The background of the cover features a complex, three-dimensional molecular model. It consists of numerous spheres in shades of purple, teal, and yellow, connected by thin grey rods representing chemical bonds. The spheres are arranged in a way that suggests a crystalline or complex organic structure. The overall color palette is dominated by these three colors, with the purple being the most prominent.

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

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Water-Resources Investigations Report 01–4144

National Water-Quality Assessment Program

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By D.J. Gellenbeck and D.W. Anning

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National Water-Quality Assessment Program

Tucson, Arizona
2002

U.S. DEPARTMENT OF THE INTERIOR
GALE A. NORTON, Secretary

U.S. GEOLOGICAL SURVEY
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FOREWORD

The U.S. Geological Survey (USGS) is committed to serve the Nation with accurate and timely scientific information that helps enhance and protect the overall quality of life, and facilitates effective management of water, biological, energy, and mineral resources. Information on the quality of the Nation's water resources is of critical interest to the USGS because it is so integrally linked to the long-term availability of water that is clean and safe for drinking and recreation and that is suitable for industry, irrigation, and habitat for fish and wildlife. Escalating population growth and increasing demands for the multiple water uses make water availability, now measured in terms of quantity *and* quality, even more critical to the long-term sustainability of our communities and ecosystems.

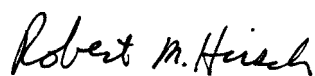
The USGS implemented the National Water-Quality Assessment (NAWQA) Program to support national, regional, and local information needs and decisions related to water-quality management and policy. Shaped by and coordinated with ongoing efforts of other Federal, State, and local agencies, the NAWQA Program 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. NAWQA results can contribute to informed decisions that result in practical and effective water-resource management and strategies that protect and restore water quality.

Since 1991, the NAWQA Program has implemented interdisciplinary assessments in more than 50 of the Nation's most important river basins and aquifers, referred to as Study Units. Collectively, these Study Units account for more than 60 percent of the overall water use and population served by public water supply, and are representative of the Nation's major hydrologic landscapes, priority ecological resources, and agricultural, urban, and natural sources of contamination.

Each assessment is guided by a nationally consistent study design and methods of sampling and analysis. The assessments thereby build local knowledge about water-quality issues and trends in a particular stream or aquifer while providing an understanding of how and why water quality varies regionally and nationally. The consistent, multi-scale approach helps to determine if certain types of water-quality issues are isolated or pervasive, and allows direct comparisons of how human activities and natural processes affect water quality and ecological health in the Nation's diverse geographic and environmental settings. Comprehensive assessments on pesticides, nutrients, volatile organic compounds, trace metals, and aquatic ecology are developed at the national scale through comparative analysis of the Study-Unit findings.

The USGS places high value on the communication and dissemination of credible, timely, and relevant science so that the most recent and available knowledge about water resources can be applied in management and policy decisions. We hope this NAWQA publication will provide you the needed insights and information to meet your needs, and thereby foster increased awareness and involvement in the protection and restoration of our Nation's waters.

The NAWQA Program 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 program, therefore, depends extensively on the advice, cooperation, and information from other Federal, State, interstate, tribal, and local agencies, non-government organizations, industry, academia, and other stakeholder groups. The assistance and suggestions of all are greatly appreciated.



Robert M. Hirsch
Associate Director for Water

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CONVERSION FACTORS

Multiply	By	To obtain
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi ²)	2.590	square kilometer
gallon (gal)	0.003785	cubic meter
million gallons (Mgal)	3,785	cubic meter

ABBREVIATED WATER-QUALITY UNITS

Chemical concentrations are given only in metric units. Chemical concentration in water is given in milligrams per liter (mg/L) or micrograms per liter (µg/L). Milligrams per liter is a unit expressing the solute mass (milligrams) per unit volume (liter) of water. One thousand micrograms per liter is equivalent to 1 milligram per liter. For concentrations less than 7,000 milligrams per liter, the numerical value is about the same as for concentrations in parts per million.

VERTICAL DATUM

Sea level: In this report, “sea level” refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)— a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called “Sea Level Datum of 1929”.

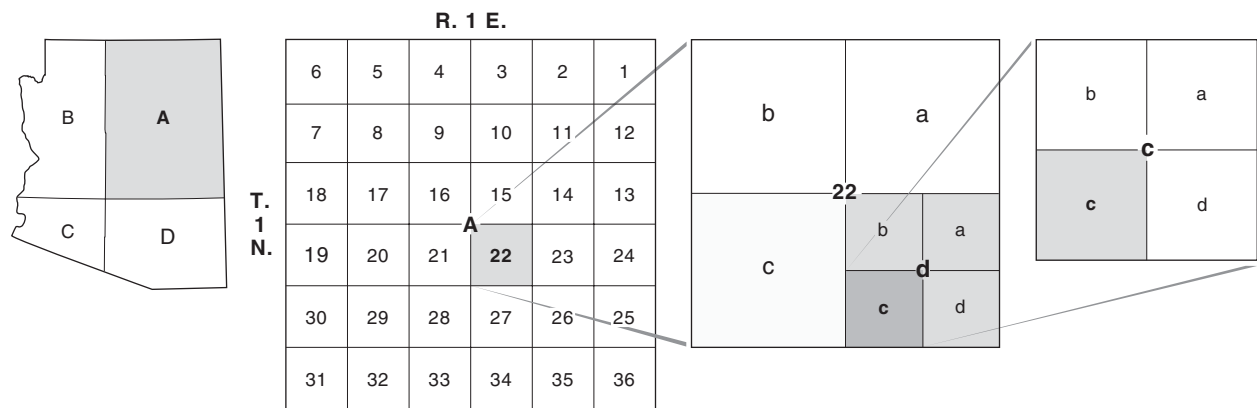
DEFINITION OF ABBREVIATIONS AND ACRONYMS

ADEQ	Arizona Department of Environmental Quality
CAP	Central Arizona Project
CAZB	Central Arizona Basins
MCL	Maximum Contaminant Level
MRL	Minimum Reporting Level
DDE	Dichlorodiphenyldichloroethene
DDT	Dichlorodiphenyldichloroethane
GCMS	Gas chromatograph/mass spectrometry with selected ion monitoring
HPLC	High-performance liquid chromatography
LUS	Land-use study
NAWQA	National Water-Quality Assessment
NWQL	National Water-Quality Laboratory
PCE	Tetrachloroethene
SUS	Sub-unit survey
TCE	Trichloroethene
TRI	Toxics Release Inventory
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VOC	Volatile organic compound
WWTP	Wastewater-Treatment Plant

WELL-NUMBERING SYSTEM, ARIZONA

The well numbers used by the U.S. Geological Survey in Arizona are in accordance with the Bureau of Land Management’s system of land subdivision. The land survey in Arizona is based on the Gila and Salt River Meridian and Base Line, which divide the State into four quadrants. These quadrants are designated counterclockwise by the capital letters, A, B, C, and D. All land north and east of the point of origin is in A quadrant, that north and west in B quadrant, that south and west in C quadrant, and that south and east in D quadrant. The first digit of a well number indicates the township; the second, the range; and the third, the section in which the well is situated. The lowercase letters *a*, *b*, *c*, and *d* after the section number indicate the well location within the section. The first letter denotes a particular 160-acre tract; the second, the 40-acre tract; and the third, the 10-acre tract. These letters also are assigned in a counterclockwise direction, beginning in the northeast quarter. If the location is known within the 10-acre tract, three lowercase letters are shown in the well number. In the example shown, well number (A-01-01)22dcc designated the well as being in the SW1/4SW1/4SE1/4, sec. 22 T. 1 N., R. 1 E. Where more than 1 well is within a 10-acre tract, consecutive numbers beginning with 1 are added as suffixes.

WELL (A-01-01)22dcc



Occurrence and Distribution of Pesticides and Volatile Organic Compounds in Ground Water and Surface Water in Central Arizona Basins, 1996–98, and Their Relation to Land Use

By D.J. Gellenbeck and D.W. Anning

Abstract

Samples of ground water and surface water from the Sierra Vista subbasin, the Upper Santa Cruz Basin, and the West Salt River Valley were collected and analyzed to determine the occurrence and distribution of pesticides and volatile organic compounds in central Arizona. The study was done during 1996–98 within the Central Arizona Basins study unit of the National Water-Quality Assessment program. This study included 121 wells and 4 surface-water sites in the 3 basins and the analyses of samples from 4 sites along the Santa Cruz River that were part of a separate study. Samples were collected from 121 wells and 3 surface-water sites for pesticide analyses, and samples were collected from 109 wells and 3 surface-water sites for volatile organic compound analyses.

Certain pesticides detected in ground water and surface water can be related specifically to agricultural or urban uses; others can be related to multiple land uses. Effects from historical agriculture are made evident by detections of DDE in ground-water and surface-water samples collected in the West Salt River Valley and detections of atrazine and deethylatrazine in the ground water in the Upper Santa Cruz Basin. Effects from present agriculture are evident in the seasonal variability in concentrations of pre-emergent pesticides in surface-water samples from the West Salt River Valley. Several detections of DDE and dieldrin in surface water were higher than established water-quality limits. Effects of urban land use are made evident by detections of volatile organic compounds in ground water and surface water from the West Salt River Valley. Detections of volatile organic compounds in surface water from the Santa Cruz River near Nogales, Arizona, also are indications of the effects of urban land use. One detection of tetrachloroethene in ground water was higher than established water-quality limits.

Water reuse is an important conservation technique in the Southwest; however, the reuse of water provides a transport mechanism for pesticides and volatile organic compounds to reach areas that are not normally affected by manmade compounds from specific land-use activities. The most complex mixture of pesticides and volatile organic compounds is in the West Salt River Valley and is the result of water-management practices and the combination of land uses in this basin throughout history.

INTRODUCTION

Predicted population growth in Arizona will result in an increased demand for good-quality drinking water. Between 1980 and 1990, the population in Arizona increased by 35 percent; and between 1990

and 2000, the population increased by another 40 percent (Arizona Department of Economic Security, rev. March 27, 2001). Most population growth was in and near the metropolitan areas of Phoenix and Tucson (Cordy and others, 1998). As the demand for good-quality drinking water increases in these metropolitan

areas, knowledge about the occurrence and distribution of organic compounds in the water resources becomes more important. To date (2000), there have been few studies that completed an assessment of these compounds on a large scale in Arizona.

The National Water-Quality Assessment (NAWQA) program begun by the U.S. Geological Survey (USGS) provided the opportunity to assess the occurrence and distribution of organic and inorganic compounds in the water resources of central Arizona during 1996–98. The objectives of the NAWQA program are to describe the current water-quality conditions and trends in rivers, streams, and ground water and to understand the natural and human factors that affect the conditions and trends in water quality throughout the Nation (Hirsch and others, 1988). The Central Arizona Basins (CAZB) study area (fig. 1), which includes 34,700 mi², was one of more than 50 study areas across the United States that were selected to help meet these objectives. Surface-water and ground-water samples from the CAZB study area were analyzed to determine the occurrence and distribution of pesticides and volatile organic compounds (VOCs) in south-central Arizona during 1996–98.

Purpose and Scope

This report presents analytical results for pesticides and VOCs in ground water and surface water in the southern and central parts of the CAZB study area during 1996–98. In this report, the term “pesticides” refers to pesticide parent and degradation compounds. Activities in urban and agricultural land-use areas are evaluated as possible sources of pesticides and VOCs detected in the water samples. During 1996–98, ground-water samples were collected from three basins—the West Salt River Valley, the Sierra Vista subbasin, and the Upper Santa Cruz Basin. Samples for pesticide analyses were collected at 121 wells, and samples for VOC analyses were collected at 109 wells. Surface-water samples primarily were collected from four sites in southern and central Arizona; at one site, alternate sampling locations were used depending on flow conditions. During 1996–98, 77 samples for pesticide analyses were collected at 3 of the 4 surface-water sites, and 13 samples for VOC analyses were collected at 3 of the 4 surface-water sites. Comparisons of occurrence and distribution of pesticides and VOCs

among the ground-water basins and seasonal variability of pesticide occurrence and distribution at some surface-water sites are included in this report.

Quality-control samples were collected to evaluate the quality of the environmental data. During 1996–98, 12 different types of quality-control samples were collected to evaluate contamination, bias, and variability in the ground-water and surface-water data. The discussion of these results is included in the section entitled “Quality-Assurance Information.”

Acknowledgments

Henry Sanger, Alissa Coes, Dave Peyton, Jack Edmonds, Julie Rees, Karen Beaulieu, Joe Capesius, Laurie Wirt, Christie O’Day, Ann Tillery, Ken Galyean, Rodrigo Morales, David Graham, and Gail Cordy (USGS) all participated in collection of ground-water and surface-water samples. Todd Ingersoll, Ray Davis, Melissa Butler, and Dawn McDoniel (USGS) processed many of the samples for pesticide analyses in the office laboratory. Alice Konieczki (USGS) collected samples on the Santa Cruz River; without these data, no information would be available about pesticides and VOCs in surface water from the Upper Santa Cruz Basin. Many of these people donated several hours of their personal time to ensure the accuracy and completeness of the data presented.

Ken Agnew, University of Arizona, Pesticide and Information Office, provided information for pesticides used in the study area. Private land owners allowed USGS personnel to measure water levels, sample ground water, drill monitoring wells, and sample surface water on their property. Many municipal agencies permitted sampling of their wells and allowed access to well records.

Description of Study Area

The CAZB study area has been divided into two hydrologic provinces—the Basin and Range Lowlands and the Central Highlands—on the basis of physiographic and hydrologic characteristics (Fenneman, 1931). The data discussed in this report are from the Basin and Range Lowlands Province of the CAZB study area, which includes about 19,000 mi² of southern and central Arizona. Altitudes range from about 800 ft above sea level west of Phoenix near the study-area boundary to about 9,470 ft southeast of Sierra Vista (Cordy and others, 1998).

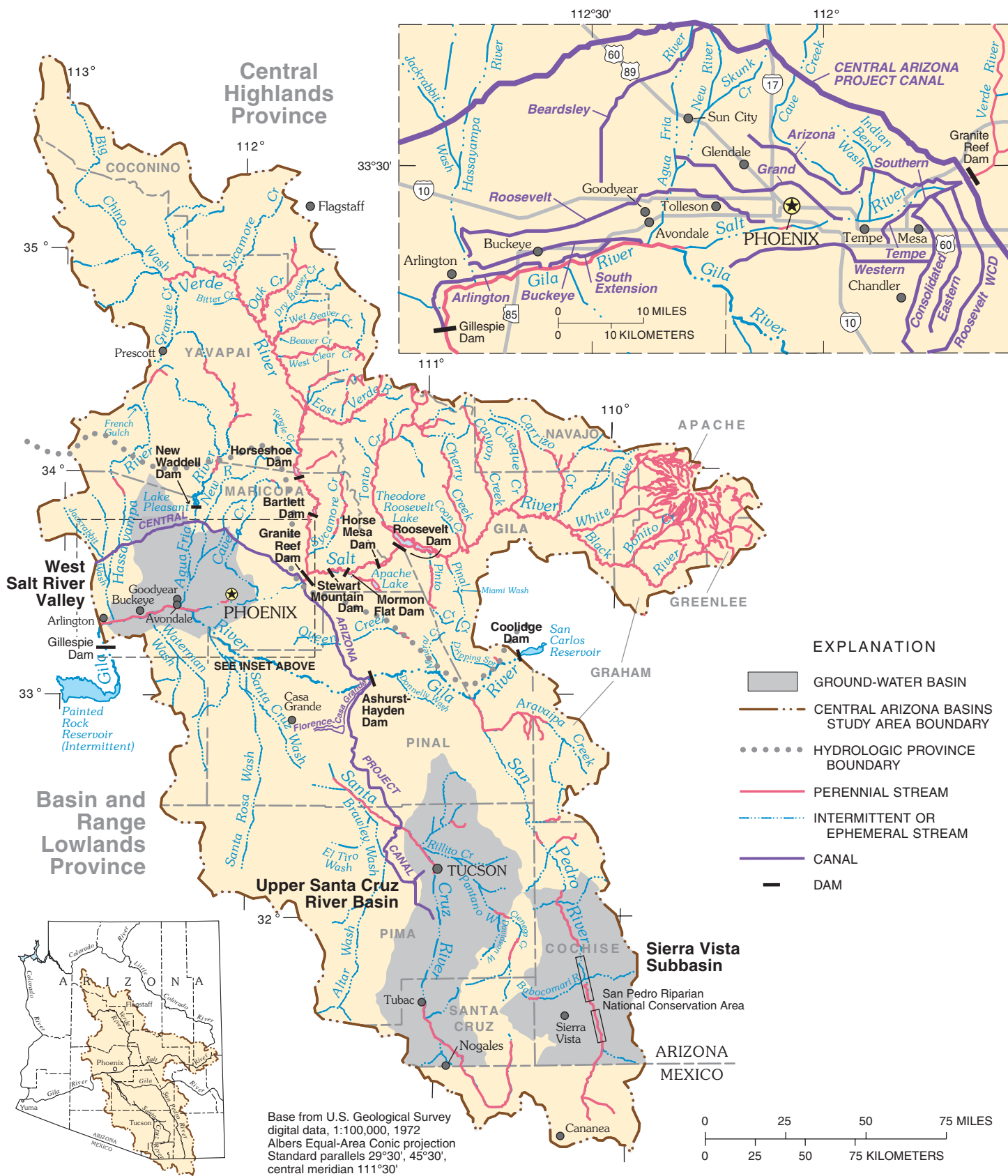


Figure 1. Principal perennial and intermittent or ephemeral streams, and dams and selected canals, Central Arizona Basins study area (perennial reaches from Arizona Game and Fish Department, 1993; digital data modified from U.S. Geological Survey, 1974–86; urban digital data for 1990 from Maricopa Association of Governments, Pima County, and the University of Arizona).

Geologic Setting

The present-day geologic setting in the southern and central parts of the CAZB study area is in part the result of normal faulting during the Basin and Range Disturbance (Damon and others, 1984; Shafiqullah and others, 1980) that resulted in uplifted and downdropped blocks that form the mountains and valleys, respectively. Bedrock in the mountains includes Precambrian metamorphic and granitic rocks; Paleozoic sandstone, limestone, and shale; Mesozoic granitic, volcanic, and sedimentary rocks; and Cenozoic granitic, volcanic, and sedimentary rocks (Reynolds, 1988).

In the Basin and Range Lowlands, sediments were eroded from the surrounding uplifted mountains and deposited in the valleys in each basin during a period of internal drainage. The basin-fill deposits may be as much as 12,000 ft thick (Cordy and others, 1998). Anderson and others (1992) identified these deposits as weakly to highly consolidated gravel, sand, silt, and clay that range in age from late Tertiary to Quaternary. Evaporite and mudstone deposits are found within the lower part of the basin-fill deposits. Stream alluvium overlies the basin-fill deposits and is present along the surface-water drainages in most of the alluvial basins.

General Surface-Water and Ground-Water Conditions

In the CAZB study area, the hydrologic system in the Basin and Range Lowlands is dominated by the regulation of streamflow and large amounts of ground-water pumping. Reservoirs and diversions on the Salt, Verde, and Agua Fria Rivers regulate surface water that contributes flow to the Gila River from the Central Highlands (fig. 1). Within the Basin and Range Lowlands, almost all flow in the Gila River is diverted at Ashurst-Hayden Dam into the Florence-Casa Grande Canal (fig. 1). Between this diversion and the metropolitan area of Phoenix, the flow in the Gila River is ephemeral, and the sources of streamflow are mainly irrigation-return flow and treated-sewage effluent.

The San Pedro and Santa Cruz Rivers in the Basin and Range Lowlands flow from Mexico northward into Arizona and contribute flow to the Gila River before the Gila River enters the metropolitan area of Phoenix. The headwaters of the San Pedro River are in Mexico, and flow is perennial in some reaches and intermittent in others (fig. 1). The headwaters of the Santa Cruz River are in Arizona, and a perennial reach of the river flows southward into Mexico and then northward back

into Arizona. In Arizona, the Santa Cruz River contains perennial and ephemeral reaches. Treated-sewage effluent from wastewater-treatment plants (WWTPs) on the Santa Cruz River provide base flow between Nogales and Tubac and near Tucson. The channel of the Santa Cruz River becomes a network of distributary channels that are ephemeral between Tucson and the confluence with the Gila River. These distributary channels create a disconnection of the river. The Santa Cruz River contains irrigation-return flow in this reach.

Within the metropolitan area of Phoenix, downstream from canal diversions, and upstream from the confluence of the Salt and Gila Rivers, the primary source of water in the Salt River is outflow from the WWTPs at 23rd Avenue and 91st Avenue. These WWTPs process 71.3 billion gallons of sewage annually from the metropolitan Phoenix area (City of Phoenix, 1999). Seasonal floods and irrigation-return flow also can contribute to this reach. Downstream from the confluence of the Gila and Agua Fria Rivers, most of the surface water is diverted into the Buckeye Canal operated by the Buckeye Irrigation District (fig. 2). Diverted surface water in this canal, as well as other canals in the metropolitan area of Phoenix, is supplemented with ground water.

Farther downstream, irrigation-return flows contribute to the surface water in the Gila River. The Hassayampa River primarily is ephemeral; irrigation-return flow is the source of water in localized reaches and enters the Gila River at the confluence.

Ground water in the Basin and Range Lowlands primarily is in the stream alluvium and basin-fill deposits. The most productive aquifers are the thick basin-fill deposits. Most water is obtained from the upper 1,000 ft of these deposits and generally is under unconfined conditions (Anderson and others, 1992). Primary locations of ground-water recharge are along mountain fronts and along the axes of structural basins where major streams and rivers contain flow for long periods. Irrigation water applied at amounts that exceed crop requirements provides recharge to the underlying aquifer in areas of active cultivation and in urban areas where landscapes are overwatered. Seepage from unlined irrigation canals also can provide recharge to aquifers.

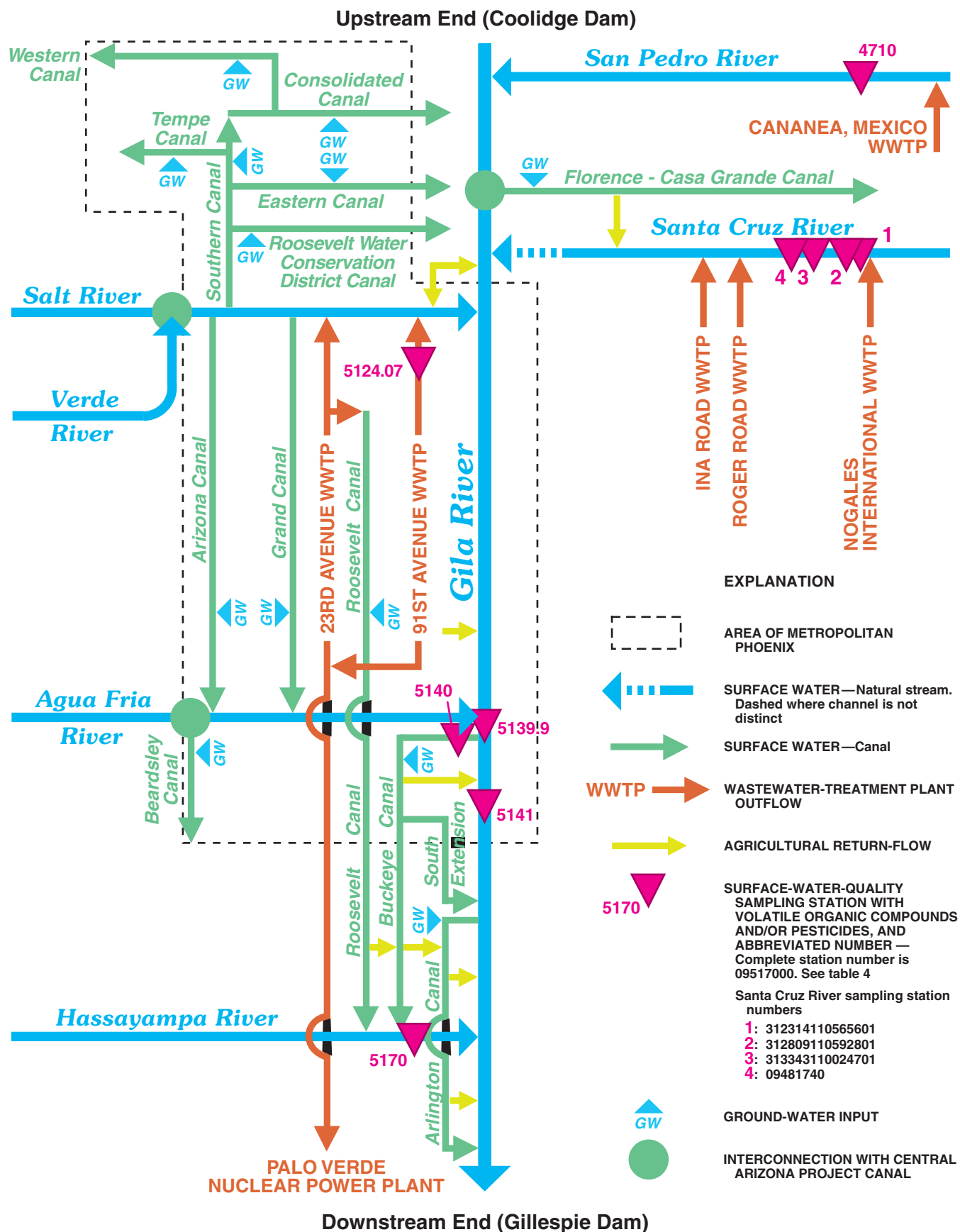


Figure 2. Surface-water sites, selected canals, wastewater-treatment plant outflows, interconnections with the Central Arizona Project Canal, agricultural return flows, and ground-water inputs to canals within the Central Arizona Basins study area.

Natural ground-water movement generally parallels surface-water movement within each basin; ground water moves from the mountains surrounding the basin toward the stream and then along the structural axis of the basin. Depth to ground water ranges from zero near perennial streams and some irrigated areas to as much as 1,300 ft below land surface (Cordy and others, 1998). In some basins, water levels have declined as much as 400 ft (Anderson and others, 1992, pl. 2). In the metropolitan area of Phoenix (Thomsen and Miller, 1991, sheet 1) and in the agricultural area near Casa Grande (Thomsen and Baldys, 1985, sheet 1), the direction of ground-water movement has been altered and is toward the pumping centers. Ground-water discharge from aquifers in these areas occurs by evapotranspiration, discharge to streams as base flow, underflow to downgradient basins, and by ground-water pumping in the agricultural and urban areas (Anderson and others, 1992).

Population and Land Use

The two largest population centers in the Basin and Range Lowlands of the CAZB are the metropolitan areas of Phoenix and Tucson (fig. 3). Of the 3,665,230 people counted in 1990 in Arizona by the U.S. Census Bureau, 53 percent resided in the metropolitan area of Phoenix and 16 percent resided in the metropolitan area of Tucson (U.S. Bureau of the Census, 1991). Population growth in the State of Arizona between 1990 and 2000 was 40 percent (Arizona Department of Economic Security, rev. March 27, 2001).

Land use in the Basin and Range Lowlands, excluding land in Mexico, primarily is rangeland (74 percent; fig. 3). Most of the remaining area is forest (7 percent), urban (8 percent), or agricultural (8 percent). In 1990, cotton comprised 68 percent of the crop acreage in the CAZB; alfalfa and other hay comprised 13 percent, and wheat and barley comprised 11 percent (Arizona Agricultural Statistics Service, 1991). The compilation of the digital land-use and land-cover geographic information system data for the CAZB study area (fig. 3) is described in more detail in Cordy and others (1998).

The Sierra Vista subbasin was considered to have minimal urban development (Gellenbeck and Coes, 1999). The population in the area of Sierra Vista is one percent of the total in Arizona (U.S. Bureau of the

Census, 1991). This subbasin has a small amount of urban (2 percent) and agricultural (1 percent) lands. Most of the land area is rangeland (83 percent) or forest (13 percent).

In the West Salt River Valley and the Upper Santa Cruz Basin, the land use has more urban development than in the Sierra Vista subbasin. As of 1990, 40 percent of the land in the West Salt River Valley was rangeland, 32 percent was urban, and 25 percent was agricultural. As of 1990, 60 percent of the land in the Upper Santa Cruz Basin was rangeland, 14 percent was forest, 22 percent was urban, and 2 percent was agricultural. The metropolitan areas of Phoenix and Tucson in the West Salt River Valley and the Upper Santa Cruz Basin, respectively, have had extensive population growth over the last decade; consequently, the urban land-use area more than doubled in the CAZB from 1980 to 1990 (Cordy and others, 1998). These population and land-use changes could have possible effects on water use, quantity, and quality (Cordy and others, 1998).

Sources of Organic Compounds

Information about sources of pesticides and VOCs in the CAZB is difficult to obtain and summarize because those types of data were not collected in the past. The available data for pesticides are not complete owing to the lack of historical data compilation; therefore, estimates of applications and releases used in this report are probably lower than the amounts actually used. Information about VOCs released to the environment is even less complete, and most of this information is based on known contamination sites. Because sources of VOCs are varied, the information about VOC releases is general.

Pesticides

In Arizona, the amount of pesticides used in agricultural areas has been estimated using various methods. Sales data derived from voluntary questionnaires provide some information about pesticide use in Arizona. Limitations of these data include: (1) the data cannot be correlated with usage because the compounds may have been used outside Arizona, or in a different year than when they were purchased, and (2) the data are based on voluntary surveys completed by distributors (Brew and Baker, 1987).

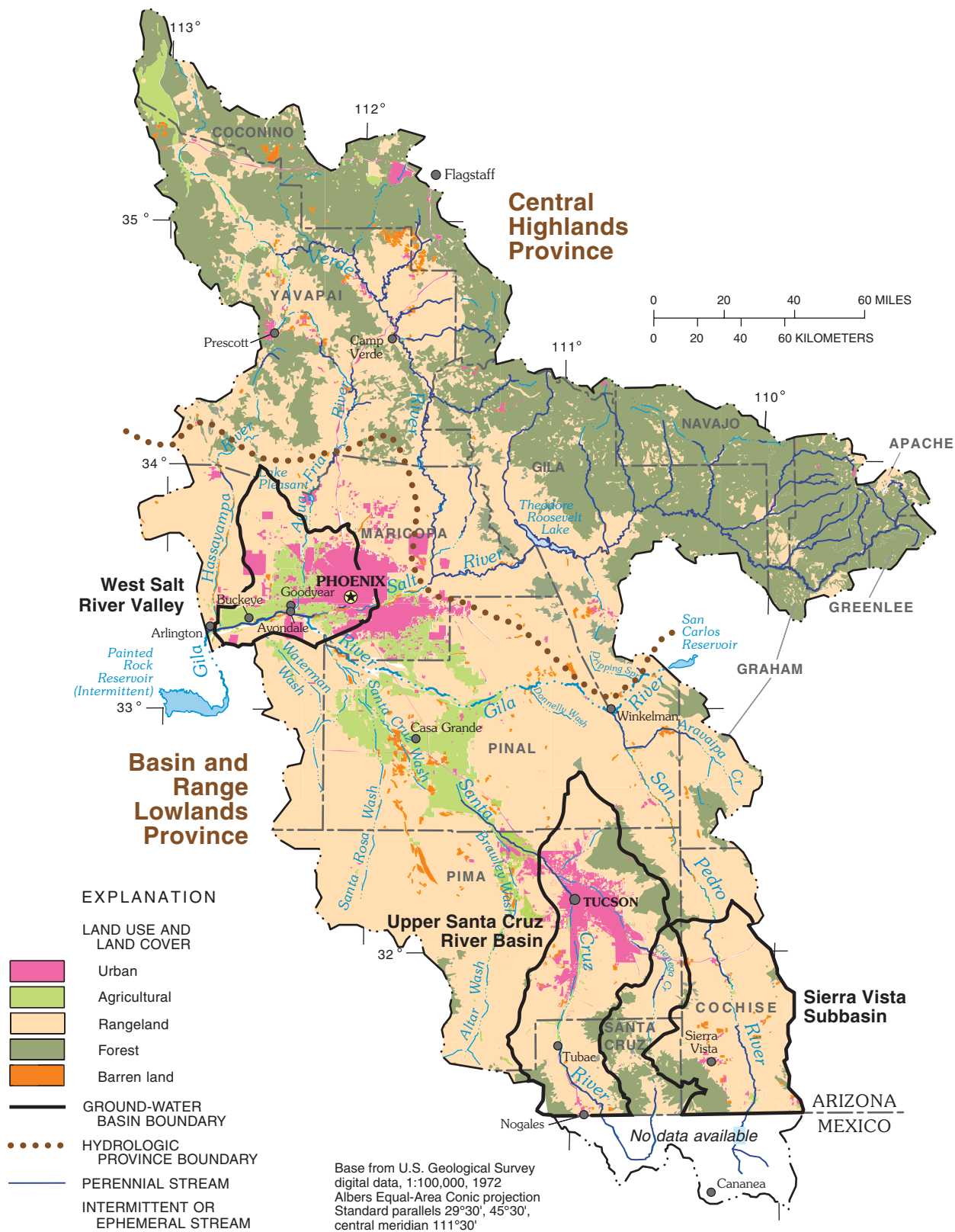


Figure 3. Land use and land cover in the Central Arizona Basins study area.

The small number of respondents to these surveys distorts the resulting data. Because of a lack of participation and regulations that require information about pesticide application, the sales survey is being replaced by a computer database (Ken Agnew, Pesticide Information and Training Office, University of Arizona, oral commun., 1999). Data on pesticide use in this database will be more accurate and complete than the sales data and will include acres treated, pounds of active ingredient, and date of application. Because reporting is mandated only for commercial applications, the information on pesticide use in Arizona will not be complete; however, the data will be more extensive than the historical data.

Accurate information on the amounts of pesticides used in Arizona is not available for historical periods because of the unreliable nature of the pesticide-use information from the sales data. The best description of pesticide use in Arizona through time may be the trends in the use of specific pesticides on cotton compiled from questionnaires and personal interviews with entomologists, extension agents, pest-control advisors, applicators, and growers (Brew and Baker, 1987). Because cotton has been a major crop in Arizona and more insecticides are applied to cotton than other crops (Brew and Baker, 1987), the summary of this information can provide some insight into the pesticides used in Arizona. One important trait from these historical data is the use of the same compounds over several decades, including the insecticides sulfur and parathion and the herbicides sodium chlorate and trifluralin ([table 1](#)).

Dichlorodiphenyldichloroethane (DDT) and toxaphene were used in the late 1940s, 1950s, and early 1960s on cotton crops in Arizona. DDT was used to eradicate the lygus bug, cotton leaf perforater, and the pink bollworm from cotton crops (Brew and Baker, 1987). In 1965, because of contamination of milk and hay, Arizona became the first state in the United States to restrict the use of DDT, and in 1969, a total restriction for use was enacted (Brew and Baker, 1987). Toxaphene also was used to eradicate pests on cotton and other crops in Arizona (Brew and Baker, 1987). Milk contamination and the reduced effectiveness of toxaphene resulted in its removal from the recommended list of pesticides in Arizona in 1976 (Brew and Baker, 1987).

Pesticide use on crops in Arizona changed dramatically in the 1970s. The most notable changes were the increased use of herbicides and decreased

amount of insecticides used on crops because of the development of synthetic pyrethroid insecticides that could be used in smaller amounts (Brew and Baker, 1987). The development of biological pest control also reduced the amount of pesticides applied.

The trend toward smaller amounts of pesticides applied to crops continued in the 1980s because several Federal and State regulations limited the use of pesticides. In addition, limits on ground-water withdrawals resulted in decreased irrigation and a reduction in the area under cultivation. The increased use of pheromones and other biological techniques to reduce the effects of pests also helped to reduce the need for pesticides.

Data for general pesticide use in Arizona in the 1990s are not available; therefore, pesticide use in Arizona was characterized on the basis of a summary of the pesticides used on cotton crops in the United States (Padgitt, 1997). In the early 1990s, the use of herbicides on cotton remained similar to use in the 1980s. The use of insecticides on cotton crops increased in the mid-1990s because of expanded acreage and more intensive treatments per acre. The amounts used in the 1990s may be larger than those used in the 1980s; however, the amounts are less than half the estimated amounts used in the 1960s and 1970s (Padgitt, 1997).

The amount of pesticides applied in agricultural areas where ground-water and (or) surface-water samples were collected in 1996–98 for analyses of organic compounds varies greatly on the basis of location ([table 2](#)). Estimates are not available for pesticide use in other land-use types. The highest pesticide usage during the sampling period was in the West Salt River Valley, which historically had some of the largest areas of agriculture in the State (Brew and Baker, 1987). In a study of shallow ground water in the western part of the West Salt River Valley, a small area of primarily agricultural land use accounted for about one-half of the pesticides used in this basin ([table 2](#)). Some pesticides were used in the Upper Santa Cruz Basin, but in general, the amounts are insignificant compared to the amounts of pesticides used in the West Salt River Valley. Only three pesticides were reportedly used in the Sierra Vista subbasin during 1996–98 ([table 2](#)).

