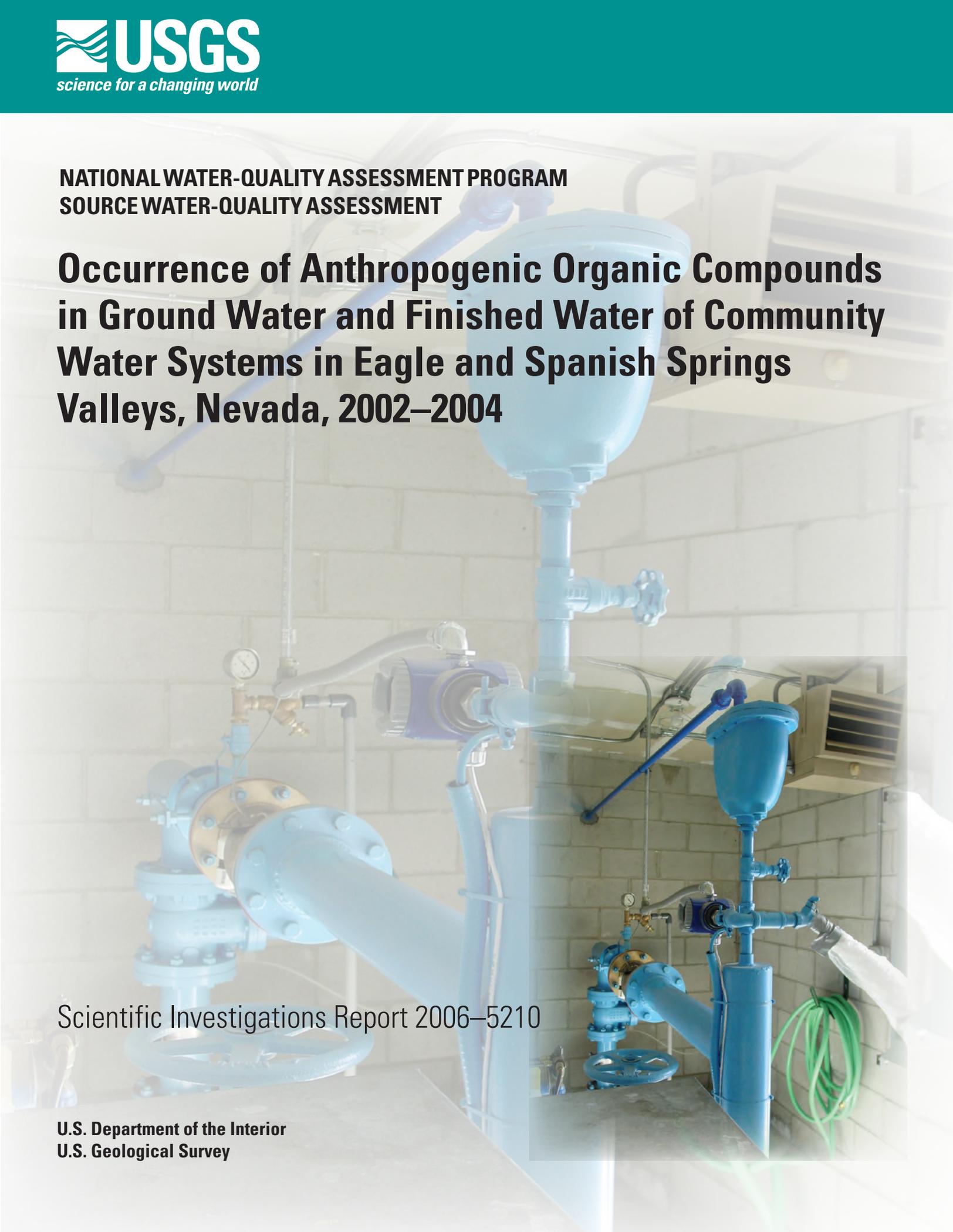


**NATIONAL WATER-QUALITY ASSESSMENT PROGRAM
SOURCE WATER-QUALITY ASSESSMENT**

Occurrence of Anthropogenic Organic Compounds in Ground Water and Finished Water of Community Water Systems in Eagle and Spanish Springs Valleys, Nevada, 2002–2004

Scientific Investigations Report 2006–5210

**U.S. Department of the Interior
U.S. Geological Survey**



Cover: Photograph of one of the public supply wells sampled in this study. (photograph by Michael R. Rosen, U.S. Geological Survey.)

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By Michael R. Rosen, Donald H. Schaefer, Patricia L. Toccalino, and Gregory C. Delzer

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U.S. Department of the Interior
DIRK A. KEMPTHORNE, Secretary

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Foreword

The U.S. Geological Survey (USGS) is committed to providing the Nation with accurate and timely scientific information that helps enhance and protect the overall quality of life and that facilitates effective management of water, biological, energy, and mineral resources (<http://www.usgs.gov>). Information on the quality of the Nation's water resources is critical to assuring the long-term availability of water that is safe for drinking and recreation and suitable for industry, irrigation, and habitat for fish and wildlife. Population growth and increasing demands for multiple water uses make water availability, now measured in terms of quantity and quality, even more essential to the long-term sustainability of our communities and ecosystems.

The USGS implemented the National Water-Quality Assessment (NAWQA) Program in 1991 to support national, regional, and local information needs and decisions related to water-quality management and policy (<http://water.usgs.gov/nawqa>). Shaped by and coordinated with ongoing efforts of other Federal, State, and local agencies, the NAWQA Program is designed to answer: What is the condition of our Nation's streams and ground water? How are the conditions changing over time? How do natural features and human activities affect the quality of streams and ground water, and where are those effects most pronounced? By combining information on water chemistry, physical characteristics, stream habitat, and aquatic life, the NAWQA Program aims to provide science-based insights for current and emerging water issues and priorities.

From 1991–2001, the NAWQA Program completed interdisciplinary assessments in 51 of the Nation's major river basins and aquifer systems, referred to as Study Units (<http://water.usgs.gov/nawqa/studyu.html>). Baseline conditions were established for comparison to future assessments, and long-term monitoring was initiated in many of the basins. During the next decade, 42 of the 51 Study Units will be reassessed so that 10 years of comparable monitoring data will be available to determine trends at many of the Nation's streams and aquifers. The next 10 years of study also will fill in critical gaps in characterizing water-quality conditions, enhance understanding of factors that affect water quality, and establish links between sources of contaminants, the transport of those contaminants through the hydrologic system, and the potential effects of contaminants on humans and aquatic ecosystems.

The USGS aims to disseminate credible, timely, and relevant science information to inform practical and effective water-resource management and strategies that protect and restore water quality. We hope this NAWQA publication will provide you with insights and information to meet your needs, and will foster increased citizen awareness and involvement in the protection and restoration of our Nation's waters.

The USGS recognizes that a national assessment by a single program cannot address all water-resource issues of interest. External coordination at all levels is critical for a fully integrated understanding of watersheds and for cost-effective management, regulation, and conservation of our Nation's water resources. The NAWQA Program, therefore, depends on advice and information from other agencies—Federal, State, interstate, Tribal, and local—as well as nongovernmental organizations, industry, academia, and other stakeholder groups. Your assistance and suggestions are greatly appreciated.

Robert M. Hirsch
Associate Director for Water

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Conversion Factors and Datum

| Multiply | By | To obtain |
|---------------------------------|-----------|---|
| Length | | |
| foot (ft) | 0.3048 | meter (m) |
| mile (mi) | 1.609 | kilometer (km) |
| Volume | | |
| acre-foot (acre-ft) | 0.001233 | cubic hectometer (hm ³) |
| Flow rate | | |
| acre-foot per year (acre-ft/yr) | 1,233 | cubic meter per year (m ³ /yr) |
| acre-foot per year (acre-ft/yr) | 0.001233 | cubic hectometer per year (hm ³ /yr) |

Concentrations of chemical constituents in water are given in either milligrams per liter (mg/L) or micrograms per liter ($\mu\text{g/L}$).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Abbreviations and Acronyms

| | |
|------------|--|
| > | greater than |
| ≥ | greater than or equal to |
| < | less than |
| acre-ft/yr | acre-feet per year |
| km | kilometer |
| mg/L | milligrams per liter |
| µg/L | micrograms per liter |
| AHTN | Acetyl hexamethyl tetrahydronaphthalene |
| BQmax | Maximum benchmark quotient (ratio of maximum detected concentration to human-health benchmark) |
| BTEX | Benzene, toluene, ethylbenzene, and xylene |
| CASRN | Chemical Abstract Services Registry Number |
| CCR | Consumer Confidence Report |
| CWS | Community water system |
| ET | Evapotranspiration |
| GC/MS | Gas chromatography/mass spectrometry |
| GRSL | Great Salt Lake Valley |
| GW–SWQA | Ground-water Source Water-Quality Assessment |
| HBSL | Health-Based Screening Level |
| HCFC–22 | Hydrochlorofluorocarbon-22 |
| LRL | Laboratory reporting level |
| MAS | Major aquifer study |
| MCL | Maximum Contaminant Level |
| MCLG | Maximum Contaminant Level Goal |
| MRL | Minimum reporting level |
| MTBE | Methyl <i>tert</i> -butyl ether |
| NA | Not available, not applicable |
| NAWQA | U.S. Geological Survey National Water-Quality Assessment Program |
| NBHP | Nevada Bureau of Health Protection |
| ND | Not detected |
| NDEP | Nevada Department of Environmental Protection |
| NVBR | Nevada Basin and Range |
| NWQL | U.S. Geological Survey National Water-Quality Laboratory |
| ORD | Office of Research and Development (U.S. Environmental Protection Agency) |
| OW | Office of Water (U.S. Environmental Protection Agency) |
| PAH | Polycyclic aromatic hydrocarbon |
| PCE | Perchloroethene |
| SWQA | Source Water-Quality Assessment |
| UrLus | Urban land-use study |
| USEPA | U.S. Environmental Protection Agency |
| USGS | U.S. Geological Survey |
| VOC | Volatile organic compound |

Occurrence of Anthropogenic Organic Compounds in Ground Water and Finished Water of Community Water Systems in Eagle and Spanish Springs Valleys, Nevada, 2002–2004

By Michael R. Rosen, Donald H. Schaefer, Patricia L. Toccalino, and Gregory C. Delzer

Abstract

As a part of the U.S. Geological Survey's National Water-Quality Assessment Program, an effort to characterize the quality of major rivers and aquifers used as a source of supply to some of the largest community water systems (CWSs) in the United States has been initiated. These studies, termed Source Water-Quality Assessments (SWQAs), consist of two sampling phases. Phase 1 was designed to determine the frequency of detection and concentrations of about 260 volatile organic compounds (VOCs), pesticides and pesticide degradates, and other anthropogenic organic compounds in source water of 15 CWS wells in each study. Phase 2 monitors concentrations in the source water and also the associated finished water of CWSs for compounds most frequently detected during phase 1. One SWQA was completed in the Nevada Basin and Range area in Nevada. Ten CWS wells in Eagle Valley and five CWS wells in Spanish Springs Valley were sampled. For phase 2, two wells were resampled in Eagle Valley. Samples were collected during 2002–2004 for both phases.

Water use in Eagle Valley is primarily for domestic purposes and is supplied through CWSs. Ground-water sources provide about 55 percent of the public-water supply, and surface-water sources supply about 45 percent. Lesser amounts of water are provided by domestic wells. Very little water is used for agriculture or manufacturing. Spanish Springs Valley has water-use characteristics similar to those in Eagle Valley, although there is more agricultural water use in Spanish Springs Valley than in Eagle Valley.

Maximum contaminant concentrations were compared to two human-health benchmarks, if available, to describe the water-quality data in a human-health context for these findings. Measured concentrations of regulated contaminants

were compared to U.S. Environmental Protection Agency and Nevada Maximum Contaminant Level (MCL) values. Measured concentrations of unregulated contaminants were compared to Health-Based Screening Levels, which are not regulatory standards and are not legally enforceable values. All of the contaminants detected in this study were found at concentrations less than available human-health benchmarks.

In the source waters sampled in phase 1, 10 contaminants of the approximately 260 measured were detected in samples collected from Eagle Valley, and 4 contaminants were detected in samples from Spanish Springs Valley. The most frequently detected compounds in the Eagle Valley source water were chloroform (a disinfection by-product), which was detected in samples from four wells, and deethylatrazine (a degradation product of the herbicide atrazine), which was detected in samples from three wells. Each of the four contaminants detected in the Spanish Springs Valley source waters was detected in samples from one well.

The detection frequencies of VOCs and pesticides in samples from the SWQA wells were similar to those in samples from both shallow and deep monitoring wells in Carson City, Reno, and Spanish Springs. This indicates that the SWQA sampling is representative of the organic chemical compounds likely to be detected in the aquifers sampled. However, more organic compounds were detected at low frequencies and concentrations in samples from the monitoring wells than in samples from SWQA wells.

Three contaminants were detected in one finished-water sample collected from Eagle Valley. Comparison of SWQA results in the Nevada Basin and Range Study Unit to results of an SWQA in the larger urban area of Salt Lake City showed that fewer anthropogenic compounds were detected in Eagle and Spanish Springs Valleys and generally at lower concentrations than in the Salt Lake City study.

