bit were pressure washed between sites. Casing and screen material consisted of threaded, schedule-40 polyvinylchloride (PVC). The well screens and casing were pre-cleaned and sealed in plastic until installed. Wells were screened within 50 ft of the ground surface except site 32, which was screened from 55 to 60 ft. All new wells were developed by bailing and pumping; a minimum of 25 well-bore volumes of water were removed.

The other 25 wells were selected from existing ground-water monitoring wells maintained by the USGS or the Las Vegas Valley Water District. Existing wells were selected to provide the best possible areal coverage of the Las Vegas urban area and to comply with NAWQA well-installation protocols, as determined from available well-construction information, to the fullest possible extent.

Sample Collection and Analysis

Wells were sampled according to protocols developed for the NAWQA program (Hardy and others, 1989). Prior to sampling the wells, standing water in the casing was removed by purging at least three well-bore volumes of water. All water samples were pumped to the surface by a bladder pump with Teflon[2] and Teflon-coated delivery materials. Water temperature, pH, dissolved oxygen, and specific conductance were monitored during purging using a flow-through chamber to reduce contact of the sample with the atmosphere. Samples were not collected until these properties stabilized.

Quality-assurance samples including duplicates, equipment blanks, trip blanks, spikes, and spiked replicates also were collected and analyzed. Analytical results of the quality-assurance samples and a complete list of water-quality constituents and properties included in the sampling program were compiled in the 1993 water-resources data report for Nevada (Emett and others, 1994, p. 583-588).

Major and trace-constituent samples were collected in cooperation with the USGS Corrosion by Wet Precipitation research group (CWP). These samples were analyzed by the CWP research group in Boulder, Colo., with the exception of aluminum, arsenic, chromium, and selenium at sites 16, 18, 20, and 29, according to USGS protocols (Skougstad and others, 1979; Garbarino and Taylor, 1979, 1980; Crock and Lichte, 1982; Fishman and Friedman, 1989; Welsch and others, 1990; Roth, 1994; Brinton and others, 1995). The exceptions noted above were analyzed by either the USGS National Water-Quality Laboratory in Arvada, Colo., or the Geologic Division Branch of Geochemistry in Lakewood, Colo. Analytical results reported as "dissolved" were determined from samples filtered through 0.45-micron membranes for samples analyzed at the USGS National Water-Quality Laboratories and 0.10-micron membranes for samples analyzed at the CWP research group laboratory. Analytical results of quality-assurance and quality-control samples analyzed by CWP research group are available from their project laboratory in Boulder, Colo., upon request.

Analyses of nutrients, radionuclides, pesticides, major constituents (sites 22 and 27), and volatile organic compounds were made by the USGS National Water-Quality Laboratory using USGS approved methods (Thatcher and others, 1977; Wershaw and others, 1987; Fishman and Friedman, 1989; Rose and Schroeder; 1995; Zaugg and others, 1995). Field analyses of alkalinity were made on site using the protocol described by Shelton (1994).

DISCUSSION OF RESULTS

None of the shallow wells sampled in the Las Vegas urban area as part of this study are used as sources of drinking water. Nonetheless, comparisons of data on ground-water quality with drinking-water regulations serve primarily to provide an indication of the general quality of shallow ground water in the study area. Water that meets drinking-water regulations generally is considered to be of good quality and suitable for most beneficial uses (La Camera and Westenburg, 1994, p. 35).

Drinking-water regulations are defined by the U.S. Environmental Protection Agency (USEPA) to ensure that safe drinking water is supplied to the public. Water-quality regulations referenced in the following discussion and presented in table 1 include proposed, draft, and final primary maximum contaminant levels (MCL's) and adult lifetime health advisories (HA's). These regulations are emphasized (fig. 4) because they have human-health implications. Only the final MCL's are enforceable for public water-supply systems. Secondary maximum contaminant levels (SCML's) are aesthetic-based levels that are enforced by the State of Nevada for public water-supply systems (table 1). SCML's, if exceeded, may not cause health problems but may result in water that is unpleasant to drink. The HA is the maximum concentration in drinking water that is not expected to cause any adverse effects over a lifetime of exposure, with a margin of safety (Squillace and others, 1995, p. 3).

Information on well completion and on-site measurements of water levels and physical and chemical properties of the ground water sampled are presented in table 2. These water levels and on-site physical and chemical properties were measured on the same day and just prior to collection of ground-water samples for chemical analyses.

Dissolved-solids concentrations (calculated as the sum of dissolved constituents) ranged from 351 to 5,700 mg/L (table 3 and fig. 4). Concentrations generally were lower in the northern part of the urban area and higher in the southern part. Dissolution of minerals in most rocks and soils contributes to concentrations of dissolved solids in ground water, although the presence of industrial or agricultural wastewater or sewage can increase the dissolved-solids concentration of water (Garcia, 1989, p. 40). Evapotranspiration also can concentrate dissolved solids in ground water in arid climates (Dubrovsky and others, 1993, p. 547). The proposed MCL (500 mg/L) for sulfate, a major component of the dissolved-solids concentration at most sites, was exceeded in water samples from all sites except 1, 2, 5, and 6 (table 3 and fig. 4).