Table 1. Recommended insecticides, herbicides, and defoliants for cotton crops in Arizona, 1940–87

[Lists are in order of preference of use; Source: Brew and Baker (1987)]

1940–45	1955	1965	1970	1975	1980	1985–87
Insecticides						
Sulfur	Toxaphene	DDT	Azinphos-methyl	Methyl parathion	Chlordimeform	Chlordimeform
Cryolite	DDT	Toxaphene	Monocrotophos	Azinphos-methyl	Permethrin	Methyl parathion
Sodium arsenite	Sulfur	Endosulfan	Toxaphene	Toxaphene	Azinphos-methyl	Cypermethrin
Calcium arsenate	Parathion	Malathion	Methyl parathion	Chlordimeform	Fenvalerate	Fenvalerate
Nicotene sulfate	BHC	Dicrotophos	Parathion	Methomyl	Methyl parathion	Methomyl
Pyrethrum	Demeton	Azinphos-methyl	Dimethoate	Monocrotophos	Methomyl	Monocrotophos
Sabadilla	Aramite	Methyl parathion	Malathion	Aldicarb	Monocrotophos	Azinphos-methyl
Paris green	Dieldrin	Parathion	Sulfur	Dicofol	Sulprofos	Gossyplure
Rotenone	Endothall	Dimethoate	Dicofol	Dimethoate	Gossyplure	Acephate
Calcium cyanide		Sulfur		Carbaryl	EPN	Permethrin
Carbon bisulfide		Dibrom		Dicrotophos	Dimethoate	Malathion
					Aldicarb	Propargite
					Chlorpyrifos	Oxamyl
					Dicofol	Dicofol
					Propargite	Dimethoate
					Sulfur	Chlorpyrifos
					Dicrotophos	Aldicarb
					Methidathion	Sulfur
						Sulprofos
						Flucythrinate
Herbicides/Defoliants						
Sodium chlorate	Sodium chlorate	Sodium chlorate	Sodium chlorate	Sodium chlorate	Sodium chlorate	DEF
	Diuron	Diuron	Trifluralin	Trifluralin	Trifluralin	Sodium chlorate
	Dalapon	Trifluralin	Dalapon	Prometryn	Prometryn	Trifluralin
	Minuron	Dalapon	Diuron	MSMA	MSMA	Prometryn
	TCA	TCA	Monuron	Diuron	DSMA	Diuron
		Monuron	Chlorothal	Profluralin	Pendimethalin	Glyphosate
				Chlorothal	Glyphosate	Fluazifop-butyl
				Bensulide	Diuron	Arsenic acid
					Profluralin	MSMA
						Pendimethalin
						Paraquat
						Sethoxydin
						Cyanazine

Volatile Organic Compounds

Information about sources of VOCs is not as readily available as information about pesticides; therefore, there is a general lack of information about the origin of VOCs in the CAZB. One source of information is the Toxics Release Inventory (TRI) maintained by the USEPA (U.S. Environmental Protection Agency, 1998). Data for 1995 indicate that no compounds were released to water in the CAZB, but several compounds were released to air (Arizona Department of Environmental Quality, 1997).

Transport of VOCs from air to water is possible (Squillace and others, 1999). Some of the compounds released to air in the CAZB in 1995 include 1,1,1-trichloroethane, trichloroethene (TCE), and trichloromethane (Arizona Department of Environmental Quality, 1997). Information from the TRI data indicates that most of the VOC release sites are in the metropolitan areas of Phoenix and Tucson (U.S. Environmental Protection Agency, 1998). Because of possible transport of VOCs from the atmosphere to the ground water, detection of VOCs in the ground water near the release sites is possible.

Table 2. Pesticides applied in the ground-water study areas, Central Arizona Basins study area, 1996–98

[Source: Ken Agnew, Pesticide Information and Training Office, University of Arizona, written commun. (1999). Values are in pounds of active ingredient. Only pesticides analyzed in ground-water and surface-water samples are included]

Compound Name	Ground-water study areas											
	West Salt River Valley						Upper Santa Cruz Basin			Sierra Vista Subbasin		
	Agricultural land-use study area			Basinwide								
	1996	1997	1998	1996	1997	1998	1996	1997	1998	1996	1997	1998
2,4-D	514	274	499	3,584	569	994	0	0	0	0	0	0
Aldicarb	2,392	1,321	584	7,834	2,782	2,319	3,011	4,549	0	0	0	0
Atrazine	1,367	851	136	1,814	1,052	749	0	0	0	0	0	0
Azinphos-methyl	0	30	0	0	30	0	0	0	0	0	0	0
Bromoxynil	0	0	21	45	0	141	85	93	70	0	0	0
Carbaryl	0	773	0	881	1,475	795	0	0	0	0	0	0
Carbofuran	440	273	277	1,198	474	685	0	0	0	0	0	0
Chlorothalonil	0	0	0	257	140	1,110	0	0	0	0	0	0
Chlorpyrifos	14,472	6,953	1,989	30,061	13,956	5,448	367	0	396	0	70	0
Cyanazine	0	939	0	1,037	2,187	0	0	0	0	0	0	0
DCPA	0	0	0	144	168	168	0	0	0	0	0	0
Diazinon	0	0	0	503	163	147	0	0	0	0	0	0
Dicamba	77	21	161	851	264	898	0	0	0	0	0	0
Dichloropropene	130,227	63,240	98,175	178,332	112,992	126,963	0	0	0	0	0	0
Dimethoate	329	834	568	3,056	3,752	2,462	0	40	0	0	0	0
Disulfoton	922	868	862	1,474	1,216	1,574	0	0	0	0	0	0
Diuron	147	105	77	374	423	279	112	2	0	0	1	0
EPTC	1,412	902	752	8,529	9,783	9,950	0	0	0	0	0	0
Esfenvalerate	3	0	0	364	124	118	0	0	0	0	0	0
Malathion	1,018	5,584	3,764	4,711	12,427	7,618	2,493	1,596	3,754	0	0	0
MCPA	156	56	83	1,398	576	1,988	0	0	0	0	0	0
Methomyl	105	1,558	137	2,673	3,238	2,447	0	60	185	22	47	23
Methyl parathion	6,285	2,489	914	7,827	4,858	1,394	89	165	218	0	0	0
Metolachlor	0	0	0	40	0	0	0	0	0	0	0	0
Metribuzin	0	0	0	220	93	890	0	0	0	0	0	0
Norflurazon	0	0	0	16	0	0	0	0	0	0	0	0
Oryzalin	0	0	0	1,834	2,860	1,530	0	0	0	0	0	0
Oxamyl	3,217	2,776	657	6,567	3,800	935	347	128	0	0	0	0
Pendimethalin	2,928	2,056	1,991	3,426	2,887	2,656	45	0	0	0	0	0
Permethrin	43	215	339	679	751	1,064	0	0	0	0	0	0
Phorate	436	268	305	436	268	305	0	0	0	0	0	0
Trifluralin	3,327	4,276	10,061	15,421	12,282	16,249	0	13	0	16	0	0
Totals	169,817	96,662	122,352	285,586	195,590	191,876	6,549	6,646	4,623	38	118	23

The ADEQ has identified VOCs, which include gasoline compounds, solvents, and refrigerants, as contaminants of high concern in ground water in Arizona (Marsh, 1994). Leaking underground-storage tanks and disposal of solvents were linked to most of the documented cases of ground water contaminated by VOCs. High-technology manufacturing facilities (mostly electronics and aerospace industries) use solvents for degreasing and are in the urban areas of the State where most of the ground water that is contaminated by VOCs has been identified. Disposal of solvents has occurred since the 1950s and probably earlier. Recent contamination of ground water by VOCs is attributed to disposal or leaks at dry-cleaning facilities. Use of some public drinking-water wells in Phoenix and Tucson has been discontinued because of contamination by VOCs (Marsh, 1994).

STUDY DESIGN

The study design for the CAZB was based on NAWQA guidelines and on the major water-quality issues in the study area. The major water-quality issues in the CAZB study area include: effects of discharge of treated-sewage effluent on surface-water and ground-water quality, aquatic life, and instream flows near urban areas; movement and fate of organic contaminants in ground water from industrial discharges, spills, landfills, and other point sources in urban areas; and movement and fate of fertilizers, pesticides, and other contaminants from nonpoint sources such as irrigation-return flow and stormwater runoff (Cordy, 1994). These issues were the primary basis for selecting sites for sampling of organic compounds in ground water and surface water.

The study design used for this project is an attempt to characterize the occurrence and distribution of water quality in the ground-water and surface-water resources that are used in the CAZB. The results presented in this report accurately represent the water quality at the specific sites sampled and only generally characterize the entire resource.

Ground Water

The NAWQA ground-water study is designed to assess water-quality conditions of the major aquifers in each study area (Gilliom and others, 1995). Sampling

sites used during 1996–98 within the CAZB study area included two basins where ground water is used in large quantities and ground-water quality has been, or has the potential to be, affected by human activities and one basin where ground-water quality was not expected to be affected by human activities. The basins chosen for study include the West Salt River Valley, Upper Santa Cruz Basin, and Sierra Vista subbasin (fig. 4). Two different types of NAWQA ground-water studies were completed in the CAZB in the chosen sampling areas—subunit surveys (SUSs) and land-use studies (LUSs).

Sub-Unit Survey

Three SUSs were conducted in the CAZB in 1996–98. The purpose of NAWQA SUSs is to broadly characterize the water quality of major aquifer systems in a study area primarily by sampling existing wells (Gilliom and others, 1995). Areas where ground water is being used for industry, irrigation, or public or domestic water supply are given priority for sampling over those areas where ground water is not used. Of water being used in the CAZB, 96 percent is used in the Basin and Range Lowlands. Of this amount, 80 percent is drawn from ground-water resources (Cordy and others, 1998). The largest use of ground water is for agriculture followed by municipal supply (Cordy and others, 1998). Increased amounts of good-quality drinking water will be needed in those areas where the population is growing fastest, specifically in the West Salt River Valley and the Upper Santa Cruz Basin. Consequently, these two areas were prioritized for study. The likelihood of degradation of ground-water quality, such as that from high nitrate concentrations and the existence of pesticides and VOCs, also was a factor in the prioritizing of these two basins. An SUS was completed in the Sierra Vista subbasin to provide a comparison with conditions in the West Salt River Valley and the Upper Santa Cruz Basin because the Sierra Vista subbasin was thought to be minimally affected by human activities (Coes and others, 1999).

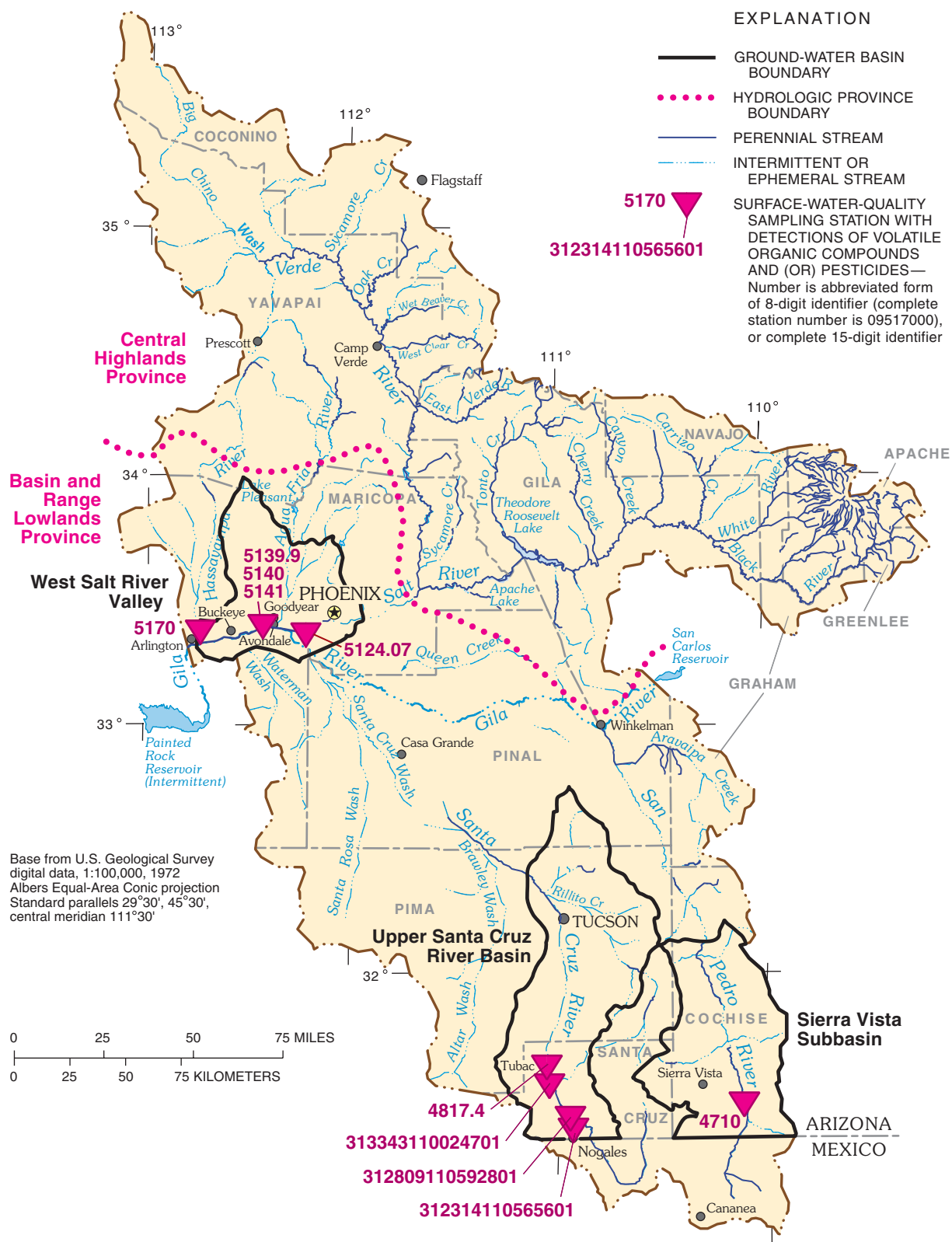


Figure 4. Surface-water sites and ground-water basins where samples were collected for pesticide and volatile organic compound analyses, Central Arizona Basins study area, 1996–98.

The following statistically based, stratified-random approach was used to select existing wells for each SUS. Computer software (Scott, 1990) was used to divide each SUS into a specific number of equal-area polygons, referred to as cells. Within each cell, a suitable existing well was found for sampling near a point chosen randomly by the computer software. A well was suitable for sampling if it had a submersible pump, a sampling point between the pump and any treatment system and (or) storage tanks, a measuring point to determine depth to water; if construction information (depth, perforated interval, casing diameter, and driller's log) was available; and if the well owner gave permission to sample. For some locations, a well with all of the characteristics listed above was not available; in these cases, wells were sampled that did not have all of the characteristics.

Sixty-four existing wells in the West Salt River Valley were sampled during 1996–97 (table 3). Water from these wells is used for domestic and municipal drinking water, irrigation, livestock, and (or) industrial uses. The computer software (Scott, 1990) was used to select 35 wells from the 64 sampled as the basis for characterizing the ground-water quality in the West Salt River Valley and for comparisons with results from other ground-water studies in the CAZB. All of these

wells were sampled for pesticide analyses, and 30 were sampled for VOC analyses. Depth of the 35 wells ranged from 100 to 1,445 ft below land surface.

Twenty-nine wells were sampled in the Upper Santa Cruz Basin SUS in 1998 (table 3). Depth of the wells ranged from 40 to 800 ft below land surface. Water from these wells is used for domestic drinking water, irrigation, livestock, and (or) industrial uses. Thirty equal-area cells were used for well selection. A suitable well for sampling could not be found in one cell.

Nineteen wells were sampled in the Sierra Vista subbasin SUS in 1996 (table 3). Depth of the wells ranged from 90 to 1,003 ft below land surface. Water from these wells is used for domestic drinking water, irrigation, livestock, and (or) industrial uses. Twenty equal-area cells were used for this SUS. A suitable well for sampling could not be found in one cell. Ground-water samples were analyzed for pesticides using capillary-column gas chromatography/mass spectrometry with selected-ion monitoring (GCMS). Samples were not collected for high-performance liquid chromatography (HPLC) analyses because of the low percentage of agricultural land use in the basin (see section entitled “Field and Laboratory Methods”).

Table 3. Study areas where ground-water samples were collected for pesticide and (or) volatile organic compound analyses, Central Arizona Basins study area, 1996–98

[HPLC, high-performance liquid chromatography; GCMS, gas chromatography/mass spectrometry; PT/GCMS, purge and trap gas chromatography/mass spectrometry]

Study area	Sampling period	Number of samples		
		Pesticides		Volatile organic compounds PT/GCMS
		HPLC	GCMS	
West Salt River Valley				
Sub-unit survey ¹	02–96 to 09–97	64	64	52
Agricultural land-use study ²	08–97 and 02–98	18	18	18
Upper Santa Cruz Basin sub-unit survey	04–98 to 07–98	29	29	29
Sierra Vista subbasin sub-unit survey	06–96 to 10–96	0	19	19

¹Only 35 wells are used in this report.

²Nine wells were sampled one time in August 1997 and one time in February 1998.

Agricultural Land-Use Study

One LUS was completed in the CAZB in 1997–98. The purpose of NAWQA LUSs is to assess the concentrations and distribution of water-quality constituents in shallow ground water recharged in the last 10 years beneath the most significant land-use settings (Gilliom and others, 1995). The CAZB LUS characterizes the effects of agricultural activities in the southwestern part of the West Salt River Valley. This study included drilling, constructing, and sampling nine monitoring wells that range in depth from 20 to 83 ft below the land surface and have 5-foot perforated intervals within the top 10 ft of the water table. Drilling sites were located by identifying an area in the West Salt River Valley that had primarily agricultural land use and depths to ground water that were less than 100 ft. Ten equal-area cells were used for site selection; nine sites were acceptable for installation of wells. Construction data for these wells are available in Tadayon and others (1999); all wells have polyvinyl-chloride casing and screens. Sampling of these wells occurred at two different times during the growing season—August 1997 at the end of the intensive irrigation season (summer months) and February 1998 before the beginning of the intensive irrigation season (table 3).

Surface Water

The NAWQA surface-water studies focus on assessing the most important water-quality conditions of streams and rivers in each study unit (Gilliom and others, 1995). In the CAZB study area, the most important surface-water quality concerns are the effects of discharge of treated-sewage effluent, irrigation-return flow, and stormwater runoff (Cordy, 1994). Eleven surface-water sites were used in the sampling network in the CAZB. Samples for analyses of pesticides and VOCs were collected from four sites (fig. 4; table 4). In addition to surface-water sites sampled by CAZB personnel, three sites were sampled on the Santa Cruz River, and one site was sampled on Nogales Wash as part of another project (fig. 4; table 4). Sampling and analytical procedures were the same as those used at CAZB sites. Data from these sites are discussed in this report. Surface-water samples were collected during two streamflow conditions: low-flow samples, collected during normal streamflow conditions, and high-flow samples, collected during storm runoff.

Two types of surface-water sampling sites are included in the NAWQA design—basic fixed sites and intensive fixed sites. Basic fixed sites were to be used to “characterize the spatial and temporal distribution of general water quality and constituent transport in relation to hydrologic conditions and contaminant sources” (Gilliom and others, 1995). Intensive fixed sites were to be used to “characterize seasonal and short-term temporal variability of general water-quality and constituent transport and determine the occurrence and seasonal patterns in concentrations and transport of dissolved pesticides” (Gilliom and others, 1995).

The main difference between the use of basic fixed sites and the use of intensive fixed sites is the frequency of sampling. High frequency sampling at a few intensive fixed sites during key time periods can provide more useful information compared with monthly sampling at the basic fixed sites. Additionally, the surface-water sites are classified either as integrators (sites that are used to characterize the water quality for large, heterogeneous basins that are affected by a combination of possible point, nonpoint, and natural contaminant sources) or indicators (sites that are used to characterize the water quality for smaller, homogeneous basins that are affected by specific point, nonpoint, or natural contaminant sources). Additional samples for pesticide and VOC analyses were collected at four sites along the Santa Cruz River near Tubac during 1997–98 as part of a separate USGS study.

Basic Fixed Sites

Samples for pesticide and VOC analyses were collected at two basic fixed sites (table 4)—San Pedro River at Charleston (09471000) and 91st Avenue wastewater-treatment plant outfall near Phoenix (09512407).

The site on the San Pedro River in the Sierra Vista subbasin was selected as a reference site for the Basin and Range Lowlands. The San Pedro River is one of the last free-flowing rivers in this hydrologic province (Cordy and others, 1998). VOCs were not analyzed in water from this site because typical sources of VOCs including urban and industrial land-use activities are not widespread in the drainage area. To determine the effect of agricultural activities adjacent to the river in the basin, six samples collected at this site from January to October 1997 were analyzed for pesticides (table 4).

Table 4. Surface-water sites where samples were collected for pesticide and (or) volatile organic compound analyses, Central Arizona Basins study area, 1996–98

[HPLC, high-performance liquid chromatography; GCMS, gas chromatography/mass spectrometry; PT/GCMS, purge and trap gas chromatography/mass spectrometry; WSRV, West Salt River Valley; USC, Upper Santa Cruz Basin; BFS, basic fixed site; IFS, intensive fixed site; IND, indicator site; INT, integrator site]

Site name	Site number	Ground-water basin	Type of site	Sampling period	Number of samples		
					Pesticides	Volatile organic compounds	
					HPLC	GCMS	PT/GCMS
Sites used in this study							
San Pedro River at Charleston	09471000	Sierra Vista subbasin	BFS-IND	01–97 to 10–97	6	6	0
91st Avenue waste-water treatment plant outfall near Phoenix	09512407	WSRV	BFS-IND	06–96 to 04–97	0	0	6
Gila River at Buckeye Canal:		WSRV	IFS-INT				
Gila River above diversions, at the head of Buckeye Canal ¹	09513990			02–96 to 03–96	2	2	0
Buckeye Canal near Avondale	09514000			12–96 to 02–98 06–96 to 04–97	28 0	28 0	0 5
Gila River at Estrella Parkway near Goodyear ²	09514100			04–98	1	1	0
Hassayampa River near Arlington	09517000	WSRV	IFS-IND	02–96 to 02–98 06–96 to 12–96	40 0	40 0	0 2
Sites used in separate study							
Nogales Wash near the Nogales International Wastewater Treatment Plant	312314110565601	USC	---	11–97 06–98	1 1	1 1	1 1
Santa Cruz River near Rio Rico, Arizona	312809110592801	USC	---	11–97 06–98	1 1	1 1	1 1
Santa Cruz River at Santa Gertrudis Lane	313343110024701	USC	---	11–97 06–98	1 1	1 1	1 1
Santa Cruz River at Tubac, Arizona	09481740	USC	---	11–97 06–98	1 1	1 1	1 1

¹ Site used before site 09514000 was established.

² Site used when high flows were present at 09514000.

The site at the 91st Avenue WWTP is within the West Salt River Valley and was selected as an indicator of treated-sewage effluent. Water-quality data from this basic fixed site were used to characterize the effect of sewage effluent at an intensive fixed site that is downstream, Gila River at Buckeye Canal. Because the input to the site at the WWTP includes water collected from a large urban area, six samples collected from June 1996 to April 1997 were analyzed for VOCs. Only a small number of samples were collected because high temperatures during most of the year can cause volatilization of most VOCs from the surface water.

Intensive Fixed Sites

Samples for pesticide and VOC analyses were collected at two intensive fixed sites (table 4)—the Hassayampa River near Arlington (09517000) and the Gila River at Buckeye Canal. On the basis of flow conditions, three different sampling locations were used during 1996–98 for the site on the Gila River at Buckeye Canal. During periods of low flow, all of the flow in the river is diverted into Buckeye Canal, whereas, during high flows only a portion of the low is diverted to protect the canal. Initially, NAWQA samples were collected during low flow at the Gila

River above diversions at the head of Buckeye Canal (09513990). In May 1996, the sampling site was moved 0.3 mi downstream in the canal (Buckeye Canal near Avondale- 09514000) to take advantage of better sampling conditions. During a single high flow in April 1998, a sample was collected at the Gila River at Estrella Parkway near Goodyear (09514100) because most of the flow was in the river channel.

Despite their varied locations, samples from these sites were considered representative of flow at the Gila River at Buckeye Canal, and they are treated in this report as a single set of samples from the site.

The site, Gila River at Buckeye Canal, was selected as an integrator site for characterizing streamflow leaving the CAZB study area. Because surface-water diversions in the CAZB study area and specifically within the Phoenix metropolitan area ([fig. 2](#)) are complex, the sources of surface water at this site are not always the same. Water quality is representative of different hydrologic provinces of the CAZB study area depending on the time of sample collection. For most samples, the source of surface water was base flow from the Gila River that is generally discharge from the 91st Avenue WWTP and ground-water inflow. Some samples included flow from rivers in the Central Highlands Province owing to releases from reservoirs upstream. Samples were collected for pesticide and VOC analyses at this site to determine the effects of local agricultural activities and upstream urban land use.

The Hassayampa River site was selected as an indicator site of agricultural activities in the CAZB. Two major irrigation canals—Buckeye Canal and Roosevelt Canal—drain into the river channel above the sampling site. The Hassayampa River is ephemeral above these canal inflow points. The source of water at this site is irrigation-return flow from these canals except during periods of runoff. Samples were collected at this site and analyzed for pesticides to determine the effects of the agricultural activities on surface-water quality in this drainage basin. Samples were collected at this site and analyzed for VOCs to determine the effects of wastewater from the 91st Avenue WWTP.

METHODS OF DATA COLLECTION AND ANALYSIS

Data were collected and samples were analyzed according to NAWQA standards and protocols with the exception of analytical techniques for some pesticide degradation compounds. For many of the analyses, the concentrations of compounds detected were less than the minimum reporting level (MRL) for the analytical method; these compounds were positively identified in samples, but the concentrations were estimated. Because of these results, numbers of detections of compounds rather than concentrations of compounds are sometimes discussed in this report. VOC data not previously published are presented in the section of this report entitled “[Basic Data](#)”; all other environmental data discussed in this report are presented in other reports (Smith and others, 1997; Tadayon and others, 1998 and 1999).

Field and Laboratory Methods

Koterba and others (1995) and Lapham and others (1995) describe field methods used for NAWQA ground-water sampling. Field methods used for NAWQA surface-water sampling during 1996–98 are described in detail by Shelton (1994). Methods used to collect surface-water samples for VOC analyses are described by Shelton (1997).

Samples collected during 1996–98 were analyzed for pesticides and VOCs at the National Water Quality Laboratory (NWQL) and the USGS Organic Geochemistry Research Laboratory. Water samples were analyzed at the NWQL for 86 pesticides or pesticide-degradation compounds using two different analytical methods ([table 5](#)). One method analyzes for 47 pesticides and uses GCMS on elutions from a C-18 column (Zaugg and others, 1995), and the other method analyzes for 39 pesticides (primarily those used in agricultural applications) and uses HPLC on elutions from a Carboapak-B cartridge (Werner and others, 1996). After review of data produced from the HPLC method, the MRLs for some pesticides were increased after December 15, 1997 (W.T. Foreman, chemist, and R.J. Gilliom, hydrologist, USGS, written commun., 1998; table 5, this report). Reported concentrations of some compounds determined from the HPLC method were qualified as estimated because of variable performance during the analytical process (W.T. Foreman, chemist, and R.J. Gilliom, hydrologist, USGS, written commun., 1998; table 5, this report).

Table 5. Pesticide and pesticide-degradation compound analyses by the National Water Quality Laboratory for surface-water and ground-water samples, Central Arizona Basins study area, 1996–98

[Concentrations are in micrograms per liter; HPLC, high-performance liquid chromatography; GCMS, gas chromatography/mass spectrometry; NA, not applicable; Type: H, herbicide; I, insecticide; DP, degradation compound; F, fungicide]

Pesticide	Type	WATSTORE code	Trade name(s)	Analysis method	Minimum reporting level
Acetochlor	H	49260	Acenit, Guardian, and many other names	GCMS	0.002
Acifluorfen	H	49315	Blazer, Tackle	HPLC	.035
Alachlor	H	46342	Lasso	GCMS	.002
Aldicarb	I	49312	Temik	HPLC	^{1,2} .550
Aldicarb sulfone	DP (Aldicarb)	49313	NA	HPLC	^{1,2} .100
Aldicarb sulfoxide	DP (Aldicarb)	49314	NA	HPLC	^{1,2} .021
Atrazine	H	39632	AAtrex	GCMS	.001
Azinphos-methyl	I	82686	Guthion	GCMS	.001
Benfluralin	H	82673	Balan, Benefin	GCMS	.002
Bentazon	H	38711	Basagran	HPLC	.014
Bromacil	H	04029	Bromax 90, Urox B	HPLC	.035
Bromoxynil	H	49311	Buctril, Brominal	HPLC	.035
Butylate	H	04028	Sutan	GCMS	.002
Carbaryl	I	82680	Sevin	GCMS	.003
Carbaryl	I	49310	Sevin	HPLC	.008
Carbofuran	I	82674	Furadan	GCMS	.003
Carbofuran	I	49309	Furadan	HPLC	¹ .120
Chloramben	H	61188 orig.49307	Amiben	HPLC	¹ .420
Chlorothalonil	F	49306	Bravo	HPLC	^{1,2} .480
Chlorpyrifos	I	38933	Dursban, Lorsban	GCMS	.004
Clopyralid	H	49305	Lontrel	HPLC	¹ .230
Cyanazine	H	04041	Bladex	GCMS	.004
2,4-D	H	39732	2,4-D and many other names	HPLC	¹ .150
Dacthal	H	82682	DCPA, Chlorthal, Clorthal-dimethyl	GCMS	.002
Dacthal mono-acid	H	49304	D. monoacid	HPLC	.017
2,4-DB	H	38746	Butoxone	HPLC	¹ .240
DDE	DP (DDT)	34653	NA	GCMS	.006
Deethylatrazine	DP (Atrazine)	04040	NA	GCMS	.002
Diazinon	I	39572	Diazinon and many other names	GCMS	.002
Dicamba	H	38442	Banvel	HPLC	.035
Dichlobenil	H	49303	Casoron	HPLC	^{1,2} 1.200
Dichlorprop	H	49302	2,4-DP	HPLC	.032
Dieldrin	I	39381	Panoram D-31	GCMS	.001
2,6-Diethylaniline	DP (Alachlor)	82660	NA	GCMS	.003
Dinoseb	H	49301	Basanite and many other names	HPLC	.035

See footnotes at end of table.

Table 5. Pesticide and pesticide-degradation compound analyses by the National Water Quality Laboratory for surface-water and ground-water samples, Central Arizona Basins study area, 1996–98—Continued

Pesticide	Type	WATSTORE code	Trade name(s)	Analysis method	Minimum reporting level
Disulfoton	I	82677	Disyston and many other names	GCMS	.017
Diuron	H	49300	Diurex and many other names	HPLC	.020
DNOC	I	49299	Sinox and many other names	HPLC	^{1,2} .420
EPTC	H	82668	Eptam	GCMS	.002
Ethalfuralin	H	82663	Sonalan	GCMS	.004
Ethoprop	I	82672	Mocap	GCMS	.003
Fenuron	H	49297	Beet-Kleen	HPLC	.013
Fluometuron	H	38811	Cotoran	HPLC	.035
Fonofos	I	04095	Dyfonate	GCMS	.003
<i>alpha</i> -HCH	I	34253	Lindane (impurity)	GCMS	.002
<i>gamma</i> -HCH	I	39341	Lindane	GCMS	.004
3-Hydroxycarbofuran	DP (Carbofuran)	49308	NA	HPLC	.014
Linuron	H	82666	Lorox	GCMS	.002
Linuron	H	38478	Lorox	HPLC	.018
MCPA	H	38482	MCPA and many other names	HPLC	¹ .170
MCPB	H	38487	Thistrol	HPLC	¹ .140
Malathion	I	39532	Malathion and many other names	GCMS	.005
Methiocarb	I	38501	Mesurool	HPLC	.026
Methomyl	I	49296	Lannate and many other names	HPLC	.017
Methyl parathion	I	82667	Penncap-M	GCMS	.006
Metolachlor	H	39415	Dual	GCMS	.002
Metribuzin	H	82630	Lexone, Sencor	GCMS	.004
Molinate	H	82671	Ordram	GCMS	.004
Napropamide	H	82684	Devrinol	GCMS	.003
Neburon	H	49294	Neburex	HPLC	.015
Norflurazon	H	49293	Evital, Zorial	HPLC	.024
Oryzalin	H	49292	Surflan	HPLC	¹ .310
Oxamyl	I	38866	Vydate	HPLC	.018
Parathion	I	39542	Alkron and many other names	GCMS	.004
Pebulate	H	82669	Tillam	GCMS	.004
Pendimethalin	H	82683	Prowl	GCMS	.004
<i>cis</i> -Permethrin	I	82687	Ambush, Pounce	GCMS	.005
Phorate	I	82664	Thimet and many other names	GCMS	.002
Picloram	H	49291	Tordon	HPLC	.050
Prometon	H	04037	Pramitol	GCMS	.018
Pronamide	H	82676	Kerb	GCMS	.003

Table 5. Pesticide and pesticide-degradation compound analyses by the National Water Quality Laboratory for surface-water and ground-water samples, Central Arizona Basins study area, 1996–98—Continued

Pesticide	Type	WATSTORE code	Trade name(s)	Analysis method	Minimum reporting level
Propachlor	H	04024	Ramrod	GCMS	.007
Propanil	H	82679	Stampede	GCMS	.004
Propargite	I	82685	Comite, Omite	GCMS	.013
Propham	H	49236	IPC	HPLC	.035
See footnotes at end of table.					
Propoxur	I	38538	Baygon	HPLC	.035
Silvex	H	39762	2,4,5-TP	HPLC	.021
Simazine	H	04035	Princep, Aquazine	GCMS	.005
2,4,5-T	H	39742	Line Rider and many other names	HPLC	.035
Tebuthiuron	H	82670	Spike, Graslan	GCMS	.010
Terbacil	H	82665	Sinbar	GCMS	.007
Terbufos	I	82675	Counter	GCMS	.013
Thiobencarb	H	82681	Bolero	GCMS	.002
Triallate	H	82678	Far-Go	GCMS	.001
Triclopyr	H	49235	Garlon	HPLC	¹ .250
Trifluralin	H	82661	Treflan and many other names	GCMS	.002

¹ Minimum reporting level was increased after December 15, 1997.

² If compound is in sample, concentration is estimated.

In addition to analyses completed by the NWQL, some samples were analyzed for pesticide-degradation compounds by the USGS Organic Geochemistry Research Laboratory in Lawrence, Kansas (table 6). Analytical methods included elutions from a C-18 column and GCMS and HPLC (Hostetler and Thurman, 1999).

Table 6. Pesticide-degradation compound analyses by the U.S. Geological Survey, Organic Geochemistry Research Group, Lawrence, Kansas, for ground-water and surface-water samples, Central Arizona Basins study area, 1996–98

[HPLC, high-performance liquid chromatography; GCMS, gas chromatography/mass spectrometry]

Pesticide-degradation compound	Pesticide source	Analytical method
Acetochlor ESA	Acetochlor	HPLC
Alachlor ESA	Alachlor	HPLC
Metolachlor ESA	Metolachlor	HPLC
Deisopropylatrazine	Atrazine	GCMS
3,4-Dichloroaniline	Propanil, Linuron	GCMS

Data for VOCs were produced by three different analytical methods following sampling in 1996–98 (table 7). Purge-and-trap capillary-column GCMS was used to determine 60 VOCs at a MRL of 0.2 µg/L (Rose and Schroeder, 1995) in samples collected prior to March 27, 1996. Water samples collected after March 27, 1996, also were analyzed by purge-and-trap capillary-column GCMS according to Connor and others (1998). The analytical method used after March 27, 1996, provides reliable evidence of the presence of an analyte and is suitable for reporting concentrations at submicrogram-per-liter levels for 87 VOCs. After May 1997, vinyl acetate was eliminated from the analysis because of poor analytical performance. The method also allows for reporting estimated concentrations of other tentatively identified VOCs. The main difference between data obtained before October 1, 1996, and data obtained after this date is how low-level detections of VOCs that were affected by laboratory contaminants were evaluated or censored in relation to internal laboratory blanks.