Introduction

In 1991, the U.S. Geological Survey (USGS) began the National Water-Quality Assessment (NAWQA) Program to (1) provide a nationally consistent description of current water-quality conditions for 51 of the largest and most important river basins and aquifers across the Nation; (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. This information, which will be obtained on a continuing basis, is being made available to water managers, policy makers, and the general public to provide an improved scientific basis for evaluating the effectiveness of water-quality management programs and for predicting the likely effects of contemplated changes in land and water-management practices. The first decade of the NAWQA Program focused on describing current water-quality conditions.

Beginning in 2001, NAWQA began its second decade of intensive assessment activities, returning to 42 (14 studies beginning in each of 2001, 2004, and 2007) of the 51 original river basins and aquifers studied (fig. 1). A new assessment activity during the second decade of NAWQA is termed Source Water-Quality Assessments (SWQAs). SWQAs characterize the water quality of major rivers and aquifers used as a source of water supply to some of the largest community water systems (CWS) in the United States and then characterize the associated finished water.

The intent of SWQAs is to help bring ambient and other water-quality data monitored by the NAWQA Program into context with data from waters directly used as a drinking-water supply. Additionally, SWQAs intend to complement drinking-water monitoring required by Federal, State, and local programs, which focus primarily on post-treatment compliance monitoring. Through SWQAs, NAWQA is increasing its emphasis on characterizing rivers and aquifers that are important sources of drinking water and will continue to collaborate with other agencies and organizations involved with supplying and managing drinking water.

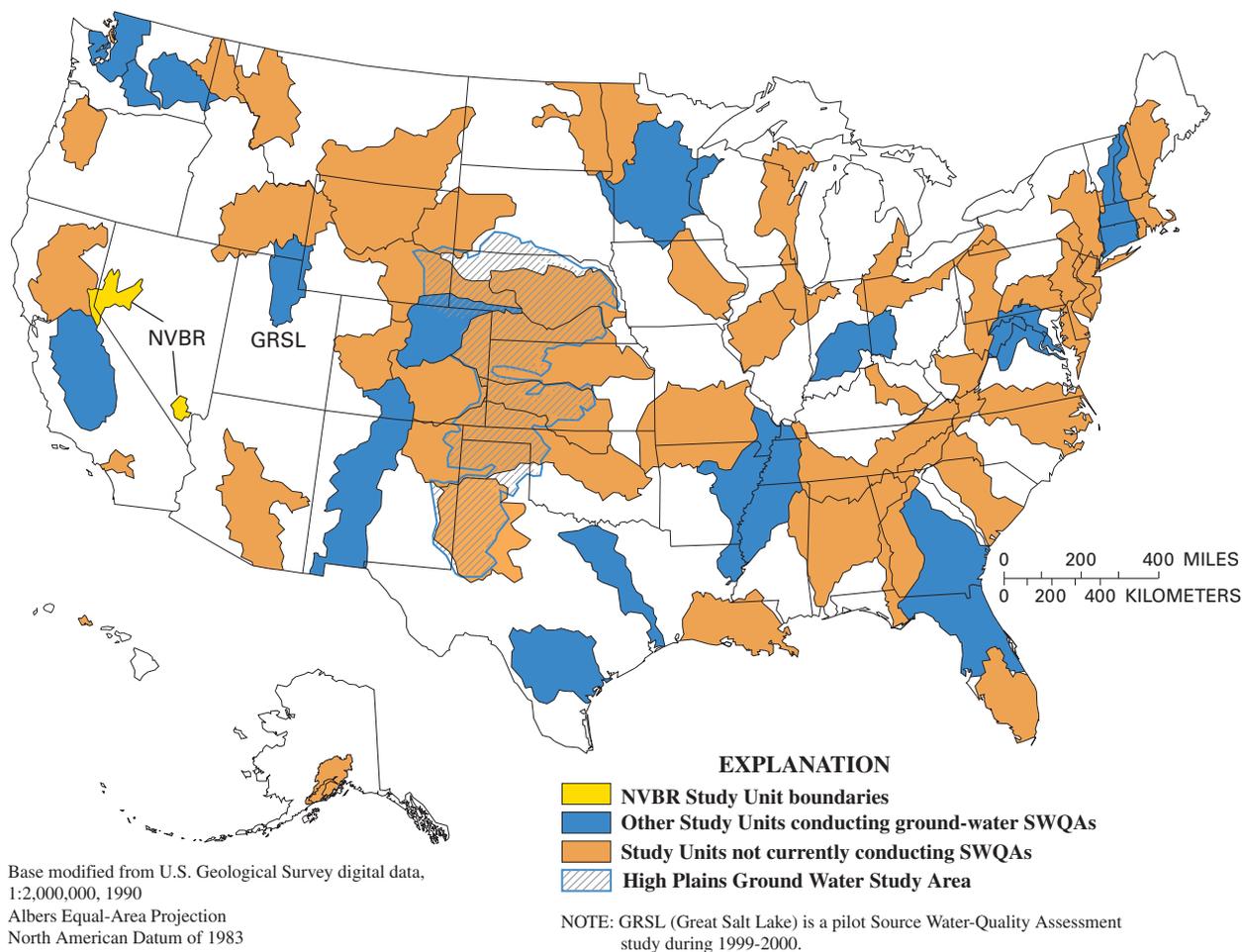


Figure 1. Location of National Water-Quality Assessment (NAWQA) Study Units, Nevada Basin and Range (NVBR) Study Unit, and Study Units that have completed or are conducting ground-water Source Water-Quality Assessments (SWQAs).

SWQAs are two-phase sampling activities. The occurrence of a broad list of anthropogenic organic compounds (Appendixes 1–3) in source waters that have some of the largest withdrawals for drinking-water supply is assessed during phase 1. These anthropogenic compounds include about 260 volatile organic compounds (VOCs), pesticides and degradates, and other anthropogenic organic compounds. The frequency of detection and concentration of compounds found in the source water and the associated treated (finished) water are assessed during phase 2.

Ground-water SWQAs (GW–SWQAs) began sampling in 2001 and 17 have currently (2006) been completed (fig. 1). One study was completed in the Nevada Basin and Range (NVBR) Study Unit during 2002–2004. The NVBR Study Unit includes the Truckee and Carson River Basins in northwestern Nevada and northeastern California and the Las Vegas Valley area in southeastern Nevada (fig. 2). These two areas represent many of the diverse environments found in the Basin and Range physiographic province, which is characterized by high mountains surrounding valleys underlain by thick, unconsolidated deposits (Covay and others, 1996).

Purpose and Scope

The purpose of this report is to characterize the occurrence and concentrations of anthropogenic organic compounds in ground waters used as primary sources of public supply in the Eagle and Spanish Springs Valleys of the NVBR Study Unit and to compare the data collected to data from water samples collected from other drinking-water supplies nationwide. Concentrations of these compounds are compared to human-health benchmarks. In addition, the occurrence and concentrations of anthropogenic organic compounds in finished water from two of the supply wells in Eagle Valley also are characterized.

Acknowledgments

The authors gratefully acknowledge Tom Hoffert and LeAnn Warne of Carson City Utilities and Dan Dragan and John Hulett of Washoe County Department of Water Resources for their support and assistance in this investigation. The authors also would like to acknowledge the assistance of Nyle Pennington, Angi Paul, Karen Thomas, and Tim Rowe in collecting the samples used in this study.

Description of Study Area

Two areas within the NVBR Study Unit were included in this SWQA. The first study area is Eagle Valley (fig. 3), which includes Carson City and is part of the Carson River Basin. The population of Carson City has experienced a

steady increase since the 1970s. It has grown from about 36,000 residents in 1986 to more than 55,000 in 2003, with an average annual growth during this period of 2.5 percent (Nevada State Demographer's Office, 2004).

The second area is Spanish Springs Valley (fig. 4), about 5 miles (mi) north of Sparks in Washoe County, which is located in the Truckee River Basin. The population of Spanish Springs Valley has grown substantially since the early 1980s, and this growth has affected the hydrology of the basin (Berger and others, 1997).

These two areas were chosen for an SWQA because they have some of the largest withdrawals of ground water used for drinking water in this portion of the NVBR Study Unit. The two areas also have similar hydrologic and geologic characteristics, but differing rates of population increase, and differing potential sources of ground-water contaminants.

Land and Water Use

Land use in Eagle Valley slowly changed during the past several decades from unused scrubland, pasture, and agricultural areas to urban areas. The initial developed areas slowly expanded out in all directions as urbanization progressed, and only a small part of the valley currently (2006) is used for pasture or agriculture. As land-use patterns changed from scrubland, pasture, or agriculture to urban, the use of fertilizers, pesticides, and other anthropogenic organic compounds increased. Irrigation of lawns and outflow from septic tanks are capable of moving, at least in some areas, these compounds down to the water table.

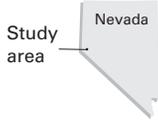
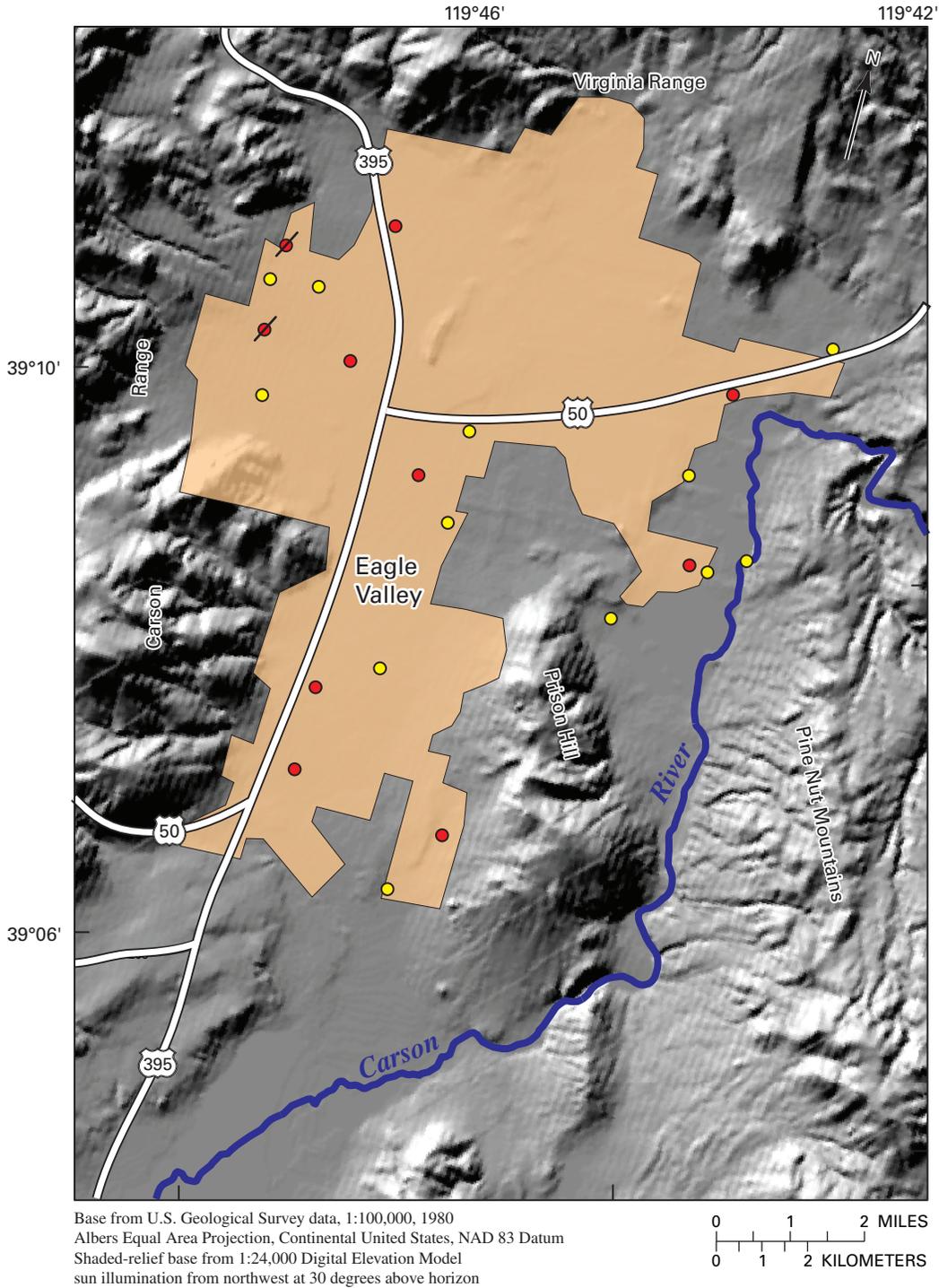
Water use in Eagle Valley is primarily for domestic purposes and is supplied through one CWS. In 2002, ground-water pumping provided about 55 percent of the public-water supply, and surface-water sources supplied the remaining 45 percent (Nevada State Engineer's Office, written commun., 2003). The public-water supply system is considered "large" (population served between 10,001 and 100,000 people) by the U.S. Environmental Protection Agency (USEPA) Safe Drinking Water Information System (U.S. Environmental Protection Agency, 2002a). Lesser amounts of water are provided by domestic wells, but very little water is used for agriculture or manufacturing. Most of the homes in Eagle Valley are served by a wastewater-treatment plant that exports effluent out of the hydrographic basin or uses it to irrigate golf courses and for dust control within the basin.