Radon activities equaled or exceeded the proposed MCL (300 picocuries per liter) in 83 percent of the samples analyzed (table 3 and fig. 4). Radon activities were lower than the MCL in samples from sites 2, 5, 7, 10, and 25. According to Hem (1985, p. 149), radon-222 is a soluble, naturally occurring radioisotope derived from radium in the solids of an aquifer (in a radioactive-decay series beginning with uranium-238). Uranium concentrations exceeded the proposed MCL (20 µg/L) in three of the five samples analyzed (table 3 and fig. 4). Samples from sites 18, 20, and 29 contained uranium concentrations of 35, 56, and 27 µg/L, respectively. The concentration of uranium in ground water largely is controlled by the occurrence of uranium in rocks and soils, and redox conditions in water (Hoffman and others, 1990, p. 38).

Concentrations of nitrite plus nitrate equaled or exceeded the final MCL (10 mg/L as N) in samples from sites 7, 13, 16, and 30 (table 4 and fig. 4). According to Dettinger (1987, p. 36), nitrate concentrations in shallow ground water of the Las Vegas Valley are spatially quite variable and probably related to local disposal of wastewater, lawn irrigation, and possibly the use of fertilizer in central parts of the valley.

Among the determined trace elements (table 5), lead concentrations in samples from sites 6, 20, 25, and 29 exceeded the final MCL of 15 µg/L (table 5 and fig. 4). Lead can be dissolved in small amounts from soils and rocks containing minerals such as galena. Lead from the combustion of "leaded" gasoline also can increase concentrations of lead in ground water (Hem, 1985, p. 143-144).

Synthetic organic compounds classified as volatile organic compounds (VOC's) and pesticides are shown in tables 6 and 7, respectively. Only those organic compounds that were detected in at least one sample are included in the tables. Concentrations of these organic compounds were below MCL's in all but one sample. Concentrations of the VOC's tetrachloroethylene and trichloroethylene at site 9 exceed final MCL's (5 µg/L). Tetrachloroethylene and trichloroethylene are frequently used as industrial solvents for dry cleaning and metal degreasing. Trichloroethylene also may form in ground water from degradation of tetrachloroethylene (Thodal, 1992, p. 28).

As part of the USGS NAWQA program, concentrations of 60 VOC's were analyzed for samples from 211 shallow wells in 8 urban areas and 524 shallow wells in 20 agricultural areas nationwide. Chloroform and methyl tert-butyl ether (MTBE) were the two most frequently detected VOC's (Squillace and others, 1995).

Phenols, chloroform, and MTBE were the most frequently detected VOC's in the Las Vegas urban area. Phenols were detected at 74 percent of the sites sampled at concentrations ranging from 1 µg/L to 4 µg/L (table 6). The draft HA for phenols is 4,000 µg/L. The analysis of phenols is a gross analysis of total phenol concentration. Phenol is primarily an industrial chemical used in the production of compounds such as phenolic resins, germicides, pharmaceuticals, fungicides, dyes, herbicides, plastics, explosives, antiseptic throat lozenges, and skin medications (Smith and others, 1988, p. 44).

Chloroform was detected in water samples from 72 percent of the sites (table 6). Concentrations ranged from the reporting level of 0.2 µg/L to 12 µg/L, which are below the final MCL of 100 µg/L. Chloroform is a trichloromethane (THM). Some uses include the manufacture of fluorocarbon refrigerants, propellants, plastics, anesthetics, and pharmaceuticals. Chloroform also can be produced inadvertently during the chlorination of water supplies or when chlorine combines with dissolved organic carbon in water (Thodal, 1992, p. 25).

MTBE was detected in samples from sites 10, 17, 20, and 22 (table 6). The concentrations of MTBE in samples from the urban area were all below 20 µg/L, the draft HA. MTBE is a compound made from methanol that is used to increase the octane of gasoline and improve air quality in urban areas. Sources of MTBE releases into the environment are not well quantified, but leaking underground storage tanks and spills at the land surface are known sources of MTBE contamination (Squillace and others, 1995).

Pesticides detected during the study are listed in table 7. In the Las Vegas urban area, prometon was the most frequently detected pesticide. Prometon was detected in water samples from sites 13, 16, 18, 25, and 26. The draft HA for prometon is 100 µg/L. Atrazine and simazine were the second and third most frequently detected pesticides with three detections of atrazine and two detections of simazine. All detections were well below the final MCL's for these two pesticides (3 and 4 µg/L, respectively). Prometon, atrazine, and simazine are water-soluble triazine herbicides used for crop and noncrop applications. They are used primarily for pre-emergent and early post-emergent control of grass and broadleaf weeds (Jordan and Cudney, 1987, p. 23; Meister Publishing Co., 1991, p. C24).

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[1] Formal hydrographic areas in Nevada were delineated systematically by the U.S. Geological Survey and Nevada Division of Water Resources in the late 1960's for scientific and administrative purposes (Rush, 1968; Cardinalli and others, 1968). The official hydrographic area names, numbers, and geographic boundaries continue to be used in Geological Survey scientific reports and Division of Water Resources administrative activities.

[2] Any use of trade names in this publication is for descriptive purposes only and does not constitute endorsement by the U.S. Government.