Table 7. Volatile organic compound analyses by the National Water Quality Laboratory for ground-water and surface-water samples, Central Arizona Basins study area, 1996–98

[WATSTORE, National Water Data Storage Retrieval System]

Volatile organic compound	WATSTORE Code	Minimum reporting level		
		Prior to March 27, 1996	March 27 to June 9, 1997	June 10, 1997, to September 30, 1998
Dibromomethane	30217	0.2	0.1	0.05
Bromodichloromethane	32101	.2	.1	.048
Dibromochloromethane	32105	.2	.1	.182
Trichloromethane	32106	.2	.05	.052
Methylbenzene	34010	.2	.05	.038
Chlorobenzene	34301	.2	.05	.028
Tetrachloroethene	34475	.2	.05	.038
1,4–Dichlorobenzene	34571	.2	.05	.05
Carbon disulfide	77041	---	.05	.08
Bromochloromethane	77297	.2	.1	.044
Tetrachloromethane	32102	.2	.05	.088
1,2–Dichloroethane	32103	.2	.05	.134
Tribromomethane	32104	.2	.2	.104
Benzene	34030	.2	.05	.032
2–Propenal	34210	---	2.	1.43
2–Propenenitrile	34215	---	2.	1.23
Chloroethane	34311	.2	.1	.120
Ethylbenzene	34371	.2	.05	.03
1,1,1,2,2,2–Hexa-chloroethane	34396	---	.05	.362
Bromomethane	34413	.2	.1	.148
Chloromethane	34418	.2	.2	.254
Dichloromethane	34423	.2	.1	.382
Trichlorofluoromethane	34488	.2	.1	.092
1,1–Dichloroethane	34496	.2	.05	.066
1,1–Dichloroethene	34501	.2	.1	.044
1,1,1–Trichloroethane	34506	.2	.05	.032
1,1,2–Trichloroethane	34511	.2	.1	.064
1,1,2,2–Tetrachloroethane	34516	.2	.1	.132
1,2–Dichlorobenzene	34536	.2	.05	.048
1,2–Dichloropropane	34541	.2	.05	.068
trans–1,2–Dichloroethene	34546	.2	.05	.032
1,2,4–Trichlorobenzene	34551	.2	.2	.188
1,3–Dichlorobenzene	34566	.2	.05	.054
Dichlorodifluoromethane	34668	.2	.2	.096
Naphthalene	34696	.2	.2	.250
trans–1,3–Dichloropropene	34699	.2	.1	.134
cis–1,3–Dichloropropene	34704	.2	.1	.092
Chloroethene	39175	.2	.1	.112
Trichloroethene	39180	.2	.05	.038
Hexachlorobutadiene	39702	.2	.2	.142
Methyl acrylate	49991	---	2.	.612
1,2,3,4–Tetramethylbenzene	49999	---	.05	.230
1,2,3,5–Tetramethylbenzene	50000	---	.05	.240

Bromoethene	50002	---	.1	.1
Ethyl-tert-butyl ether	50004	---	.1	.054
tert-Amyl methyl ether	50005	---	.1	.112
trans-1,4-Dichloro-2-butene	73547	---	5.	.692
Ethyl methacrylate	73570	---	1.0	.278
Vinyl acetate	77057	---	5.	---
cis-1,2-Dichloroethene	77093	.2	.05	.038
2-Hexanone	77103	---	5.	.746
Ethenylbenzene	77128	.2	.05	.042
1,2-Dimethylbenzene	77135	---	.05	.064
1,1-Dichloropropene	77168	.2	.05	.026
2,2-Dichloropropane	77170	.2	.05	.078
1,3-Dichloropropane	77173	.2	.05	.116
2-Ethyltoluene	77220	---	.05	.10
1,2,3-Trimethylbenzene	77221	---	.05	.124
1,2,4-Trimethylbenzene	77222	.2	.05	.056
(1-Methylethyl)benzene	77223	.2	.05	.032
n-Propylbenzene	77224	.2	.05	.042
1,3,5-Trimethylbenzene	77226	.2	.05	.044
1-Chloro-2-methylbenzene	77275	.2	.05	.042
1-Chloro-4-methylbenzene	77277	.2	.05	.056
n-Butylbenzene	77342	.2	.05	.186
(1-Methylpropyl)benzene	77350	.2	.05	.048
(1,1-Dimethylethyl)benzene	77353	.2	.05	.096
1-Isopropyl-4-methylbenzene	77356	.2	.05	.110
Iodomethane	77424	---	.05	.076
1,2,3-Trichloropropane	77443	.2	.2	.07
1,1,1,2-Tetrachloroethane	77562	.2	.05	.044
1,2,3-Trichlorobenzene	77613	.2	.2	.266
1,2-Dibromomethane	77651	.2	.1	.036
1,1,2-Trichloro-1,2,2-trifluoroethane	77652	.2	.05	.032
Methyl tert-butyl ether	78032	.2	.1	.112
3-Chloro-1-propene	78109	---	.1	.196
4-Methyl-2-pentanone	78133	---	5.	.374
Xylenes, Total	81551	.2	¹ ---	¹ ---
Acetone	81552	---	5.	4.90
Bromobenzene	81555	.2	.05	.036
Diethyl ether	81576	---	.1	.170
Diisopropyl ether	81577	---	.1	.098
Methyl acrylonitrile	81593	---	2.	.570
2-Butanone	81595	---	5.	1.65
Methyl methacrylate	81597	---	1.	.35
Tetrahydrofuran	81607	---	5.	1.15
1,2-Dibromo-3-chloropropane	82625	.2	.5	.214
1,3-Dimethylbenzene and 1,4-Dimethylbenzene	85795	---	.05	.064

From March 27, 1996, to October 1, 1996, environmental samples found to contain laboratory-derived contaminants were censored (that is, reported as less than the detection limit) regardless of the magnitude of daily laboratory-blank values. Additional laboratory-blank samples were incorporated into the analytical sequence after October 1, 1996, to help distinguish between true low-level environmental concentrations and low-level environmental concentrations caused by laboratory background contamination. Laboratory contaminants that were censored were benzene, ethylbenzene, methylbenzene, xylenes, 1,4-dichlorobenzene, dichloromethane, acetone, and carbon disulfide. The automatic censoring used from March 27, 1996, to October 1, 1996, resulted in an underestimate of the occurrence of the censored compounds in environmental samples. Detections of benzene and carbon disulfide were reported for ground-water samples during this time period.

Quality Assurance

Quality-control samples were collected and analyzed as part of the ground-water and surface-water data collection. Evaluation of the quality-control samples for pesticides and VOCs in ground water indicated that the environmental data generally are acceptable. Some detections of VOCs are considered to be the result of sample contamination. Evaluation of quality-control samples for pesticides in surface water indicated that the associated environmental data are acceptable. The quality-control samples for VOCs in surface water are inadequate to determine whether the associated environmental data are acceptable. The quantity of quality-control samples was not sufficient to characterize the quality of environmental data throughout the entire sampling period. A detailed discussion of the quality assurance is included in the section entitled “Quality-Assurance Information.”

Statistical Methods

Concentrations of organic compounds detected in ground-water and surface-water samples generally were below the MRLs or qualified as estimated. Interpretation of the data is based primarily on the number of detections and not the reported concentrations.

The Kruskal-Wallis test for ordered categorical responses was applied (Helsel and Hirsch, 1992; p. 382) to compare results among the SUSs. For this test, laboratory results were categorized into three responses—below the reporting limit, above the reporting limit, and estimated (the compound was detected in the sample, but the concentration was not considered accurate). The Kruskal-Wallis test statistic was computed, and the results indicated whether the null hypothesis, which is that the proportion of data in each response category was the same for each ground-water study, was considered valid at the 95-percent confidence level. If the Kruskal-Wallis test indicated that there were differences between the SUSs, the Tukey test was applied to identify the specific differences.

OCCURRENCE AND DISTRIBUTION OF PESTICIDES AND VOLATILE ORGANIC COMPOUNDS IN GROUND WATER AND SURFACE WATER AND RELATION TO LAND USE

The occurrence and distribution of pesticides and VOCs in ground water and surface water from the areas studied during 1996–98 range from no detections to several detections in localized areas. The basin that is considered minimally developed, the Sierra Vista subbasin, had the fewest detections of pesticides and VOCs in ground water and of pesticides in surface water. Basins that are considered developed, the Upper Santa Cruz Basin and the West Salt River Valley, have some large localized areas that have water quality that is affected by human activities. The largest number of detections of pesticides and VOCs occurred in ground water and surface water in the agricultural area in the western part of the West Salt River Valley.

Pesticides

Detections of pesticides in ground water and surface water in the CAZB indicate the effects on water quality of both agricultural and urban pesticides used on the land surface. The largest number of detections of pesticides occurred in shallow ground water beneath the agricultural area in the West Salt River Valley (fig. 5). Fewer detections were found in ground water from the SUSs.

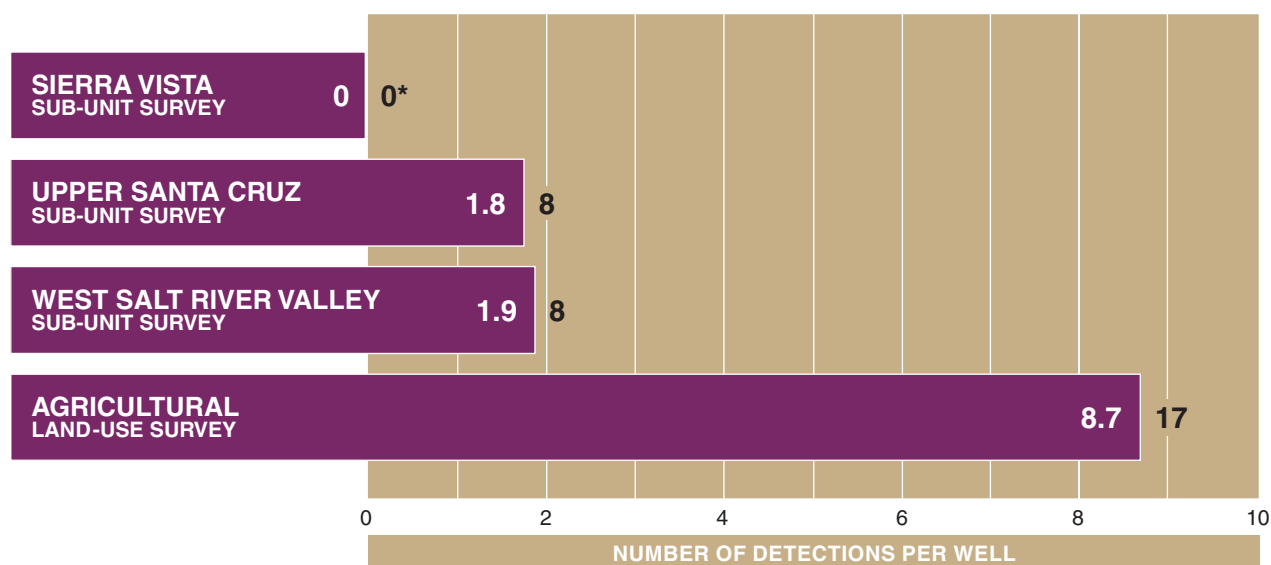


Figure 5. Number of pesticide detections per well, Central Arizona Basins study area, 1996–98. Detections per well equal number of pesticide detections divided by number of samples with detections. Numbers in black are the number of samples with pesticides detected. * No samples for HPLC analysis were collected in the Sierra Nevada sub-unit survey.

Minimally Developed Basin

Ground-water and surface-water samples from the minimally developed Sierra Vista subbasin did not contain any of the 47 or 86 pesticides for which these samples were analyzed, respectively (table 8). Quality control samples indicate that sample contamination was not an issue for ground-water samples from this basin. These results indicate that the water quality in this basin is not severely affected by sources of pesticides.

When pesticide detections for the minimally developed basin are compared with the results from other ground-water studies in the CAZB, it is apparent that the distribution of pesticide detections corresponds to the relative amounts of urban and agricultural land-use in each basin (fig. 5). The minimally developed basin had the fewest number of detections per well, and the other two basins had the most detections. The number of detections per well is determined by dividing the number of pesticide detections from all samples in a SUS or LUS survey by the number of samples with detections. Samples from the LUS had the highest number of detections of pesticides per well. This result corresponds with the intensive agricultural land use and shallow depths to ground water in the LUS area compared to conditions in the SUS areas. Statistical comparisons of pesticide detections for the

SUSs indicated that the results for the Sierra Vista SUS were different than those for the Upper Santa Cruz Basin and the West Salt River Valley SUSs at the 95- and 90-percent confidence levels, respectively. No difference was identified between pesticide results for the Upper Santa Cruz Basin SUS and results for the West Salt River Valley SUS. Comparison between the SUSs and the agricultural LUS was not deemed appropriate because of the large difference in available samples and the difference in well types.

Of the six surface-water samples collected for analyses of pesticides from the San Pedro River at Charleston (09471000), two samples represented high-flow conditions and four samples represented low-flow conditions. A sample collected on June 24, 1997, contained DDE at an estimated concentration (below the MRL) of 0.0007 µg/L. Samples collected at sites on the Buckeye Canal and the Hassayampa River on June 17 and June 18, 1997, respectively, also had detectable concentrations of DDE. Because the same sampling equipment was used at all sites, the detection of DDE at San Pedro on June 24 could represent carryover from samples collected on June 17 and June 18. Because of the possibility of carryover contamination, the detection of DDE in the San Pedro River will be considered a nondetection in this report. This decision is supported by the lack of detections of DDE in bed-sediment and fish-tissue samples collected from the San Pedro River (Gebler, 2000).

Table 8. Number of pesticides detected in ground-water and surface-water samples, Sierra Vista subbasin, Central Arizona Basins study area, 1996–97

[Dashes indicate that the information is not applicable]

Ground-water study name or surface-water site name	Medium sampled	Surface-water site number	Pesticides			
			Samples collected	Detections	Samples with detectable concentrations	Compounds detected
Sierra Vista subbasin	ground water	---	19	¹ 0	0	0
San Pedro River at Charleston	surface water	09471000	6	0	0	0

¹ Analyses of pesticides using the HPLC method were not completed.

The results from ground-water and surface-water samples from the Sierra Vista subbasin are important because they represent water quality in an area of the CAZB where pesticides generally have not been used on the land surface. Data like these have not been available before this study, and they provide important baseline information for future monitoring in this basin.

Developed Basins

Ground-water and surface-water samples from the Upper Santa Cruz Basin and the West Salt River Valley were used to characterize areas in which water quality is affected by human activities. In these basins, ground water and surface water are affected by pesticides currently used and pesticides used in the past. Pesticides detected in ground water and surface water can be attributed to present-day urban and agricultural land use (U.S. Geological Survey, 1999); other pesticides can be attributed to the historical land use that previously dominated the landscape.

Concentrations of pesticides detected in ground water in these basins were below current water-quality limits established by the USEPA (1996) and the State of Arizona (1996); some concentrations of pesticides in surface water were above the water-quality limits (table 9). The detections indicate that the ground water and surface water in these areas are susceptible to contamination by human activities, and the results may provide information on the contaminant sources and transport processes.

Upper Santa Cruz Basin

Agricultural activities have been present in the Upper Santa Cruz Basin since the early 1900s (Water Resources Research Center, 1999), but the effects of these activities on ground water are not widely distributed. Detections of pesticides in the Santa Cruz River near Nogales indicate that urban activities are affecting the surface-water quality because the pesticides detected are characterized as “urban insecticides.” A few detections of pesticides in surface-water samples were higher than established water-quality limits of the USEPA and the State of Arizona (table 9).

Samples from 8 wells (28 percent; table 10) in the Upper Santa Cruz Basin (fig. 6) contained 5 of the 86 pesticides analyzed. Deethylatrazine was the most frequently detected compound and was detected in 6 samples; atrazine was detected in 5 samples; and prometon, 2,4-D, and diuron were detected in 1 sample each.

Samples from five wells—SC5, SC7, SC8, SC12, and SC16—contained atrazine and deethylatrazine. Deethylatrazine is a degradation compound of the herbicide atrazine. Atrazine is a selective herbicide that controls broadleaf and grassy weeds in agricultural areas and also is applied as a nonselective herbicide in nonagricultural areas (Extension Toxicology Network, 1996). This compound is highly persistent in soil and is moderately to highly mobile in the subsurface.

Table 9. Maximum Contaminant Levels, human health advisory limits, aquifer water-quality standards, and surface-water standards for pesticides detected in ground-water and surface-water samples, Central Arizona Basins study area, 1996–98

[Constituents are dissolved and are reported in micrograms per liter; HAL, U.S. Environmental Protection Agency established human health advisory level for drinking water; MCL, Maximum Contaminant Level; E, concentration is estimated; dashes indicate no data]

Constituent	Concentration range of detections		U.S. Environmental Protection Agency ¹	
	Ground water	Surface water	HAL ³	Primary MCL
Atrazine	E0.00267–.079	0.00486–.0366	---	3
Chlorpyrifos	E.0035	.0088–.154	20	---
Cyanazine	---	.007–.635	⁵ 1	---
DDE	E.0012–.0076	.00191–.012	---	---
Dieldrin ⁶	.006–.033	.0103	---	---
Disulfoton	---	.826	.3	---
Diuron	.04–E5.53	---	10	---
Lindane (gamma-HCH)	---	.006–.030	.2	.2
Metribuzin	.007	.0169–.153	100	---
Prometon	E.0024–.108	.0057–.0378	⁷ 100	---
Simazine	E.0014–.0662	.00554–.0365	---	4
Terbacil	E.015	---	90	---
Trifluralin	E.0027–.0089	.00176–.097	5	---

State of Arizona

Constituent	Aquifer water-quality standard	Surface water			
		Fish consumption	Agricultural livestock watering	Agricultural irrigation	Aquatic and wildlife ⁴
Atrazine	---	---	---	---	---
Chlorpyrifos	---	---	---	---	---
Cyanazine	---	---	---	---	---
DDE	---	0.0006	0.001	0.001	0.02
Dieldrin ⁶	---	.0002	⁷ .003	⁷ .003	.002
Disulfoton	---	---	---	---	---
Diuron	---	---	---	---	---
Lindane (gamma-HCH)	0.2	.02	---	---	.61
Metribuzin	---	---	---	---	---
Prometon	---	---	---	---	---
Simazine	4	---	---	---	---
Terbacil	---	---	---	---	---
Trifluralin	---	---	---	---	---

¹U.S. Environmental Protection Agency, 1996.

²State of Arizona, 1996.

³Standard is for lifetime exposure for 70-kilogram adult.

⁴Standard for chronic toxicity.

⁵Draft.

⁶Standard is 0.003 aldrin/dieldrin.

⁷Under review.

Table 10. Number of pesticides detected in ground-water and surface-water samples in the Upper Santa Cruz Basin, Central Arizona Basins study area, 1996–98

[Dashes indicate that the information is not applicable]

Ground-water study name or surface-water site name	Medium sampled	Surface-water site number	Samples collected	Pesticides		
				Detections	Samples with detectable concentrations	Compounds detected
Upper Santa Cruz sub-unit survey	ground water	---	29	14	8	5
Nogales Wash near the Nogales International Wastewater Treatment Plant	surface water	312314110565601	2	2	2	1
Santa Cruz River near Rio Rico, Arizona	surface water	312809110592801	2	11	2	6
Santa Cruz River at Santa Gertrudis Lane	surface water	313343110024701	2	11	2	6
Santa Cruz River at Tubac, Arizona	surface water	09481740	2	9	2	6

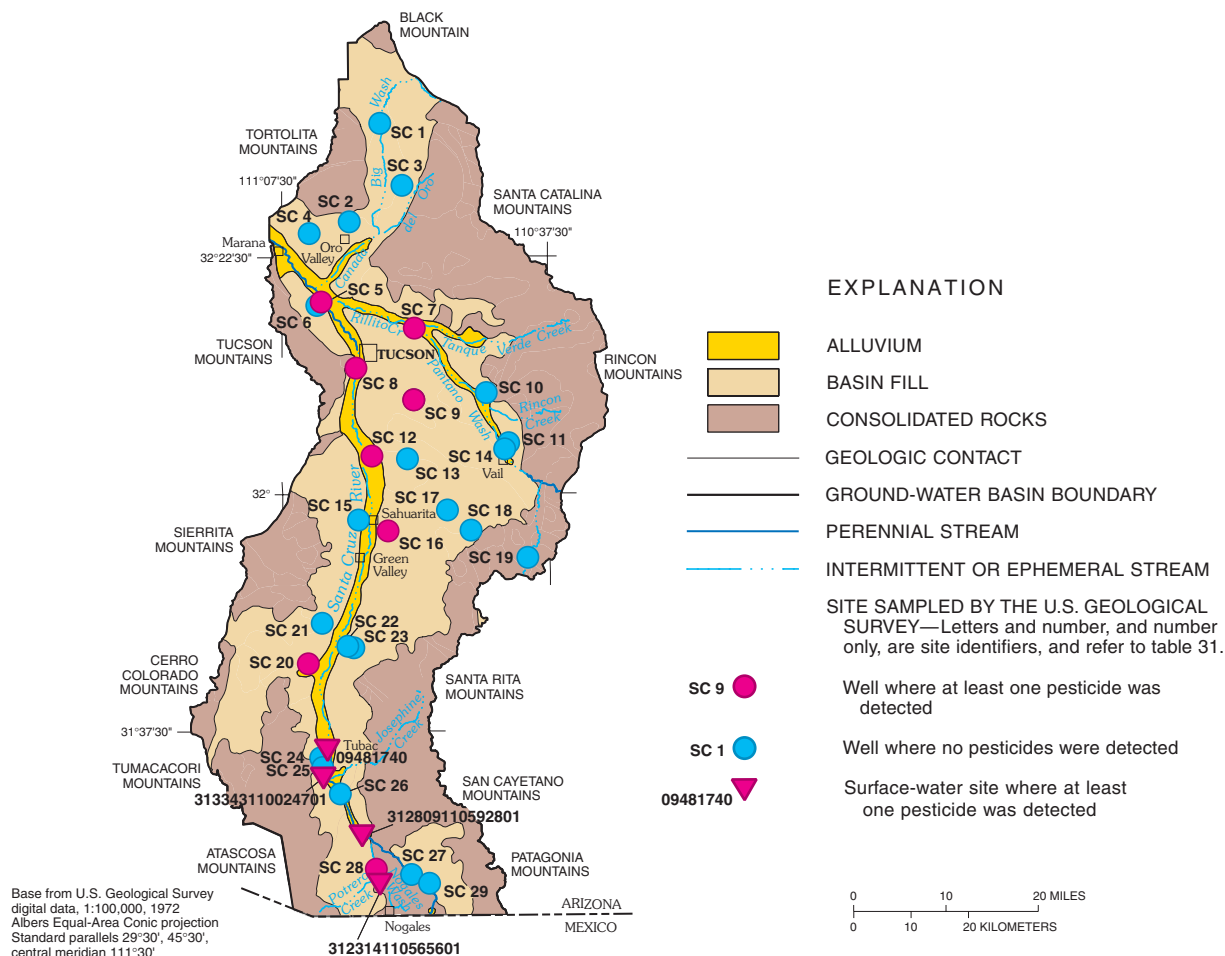


Figure 6. Locations of ground-water and surface-water sites where samples were collected for pesticide analyses, Upper Santa Cruz Basin, Central Arizona Basins study area.

Detections of atrazine and its degradation compounds, including deethylatrazine, can be expected where this compound is used, especially in areas with shallow depths to ground water and significant recharge (Extension Toxicology Network, 1996). Wells SC5, SC7, and SC8 are in areas of historic agriculture, and agricultural activities have resulted in elevated concentrations of calcium, potassium, alkalinity, and dissolved solids (Coes and others, 2000). Pesticides detected in samples from these wells probably are the result of past applications in these areas. Wells SC12 and SC16 are near areas of agricultural activities, but these activities are not as close to the wells as the historical agricultural areas are to wells SC5, SC7, and SC8. The land surrounding SC12 has been used only to graze cattle; however, the well is about 1 mi east of the Santa Cruz River, which could provide transport of pesticides from upgradient agricultural areas. SC16 is in a newly developed area originally used for rangeland. The only known historical agricultural activities are downgradient from this well. Prometon, 2,4-D, and diuron are considered to be primarily from urban applications, although diuron was used on crops in agricultural areas in 1996 (table 2).

Surface-water samples were collected during low-flow conditions at three sites along the Santa Cruz River and at one site on Nogales Wash, which is a tributary of the Santa Cruz River (fig. 6 and table 10). Seven of the 86 pesticides analyzed were detected in these surface-water samples. Prometon was detected at three of the four sites—Nogales Wash, the Santa Cruz River at Santa Gertrudis Lane, and the Santa Cruz River at Tubac. Chlorpyrifos, lindane, malathion, diazinon, and carbaryl were detected at the three sites along the Santa Cruz River but not at Nogales Wash. The concentration of lindane in the two samples from the Santa Cruz River near Rio Rico exceeded the State of Arizona surface-water standard for fish consumption ($0.02\ \mu\text{g/L}$; table 9). Ethalfuralin was detected at the Santa Cruz River near Rio Rico. Pesticides detected at these sites that are identified as “urban insecticides” (U.S. Geological Survey, 1999) are prometon, diazinon, carbaryl, malathion, and chlorpyrifos. Detections of these insecticides indicate that urban activities near Nogales are affecting surface-water quality in this area.

West Salt River Valley

Ground-water and surface-water samples from the West Salt River Valley contained more detectable pesticides than samples from any other area sampled in the CAZB during 1996–98. This basin has the most complex combination of land-use types in the CAZB, and the occurrence and distribution of pesticides reflects that combination. The pesticides detected are used in both agricultural and urban land uses. Detections were most numerous in samples of the shallow ground water from the agricultural area in the southwestern part of the basin. Seasonal patterns of pesticides in surface water at two sites in the agricultural area reflect the timing of application of these pesticides. Reuse of water in this arid area contributes to the transport of pesticides from the urban to the agricultural areas.

Ground Water

A variety of pesticides were detected in the two ground-water studies completed in the West Salt River Valley. Twenty-three percent of the 35 wells sampled for the SUS had detectable concentrations of pesticides (table 11). At least one pesticide was detected in samples from each of the nine wells in the LUS collected in August 1997 and February 1998. Concentrations of pesticides in ground water did not exceed limits established by the USEPA or the State of Arizona. Detections of pesticides in samples from the LUS wells were more numerous than detections in samples from any other group of wells in the CAZB during 1996–98. The ground-water quality in the West Salt River Valley generally represents conditions after large increases in population and agricultural and urban land use.

Eight of 86 pesticides analyzed were detected in water from 8 of the 35 wells sampled for the West Salt River Valley SUS. Numbers of detections for wells in the SUS varied throughout the basin, and pesticides were detected most frequently in samples from the southern part of the basin (fig. 7). The most frequently detected compound was deethylatrazine, which was detected in samples from 4 wells; atrazine, s-ethyl dipropylthiocarbamate (EPTC), simazine, and prometon were detected in samples from 2 wells; and DDE, acetochlor, and triallate each were detected in samples from 1 well.

Table 11. Number of pesticides detected in ground-water and surface-water samples, West Salt River Valley, Central Arizona Basins study area, 1996–98

[Dashes indicate that the information is not applicable. Data for agricultural land-use study represent two sampling efforts—August 1997 and February 1998]

Ground-water study name or surface-water site name	Medium sampled	Surface-water site number	Pesticides			
			Samples collected	Detections	Samples with detectable concentrations	Compounds detected
West Salt River Valley sub-unit survey	Ground water	---	35	15	8	8
Agricultural land-use study	Ground water	---	18	78	17	10
Gila River at Buckeye Canal	Surface water		31	210	31	23
Gila River above diversions at head of Buckeye Canal		09513990				
Buckeye Canal near Avondale		09514000				
Gila River at Estrella Parkway		09514100				
Hassayampa River near Arlington	Surface water	09517000	40	317	38	26

Deethylatrazine and atrazine were detected in samples from SUS wells in agricultural and nonagricultural areas. The detection of pesticides is attributed to characteristics of the pesticide and hydrogeologic conditions, as well as to land use. Atrazine is persistent in the subsurface (Extension Toxicology Network, 1996). The depths to water in 3 of the 4 wells where deethylatrazine was detected were 65 ft or less (Edmonds and Gellenbeck, 2002). Depth to water was more than 400 ft at one well. The combination of persistence and shallow depths to ground water probably contributed to these detections.

EPTC, simazine, and prometon are not as persistent in the subsurface as atrazine (Extension Toxicology Network, 1996; U.S. Department of Agriculture, 1995); therefore, the detection of these compounds may depend on when samples are collected. EPTC was detected in wells in agricultural areas, but simazine and prometon were detected in wells in an urban area. EPTC is used as a selective pre-emergent herbicide for control of grassy weeds, perennial weeds, and some broadleaf weeds in a variety of crops (Extension Toxicology Network, 1996). EPTC has a low persistence in the soil and a half-life of less than one week (Extension Toxicology Network, 1996). Sampling must have occurred close to the time of application for this compound to have been detected in the ground water. Simazine is applied in both agricultural and nonagricultural settings to control

broadleaf weeds and annual grasses (Extension Toxicology Network, 1996). Prometon is applied in nonagricultural settings to control perennial broadleaf and grassy weeds (U.S. Department of Agriculture, 1995). Both compounds are mobile in the subsurface, especially in sandy loam soils (U.S. Department of Agriculture, 1995).

The detections of pesticides in nine wells in the agricultural LUS area in the southwestern part of the West Salt River Valley most clearly reflect the effects of present agricultural activities on ground-water quality, although the detection of some compounds is considered a consequence of urban activities (Edmonds and Gellenbeck, 2002). At least one pesticide was detected in samples from each of the nine wells (fig. 7). Twelve of the 86 pesticides analyzed were detected in samples from 8 of the 9 wells for the LUS in August 1997. Six of the 86 pesticides analyzed were detected in samples from all 9 wells in February 1998. The difference in the number of compounds detected in August and February could be related to the timing of the sampling relative to the irrigation season. The August sampling occurred at the end of the irrigation season, and all the compounds applied during that season could have been transported to the ground water. By February, several months had passed since the last irrigation; therefore, the compounds detected at that time were those that are persistent in the subsurface.

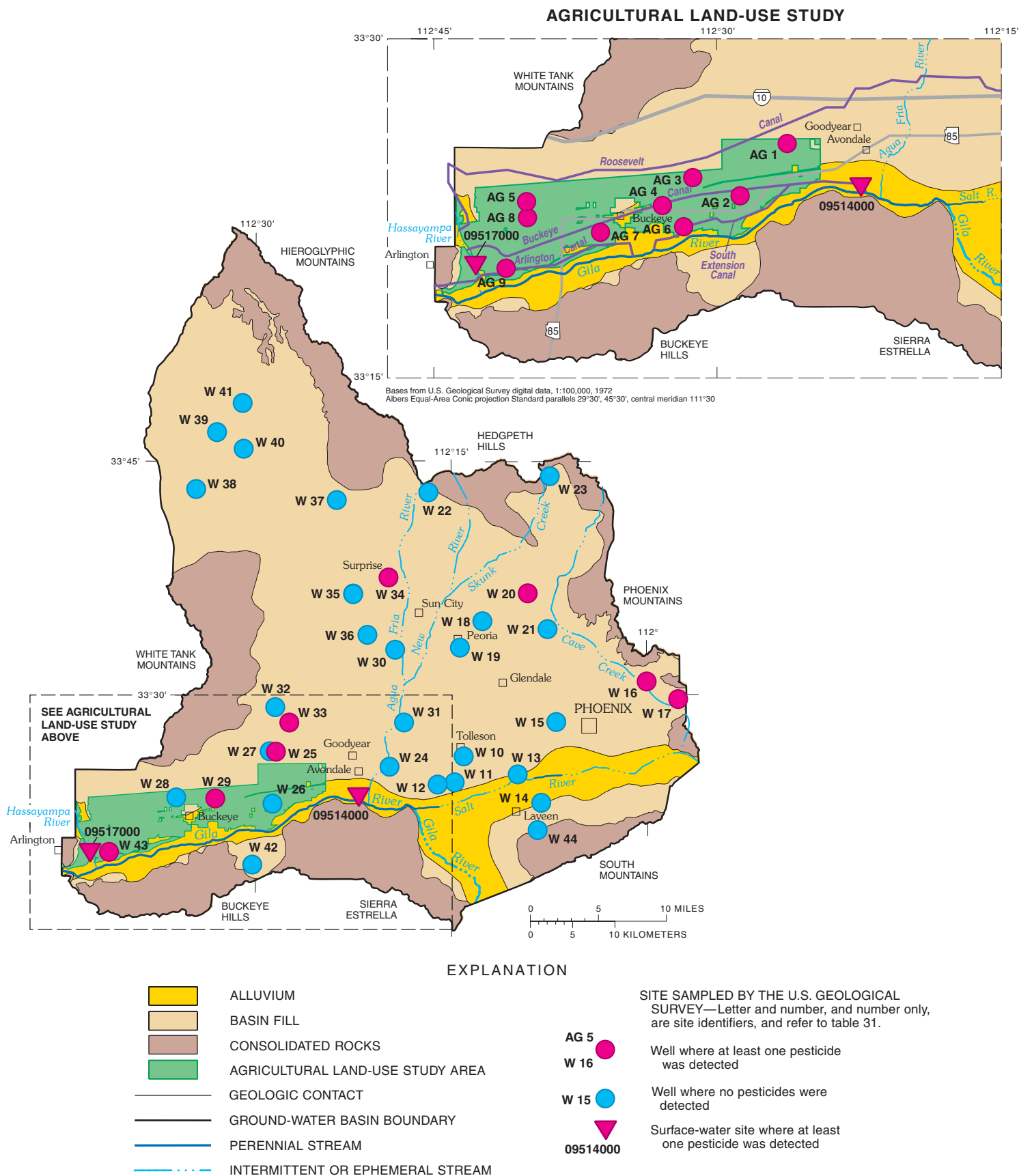


Figure 7. Locations of ground-water and surface-water sites where samples were collected for pesticide analyses, West Salt River Valley, Central Arizona Basins study area.

Atrazine and deethylatrazine were the most frequently detected compounds and were detected in eight (89 percent) of the wells during both the August and February sampling periods. The ratio between deethylatrazine and atrazine can provide information about the degradation of atrazine in the subsurface. The ratio of deethylatrazine to atrazine was higher in samples collected in February 1998 than in the samples collected in August 1997 (fig. 8). These results indicate that atrazine is degrading in the shallow ground water between irrigation seasons (Edmonds and Gellenbeck, 2002). Bias due to matrix effects may affect the concentration of deethylatrazine; however, the difference in the ratios probably is not affected. Deisopropyl atrazine, which also is a pesticide-degradation product of atrazine was detected in wells AG6 and AG2 in August 1997 and in AG6 in February 1998 (E.M. Thurman, chemist, USGS, written commun., 1998). These data indicate that atrazine is breaking down in the ground water in this agricultural area.

For some pesticides, only the pesticide-degradation products were detected. One pesticide-degradation product—3,4-dichloroaniline—was detected in three samples collected in August 1997 and two samples collected in February 1998 (E.M. Thurman, chemist, USGS, written commun., 1998). The source of this degradation compound could be either propanil or linuron. Both propanil and linuron are used as herbicides. Propanil is used as a post-emergent herbicide on wheat and other crops. Linuron is used as a pre- and post-emergent herbicide on cotton and other crops. These compounds were not reported as being used in the agricultural LUS area (table 2), but nonreported uses could be sources of this degradation product. The presence of this pesticide-degradation compound in the absence of the parent compound is an indication of how quickly some pesticides breakdown in the environment.

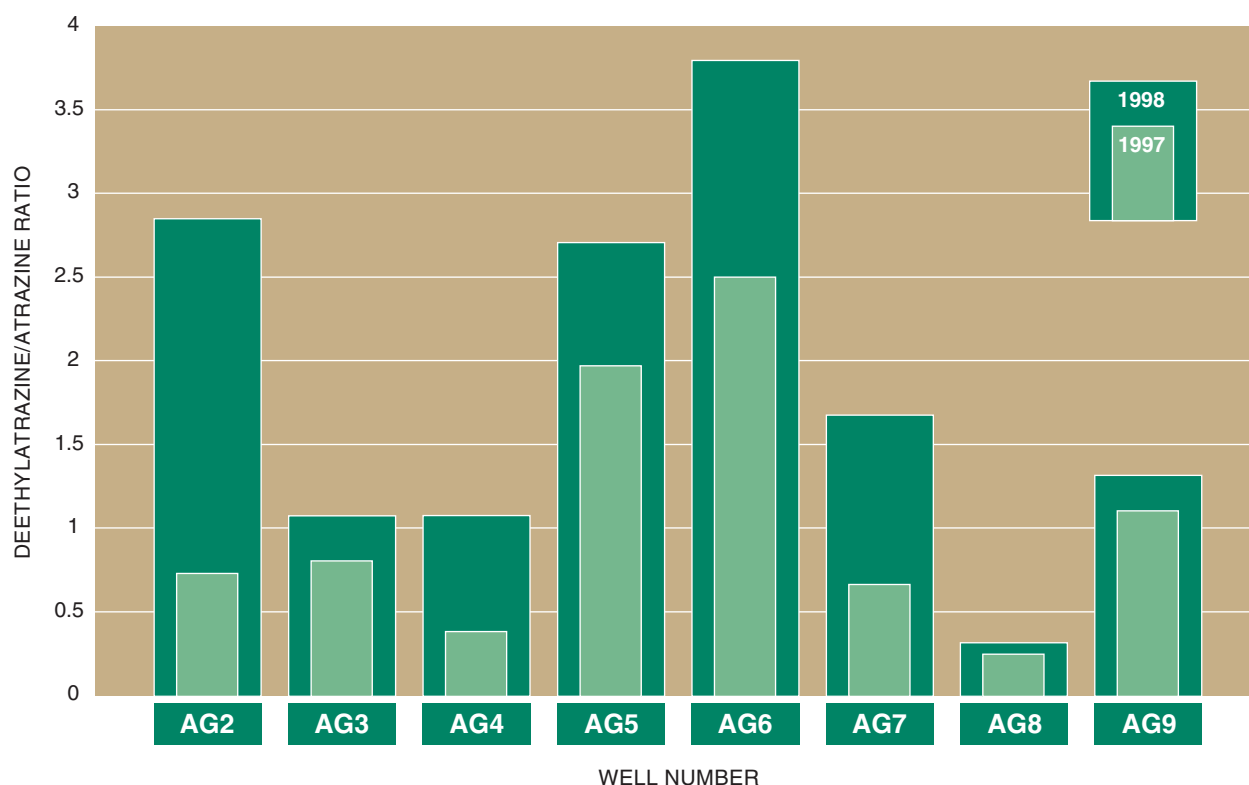


Figure 8. Deethylatrazine/atrazine ratios for samples from wells in the agricultural land-use study area, Central Arizona Basins study area, August 1997 and February 1998.

Diuron was detected in samples collected from 5 wells in August 1997 (55 percent) and in samples collected from 4 wells in February 1998 (44 percent). Diuron is a herbicide that controls a wide variety of annual and perennial broadleaf and grassy weeds and is applied in agricultural and nonagricultural areas (Extension Toxicology Network, 1996). Diuron has been recommended for cotton crops in Arizona since 1955 (Brew and Baker, 1987; [tables 1](#) and [2](#), this report). Although detections of diuron have been associated with urban land use (U.S. Geological Survey, 1999), diuron has been used for a long period of time in the West Salt River Valley on cotton crops, and its presence in ground water probably is related to land-surface application.

Simazine was detected in samples collected from 4 wells in August 1997 (44 percent) and in samples collected from 7 wells in February 1998 (78 percent). Prometon was detected in samples collected from 2 wells in August 1997 (22 percent) and in samples collected from 5 wells in February 1998 (55 percent). These detections indicate that pesticides applied for agricultural and nonagricultural uses are reaching the shallow ground water in this agricultural area.