Development in Spanish Springs Valley was virtually non-existent prior to about 1960, except for a few agricultural homesteads in the southern part of the valley (fig. 4). Based on comparisons of aerial photographs taken in 1956, 1977, and 1994 and of assessor parcel maps, general agricultural land use within the area serviced by the Orr Ditch has remained relatively unchanged, although some acreage has been developed in the southwest part of the valley. Urban growth and development in Spanish Springs Valley increased sharply after 1979 when the population increased from less



Base from U.S. Geological Survey digital data;
1:100,000, 1977-85
Albers Equal-Area Conic projection
Standard parallels 29°30'30"
Central meridian 119°00'

Figure 2. Nevada Basin and Range (NVBR) Study Unit.



- EXPLANATION**
- Carson City urban area
 - Supply wells**
 - Not sampled for Source Water-Quality Assessments
 - Sampled during phase 1
 - Sampled during phase 2

Figure 3. Eagle Valley well locations.

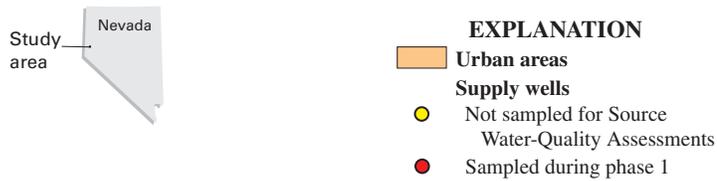
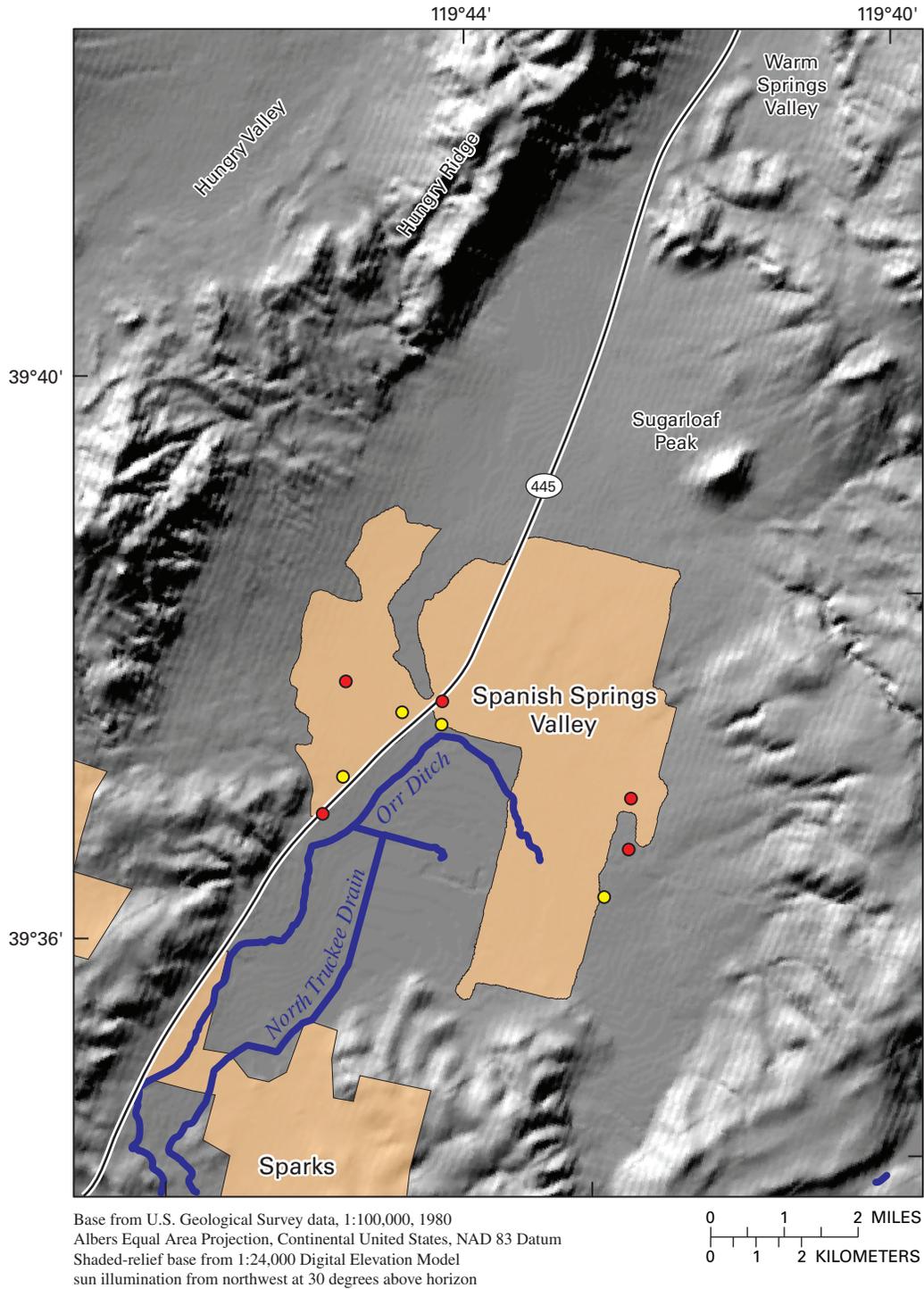


Figure 4. Spanish Springs Valley well locations.

than 800 in 1979 to more than 4,000 in 1990 (Berger and others, 1997). These increases in urban development can affect which compounds are used on the land surface that may move downward into the ground-water system.

Population estimates for 2000 indicate that more than 18,000 people live in Spanish Springs Valley (Lopes and Evetts, 2004). Most subdivisions are located around the northern perimeter of Orr Ditch with smaller subdivisions in the southern part of the valley. Individual home sites also are scattered in the northern part of the basin in and adjacent to the surrounding mountains (fig. 4).

Spanish Springs Valley has water-use characteristics similar to those in the Eagle Valley, although there is slightly more agricultural water use in the Spanish Springs Valley than in Eagle Valley. As of 1994, more than 3,000 suburban houses have water supplied by a CWS (one public and one private); however, nearly 1,000 of these houses receive water from a supplier outside of the valley (Berger and others, 1997). Of the total number of houses supplied by a CWS, 1,600 have septic systems and about 1,400 are served by wastewater-treatment facilities located outside the basin. There currently (2006) is a plan for converting houses on septic systems to a centralized sewage disposal system, and no new septic systems are allowed in Spanish Springs Valley. Almost 200 houses have domestic wells with septic systems. In 2000, 44 percent of Spanish Springs Valley’s population was serviced by Washoe County water-supply system, with the remaining 56 percent either using a private supply system or their own domestic wells (Lopes and Evetts, 2004, p. 20). The Washoe County public water utility supplied more than 10,000 people

with drinking water in 2004 and is considered a “large” CWS (population served between 10,001 and 100,000 people) by the USEPA Safe Drinking Water Information System (U.S. Environmental Protection Agency, 2002a).

In 2000, total ground water pumped in Nevada was about 1.4 million acre-feet (acre-ft) (Lopes and Evetts, 2004), and included all types of water use in the State. Figure 5 shows the distribution of ground-water use in 2000. Total ground water pumped in the State for use as drinking water (including public water systems and self-supplied domestic wells) was about 260,000 acre-ft. Total ground water pumped for the same use in Eagle Valley in 2000 totaled 18,200 acre-ft or 7 percent of the State as a whole. Total ground-water use for the Spanish Springs Valley for 2000 was 5,360 acre-ft or about 2 percent of the total ground water pumped for the State of Nevada.

In contrast, Las Vegas Valley, the largest urban area in the State, consumed 73,600 acre-ft for public supply purposes in 2000 and accounted for 28 percent of Nevada’s total public-supply pumpage (Lopes and Evetts, 2004). The Las Vegas Valley was not chosen for a SWQA because most of the ground water used for drinking-water supplies in Las Vegas Valley is recycled Colorado River water that is recharged to the aquifer during the winter and pumped out during the summer (Southern Nevada Water Authority, 2005) and therefore is not representative of land-use effects on the aquifer. Considerable sampling of public-supply wells in the Las Vegas area was done in 1995 during the first NAWQA cycle (Lico, 1998).

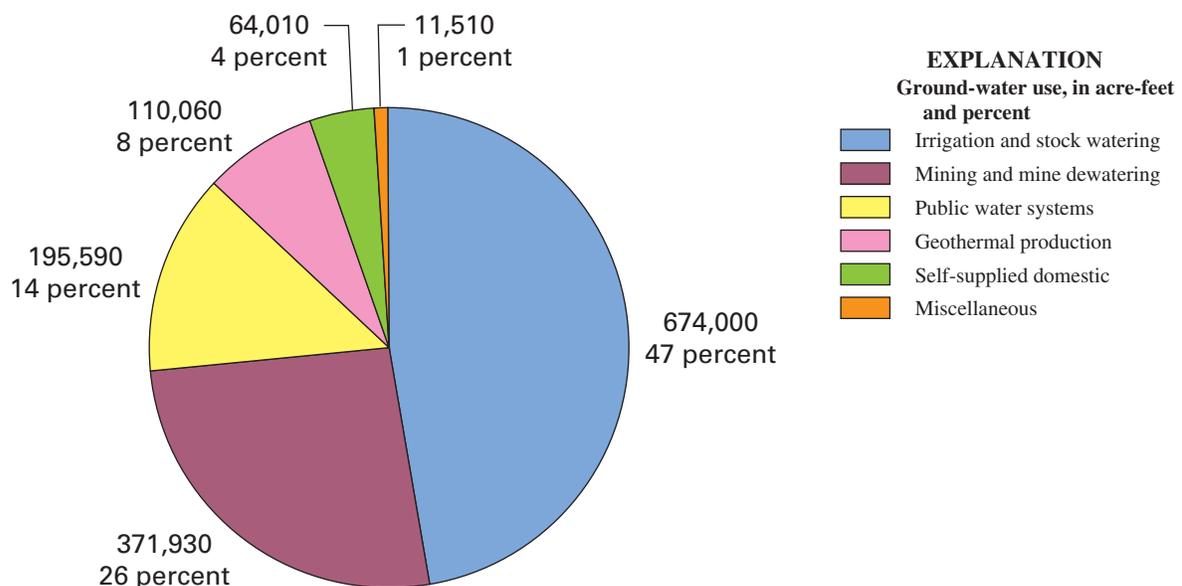


Figure 5. Ground-water use in Nevada, in acre-feet and percent, 2000 (Lopes and Evetts, 2004).

Ground-Water Hydrology

Ground water occurs in unconfined to confined Quaternary-age basin-fill sediments and Mesozoic-age fractured bedrock in Eagle Valley. Most ground-water wells, however, are completed in basin-fill deposits. Figure 6 shows a conceptual model of the ground-water system in Eagle Valley. Ground-water recharge originates as precipitation in the surrounding mountains, and ground water generally moves eastward through Eagle Valley basin-fill sediments (Worts and Malmberg, 1966; Arteaga, 1986). Discontinuous clay layers near the center of the valley are as much as 270 feet (ft) thick, restrict vertical flow, and produce localized, artesian conditions (Arteaga, 1986).

Prior to ground-water development in Eagle Valley, ground water was discharged by evapotranspiration through phreatophytes and pasture grasses and by subsurface flow to the Carson River. Since development, ground-water pumping, mostly for municipal supply, has diverted ground water that would historically discharge through these two mechanisms.

Thickness of the basin fill averages about 600 ft with a maximum thickness of more than 1,500 ft. Well depths range from 200 ft deep to more than 1,200 ft deep. The wells generally are screened in the aquifer composed of unconsolidated Quaternary-age sediments. In some cases, the

upper portion of the well screens may be within the upper 100 ft of the aquifer. Depths to water in the wells range from 20 ft to more than 300 ft below land surface.

The discontinuity of clay layers in the central part of the basin can provide a direct connection to deeper parts of the aquifer and make it susceptible to contamination from sources at the surface (Lico, 1998, p. 1). Other factors, such as fissuring of the confining layers by overpumpage, fracture or collapse of a well casing due to subsidence, improper well construction or surface sealing, and movement of water between the shallow and deeper parts of the aquifer through abandoned or non-pumping wells, may affect the protection of the deeper parts of the aquifer from surface contamination. With increasing use and amounts of fertilizers, pesticides, and other anthropogenic chemicals applied to the land, these pathways may allow more of these compounds to move downward to the ground-water system. Shallow wells may be the most vulnerable to ground-water contamination.