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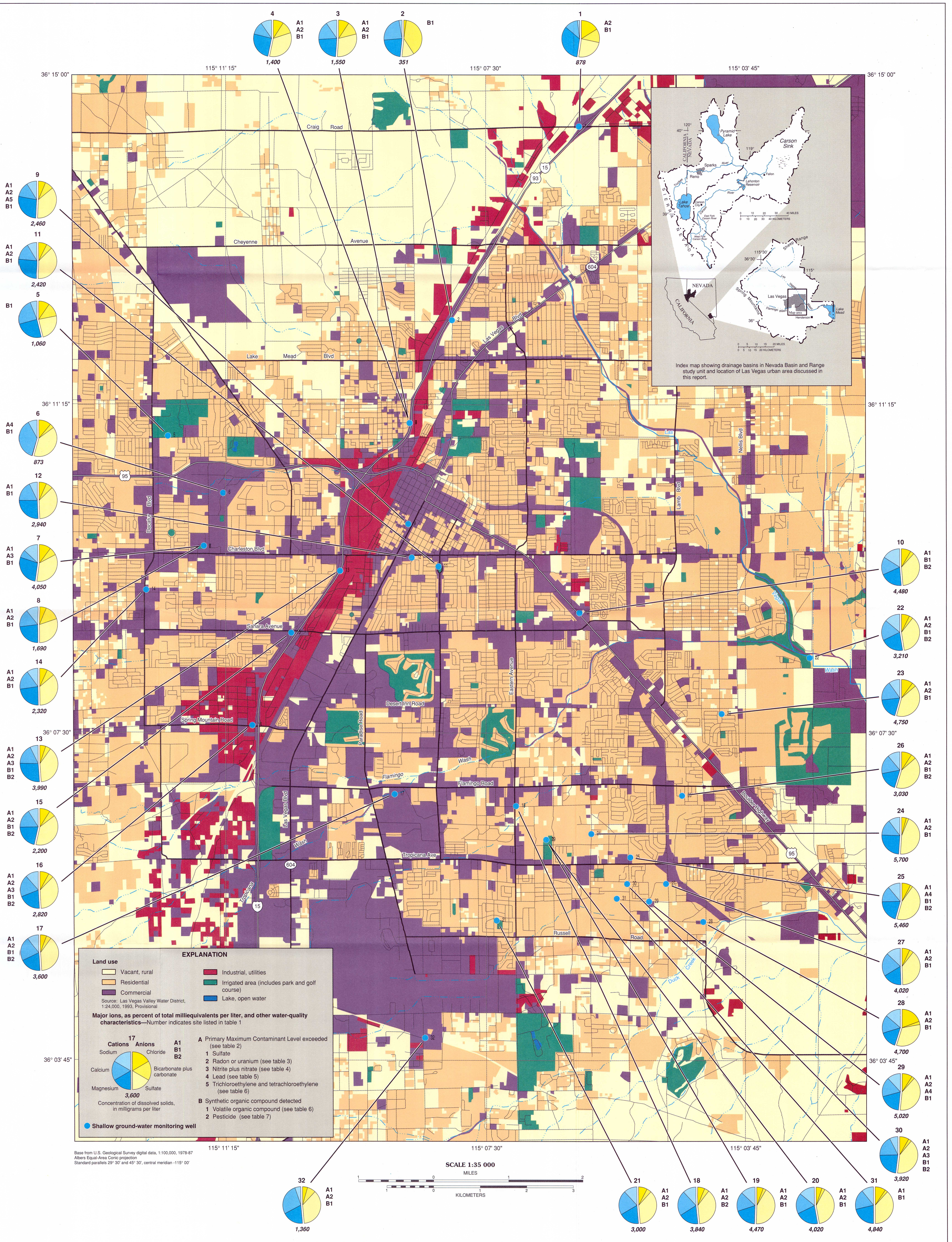

Figure 4.—Map showing location of shallow monitoring wells, land use, and selected water-quality characteristics for shallow ground-water samples collected from Las Vegas urban area, Nevada, August 1993.

Table 1. Selected primary and secondary maximum contaminant levels for drinking water and adult lifetime health advisories (from U.S. Environmental Protection Agency, 1996)

[Abbreviations and symbols: P, proposed; D, draft; F, final; µg/L, micrograms per liter; mg/L, milligrams per liter; pCi/L, picocuries per liter; U, under review; --, not available.]