DDE was detected in samples collected from 6 wells in August 1997 (67 percent) and in samples collected from 4 wells in February 1998 (44 percent). All but one of these detections were below the MRL (Tadayon and others, 1999). DDE is a degradation compound of DDT, an insecticide that was used in agricultural areas of the West Salt River Valley from 1944 until its use was banned in Arizona in 1965 (Brew and Baker, 1987). Previous studies have detected DDE in soils in the West Salt River Valley (Brown, 1993). DDT and DDE are highly persistent in the soil and have low solubilities in water; consequently, over long periods of time, it may be possible that the compounds leach into the ground water (Extension Toxicology Network, 1996).

Dieldrin has not been used for the last 10 years, but was detected in samples collected from 2 wells (AG5 and AG8) during August 1997 and February 1998. Dieldrin was recommended for cotton crops around 1955 when cotton was the primary crop in the area (Brew and Baker, 1987; [table 1](#), this report). Dieldrin is an insecticide and also a pesticide-degradation compound of aldrin. Uses of aldrin and dieldrin were banned in 1972 except for subsurface termite control, nonfood agricultural uses, and moth proofing in closed

systems in manufacturing processes (U.S. Environmental Protection Agency, 1980). By 1987, industry had removed these compounds from the marketplace for all uses (U.S. Environmental Protection Agency, 1995). The persistence of this insecticide is indicated by detections of dieldrin in shallow ground water more than 20 years after its use was banned.

Surface Water

Two surface-water sampling sites—Gila River at Buckeye Canal and Hassayampa River near Arlington—were used to determine the occurrence and distribution of pesticides in surface water affected by land-use activities in the West Salt River Valley ([table 11](#)). Although the sampling site on the Hassayampa River is outside the western boundary of the West Salt River Valley, it is included in this section because the base flow at this site is maintained by flow from the Buckeye Canal.

Twenty-three of the 86 pesticides analyzed were detected in 31 samples collected at the 3 sites used to represent the Gila River at Buckeye Canal ([table 11](#)) from February 1996 through April 1998. Of the 31 samples, 1 sample was collected during high-flow conditions due to releases from the reservoir upstream and 30 samples were collected during low-flow conditions ([fig. 9](#)). Concentrations of DDE in 12 samples (39 percent) exceeded the surface-water standards for agricultural irrigation, agricultural livestock watering, and fish consumption (State of Arizona, 1996; [table 9](#), this report). Concentrations of dieldrin in 1 sample exceeded the fish-consumption and aquatic and wildlife standards for dieldrin. Eleven different pesticides were detected in more than 5 samples. Included in these 11 pesticides were 4 pre-emergent herbicides—simazine, trifluralin, EPTC, and dacthal—that were detected in samples collected during planting of crops, primarily between December and April ([fig. 9](#)).

Four other compounds detected in more than five samples were chlorpyrifos, diazinon, prometon, and malathion. Chlorpyrifos, diazinon, and malathion are insecticides used in agricultural and nonagricultural settings (Extension Toxicology Network, 1996).

A possible source of these four compounds is the same as the primary source of the water—outflow from the 91st Avenue WWTP. Diazinon and malathion are commonly used in residential applications, so it is

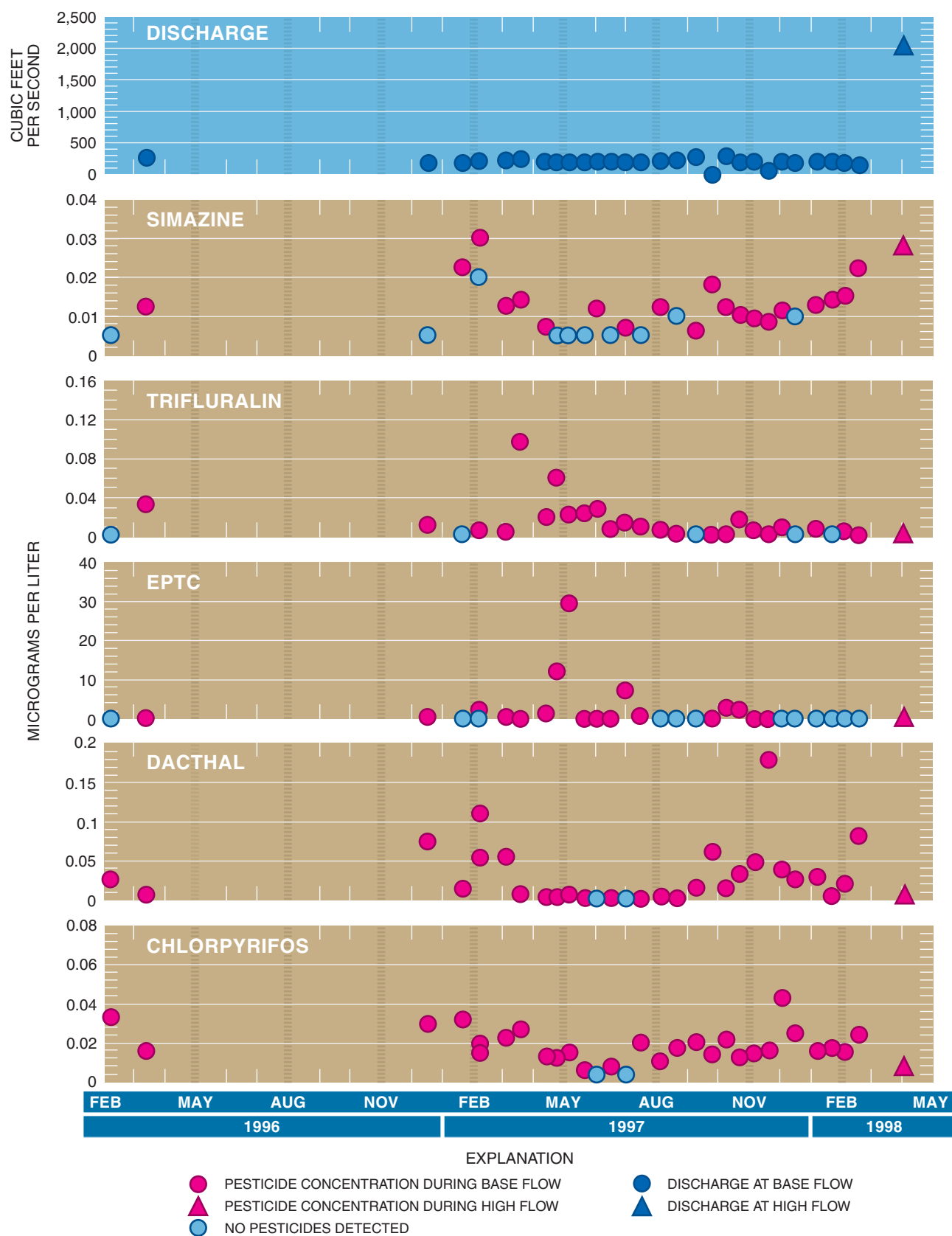


Figure 9. Selected pesticides detected in surface-water samples collected from the Gila River at Buckeye Canal, West Salt River Valley, Central Arizona Basins study area, 1996–98.

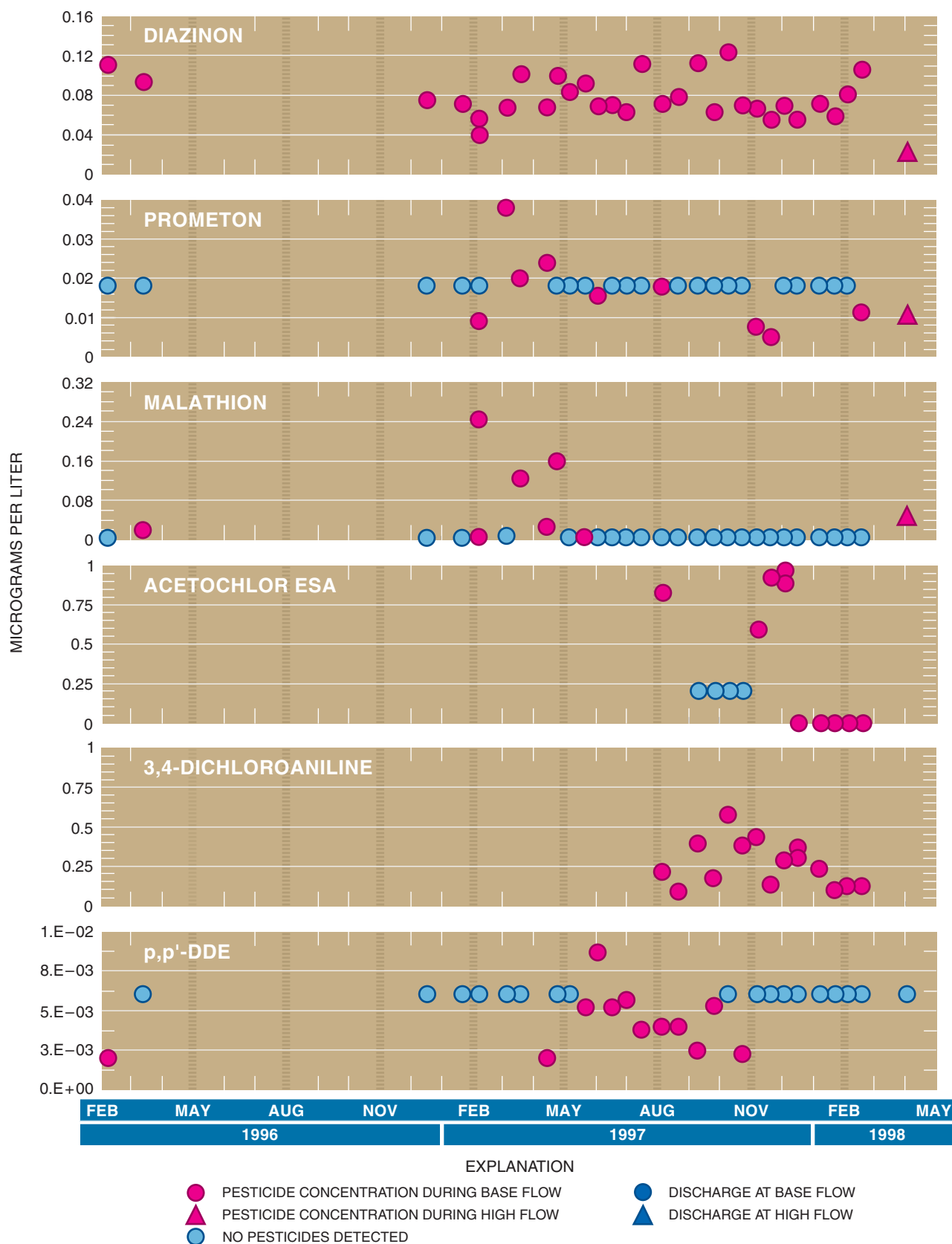


Figure 9. Continued.

possible that these compounds are transported to the WWTP from household wastes and through the treatment processes to the outflow. The outflow is then diverted to the Buckeye Canal for use as irrigation. Chlorpyrifos and diazinon also may be from agricultural land downstream from the 91st Avenue WWTP. After application, transport of chlorpyrifos to the surface water may be delayed because it can be strongly adsorbed to soils (U.S. Department of Agriculture, 1995). Desorption from the soils can explain its persistence in surface water throughout the year. Diazinon has a low persistence in soils and seldom migrates below the top half inch in soil (Extension Toxicology Network, 1996). Malathion was detected in a few samples collected from February through May 1997. This period corresponds with the early planting season; therefore, the source of this insecticide may be primarily agricultural.

Pesticide-degradation compounds including DDE, acetochlor ESA, and 3,4-dichloroaniline were detected in several samples from Gila River at Buckeye Canal (Tadayon and others, 1998 and 1999; E.M. Thurman, chemist, USGS, written commun., 1998). The source of DDE probably is DDT that was applied in the past and is now present as DDE in the soils in the local area (Brown, 1993). The parent compounds of acetochlor ESA and 3,4-dichloroaniline were not detected in the surface-water samples.

The detections of only pesticide-degradation products for a short period during the irrigation season indicates that the pesticides are degrading quickly in the environment. Detections of 3,4-dichloroaniline were more numerous than detections of other degradation compounds probably because of the degradation of several different pesticides including diuron (tables 1 and 2).

The sample collected in April 1998 from the Gila River at Buckeye Canal (09514100) is from a release of surface water from a reservoir upstream on the Salt River and included detectable concentrations of some pesticide compounds (fig. 9). Of the 11 compounds most often detected in samples from this site, 4 compounds from agricultural and nonagricultural uses were detected in this sample (fig. 9). Of the 4 compounds detected, only simazine had a higher concentration in this sample than in samples collected during low-flow conditions. Lower concentrations may be the result of dilution. The source-and-transport processes associated with the high concentration of simazine in this sample are unknown.

Twenty-six of the 86 pesticides analyzed were detected in 38 samples collected from the Hassayampa River near Arlington (table 11) between February 1996

and February 1998. Six samples were collected during high-flow conditions, and 31 samples were collected during low-flow conditions. Thirty-three samples (89 percent) exceeded the agricultural irrigation, agricultural livestock watering, and fish-consumption standards for DDE (State of Arizona, 1996; table 9, this report). Fourteen different pesticides were detected in more than 5 samples (fig. 10). Of these 14 pesticides, 6 pre-emergent herbicides—simazine, trifluralin, EPTC, dacthal, linuron, and pendimethalin—were detected between October and May. Most of these compounds are applied to the fields before the appearance of broadleaf weeds and grasses; linuron and pendimethalin also may be applied after grasses and weeds have sprouted.

The other 8 pesticides that were detected in more than 5 samples were chlorpyrifos, diazinon, prometon, malathion, atrazine, deethylatrazine, DDE, and 3,4-dichloroaniline. Chlorpyrifos and diazinon were detected in surface-water samples from this site throughout the year and are similar to detections at the Gila River at Buckeye Canal. The highest concentrations of chlorpyrifos and diazinon in the Hassayampa River near Arlington (0.154 and 0.207 $\mu\text{g/L}$, respectively) are higher than those from the Gila River at Buckeye Canal (0.0429 and 0.123 $\mu\text{g/L}$, respectively). Higher concentrations in the Hassayampa River probably are due to the denser agricultural land use upstream from this site compared with the Gila River at Buckeye Canal. Variation in replicate samples could be related to sample processing and analytical procedures. Because these compounds are used in agricultural and nonagricultural settings, the source of the compounds could be outflow from the 91st Avenue WWTP, runoff from agricultural fields downstream from the 91st Avenue WWTP, and (or) desorption from soils.

Deethylatrazine, DDE, and 3,4-dichloroaniline are degradation compounds of pesticides used in the area (atrazine, DDT, and diuron, respectively). Deethylatrazine was detected during April–December—the same time period that the parent compound, atrazine, was detected. Detections of DDE in samples from the Hassayampa River near Arlington occurred throughout the year. The DDE may be transported in runoff from agricultural fields (Brown, 1993) upgradient from this site. Detections of 3,4-dichloroaniline were expected because diuron, one of several parent compounds for this degradation product, was used in the area (tables 1 and 2).

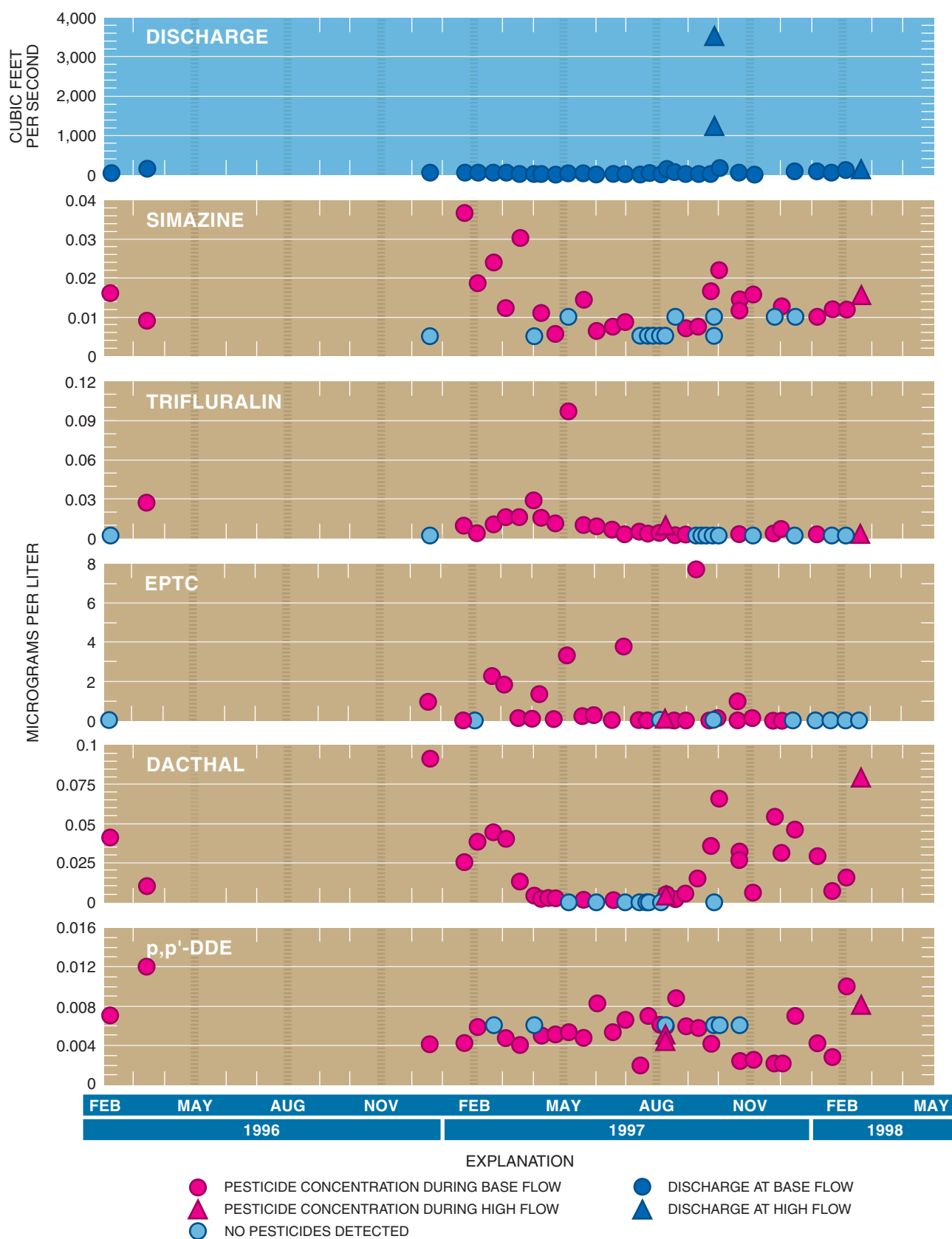


Figure 10. Selected pesticides detected in surface-water samples collected from the Hassayampa River near Arlington, West Salt River Valley, Central Arizona Basins study area, 1996–98.

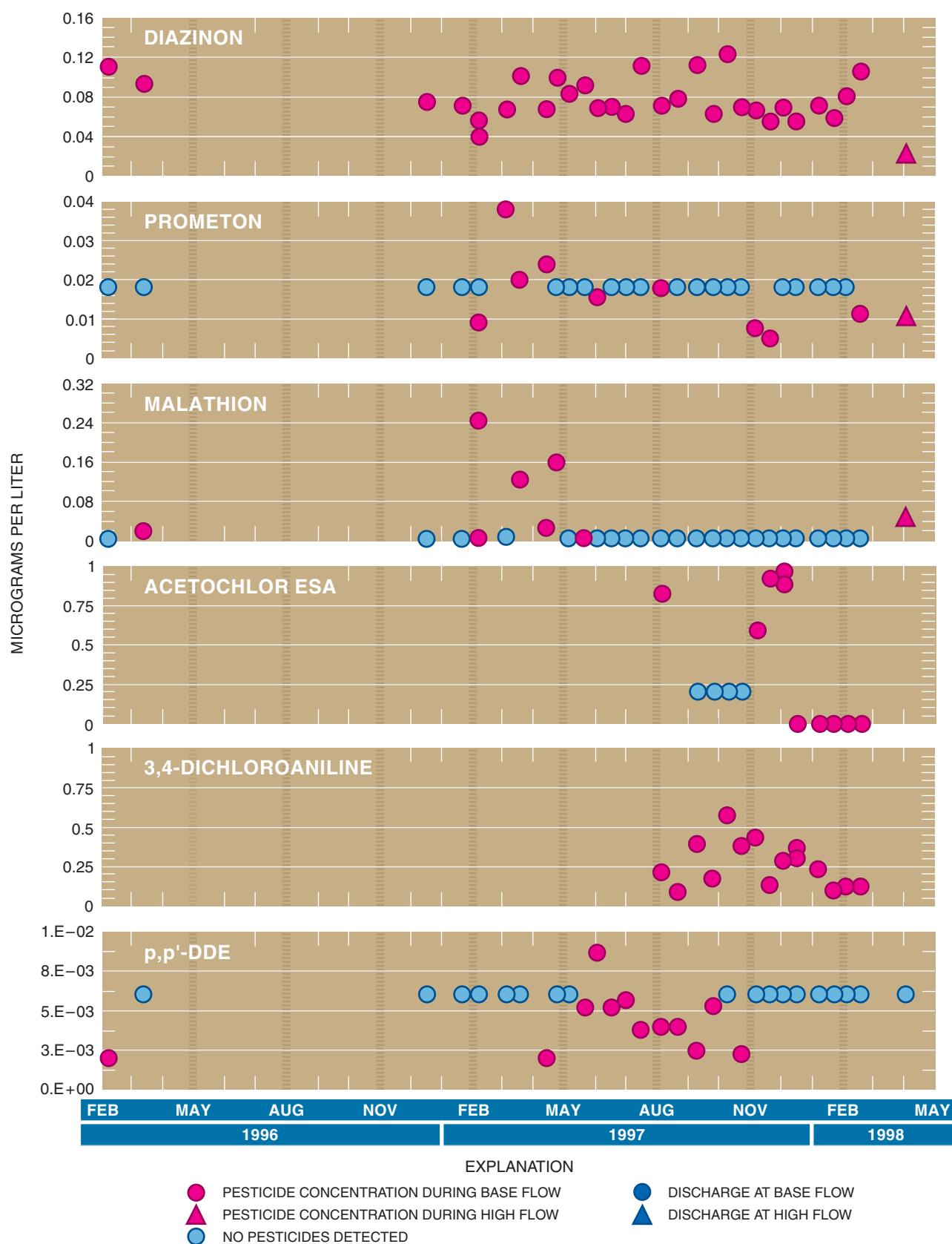


Figure 10. Continued.

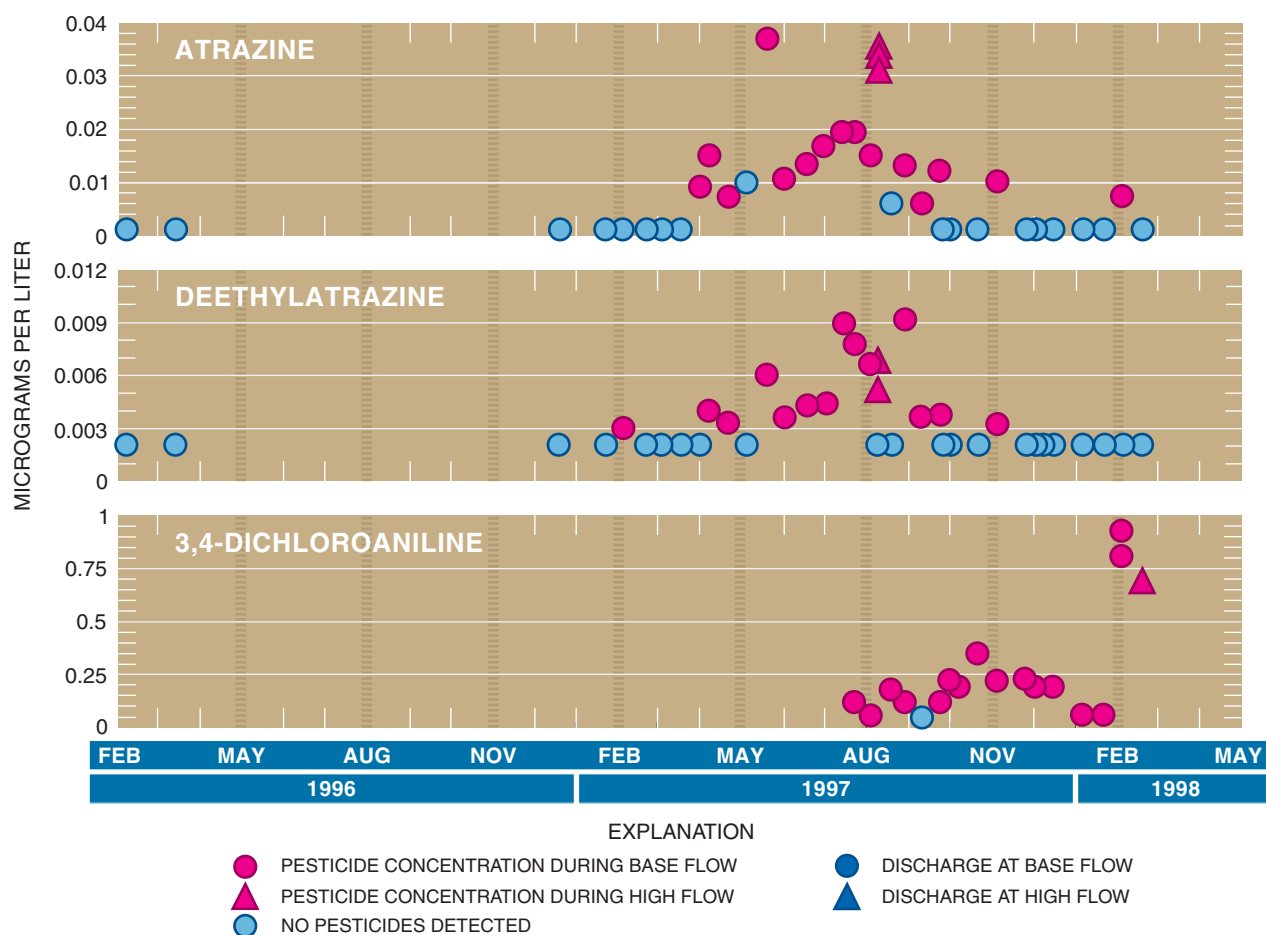


Figure 10. Continued.

Six high-flow samples were collected from the Hassayampa River near Arlington in August 1997 (three samples), September 1997 (two samples), and February 1998 (one sample). In the high-flow sample collected in September 1997, pesticide concentrations were low or nondetected. High-flow samples collected in August 1997 had detections of 13 compounds. Comparison between concentration in high-flow and low-flow samples indicates that sometimes concentrations were higher in high-flow samples for some pesticides and at other times concentrations of these same pesticides were equal to or lower than those in low-flow samples. Concentrations of prometon, cyanazine, atrazine, methyl parathion, and carbaryl were higher in high-flow samples. Concentrations of deethylatrazine, DDE, chlorpyrifos, trifluralin, EPTC, dacthal, and pendimethalin in the high-flow samples were similar to concentrations in low-flow samples. Concentrations of dacthal, DDE, prometon, and 3,4-dichloroaniline were somewhat higher in the high-flow sample collected in February 1998, than in other

samples collected earlier in 1998 at lower discharges. Variation in concentrations due to processing and analytical techniques could account for some of the differences in the concentrations of DDE and prometon. Reasons for the differences in concentrations between high-flow and low-flow samples could include differences in time of application, degree of adsorption of the compounds to soil, and origin of runoff. Without more detailed information, the cause of these differences cannot be determined.

Concentrations of some pesticide compounds in surface water in the West Salt River Valley appear to vary throughout the year, and concentrations of other pesticide compounds remain somewhat constant. Pre-emergent pesticides, which include simazine, trifluralin, EPTC, and dacthal, exhibit the most pronounced seasonal variations ([figs. 9 and 10](#)). At the Gila River at Buckeye Canal, these compounds were detected primarily from December through April; at the Hassayampa River near Arlington, these compounds were detected primarily from October through May.

The Hassayampa River drainage is larger than the Gila River at Buckeye Canal drainage; therefore, travel times for compounds can be longer, which results in longer detection periods.

DDE was detected in samples collected from the Gila River at Buckeye Canal from April through December 1997 and in samples collected from the Hassayampa River near Arlington throughout the sampling period. Because this compound was detected at the Gila River at Buckeye Canal during the intense irrigation season, it is possible that the source of this compound is the agricultural fields upstream and not outflow from the 91st Avenue WWTP, which is the source of most of the water at this site. Detections of DDE at the Hassayampa River near Arlington throughout the sampling period indicate that the transport mechanism operates all year. For those compounds that occur throughout the year, likely sources are WWTP outflow, desorption from soils, and runoff from agricultural areas.

One major source of water for the Gila River at Buckeye Canal and Hassayampa River near Arlington is outflow from the 91st Avenue WWTP, which is available throughout the year and is primarily affected by urban activities. Although the reuse of water is important for conservation efforts, it provides a mechanism for pesticides in the water to move from urban land-use areas to agricultural land-use areas. The reuse of treated effluent for irrigation water and the reuse of irrigation tail water result in a complex mixture of pesticides in the West Salt River Valley. This complex mixture and the water-management practices in the West Salt River Valley make it difficult to determine the original sources of pesticides in surface water and ground water. Although the presence of some pesticides clearly is the result of historical use for agriculture, the presence of others could be related to either agriculture or urban land use. The presence of DDE in shallow ground water and surface water is the result of agricultural use of DDT in this area more than 30 years ago. The presence of some herbicides including simazine and prometon can be related to agricultural or urban land use. Insecticides that are linked to urban uses, including chlorpyrifos, diazinon, and malathion, also were detected in the Gila River at Buckeye Canal. Without more detailed studies of water sources, it is impossible to identify which land-use activity is the source of some pesticides in the West Salt River Valley.

Volatile Organic Compounds

Ground water and surface water sampled in the CAZB during 1996–98 contained a large variety of VOCs, especially in those areas where urban land use is prevalent. Most of the detectable concentrations were low and less than water-quality limits. VOCs are present in ground water and surface water in some areas of the CAZB, but not at a level that requires action by an enforcement agency. Identification of specific sources of VOCs is difficult because of the various pathways that ground water may have taken to the well that was sampled or the various sources of water contributing to flow at the surface-water sampling location. The difficulty of identifying specific sources was increased because the detectable concentrations of VOCs were very low. Generally-known sources of VOCs are included in this report as a guide for the reader. Specific sources of VOCs in a localized area are presented if they were pertinent, but this study did not verify that those sources contributed the VOCs to the well or surface-water sampled. The co-occurrence of several VOCs or VOCs with pesticides and nitrate is not considered in the current implementation of water-quality limits. Many samples from ground water and surface water in the CAZB that had detectable concentrations of VOCs and (or) pesticides also had detectable concentrations of more than one compound. Little is known about the potential health effects from the co-occurrence of several VOC and pesticide compounds (Squillace and others, 1999).

Minimally Developed Basin

In the Sierra Vista subbasin, ground-water samples were collected to evaluate the occurrence and distribution of VOCs. No surface-water samples were collected for VOC analyses in this subbasin. Eleven of the 87 VOCs analyzed were detected in 14 wells (74 percent; [fig. 11](#) and [table 12](#)). 1,2,4-trimethylbenzene was the most frequently detected compound and was detected in 10 samples. PCE was detected in 3 samples; chloromethane, dichlorodifluoromethane, and carbon disulfide were detected in 2 samples; and bromodichloromethane, tribromomethane, benzene, chlorobenzene, acetone, and tetrahydrofuran were detected in 1 sample each. Two detections of trichloromethane are not considered in this report because detections occurred in a field blank in the same time period. Concentrations were not higher than water-quality limits established by the USEPA (1996) and the State of Arizona (1996; [table 13](#), this report).

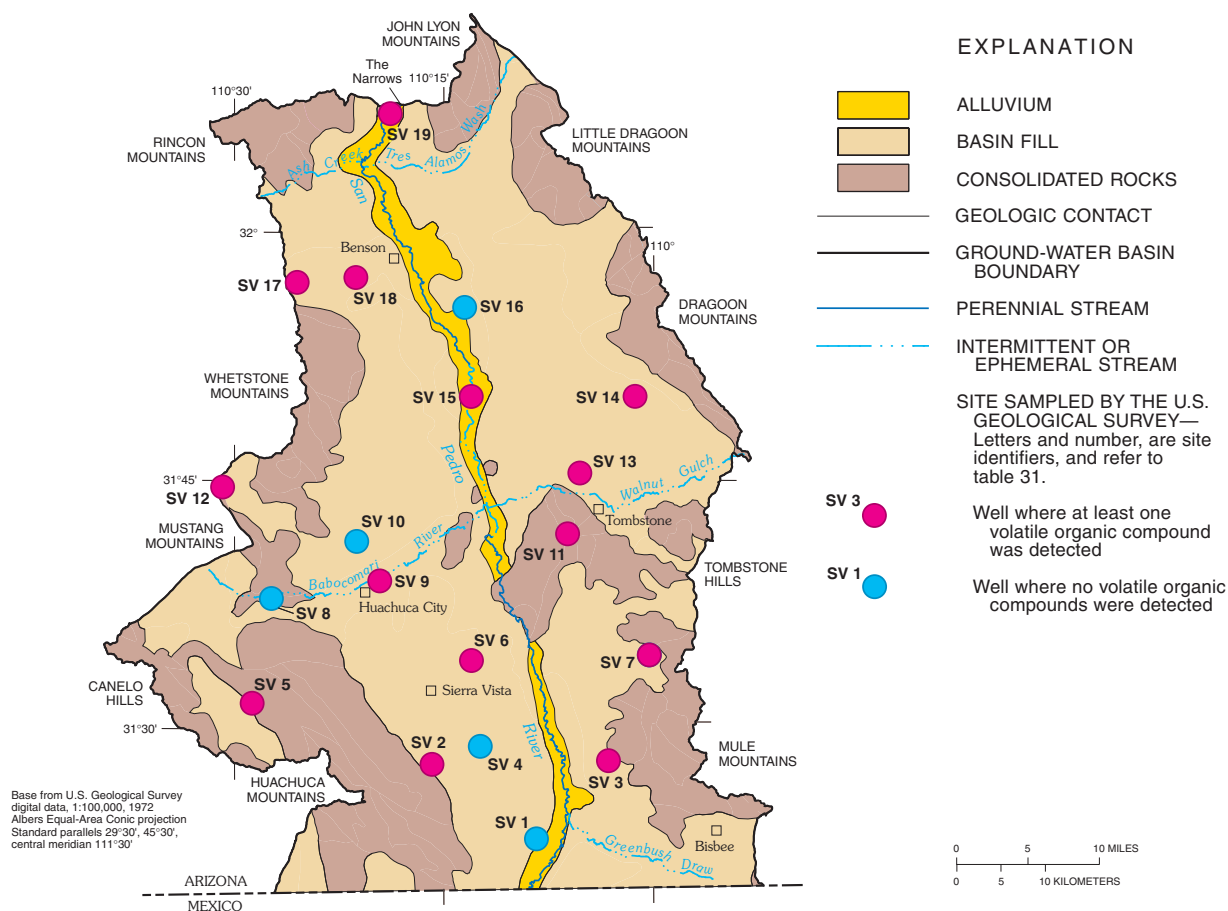


Figure 11. Locations of ground-water sites where samples were collected for volatile organic compound analyses, Sierra Vista subbasin, Central Arizona Basins study area, 1996–97.

Table 12. Number of volatile organic compounds detected in ground-water samples in the Sierra Vista subbasin, Central Arizona Basins study area, 1996–97

Ground-water study name	Volatile organic compounds			
	Samples collected	Detections	Samples with detectable concentrations	Compounds detected
Sierra Vista subbasin sub-unit survey	19	25	14	11

Table 13. Maximum Contaminant Levels, human health advisory limits, aquifer water-quality standards, and surface-water standards for volatile organic compounds detected in ground-water and surface-water samples, Central Arizona Basins study area, 1996–98

[Constituents are dissolved and are reported in micrograms per liter; HAL, U.S. Environmental Protection Agency established human health advisory level for drinking water; MCL, Maximum Contaminant Level; E, concentration is estimated; dashes indicate no data]

Constituent	Concentration range of detections		U.S. Environmental Protection Agency ¹		State of Arizona ²				
	Ground water	Surface water	HAL ³	Primary MCL	Aquifer water-quality standard	Surface water			
						Fish consumption	Agri-cultural livestock watering	Agri-cultural irrigation	Aquatic and wildlife ⁴
Benzene	E0.006–E.020	E.015	---	5	5	120	---	---	700
Bromodichloromethane	E.01–297	E0.1–4	---	⁵ 100	---	22	---	---	---
Tetrachloromethane	---	E.06	---	5	5	5.5	---	---	1,100
Chloromethane	E.008–E.1	E.04–E.218	3	---	---	---	---	---	15,000
1,1,1-Trichloroethane	E.01	E.01	---	200	200	---	---	---	1,600
1,1-Dichloroethene	E.03	---	---	7	7	4.5	---	---	950
Methyl tert-butyl ether	E.05–E.06	E.04–E.061	⁶ 20–200	---	---	---	---	---	---
Tetrachloroethene	E.005–5.48	E.03–3.6	---	5	5	11	---	---	680
Trichloroethene	E.01–1.26	E.02–E.04	---	5	5	---	---	---	1,300
Trichloromethane	.008–.498	.75–8.1	---	⁵ 100	---	---	---	---	---

¹U.S. Environmental Protection Agency, 1996.

²State of Arizona, 1996.

³Standard is for lifetime exposure for 70-kilogram adult.

⁴Standard is for chronic toxicity.

⁵Draft.

⁶Action level.