The hydrogeology of Spanish Springs Valley is similar to the Eagle Valley conceptual model shown in figure 6, and most ground water utilized for municipal supplies occurs in the Quaternary-age basin-fill alluvial sediments and the surrounding Tertiary-age bedrock under both water-table and confined conditions. Ground-water recharge in Spanish Springs Valley currently (2006) is derived from imported

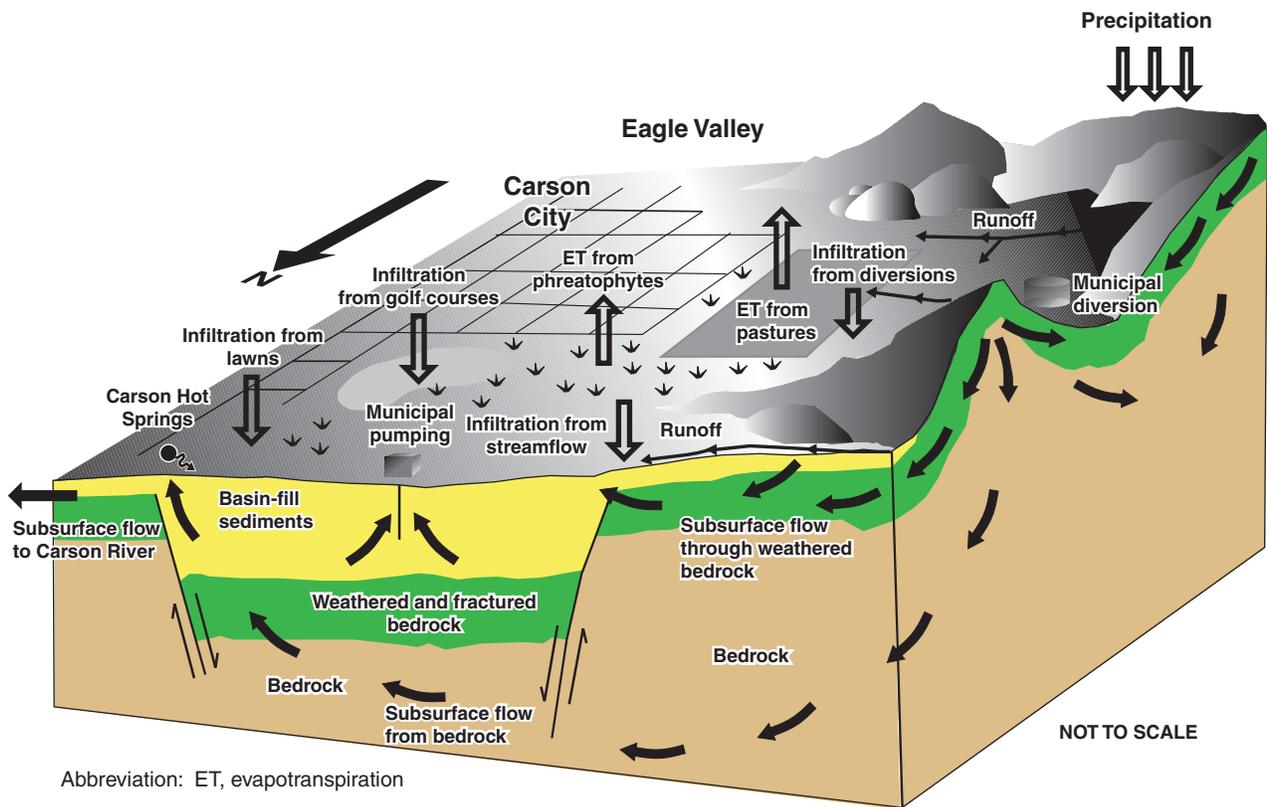


Figure 6. Conceptual hydrologic block diagram of Eagle Valley (modified from Maurer and others, 1996, figure 3).

surface water and precipitation falling within the drainage basin. Ground water also is found in localized areas of highly fractured Tertiary-age volcanic bedrock, generally under confined conditions. Ground water generally moves in an easterly direction towards the North Truckee Drain, irrigated areas, and areas of evapotranspiration (Berger and others, 1997). Depths of supply wells range from 400 ft to more than 1,000 ft deep, and depths to water vary from 200 ft to more than 500 ft below land surface.

Spanish Springs Valley also has discontinuous clay layers and many of the same hydrogeologic features as Eagle Valley that could act as pathways for surface contaminants to reach deep wells. The rapidly expanding urban area in the valley could provide a source of contaminants that may ultimately reach supply wells.

Study Design and Methods

The SWQA in the NVBR Study Unit was a two-phase study during 2002–2004. During the phase 1, source water from 15 CWS wells was sampled to obtain baseline information on the occurrence of about 260 anthropogenic organic compounds. Sampling during phase 2 consisted of resampling source water and finished water for those contaminants found most frequently during phase 1. The number of wells to be sampled in each basin was arbitrarily chosen and were stratified based upon the relative populations in each basin. Ultimately, 10 wells were selected for sampling in Eagle Valley and 5 wells were selected in Spanish Springs Valley. The highest producing wells based on pumping volume within each basin were selected for sampling. These wells tend to stress the ground-water systems more, have a larger cone of depression, and hence are more likely to capture anthropogenic contaminants than lower producing wells. Wells also were selected based on location; selected wells needed to be at least 0.62 mile (1 kilometer) apart to minimize sampling the same volume of water from the aquifer.

All the supply wells in Eagle Valley and Spanish Springs Valley that were sampled for the SWQA also are located within the boundaries of two other NVBR ground-water networks. The supply wells are located within the Reno-Carson City major aquifer study (MAS) that was sampled in 2003. MASs are designed to sample wells that are located within an aquifer used as a major source of drinking-water supply. The supply wells located in Carson City are within the boundaries of the Reno-Carson City urban land-use study (UrLUS) sampled in 2002. The wells sampled for MASs generally have deeper well screens than those sampled for UrLUSs. All three of these networks combined provide a large data set of ground-water analyses.

All the wells sampled for the GW–SWQA had inline chlorinators at the well head. Either these chlorinators were turned off before sampling or sampling was done at a

discharge point before the chlorinator. Source-water samples were processed according to the guidelines outlined in Koterba and others (1995). However, finished-water samples, which contain free chlorine, were processed by adding ascorbic acid, and for some constituents by adding a pH buffer, to the sample prior to shipping to the laboratory to stabilize the sample (Mark Sandstrom, U.S. Geological Survey, oral commun., 2005). Finished-water samples were collected immediately after chlorination so these samples do not account for increased contact time obtained through the distribution system.

Wells sampled during phase 2 of the study were selected based on five criteria. First, wells were selected to be resampled along with their associated finished water in order to capture the occurrence of those compounds found most frequently. Second, wells were selected within an individual GW–SWQA if any compound was detected in samples from two or more wells and if the compound was not already sufficiently monitored through the first well selection criterion. Third, wells from which samples contained detected concentrations of 6 or more of the approximately 260 compounds monitored (Appendixes 1–3) were selected. Fourth, any well with samples containing concentrations greater than 10 µg/L of any compound was selected to monitor that particular compound. Finally, input from the scientists conducting GW–SWQAs was obtained to attempt to select wells to monitor any contaminants that were considered to be of local concern that would not have been monitored otherwise. Because most of the wells monitored as part of this SWQA did not meet any of the aforementioned selection criteria, the quality of the source water monitored was considered to be of high quality. As such, only 2 of the original 15 wells sampled were selected to be resampled during phase 2 along with their associated finished water.

Samples collected for this study were analyzed at the USGS National Water-Quality Laboratory (NWQL) in Denver, Colorado, for inorganic and organic constituents including selected nutrients, trace elements, VOCs, pesticides, pesticide degradates, and other anthropogenic organic compounds. However, only organic constituent data are presented in this report. Analytical methods used for trace elements were primarily inductively coupled plasma/mass spectrometry, atomic adsorption spectrometry, or ion chromatography, and are described in Fishman and Friedman (1989), Fishman (1993), and Faires (1993). Nutrient concentrations were determined by colorimetry (Fishman, 1993; Patton and Truitt, 1992). Water samples were analyzed for pesticides using capillary column gas chromatography/mass spectrometry (GC/MS) (Zaugg and others, 1995; Lindley and others, 1996; Furlong and others, 2001) and for VOCs by using purge and trap capillary column GC/MS (Conner and others, 1998). Other anthropogenic organic compounds were analyzed by solid phase extraction and capillary-column GC/MS (Zaugg and others, 2002).

The minimum reporting level (MRL) is the smallest measured concentration of a constituent that may be reliably reported using a given analytical method (Timme, 1995). Concentrations greater than (>) the MRL are reported as detected concentrations. Some analyte concentrations were flagged with an “E” to indicate estimated values. Concentrations are estimated when a compound is found to be present in a water sample but the concentration is less than the lowest-daily calibration standard.

Quality-assurance/quality-control samples were collected following methods by Koterba and others (1995). All SWQA data are reviewed on an annual basis to evaluate systematic contamination. If systematic contamination is identified, those data are removed from the data set and not used in subsequent data analyses (D.A. Bender (VOCs), J.A. Hopple (pesticides), and J.A. Kingsbury (other anthropogenic compounds), U.S. Geological Survey, written commun., 2006). However, field-blank samples collected as part of the NVBR SWQA did not contain any compounds detected in source or finished water and, as such, no data were excluded from this data set.

Regulatory and Non-Regulatory Human-Health Benchmarks

Measured concentrations of contaminants in untreated water samples can be compared, where appropriate, to available human-health benchmarks, such as State and USEPA drinking-water standards or guidelines, to provide a human-health context for these findings. Comparisons of measured concentrations to these human-health benchmarks often are useful for local, State, and Federal water-resource managers and others charged with protecting and managing drinking-water resources.

Regulated contaminants have Federal or State drinking-water standards called Maximum Contaminant Levels (MCLs), both of which are legally enforceable. State drinking-water standards are equal to, or more stringent than, USEPA standards. MCLs pertain to finished drinking water from public water systems including municipal water companies,

Consumer Confidence Reports and Source Water-Quality Assessments

Since 1999, the U.S. Environmental Protection Agency (USEPA) has required water suppliers to provide annual drinking-water quality reports called Consumer Confidence Reports (CCRs) to their customers (U.S. Environmental Protection Agency, 1998: <http://www.epa.gov/safewater/ccr/ccrfact.html>). CCRs are the centerpiece of the right-to-know provisions of the 1996 Amendments to the Safe Drinking Water Act. Each CCR provides consumers with fundamental information about their drinking water including (1) the source of the drinking water, (2) a brief summary of the susceptibility to contamination of the local drinking-water source, (3) the concentrations (or range of concentrations) of any contaminants found in local drinking water, as well as their USEPA Maximum Contaminant Levels (MCLs), which are legally enforceable drinking-water standards and are the highest allowed concentrations of contaminants in drinking water, for comparison, and (4) phone numbers for additional sources of information.

Information in CCRs is specific to a particular water utility. Water utilities analyze finished-water samples primarily for regulated contaminants (compounds with MCLs) using USEPA analytical methods for the purpose of compliance monitoring. In contrast, Source Water-Quality Assessments (SWQAs) performed by the U.S. Geological Survey (USGS) are not conducted for compliance monitoring and encompass data from multiple water utilities spatially distributed across the Nation. As part of SWQAs, both source- and finished-water samples are analyzed using USGS analytical methods, where source water is the raw (ambient) water collected at the surface-water intake or supply well prior to water treatment, and finished water is the treated water sampled prior to entering the distribution system. USGS analytical methods used in SWQAs typically have lower analytical reporting levels than those used in USEPA analytical methods; therefore, contaminant detection frequencies reported in SWQA reports may be higher than detection frequencies for the same contaminants reported in CCRs. In SWQAs, concentrations of regulated and unregulated contaminants in source and finished water are compared to MCLs and Health-Based Screening Levels (HBSLs), respectively. HBSLs are estimates of benchmark concentrations of contaminants in water that (1) may be of potential human-health concern, (2) can be used as threshold values against which measured concentrations of contaminants in ambient water samples can be compared, and (3) are consistent with USEPA Office of Water methodologies for setting non-enforceable drinking-water guideline values. HBSLs are not legally enforceable regulatory standards, and water utilities are not required to compare contaminant monitoring results to HBSLs.

homeowner associations, schools, businesses, campgrounds, and shopping malls. MCLs protect drinking-water quality by limiting the levels of specific contaminants in water that can adversely affect public health (U.S. Environmental Protection Agency, 2002b). CWSs are required to collect water samples at designated intervals and locations, and to test the water samples in State-approved laboratories. MCL violations occur when tests indicate that the level of contamination in finished water is greater than USEPA or State MCL values based on the average of quarterly samples. MCL violations indicate a potential health risk, which may be immediate or long term. If a public water system violates USEPA or State MCLs, the supplier is required to notify the public (U.S. Environmental Protection Agency, 2003a). Unregulated contaminants may have nonenforceable USEPA drinking-water guidelines called Lifetime Health Advisory and Risk-Specific Dose values.

Federal drinking-water standards or guidelines currently (2006) are not available for nearly one-half of the VOCs, pesticides, and pesticide degradation products most routinely measured in water by NAWQA (Toccalino and others, 2005). To supplement existing Federal drinking-water standards

and guidelines, USGS began a collaborative project in 1998 with USEPA, the New Jersey Department of Environmental Protection, and the Oregon Health & Science University to develop additional human-health benchmarks called Health-Based Screening Levels (HBSLs) for selected unregulated contaminants analyzed by NAWQA (Toccalino and others, 2003).

HBSLs are not regulatory standards and are not enforceable, and water systems are not required to monitor for any unregulated contaminants for which HBSLs have been developed. HBSLs are estimates of benchmark concentrations that can be used as thresholds against which measured contaminant concentrations in water can be compared to evaluate water-quality data in a human-health context. HBSLs can be used as planning tools to help prioritize contaminants that may merit further study or monitoring and to provide an early indication of contaminant concentrations of potential human-health concern in water resources (Toccalino and others, 2005). Table 1 provides descriptions of various Federal, State, and other human-health benchmarks applied in this study.

Table 1. Descriptions of human-health benchmarks related to drinking water described in this report.