Constituent	Primary maximum contaminant level (and status)	Secondary maximum contaminant level (and status)	Adult lifetime health advisory (and status)
Inorganics			
Aluminum	--	50-200 µg/L (F)	--
Arsenic	50 µg/L (U)	--	--
Barium	2,000 µg/L (F)	--	2,000 µg/L (F)
Beryllium	4 µg/L (F)	--	--
Boron	--	--	600 µg/L (D)
Cadmium	5 µg/L (F)	--	5 µg/L (F)
Chloride	--	250 mg/L (F)	--
Chromium	100 µg/L (F)	--	100 µg/L (F)
Copper	--	1,000 µg/L (F)	--
Iron	--	300 µg/L (F)	--
Lead	15 µg/L (F)	--	--
Manganese	--	50 µg/L (F)	--
Molybdenum	--	--	40 µg/L (D)
Nickel	100 µg/L (F)	--	100 µg/L (F)
Nitrate (as N)	10 mg/L (F)	--	--
Nitrite + Nitrate (as N)	10 mg/L (F)	--	--
Nitrite (as N)	1 mg/L (F)	--	--
Selenium	50 µg/L (F)	--	--
Solids, dissolved	--	500 mg/L (F)	--
Sulfate	500 mg/L (P)	250 mg/L (F)	--
Zinc	--	5,000 µg/L (F)	2,000 µg/L (F)
Radionuclides			
Radon	300 pCi/L (P)	--	--
Uranium	20 µg/L (P)	--	--
Organics			
Atrazine	3 µg/L (F)	--	3 µg/L (F)
Benzene	5 µg/L (F)	--	--
Chlorodibromoethane	[a]100 µg/L (F)	--	--
Chloroform	[a]100 µg/L (F)	--	--
Dichlorobromoethane	[a]100 µg/L (F)	--	--
Dichlorodifluoromethane	--	--	1,000 µg/L (F)
Methyl tert-butyl ether	--	--	[b]20-200 µg/L (D)
Phenols	--	--	4,000 µg/L (D)
Prometon	--	--	100 µg/L (D)
1,1-Dichloroethylene	7 µg/L (F)	--	7 µg/L (F)
Simazine	4 µg/L (F)	--	4 µg/L (F)
Tebuthiuron	--	--	500 µg/L (F)
Tetrachloroethylene	5 µg/L (F)	--	--
1,1,1-Trichloroethane	5 µg/L (F)	--	--
Trichloroethylene	5 µg/L (F)	--	--

[a] These chemicals are trihalomethanes (THM); total concentration for combined THM cannot exceed 100 µg/L.

[b] If MTBE is classified as a carcinogen, lifetime health advisory will be 20 µg/L; otherwise it will be 200 µg/L.

Table 2. Selected well-completion information, water levels, and on-site measurements of physical and chemical properties of water from shallow ground-water monitoring wells, Las Vegas urban area

USGS site identification number: Standard site identification is based on grid system of latitude and longitude. Number consists of 15 digits. First six digits denote degrees, minutes, and seconds of latitude; next seven digits denote degrees, minutes, and seconds of longitude; and last two digits (assigned sequentially) identify sites within 1-second grid. For example, site 361425115061901 is at 36°14′25″ latitude and 115°06′19″ longitude, and is first site recorded in that 1-second grid. Assigned number is retained as permanent identifier even if more precise latitude and longitude are later determined.

Total depth of well: Sources of information are drillers' logs (on file at Nevada Division of Water Resources or U.S. Geological Survey, Carson City, Nev.).

[Specific conductance, pH, water temperature, and dissolved oxygen were measured in the field. Abbreviations and symbols: °C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; --, not determined]

Site no. (fig. 4)	USGS site identification number	Land-surface altitude (feet above sea level)	Total depth of well (feet)	Screened interval (feet below land surface)	Date sampled	Water level (feet below land surface)	Specific conductance (µS/cm)	pH (standard units)	Water temperature (°C)	Oxygen, dissolved (mg/L)
1	361425115061901	1,919	84	80-84	08-20-93	62.60	1,400	7.6	25.0	5.9
2	361212115065901	1,910	46	43-46	08-22-93	27.40	600	7.5	23.0	3.9
3	361102115083601	2,010	15	11-15	08-23-93	9.16	2,390	7.1	21.5	.4
4	361102115083602	2,010	33	28-33	08-23-93	10.01	2,390	7.1	21.5	.4
5	361053115120501	2,000	33	27-31	08-22-93	9.60	1,600	7.3	20.0	3.0
6	361014115111701	2,140	40	20-40	08-23-93	12.53	1,290	10.2	21.0	--
7	360937115113401	2,155	18	14-18	08-17-93	8.93	5,320	6.7	19.5	.2
8	360937115113402	2,158	35	30-35	08-17-93	8.10	2,300	6.2	18.5	.2
9	360837115095501	2,010	22	18-22	08-21-93	7.70	3,100	7.0	23.5	1.7
10	360852115060901	1,825	25	20-25	08-20-93	6.86	5,550	7.1	24.0	.4
11	360924115081101	1,990	15	11-15	08-22-93	7.09	2,970	7.5	23.0	2.9
12	360930115083401	2,008	25	21-25	08-22-93	11.86	3,400	6.9	23.0	--
13	360921115093601	2,047	17	13-14	08-21-93	8.66	4,650	6.9	22.5	2.0
14	360908115122401	2,209	27	22-27	08-24-93	18.04	2,900	7.1	23.0	3.5
15	360838115101801	2,075	24	21-24	08-18-93	7.00	2,930	7.2	25.0	3.1
16	360735115105201	2,120	45	41-45	08-18-93	8.70	3,470	7.0	23.5	3.9
17	360648115084901	2,030	15	10-15	08-23-93	8.40	4,050	7.0	24.5	1.6
18	360640115070401	1,948	20	10-15	08-20-93	8.96	4,490	6.9	21.5	1.6
19	360617115063801	1,950	24	20-24	08-17-93	13.79	4,920	7.3	23.0	--
20	360617115063802	1,958	30	25-30	08-17-93	13.60	4,810	7.1	21.0	2.0
21	360522115072101	2,010	30	26-30	08-21-93	16.75	2,540	7.0	21.0	4.3
22	360821115025001	1,708	49	44-49	08-24-93	19.78	3,950	7.2	19.0	.1
23	360744115050801	1,730	11	7-11	08-18-93	8.33	5,540	6.9	25.0	2.1
24	360621115055901	1,938	30	24-30	08-24-93	17.89	5,950	7.0	22.0	.9
25	360605115052501	1,912	24	19-24	08-19-93	18.15	6,040	7.0	24.0	2.3
26	360647115044001	1,768	25	20-25	08-21-93	9.47	3,650	7.0	23.0	--
27	360547115045401	1,829	30	19-30	08-24-93	10.40	4,600	6.9	23.5	2.8
28	360521115042201	1,803	19	14-19	08-19-93	7.75	5,400	7.1	27.5	.6
29	360535115050901	1,872	18	14-18	08-19-93	6.20	5,570	7.1	24.0	2.7
30	360547115052801	1,919	29	24-29	08-20-93	16.24	4,650	7.2	22.0	3.5
31	360537115053701	1,912	23	17-23	08-19-93	10.33	5,600	7.1	21.0	3.2
32	360401115082301	2,086	60	55-60	08-16-93	30.01	1,830	6.7	23.0	3.9