VOCs were detected in ground-water samples from areas of the Sierra Vista subbasin that have urban land use and in areas that have rangeland. Although this subbasin is characterized as having minimal urban development (Gellenbeck and Coes, 1999), detections of VOCs indicate that ground water in localized areas could be affected by human activities. Detections of VOCs per well (fig. 12) for each ground-water study also indicate that the distribution corresponds with the amount of urban land use in each ground-water basin. Detections of VOCs per well were determined by dividing the number of VOC detections by the number of samples with detections. The highest number of detections of VOCs per well are in basins with the largest amount of urban-land use. The Upper Santa Cruz Basin SUS, the West Salt River Valley SUS, and the LUS each had more than two detections of VOCs per well (fig. 12), and the Sierra Vista SUS had fewer than two detections of VOCs per well. Statistical comparisons of VOC results from the SUSs identified no difference among the SUSs.

The most frequently detected VOC, 1,2,4-trimethylbenzene, has several possible sources. The largest users of 1,2,4-trimethylbenzene are chemical companies that make trimellitic anhydride. Dyes and perfumes also are sources of this compound (Sax and Lewis, 1987). Specific sources in the Sierra Vista subbasin could not be identified.

A sample from well SV18 contained the most VOCs (three)—chloromethane, carbon disulfide, and 1,2,4-trimethylbenzene. SV18 is south of Interstate 10 and downgradient from a gas station, which could be sources for the VOCs detected. Natural sources of chloromethane from fungus (Harper, 1985), forest fires (Palmer, 1976), and volcanic gases (Inn and others, 1981), and natural sources of carbon disulfide from volcanic gases (Inn and others, 1981) and mushrooms (Turner and others, 1975) also could have contributed the VOCs to the ground water.

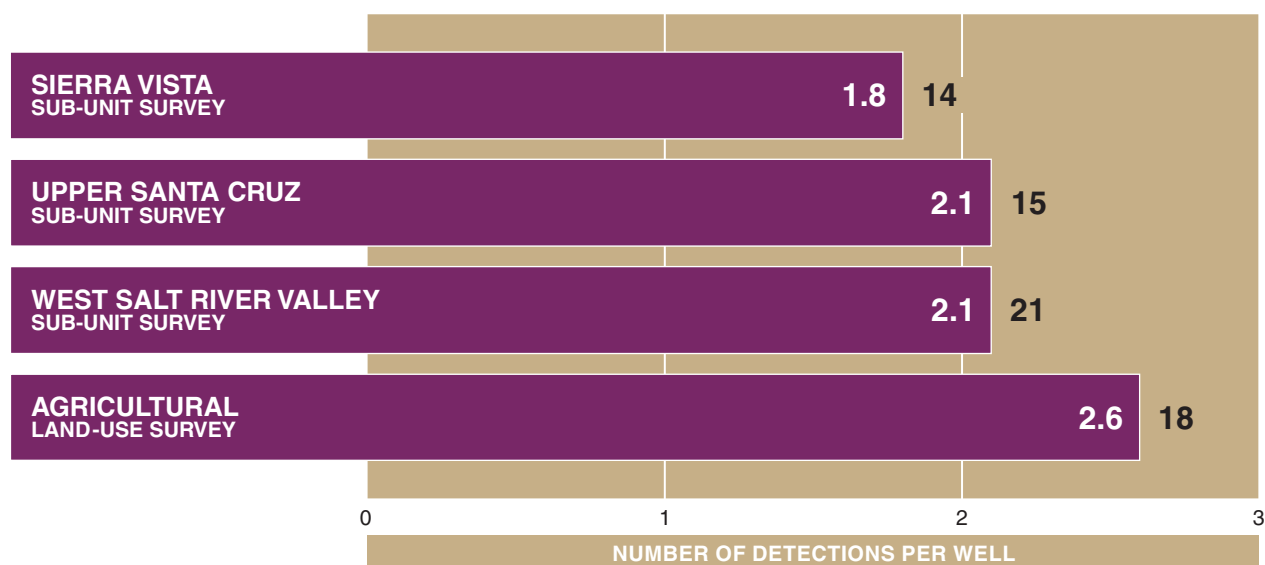


Figure 12. Number of volatile organic compound detections per well, Central Arizona Basins study area, 1996–98. Detections per well equal number of volatile organic compound detections divided by number of samples with detections. Numbers in black are the number of samples with volatile organic compounds detected.

Samples from two wells—SV2 and SV9—contained two VOCs, one of which was PCE. PCE is a solvent and one of the most commonly detected VOCs in ground water in the United States (Squillace and others, 1999). SV2 is in a housing area where PCE is not likely used. SV9 is downgradient from a landfill that could be the source of PCE and dichlorodifluoromethane that also was detected in the sample from this well. The Babocomari River, which is a few hundred feet from SV9, may aid in the transport of compounds to ground water that flows to this well.

Developed Basins

Detections of VOCs in the West Salt River Valley and the Upper Santa Cruz Basin unexpectedly are similar to the results for ground water in the Sierra Vista subbasin. The presence of VOCs generally reflects the urban land uses in these basins. The largest number of detections occurred in ground-water and surface-water samples from the West Salt River Valley.

Upper Santa Cruz Basin

Detections of VOCs in the Upper Santa Cruz Basin indicate that activities in urban areas in this basin are affecting the ground-water and surface-water quality.

Detections of VOCs in ground water and surface water in the Nogales area support findings of previous studies conducted in this area (Marsh, 1994). Detections of VOCs in ground water near Tucson indicate that water quality is being affected by VOCs used on the land surface.

Eleven VOCs (of the analytical suite of 86) were detected in samples from 15 wells (52 percent) in the Upper Santa Cruz Basin (table 14; fig. 13). The most commonly detected VOC was trichloromethane, which was detected in seven samples; chloromethane and 1,4-dichlorobenzene were detected in five samples; PCE was detected in four samples; methylbenzene was detected in three samples; bromodichloromethane and 1,2-dichlorobenzene were detected in two samples; and trichlorofluoromethane, dichloro-difluoromethane, trichloroethene, and 1,2,4-trimethylbenzene were detected in one sample each. Twenty-four detections of 1,2,4-trimethylbenzene were the result of sample contamination; the compound was detected in field blanks during the same time period that it was detected in environmental samples. The concentration of PCE in one sample exceeded established limits of the USEPA (1996) and the State of Arizona (1996).

Table 14. Number of volatile organic compounds detected in ground-water and surface-water samples, Upper Santa Cruz Basin, Central Arizona Basins study area, 1996–98

Ground-water study name or surface-water site name	Medium sampled	Surface-water site number	Volatile organic compounds			
			Samples collected	Detections	Samples having detectable concentrations	Compounds detected
Upper Santa Cruz sub-unit survey	Ground water	---	29	32	15	11
Nogales Wash near the Nogales	Surface water	312314110565601	2	7	2	5
Downstream from Nogales International Wastewater Treatment Plant						
Santa Cruz River near Rio Rico, Arizona	Surface water	312809110592801	2	6	2	4
Santa Cruz River at Santa Gertrudis Lane	Surface water	313343110024701	2	3	1	3
Santa Cruz River at Tubac, Arizona	Surface water	09481740	2	6	2	4

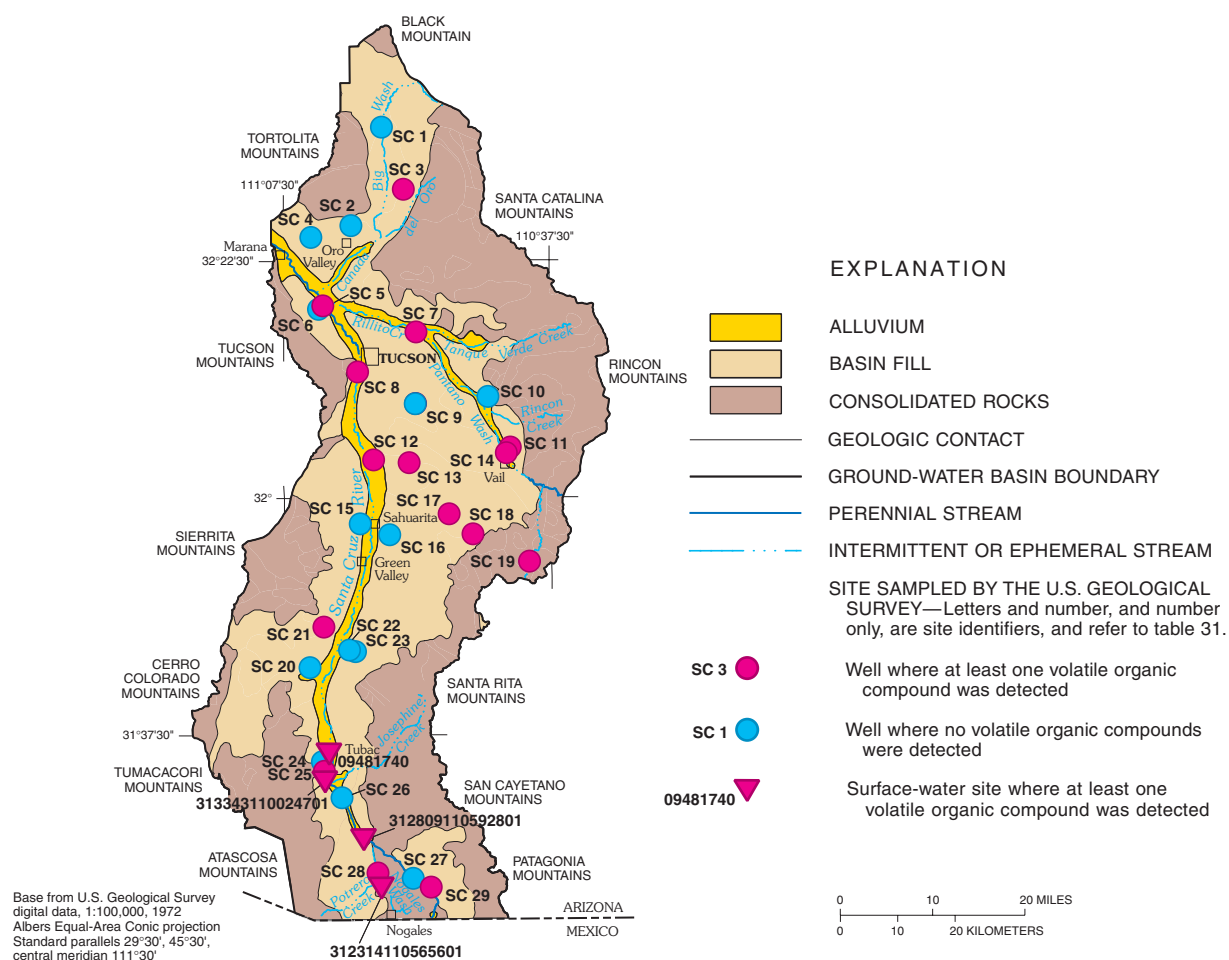


Figure 13. Locations of ground-water and surface-water sites where samples were collected for volatile organic compound analyses, Upper Santa Cruz River Basin, Central Arizona Basins study area.

Samples from wells SC5 (five VOCs detected), SC17 (four VOCs detected), and SC28 (five VOCs detected) had the most VOCs detected. The following VOCs were detected in samples from at least two wells: bromodichloromethane (SC17 and SC28), 1,4-dichlorobenzene (SC5 and SC17), trichloromethane (SC5, SC17, and SC28), PCE (SC5 and SC28), and 1,2-dichlorobenzene (SC5 and SC28). In addition, a sample from well SC28 also contained detectable concentrations of TCE. SC28 is no longer used because of the high PCE concentrations (Pat Clymer, Arizona Department of Environmental Quality, oral commun., 1999); the concentration of PCE in this sample, 5.48 µg/L, is above the aquifer water-quality standard of 5 µg/L (State of Arizona, 1996). According to Western Technologies, Inc. (1997), the source of PCE in this well is local to the area around the well. Well SC28 is at a produce shipping center near Nogales that is a high-traffic area for vehicles. Although the detection of PCE at well SC28 was the only detection of a VOC in ground water in this area, there is known ground-water contamination by VOCs, including TCE and many of its degradation products, in the Nogales area (Marsh, 1994). Well SC5 is downgradient from effluent releases in the Santa Cruz River and is about 1 mi west of the river. A landfill near the river (Marsh, 1994) could be a source of the VOCs detected in ground water from this well. Well SC17 is in a newly developed residential area that was used originally for rangeland. There are no obvious sources of VOCs near this well.

Samples from seven wells—SC5, SC8, SC12, SC17, SC19, SC25, and SC28—had detectable concentrations of trichloromethane. This compound is a solvent and a common byproduct of chlorinated drinking water, as well as a disinfection byproduct that may enter ground water through lawn irrigation, leaking water mains, and sewers (Squillace and others, 1999). Morrow (1999) linked trichloromethane in domestic wells to the use of bleach for disinfecting the wells; this practice also is used in Arizona (Doug Towne, hydrologist, Arizona Department of Environmental Quality, oral commun., 1999).

Detections of PCE also indicate that VOCs used at the land surface are reaching the ground water in this basin. PCE was detected in samples from wells SC5,

SC8, and SC28. Marsh (1994) lists many potential sources of PCE, as well as local use of solvents containing PCE.

Surface-water samples were collected during low-flow conditions at three sites along the Santa Cruz River and one site on Nogales Wash, which is tributary to the Santa Cruz River ([table 8](#)). Ten VOCs were detected in samples collected at all sites in November 1997 and June 1998—chloroform, toluene, benzene, chloromethane, dichloromethane, 1,4-dichlorobenzene, carbon disulfide, styrene, 4-isopropyl-1-methylbenzene, and methyl tert-butyl ether (MTBE). Concentrations were low for these VOCs; however, the detections indicate that there is some effect from urban activities upstream from the sampling sites near Nogales, Arizona.

West Salt River Valley

Detections of VOCs in ground-water and surface-water samples from the West Salt River Valley exceeded those for any other basin during 1996–98. Activities in the large urban area in this basin are the likely source of most of the VOCs. Several known ground-water contamination sites are in the West Salt River Valley (Marsh, 1994). Surface-water samples from the largest WWTP in the basin contained several VOCs, which probably derive from urban wastewater and the chemical reactions that occur during the wastewater-treatment processes. Surface-water samples from the Gila River at Buckeye Canal, downstream from the WWTP, contain fewer VOCs than samples from the WWTP. This difference could indicate that volatilization of compounds is occurring.

Ground Water

Eighteen VOCs were detected in 21 (70 percent) of the 30 wells sampled for VOCs in the West Salt River Valley SUS ([fig. 14](#); [table 15](#)). Most samples collected for this SUS were analyzed for 86 VOCs; samples collected before March 27, 1996, were analyzed for 60 VOCs, and the MRLs for these analyses were higher than the MRLs for analyses of samples collected after March 27. None of the detections of VOCs occurred in the five samples collected before March 27, 1996.

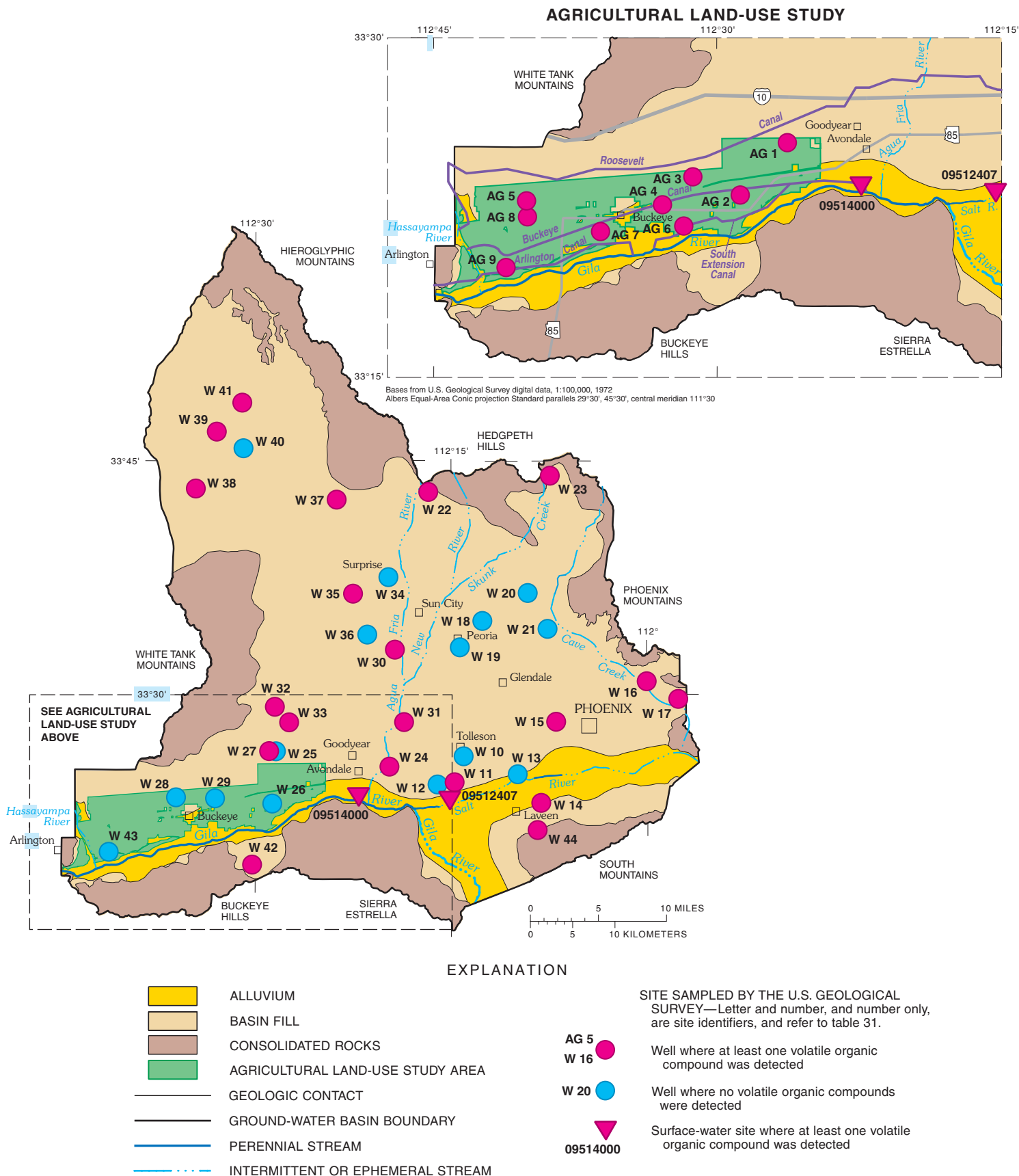


Figure 14. Locations of ground-water and surface-water sites where samples were collected for volatile organic compound analyses, West Salt River Valley, Central Arizona Basins study area.

Table 15. Number of volatile organic compounds detected in ground-water and surface-water samples, West Salt River Valley, Central Arizona Basins study area, 1996–98

[Dashes indicate that the information is not applicable. Data for agricultural land-use study represents two sampling efforts—August 1997 and February 1998]

Ground-water study name or Surface-water site name	Medium sampled	Surface-water site number	Volatile organic compounds			
			Samples collected	Detections	Samples with detections	Compounds
West Salt River Valley sub-unit survey	Ground water	---	30	44	21	18
Agricultural land-use study	Shallow ground water	---	18	46	18	10
91st Avenue Wastewater Treatment Plant outfall	Surface water	09512407	6	77	6	26
Gila River at Buckeye Canal	Surface water		5	34	5	15
Gila River above diversions at head of Buckeye Canal		09513990				
Buckeye Canal near Avondale		09514000				
Gila River at Estrella Parkway near Goodyear		09514100				

The most frequently detected VOC was 1,2,4-trimethyl-benzene, which was detected in eight samples. Chloromethane, carbon disulfide, and iodomethane were detected in four samples. Trichloromethane, TCE, and 1,4-dichlorobenzene were detected in three samples. Bromodichloromethane, PCE, 1,1-dichloro-ethane, and MTBE were detected in two samples; and benzene, trichlorofluoromethane, 1,1,1-trichloro-ethane, 1,1,2-trichloro-1,2,2-trifluoroethane, 1-chloro-2-methyl benzene, 1,1-dichloroethene, and acetone were each detected in one sample. Four detections of trichloromethane and dichloromethane, three detections of PCE and 1,4-dichlorobenzene, two detections of 1,2-dimethylbenzene, and one detection of acetone and ethylbenzene were not evaluated for this report because these compounds were detected in field blanks associated with the environmental samples.

The VOCs detected in ground water come from a variety of sources that are difficult to determine. 1,2,4-trimethylbenzene could be from various urban land-use areas because of the variety of sources for this compound. Chloromethane, carbon disulfide, and

iodomethane have natural and man-made sources that could contribute these compounds to the environment. Natural sources of chloromethane and carbon disulfide, such as fungus, forest fires, and volcanic gases (Harper, 1985; Inn and others, 1981; Palmer, 1976) could be contributing to the ground water. Chloromethane is manufactured for use as a refrigerant, methylating agent, dewaxing agent, and catalytic solvent in synthetic rubber production (U.S. Environmental Protection Agency, 1996). Rayon manufacturing is a source of manmade carbon disulfide (U.S. Environmental Protection Agency, 1994). Natural sources of iodomethane include microbial fermentation (Lovelock, 1975). Iodomethane is used as a methylating agent in organic synthesis and also is in exhaust gases from nuclear reactors (Howard, 1993).

MTBE is a fuel oxygenate added to improve air quality in metropolitan areas such as Phoenix (Pitzl, 1997). At least two wells owned by the City of Phoenix are no longer used because MTBE concentrations of 46 to 200 µg/L were measured in the ground water (Marsh, 1994). Sources of MTBE include point sources, such as leaking gasoline storage tanks, and nonpoint sources, such as precipitation and urban runoff (Squillace and others, 1998).

At least 4 VOCs were detected in 3 of the 21 wells that had detectable concentrations of VOCs (table 16). The VOCs detected in these wells are either refrigerants, solvents, or are used to make solvents. These detections may be typical for small-capacity wells in the metropolitan Phoenix area and are similar to detections in wells in previous studies (Marsh, 1994). Although only 3 wells had detectable concentrations of 4 or more VOCs, the large variety of VOCs and the large area where samples contained VOCs, indicate that much of the ground water in the West Salt River Valley is affected by human activities.

At least one VOC was detected in samples from each of the nine wells in the agricultural LUS area in August 1997 and February 1998. Eight different VOCs (of the analytical suite of 86) were detected a total of 23 times in samples collected in August 1997 and February 1998. Some detections of 1,4-dichlorobenzene, chloromethane, and 1,2,4-trimethylbenzene were not considered in this report because these compounds were detected in the field blanks associated with the environmental samples. Four detections of 1,4-dichlorobenzene in samples collected in August and three detections in samples collected in February were affected by sample contamination. Nine detections of chloromethane in samples collected in August and two detections of 1,2,4-trimethylbenzene in samples collected in February were affected by sample contamination.

The most frequently detected VOC was trichloromethane, which was detected in each of the nine wells during both sampling periods. Effluent water from the 91st Avenue WWTP is applied to fields near the nine wells; therefore, outflow from the WWTP could be the source of the trichloromethane.

Bromodichloromethane often is detected along with trichloromethane because it is also a byproduct of chlorinated drinking water. Bromodichloromethane was detected in wells AG1 and AG5. The source of this compound probably is outflow from the WWTP.

The second most commonly detected VOC in the LUS wells was PCE, which was detected in three wells in August 1997 and in five wells in February 1998. Four of the five wells where the compound was detected in February 1998 are downgradient from a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site at the Phoenix-Goodyear Airport. Ground water at this site is contaminated with TCE and PCE (Marsh, 1994). PCE and TCE were detected during both sampling periods. The CERCLA site may be the source of PCE and TCE in these wells; however, local use of the compounds also could be a source. All but one of these detections was below the MRL.

Dibromochloropropane (DBCP) was detected in one well in February 1998. This compound, although considered a VOC, was the first pesticide detected in ground water in Arizona (Daniel and others, 1988) and was applied to soils in citrus and cotton fields from the 1950s through the 1980s to control nematodes (Daniel and others, 1988; Brew and Baker, 1987). Daniel and others (1988) reported many detections of this compound throughout the West Salt River Valley, but the compound was detected only once during sampling of wells in the West Salt River Valley in 1996–98. The reason for the lack of detections during 1996–98 is unclear; possible reasons include degradation of the parent compound and (or) differences in sampling locations.

Table 16. Volatile organic compounds in water from three wells having the highest number of detections, West Salt River Valley, Central Arizona Basins study area, 1996–98

Well number	Number of volatile organic compounds detected	Volatile organic compounds
W15	4	Tetrachloroethene, trichloroethene, methyl tert-butyl ether, 1,1,2-trichloro-1,2,2-trifluoroethane
W16	5	Trichloroethene, methyl tert-butyl ether, bromodichloromethane, 1,1-dichloroethane, trichlorofluoromethane
W17	6	Trichloroethene, bromodichloromethane, 1,1-dichloroethane, 1,1-dichloroethene, 1,1,1-trichloroethane, carbon disulfide

Surface Water

Surface-water samples were collected at three sites in the West Salt River Valley for VOC analyses—91st Avenue WWTP outfall near Phoenix, Gila River at Buckeye Canal (09514000), and the Hassayampa River near Arlington ([table 15](#); [fig. 14](#)). A discussion of VOC results from the Hassayampa River is not included in this report because of the limited data available. None of the VOC concentrations in surface-water samples were above established limits of the USEPA (1996) or the State of Arizona (1996; [table 13](#), this report).

Twenty-six VOCs (of the analytical suite of 86) were detected in 6 samples collected at the 91st Avenue WWTP from June 1996 through April 1997. All of these samples were collected during low-flow conditions. Some detections of methyl-benzene, chlorobenzene, ethylbenzene, 1,4-dichlorobenzene, carbon disulfide, 1,2,4-trimethylbenzene, acetone, tetrahydrofuran, and 1,3- and 1,4-dimethylbenzene are not considered in this report because the same compounds were detected in the field blanks associated with the environmental samples. Of the 26 compounds, 5 were detected in each of the 6 samples—bromodichloromethane, dibromochloromethane, trichloromethane, PCE, and bromochloromethane. Bromodichloromethane, chlorodibromomethane, and trichloromethane are trihalomethanes (THMs); the presence of these compounds is an indication that chlorination processes may be affecting the surface-water quality (Squillace and others, 1999). PCE is a common VOC detected in ground water in this area. Bromochloromethane that is primarily used for organic synthesis was one of two VOCs identified as being unique in urban areas by Squillace and others (1999).

Fifteen VOCs (of the analytical suite of 86) were detected in the 5 samples collected at the Gila River at Buckeye Canal from June 1996 through April 1997. All of these samples were collected during low-flow conditions. Of the 15 compounds, trichloromethane was detected in all 5 samples. The fewer number of VOCs detected at this site compared with the number detected at the 91st Avenue WWTP indicates that the VOCs are volatilizing from the surface water as it travels downstream, or that dilution from other water inputs is affecting the concentration of these compounds.

Detections of VOCs in ground water and surface water are indications of the effects of human activities in the metropolitan Phoenix area on water quality. PCE in ground-water samples collected in the metropolitan Phoenix area and in surface-water samples collected at the 91st Avenue WWTP and the Gila River at Buckeye

Canal also is indicative of the effects of urban activities. These results are similar to results reported for the entire United States by Squillace and others (1999).

SUMMARY AND CONCLUSIONS

An assessment of pesticides and VOCs in ground water and surface water was completed in the CAZB study area for the USGS NAWQA program during 1996–98. Samples of ground water were collected from 121 wells, and samples of surface water were collected from 4 sites. Samples were collected from 121 wells and 3 surface-water sites for pesticide analyses, and samples were collected from 109 wells and 3 surface-water sites for VOC analyses. Pesticides have been used extensively in localized areas of the CAZB since the 1940s. VOCs have been used in industrial areas of the CAZB and have been detected in ground water, primarily in urban areas.

The study design for ground water included sampling in three ground-water basins. The West Salt River Valley and the Upper Santa Cruz Basin were included because ground water in those areas is used in large quantities, and ground-water quality has been, or has the potential to be, affected by human activities. The Sierra Vista subbasin was included to represent a minimally developed basin for comparison to the West Salt River Valley and the Upper Santa Cruz Basin. Results from the Sierra Vista subbasin provided information that can be used for the design and assessment of future monitoring. Two different types of ground-water studies were completed—SUSs to generally characterize the ground-water quality of an aquifer, and a LUS to characterize the ground-water quality beneath an agricultural area. Wells sampled for the SUSs were existing wells used for industrial, irrigation, stock, and municipal and domestic water supplies. In the West Salt River Valley, 35 of 64 wells sampled were used for evaluation of pesticides and VOCs. In the Upper Santa Cruz Basin, 29 wells were used, and in the Sierra Vista subbasin, 19 wells were used. For the agricultural LUS, 9 monitoring wells were installed and were sampled twice.

Surface-water sites sampled for pesticides and (or) VOCs were on four rivers in the CAZB—the San Pedro, Gila, Hassayampa, and Santa Cruz Rivers. One site was on the San Pedro River. A group of three sites was sampled at the Gila River at Buckeye Canal; one site was sampled at the outfall of the 91st

Avenue WWTP; and one site was sampled on the Hassayampa River near Arlington. Data from a group of four sites on the Santa Cruz River near Nogales that were sampled for another project also were used.

Detections of pesticides in ground water and surface water indicate that pesticides used in agricultural and urban areas are affecting the water quality. Twenty-eight percent of the wells sampled in the Upper Santa Cruz Basin and all surface-water samples collected from the Santa Cruz River and Nogales Wash had detectable concentrations of pesticides. Thirty-three percent of the wells sampled and nearly all the surface-water samples in the West Salt River Valley had detectable concentrations of pesticides. At least one pesticide was detected in all wells in the agricultural area of the West Salt River Valley. Pesticides applied for agricultural and urban uses were detected in the West Salt River Valley and the Upper Santa Cruz Basin. Pesticides detected in the Santa Cruz River and Nogales Wash were insecticides used in urban areas; the detections indicate effects of urban land use upstream. Pesticides detected in ground water from the agricultural area were those that were applied for agricultural and urban uses. Surface-water samples from the Gila River at Buckeye Canal and the Hassayampa River near Arlington contained pesticides used in agricultural and urban areas. Among the SUSs, the West Salt River Valley and the Upper Santa Cruz Basin had the largest number of detections per well for VOCs and pesticides. Ground water from each well in the agricultural LUS had one VOC detected. No pesticides were detected in ground-water or surface-water samples from the Sierra Vista subbasin.

Detections of VOCs in ground water and surface water indicate that the areas sampled are affected by VOCs; however, the concentrations are less than established water-quality limits. In the Sierra Vista subbasin, 74 percent of the wells sampled contained VOCs. This result was much higher than expected because the subbasin has a small amount of urban land use, and it indicates that ground water in localized areas of this subbasin is affected by human activities. No surface-water samples were collected in the Sierra Vista subbasin for VOC analyses. Fifty-two percent of the wells sampled in the Upper Santa Cruz Basin contained at least one VOC. Detections of VOCs in every surface-water sample from the Santa Cruz River and Nogales Wash indicate the effects of urban activities upstream. Seventy percent of the wells sampled in the West Salt River Valley contained at least one VOC, and all wells in the agricultural area contained at least one VOC. Surface-water samples

from the 91st Avenue WWTP and the Gila River at Buckeye Canal contained VOCs that can be related to urban land uses and well-chlorination processes.

Concentrations of pre-emergent pesticides detected at the Gila River at Buckeye Canal and the Hassayampa River near Arlington showed evidence of seasonal variability. Detections of DDE at the Gila River at Buckeye Canal also appeared to have some seasonal variability. Seasonal variability could be caused by irrigation-return flow that enters the canal from April through December. The detection of DDE in the Hassayampa River near Arlington throughout the year indicates that a transport mechanism operates all year.

Historical and present land-use activities appear to be affecting the quality of ground water and surface water in the areas sampled. The most prevalent indicator of the effects of historical agricultural land use are detections of DDE in ground water and surface water in the West Salt River Valley. Detections of atrazine and deethylatrazine in ground water from the Upper Santa Cruz Basin also indicate the effects of historical agriculture in this area. These compounds have not been used for decades in the areas where detections occurred. In the Tucson area, VOCs and pesticides associated with urban areas were detected in ground water. In the Nogales area, detections of VOCs and pesticides in ground water and surface water associated with urban areas indicate the effects of the urban land-use activities.

Detections of pesticides and VOCs in surface water and ground water are the most complex in the West Salt River Valley. The highest number of different pesticides and VOCs were detected in ground-water and surface-water samples from this basin. Detections of PCE and TCE in ground water and surface water are the most apparent indicators that urban land-use activities are affecting water quality.

The effects of present agriculture are best characterized by pesticides detected in ground water from the monitoring wells in the agricultural LUS and surface water from the Gila River at Buckeye Canal and the Hassayampa River near Arlington. Pesticides and VOCs detected at these sites also are indicators of urban land use. Pesticides primarily used in urban areas were detected in samples that also contained pesticides primarily used in agricultural areas. The complex mixture of pesticides in ground water and surface water is the direct result of the mixture of land uses and water-management practices in the West Salt River Valley. The reuse of water provides a mechanism for transport of pesticides and VOCs to areas that may not normally be affected by these compounds. A more

detailed study of the sources of water is required to better determine whether urban or agricultural land-use activities are the sources of specific compounds.

Concentrations of pesticides and VOCs generally are less than the current established water-quality limits. Potential health effects from the occurrence of several compounds in the same water are not well known, and more than one compound was detected in several ground-water and surface-water samples in this study. The detections of pesticides and VOCs are important because they indicate that the ground-water and surface-water resources in the CAZB study area are susceptible to contamination by human activities.

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QUALITY-ASSURANCE INFORMATION

Quality-assurance procedures were followed to minimize negative effects on environmental data. Quality-control samples were collected to quantify bias and variability in the environmental ground-water and surface-water data. Designs of the ground-water quality-assurance plan and quality-control sample collection for NAWQA are described in Koterba and others (1995). Designs of the surface-water quality-assurance plan and quality-control sample collection for NAWQA are described in Mueller and others (1997). Discussion of quality-assurance and quality-control samples in this section is limited to those samples associated with pesticide and VOC data. Several types of quality-control samples were used to evaluate the quality of the environmental data (table 17).

Systematic contamination was identified if a compound was detected in more than 50 percent of the field blanks collected during 1996–98. Contamination of a specific compound was considered if the concentration in the environmental sample was less than 10 times the median concentration of the field blanks (Tadayon and others, 1999). Sample populations for ground water and surface water were considered separately. For this report, sample contamination of VOCs was considered chronologically using results from field blanks. If a VOC was detected in a field

blank before collection of an environmental sample, detection of that VOC in the environmental sample was considered to be affected by sample contamination. The results of this approach do not take into account detection of a VOC in a source solution blank. Because it is possible that source solution blanks were contaminated during collection procedures in the field, it was difficult to determine the composition of the original source solution.

Ground Water

Quality-control samples used to evaluate pesticide and VOC data included field and equipment blanks, source solution blanks, PVC-wash samples, field-matrix spikes, laboratory-matrix spikes, laboratory-set spikes, and recoveries of surrogates (compounds at specific concentrations added to environmental samples to evaluate sampling and analytical processes). Source-solution blanks were used for VOC analyses only after June 1, 1997. To determine the quality of extraction techniques at the office laboratory, replicate pesticide samples were extracted and analyzed at the NWQL and compared to samples extracted at the office laboratory and analyzed at the NWQL.

Table 17. Quality-control samples collected in the Central Arizona Basins study area, 1996–98

Quality-control sample	Description
Field blank	A blank solution subjected to the same aspects of sample collection, field processing, preservation, transportation, and laboratory handling as an environmental sample.
Equipment blank	A blank solution processed in the office laboratory through all equipment used for collecting and processing an environmental sample.
Source-solution blank	A blank solution placed directly into sample containers in the field.
PVC-wash sample	Tap water used to rinse PVC casing before installation in monitoring wells.
Field-matrix spike	Replicate ground-water or surface-water samples that have a specific amount of a mixture (spike solution) added that contains several of the compounds to be analyzed.
Laboratory-matrix spike	Environmental samples that were spiked and extracted at the NWQL.
Laboratory-set spike	Reagent-grade water that contains spike solutions. For pesticide analyses 0.1 µL and 0.5 µL were used for GCMS and HPLC methods.
Concurrent replicates	Environmental samples collected from the same site by different sampling crews as close in time as possible.
Sequential replicates	A single environmental sample collected at one time that is split into multiple samples.
Canister blank	VOC-free water from the canister used to hold the VOC surface-water sampler.
Sampler blank	A blank collected after the canister blank. The sampler is submerged into the canister and a sample is collected from the sampler for VOC analyses.
Trip blank	A blank solution put in a sample container at the NWQL and kept with the set of environmental samples during storage, transport, and analysis.

Field blanks for ground water were collected at 16 and 18 sites for analyses of pesticides using HPLC and GCMS methods, respectively (table 18). Field blanks were collected by passing pesticide-free water through the sampling equipment subsequent to collection of the environmental samples and subsequent to cleaning of the sampling equipment. No pesticide compounds were detected in any of the 16 field blanks collected for HPLC analyses. GCMS methods detected DDE and dacthal at concentrations less than the MRLs at two sites and one site, respectively. These detections do not constitute systematic contamination and did not affect the ground-water pesticide data used in this report.

A total of 18 VOCs were detected in 18 ground-water field blanks; all 18 compounds were found in at least 1 of the 10 source-solution samples analyzed after June 1, 1997. Other than these detections, no VOCs were detected in more than 50 percent of field blanks (tables 19 and 20). Analysis of the occurrence of VOCs in field blanks and environmental samples resulted in the elimination of detections of trichloromethane, ethylbenzene, chloromethane, dichloromethane, tetrachloroethene, 1,4-dichlorobenzene, 1,2-dimethyl-benzene, 1,2,4-trimethylbenzene, and acetone from consideration during interpretation. Specific detections are discussed in the text of the report where appropriate.