[Maximum Contaminant Levels (MCLs) (Federal and State) are enforceable standards; the remainder of the listed benchmarks are nonenforceable guidelines or public-health goals. HBSL, Health-Based Screening Level; MCLG, Maximum Contaminant Level Goal; MTBE, methyl *tert*-butyl ether; NBHP, Nevada Bureau of Health Protection; NDEP, Nevada Division of Environmental Protection; OW, Office of Water (USEPA); USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey]

| Human-health benchmark | Acronym | Agency | Description | References |
|---|------------|------------|--|---|
| Health-Based Screening Level | HBSL | USGS | Estimates of benchmark concentrations in water that (a) may be of potential human-health concern; (b) can be used as threshold values against which measured concentrations of contaminants in ambient water samples can be compared; and (c) are consistent with USEPA Office of Water methodologies for setting drinking-water Lifetime Health Advisory and Risk-Specific Dose values (U.S. Environmental Protection Agency, 1988, 1993). | (Toccalino and others, 2003) |
| Maximum Contaminant Level (Federal) | USEPA MCL | USEPA (OW) | The maximum permissible level of a contaminant in water that is delivered to any user of a public water system. MCLs are set as close to Maximum Contaminant Level Goals (MCLGs) as feasible using the best available treatment technology and taking cost into consideration. The MCLG is the concentration of a contaminant in drinking water at which no known or anticipated adverse health effects occur and which allows an adequate margin of safety. | (U.S. Environmental Protection Agency, 2003b, 2004) |
| Maximum Contaminant Level (State) | Nevada MCL | NBHP | The maximum permissible level of a contaminant in water measured at the point of entry to the distribution system or at the free-flowing outlet of the ultimate user of a public water system or other water system to which State primary drinking-water regulations apply. | (Nevada State Health Division, 2005) |
| NDEP Oxygenated Fuel Corrective Action Guidance | MTBE | NDEP | Ground-water clean-up action levels for MTBE vary depending on the potential for human-health exposure, potential for exposure of other fauna, and proximity to sensitive environments. The interim action level established by NDEP for the occurrence of MTBE in ground water is based on health advisories established by USEPA in conjunction with other agencies. | (Nevada Division of Environmental Protection, 2005) |

Occurrence of Anthropogenic Organic Compounds in Ground Water and Finished Water

Results from source-water (ground-water) samples collected during phase 1 of the study and from source-water and finished-water samples collected during phase 2 of the study are described in this section of the report. The ratio between the measured maximum concentrations and the human-health benchmarks are assessed to describe the water-quality data in a human-health context. For ground-water data collected in this study, a maximum benchmark quotient (BQ_{max}), which is the ratio of the maximum detected concentration of a contaminant to its USEPA MCL value (for a regulated compound) or to its USGS HBSL value (for an unregulated compound), are calculated for individual detected contaminants. For regulated compounds with Nevada MCL values but no USEPA MCL values, BQ_{max} values are calculated using Nevada MCL values. USEPA drinking-water standards (MCLs) apply to finished water; source water is a not required to meet these standards.

Concentrations of potential human-health concern are defined as those contaminant concentrations greater than or equal to (\geq) applicable human-health benchmarks (that is, BQ_{max} \geq 1). Contaminants detected at concentrations less than ($<$) but within a factor of 10 of MCLs or HBSLs (that is, $1 > \text{BQ}_{\text{max}} \geq 0.1$) are defined as contaminants that may warrant inclusion in a low-concentration, trends-monitoring strategy. The selection of 0.1 as the benchmark threshold for identifying contaminants that warrant further monitoring is consistent with various State and USEPA practices (for example, see U.S. Environmental Protection Agency, 2003c). However, none of the constituents detected in this study had BQ_{max} \geq 0.1.

Phase 1: Source Water

Source water refers to that portion of pumped ground water that will eventually be treated and distributed to households for drinking water. Ground water in Eagle and Spanish Springs Valleys generally requires no treatment other than chlorination used for disinfection. All wells sampled for source water in the two valleys had in-line chlorinators at the well head.

Eagle Valley

In October 2002, 10 CWS wells in Eagle Valley were sampled (fig. 3) for all constituents listed in Appendixes 1–3. Table 2 presents both the regulated and unregulated anthropogenic organic compounds detected in the samples from the 10 Eagle Valley wells.

The most frequently detected compound, found in samples from 4 of the 10 wells, was chloroform, also known as trichloromethane (table 2). Chloroform is a disinfection by-product resulting from chlorine reacting with organic material in the water. It can potentially be found in ground water as a result of infiltration of chlorinated water used to irrigate lawns and golf courses. Most of the industrial chloroform produced in the United States is used to make the refrigerant hydrochlorofluorocarbon-22 (HCFC-22). The remainder of the chloroform is produced for export, as a solvent in the pharmaceutical industry, and for producing dyes and pesticides. Chloroform was used in the past as an extraction solvent for fats, oils, greases, and other products; as a dry cleaning spot remover; in fire extinguishers; as a fumigant; and as an anesthetic. However, chloroform is no longer used in these products. Industrial use of chloroform is infrequent in the Eagle Valley and Spanish Springs Valley areas and is not considered a major source of chloroform in this study.

The second most frequently detected compound was deethylatrazine, found in samples from 3 of the 10 wells. Deethylatrazine is a metabolite of the herbicide atrazine, which frequently is used to control broadleaf and grassy weeds. Three compounds were found in samples from 2 of the 10 wells: atrazine; perchloroethene (PCE) (also known as tetrachloroethylene), which is a solvent used in dry cleaning and other industrial purposes; and bromoform (also known as tribromomethane), which is another disinfection by-product. Five other regulated and unregulated compounds were detected in samples from 1 of 10 wells and in small concentrations: *cis*-1,2-dichloroethylene, a solvent; methyl *tert*-butyl ether (MTBE), an additive to gasoline; deisopropylatrazine, a metabolite of atrazine; metsulfuron methyl, an herbicide; and acetyl hexamethyl tetrahydronaphthalene (AHTN), a chemical used in fragrances.

None of the detected compounds with human-health benchmarks had concentrations of potential human-health concern because maximum concentrations ranged from 12- to 100,000-fold less than MCLs or HBSLs (BQ_{max} $<$ 1) in all samples. Deethylatrazine, deisopropylatrazine, and AHTN do not have human-health benchmarks to use for comparison with detected concentrations due to a lack of toxicity information.

Spanish Springs Valley

In October 2002, five CWS wells in Spanish Springs Valley were sampled (fig. 4), and an example of one of the valley's well heads is shown in figure 7. Table 3 presents the results of the sampling for three regulated anthropogenic organic compounds found in the ground water in Spanish Springs: atrazine, bromoform, and chloroform. Each of the compounds were detected in samples from 1 of the 5 wells sampled, and all maximum concentrations were 300- to 4,000-fold less than MCLs. Deethylatrazine was the only

Table 2. Concentrations and detection frequencies of anthropogenic organic compounds detected in samples from community water systems, Eagle Valley, October 2002.

[Compound: M, metabolite; P, pesticide; V, volatile organic compound. CASRN, Chemical Abstract Services Registry No.; MRL, minimum reporting level; USEPA, U.S. Environmental Protection Agency; HBSSL, Health-Based Screening Level; BQmax, maximum benchmark quotient = ratio of maximum detected concentration to human-health benchmark; MCL, Maximum Contaminant Level; µg/L, microgram per liter; E, estimated; NA, toxicity data not available; --, no data]

| Compound | Regulated (R) or unregulated (U) | CASRN | Number of samples | Number of samples with detections | Percentage of samples with detections | MRL (µg/L) | Maximum detected concentration (µg/L) | USEPA MCL ¹ (µg/L) | Nevada MCL ² (µg/L) | HBSSL ³ (µg/L) | BQmax |
|--|----------------------------------|------------|-------------------|-----------------------------------|---------------------------------------|------------|---------------------------------------|-------------------------------|--------------------------------|---------------------------|--------|
| Chloroform (trichloromethane) (V) | R | 67-66-3 | 10 | 4 | 40 | 0.02 | 0.17 | 80 | 80 | -- | 0.002 |
| Deethylatrazine (M) | U | 6190-65-4 | 10 | 3 | 30 | .003 | E.003 | -- | -- | NA | -- |
| Atrazine (P) | R | 1912-24-9 | 10 | 2 | 20 | .004 | E.003 | 3 | 3 | -- | .001 |
| Perchloroethene (PCE) (V) | R | 127-18-4 | 10 | 2 | 20 | .5 | .4 | 5 | 5 | -- | .08 |
| Bromoform (tribromomethane) (V) | R | 75-25-2 | 10 | 2 | 20 | .5 | E.2 | 80 | 80 | -- | .002 |
| cis-1,2-Dichloroethylene (V) | R | 156-59-2 | 10 | 1 | 10 | .01 | E.02 | 70 | 70 | -- | .0003 |
| Methyl <i>tert</i> -butyl ether (MTBE) (V) | R | 1634-04-4 | 10 | 1 | 10 | .1 | E.04 | -- | 20 | -- | .002 |
| Deisopropylatrazine (M) | U | 1007-28-9 | 10 | 1 | 10 | .05 | E.004 | -- | -- | NA | -- |
| Metsulfuron methyl (P) | U | 74223-64-6 | 10 | 1 | 10 | .02 | E.02 | -- | -- | 2,000 | .00001 |
| Acetyl hexamethyl tetrahydronaphthalene (AHTN) (V) | U | 21145-77-7 | 10 | 1 | 10 | .5 | E.012 | -- | -- | NA | -- |

¹U.S. Environmental Protection Agency (2003b, 2004).

²Nevada State Health Division (2005).

³Toccalino and others (2003).

Table 3. Concentrations and detection frequencies of anthropogenic organic compounds detected in samples from community water systems, Spanish Springs Valley, October 2002.

[Compound: M, metabolite; P, pesticide; V, volatile organic compound. CASRN, Chemical Abstract Services Registry No.; MRL, minimum reporting level; USEPA, U.S. Environmental Protection Agency; HBSSL, Health-Based Screening Level; BQmax, maximum benchmark quotient = ratio of maximum detected concentration to human-health benchmark; MCL, Maximum Contaminant Level; µg/L, microgram per liter; E, estimated; NA, toxicity data not available; --, no data]

| Compound | Regulated (R) or unregulated (U) | CASRN | Number of samples | Number of samples with detections | Percentage of samples with detection | MRL (µg/L) | Maximum detected concentration (µg/L) | USEPA MCL ¹ (µg/L) | Nevada MCL ² (µg/L) | HBSSL ³ (µg/L) | BQmax |
|-----------------------------------|----------------------------------|-----------|-------------------|-----------------------------------|--------------------------------------|------------|---------------------------------------|-------------------------------|--------------------------------|---------------------------|-------|
| Atrazine (P) | R | 1912-24-9 | 5 | 1 | 20 | 0.004 | 0.01 | 3 | 3 | -- | 0.003 |
| Bromoform (tribromomethane) (V) | R | 75-25-2 | 5 | 1 | 20 | .5 | E.02 | 80 | 80 | -- | .0003 |
| Chloroform (trichloromethane) (V) | R | 67-66-3 | 5 | 1 | 20 | .02 | .05 | 80 | 80 | -- | .0006 |
| Deethylatrazine (M) | U | 6190-65-4 | 5 | 1 | 20 | .003 | E.04 | -- | -- | NA | -- |

¹U.S. Environmental Protection Agency, 2003b, 2004.

²Nevada State Health Division, 2005.

³Toccalino and others, 2003.

Arsenic and Nitrate: Other Regionally Important Contaminants

Although this report focuses on anthropogenic organic contaminants found in ground water, inorganic compounds that have potential human-health concerns also have been detected. Two such constituents that have become important in the desert southwest and that also were monitored as part of this Source Water-Quality Assessment (SWQA) are nitrate and arsenic.

In urban areas, nitrate is a compound commonly found in ground water that may be introduced from septic tanks, from reclaimed sewage water for irrigation, and through fertilization of lawn and garden areas. All three of these potential sources are common in the SWQA study area. Nitrate concentrations in the 15 supply wells sampled for this study ranged from no detection to 8.1 mg/L; all measured concentrations were less than the U.S. Environmental Protection Agency (USEPA) drinking-water standard of 10 mg/L for nitrate (U.S. Environmental Protection Agency, 2004).

Arsenic is a naturally occurring trace element in ground water. In Eagle and Spanish Springs Valleys, its occurrence is related to the local geology (Welch and others, 1999). Arsenic concentrations for the 15 supply wells sampled ranged from 0.45 $\mu\text{g/L}$ to more than 18 $\mu\text{g/L}$. Samples from three wells had arsenic concentrations that were greater than the USEPA drinking-water standard of 10 $\mu\text{g/L}$ for arsenic (U.S. Environmental Protection Agency, 2004).

To overcome individual high arsenic and nitrate concentrations in wells, most utility companies will blend water from many wells so that concentrations of these constituents in distributed water do not exceed drinking-water standards. Blending is the technique used in this SWQA study area when arsenic concentrations in an individual well exceed the USEPA drinking-water standard.



Figure 7. A supply well in Spanish Springs Valley.

unregulated compound detected in samples from Spanish Springs, and was detected in 1 of the 5 wells sampled (table 3). Because of the low overall detection of any compounds, no additional sampling of supply wells or finished water in Spanish Springs was done in August 2004 for phase 2 of this study.

Phase 2: Source and Finished Water

Due to infrequent occurrences and low concentrations during phase 1 of sampling, only two CWS wells in Eagle Valley (fig. 3) and their associated finished water were selected for another round of sampling during phase 2. Samples collected during phase 2 were analyzed for the VOCs listed in Appendix 1. The compounds detected during this sampling are shown in table 4. PCE was detected in the source water, but in samples from only one well and at a lower concentration than during the previous sampling. Bromoform also was detected in phase 2 of source-water sampling, also at a lower concentration. Neither of these constituents had concentrations greater than MCLs.