Table 3. Major ions, dissolved solids, and radionuclides in water samples from shallow ground-water monitoring wells, Las Vegas urban area. Analyses by U.S. Geological Survey, Corrosion by Wet Precipitation Research Laboratory, Boulder, Colo., except as noted

[Alkalinity, carbonate, and bicarbonate were measured in the field. Abbreviations and symbols: mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; --, not determined or, for carbonate, not detected]

Site no. (fig. 4)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Alkalinity (mg/L as $CaCO_3$)	Bicarbonate, (mg/L as HCO_3)	Carbonate, (mg/L as CO_3)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Solids, dissolved residue on evaporation[a] (mg/L)	Solids, dissolved, sum of constituents (mg/L)	Radon-222, total[a] (pCi/L)	Uranuim (natural), dissolved[a] (µg/L as U)
1	74	120	13	3.5	184	224	--	340	170	922	878	500	--
2	[a]60	[a]34	[a]7.7	[a]2.3	246	300	--	[a]67	[a]11	347	351	230	--
3	160	140	110	32	294	359	--	720	170	1,830	1,550	610	--
4	100	140	100	20	237	289	--	720	150	1,550	1,400	420	--
5	170	110	50	5.5	220	268	--	430	140	1,130	1,060	230	7.0
6	190	.4	46	13	35	0	31	480	99	910	873	--	--
7	330	420	370	34	389	475	--	2,100	460	1,740	4,050	370	--
8	180	160	140	8.2	445	543	--	820	120	4,660	1,690	250	--
9	210	260	160	32	308	376	--	1,390	180	2,650	2,460	500	--
10	440	340	520	52	227	277	--	2,500	430	4,860	4,480	290	--
11	230	240	150	21	195	238	--	1,400	210	--	2,420	370	--
12	340	300	160	27	289	353	--	1,700	200	3,110	2,940	--	--
13	450	410	210	45	303	370	--	2,400	240	4,620	3,990	440	--
14	260	210	170	13	256	312	--	1,300	190	2,390	2,320	440	--
15	230	180	140	35	200	244	--	1,300	230	2,470	2,260	690	--
16	350	220	240	16	203	248	--	1,600	250	2,970	2,820	570	15
17	500	260	260	32	250	305	--	2,100	230	3,820	3,600	470	--
18	530	260	330	30	247	301	--	2,200	280	4,190	3,840	450	35
19	470	330	410	24	195	238	--	2,800	290	4,620	4,470	400	--
20	470	320	410	25	195	238	--	2,400	240	4,570	4,020	460	56
21	410	210	260	19	194	237	--	1,700	260	3,200	3,000	300	--
22	[a]370	[a]250	[a]320	[a]31	166	203	--	[a]1,800	[a]250	3,240	3,210	980	--
23	480	330	330	73	264	322	--	2,800	530	5,140	4,750	340	--
24	500	530	420	37	216	264	--	3,800	260	5,820	5,700	440	--
25	470	400	410	56	182	222	--	3,500	480	6,010	5,460	280	--
26	310	190	230	31	202	246	--	1,800	310	3,020	3,030	480	--
27	a510	[a]250	[a]360	[a]25	216	264	--	[a]2,300	[a]310	2,080	4,020	640	--
28	460	270	460	45	198	242	--	2,300	1,000	4,360	4,700	500	--
29	540	360	420	33	201	245	--	3,000	510	5,060	5,020	450	27
30	430	340	210	36	157	192	--	2,400	370	4,480	3,920	400	--
31	540	400	380	45	183	223	--	2,800	520	--	4,840	--	--
32	240	100	52	9.0	162	197	--	770	74	1,490	1,360	380	--

[a] Analysis by U.S. Geological Survey, National Water Quality Laboratory, Arvada, Colo.