Equipment blanks were collected from the Bennett submersible pump and other equipment used to sample ground water from the monitoring wells installed for the agricultural LUS. These samples were collected in the office before each of the sampling efforts in August 1997 and February 1998 to identify constituents or compounds that may be introduced to the environmental samples from the equipment. No pesticide compounds were detected in either of the equipment blanks (table 18). One VOC—1,2,4-trimethylbenzene—was detected in equipment blanks and the accompanying source-solution blanks. These detections did not affect interpretation of the environmental data.

Two PVC-wash samples had detectable concentrations of 25 different VOCs (table 21). Of these compounds, five also were detected in environmental samples from the nine monitoring wells. Of these five compounds, three—bromodichloromethane, chloromethane, and carbon disulfide—were detected three times or less in environmental samples from the monitoring wells and are not

considered an indication of sample contamination. Trichloromethane, which was detected in ground water from each of the nine monitoring wells and PVC-wash samples, was not detected in any field blank. Detections of trichloromethane in environmental samples from the monitoring wells, therefore, are not the result of contamination.

Field-matrix spikes were collected to provide information on the bias and variability of results due to field and laboratory techniques, the stability of compounds during typical sample holding times, and interference from the ground-water composition (matrix effects). The ground-water samples were spiked in the field during sample preservation.

Field-matrix spikes for pesticides in ground-water samples were collected and analyzed by HPLC and GCMS using 100 µL of spike solution. Median recoveries ranged from 56 to 158 percent for field-matrix spikes for GCMS analyses and from 14 to 101 percent for HPLC analyses (table 22). Median recoveries for 4 laboratory-matrix spikes for GCMS analyses ranged from 49 to 136 percent and for HPLC analyses ranged from 50 to 120 percent (table 22). The laboratory-set spikes indicated that the analytical performance of 10 pesticides is considered to be poor (Jeff Martin, hydrologist, USGS, written commun., 1999). For these 10 pesticides (table 22), recoveries of compounds in the spike solution are either extremely low or extremely high compared to the ideal recovery of 100 percent.

Comparison of the median recovery of the field-matrix spikes to the laboratory-matrix spikes and the laboratory-set spikes indicates any biases that may have occurred in the pesticide data because of field techniques and (or) matrix effects. Bias in the data was identified by comparing the difference between median recoveries for field-matrix spikes to the interquartile range (IQR) of the laboratory-matrix spikes and laboratory-set spikes. Bias due to field techniques was identified when the difference between median recoveries for field-matrix spikes and laboratory-matrix spikes exceeded the IQR of the laboratory-matrix spikes. The results for twenty-two compounds were considered to have some bias owing to field techniques (table 22). Bias because of matrix effects was identified when the difference between median recoveries for the field-matrix spikes and laboratory-set spikes was greater than the IQR of the laboratory-set spikes. Twenty compounds were considered to have some bias due to matrix effects. No adjustments were made to the

environmental data to compensate for any bias, but these results were considered during interpretation of the environmental data.

Surrogate compounds were added to environmental and quality control samples to provide information about matrix effects and gross sample-processing error. The surrogate compounds used are not normally found in environmental samples, but do behave like some of the compounds in the analysis. For interpretation, only results for surrogate compounds in environmental samples are discussed because they represent the variety of water types collected. For samples analyzed for pesticide compounds using GCMS, three surrogate compounds were used—diazinon-d10, terbuthylazine, and alpha-D6-1,2,3,4,5,6-hexachlorocyclohexane. In environmental ground-water samples collected during 1996–98, the median recoveries were 99 to 108 percent ([table 23](#)). For samples analyzed for pesticides using the HPLC method, one surrogate compound was used—4-bromo-3,5-dimethyl phenyl-n-methylcarbamate. The median recovery of this surrogate in all ground-water samples was 89.5 percent. No adjustments were made to ground-water pesticide data on the basis of surrogate recoveries.

Two types of spike solutions were used during the sampling period for VOC field-matrix spikes. Of the 26 field-matrix spikes completed for ground-water samples during 1996–98, 22 were spiked with a solution that contained 13 VOC compounds and 4 were spiked with a solution that contained 87 VOC compounds ([table 24](#)). Field-matrix spikes collected prior to June 1997 were spiked with 100 µL of spike solution; after June 1997, 20 µL of spike solution was used. The volume of spike solution was reduced to better evaluate the field and laboratory techniques at lower concentrations. Median recoveries of VOCs from field-matrix spikes ranged from 38 to 118 percent for individual compounds. One sample was spiked at the NWQL for 13 VOCs; recoveries for that sample were within one standard deviation of the median values for field-matrix spikes. Median recoveries of 2-propenal, chloromethane, and dichlorodifluoromethane in the field-matrix spikes were less than 60 percent. These recoveries indicate a possible negative bias in the data for these compounds owing to degradation or matrix effects. These compounds may not have been detected in ground-water samples if present in low concentrations. No adjustments were made to ground-water VOC data to compensate for this possible bias.

Three surrogate compounds were added to all VOC samples at the NWQL to evaluate matrix effects of sample-processing errors—1,4-bromofluorobenzene, 1,2-dichloroethane-d4, and toluene-d8. The median recoveries for these three compounds ranged from 95 to 106 percent ([table 23](#)). The recoveries for the VOC surrogate compounds indicate that the ground-water VOC data are acceptable.

Surface Water

Quality-control samples collected to evaluate surface-water pesticide data included field and equipment blanks, replicate samples, and two field-matrix spikes. Surface-water VOC data were evaluated using sampler blanks, canister blanks, source-solution blanks, and a trip blank. Quality-control samples for surface-water VOC data were collected at the 91st Avenue WWTP.

Seven pesticide field blanks were collected at four surface-water sites where pesticide samples were collected ([table 25](#)). Field blanks were collected before the environmental sample was collected by passing pesticide-free water through all surface-water sampling equipment. One field blank collected at the Hassayampa River near Arlington had a detectable concentration of DDE. No systematic contamination was identified for surface-water pesticide data.

Blank samples for VOCs in surface water included one sampler blank collected in June 1996 and a combination sampler and canister blank collected in January 1997. A source-solution blank also was collected in association with the sampler blank collected in the office laboratory in June 1996. In June 1996, all four compounds detected in the sampler blank collected also were detected in the associated source-solution blank ([table 26](#)). In January 1997, a sampler blank and a canister blank were collected. Analyses from the sampler and canister blanks were used to determine which surface-water samples were affected by sample contamination. Sample contamination was identified if a VOC was detected in a sampler or canister blank and if the concentration in the environmental samples was less than 10 times the concentration in the sampler or canister blank. Some detections of methylbenzene, chlorobenzene, ethylbenzene, 1,4-dichlorobenzene, carbon disulfide, 1,2,4-trimethylbenzene, acetone, and 1,3- and 1,4-dimethylbenzene were affected by sample contamination.

Surface-water field-matrix spikes were collected to evaluate pesticide and VOC sampling and analytical procedures. One field-matrix spike was collected to evaluate the surface-water VOC data, and two field-matrix spikes were collected to evaluate the surface-water pesticide data.

The field-matrix spikes for pesticides in surface-water samples included both analytical methods—HPLC and GCMS—using 100 µL of spike solution. Median recoveries for the GCMS method ranged from 0 to 318 percent, and median recoveries for the HPLC method ranged from 0 to 136 percent (table 27). Measurable recoveries of 75 compounds occurred in at least one field-matrix spike. When the median recoveries for the 75 compounds were compared to the median recoveries for the laboratory-set spikes (table 22), recoveries for 41 compounds were outside the IQR for the laboratory-set spikes. These results indicate that a bias owing to matrix effects could be affecting the recoveries of those compounds in surface-water samples. The small number of field-matrix spikes limits an evaluation of the bias; no adjustments were made to surface-water pesticide data on the basis of these results.

Median recoveries of surrogate pesticide compounds in surface-water samples analyzed using the GCMS method indicate no systematic problems with matrix effects or sample-processing errors. The median recoveries for the three surrogate compounds range from 100 to 151 percent (table 23). Recovery of the surrogate compound for pesticides analyzed using the HPLC method was 93 percent; this result indicates that the environmental samples are likely not affected by matrix effects or sample-processing errors. The surrogate compound for the HPLC method was added to 52 of the 73 samples analyzed for pesticides between December 1996 and April 1998; therefore, these results may not be indicative of all the environmental surface-water samples collected.

The field-matrix spikes for VOCs used 100 µL of spike solution that contained 13 VOC compounds (table 24). Recoveries for these 13 compounds ranged from 27 to 86 percent. Recoveries for all 13 compounds were less than the median recoveries for ground-water field-matrix spikes. Recoveries for most compounds were within the IQR of the field-matrix spikes for ground water except 1,2-dichloroethane and tribromomethane (table 24). This limited data could indicate that there is a bias towards lower values in surface-water samples analyzed for VOCs. Some VOCs

may not have been detected if present in low concentrations in some surface-water samples. Because only one VOC field-matrix spike was collected, this interpretation was not applied to environmental surface-water VOC data.

Recoveries for the three surrogate compounds used for VOC analyses indicate that matrix effects and sample-processing errors did not affect the environmental surface-water VOC data. The median recoveries for the three surrogate compounds range from 99.5 to 105 percent (table 23), and are considered acceptable in this report.

Replicate samples were collected and analyzed to evaluate the variability in pesticide compound concentrations caused by differences in sample collection, processing procedures, and analytical techniques. Concurrent replicates were collected at the Gila River at Buckeye Canal and the Hassayampa River near Arlington during March and July 1997. Each of the concurrent samples was split into two split-replicate samples (table 28). Evaluation of these replicates identified variability due to sample collection procedures by comparing the difference between split replicates to the difference between concurrent replicates. Two additional split replicates were collected at both sites (table 29). Three of the split-replicate samples were used to determine if any difference existed between samples extracted at the NWQL and samples extracted at the office laboratory. Only one compound was detected in the replicates of those analyzed by the HPLC method; because of the limited data, the performance of this method could not be evaluated.

For evaluation of the concurrent replicates, detections of 17 compounds can be considered. Median values of differences between concurrent replicate samples ranged from 2 to 18 percent. Variability due to differences in sampling techniques can be evaluated using data from concurrent replicates. For evaluation of split replicates, detections of 21 compounds can be evaluated. Median values of differences between split replicates ranged from 3 to 33 percent. Variability due to differences in processing and analytical procedures can be evaluated using data from split replicates. For the 17 compounds that were detected in both types of replicate samples, variability due to differences in processing and analytical procedures appears to be greater than variability due to sampling techniques. For most compounds, the median percent difference between concurrent and replicate samples was less than

5 percent; the difference was more than 5 percent for one compound—pendimethalin. For this compound, some variation in concentrations may be due to differences in sampling procedures.

For split-replicate samples, six compounds have median differences greater than 10 percent—cyanazine, DDE, deethylatrazine, gamma-HCH, prometon, and simazine. Variation in the concentrations of these compounds could be due to differences in processing and analytical procedures; this was considered during interpretation of these data. By comparing concentrations of these compounds in samples from the Hassayampa River near Arlington with concentrations in samples from the Gila River at Buckeye Canal, it was determined that processing and analytical procedures were the causes for differences.

Two split replicates were collected at the 91st Avenue WWTP to determine variability of VOC concentrations. Concentration data for 36 of the 86 compounds analyzed could be used in this analysis ([table 26](#)). The median percent differences for the 14 compounds that have measurable, nonestimated concentrations ranged from 2 to 178. The range for all compounds with measurable values (both estimated and nonestimated) was 0 to 186 percent. These results indicate that variability in the environmental samples may be due to differences in sampling and analytical procedures and not variations in environmental conditions. Because only 14 VOCs in two split replicates could be evaluated, it is difficult to determine the application of these results to the environmental data.

QUALITY-ASSURANCE DATA

Table 18. Pesticide and pesticide-degradation compounds detected in field and equipment blanks for ground-water samples, Central Arizona Basins study area, 1996–98

[Site identifier (see table 31). Concentrations in micrograms per liter unless otherwise indicated. Dashes indicate data are not available. Bold type indicates results where the compound was present in sample. FB, field blank; EB, equipment blank; <, less than]

Constituent	Site identifier																			
	W12	W13	W45	AG3	W61	AG5	W30	W63	W41	W65	AG6	W47	AG9	SC11	SV16	SC21	SV8	SC28	Office Blanks	
Sample date	4-10-97	6-17-97	6-18-97	8-28-97	3-7-96	2-3-98	5-6-97	4-26-96	4-17-96	2-15-96	2-11-98	9-9-97	8-21-97	5-13-98	9-17-97	6-3-98	6-25-96	7-9-98	8-18-97	2-2-98
Blank type	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	EB
Acetochlor	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Acifluorfen	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	---	<0.035	---	<0.035	<0.035	<0.035
Alachlor	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Aldicarb	<0.55	<0.55	<0.55	<0.55	<0.55	<0.55	<0.55	<0.55	<0.55	<0.55	<0.55	<0.55	<0.55	<0.55	---	<0.55	---	<0.55	<0.55	<0.55
Aldicarb sulfone	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	---	<1	---	<1	<1	<1
Aldicarb sulfoxide	<0.021	<0.021	<0.021	<0.021	<0.021	<0.021	<0.021	<0.021	<0.021	<0.021	<0.021	<0.021	<0.021	<0.021	---	<0.021	---	<0.021	<0.021	<0.021
Atrazine	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Azinphos-methyl	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Benfluralin	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Bentazon	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	---	<0.014	---	<0.014	<0.014	<0.014
Bromacil	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	---	<0.035	---	<0.035	<0.035	<0.035
Bromoxynil	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	---	<0.035	---	<0.035	<0.035	<0.035
Butylate	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Carbaryl ²	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Carbaryl ³	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	---	<0.008	---	<0.008	<0.008	<0.008
Carbofuran ²	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Carbofuran ³	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	---	<0.12	---	<0.12	<0.12	<0.12
Chloramben	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	---	<0.42	---	<0.42	<0.42	<0.42
Chlorothalonil	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	---	<0.035	---	<0.035	<0.035	<0.035
Chlorpyrifos	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Clpyralid	<0.23	<0.23	<0.23	<0.23	<0.23	<0.23	<0.23	<0.23	<0.23	<0.23	<0.23	<0.23	<0.23	<0.23	---	<0.23	---	<0.23	<0.23	<0.23
Cyanazine	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
2,4-D	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	---	<0.15	---	<0.15	<0.15	<0.15
Dacthal	<0.002	<0.002	¹ 0.000858	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Dacthal mono-acid	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	---	<0.017	---	<0.017	<0.017	<0.017
2,4-DB	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	---	<0.24	---	<0.24	<0.24	<0.24
p,p'-DDE	<0.006	<0.006	<0.006	¹ 0.0013	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
Deethylatrazine	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Diazinon	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Dicamba	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	---	<0.035	---	<0.035	<0.035	<0.035

See footnotes at end of table.

Table 18. Pesticide and pesticide-degradation compounds in field and equipment blanks for ground-water samples, Central Arizona Basins study area, 1996–98—Continued

Constituent	Site identifier																QA		QA Blank
	W12	W13	W45	AG3	W61	AG5	W30	W63	W41	W65	AG6	W47	AG9	SC11	SV16	SC21	SV8	SC28	
Dichlobenil	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	---	<1.2	---	<1.2	---	<1.2	<1.2
Dichlorprop	<.032	<.032	<.032	<.032	<.032	<.032	<.032	<.032	<.032	<.032	<.032	<.032	<.032	<.032	---	<.032	---	<.032	<.032
Dieldrin	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
2,6-Diethylaniline	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003
Dinoseb	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	---	<.035	---	<.035	<.035
Disulfoton	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017
Diuron	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02	---	<.02	---	<.02	---	<.02	<.02
DNOC	<.42	<.42	<.42	<.42	<.42	<.42	<.42	<.42	<.42	<.42	<.42	<.42	<.42	<.42	---	<.42	---	<.42	<.42
EPTC	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002
Ethalfuralin	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004
Ethoprop	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003
Fenuron	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	---	<.013	---	<.013	<.013
Flumeturon	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	---	<.035	---	<.035	<.035
Fonofos	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003
alpha-HCH	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002
gamma-HCH	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004
B-Hydroxycarbofuran	<.014	<.014	<.014	<.014	<.014	<.014	<.014	<.014	<.014	<.014	<.014	<.014	<.014	<.014	---	<.014	---	<.014	<.014
Linuron ²	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002
Linuron ³	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	---	<.018	---	<.018	<.018
MCPA	<.17	<.17	<.17	<.17	<.17	<.17	<.17	<.17	<.17	<.17	<.17	<.17	<.17	<.17	---	<.17	---	<.17	<.17
MCPB	<.14	<.14	<.14	<.14	<.14	<.14	<.14	<.14	<.14	<.14	<.14	<.14	<.14	<.14	---	<.14	---	<.14	<.14
Malathion	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005
Methiocarb	<.026	<.026	<.026	<.026	<.026	<.026	<.026	<.026	<.026	<.026	<.026	<.026	<.026	<.026	---	<.026	---	<.026	<.026
Methomyl	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017	---	<.017	---	<.017	<.017
Methyl parathion	<.006	<.006	<.006	<.006	<.006	<.006	<.006	<.006	<.006	<.006	<.006	<.006	<.006	<.006	<.006	<.006	<.006	<.006	<.006
Metolachlor	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002
Meribuzin	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004
Molinate	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004
Napropamide	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003
Neburon	<.015	<.015	<.015	<.015	<.015	<.015	<.015	<.015	<.015	<.015	<.015	<.015	<.015	<.015	---	<.015	---	<.015	<.015
Norflurazon	<.024	<.024	<.024	<.024	<.024	<.024	<.024	<.024	<.024	<.024	<.024	<.024	<.024	<.024	---	<.024	---	<.024	<.024
Oryzalin	<.31	<.31	<.31	<.31	<.31	<.31	<.31	<.31	<.31	<.31	<.31	<.31	---	<.31	---	<.31	---	<.31	<.31
Oxamyl	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	---	<.018	---	<.018	<.018
Pebulate	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004
Parathion	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004

See footnotes at end of table.

Table 18. Pesticide and pesticide-degradation compounds in field and equipment blanks for ground-water samples, Central Arizona Basins study area, 1996–98—Continued

Constituent	Site identifier															QA					
	W12	W13	W45	AG3	W61	AG5	W30	W63	W41	W65	AG6	W47	AG9	SC11	SV16	SC21	SV8	SC28	Blank	QA	
Pendimethalin.....	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	
cis-Permethrin.....	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	
Phorate.....	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	
Picloram.....	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	---	<.05	---	<.05	<.05	<.05	
Prometon.....	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	
Pronamide.....	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	
Propachlor.....	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	
Propanil.....	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	
Propargite.....	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	
Propam.....	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	---	<.035	---	<.035	<.035	<.035	
Propoxur.....	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	---	<.035	---	<.035	<.035	<.035	
Silvex.....	<.021	<.021	<.021	<.021	<.021	<.021	<.021	<.021	<.021	<.021	<.021	<.021	<.021	<.021	---	<.021	---	<.021	<.021	<.021	
Simazine.....	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	
2,4,5-T.....	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	---	<.035	---	<.035	<.035	<.035	
Tebuthiuron.....	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	
Terbacil.....	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	
Terbufos.....	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	
Thiobencarb.....	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	
Triallate.....	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	
Triclopyr.....	<.25	<.25	<.25	<.25	<.25	<.25	<.25	<.25	<.25	<.25	<.25	<.25	<.25	<.25	---	<.25	---	<.25	<.25	<.25	
Trifluralin.....	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	
Surrogate recoveries (percent)																					
BDMC.....	91	97	90	172	80	70	68	160	80	---	73	97	79	93	---	72	---	69	81	69	
Diazinon-D10.....	94	95	96	98	90	99	96	109	100	100	85	95	97	112	95	120	100	96	97	102	
Terbutylazine.....	86	111	115	120	94	108	108	123	113	111	96	107	115	93	105	127	117	95	103	108	
Alpha-HCH-D6.....	108	103	107	115	90	89	94	105	100	100	99	91	106	104	88	106	105	96	98	91	

¹Estimated.

²Compound analyzed by chromatography/mass spectrometry.

³Compound analyzed by high-performance liquid chromatography

Table 19. Volatile organic compounds detected in field blanks for ground-water samples collected March 7 to September 17, 1996, Central Arizona Basins study area

[Dashes indicate data are not available. Bold type indicates results where the compound was present in sample.]

Constituent	Well name					
	W65	W61	W41	SV8	SV13	SV16
Sample date	2-15-96	3-7-96	4-17-96	6-25-96	8-14-96	9-17-96
Source solution lot number	95228	95228	95228	95228	95304	95304
Dibromomethane	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1
Bromodichloromethane	<.2	<.2	¹.01	<.1	<.1	<.1
Tetrachloromethane	<.2	<.2	<.05	<.05	<.05	<.05
1,2-Dichloroethane	<.2	<.2	<.05	<.05	<.05	<.05
Tribromomethane	<.2	<.2	<.2	<.2	<.2	<.2
Dibromochloromethane	<.2	<.2	<.1	<.1	<.1	<.1
Trichloromethane	<.2	<.2	¹ .04	¹ .04	¹ .12	<.08
Methylbenzene	<.2	<.2	<.05	<.05	<.05	<.05
Benzene	<.2	<.2	<.05	<.05	<.05	<.05
2-Propenal	---	---	<.2	<.2	<.2	<.2
2-Propenenitrile	---	---	<.2	<.2	<.2	<.2
Chlorobenzene	<.2	<.2	¹.01	<.05	<.05	<.05
Chloroethane	<.2	<.2	<.1	<.1	<.1	<.1
Ethylbenzene	<.2	<.2	<.05	<.05	<.05	<.05
1,1,1,2,2,2-Hexa-chloroethane	---	---	<.05	<.05	<.05	<.05
Bromomethane	<.2	<.2	<.1	<.1	<.1	<.1
Chloromethane	<.2	<.2	<.2	<.2	<.2	<.2
Dichloromethane	<.2	<.2	<.1	<.1	<.1	<.1
Tetrachloroethene	<.2	<.2	<.05	<.05	<.05	<.05
Trichlorofluoromethane	<.2	<.2	<.1	<.1	<.1	<.1
1,1-Dichloroethane	<.2	<.2	<.05	<.05	<.05	<.05
1,1-Dichloroethene	<.2	<.2	<.1	<.1	<.1	<.1
1,1,1-Trichloroethane	<.2	<.2	<.05	<.05	<.05	<.05
1,1,2-Trichloroethane	<.2	<.2	<.1	<.1	<.1	<.1
1,1,2,2-Tetrachloroethane	<.2	<.2	<.1	<.1	<.1	<.1
1,2-Dichlorobenzene	<.2	<.2	<.05	<.05	<.05	<.05
1,2-Dichloropropane	<.2	<.2	¹.02	<.05	<.05	<.05
trans-1,2-Dichloroethene	<.2	<.2	<.05	<.05	<.05	<.05
1,2,4-Trichlorobenzene	<.2	<.2	<.2	<.2	<.2	<.2
1,3-Dichlorobenzene	<.2	<.2	<.05	<.05	<.05	<.05
1,4-Dichlorobenzene	<.2	<.2	<.05	<.05	<.05	<.05
Dichlorodifluoromethane	<.2	<.2	<.2	<.2	<.2	<.2
Naphthalene	<.2	<.2	<.2	<.2	<.2	<.2
trans-1,3-Dichloropropane	<.2	<.2	<.1	<.1	<.1	<.1
cis-1,3-Dichloropropene	<.2	<.2	<.1	<.1	<.1	<.1
Chloroethene	<.2	<.2	<.1	<.1	<.1	<.1

See footnote at end of table.

Table 19. Volatile organic compounds detected in field blanks for ground-water samples collected March 7 to September 17, 1996, Central Arizona Basins study area—Continued

Constituent	Well name					
	W65	W61	W41	SV8	SV13	SV16
Trichloroethene	<.2	<.2	<.05	<.05	<.05	<.05
Hexachlorobutadiene	<.2	<.2	<.2	<.2	<.2	<.2
Methyl acrylate	---	---	<.2.	<.2.	<.2.	<.2.
1,2,3,4-Tetramethylbenzene	---	---	<.05	<.05	<.05	<.05
1,2,3,5-Tetramethylbenzene	---	---	<.05	<.05	<.05	<.05
Bromoethene	---	---	<.1	<.1	<.1	<.1
Ethyl-tert-butyl ether	---	---	<0.1	<0.1	<0.1	<0.1
tert-Amyl methyl ether	---	---	<.1	<.1	<.1	<.1
trans-1,4-Dichloro-2-butene	---	---	<.5.	<.5.	<.5.	<.5.
Ethyl methacrylate	---	---	<1.	<1.	<1.	<1.
Carbon disulfide	---	---	¹ .006	<.05	<.05	<.05
Vinyl acetate	---	---	<.5.	<.5.	<.5.	<.5.
cis-1,2-Dichloroethene	<0.2	<0.2	<.05	<.05	<.05	<.05
2-Hexanone	----	----	<.5.	<.5.	<.5.	<.5.
Ethenylbenzene	<.2	<.2	<.05	<.05	<.05	<.05
1,2-Dimethylbenzene	---	---	<.05	<.05	<.05	<.05
1,1-Dichloropropene	<.2	<.2	<.05	<.05	<.05	<.05
2,2-Dichloropropane	<.2	<.2	<.05	<.05	<.05	<.05
1,3-Dichloropropane	<.2	<.2	<.05	<.05	<.05	<.05
2-Ethyltoluene	---	---	<.05	<.05	<.05	<.05
1,2,3-Trimethylbenzene	---	---	<.05	<.05	<.05	<.05
1,2,4-Trimethylbenzene	<.2	<.2	¹ .01	¹ .05	.11	¹ .05
(1-Methylethyl)benzene	<.2	<.2	<.05	<.05	<.05	<.05
n-Propylbenzene	<.2	<.2	<.05	<.05	<.05	<.05
1,3,5-Trimethylbenzene	<.2	<.2	<.05	<.05	<.05	<.05
1-Chloro-2-methylbenzene	<.2	<.2	<.05	<.05	<.05	<.05
1-Chloro-4-methylbenzene	<.2	<.2	<.05	<.05	<.05	<.05
Bromochloromethane	<.2	<.2	<.1	<.1	<.1	<.1
n-Butylbenzene	<.2	<.2	<.05	<.05	<.05	<.05
(1-Methylpropyl)benzene	<.2	<.2	<.05	<.05	<.05	<.05
(1,1-Dimethylethyl)benzene	<.2	<.2	<.05	<.05	<.05	<.05
1-Isopropyl-4-methylbenzene	<.2	<.2	<.05	<.05	<.05	<.05
Iodomethane	---	---	<.05	<.05	<.05	<.05
1,2,3-Trichloropropane	<.2	<.2	<.2	<.2	<.2	<.2
1,1,1,2-Tetrachloroethane	<.2	<.2	<.05	<.05	<.05	<.05
1,2,3-Trichlorobenzene	<.2	<.2	<.2	<.2	<.2	<.2
1,2-Dibromomethane	<.2	<.2	<.1	<.1	<.1	<.1
1,1,2-Trichloro-1,2,2-trifluoroethane	<.2	<.2	<.05	<.05	<.05	<.05
Methyl tert-butyl ether	<.2	<.2	<.1	<.1	<.1	<.1
3-Chloro-1-propene	---	---	<.1	<.1	<.1	<.1

See footnote at end of table.

Table 19. Volatile organic compounds detected in field blanks for ground-water samples collected March 7 to September 17, 1996, Central Arizona Basins study area—Continued

Constituent	Well name					
	W65	W61	W41	SV8	SV13	SV16
4-Methyl-2-pentanone	---	---	<5.	<5.	<5.	<5.
Xylenes	<.2	<.2	---	---	---	---
Acetone	----	----	8.3	<5.	<5.	<5.
Bromobenzene	<.2	<.2	<.05	<.05	<.05	<.05
Diethyl ether	---	---	<.1	<.1	<.1	<.1
Diisopropyl ether	---	---	<.1	<.1	<.1	<.1
Methyl acrylonitrile	---	---	<2.	<2.	<2.	<2.
2-Butanone	---	---	¹ 4	<5.	<5.	<5.
Methyl methacrylate	---	---	<1.	<1.	<1.	<1.
Tetrahydrofuran	---	---	¹ 6	<5.	<5.	<5.
1,2-Dibromo-3-chloropropane	<1.	<1.	<.5	<.5	<.5	<.5
1,3-Dimethylbenzene and 1,4-Dimethylbenzene	---	---	<.05	<.05	<.05	<.05

¹Estimated.

Table 20. Volatile organic compounds detected in field blanks, source-solution blanks, and equipment blanks for ground-water samples collected October 1, 1996, to July 9, 1998, Central Arizona Basins study area

[Site identifier (see [table 31](#)): FB, field blank; SSB source-solution blank; EB, equipment blank. Dashes indicate data are not available. Concentrations in micrograms per liter unless otherwise noted. Bold type indicates results where compound was present in sample. Office blanks were prepared in the field office in Tempe, Arizona]

Constituent	Site Identifier													
	W12	W20	W30	W45	AG9	AG3	AG5	AG6	SC11	SC21	SC28	Office Blanks		
Sample date	4-10-97	4-24-97	5-6-97	6-18-97	8-21-97	8-28-97	2-3-98	2-11-98	5-13-98	6-3-98	7-9-98	8-18-97	2-2-98	
Source solution lot number.....	96151	96151	96151	96151	97045	97045	97149	97149	37220	37220	37220	97045	97149	
Blank type.....	FB	FB	FB	SSB	FB	SSB	SSB	SSB	FB	SSB	FB	SSB	EB	
Dibromomethane	<0.1	<0.1	<0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Bromodichloromethane	<1	<1	<1	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48
Tetrachloromethane	<0.5	<0.5	<0.5	<0.88	<0.88	<0.88	<0.88	<0.88	<0.88	<0.88	<0.88	<0.88	<0.88	<0.88
1,2-Dichloroethane	<0.5	<0.5	<0.5	<1.34	<1.34	<1.34	<1.34	<1.34	<1.34	<1.34	<1.34	<1.34	<1.34	<1.34
Tribromomethane	<2	<2	<2	<1.04	<1.04	<1.04	<1.04	<1.04	<1.04	<1.04	<1.04	<1.04	<1.04	<1.04
Dibromochloromethane	<1	<1	<1	<1.82	<1.82	<1.82	<1.82	<1.82	<1.82	<1.82	<1.82	<1.82	<1.82	<1.82
Trichloromethane.....	1.05	1.04	1.04	1.04	<0.52	<0.52	<0.52	<0.52	<0.52	<0.52	<0.52	<0.52	<0.52	<0.52
Methylbenzene	4.47	<0.5	<0.5	<0.38	<0.38	<0.38	1.01	<0.38	<0.38	1.027	<0.38	<0.38	<0.38	<0.38
Benzene	<0.5	<0.5	<0.5	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32
2-Propenal.....	<2	<2	<2	<1.43	<1.43	<1.43	<2.50	<2.50	<2.50	<2.50	<2.50	<2.50	<2.50	<2.50
2-Propenenitrile	<2	<2	<2	<1.23	<1.23	<1.23	<1.23	<1.23	<1.23	<1.23	<1.23	<1.23	<1.23	<1.23
Chlorobenzene.....	1.02	1.02	1.02	1.02	<0.28	<0.28	<0.28	<0.28	<0.28	<0.28	<0.28	<0.28	<0.28	<0.28
Chloroethane.....	<1	<1	<1	<1.20	<1.20	<1.20	<1.20	<1.20	<1.20	<1.20	<1.20	<1.20	<1.20	<1.20
Ethylbenzene.....	1.03	1.02	1.02	1.03	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
1,1,1,2,2,2-Hexa-chloroethane ...	<0.5	<0.5	<0.5	<3.62	<3.62	<3.62	<3.62	<3.62	<3.62	<3.62	<3.62	<3.62	<3.62	<3.62
Bromomethane	<1	<1	<1	<1.48	<1.48	<1.48	<1.48	<1.48	<1.48	<1.48	<1.48	<1.48	<1.48	<1.48
Chloromethane	<2	<2	<2	<2.54	1.01	1.1	1.09	1.08	1.1	<2.54	<2.54	1.124	1.119	<2.54
Dichloromethane	<1	<1	1.03	<3.82	<3.82	<3.82	<3.82	<3.82	<3.82	<3.82	<3.82	<3.82	<3.82	<3.82
Tetrachloroethene	1.008	<0.5	<0.5	1.006	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38
Trichlorofluoromethane.....	<1	<1	<1	<0.92	<0.92	<0.92	<0.92	<0.92	<0.92	<0.92	<0.92	<0.92	<0.92	<0.92
1,1,1,1-Dichloroethane	<0.5	<0.5	<0.5	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66
1,1,1-Dichloroethene	<1	<1	<1	<0.44	<0.44	<0.44	<0.44	<0.44	<0.44	<0.44	<0.44	<0.44	<0.44	<0.44
1,1,1,1-Trichloroethane	<0.5	<0.5	<0.5	<0.32	<0.32	<0.32	<0.32	1.021	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32
1,1,1,2-Trichloroethane	<1	<1	<1	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
1,1,2,2-Tetrachloroethane	<1	<1	<1	<1.32	<1.32	<1.32	<1.32	<1.32	<1.32	<1.32	<1.32	<1.32	<1.32	<1.32
1,2-Dichlorobenzene	<0.5	<0.5	<0.5	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48
1,2-Dichloropropane.....	<0.5	1.01	<0.5	1.01	<0.68	<0.68	<0.68	<0.68	<0.68	<0.68	<0.68	<0.68	<0.68	<0.68
trans-1,2-Dichloroethene.....	<0.5	<0.5	<0.5	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32
1,2,4-Trichlorobenzene.....	<2	<2	<2	<1.88	<1.88	<1.88	<1.88	<1.88	<1.88	<1.88	<1.88	<1.88	<1.88	<1.88
3-Dichlorobenzene	<0.5	<0.5	<0.5	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54

See footnote at end of table.

Table 20. Volatile organic compounds detected in field blanks, source-solution blanks, and equipment blanks for ground-water samples collected October 1, 1996, to July 9, 1998, Central Arizona Basins study area—Continued

Constituent	Well name												
	W12	W20	W30	W45	AG9	AG3	AG5	AG6	SC11	SC21	SC28	QABlank	QA Blank
1,4-Dichlorobenzene	1.02	1.02	<0.5	<0.5	<0.5	1.06	1.02	<0.5	<0.5	<0.5	<0.5	1.01	<0.5
Dichlorodifluoromethane	<0.2	<0.2	<0.2	<0.096	<0.096	<0.096	<0.096	<0.096	<0.096	<0.096	<0.138	<0.096	<0.096
Naphthalene	<2	<2	<2	<250	<250	<250	<250	<250	<250	<250	<250	<250	<250
trans-1,3-Dichloropropane	<1	<1	<1	<134	<134	<134	<134	<134	<134	<134	<134	<134	<134
cis-1,3-Dichloropropene	<1	<1	<1	<092	<092	<092	<092	<092	<092	<092	<092	<092	<092
Chloroethene	<1	<1	<1	<112	<112	<112	<112	<112	<112	<112	<112	<112	<112
Trichloroethene	<0.5	<0.5	<0.5	<038	<038	<038	<038	<038	<038	<038	<038	<038	<038
Hexachlorobutadiene	<2	<2	<2	<142	<142	<142	<142	<142	<142	<142	<142	<142	<142
Methyl acrylate	<2	<2	<2	<612	<612	<612	<612	<612	<612	<612	<1,357	<612	<612
1,2,3,4-Tetramethyl-benzene	<0.5	<0.5	<0.5	<230	<230	<230	<230	<230	<230	<230	<230	<230	<230
1,2,3,5-Tetramethyl-benzene	<0.5	<0.5	<0.5	<240	<240	<240	<240	<240	<240	<240	<240	<240	<240
Bromoethene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Ethyl-tert-butyl ether	<1	<1	<1	<054	<054	<054	<054	<054	<054	<054	<054	<054	<054
tert-Amyl methyl ether	<1	<1	<1	<112	<112	<112	<112	<112	<112	<112	<112	<112	<112
trans-1,4-Dichloro-2-butene	<5	<5	<5	<692	<692	<692	<692	<692	<692	<692	<692	<692	<692
Ethyl methacrylate	<1	<1	<1	<278	<278	<278	<278	<278	<278	<278	<278	<278	<278
Carbon disulfide	<0.5	1.01	<0.5	<08	<08	<08	<08	<08	<08	<08	<37	<08	<08
Vinyl acetate	<5	<5	<5	<038	<038	<038	<038	<038	<038	<038	<038	<038	<038
cis-1,2-Dichloroethene	<0.5	<0.5	<0.5	<038	<038	<038	<038	<038	<038	<038	<038	<038	<038
2-Hexanone	<5	<5	<5	<746	<746	<746	<746	<746	<746	<746	<746	<746	<746
Etherylbenzene	1.02	1.01	<0.5	1.01	<042	<042	<042	<042	<042	<042	<042	<042	<042
1,2-Dimethylbenzene	1.02	1.01	1.01	1.02	<064	<064	<064	<064	<064	<064	<064	<064	<064
1,1-Dichloropropene	<0.5	<0.5	<0.5	<026	<026	<026	<026	<026	<026	<026	<026	<026	<026
2,2-Dichloropropane	<0.5	<0.5	<0.5	<078	<078	<078	<078	<078	<078	<078	<078	<078	<078
1,3-Dichloropropane	<0.5	<0.5	<0.5	<116	<116	<116	<116	<116	<116	<116	<116	<116	<116
2-Ethyltoluene	<0.5	<0.5	<0.5	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
1,2,3-Trimethylbenzene	<0.5	<0.5	<0.5	<124	<124	<124	<124	<124	<124	<124	<124	<124	<124
1,2,4-Trimethylbenzene	<0.5	<0.5	<0.5	1.01	1.04	1.03	1.03	1.025	<056	1.016	0.921	1.06	1.025
(1-Methylethyl)benzene	<0.5	<0.5	<0.5	<032	<032	<032	<032	<032	<032	<032	<032	<032	<032
n-Propylbenzene	<0.5	<0.5	<0.5	<042	<042	<042	<042	<042	<042	<042	<042	<042	<042
1,3,5-Trimethylbenzene	<0.5	<0.5	<0.5	<044	<044	<044	<044	<044	<044	<044	<044	<044	<044
1-Chloro-2-methylbenzene	<0.5	<0.5	<0.5	<042	<042	<042	<042	<042	<042	<042	<042	<042	<042
1-Chloro-4-methylbenzene	<0.5	<0.5	<0.5	<056	<056	<056	<056	<056	<056	<056	<056	<056	<056
n-Butylbenzene	<0.5	<0.5	<0.5	<186	<186	<186	<186	<186	<186	<186	<186	<186	<186

See footnote at end of table.