Most of the CWS wells on the western side of Eagle Valley discharge water into the treatment plant. The water is blended at the plant and then distributed to users. Both of the wells sampled discharge water to one treatment plant. As such, 2 source-water samples and 1 finished-water sample were collected. Finished water was sampled at the treatment plant at a point before the finished water enters the distribution system. Based on information from the utility staff, the appropriate amount of time between sampling the source and finished water was allowed, such that the finished water adequately represented the treated source water.

Two regulated compounds were detected in the finished water, PCE and bromoform (table 4). The concentration of PCE was slightly lower in the finished water (0.1 $\mu\text{g/L}$) than in the source water (0.3 $\mu\text{g/L}$). The concentration of bromoform in the finished water

Table 4. Volatile organic compounds detected and maximum concentrations in samples from two Eagle Valley wells and finished water.

[BQmax, maximum benchmark quotient = ratio of maximum detected concentration to human-health benchmark; µg/L, microgram per liter; E, estimated; ND, not detected; --, no data]

| Well | Compounds | Source water Phase 1 | | Source water Phase 2 | | Finished water Phase 2 | |
|----------------|-----------------------------|------------------------------|-------|------------------------------|-------|------------------------------|-------|
| | | Maximum concentration (µg/L) | BQmax | Maximum concentration (µg/L) | BQmax | Maximum concentration (µg/L) | BQmax |
| Eagle Valley A | Perchloroethene (PCE) | 0.4 | 0.08 | E0.3 | 0.06 | E0.1 | 0.02 |
| | Bromoform (tribromomethane) | E.2 | .003 | E.08 | .001 | E.06 | .0007 |
| Eagle Valley B | Bromoform (tribromomethane) | E.09 | .001 | ND | -- | E.06 | .0007 |

(0.06 µg/L) was slightly higher than in the source water of one well (not detected) and slightly lower than in the source water of the other well (0.08 µg/L). Neither PCE nor bromoform had concentrations greater than MCLs.

No additional unregulated compounds were found in the source water analyzed during phase 2 of sampling; however, phenanthrene was detected in the finished-water sample (not shown in table 4). Phenanthrene is a polycyclic aromatic hydrocarbon (PAH) that can be derived from coal tar and is ubiquitous in the environment as a product of incomplete combustion of fossil fuels and wood.

Although only 2 supply-well samples and 1 finished-water sample were collected, some inferences can be made with regard to the concentrations in the finished water. PCE and bromoform were detected in at least one of the supply-well samples and in the finished water. The slightly higher bromoform concentration in the finished water than in the source water of one of the wells sampled may be a result of disinfection using chlorine or mixing of waters from other wells at the treatment plant to obtain the final blended finished water. In contrast, the concentrations of PCE and bromoform were lower in the finished water than in the source-water sample from one supply well that contained these compounds. This could be a function of dilution by water from other supply wells.

Comparison of Study Results to Other Community Water-Supply Well Data Sets

Analysis of source-water data from CWS supply wells has not been done previously in Nevada and is only infrequently done in the United States. To assess how organic contaminants found in the NVBR SWQA compare with those reported in previous work in the basins and in similar aquifers in the western United States, results from published studies from Nevada and Utah and in a national study were

used for comparison. However, the focus of these other studies generally was different (except the Utah study) than for this study, and therefore data from the previous studies do not provide a direct comparison to the data collected for this SWQA.

During previous work in the Eagle Valley area (Welch and others, 1997), samples were collected from several of the CWS wells that also were sampled for this study. Many of the same VOCs and pesticides were analyzed in both studies, although MRLs were universally higher in the earlier study (Whitney, 1994). One well that was sampled in both studies contained 1.4 µg/L of PCE when sampled in 1988 (Whitney, 1994, table 22) but contained only 0.01 µg/L when sampled in 2002. None of the other wells in common had any detections. Most of the wells sampled in the earlier study were shallow wells, so little additional comparison can be made between the data sets. It is interesting to note that out of analyses for some of the most commonly detected compounds in 2002—atrazine, PCE, bromoform, and chloroform—only one detection of PCE was found in 1988.

In a recent NAWQA UrLUS (2002) of 34 shallow monitoring wells (median well depth 47 ft) in Carson City (16 wells) and Reno (18 wells), 24 different organic compounds were detected at low concentrations, 11 of which were common to both areas (table 5; data in Berris and others, 2003). The most commonly detected compounds were chloroform (detection frequency of 44 percent), PCE (detection frequency of 35 percent), and triazine herbicides (atrazine, prometon, deethylatrazine, and simazine, which were detected in 15 to 24 percent of samples). Other commonly detected compounds included benzene, toluene, ethylbenzene, and xylene (BTEX) compounds.

In a recent NAWQA MAS (2003) of 30 deep wells (median well depth 347 ft) in Carson City, Reno, and Spanish Springs Valley (data in Stockton and others, 2003), 19 different organic compounds were detected at low concentrations, most of which were the same compounds detected at similar detection frequencies as the ones found in the shallow UrLUS monitoring wells (table 5). Bromoform was detected in the samples from the deeper MAS wells and

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Table 5. Comparison of detected compounds between the Source Water-Quality Assessment (SWQA) study and other local (urban land-use study (UrLUS) and major aquifer study (MAS) and national (random survey) studies.

[AHTN, acetyl hexamethyl tetrahydronaphthalene; MRL, maximum reporting level; n, number of samples; NA, not analyzed; ND, not detected; --, not applicable]

| Compound | SWQA Eagle Valley | | SWQA Spanish Springs Valley | | UrLUS Carson City and Reno | | MAS Carson City, Reno, and Spanish Springs | | National random survey ¹ | |
|----------------------------------|------------------------------------|------|-----------------------------------|------|------------------------------------|------|--|------|-------------------------------------|------|
| | Detection frequency (percent) n=10 | Rank | Detection frequency (percent) n=5 | Rank | Detection frequency (percent) n=34 | Rank | Detection frequency (percent) n=30 | Rank | Percent above MRL n=561-579 | Rank |
| Chloroform | 40 | 1 | 20 | 1 | 44 | 1 | 43 | 1 | 12.0 | 1 |
| Deethylatrazine | 30 | 2 | 20 | 1 | 24 | 3 | 21 | 4 | NA | -- |
| Atrazine | 20 | 3 | 20 | 1 | 21 | 4 | 14 | 6 | NA | -- |
| Bromoform | 20 | 3 | 20 | 1 | ND | -- | 20 | 5 | 4.7 | 5 |
| Perchloroethene | 20 | 3 | ND | -- | 35 | 2 | 33 | 3 | 3.3 | 6 |
| <i>cis</i> -1,2-Dichloroethylene | 10 | 4 | ND | -- | 3 | 8 | ND | -- | 1.9 | 7 |
| Methyl <i>tert</i> -butyl ether | 10 | 4 | ND | -- | 15 | 5 | 7 | 9 | 5.4 | 4 |
| Deisopropylatrazine | 10 | 4 | ND | -- | ND | -- | ND | -- | NA | -- |
| Metsulfuron methyl | 10 | 4 | ND | -- | ND | -- | ND | -- | NA | -- |
| AHTN | 10 | 4 | ND | -- | ND | -- | ND | -- | NA | -- |
| Carbon disulfide | ND | -- | ND | -- | 15 | 5 | ND | -- | NA | -- |
| Prometon | ND | -- | ND | -- | 15 | 5 | ND | -- | NA | -- |
| Simazine | ND | -- | ND | -- | 15 | 5 | ND | -- | NA | -- |
| 1,2,4-Trimethylbenzene | ND | -- | ND | -- | 9 | 6 | 37 | 2 | .18 | 16 |
| 1,1,1-Trichloroethane | ND | -- | ND | -- | 9 | 6 | 10 | 8 | 1.7 | 8 |
| Toluene | ND | -- | ND | -- | 9 | 6 | ND | -- | .53 | 12 |
| <i>m</i> - and <i>p</i> -Xylene | ND | -- | ND | -- | 6 | 7 | ND | -- | .71 | 11 |
| <i>p</i> -Isopropyltoluene | ND | -- | ND | -- | 3 | 8 | ND | -- | ND | -- |
| Thiobencarb | ND | -- | ND | -- | 3 | 8 | ND | -- | NA | -- |
| Tetrahydrofuran | ND | -- | ND | -- | 3 | 8 | 7 | 9 | NA | -- |
| 1,1-Dichloroethane | ND | -- | ND | -- | 3 | 8 | 7 | 9 | 1.9 | 7 |
| 1,1-Dichloroethylene | ND | -- | ND | -- | 3 | 8 | 10 | 8 | 1.4 | 9 |
| 1,2-Dichloroethane | ND | -- | ND | -- | 3 | 8 | ND | -- | .52 | 13 |
| <i>trans</i> -1,2-Dichloroethane | ND | -- | ND | -- | 3 | 8 | ND | -- | NA | -- |
| Benzene - total | ND | -- | ND | -- | 3 | 8 | ND | -- | .34 | 15 |
| Carbon tetrachloride | ND | -- | ND | -- | 3 | 8 | ND | -- | .86 | 10 |
| Chlorodibromomethane | ND | -- | ND | -- | 3 | 8 | 20 | 5 | 6.1 | 2 |
| Vinyl chloride | ND | -- | ND | -- | 3 | 8 | 3 | 10 | .17 | 17 |
| Bromodichloromethane | ND | -- | ND | -- | ND | -- | 20 | 5 | 5.9 | 3 |
| Dichloromethane | ND | -- | ND | -- | ND | -- | 13 | 7 | NA | -- |
| Trichloroethene | ND | -- | ND | -- | ND | -- | 13 | 7 | 3.3 | 6 |
| Dibromomethane | ND | -- | ND | -- | ND | -- | 7 | 9 | .36 | 14 |
| Desulfinylfipronil amide | ND | -- | ND | -- | ND | -- | 3 | 10 | NA | -- |
| Median well depth (feet) | 490 | -- | 400 | -- | 47 | -- | 347 | -- | Variable | -- |

¹Includes only samples collected from community water systems supplied by ground water.

the GW–SWQA study, but not in samples from the shallow UrLUS wells. This is because the deeper wells in the MAS also are water-supply wells in Reno. Chloroform also was detected in these same well samples at a higher concentration than in other well samples from the MAS (Stockton and others, 2003). This likely indicates that chlorine was used to disinfect these wells and that the bromoform detected is a by-product of this treatment. The shallow wells that were sampled are mostly monitoring and domestic wells and generally have not been subjected to this type of disinfection.

A nationwide study examined the occurrence of MTBE and other VOCs in the Nation’s drinking-water sources during 1999–2001 (Ivahnenko and others, 2001). The study consisted of a random survey of 954 CWS throughout the United States (Grady, 2003) and a focused survey of 134 CWSs (Delzer and Ivahnenko, 2003) that were supplied by ground water or surface water. Again, examining the commonly detected VOCs in both Eagle Valley and Spanish Springs Valley, table 5 shows the comparison of results between samples collected in those valleys and the samples collected for the nationwide random survey from 579 CWSs supplied by ground water.

All percentages of detections in the three NVBR studies—SWQA in Eagle and Spanish Springs Valleys and the MAS study—were greater than in the nationwide survey (table 5), but this is partly due to the difference in sample size between the NVBR studies and the national study, and partly because the NVBR studies were directed to one aquifer rather than a random selection of aquifers that were selected for the national survey. However, detection frequencies in both shallow and deep wells in the NVBR studies are relatively similar even when the sample size increases to 30 wells. This indicates that the frequency of detection in deeper wells is likely to be similar throughout the aquifers studied even if more wells are sampled. Therefore, the detection frequencies observed in CWS wells sampled for the SWQA appear to be representative of the aquifer as a whole.

Pesticide detection frequencies in the GW–SWQA were 27 percent for deethylatrazine and 20 percent for atrazine. Their occurrence in the shallow (UrLUS) and deep (MAS)

well sampling studies was about the same (24 and 21 percent for deethylatrazine and atrazine, respectively, in the shallow wells, and 21 and 14 percent in the deep wells). Again, this indicates that the SWQA study is representative of the concentrations found in the aquifer.

Although analyses of data from other SWQAs conducted at the same time as this one are not completed to date (August 2006), the NAWQA Great Salt Lake (GRSL) Study Unit in Utah (fig. 1) did a similar study in 2001 (Thiros and Manning, 2004a, 2004b). Although the hydrogeology is not entirely similar (Thiros and Manning, 2004a) and the Salt Lake Valley area pumps considerably more ground water (79,000 acre-ft/yr) than both Eagle and Spanish Spring Valleys combined (23,500 acre-ft/yr), changing land-use patterns are very similar between the two areas, although more industrialized areas occur in the GRSL. Table 6 lists the five most frequently detected compounds that the two studies had in common as well as detection frequency, maximum concentration, and BQmax values. Other compounds were detected in supply wells from both studies.

The detection frequencies of the five compounds in table 6 are reasonably similar although the maximum detected concentrations are higher in the GRSL Study Unit than the NVBR Study Unit, especially for chloroform and PCE. It is interesting to note that the BQmax values for chloroform and PCE in the GRSL Study Unit are both greater than 0.1, indicating that these two compounds may warrant further evaluation in the context of factors such as the magnitude of the BQmax values, detection frequency, and the use of the water (Toccalino and others, 2004). However, the higher chloroform concentrations found in the GRSL Study Unit samples can be attributed to sampling CWS wells that also are used as injection wells for water treated with chlorine for disinfection (Thiros and Manning, 2004b). Although sampling was done months after treated water was injected into the well, residual chlorine appears still to have been present (Susan Thiros, U.S. Geological Survey, oral commun., 2005).