Table 4. Dissolved nutrients and organic carbon in water samples from shallow ground-water monitoring wells, Las Vegas urban area. Analyses by U.S. Geological Survey, National Water Quality Laboratory, Arvada, Colo.

[Abbreviations and symbols: mg/L, milligrams per liter; <, less than]

Site no. (fig. 4)	Nitrogen, nitrite + nitrate (mg/L as N)	Nitrogen, nitrite (mg/L as N)	Nitrogen, ammonia (mg/L as N)	Nitrogen, ammonia + organic (mg/L as N)	Orthophosphorus (mg/L as P)	Phosphorus (mg/L as P)	Carbon, organic (mg/L as C)
1	0.76	<0.01	0.03	<0.2	<0.01	<0.01	0.5
2	.38	<.01	.01	<.2	<.01	<.01	.3
3	4.3	.03	.26	.5	.07	.06	1.9
4	7.3	.02	.03	<.2	.02	<.01	1.0
5	6.2	<.01	.02	<.2	<.01	<.01	1.1
6	.052	.02	.04	.3	<.01	<.01	1.0
7	41	.01	.05	2.1	<.01	<.01	17
8	7.9	.06	.02	.3	.01	<.01	2.1
9	3.1	<.01	.02	<.2	.02	<.01	1.6
10	2.3	.02	.04	.2	<.01	<.01	2.7
11	1.6	<.01	.15	<.2	.08	.08	34
12	5.8	.02	.03	<.2	<.01	<.01	2.4
13	10	<.01	.06	.2	.01	<.01	2.7
14	3.1	.02	.02	<.2	<.01	<.01	2.5
15	8.7	<.01	.03	.4	<.01	.03	1.5
16	12	<.01	.03	<.2	<.01	.03	1.3
17	5.9	.05	.05	.2	<.01	<.01	3.6
18	3.7	<.01	.06	.3	.01	<.01	3.3
19	4.0	<.01	.04	<.2	<.01	<.01	1.8
20	3.3	<.01	.04	<.2	<.01	<.01	1.7
21	8.0	<.01	.08	.3	.01	<.01	2.1
22	1.5	<.01	.04	.2	.02	<.01	2.0
23	2.7	<.01	.05	.4	<.01	.02	3.7
24	2.7	<.01	.04	<.2	.02	<.01	2.2
25	8.3	.01	.07	.3	<.01	<.01	3.8
26	4.4	<.01	.04	.4	<.01	<.01	1.2
27	5.3	<.01	.06	<.2	<.01	<.01	1.6
28	2.2	.02	.08	<.2	.02	.02	.7
29	4.8	<.01	.06	<.2	<.01	<.01	1.4
30	12	<.01	.04	<.2	<.01	<.01	1.7
31	6.0	<.01	.06	.2	<.01	<.01	1.5
32	.39	<.01	.04	.2	<.01	.01	.6

Table 5. Dissolved trace elements in water samples from shallow ground-water monitoring wells, Las Vegas urban area. Analyses by U.S. Geological Survey, Corrosion by Wet Precipitation Research Laboratory, Boulder, Colo., except as noted

[Abbreviations and symbols: µg/L, micrograms per liter; --, not determined; <, less than]