Table 20. Volatile organic compounds detected in field blanks, source-solution blanks, and equipment blanks for ground-water samples collected October 1, 1996, to July 9, 1998, Central Arizona Basins study area—Continued

Constituent	Well name											
	W12	W20	W30	W45	AG9	AG3	AG5	AG6	SC11	SC21	SC28	QA Blank
Bromochloromethane	<1	<1	<1	<0.44	<0.44	<0.44	<0.44	<0.44	<0.44	<0.44	<0.44	<0.44
(1-Methylpropyl)benzene	<0.05	<0.05	<0.05	<0.048	<0.048	<0.048	<0.048	<0.048	<0.048	<0.048	<0.048	<0.048
(1,1-Dimethylethyl)benzene	<0.5	<0.5	<0.5	<0.96	<0.96	<0.96	<0.96	<0.96	<0.96	<0.96	<0.96	<0.96
1-Isopropyl-4-methylbenzene	<0.5	<0.5	<0.5	<1.10	<1.10	<1.10	<1.10	<1.10	<1.10	<1.10	<1.10	<1.10
Iodomethane	<0.5	<0.5	<0.5	<0.76	<0.76	<0.76	<0.76	<0.76	<0.76	<0.76	<0.76	<0.76
1,2,3-Trichloropropane	<2	<2	<2	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
1,1,1,2-Tetrachloroethane	<0.5	<0.5	<0.5	<0.44	<0.44	<0.44	<0.44	<0.44	<0.44	<0.44	<0.44	<0.44
1,2,3-Trichlorobenzene	<2	<2	<2	<2.66	<2.66	<2.66	<2.66	<2.66	<2.66	<2.66	<2.66	<2.66
1,2-Dibromomethane	<1	<1	<1	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36
1,1,2-Trichloro-1,2,2-trifluoroethane	<0.5	<0.5	<0.5	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32
Methyl tert-butyl ether	<1	<1	<1	<1.12	<1.12	<1.12	<1.12	<1.12	<1.12	<1.12	<1.12	<1.12
3-Chloro-1-propene	<1	<1	<1	<1.96	<1.96	<1.96	<1.96	<1.96	<1.96	<1.96	<1.96	<1.96
4-Methyl-2-pentanone	<5	<5	<5	<3.74	<3.74	<3.74	<3.74	<3.74	<3.74	<3.74	<3.74	<3.74
Acetone	<5	<5	2.54	<4.90	<4.90	<4.90	<4.90	<4.90	1.28	<4.90	<4.90	<4.90
Bromobenzene	<0.5	<0.5	<0.5	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36
Diethyl ether	<1	<1	<1	<1.70	<1.70	<1.70	<1.70	<1.70	<1.70	<1.70	<1.70	<1.70
Diisopropyl ether	<1	<1	<1	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98
Methyl acrylonitrile	<2	<2	<2	<5.70	<5.70	<5.70	<5.70	<5.70	<5.70	<5.70	<5.70	<5.70
2-Butanone	1.01	<5	1.7	<1.65	<1.65	<1.65	<1.65	<1.65	<1.65	<1.65	<1.65	<1.65
Methyl methacrylate	<1	<1	<1	<3.35	<3.35	<3.35	<3.35	<3.35	<3.35	<3.35	<3.35	<3.35
Tetrahydrofuran	1.36	1.43	1.42	1.1	<1.15	<1.15	<1.15	<1.15	<1.15	<1.15	<1.15	<1.15
1,2-Dibromo-3-chloropropane	<5	<5	<5	<2.14	<2.14	<2.14	<2.14	<2.14	<2.14	<2.14	<2.14	<2.14
1,3-Dimethylbenzene & 1,4-Dimethylbenzene	1.04	1.03	1.02	1.03	<0.64	<0.64	<0.64	1.012	<0.64	<0.64	<0.64	<0.64

¹Estimated.

Table 21. Volatile organic compounds detected in trip blanks and polyvinyl chloride wash samples for ground-water samples, Central Arizona Basins study area, 1996–98

[Site identifier (see [table 31](#)); TB, Trip blank; PVC, polyvinyl-chloride wash. Concentrations are in micrograms per liter unless otherwise indicated. Dashes indicate data are not available. Bold type indicates results where the compound was present in sample.]

Constituent	Site identifier			
	SV13	W34	SC11	AG5
Sample date	8-14-96	5-5-97	5-13-98	7-26-97
Blank type	TB	TB	TB	PVC
Dibromomethane	<0.1	<0.1	<0.05	¹ 0.01
Bromodichloromethane	<.1	<.1	<.048	¹ .01
Tetrachloromethane	<.05	<.05	<.088	<.088
1,2-Dichloroethane	<.05	<.05	<.134	<.134
Tribromomethane	<.2	<.2	<.104	1.31
Dibromochloromethane	<.1	<.1	<.182	¹ .06
Trichloromethane	<.05	<.05	<.052	¹ .05
Methylbenzene	<.05	<.05	¹.029	¹ .06
Benzene	<.05	<.05	<.032	¹ .03
2-Propenal	<2.	<2.	---	<1.43
2-Propenenitrile	<2.	<2.	<1.23	<1.23
Chlorobenzene	<.05	<.05	<.028	<.028
Chloroethane	<.1	<.1	<.120	<.120
Ethylbenzene	<.05	<.05	<.03	¹ .01
1,1,1,2,2,2-Hexa-chloroethane	<.05	<.05	<.362	<.362
Bromomethane	<.1	<.1	<.148	<.148
Chloromethane	<.2	<.2	<.254	<.254
Dichloromethane	<.1	<.1	<.382	<.382
Tetrachloroethene	<.05	<.05	<.038	<.038
Trichlorofluoromethane	<.1	<.1	<.092	<.092
1,1-Dichloroethane	<.05	<.05	<.066	<.066
1,1-Dichloroethene	<.1	<.1	<.044	<.044
1,1,1-Trichloroethane	<.05	<.05	<.032	<.032
1,1,2-Trichloroethane	<.1	<.1	<.064	<.064
1,1,2,2-Tetrachloroethane	<.1	<.1	<.132	<.132
1,2-Dichlorobenzene	<.05	<.05	<.048	<.048
1,2-Dichloropropane	<.05	<.05	<.068	<.068
trans-1,2-Dichloroethene	<.05	<.05	<.032	<.032
1,2,4-Trichlorobenzene	<.2	<.2	<.188	<.188
1,3-Dichlorobenzene	<.05	<.05	<.054	<.054
1,4-Dichlorobenzene	¹.07	<.05	<.05	<.05
Dichlorodifluoromethane	<.2	<.2	<.096	<.096
Naphthalene	<.2	<.2	<.250	<.250
trans-1,3-Dichloropropane	<.1	<.1	<.134	<.134
cis-1,3-Dichloropropene	<.1	<.1	<.092	<.092
Chloroethene	<.1	<.1	<.112	<.112
Trichloroethene	<.05	<.05	<.038	<.038
Hexachlorobutadiene	<.2	<.2	<.142	<.142
Methyl acrylate	<2.	<2.	<.612	<.612
1,2,3,4-Tetramethylbenzene	<.05	<.05	<.230	<.230
1,2,3,5-Tetramethylbenzene	<.05	<.05	<.240	<.240
Bromoethene	<.1	<.1	<.1	<.1
Ethyl-tert-butyl ether	<.1	<.1	<.054	<.054

See footnote at end of table.

Table 21. Volatile organic compounds detected in trip blanks and polyvinyl chloride wash samples for ground-water samples, Central Arizona Basins study area, 1996-98—Continued

Constituent	Site identifier				
	SV13	W34	SC11	AG5	
tert-Amyl methyl ether	<0.1	<0.1	<0.112	<0.112	<0.112
trans-1,4-Dichloro-2-butene	<5.	<5.	<.692	<.692	<.692
Ethyl methacrylate	<1.	<1.	<.278	<.278	<.278
Carbon disulfide	<.05	<.05	<.08	¹ .02	<.08
Vinyl acetate	<5.	<5.	---	---	---
cis-1,2-Dichloroethene	<.05	<.05	<.038	<.038	<.038
2-Hexanone	<5.	<5.	<.746	<.746	<.746
Ethenylbenzene	<.05	<.05	<.042	<.042	<.042
1,2-Dimethylbenzene	<.05	<.05	<.064	¹ .02	¹ .01
1,1-Dichloropropene	<.05	<.05	<.026	<.026	<.026
2,2-Dichloropropane	<.05	<.05	<.078	<.078	<.078
1,3-Dichloropropane	<.05	<.05	<.116	<.116	<.116
2-Ethyltoluene	<.05	<.05	<.1	<.1	¹ .05
1,2,3-Trimethylbenzene	<.05	<.05	<.124	<.124	¹ .03
1,2,4-Trimethylbenzene	<.05	<.05	<.056	¹ .02	.185
(1-Methylethyl)benzene	<.05	<.05	<.032	<.032	<.032
n-Propylbenzene	<.05	<.05	<.042	<.042	¹ .02
1,3,5-Trimethylbenzene	<.05	<.05	<.044	<.044	¹ .02
1-Chloro-2-methylbenzene	<.05	<.05	<.042	<.042	<.042
1-Chloro-4-methylbenzene	<.05	<.05	<.056	<.056	<.056
Bromochloromethane	<.1	<.1	<.044	<.044	<.044
n-Butylbenzene	<.05	<.05	<.186	<.186	<.186
(1-Methylpropyl)benzene	<.05	<.05	<.048	<.048	<.048
(1,1-Dimethylethyl)benzene	<.05	<.05	<.096	<.096	<.096
1-Isopropyl-4-methylbenzene	<.05	<.05	<.110	¹ .008	<.11
Iodomethane	<.05	<.05	<.076	<.076	¹ .1
1,2,3-Trichloropropane	<.2	<.2	<.07	<.07	<.07
1,1,1,2-Tetrachloroethane	<.05	<.05	<.044	<.044	<.044
1,2,3-Trichlorobenzene	<.2	<.2	<.266	<.266	<.266
1,2-Dibromomethane	<.1	<.1	<.036	<.036	<.036
1,1,2-Trichloro-1,2,2-trifluoroethane	<.05	<.05	<.032	<.032	<.032
Methyl tert-butyl ether	<.1	<.1	<.112	¹ .08	¹ .04
3-Chloro-1-propene	<.1	<.1	<.196	<.196	<.196
4-Methyl-2-pentanone	<5.	<5.	<.374	<.374	2.12
Acetone	<5.	<5.	<4.90	¹ 11.	¹ 24.
Bromobenzene	<.05	<.05	<.036	<.036	<.036
Diethyl ether	<.1	<.1	<.170	<.170	<.170
Diisopropyl ether	<.1	<.1	<.098	<.098	<.098
Methyl acrylonitrile	<.2	<.2	<.570	<.570	<.570
2-Butanone	<5.	<5.	<1.65	<1.65	<1.65
Methyl methacrylate	<1.	<1.	<.35	<.35	<.35
Tetrahydrofuran	<5.	<5.	<1.15	<1.15	<1.15
1,2-Dibromo-3-chloropropane	<.5	<.5	<.214	<.214	<.214
1,3-Dimethylbenzene and 1,4-Dimethylbenzene	<.05	<.05	<.064	¹ .05	<.064

¹Estimated.

Table 22. Percent recovery statistics for pesticides and pesticide-degradation compounds detected in field-matrix and laboratory-spike samples for ground-water samples and in laboratory set-spike samples, Central Arizona Basins study area, 1996–98

[Concentrations are in micrograms per liter unless otherwise indicated. Dashes indicate no data available. Compounds in **bold** font may be affected by matrix effects; compounds shaded may be affected by field techniques; n, number of samples; IQR, interquartile range; FMS–LS, field-matrix spike sample median minus the laboratory-spike sample median; FMS–SS, field-matrix spike median minus the set-spike median; GCMS, gas chromatography/mass spectrometry; HPLC, high-performance liquid chromatography; WATSTORE, National Water Data Storage Retrieval System]

Pesticide	WATSTORE Code	Analysis method	Percent recovery											
			Field-matrix spike samples				Laboratory-spike samples				Set spikes ¹		Relative difference	
			n	Range	Median	IQR	n	Range	Median	IQR	Median	IQR	FMS–LS	FMS–SS
Acetochlor	49260	GCMS	21	81–120	109	8	4	84–109	104	6	102	12	5	12
Acifluorfen	49315	HPLC	22	57–117	87	12	3	85–118	94	17	88	11	7	1
Alachlor	46342	GCMS	21	87–118	109	7	4	93–113	106	14	102	11	3	7
Aldicarb ²	49312	HPLC	16	30–94	61	32	3	29–84	77	28	43	28	21	41
Aldicarb sulfone ²	49313	HPLC	22	0–51	14	33	3	49–76	58	14	60	16	76	77
Aldicarb sulfoxide ²	49314	HPLC	22	0–103	60	46	3	63–150	120	43	90	25	50	33
Atrazine	39632	GCMS	21	80–118	102	13	4	89–112	104	8	100	11	3	2
Azinphos-methyl	82686	GCMS	21	43–729	100	59	4	48–113	99	18	80	56	1	25
Benfluralin	82673	GCMS	21	36–102	78	32	4	72–94	83	21	67	21	6	16
Bentazon	38711	HPLC	20	60–94	78	12	3	73–92	76	9	80	13	3	3
Bromacil	04029	HPLC	22	65–102	85	20	3	71–99	90	14	82	15	6	3
Bromoxynil	49311	HPLC	22	12–101	84	10	3	82–87	82	2	85	11	3	1
Butylate	04028	GCMS	21	86–121	101	9	4	85–104	95	11	89	9	6	13
Carbaryl ²	82680	GCMS	21	51–491	158	138	4	106–207	129	36	126	74	23	26
Carbaryl	49310	HPLC	20	47–97	79	8	3	72–94	80	11	88	12	2	11
Carbofuran ²	82674	GCMS	21	68–267	130	76	4	103–170	130	21	113	37	0	15
Carbofuran	49309	HPLC	22	69–121	82	21	3	67–110	99	22	83	15	17	1
Chloramben	49307	HPLC	16	0–95	47	70	1	88	---	---	70	18	---	33
Chloro-thalonil ²	49306	HPLC	20	0–58	25	20	3	19–87	56	34	36	20	54	30
Chlorpyrifos	38933	GCMS	21	68–107	93	23	4	82–104	84	7	90	12	11	4
Clopyralid	49305	HPLC	21	0–68	25	61	3	67–81	77	7	77	19	67	67
Cyanazine	04041	GCMS	21	28–132	107	24	4	37–123	109	31	103	25	1	4
2,4-D	39732	HPLC	20	46–99	82	9	3	67–89	79	11	86	12	4	4
Dacthal	82682	GCMS	21	91–125	110	20	4	92–127	113	9	103	13	3	7
Dacthal mono-acid	49304	HPLC	22	60–107	88	5	3	85–90	86	2	83	11	2	6
2,4-DB	38746	HPLC	22	8–121	74	14	3	71–83	73	6	81	16	2	8
p,p'-DDE	34653	GCMS	21	50–119	75	23	4	51–103	55	17	58	13	37	29
Deethyl-atrazine ²	04040	GCMS	21	27–85	56	23	4	36–79	49	12	45	18	14	24
Diazinon	39572	GCMS	21	62–105	94	13	4	62–94	87	13	88	12	8	7
Dicamba	38442	HPLC	22	15–103	73	28	3	68–86	77	9	82	12	4	11
Dichlobenil ²	49303	HPLC	13	4–90	58	10	3	43–72	63	14	48	38	8	21

See footnotes at end of table.

Table 22. Percent recovery statistics for pesticides and pesticide-degradation compounds detected in field-matrix and laboratory-spike samples for ground-water samples and in laboratory set-spike samples, Central Arizona Basins study area, 1996–98—Continued

Pesticide	WATSTORE Code	Analysis method	Percent recovery											
			Field matrix spike samples				Laboratory spike samples				Set spikes ¹		Relative difference	
			n	Range	Median	IOR	n	Range	Median	IOR	Median	IOR	FMS-LS	FMS-SS
Dichlorprop	49302	HPLC	22	54–100	81	12	3	86–95	92	4	85	12	12	5
Dieldrin	39381	GCMS	21	82–128	101	11	4	74–91	86	9	81	16	17	24
2,6-Diethyl-aniline	82660	GCMS	21	67–106	93	11	4	84–104	90	7	85	9	3	9
Dinoseb	49301	HPLC	20	63–95	82	7	3	81–83	82	1	81	14	0	2
Disulfoton	82677	GCMS	21	37–112	81	29	4	78–104	86	11	73	23	6	11
Diuron	49300	HPLC	13	31–130	85	10	3	79–99	80	10	88	13	6	4
DNOC²	49299	HPLC	22	0–73	52	19	3	19–56	50	18	39	19	4	34
EPTC	82668	GCMS	21	70–107	94	16	4	78–105	88	12	90	9	7	4
Ethalfuralin	82663	GCMS	21	52–133	93	38	4	87–123	105	33	78	23	12	19
Ethoprop	82672	GCMS	21	63–119	102	12	4	73–106	97	18	95	17	5	7
Fenuron	49297	HPLC	22	68–94	84	13	3	80–103	84	12	89	11	0	5
Fluometuron	38811	HPLC	22	73–109	87	11	3	79–101	92	11	93	18	5	6
Fonofos	04095	GCMS	21	63–103	92	6	4	89–96	94	3	88	13	1	5
<i>alpha</i> -HCH	34253	GCMS	12	82–121	102	13	1	83	---	---	90	13	---	13
<i>gamma</i> -HCH	39341	GCMS	21	81–120	99	19	4	82–108	90	13	92	15	10	8
3-Hydroxy-carbo-furan	49308	HPLC	22	49–106	74	21	3	59–111	78	26	76	13	6	3
Linuron	82666	GCMS	21	82–221	116	41	4	67–118	98	22	101	29	18	14
Linuron	38478	HPLC	20	58–99	80	12	3	78–105	95	14	85	10	16	6
MCPA	38482	HPLC	22	37–99	70	22	3	55–71	66	8	84	13	7	17
MCPB	38487	HPLC	22	21–93	69	17	3	68–78	75	5	77	15	9	11
Malathion	39532	GCMS	21	71–111	99	18	4	87–123	98	16	95	22	1	4
Methiocarb	38501	HPLC	22	47–93	75	16	3	71–90	77	9	85	14	3	12
Methomyl	49296	HPLC	22	64–99	88	18	3	71–103	103	16	90	16	15	3
Methyl parathion	82667	GCMS	21	50–240	99	60	4	86–132	103	12	89	27	4	11
Metolachlor	39415	GCMS	21	95–166	120	10	4	80–123	110	22	106	16	9	13
Metribuzin	82630	GCMS	21	69–111	88	25	4	78–128	95	17	78	18	7	13
Molinate	82671	GCMS	21	70–107	95	10	4	88–103	97	7	94	8	2	1
Napropamide	82684	GCMS	21	86–127	97	11	4	85–98	94	3	94	15	3	3
Neburon	49294	HPLC	22	0–98	72	25	3	76–105	77	15	85	13	7	16
Norflurazon	49293	HPLC	20	72–112	86	25	3	79–101	98	11	88	12	12	2
Oryzalin	49292	HPLC	18	21–77	65	20	3	56–105	105	25	75	22	38	13
Oxamyl	38866	HPLC	22	29–76	64	13	3	62–90	66	14	77	13	4	17
Parathion	39542	GCMS	21	49–127	93	46	4	98–123	105	17	93	22	12	0
Pebulate	82669	GCMS	21	69–120	99	15	4	87–105	92	5	90	8	8	8
Pendimeth-alin	82683	GCMS	21	35–120	93	32	4	85–94	92	4	73	24	0	27
cis-Per-methrin	82687	GCMS	21	29–115	60	15	4	30–66	63	14	45	19	4	34

See footnotes at end of table.

Table 22. Percent recovery statistics for pesticides and pesticide-degradation compounds detected in field-matrix and laboratory-spike samples for ground-water samples and in laboratory set-spike samples, Central Arizona Basins study area, 1996–98—Continued

Pesticide	WATSTORE Code	Analysis method	Percent recovery											
			Field matrix spike samples				Laboratory spike samples				Set spikes ¹		Relative difference	
			n	Range	Median	IQR	n	Range	Median	IQR	Median	IQR	FMS–LS	FMS–SS
Phorate	82664	GCMS	21	41–112	82	22	4	75–94	83	13	72	19	0	14
Picloram	49291	HPLC	21	17–93	76	30	3	41–90	80	25	81	13	4	6
Prometon	04037	GCMS	21	74–129	103	20	4	88–107	92	12	71	43	11	45
Pronamide	82676	GCMS	12	69–109	91	26	1	106	---	---	89	14	---	2
Propachlor	04024	GCMS	21	95–113	105	7	4	93–138	112	27	105	14	6	0
Propanil	82679	GCMS	21	74–123	109	15	4	103–113	112	4	108	17	3	1
Propargite	82685	GCMS	21	49–145	88	33	4	61–109	68	21	71	23	30	24
Propham	49236	HPLC	17	50–96	62	13	2	67–80	73	7	68	21	16	9
Propoxur	38538	HPLC	22	60–230	78	21	3	64–91	88	14	73	11	11	7
Silvex	39762	HPLC	22	35–96	84	13	3	83–86	84	2	88	13	0	4
Simazine	04035	GCMS	21	77–119	103	8	4	93–111	102	8	101	13	1	2
2,4,5-T	39742	HPLC	16	84–127	101	26	3	81–89	82	4	82	11	22	23
Tebuthiuron	82670	GCMS	21	75–141	103	45	4	129–163	136	17	116	39	24	11
Terbacil ²	82665	GCMS	21	58–120	89	17	4	78–116	98	18	80	29	9	11
Terbufos	82675	GCMS	21	54–110	92	13	4	83–90	84	3	76	18	9	21
Thiobencarb	82681	GCMS	21	72–120	107	11	4	96–113	103	4	100	15	4	7
Triallate	82678	GCMS	21	64–122	94	13	4	87–104	92	6	89	14	2	5
Triclopyr	49235	HPLC	20	47–98	77	25	3	43–72	53	14	79	12	46	2
Trifluralin	82661	GCMS	21	37–111	77	33	4	75–104	90	27	71	23	14	9

¹Source: J.D. Martin, hydrologist, U.S. Geological Survey, written commun., 1999.

²Analytical performance for this compound is considered poor (J.D. Martin, hydrologist, U.S. Geological Survey, written commun., 1999).

Table 23. Percent recovery statistics for surrogate compounds for pesticides and volatile organic compounds detected in ground-water and surface-water samples, Central Arizona Basins study area, 1996–98

Compound name	Percent recovery for environmental ground-water samples				Percent recovery for environmental and replicate surface-water samples			
	Number of samples	Minimum	Maximum	Median	Number of samples	Minimum	Maximum	Median
Surrogate compounds for pesticides analyzed by gas chromatography/mass spectrometry								
Terbutylazine	108	3	221	108	73	96	303	151
alpha-HCH-D6	108	3	220	100	73	69	154	99
Diazinon-D10	108	3	200	99	73	75	165	100
Surrogate compound for pesticides analyzed by high-performance liquid chromatography								
BDMC	90	54	117	89.5	73	52	214	93
Surrogate compounds for volatile organic compounds								
1,2-Dichloroethane-d4	88	90	125	106	12	98	114	105
Toluene-d8	88	94	111	99	12	98	101	99.5
1,4-Bromofluorobenzene	88	79	122	95	12	97	105	100

Table 24. Percent recovery statistics for volatile organic compounds detected in field-matrix spike samples for ground-water and surface-water samples, Central Arizona Basins study area, 1996–98

[Dashes indicate no data available; n, number of samples; WATSTORE, National Water Data Storage Retrieval System]

Volatile organic compound	WATSTORE code	Ground-water samples				Surface-water sample	
		n	Range of recoveries, in percent	Median recovery, in percent	Interquartile range	n	Recovery, in percent
Dibromomethane	30217	4	81–89	85	7	0	---
Bromodichloromethane	32101	25	69–160	96	30	1	86
Dibromochloromethane	32105	25	67–137	96	20	1	83
Trichloromethane	32106	4	81–153	118	69	0	---
Methylbenzene	34010	4	90–96	90	2	0	---
Chlorobenzene	34301	4	83–88	86.5	3	0	---
Tetrachloroethene	34475	25	44–192	91	57	1	76
1,4-Dichlorobenzene	34571	25	54–153	86	38	1	67
Carbon disulfide	77041	4	72–88	80	4	0	---
Bromochloromethane	77297	4	82–87	84.5	4	0	---
Tetrachloromethane	32102	25	44–192	87	39	1	63
1,2-Dichloroethane	32103	25	76–160	100	26	1	71
Tribromomethane	32104	25	75–137	99	19	1	73
Benzene	34030	4	84–88	85.5	3	0	---
2-Propenal	34210	4	35–41	37.5	2	0	---
2-Propenenitrile	34215	4	84–92	87	7	0	---
Chloroethane	34311	4	66–82	74.5	4	0	---
Ethylbenzene	34371	25	51–160	86	39	1	68
1,1,1,2,2,2-Hexachloroethane	34396	4	86–89	86.5	2	0	---
Bromomethane	34413	4	68–82	74.5	10	0	---
Chloromethane	34418	4	38–73	49.5	17	0	---
Dichloromethane	34423	4	94–102	100.5	3	0	---
Trichlorofluoromethane	34488	4	66–78	73.5	4	0	---
1,1-Dichloroethane	34496	4	84–90	88	3	0	---
1,1-Dichloroethene	34501	25	34–192	80	26	1	58
1,1,1-Trichloroethane	34506	25	51–176	91	28	1	67
1,1,2-Trichloroethane	34511	4	86–95	92.5	5	0	---
1,1,2,2-Tetrachloroethane	34516	4	89–99	92.5	3	0	---
1,2-Dichlorobenzene	34536	4	87–96	88.5	3	0	---
1,2-Dichloropropane	34541	4	82–88	85	6	0	---
trans-1,2-Dichloroethene	34546	4	83–90	87.5	3	0	---
1,2,4-Trichlorobenzene	34551	4	78–84	81	3	0	---
1,3-Dichlorobenzene	34566	4	85–90	86.5	4	0	---
Dichlorodifluoromethane	34668	4	36–97	53.5	28	0	---
Naphthalene	34696	4	61–88	74	26	0	---
trans-1,3-Dichloropropene	34699	4	80–90	82.5	6	0	---
cis-1,3-Dichloropropene	34704	4	81–88	84.5	4	0	---
Chloroethene	39175	25	0–223	64	44	1	27

Table 24. Percent recovery statistics for volatile organic compounds detected in field-matrix spike samples for ground-water and surface-water samples, Central Arizona Basins study area, 1996–98—Continued

Volatile organic compound	WATSTORE code	Ground-water samples				Surface-water sample	
		n	Range of recoveries, in percent	Median recovery, in percent	Inter-quartile range	n	Recovery, in percent
Trichloroethene	39180	25	52–192	93	43	1	69
Hexachlorobutadiene	39702	4	83–86	84	1	0	---
Methyl acrylate	49991	4	79–91	84	3	0	---
1,2,3,4-Tetramethylbenzene	49999	---	---	---	---	0	---
1,2,3,5-Tetramethylbenzene	50000	4	68–74	71	3	0	---
Bromoethene	50002	4	72–84	79	6	0	---
Ethyl-tert-butyl ether	50004	4	77–85	81	7	0	---
tert-Amyl methyl ether	50005	4	77–82	79.5	5	0	---
trans-1,4-Dichloro-2-butene	73547	4	78–88	79	4	0	---
Ethyl methacrylate	73570	4	72–80	75.5	6	0	---
Vinyl acetate	77057	---	---	---	---	0	---
cis-1,2-Dichloroethene	77093	4	82–88	85.5	4	0	---
2-Hexanone	77103	4	88–99	90.5	5	0	---
Ethenylbenzene	77128	4	81–89	83.5	3	0	---
1,2-Dimethylbenzene	77135	4	89–94	90	3	0	---
1,1-Dichloropropene	77168	4	85–90	86	3	0	---
2,2-Dichloropropane	77170	4	60–65	64	1	0	---
1,3-Dichloropropane	77173	4	88–95	91.5	4	0	---
2-Ethyltoluene	77220	4	85–92	89	3	0	---
1,2,3-Trimethylbenzene	77221	4	92–101	97.5	3	0	---
1,2,4-Trimethylbenzene	77222	4	90–93	91.5	2	0	---
(1-Methylethyl)benzene	77223	4	85–91	86.5	4	0	---
n-Propylbenzene	77224	4	83–88	85	4	0	---
1,3,5-Trimethylbenzene	77226	4	83–90	88	5	0	---
1-Chloro-2-methylbenzene	77275	4	84–88	86	3	0	---
1-Chloro-4-methylbenzene	77277	4	81–88	83	3	0	---
n-Butylbenzene	77342	4	75–78	76.5	2	0	---
(1-Methylpropyl)benzene	77350	4	84–88	85	3	0	---
(1,1-Dimethylethyl)benzene	77353	4	85–90	86.5	4	0	---
1-Isopropyl-4-methylbenzene	77356	4	85–90	87	3	0	---
Iodomethane	77424	4	81–102	86.5	12	0	---
1,2,3-Trichloropropane	77443	4	86–96	91.5	3	0	---
1,1,1,2-Tetrachloroethane	77562	4	81–89	85	5	0	---
1,2,3-Trichlorobenzene	77613	4	95–104	100.5	5	0	---
1,2-Dibromomethane	77651	4	81–91	85.5	8	0	---

Table 24. Percent recovery statistics for volatile organic compounds detected in field-matrix spike samples for ground-water and surface-water samples, Central Arizona Basins study area, 1996–98—Continued

Volatile organic compound	WATSTORE code	Ground-water samples				Surface-water sample	
		n	Range of recoveries, in percent	Median recovery, in percent	Inter-quartile range	n	Recovery, in percent
1,1,2-Trichloro-1,2,2-trifluoroethane	77652	4	66–70	70	1	0	---
Methyl tert-butyl ether	78032	25	60–131	87	24	1	69
3-Chloro-1-propene	78109	4	77–81	80	1	0	---
4-Methyl-2-pentanone	78133	4	80–90	84.5	3	0	---
Xylenes, Total	81551	---	----	----	---	0	---
Acetone	81552	4	81–90	86.5	6	0	---
Bromobenzene	81555	4	82–87	84.5	2	0	---
Diethyl ether	81576	4	64–70	68	3	0	---
Diisopropyl ether	81577	4	80–86	83.5	4	0	---
Methyl acrylonitrile	81593	4	82–89	85.5	6	0	---
2-Butanone	81595	4	80–90	84.5	6	0	---
Methyl methacrylate	81597	4	64–79	70.5	5	0	---
Tetrahydrofuran	81607	4	67–80	71	6	0	---
1,2-Dibromo-3-chloropropane	82625	4	83–95	85	5	0	---
1,3-Dimethylbenzene and 1,4-Dimethylbenzene	85795	4	87–90	88.5	2	0	---

Table 25. Pesticide and pesticide-degradation compounds detected in field blanks for surface-water samples, Central Arizona Basins study area, 1996–98

[Concentrations in micrograms per liter unless otherwise indicated. Bold type indicates results where the compound was present in sample. <, less than]

Constituent	Buckeye Canal near Avondale	Hassayampa River near Arlington	San Pedro River at Charleston	Hassayampa River near Arlington	Buckeye Canal near Avondale	Hassayampa River near Arlington	Hassayampa River near Arlington
Station site number	09514000	09517000	09471000	09517000	09514000	09517000	09517000
Sample date	12–17–96	12–20–96	03–25–97	04–22–97	11–20–97	12–02–97	01–21–98
Sample time	0815	1350	1400	1130	0900	1030	0930
Acetochlor	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Acifluorfen	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Alachlor	<.002	<.002	<.002	<.002	<.002	<.002	<.002
Aldicarb	<.016	<.016	<.016	<.016	<.55	<.55	<.55
Aldicarb sulfone	<.016	<.016	<.016	<.016	<.1	<.1	<.1
Aldicarb sulfoxide	<.021	<.021	<.021	<.021	<.021	<.021	<.021
Atrazine	<.001	<.001	<.001	<.001	<.001	<.001	<.001
Azinphos-methyl	<.001	<.001	<.001	<.001	<.001	<.001	<.001
Benfluralin	<.002	<.002	<.002	<.002	<.002	<.002	<.002
Bentazon	<.014	<.014	<.014	<.014	<.014	<.014	<.014
Bromacil	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Bromoxynil	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Butylate	<.002	<.002	<.002	<.002	<.002	<.002	<.002
Carbaryl ²	<.008	<.008	<.008	<.008	<.008	<.008	<.008
Carbaryl ³	<.003	<.003	<.003	<.003	<.003	<.003	<.003
Carbofuran ²	<.028	<.028	<.028	<.028	<.12	<.12	<.12
Carbofuran ³	<.003	<.003	<.003	<.003	<.003	<.003	<.003
Chloramben	<.011	<.011	<.011	<.011	<.42	<.42	<.42
Chlorothalonil	<.035	<.035	<.035	<.035	<.48	<.48	<.48
Chlorpyrifos	<.004	<.004	<.004	<.004	<.004	<.004	<.004
Clopyralid	<.05	<.05	<.05	<.05	<.23	<.23	<.23
Cyanazine	<.004	<.004	<.004	<.004	<.004	<.004	<.004
2,4-D	<.035	<.035	<.035	<.035	<.15	<.15	<.15
Dacthal	<.002	<.002	<.002	<.002	<.002	<.002	<.002
Dacthal mono-acid	<.017	<.017	<.017	<.017	<.017	<.017	<.017
2,4-DB	<.035	<.035	<.035	<.035	<.24	<.24	<.24
p,p'-DDE	<.006	<.006	<.006	1.00184	<.006	<.006	<.006
Deethylatrazine	<.002	<.002	<.002	<.002	<.002	<.002	<.002
Diazinon	<.002	<.002	<.002	<.002	<.002	<.002	<.002
Dicamba	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Dichlobenil	<.02	<.02	<.02	<.02	<1.2	<1.2	<1.2
Dichlorprop	<.032	<.032	<.032	<.032	<.032	<.032	<.032
Dieldrin	<.001	<.001	<.001	<.001	<.001	<.001	<.001

See footnotes at end of table.