Table 6. Comparison of detection frequencies, concentrations, and benchmark quotient between the Nevada Basin and Range and Great Salt Lake Study Units for the five most frequently detected compounds.

[Compound: M, metabolite; P, pesticide; V, volatile organic compound. BQmax, maximum benchmark quotient = ratio of maximum detected concentration to human-health benchmark; GRSL, Great Salt Lake; NVBR, Nevada Basin and Range; E, estimated; µg/L, microgram per liter; n, number of samples]

| Compound | NVBR, n=15 | | | GRSL, n=31 | | |
|-----------------------------------|-------------------------------|------------------------------|-------|-------------------------------|------------------------------|-------|
| | Detection frequency (percent) | Maximum concentration (µg/L) | BQmax | Detection frequency (percent) | Maximum concentration (µg/L) | BQmax |
| Atrazine (P) | 20 | 0.01 | 0.003 | 22 | 0.03 | 0.01 |
| Deethylatrazine (M) | 27 | E.04 | NA | 32 | E.07 | NA |
| Chloroform (trichloromethane) (V) | 33 | .2 | .002 | 55 | 19.7 | .25 |
| Perchloroethene (PCE) (V) | 13 | .4 | .08 | 10 | 1 | .2 |
| cis-1,2-Dichloroethylene (V) | 7 | E.02 | .0003 | 3 | E.03 | .0004 |

If these injection wells are not used in the analysis, most of the remaining well samples have chloroform concentrations less than 1 µg/L. In addition, even when the samples were from the wells where treated water was injected into the well, the measured concentrations of chloroform and PCE were less than MCL values (BQ_{max} < 1) in the GRSL Study Unit. The differences in detection frequencies and concentrations between the two Study Units probably are to be expected based on differences in sample size of the two studies, population differences, and differences in the level of industrialization between the two study areas. However, the relatively similar results indicate that these compounds may occur at low concentrations in samples collected from other CWS wells in the desert southwest.

Summary

As part of the U.S. Geological Survey National Water-Quality Assessment Program, Eagle and Spanish Springs Valleys, in the Nevada Basin and Range (NVBR) Study Unit in northwestern Nevada, were included in a two-phase Source Water-Quality Assessment (SWQA) during 2002–2004 to characterize the quality of water in aquifers used as a source of supply to some of the largest community water systems (CWSs) in the United States. Eagle Valley, which includes Carson City, and Spanish Springs Valley, north of Sparks, have both experienced a steady population increase in the last 25 years, which may make them susceptible to ground-water contamination.

Fifteen CWS wells, 10 in Eagle Valley and 5 in Spanish Springs Valley, were sampled in phase 1 to determine the occurrence and concentrations of about 260 anthropogenic organic compounds in these source waters. Phase 2 characterized the occurrence and concentration of compounds found to occur most frequently during phase 1 in both source water and the associated treated (finished) water.

The most frequently detected compound during phase 1, found in 40 percent of the Eagle Valley wells sampled, was chloroform. The second most frequently detected compound was deethylatrazine, found in 30 percent of the Eagle Valley wells sampled. Atrazine, perchloroethene (PCE), and bromoform were each found in 20 percent of the Eagle Valley wells sampled. Other compounds found in only a single Eagle Valley supply well were *cis*-1,2-dichloroethylene, MTBE, deisopropylatrazine, metsulfuron methyl, and acetyl hexamethyl tetrahydronaphthalene (AHTN), all at low concentrations.

Based on these results, two wells were selected in Eagle Valley for phase 2 of sampling in August 2004, but with only a selected list of analyzed constituents. PCE and bromoform were detected in the source water, but at a lower concentration than during phase 1. Finished water, which also was sampled during phase 2, is composed of water pumped

from several CWS wells in the valley, including the wells that were resampled during phase 2. Finished water also was found to contain both PCE and bromoform. The concentrations of PCE and bromoform were lower in the finished water than in the source-water sample from one well, whereas bromoform had a higher concentration in the finished water than in the source water from the other well. The lower PCE and bromoform concentrations are likely due to dilution, and the higher bromoform concentration is likely the result of added disinfection chemicals or blending with other well water.

Four anthropogenic organic compounds were found in source water from Spanish Springs Valley—atrazine, chloroform, bromoform, and deethylatrazine. Each of the compounds were detected in one of the five wells sampled. Because of the low overall detection frequency of compounds in Spanish Springs Valley, no additional sampling was done for phase 2. All contaminants detected in source and/or finished water in both the Eagle and Spanish Springs Valleys had concentrations less than their applicable human-health benchmarks (Maximum Contaminant Levels for regulated compounds and Health-Based Screening Levels for unregulated compounds), where available.

The detection frequencies of the pesticides and volatile organic compounds found in the source water of the CWSs for Eagle and Spanish Springs Valleys were similar to those in samples from 34 shallow (median well depth of 47 ft) and 30 deep (median well depth of 347 ft) monitoring wells in Carson City, Reno, and Spanish Springs. However, more organic compounds were detected at low concentrations in samples from the monitoring wells than in the source water of the CWSs.

To put the SWQA ground-water quality in Eagle and Spanish Springs Valleys in perspective, the frequency of detection and maximum concentration of several anthropogenic compounds were compared to a similar study in the Great Salt Lake Valley, Utah (GRSL). Although the hydrogeology is not entirely similar and the Salt Lake Valley area pumps considerably more ground water (79,000 acre-ft/yr) than both Eagle and Spanish Spring Valleys combined (23,500 acre-ft/yr), changing land-use patterns are very similar between the two areas, although more industrialized areas occur in GRSL.

Comparing the five most commonly detected compounds (chloroform, PCE, atrazine, deethylatrazine, and *cis*-1,2-dichloroethylene) in samples from CWS wells in the two areas showed that the frequency of detection for the compounds is similar although the maximum detected concentrations are higher in the GRSL Study Unit than in the NVBR Study Unit, especially for chloroform and PCE. This is to be expected, however, based on population differences and differences in the level of industrialization between the two Study Units. However, the relatively similar results between the NVBR and GRSL studies indicate that at least some of these compounds may occur at low concentrations in samples collected from other CWS wells in the desert southwest.

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Appendixes

Appendix 1. Volatile organic compounds analyzed in this study.

[CASRN, Chemical Abstracts Service Registry Number; µg/L, microgram per liter. Shading denotes compounds detected in this study]

| Analyte | CASRN | Minimum reporting level (µg/L) | Description of detected compound |
|-------------------------------------|----------|--------------------------------|--|
| 1,2,3,4-Tetramethylbenzene | 488-23-3 | 0.14 | |
| 1,2,3,5-Tetramethylbenzene | 527-53-7 | .14 | |
| 2-Butanone | 78-93-3 | 2 | |
| <i>trans</i> -1,4-Dichloro-2-butene | 110-57-6 | .7 | |
| 2-Hexanone | 591-78-6 | .4 | |
| 4-Methyl-2-pentanone | 108-10-1 | .37 | |
| Acetone | 67-64-1 | 6 | |
| Acrylonitrile | 107-13-1 | .8 | |
| Benzene | 71-43-2 | .021 | |
| 1,2,3-Trichlorobenzene | 87-61-6 | .18 | |
| 1,2,3-Trimethylbenzene | 526-73-8 | .06 | |
| 1,2,4-Trichlorobenzene | 120-82-1 | .12 | |
| Bromobenzene | 108-86-1 | .028 | |
| Chlorobenzene | 108-90-7 | .028 | |
| Ethylbenzene | 100-41-4 | .03 | |
| 1,3-Dichlorobenzene | 541-73-1 | .03 | |
| Butylbenzene | 104-51-8 | .12 | |
| <i>n</i> -Propylbenzene | 103-65-1 | .042 | |
| 1,2-Dichlorobenzene | 95-50-1 | .048 | |
| 1,4-Dichlorobenzene | 106-46-7 | .034 | |
| <i>sec</i> -Butylbenzene | 135-98-8 | .06 | |
| <i>tert</i> -Butylbenzene | 98-06-6 | .06 | |
| Bromoethene | 593-60-2 | .1 | |
| Bromoform | 75-25-2 | .1 | Also known as tribromomethane, by-product when chlorine is added to water-supply systems |
| Hexachlorobutadiene | 87-68-3 | .14 | |
| Carbon disulfide | 75-15-0 | .038 | |
| Tetrachloromethane | 56-23-5 | .06 | |
| Chloroform | 67-66-3 | .024 | Also known as trichloromethane, by-product when chlorine is added to water-supply systems; used as a solvent |
| Isopropylbenzene | 98-82-8 | .038 | |
| 1,1,1,2-Tetrachloroethane | 630-20-6 | .03 | |
| 1,1,1-Trichloroethane | 71-55-6 | .032 | |
| 1,1,2-Trichlorotrifluoroethane | 76-13-1 | .038 | |
| 1,2-Dibromoethane | 106-93-4 | .036 | |
| 1,2-Dichloroethane | 107-06-2 | .13 | |
| Hexachloroethane | 67-72-1 | .14 | |
| 1,1,2,2-Tetrachloroethane | 79-34-5 | .08 | |
| Chloroethane | 75-00-3 | .12 | |
| Diethyl ether | 60-29-7 | .08 | |
| Ethyl <i>tert</i> -butyl ether | 637-92-3 | .03 | |
| <i>cis</i> -1,2-Dichloroethylene | 156-59-2 | 0.024 | Used as a solvent for waxes and resins; used as a refrigerant |
| Perchloroethene | 127-18-4 | .03 | Also known as tetrachloroethylene and PCE, primarily used as dry cleaning agent |
| <i>trans</i> -1,2-Dichloroethylene | 156-60-5 | .032 | |
| Trichloroethylene | 79-01-6 | .038 | |
| 1,1-Dichloroethane | 75-34-3 | .035 | |

Appendix 1. Volatile organic compounds analyzed in this study.—Continued

[CASRN, Chemical Abstracts Service Registry Number; µg/L, microgram per liter. Shading denotes compounds detected in this study]

| Analyte | CASRN | Minimum reporting level (µg/L) | Description of detected compound |
|--|--|--------------------------------|----------------------------------|
| Tetrahydrofuran | 109-99-9 | 1 | |
| Diisopropyl ether | 108-20-3 | .1 | |
| <i>m</i> - and <i>p</i> -Xylene | <i>m</i> =108-38-3 <i>p</i> =106-42-3 | .06 | |
| 1,3,5-Trimethylbenzene | 108-67-8 | .044 | |
| Ethyl methacrylate | 97-63-2 | .18 | |
| Methyl methacrylate | 80-62-6 | .2 | |
| Methyl acrylonitrile | 126-98-7 | .4 | |
| Bromochloromethane | 74-97-5 | .12 | |
| Bromodichloromethane | 75-27-4 | .028 | |
| Dibromochloromethane | 124-48-1 | .1 | |
| Dichlorodifluoromethane | 75-71-8 | .18 | |
| Trichlorofluoromethane | 75-69-4 | .08 | |
| Methyl acrylate | 96-33-3 | 1 | |
| Bromomethane | 74-83-9 | .26 | |
| Chloromethane | 74-87-3 | .17 | |
| Methyl iodide | 74-88-4 | .5 | |
| Methyl <i>tert</i> -butyl ether (MTBE) | 1634-04-4 | .1 | Gasoline additive |
| Dibromomethane | 74-95-3 | .05 | |
| Dichloromethane | 75-09-2 | .06 | |
| Naphthalene | 91-20-3 | .52 | |
| <i>o</i> -Xylene | 95-47-6 | .038 | |
| 4-Isopropyl-1-methylbenzene | 99-87-6 | .08 | |
| 1,2,3-Trichloropropane | 96-18-4 | .18 | |
| 1,3-Dichloropropane | 142-28-9 | .06 | |
| 2,2-Dichloropropane | 594-20-7 | .05 | |
| 1,2-Dibromo-3-chloropropane | 96-12-8 | .51 | |
| 1,1-Dichloropropene | 563-58-6 | .026 | |
| 3-Chloropropene | 107-05-1 | .5 | |
| <i>cis</i> -1,3-Dichloropropene | 10061-01-5 | .05 | |
| <i>trans</i> -1,3-Dichloropropene | 10061-02-6 | .09 | |
| 1,2-Dichloropropane | 78-87-5 | .029 | |
| 1,2,4-Trimethylbenzene | 95-63-6 | .056 | |
| <i>tert</i> -Pentyl methyl ether | 994-05-8 | .04 | |
| Toluene | 108-88-3 | .02 | |
| 2-Chlorotoluene | 95-49-8 | .04 | |
| <i>o</i> -Ethyl toluene | 611-14-3 | .06 | |
| 4-Chlorotoluene | 106-43-4 | .05 | |
| Vinyl chloride | 75-01-4 | .08 | |
| 1,1,2-Trichloroethane | 79-00-5 | .04 | |
| 1,1-Dichloroethylene | 75-35-4 | .024 | |

Appendix 2. Pesticides analyzed in this study.