Site no. (fig. 4)	Aluminum (µg/L as Al)	Arsenic, (µg/L as As)	Boron (µg/L as B)	Barium (µg/L as Ba)	Beryllium (µg/L as Be)	Cadmium (µg/L as Cd)	Chromium (µg/L as Cr)	Cobalt (µg/L as Co)	Copper (µg/L as Cu)	Iron (µg/L as Fe)	Lead (µg/L as Pb)	Lithium (µg/L as Li)	Manganese (µg/L as Mn)	Molybdenum (µg/L as Mo)	Nickel (µg/L as Ni)	Selenium (µg/L as Se)	Strontium (µg/L as Sr)	Vanadium (µg/L as V)	Zinc (µg/L as Zn)
1	--	--	32	180	<1	<10	--	<10	<5	<5	<40	18	19	<50	<30	--	2,200	7	<10
2	--	[a]2	35	180	<1	<10	--	<10	<5	<5	<40	12	4	<50	<30	2	710	<5	<10
3	--	--	710	31	<1	<10	--	<10	<5	<5	<40	52	120	<50	<30	--	5,100	<5	<10
4	--	--	600	17	<1	<10	--	<10	<5	<5	<40	29	10	<50	<30	--	2,200	<5	20
5	[b]3	[a]2	94	43	<1	<10	[b]1	<10	<5	<5	<40	13	<2	<50	<30	12	1,200	<5	<10
6	--	--	200	39	<1	<10	--	<10	<5	<5	50	18	<2	<50	<30	--	1,100	7	<10
7	--	[a]<2	460	28	<1	<10	--	<10	<5	352	<40	59	230	<50	<30	8	6,200	<5	20
8	--	--	750	17	<1	<10	--	<10	<5	94	<40	24	15	<50	<30	--	1,400	<5	20
9	--	--	520	12	<1	<10	--	<10	<5	<5	<40	100	3	<50	<30	--	5,600	<5	<10
10	--	--	2,000	27	<1	<10	--	<10	<5	530	<40	150	95	100	<30	--	6,100	<5	40
11	--	--	320	18	<1	<10	--	<10	<5	59	<40	32	7	<50	<30	--	2,200	<5	10
12	--	--	520	13	<1	<10	--	<10	<5	<5	<40	47	41	<50	<30	--	5,400	<5	20
13	--	--	1,700	21	<1	<10	--	<10	<5	<5	<40	130	12	<50	<30	--	8,700	<5	<10
14	--	--	940	17	<1	<10	--	<10	<5	47	<40	51	11	<50	<30	--	2,100	<5	<10
15	--	--	780	17	<1	<10	--	<10	<5	<5	<40	67	<2	<50	<30	--	2,800	<5	<10
16	[b]2	[b]<1	710	9	<1	<10	[b]20	<10	<5	<5	<40	38	<2	<50	30	[b]36	3,100	<5	<10
17	--	--	1,200	14	<1	<10	--	<10	<5	<5	<40	170	230	<50	<30	--	8,000	<5	<10
18	[b]5	[b]29	1,500	10	<1	<10	[b]<2	<10	<5	<5	<40	190	2	<50	<30	[b]12	9,000	<5	<10
19	--	[a]10	1,800	8	<1	<10	--	<10	<5	<5	<40	160	4	<50	<30	34	6,500	<5	<10
20	[b]6	[b]8	2,000	11	1	<10	[b]<2	<10	<5	<5	40	170	8	<50	<30	[b]28	7,100	<5	<10
21	--	--	710	16	<1	<10	--	<10	<5	35	<40	61	120	<50	<30	--	4,400	<5	20
22	--	--	--	--	<1	<10	--	<10	<5	--	<40	--	--	<50	<30	--	--	--	--
23	--	--	1,500	10	<1	<10	--	<10	<5	35	<40	140	8	60	<30	--	8,900	7	<10
24	--	--	1,800	7	<1	<10	--	<10	<5	12	<40	180	4	<50	<30	--	5,600	<5	<10
25	--	--	3,600	12	<1	<10	--	<10	<5	<5	50	280	6	<50	<30	--	7,200	<5	<10
26	--	--	1,300	12	<1	<10	--	<10	<5	<5	<40	220	<2	<50	<30	--	7,600	<5	<10
27	--	--	--	--	<1	<10	--	<10	<5	--	--	--	--	<50	<30	--	--	--	--
28	--	--	1,300	14	<1	<10	--	<10	<5	12	<40	370	6	<50	<30	--	7,000	<5	30
29	[b]6	[b]17	2,300	8	<1	<10	[b]<3	<10	<5	<5	60	190	5	<50	<30	[b]48	7,300	<5	<10
30	--	--	2,600	8	<1	<10	--	<10	<5	<5	<40	160	3	<50	<30	--	6,000	<5	<10
31	--	--	1,900	8	<1	<10	--	<10	<5	<5	<40	180	<2	90	<30	--	6,800	<5	<10
32	--	--	200	10	<1	<10	--	<10	<5	<5	<40	52	<2	<50	<30	--	2,600	<5	<10

[a] Analysis by U.S. Geological Survey, Geologic Division, Branch of Geochemistry.

[b] Analysis by U.S. Geological Survey, National Water Quality Laboratory, Arvada, Colo.

Table 6. Volatile organic compounds detected in water samples from shallow ground-water monitoring wells, Las Vegas urban area. Analyses by U.S. Geological Survey, National Water Quality Laboratory, Arvada, Colo.

[Abbreviations and symbols: µg/L, micrograms per liter; --, not sampled; <, less than]