[CASRN, Chemical Abstracts Service Registry Number; µg/L, micrograms per liter; --, not available. Shading denotes compounds detected in this study]

| Analyte | CASRN | Minimum reporting level (µg/L) | Description of detected compound |
|---|-------------|--------------------------------|--|
| 2,4-D | 94-75-7 | 0.038 | |
| 2,4-D methyl ester | 1928-38-7 | .016 | |
| 2,4-DB | 94-82-6 | .02 | |
| 2-Hydroxy-4-isopropylamino-6-ethylamino-s-triazine (OIET) | 2163-68-0 | .032 | |
| 3(4-Chlorophenyl)-1-methyl urea | 5352-88-5 | .036 | |
| 3-Ketocarbofuran | 16709-30-1 | .02 | |
| Acifluorfen | 50594-66-6 | .028 | |
| Aldicarb | 116-06-3 | .04 | |
| Aldicarb sulfone | 1646-88-4 | .018 | |
| Aldicarb sulfoxide | 1646-87-3 | .022 | |
| Chloramben, methyl ester | 7286-84-2 | .024 | |
| Atrazine | 1912-24-9 | .007 | Herbicide |
| Bendiocarb | 22781-23-3 | .02 | |
| Benomyl | 17804-35-2 | .022 | |
| Bensulfuron-methyl | 83055-99-6 | .018 | |
| Bentazon | 25057-89-0 | .012 | |
| Bromacil | 314-40-9 | .018 | |
| Bromoxynil | 1689-84-5 | .028 | |
| Carbaryl | 63-25-2 | .018 | |
| Carbofuran | 1563-66-2 | .016 | |
| 3-Hydroxycarbofuran | 16655-82-6 | .008 | |
| Chlorimuron-ethyl | 90982-32-4 | .032 | |
| Chlorothalonil | 1897-45-6 | .035 | |
| Clopyralid | 1702-17-6 | .024 | |
| Cycloate | 1134-23-2 | .014 | |
| Dacthal monoacid | 887-54-7 | .028 | |
| 2-Chloro-4-isopropylamino-6-amino-s-triazine (CIAT) | 6190-65-4 | .006 | Breakdown product of atrazine; also referred to as deethylatrazine |
| Chlordiamino-s-triazine (CAAT) | 3397-62-4 | .022 | |
| 2-Chloro-6-ethylamino-4-amino-s-triazine (CEAT) | 1007-28-9 | .08 | Breakdown product of atrazine; also referred to as deisopropylatrazine |
| Dicamba | 1918-00-9 | .036 | |
| Dichlorprop | 120-36-5 | .028 | |
| Dinoseb | 88-85-7 | .038 | |
| Diphenamid | 957-51-7 | .01 | |
| Diuron | 330-54-1 | .014 | |
| Fenuron | 101-42-8 | .018 | |
| Flumetsulam | 98967-40-9 | .04 | |
| Fluometuron | 2164-17-2 | .016 | |
| Imazaquin | 81335-37-7 | .036 | |
| Imazethapyr | 81335-77-5 | .038 | |
| Imidacloprid | 138261-41-3 | .02 | |
| Linuron | 330-55-2 | .014 | |
| MCPA | 94-74-6 | .03 | |
| MCPB | 94-81-5 | .01 | |
| Metalaxyl | 57837-19-1 | .0051 | |
| Methiocarb | 2032-65-7 | .01 | |
| Methomyl | 16752-77-5 | .02 | |

Appendix 2. Pesticides analyzed in this study.—Continued

[CASRN, Chemical Abstracts Service Registry Number; µg/L, micrograms per liter; --, not available. Shading denotes compounds detected in this study]

| Analyte | CASRN | Minimum reporting level (µg/L) | Description of detected compound |
|---------------------------------|-------------|--------------------------------|--|
| Metsulfuron methyl | 74223-64-6 | 0.025 | Pesticide for weed control and suppression of grasses along rights-of-way, storage areas, roadside turf, fence rows, industrial turf, and highways |
| Neburon | 555-37-3 | .012 | |
| Nicosulfuron | 111991-09-4 | .04 | |
| Norflurazon | 27314-13-2 | .02 | |
| Oryzalin | 19044-88-3 | .012 | |
| Oxamyl | 23135-22-0 | .03 | |
| Picloram | 1918-02-1 | .032 | |
| Prometon | 1610-18-0 | .01 | |
| Propham | 122-42-9 | .03 | |
| Propiconazole | 60207-90-1 | .01 | |
| Propoxur | 114-26-1 | .008 | |
| Siduron | 1982-49-6 | .02 | |
| Simazine | 122-34-9 | .005 | |
| Sulfometuron-methyl | 74222-97-2 | .038 | |
| Tebuthiuron | 34014-18-1 | .016 | |
| Terbacil | 5902-51-2 | .016 | |
| Tribenuron-methyl | 101200-48-0 | .0088 | |
| Triclopyr | 55335-06-3 | .026 | |
| 1-Naphthol | 90-15-3 | .0882 | |
| 2-Chloro-2,6-diethylacetanilide | 6967-29-9 | .005 | |
| 2-Ethyl-6-methylaniline | 24549-06-2 | .0045 | |
| 3,4-Dichloroaniline | 95-76-1 | .0045 | |
| 4-Chloro-2-methylphenol | 1570-64-5 | .0057 | |
| Acetochlor | 34256-82-1 | .006 | |
| Alachlor | 15972-60-8 | .005 | |
| 2,6-Diethylaniline | 579-66-8 | .006 | |
| Azinphos-methyl | 86-50-0 | .05 | |
| Azinphos-methyl-oxon | 961-22-8 | .07 | |
| Benfluralin | 1861-40-1 | .01 | |
| Chlorpyrifos | 2921-88-2 | .005 | |
| Chlorpyrifos, oxygen analog | 5598-15-2 | .0562 | |
| <i>cis</i> -Permethrin | 54774-45-7 | .006 | |
| Cyfluthrin | 68359-37-5 | .008 | |
| Cypermethrin | 52315-07-8 | .0086 | |
| Dacthal | 1861-32-1 | .003 | |
| Diazinon | 333-41-5 | .005 | |
| Diazinon, oxygen analog | 962-58-3 | .006 | |
| Dichlorvos | 62-73-7 | .0118 | |
| Dicrotophos | 141-66-2 | .0843 | |
| Dieldrin | 60-57-1 | .009 | |
| Dimethoate | 60-51-5 | .0061 | |
| Ethion | 563-12-2 | .004 | |
| Ethion monoxon | 17356-42-2 | .002 | |
| Fenamiphos | 22224-92-6 | .029 | |
| Fenamiphos sulfone | 31972-44-8 | .0491 | |
| Fenamiphos sulfoxide | 31972-43-7 | .0387 | |
| Desulfinylfipronil amide | -- | .029 | |

Appendix 2. Pesticides analyzed in this study.—Continued

[CASRN, Chemical Abstracts Service Registry Number; µg/L, micrograms per liter; --, not available. Shading denotes compounds detected in this study]

| Analyte | CASRN | Minimum reporting level (µg/L) | Description of detected compound |
|--------------------------------|-------------|--------------------------------|----------------------------------|
| Fipronil sulfide | 120067-83-6 | 0.013 | |
| Fipronil sulfone | 120068-36-2 | .024 | |
| Desulfinylfipronil | -- | .012 | |
| Fipronil | 120068-37-3 | .016 | |
| Fonofos | 944-22-9 | .003 | |
| Fonofos, oxygen analog | 944-21-8 | .0029 | |
| Hexazinone | 51235-04-2 | .0129 | |
| Iprodione | 36734-19-7 | .387 | |
| Isofenphos | 25311-71-1 | .0034 | |
| Malaoxon | 1634-78-2 | .0298 | |
| Malathion | 121-75-5 | .027 | |
| Methidathion | 950-37-8 | .0058 | |
| Parathion-methyl | 298-00-0 | .015 | |
| Metolachlor | 51218-45-2 | .006 | |
| Metribuzin | 21087-64-9 | .006 | |
| Myclobutanil | 88671-89-0 | .008 | |
| Paraoxon-methyl | 950-35-6 | .0299 | |
| Pendimethalin | 40487-42-1 | .022 | |
| Phorate | 298-02-2 | .011 | |
| Phorate oxygen analog | 2600-69-3 | .1048 | |
| Phosmet | 732-11-6 | .0079 | |
| Phosmet oxon | 3735-33-9 | .0511 | |
| Prometryn | 7287-19-6 | .0054 | |
| Propyzamide | 23950-58-5 | .004 | |
| Terbufos | 13071-79-9 | .017 | |
| Terbufos oxygen analog sulfone | 56070-15-6 | .0676 | |
| Terbuthylazine | 5915-41-3 | .0102 | |
| Trifluralin | 1582-09-8 | .009 | |

Appendix 3. Other anthropogenic organic compounds analyzed in this study.

[CASRN, Chemical Abstracts Service Registry Number; µg/L, microgram per liter. Shading denotes compound detected in this study]

| Analyte | CASRN | Minimum reporting level (µg/L) | Description of detected compound |
|--|------------|--------------------------------|--|
| Cotinine | 486-56-6 | 1 | |
| 5-Methyl-1H-benzotriazole | 136-85-6 | 2 | |
| Anthraquinone | 84-65-1 | .5 | |
| Acetophenone | 98-86-2 | .5 | |
| Acetyl hexamethyl tetrahydronaphthalene (AHTN) | 21145-77-7 | .5 | Polycyclic musk used in fragrances for perfumes, cosmetics, household and laundry cleaning products and air fresheners |
| Anthracene | 120-12-7 | .5 | |
| 1,4-Dichlorobenzene | 106-46-7 | .5 | |
| Benzo[<i>a</i>]pyrene | 50-32-8 | .5 | |
| Benzophenone | 119-61-9 | .5 | |
| Bromacil | 314-40-9 | .5 | |
| Bromoform | 75-25-2 | .5 | |
| 3- <i>tert</i> -Butyl-4-hydroxy anisole (BHA) | 25013-16-5 | 5 | |
| Caffeine | 58-08-2 | .018 | |
| Camphor | 76-22-2 | .5 | |
| Carbaryl | 63-25-2 | 1 | |
| Carbazole | 86-74-8 | .5 | |
| Chlorpyrifos | 2921-88-2 | .5 | |
| Cholesterol | 57-88-5 | 2 | |
| 3- <i>beta</i> -Coprostanol | 360-68-9 | 2 | |
| Isopropylbenzene | 98-82-8 | .5 | |
| N,N,-diethyl- <i>meta</i> -toluamide (DEET) | 134-62-3 | .5 | |
| Diazinon | 333-41-5 | .5 | |
| Dichlorvos | 62-73-7 | 1 | |
| Bisphenol-A | 80-05-7 | 1 | |
| Triethyl citrate (ethyl citrate) | 77-93-0 | .5 | |
| Tetrachloroethylene | 127-18-4 | .5 | |
| Fluoranthene | 206-44-0 | .5 | |
| Hexahydrohexamethylcyclopentabenzopyran (HHCB) | 1222-05-5 | .5 | |
| Indole | 120-72-9 | .5 | |
| Isoborneol | 124-76-5 | .5 | |
| Isophorone | 78-59-1 | .5 | |
| Isoquinoline | 119-65-3 | .5 | |
| <i>d</i> -Limonene | 5989-27-5 | .5 | |
| Menthol | 89-78-1 | .5 | |
| Metalaxyl | 57837-19-1 | .5 | |
| Metolachlor | 51218-45-2 | .5 | |
| Naphthalene | 91-20-3 | .5 | |
| 1-Methylnaphthalene | 90-12-0 | .5 | |
| 2,6-Dimethylnaphthalene | 581-42-0 | .5 | |
| 2-Methylnaphthalene | 91-57-6 | .5 | |
| Nonylphenol, diethoxy- (total) | 26027-38-2 | 5 | |
| Octylphenol, diethoxy | 26636-32-8 | 1 | |
| Octylphenol, monoethoxy- | 26636-32-8 | 1 | |

Appendix 3. Other anthropogenic organic compounds analyzed in this study.—Continued

[CASRN, Chemical Abstracts Service Registry Number; µg/L, microgram per liter. Shading denotes compound detected in this study]

| Analyte | CASRN | Minimum reporting level (µg/L) | Description of detected compound |
|---|------------|--------------------------------|----------------------------------|
| <i>p</i> -Cresol | 106-44-5 | 1 | |
| 4-Cumylphenol | 599-64-4 | 1 | |
| <i>para</i> -Nonylphenol (total) | 84852-15-3 | 5 | |
| 4- <i>n</i> -Octylphenol | 1806-26-4 | 1 | |
| 4- <i>tert</i> -Octylphenol | 140-66-9 | 1 | |
| Phenanthrene | 85-01-8 | .5 | |
| Phenol | 108-95-2 | .5 | |
| Pentachlorophenol | 87-86-5 | 2 | |
| Tributyl phosphate | 126-73-8 | .5 | |
| Triphenyl phosphate | 115-86-6 | .5 | |
| Tris(2-butoxyethyl)phosphate | 78-51-3 | .5 | |
| Tris(2-chloroethyl)phosphate (TCEP) | 115-96-8 | .5 | |
| Prometon | 1610-18-0 | .5 | |
| Pyrene | 129-00-0 | .5 | |
| Methyl salicylate | 119-36-8 | .5 | |
| 3-Methyl-1(H)-indole (Skatole) | 83-34-1 | 1 | |
| <i>beta</i> -Sitosterol | 83-46-5 | 2 | |
| <i>beta</i> -Stigmastanol | 19466-47-8 | 2 | |
| Triclosan | 3380-34-5 | 1 | |
| Tris(dichloroisopropyl)phosphate (TCPP) | 13674-87-8 | .5 | |

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Information regarding the National Water-Quality Assessment Program
is available at <http://water.usgs.gov/nawqa/> and
<http://nv.water.usgs.gov/nawqa>