Site no. (fig. 4)	Benzene (µg/L)	Chlorodibromomethane (µg/L)	Chloroform (µg/L)	Dichlorobromomethane (µg/L)	Dichlorodifluoromethane (µg/L)	1,1-Dichloroethylene (µg/l)	Methylene chloride (µg/L)	Methyl tert-butyl ether (µg/L)	Phenols (µg/L)	Tetrachloroethylene (µg/L)	1,2-Trans-dichloroethene (µg/L)	1,1,1-Trichloroethane (µg/L)	Trichlororethylene (µg/L)	Tri-chlorofluoromethane (µg/L)
1	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	1	<0.2	<0.2	<0.2	<0.2	<0.2
2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	2	<.2	<.2	<.2	<.2	<.2
3	<.2	<.2	.3	<.2	<.2	<.2	<.2	<.2	<1	.4	<.2	<.2	<.2	<.2
4	<.2	<.2	1.6	<.2	<.2	<.2	<.2	<.2	<1	.8	<.2	<.2	<.2	<.2
5	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	2	<.2	<.2	<.2	<.2	<.2
6	<.2	<.2	1.1	<.2	<.2	<.2	<.2	<.2	<1	<.2	<.2	<.2	<.2	<.2
7	<.2	<.2	1.2	<.2	<.2	<.2	.3	<.2	<1	.3	<.2	<.2	<.2	<.2
8	<.2	<.2	.2	<.2	<.2	<.2	<.2	<.2	1	1.3	<.2	<.2	<.2	<.2
9	.2	.9	12	.9	<.2	<.2	<.2	<.2	2	89	4.5	3.7	19	2.5
10	<.2	<.2	<.2	<.2	<.2	<.2	<.2	13	1	<.2	<.2	<.2	<.2	<.2
11	<.2	<.2	<.2	<.2	38	<.2	<.2	<.2	2	<.2	<.2	<.2	<.2	<.2
12	<.2	<.2	.2	<.2	<.2	<.2	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2
13	<.2	<.2	2.1	<.2	<.2	<.2	<.2	<.2	2	<.2	<.2	<.2	<.2	<.2
14	<.2	<.2	.4	<.2	<.2	<.2	<.2	<.2	<1	<.2	<.2	<.2	<.2	<.2
15	<.2	<.2	5.2	<.2	<.2	.2	<.2	<.2	1	<.2	<.2	.5	<.2	<.2
16	<.2	<.2	2.4	.2	<.2	<.2	<.2	<.2	3	2.6	<.2	<.2	<.2	.6
17	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.4	1	<.2	<.2	<.2	<.2	<.2
18	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<1	<.2	<.2	<.2	<.2	<.2
19	<.2	<.2	5.6	<.2	<.2	<.2	<.2	<.2	1	<.2	<.2	<.2	<.2	<.2
20	<.2	<.2	7.5	<.2	<.2	<.2	<.2	.4	1	<.2	<.2	<.2	<.2	<.2
21	<.2	<.2	6.3	<.2	<.2	<.2	<.2	<.2	1	<.2	<.2	<.2	<.2	<.2
22	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.7	<1	<.2	<.2	<.2	<.2	<.2
23	<.2	<.2	.4	<.2	<.2	<.2	<.2	<.2	3	<.2	<.2	<.2	<.2	<.2
24	<.2	<.2	.9	<.2	<.2	<.2	<.2	<.2	<1	<.2	<.2	<.2	<.2	<.2
25	<.2	<.2	5.1	<.2	<.2	<.2	<.2	<.2	1	<.2	<.2	<.2	<.2	<.2
26	<.2	<.2	1.7	<.2	<.2	<.2	<.2	<.2	1	<.2	<.2	<.2	<.2	<.2
27	<.2	<.2	4.1	<.2	<.2	<.2	<.2	<.2	1	<.2	<.2	<.2	<.2	2.6
28	<.2	<.2	.2	<.2	<.2	<.2	<.2	<.2	2	.2	<.2	<.2	<.2	<.2
29	<.2	<.2	1.8	<.2	<.2	<.2	<.2	<.2	1	.4	<.2	<.2	<.2	<.2
30	<.2	<.2	2.8	<.2	<.2	<.2	<.2	<.2	2	<.2	<.2	<.2	<.2	<.2
31	<.2	<.2	2.5	<.2	<.2	<.2	<.2	<.2	1	.6	<.2	<.2	<.2	<.2
32	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	4	<.2	<.2	<.2	<.2	<.2

Table 7. Dissolved pesticides detected in water samples from shallow ground-water monitoring wells, Las Vegas urban area. Analyses by U.S. Geological Survey, National Water Quality Laboratory, Arvada, Colo.

[Abbreviations and symbols: µg/L, micrograms per liter; --, not determined; <, less than]

Site no. (fig. 4)	Atrazine (µg/L)	Oryzalin (µg/L)	Prometon (µg/L)	Simazine (µg/L)	Tebuthiuron (µg/L)
1	<0.001	<0.019	<0.018	<0.005	<0.01
2	<.001	<.019	<.018	<.005	<.01
3	<.001	<.019	<.018	<.005	<.01
4	<.001	<.019	<.018	<.005	<.01
5	<.001	<.019	<.018	<.005	<.01
6	<.001	<.019	<.018	<.005	<.01
7	<.001	<.019	<.018	<.005	<.01
8	<.001	<.019	<.018	<.005	<.01
9	<.001	<.019	<.018	<.005	<.01
10	<.001	<.019	<.018	.022	<.01
11	<.001	<.019	<.018	<.005	<.01
12	--	<.019	--	--	--
13	<.001	<.019	.011	<.005	<.01
14	<.001	<.019	<.018	<.005	<.01
15	<.001	.080	<.018	.015	<.01
16	<.001	<.019	.006	<.005	<.01
17	.008	<.019	<.018	<.005	.035
18	.045	<.019	.004	<.005	<.01
19	<.001	<.019	<.018	<.005	<.01
20	<.001	<.019	<.018	<.005	<.01
21	<.001	<.019	<.018	<.005	<.01
22	.026	<.019	<.018	<.005	<.01
23	<.001	<.019	<.018	<.005	<.01
24	<.001	<.019	<.018	<.005	<.01
25	<.001	<.019	.018	<.005	<.01
26	<.001	<.019	.065	<.005	<.01
27	<.001	<.019	<.018	<.005	<.01
28	<.001	<.019	<.018	<.005	<.01
29	<.001	<.019	<.018	<.005	<.01
30	<.001	<.019	<.018	<.005	<.01
31	<.001	<.019	<.018	<.005	<.01
32	<.001	<.019	<.018	<.005	<.01

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