Table 25. Pesticide and pesticide-degradation compounds detected in field blanks for surface-water samples, Central Arizona Basins study area, 1996–98—Continued

Constituent	Buckeye Canal near Avondale	Hassayampa River near Arlington	San Pedro River at Charleston	Hassayampa River near Arlington	Buckeye Canal near Avondale	Hassayampa River near Arlington	Hassayampa River near Arlington
2,6-Diethylaniline	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Dinoseb	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Disulfoton	<.017	<.017	<.017	<.017	<.017	<.017	<.017
Diuron	<.02	<.02	<.02	<.02	<.02	<.02	<.02
DNOC	<.035	<.035	<.035	<.035	<.42	<.42	<.42
EPTC	<.002	<.002	<.002	<.002	<.002	<.002	<.002
Ethalfuralin	<.004	<.004	<.004	<.004	<.004	<.004	<.004
Ethoprop	<.003	<.003	<.003	<.003	<.003	<.003	<.003
Fenuron	<.013	<.013	<.013	<.013	<.013	<.013	<.013
Fluometuron	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Fonofos	<.003	<.003	<.003	<.003	<.003	<.003	<.003
<i>alpha</i> -HCH	<.002	<.002	<.002	<.002	<.002	<.002	<.002
<i>gamma</i> -HCH	<.004	<.004	<.004	<.004	<.004	<.004	<.004
3-Hydroxycarbofuran	<.014	<.014	<.014	<.014	<.014	<.014	<.014
Linuron ²	<.018	<.018	<.018	<.018	<.018	<.018	<.018
Linuron ³	<.002	<.002	<.002	<.002	<.002	<.002	<.002
MCPA	<.05	<.05	<.05	<.05	<.17	<.17	<.17
MCPB	<.035	<.035	<.035	<.035	<.14	<.14	<.14
Malathion	<.005	<.005	<.005	<.005	<.005	<.005	<.005
Methiocarb	<.026	<.026	<.026	<.026	<.026	<.026	<.026
Methomyl	<.017	<.017	<.017	<.017	<.017	<.017	<.017
Methyl parathion	<.006	<.006	<.006	<.006	<.006	<.006	<.006
Metolachlor	<.002	<.002	<.002	<.002	<.002	<.002	<.002
Metribuzin	<.004	<.004	<.004	<.004	<.004	<.004	<.004
Molinate	<.004	<.004	<.004	<.004	<.004	<.004	<.004
Napropamide	<.003	<.003	<.003	<.003	<.003	<.003	<.003
Neburon	<.015	<.015	<.015	<.015	<.015	<.015	<.015
Norflurazon	<.024	<.024	<.024	<.024	<.024	<.024	<.024
Oryzalin	<.019	<.019	<.019	<.019	<.31	<.31	<.31
Oxamyl	<.018	<.018	<.018	<.018	<.018	<.018	<.018
Parathion	<.004	<.004	<.004	<.004	<.004	<.004	<.004
Pebulate	<.004	<.004	<.004	<.004	<.004	<.004	<.004
Pendimethalin	<.004	<.004	<.004	<.004	<.004	<.004	<.004
<i>cis</i> -Permethrin	<.005	<.005	<.005	<.005	<.005	<.005	<.005
Phorate	<.002	<.002	<.002	<.002	<.002	<.002	<.002
Picloram	<.05	<.05	<.05	<.05	<.05	<.05	<.05
Prometon	<.018	<.018	<.018	<.018	<.018	<.018	<.018
Pronamide	<.003	<.003	<.003	<.003	<.003	<.003	<.003

Table 25. Pesticide and pesticide-degradation compounds detected in field blanks for surface-water samples, Central Arizona Basins study area, 1996–98—Continued

Constituent	Buckeye Canal near Avondale	Hassayampa River near Arlington	San Pedro River at Charleston	Hassayampa River near Arlington	Buckeye Canal near Avondale	Hassayampa River near Arlington	Hassayampa River near Arlington
See footnotes at end of table.							
Propachlor	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Propanil	<.004	<.004	<.004	<.004	<.004	<.004	<.004
Propargite	<.013	<.013	<.013	<.013	<.013	<.013	<.013
Propham	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Propoxur	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Silvex	<.021	<.021	<.021	<.021	<.021	<.021	<.021
Simazine	<.005	<.005	<.005	<.005	<.005	<.005	<.005
2,4,5-T	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Tebuthiuron	<.01	<.01	<.01	<.01	<.01	<.01	<.01
Terbacil	<.007	<.007	<.007	<.007	<.007	<.007	<.007
Terbufos	<.013	<.013	<.013	<.013	<.013	<.013	<.013
Thiobencarb	<.002	<.002	<.002	<.002	<.002	<.002	<.002
Triallate	<.001	<.001	<.001	<.001	<.001	<.001	<.001
Triclopyr	<.05	<.05	<.05	<.05	<.25	<.25	<.25
Trifluralin	<.002	<.002	<.002	<.002	<.002	<.002	<.002
Surrogate recoveries, in percent							
BDMC	69	36	94	76	73	69	86
Diazinon-D10	86	87	99	82	103	94	95
Terbuthylazine	87	100	109	89	116	107	106
Alpha-HCH-D6	78	75	106	71	86	78	84

¹Estimated.

²Compound analyzed by gas chromatography/mass spectrometry.

³Compound analyzed by high-performance liquid chromatography.

Table 26. Volatile organic compounds detected in field blanks, source-solution blanks, equipment blanks, trip blanks, and split replicates collected at 91st Avenue wastewater-treatment plant outfall near Phoenix, 1996–97

[Concentrations are in micrograms per liter unless otherwise noted. Dashes indicate data are not available. Bold type indicates results when compound is present. SB, sampler blank; EB, equipment blank; SSB, source-solution blank; TB, trip blank; FB, field blank; SR, split replicate; CB, canister blank; NA, not applicable; <, less than]

Constituent	Blank samples						Split-replicate samples									
	Date of sample						Date of sample		Difference in concentration		Date of sample		Difference in concentration		Number of samples	
	6–17–96		1–23–97		1–24–97		4–9–97		Absolute		Percent		Absolute		Percent	
	SB/EB	SSB	TB	SB/FB	CB	SB	SR	NA	NA	NA	NA	SR	SR	NA	NA	NA
Sample type	95304	95304	95304	95304	95304	95304	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Source solution lot number	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.01	1.01	0	0	0	1.01	1.01	0	0	0
Dibromomethane	<1	<1	<1	<1	<1	<1	5.91	3.78	2.13	44	44	.7	.73	.03	4	24
Bromodichloromethane	<1	<1	<1	<1	<1	<1	3.43	1.43	2	82	82	.35	.37	.02	6	44
Dibromochloromethane	1.07	1.08	<0.5	1.04	1.04	1.04	7.94	7.7	.24	3	3	2.6	2.7	.1	4	3
Trichloromethane	1.07	1.08	<0.5	1.04	1.04	1.04	.475	.436	.039	8	8	.29	.3	.01	3	6
Methylbenzene	<0.5	<0.5	<0.5	1.02	1.01	1.01	1.04	1.04	0	0	0	1.01	1.008	.002	22	11
Chlorobenzene ²	<0.5	<0.5	<0.5	1.006	1.006	1.006	1.72	1.1	1.62	178	178	1.1	1.2	.1	67	122
Tetrachloroethene ²	.32	.33	<0.5	.11	1.09	1.09	2.22	.632	1.588	111	111	.64	.67	.03	5	58
1,4-Dichlorobenzene	1.02	1.05	<0.5	<0.5	1.004	1.004	.201	.245	.044	20	20	1.1	1.1	0	0	10
Carbon disulfide	<1	<1	<1	<1	<1	<1	.382	.422	.04	10	10	.41	.45	.04	9	10
Bromochloromethane	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.64	1.06	1.58	186	186	<1	<1	---	---	186
Tetrachloromethane	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.76	<1	1.66	178	178	<1	<1	---	---	178
1,2-Dichloroethane	<2	<2	<2	<2	<2	<2	1.93	1.1	1.83	180	180	1.08	1.09	.01	12	96
Tri bromomethane	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<1	---	---	---	<1	<1	---	---	---
Benzene	<2	<2	<2	<2	<2	<2	<4	<4	---	---	---	<4	<4	---	---	---
2-Propenal	<2	<2	<2	<2	<2	<2	<4	<4	---	---	---	<4	<4	---	---	---
2-Propenenitrile	<1	<1	<1	<1	<1	<1	<2	<2	---	---	---	<2	<2	---	---	---
Chloroethane	<0.5	<0.5	<0.5	1.03	1.03	1.03	1.65	<1	1.55	177	177	<1	<1	---	---	177
Ethylbenzene ²	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<1	---	---	---	<1	<1	---	---	---
1,1,1,2,2,2-Hexachloroethane	<1	<1	<1	<1	<1	<1	<2	<2	---	---	---	<2	<2	---	---	---
Bromomethane	<2	<2	<2	<2	<2	<2	1.231	1.218	.013	6	6	<4	<4	---	---	---
Chloromethane	<1	1.02	<1	<1	<1	<1	1.06	1.08	.02	2	2	.87	.89	.02	2	2
Dichloromethane	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	---	---	---	<0.2	<0.2	---	---	---
Trichlorofluoromethane	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<1	---	---	---	<1	<1	---	---	---
1,1-Dichloroethane	<1	<1	<1	<1	<1	<1	1.75	<2	1.55	159	159	<2	<2	---	---	159

See footnotes at end of table.

Table 26. Volatile organic compounds detected in field blanks, source-solution blanks, equipment blanks, trip blanks, and split replicates collected at 91st Avenue wastewater-treatment plant outfall near Phoenix, 1996–97—Continued

Constituent	Blank samples				Split-replicate samples							
	Sample date				Sample date		Difference in concentration		Sample date		Difference in concentration	
	6-17-96	1-23-97	1-24-97	4-9-97	1-24-97	4-9-97	Absolute	Percent	2-5-97	Absolute	Percent	Number of samples
1,1,1-Trichloroethane	<.05	<.05	<.05	1.68	<.05	<.1	1.58	178	<.1	<.1	---	1
1,1,2-Trichloroethane	<.1	<.1	<.1	<.2	<.1	<.2	---	---	<.2	<.2	---	0
1,1,2,2-Tetrachloroethane	<.1	<.1	<.1	<.2	<.1	<.2	---	---	<.2	<.2	---	0
1,2-Dichlorobenzene	<.05	<.05	<.05	1.05	<.05	1.04	0.01	22	1.03	1.03	0	2
1,2-Dichloropropane	<.05	<.05	<.05	<.1	<.05	<.1	---	---	<.1	<.1	---	0
trans-1,2-Dichloroethene	<.05	<.05	<.05	<.1	<.05	<.1	---	---	<.1	<.1	---	0
1,2,4-Trichlorobenzene	<.2	<.2	<.2	1.1	<.2	1.1	0	0	1.1	1.1	0	2
1,3-Dichlorobenzene	<.05	<.05	<.05	<.1	<.05	1.01	.09	164	1.01	1.01	0	2
Dichlorodifluoromethane	<.2	<.2	<.2	<.4	<.2	<.4	---	---	<.4	<.4	---	0
Naphthalene	<.2	<.2	<.2	<.4	<.2	<.4	---	---	<.4	<.4	---	0
trans-1,3-Dichloropropane.....	<.1	<.1	<.1	<.2	<.1	<.2	---	---	<.2	<.2	---	0
cis-1,3-Dichloropropene	<.1	<.1	<.1	<.2	<.1	<.2	---	---	<.2	<.2	---	0
Chloroethene	<.1	<.1	<.1	1.1	<.1	<.2	---	---	<.2	<.2	---	1
Trichloroethene	<.05	<.05	<.05	1.68	<.05	<.1	1.58	178	<.1	<.1	---	1
Hexachlorobutadiene	<.2	<.2	<.2	<.4	<.2	<.4	---	---	<.4	<.4	---	0
Methyl acrylate	<.2	<.2	<.2	<.4	<.2	<.4	---	---	<.4	<.4	---	0
1,2,3,4-Tetramethylbenzene	<.05	<.05	<.05	<.1	<.05	<.1	---	---	1.007	0.093	174	1
1,2,3,5-Tetramethylbenzene	<.05	<.05	<.05	<.1	<.05	<.1	---	---	<.1	<.1	---	0
Bromoethene	<.1	<.1	<.1	<.1	<.1	<.2	---	---	<.2	<.2	---	0
Ethyl-tert-butyl ether	<.1	<.1	<.1	<.1	<.1	<.2	---	---	<.2	<.2	---	0
tert-Amyl methyl ether	<.1	<.1	<.1	<.1	<.1	<.2	---	---	<.2	<.2	---	0
trans-1,4-Dichloro-2-butene	<.5	<.5	<.5	<.5	<.5	<.5	---	---	<.5	<.5	---	0
Ethyl methacrylate	<.1	<.1	<.1	<.2	<.1	<.2	---	---	<.2	<.2	---	0
Vinyl acetate	<.5	<.5	<.5	<.5	<.5	<.5	---	---	<.5	<.5	---	0
cis-1,2-Dichloro-ethene	<.05	<.05	<.05	<.1	<.05	<.1	---	---	<.1	<.1	---	0
2-Hexanone	<.5	<.5	<.5	<.5	<.5	<.5	---	---	<.5	<.5	---	0
Ethylbenzene ²	<.05	<.05	1.01	<.1	1.01	<.1	---	---	<.1	<.1	---	0
1,2-Dimethylbenzene ²	<.05	<.05	1.02	<.1	1.02	<.1	---	---	<.1	<.1	---	0

See footnotes at end of table.

Table 26. Volatile organic compounds detected in field blanks, source-solution blanks, equipment blanks, trip blanks, and split replicates collected at 91st Avenue wastewater-treatment plant outfall near Phoenix, 1996–97—Continued

Constituent	Blank samples				Split-replicate samples									
	Sample date				Sample date	Difference in concentration		Sample date	Difference in concentration		Number of samples	Median difference in concentration		
	6-17-96	1-23-97	1-24-97	4-9-97	4-9-97	Absolute	Percent	2-5-97	Absolute	Percent	Absolute	Percent		
1,1-Dichloropropene	<.05	<.05	<.05	<.1	<.1	---	---	<.1	<.1	---	0	---		
2,2-Dichloropropane	<.05	<.05	<.05	<.1	<.1	---	---	<.1	<.1	---	0	---		
1,3-Dichloropropane	<.05	<.05	<.05	<.1	<.1	---	---	<.1	<.1	---	0	---		
2-Ethyltoluene	<.05	<.05	<.05	<.1	<.1	---	---	1,008	1,008	0	1	0		
1,2,3-Trimethylbenzene	<.05	<.05	<.05	1,02	1,02	0	0	<.1	<.1	---	1	0		
1,2,4-Trimethylbenzene ²	<.05	<.05	1,009	1,03	1,03	0	0	1,01	1,01	0	2	0		
(1-Methyl)ethylbenzene ²	<.05	<.05	1,002	<.1	<.1	---	---	<.1	<.1	---	0	---		
n-Propylbenzene	<.05	<.05	<.05	<.1	<.1	---	---	<.1	<.1	---	0	---		
1,3,5-Trimethylbenzene	<.05	<.05	<.05	<.1	1,01	0.09	164	1,01	1,009	0.001	10	0.0455		
1-Chloro-2-methylbenzene	<.05	<.05	<.05	<.1	<.1	---	---	<.1	<.1	---	0	---		
1-Chloro-4-methylbenzene	<.05	<.05	<.05	<.1	<.1	---	---	<.1	<.1	---	0	---		
n-Butylbenzene	<.05	<.05	<.05	<.1	<.1	---	---	<.1	<.1	---	0	---		
(1-Methylpropyl)benzene	<.05	<.05	<.05	<.1	<.1	---	---	<.1	<.1	---	0	---		
(1,1-Dimethyl)ethylbenzene	<.05	<.05	<.05	<.1	<.1	---	---	<.1	<.1	---	0	---		
(1,1-Dimethyl)ethylbenzene	<.05	<.05	<.05	<.1	<.1	---	---	<.1	<.1	---	0	---		
1-Isopropyl-4-methylbenzene	<.05	<.05	<.05	1,03	1,03	0	0	1,01	1,01	0	2	0		
Iodomethane	<.05	<.05	<.05	<.1	<.1	---	---	<.1	<.1	---	0	---		
1,2,3-Trichloropropane	<.2	<.2	<.2	<.4	<.4	---	---	<.4	<.4	---	0	---		
1,1,1,2-Tetrachloroethane	<.05	<.05	<.05	<.1	<.1	---	---	<.1	<.1	---	0	---		
1,2,3-Trichlorobenzene	<.2	<.2	<.2	1,04	1,04	0	0	1,04	1,05	0.01	22	0.0005		
1,2-Dibromomethane	<.1	<.1	<.1	<.2	<.2	---	---	<.2	<.2	---	0	---		
1,1,2-Trichloro-1,2,2-trifluoroethane	<.05	<.05	<.05	<.1	<.1	---	---	<.1	<.1	---	0	---		
Methyl tert-butyl ether	<.1	<.1	<.1	1,91	<.2	1.71	162	<.2	1,04	0.16	133	0.935		
3-Chloro-1-propene	<.1	<.1	<.1	<.2	<.2	---	---	<.2	<.2	---	0	---		
4-Methyl-2-pentanone	<.5	<.5	<.5	<.10	<.10	---	---	<.10	<.10	---	0	---		
Acetone ²	<.5	<.5	1,7	<.10	<.10	---	---	<.10	1,8	8.2	139	8.2		
Bromobenzene	<.05	<.05	<.05	<.1	<.1	---	---	<.1	<.1	---	0	---		
Diethyl ether	<.1	<.1	<.1	<.2	<.2	---	---	1,08	1,06	0.02	28	0.02		
Diisopropyl ether	<.1	<.1	<.1	<.2	<.2	---	---	<.2	<.2	---	0	---		

See footnote at end of table.

Table 26. Volatile organic compounds detected in field blanks, source-solution blanks, equipment blanks, trip blanks, and split replicates collected at 91st Avenue wastewater-treatment plant outfall near Phoenix, 1996–97—Continued

Constituent	Blank samples				Split-replicate samples							
	Sample date				Sample date		Difference in concentration		Sample date		Difference in concentration	
	1–23–97		1–24–97		4–9–97		Absolute		2–5–97		Absolute	
	6–17–96	1–23–97	1–24–97	1–24–97	4–9–97	4–9–97	Absolute	Percent	2–5–97	2–5–97	Absolute	Percent
Methyl acrylonitrile	<2.	<2	<2	<2	<4	<4	---	---	<4	<4	---	---
2-Butanone	<5.	<5	<5	<5	1 ¹	<10	9	164	<10	<10	---	---
Methyl methacrylate	<1.	<1	<1	<1	<2	<2	---	---	<2	<2	---	---
Tetrahydrofuran ²	<5.	<5	<5	1.3	<10.	1.4	9.6	185	1.4	1.4	0	0
1,2-Dibromo-3-chloropropane	<.5	<.5	<.5	<.5	<1.	<1.	---	---	<1.	<1.	---	---
1,3-Dimethylbenzene and 1,4-Dimethylbenzene ²	<.05	<.05	<.05	1.05	<1	<1	---	---	<1	1.02	0.08	133
				1.04							0.08	133

¹Estimated.

²Compounds may be contaminated in environmental samples.

Table 27. Summary statistics for pesticides and pesticide-degradation compounds detected in field-matrix spike samples and replicates for surface-water samples, Central Arizona Basins study area, 1996–98

[Concentrations are in micrograms per liter unless otherwise indicated. Methods of analysis for pesticide and pesticide-degradation compounds are listed in [table 5](#). Compounds in **bold** font may be affected by matrix effects. Dashes indicate no data; n, number of field-matrix spike samples or number of replicate-sample pairs; FMS–SS, field-matrix spike sample median minus the set-spike sample median (from [table 22](#))]

Pesticide	Field-matrix spike samples				Replicate samples									
	Recoveries				Sequential replicates					Concurrent replicates				
					Difference between replicates					Difference between replicates				
	n	Range, in percent	Median, in percent	FMS–SS, in percent	n	Range of concentration	Range of percent	Median concentration	Median percentage	n	Range of concentration	Range of percent	Median concentration	Median percentage
Acetochlor	2	98–110	104	2	0	---	---	---	---	0	---	---	---	---
Acifluorfen	2	30–48	39	49	0	---	---	---	---	0	---	---	---	---
Alachlor	2	102–109	106	4	0	---	---	---	---	0	---	---	---	---
Aldicarb ¹	0	---	---	---	0	---	---	---	---	0	---	---	---	---
Aldicarb sulfone ¹	0	---	---	---	0	---	---	---	---	0	---	---	---	---
Aldicarb sulfoxide ¹	0	---	---	---	0	---	---	---	---	0	---	---	---	---
Atrazine	2	93–106	100	0	4	0.0004–.00466	2–140	0.0018	10	1	0.0013	7	---	---
Azinphos-methyl	1	221	---	141	0	---	---	---	---	0	---	---	---	---
Benfluralin	2	81–150	116	49	1	.0026	12	---	---	0	---	---	---	---
Bentazon	2	43–47	45	35	0	---	---	---	---	0	---	---	---	---
Bromacil	1	130	---	48	0	---	---	---	---	0	---	---	---	---
Bromoxynil	2	83–84	84	1	0	---	---	---	---	0	---	---	---	---
Butylate	2	113–124	118	29	0	---	---	---	---	0	---	---	---	---
Carbaryl ^{1,2}	2	178–318	248	122	0	---	---	---	---	0	---	---	---	---
Carbaryl ³	1	50	---	38	3	.002–.007	6–31	.0034	9	1	.0005	2	---	---
Carbofuran ²	2	165–183	174	61	0	---	---	---	---	0	---	---	---	---
Carbofuran ³	1	104	---	21	0	---	---	---	---	0	---	---	---	---
Chloramben	1	0	---	70	0	---	---	---	---	0	---	---	---	---
Chlorothalonil ¹	1	27	---	9	0	---	---	---	---	0	---	---	---	---
Chlorpyrifos	2	97	97	7	1	0–.025	0–62	.00322	7	4	0–.00815	0–20	0.0024	11
Clopyralid	1	0	---	77	0	---	---	---	---	0	---	---	---	---
Cyanazine	2	80–126	103	0	4	.0006–.018	1–138	.00437	20	1	.00185	3	---	---
2,4-D	0	---	---	---	0	---	---	---	---	0	---	---	---	---
Dacthal	2	102–112	107	4	9	0–.0031	0–13	.00007	6	3	0–.005	0–10	.00012	7
Dacthal mono-acid	2	51–64	58	25	0	---	---	---	---	0	---	---	---	---
2,4-DB	0	---	---	---	0	---	---	---	---	0	---	---	---	---
p,p'-DDE	2	46–47	46	12	9	0–.00231	0–73	.00102	22	2	0–.0005	0–12	.00025	6
Deethylatrazine ¹	2	34–37	36	9	3	.0009–.00199	10–25	.00099	16	1	.001515	17	---	---
Diazinon	2	91–102	96	8	1	.0005–.011	2–36	.005	7	4	0–.00425	0–21	.00175	2
Dicamba	0	---	---	---	0	---	---	---	---	0	---	---	---	---
Dichlobenil ¹	0	---	---	---	0	---	---	---	---	0	---	---	---	---
Dichlorprop	2	69–136	102	17	0	---	---	---	---	0	---	---	---	---

See footnotes at end of table.

Table 27. Summary statistics for pesticides and pesticide-degradation compounds detected in field-matrix spike samples and replicates for surface-water samples, Central Arizona Basins study area, 1996–98—Continued

Pesticide	Field-matrix spike samples				Replicate samples									
	Recoveries				Sequential replicates					Concurrent replicates				
					Difference, in concentration, in percent					Difference, in concentration, in percent				
	n	Range, in percent	Median, in percent	FMS-SS, in percent	n	Range of concentration	Range of percent	Median concentration	Median percentage	n	Range of concentration	Range of percentage	Median concentration	Median percentage
Dieldrin	2	97–99	98	17	0	---	---	---	---	0	---	---	---	---
2,6-Diethyl-aniline	2	81–88	84	1	0	---	---	---	---	0	---	---	---	---
Dinoseb	2	34–38	36	45	0	---	---	---	---	0	---	---	---	---
Disulfoton	2	38–90	64	9	2	0.041–.053	6–7	0.047	6	1	0.057	7	---	---
Diuron	0	---	---	---	1	.21	3	---	---	0	---	---	---	---
DNOC ¹	2	52–56	54	15	0	---	---	---	---	0	---	---	---	---
EPTC	2	0–146	73	17	9	0–.088	0–32	.0088	10	4	.0005–.0405	3–14	0.00385	6
Ethalfuralin	2	93–182	138	60	0	---	---	---	---	0	---	---	---	---
Ethoprop	2	104–124	114	19	0	---	---	---	---	0	---	---	---	---
Fenuron	1	50	---	39	0	---	---	---	---	0	---	---	---	---
Fluometuron	1	55	---	38	0	---	---	---	---	0	---	---	---	---
Fonofos	2	84–107	96	8	0	---	---	---	---	0	---	---	---	---
<i>alpha</i> -HCH	2	90–94	92	2	0	---	---	---	---	0	---	---	---	---
<i>gamma</i> -HCH	2	120–130	125	33	3	.0017–.0028	13–24	.0025	17	1	.00155	13	---	---
3-Hydroxycarbofuran	1	49	---	27	0	---	---	---	---	0	---	---	---	---
Linuron ²	2	116	116	15	2	.003–.005	7–12	.004	10	0	---	---	---	---
Linuron ³	1	54	---	31	0	---	---	---	---	1	.001	2	---	---
MCPA	1	43	---	41	0	---	---	---	---	0	---	---	---	---
MCPB	0	---	---	---	0	---	---	---	---	0	---	---	---	---
Malathion	2	85–112	98	3	4	.001–.011	0–9	.005	4	2	.0025–.0085	2–3	.0055	3
Methiocarb	1	49	---	36	0	---	---	---	---	0	---	---	---	---
Methomyl	1	51	---	39	0	---	---	---	---	0	---	---	---	---
Methyl parathion	2	105–171	138	49	1	.0101	33	---	---	0	---	---	---	---
Metolachlor	2	116–146	131	25	0	---	---	---	---	0	---	---	---	---
Metribuzin	2	89–109	99	21	0	---	---	---	---	0	---	---	---	---
Molinate	2	101–115	108	14	0	---	---	---	---	0	---	---	---	---
Napropamide	2	91–100	96	2	0	---	---	---	---	0	---	---	---	---
Neburon	1	32	---	53	0	---	---	---	---	0	---	---	---	---
Norflurazon	1	52	---	36	0	---	---	---	---	0	---	---	---	---
Oryzalin	0	---	---	---	0	---	---	---	---	0	---	---	---	---
Oxamyl	1	30	---	47	0	---	---	---	---	0	---	---	---	---
Parathion	2	100–173	136	43	0	---	---	---	---	0	---	---	---	---
Pebulate	2	107–115	111	21	0	---	---	---	---	0	---	---	---	---
Pendimethalin	2	7–155	81	8	6	.0003–.009	1–22	.0034	9	2	.004–.01145	5–32	.007725	18
<i>cis</i> -Permethrin	2	25–31	28	17	0	---	---	---	---	0	---	---	---	---
Phorate	2	40–97	68	4	2	0–.001	0–10	0.0005	5	1	0.0005	5	---	---
Picloram	2	47–57	52	29	0	---	---	---	---	0	---	---	---	---

Table 27. Summary statistics for pesticides and pesticide-degradation compounds detected in field-matrix spike samples and replicates for surface-water samples, Central Arizona Basins study area, 1996–98—Continued

Pesticide	Field-matrix spike samples				Replicate samples									
	Recoveries				Sequential replicates					Concurrent replicates				
					Difference, in concentration, in percent					Difference, in concentration, in percent				
	n	Range, in percent	Median, in percent	FMS-SS, in percent	n	Range of concentration	Range of percent	Median concentration	Median percentage	n	Range of concentration	Range of percentage	Median concentration	Median percentage
See footnotes at end of table.														
Prometon	2	109–112	110	39	9	0–.009	0–67	.00156	12	3	.0005–.00398	2–35	.0025	9
Pronamide	2	92–108	100	11	0	---	---	---	---	0	---	---	---	---
Propachlor	2	117–129	123	18	0	---	---	---	---	0	---	---	---	---
Propanil	2	106–125	116	8	0	---	---	---	---	0	---	---	---	---
Propargite	2	90–130	110	39	0	---	---	---	---	0	---	---	---	---
Propham	1	42	----	26	0	---	---	---	---	0	---	---	---	---
Propoxur	1	81	----	8	0	---	---	---	---	0	---	---	---	---
Silvex	1	80	----	8	0	---	---	---	---	0	---	---	---	---
Simazine	2	101–106	104	3	8	.0003–.0073	2–84	.00112	11	2	.0015–.003	5–19	.00225	12
2,4,5-T	1	59	----	23	0	---	---	---	---	0	---	---	---	---
Tebuthiuron	2	109–179	144	28	0	---	---	---	---	0	---	---	---	---
Terbacil ¹	2	75–78	76	4	0	---	---	---	---	0	---	---	---	---
Terbufos	2	80–103	92	16	0	---	---	---	---	0	---	---	---	---
Thiobencarb	2	85–102	94	6	0	---	---	---	---	0	---	---	---	---
Triallate	2	80–97	88	1	0	---	---	---	---	0	---	---	---	---
Triclopyr	0	----	----	---	0	---	---	---	---	0	---	---	---	---
Trifluralin	2	80–154	117	46	1	.00003–.007	1–85	.00088	6	4	.00024–.008	2–40	.001623	9

¹Analytical performance for this compound is considered poor (J.D. Martin, hydrologist, U.S. Geological Survey, written commun., 1999).

²Compound analyzed by gas chromatography/mass spectrometry.

³Compound analyzed by high-performance liquid chromatography.

Table 28. Results of pesticide and pesticide-degradation compound analyses of concurrent replicates for surface-water samples, Central Arizona Basins study area, 1996–98[09514000, station number (see [table 4](#)). Bold type indicates results where the compound was present in sample. Concentrations are in micrograms per liter unless otherwise indicated. <, less than]

Constituents	09514000—Buckeye Canal near Avondale						09517000—Hassayampa River near Arlington											
	Concurrent replicate			Concurrent replicate			Concurrent replicate			Concurrent replicate			Concurrent replicate			Concurrent replicate		
	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate
Sample date	03–19–97			07–16–97			03–18–97			07–15–97								
Sample time	1220	1221	1230	1231	1140	1141	1140	1141	1150	1151	1200	1201	1020	1021	1030	1031		
Acetochlor	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002
Acifluorfen	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Alachlor	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002
Aldicarb	<.016	<.016	<.016	<.016	<.016	<.016	<.016	<.016	<.016	<.016	<.016	<.016	<.016	<.016	<.016	<.016	<.016	<.016
Aldicarb sulfone	<.016	<.016	<.016	<.016	<.016	<.016	<.016	<.016	<.016	<.016	<.016	<.016	<.016	<.016	<.016	<.016	<.016	<.016
Aldicarb sulfoxide	<.021	<.021	<.021	<.021	<.021	<.021	<.021	<.021	<.021	<.021	<.021	<.021	<.021	<.021	<.021	<.021	<.021	<.021
Atrazine	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
Azinphos-methyl	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
Benfluralin	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002
Bentazon	<.014	<.014	<.014	<.014	<.014	<.014	<.014	<.014	<.014	<.014	<.014	<.014	<.014	<.014	<.014	<.014	<.014	<.014
Bromacil	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Bromoxynil	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Butylate	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002
Carbaryl ²	<.008	<.008	<.008	<.008	<.008	<.008	<.008	<.008	<.008	<.008	<.008	<.008	<.008	<.008	<.008	<.008	<.008	<.008
Carbaryl ³	<.02	<.02	<.02	<.02	<.003	<.003	<.003	<.003	1.021	1.023	1.026	1.019	<.003	<.003	<.003	<.003	<.003	<.003
Carbofuran ²	<.028	<.028	<.028	<.028	<.028	<.028	<.028	<.028	<.028	<.028	<.028	<.028	<.028	<.028	<.028	<.028	<.028	<.028
Carbofuran ³	<.06	<.06	<.05	<.06	<.003	<.003	<.003	<.003	<.03	<.04	<.03	<.04	<.003	<.003	<.003	<.003	<.003	<.003
Chloramben	<.011	<.011	<.011	<.011	<.011	<.011	<.011	<.011	<.011	<.011	<.011	<.011	<.011	<.011	<.011	<.011	<.011	<.011

See footnotes at end of table.

Table 28. Results of pesticide and pesticide-degradation compound analyses of concurrent replicates for surface-water samples, Central Arizona Basins study area, 1996–98—Continued

Constituents	09514000—Buckeye Canal near Avondale				09517000—Hassayampa River near Arlington							
	Concurrent replicate		Concurrent replicate		Concurrent replicate				Concurrent replicate			
	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate
Chlorothalonil.....	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Chlorpyrifos.....	.027	.025	.029	.0208	.0216	.0157	.0191	.017	.018	.016	.017	.0544
Clorpyralid.....	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
Cyanazine.....	<.004	<.004	<.004	<.004	<.02	<.004	<.004	<.004	<.004	<.004	<.004	.0504
2,4-D.....	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Dacthal.....	.008	.007	.007	.0011	.00117	.0012	.00131	.013	.013	.013	.013	.000836
Dacthal mono-acid.....	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017
2,4-DB.....	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035
p,p'-DDE.....	<.006	<.006	<.006	.00377	.00479	.00317	.00391	.004	.005	.004	.004	.00355
Desethylatrazine.....	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	.000987
Diazinon.....	.101	.091	.089	.1	.111	.109	.104	.112	.078	.083	.079	.0219
Dicamba.....	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Dichlobenil.....	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02
Dichlorprop.....	<.032	<.032	<.032	<.032	<.032	<.032	<.032	<.032	<.032	<.032	<.032	<.032
Dieldrin.....	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
2,6-Diethylaniline.....	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003
Dinoseb.....	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Disulfoton.....	<.017	<.017	<.017	<.017	<.017	<.017	<.017	.826	.773	.722	.763	<.017
Diuron.....	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02

See footnotes at end of table.

Table 28. Results of pesticide and pesticide-degradation compound analyses of concurrent replicates for surface-water samples, Central Arizona Basins study area, 1996–98—Continued

Constituents	09514000—Buckeye Canal near Avondale						09517000—Hassayampa River near Arlington					
	Concurrent replicate			Concurrent replicate			Concurrent replicate			Concurrent replicate		
	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate
DNOC.....	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035
EPTC.....	.019	.018	.018	.522	.495	.424	.512	.12	.102	.109	.0319	.0304
Ethalfuralin.....	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004
Ethoprop.....	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003
Fenuron.....	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013
Fluometuron.....	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Fonofos.....	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003
<i>alpha</i> -HCH.....	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002
<i>gamma</i> -HCH.....	<.02	<.02	<.03	.014	.0123	.0102	.013	<.01	<.01	<.02	<.01	<.004
3-Hydroxycarbofuran.....	<.014	<.014	<.014	<.014	<.014	<.014	<.014	<.014	<.014	<.014	<.014	<.014
Linuron ²	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018
Linuron ³	<.002	<.002	<.002	<.002	<.002	<.002	<.002	.044	.039	.041	<.002	<.002
MCPA.....	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
MCPB.....	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Malathion.....	.123	.112	.116	.124	<.005	<.005	<.005	.255	.256	.246	<.005	<.005
Methiocarb.....	<.026	<.026	<.026	<.026	<.026	<.026	<.026	<.026	<.026	<.026	<.026	<.026
Methomyl.....	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017
Methyl parathion.....	<.006	<.006	<.006	<.006	<.006	<.006	<.006	<.006	<.006	<.006	<.006	<.006
Metolachlor.....	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002
Metribuzin.....	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004

See footnotes at end of table.

Table 28. Results of pesticide and pesticide-degradation compound analyses of concurrent replicates for surface-water samples, Central Arizona Basins study area, 1996–98—Continued

Constituents	09514000—Buckeye Canal near Avondale				09517000—Hassayampa River near Arlington			
	Concurrent replicate		Concurrent replicate		Concurrent replicate		Concurrent replicate	
	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate
Molinate	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004
Napropamide	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003
Neburon	<.015	<.015	<.015	<.015	<.015	<.015	<.015	<.015
Norflurazon	<.024	<.024	<.024	<.024	<.024	<.024	<.024	<.024
Oryzalin	<.019	<.019	<.019	<.019	<.019	<.019	<.019	<.019
Oxamyl	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018
Parathion	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004
Pebulate	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004
Pendimethalin	<.004	<.004	<.004	<.004	.083	.092	.088	.0434
cis-Permethrin	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005
Phorate	<.002	<.002	<.002	<.002	.011	.011	.011	<.002
Picloram	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
Prometon02	.019	.022	<.018	.029	.03	.028	1 .00874
Pronamide	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.003
Propachlor	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007
Propanil	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004
Propargite	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013
Propham	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Propoxur	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Silvex	<.021	<.021	<.021	<.021	<.021	<.021	<.021	<.021

See footnotes at end of table.

Table 28. Results of pesticide and pesticide-degradation compound analyses of concurrent replicates for surface-water samples, Central Arizona Basins study area, 1996–98—Continued

Constituents	09514000—Buckeye Canal near Avondale				09517000—Hassayampa River near Arlington											
	Concurrent replicate		Concurrent replicate		Concurrent replicate				Concurrent replicate							
	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate	Split replicate				
Simazine.....	.014	.015	.017	.018	<.005	<.005	<.005	<.005	.03	.029	.03	.026	<.005	.00624	<.005	<.005
2,4,5-T.....	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Tebuthiuron.....	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
Terbacil.....	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007
Terbufos.....	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013
Thiobencarb.....	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002
Triallate.....	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
Triclopyr.....	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
Trifluralin.....	.097	.09	.084	.087	.0105	.0107	.00992	.0108	.016	.017	.014	.016	.00498	<.002	.00525	.00522
Surrogate recoveries, in percent																
BDMC.....	---	---	---	---	137	34	131	61	127	100	89	86	97	88	105	104
Diazinon-D10.....	104	91	83	101	112	112	113	108	86	93	94	89	105	100	112	107
Terbutylazine.....	149	149	132	147	242	258	245	253	130	135	134	132	228	199	241	245
Alpha-HCH-D6.....	98	90	85	95	116	114	107	115	92	94	93	90	106	117	110	114

¹Estimated.

²Compound analyzed by gas chromatography/mass spectrometry.

³Compound analyzed by high-performance liquid chromatography.

Table 29. Pesticide and pesticide-degradation compounds detected in split-replicates for surface-water samples, Central Arizona Basins study area, 1996–98

[09514000, station number (see [table 4](#)). Concentrations are in micrograms per liter unless otherwise indicated. Sample dates and times in parentheses are for those compounds analyzed by high-performance liquid chromatography (see [table 5](#)). Bold type indicates results where the compound was present. Dashes indicate no data. <, less than]

Constituent	09514000—Buckeye Canal near Avondale				09517000—Hassayampa River near Arlington			
	Split replicate		Split replicate		Split replicate		Split replicate	
Sample date	8–5–97		8–21–97		8–4–97 (8–19–97)		2–18–98	
Sample time	1000	1001	1140	1141	1030 (1120)	1031 (1121)	1410	1411
Acetochlor	<0.002	<0.002	<0.002	---	<0.002	<0.002	<0.002	<0.002
Acifluorfen	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Alachlor	<.002	<.002	<.002	---	<.002	<.002	<.002	<.002
Aldicarb	<.016	<.016	<.016	<.016	<.016	<.016	<.55	<.55
Aldicarb sulfone	<.016	<.016	<.016	<.016	<.016	<.016	<.1	<.1
Aldicarb sulfoxide	<.021	<.021	<.021	<.021	<.021	<.021	<.021	<.021
Atrazine	.00566	<.001	<.001	---	.0151	.0173	<.001	<.001
Azinphos-methyl	<.001	<.001	<.001	---	<.001	<.001	<.001	<.001
Benfluralin	<.002	<.002	<.002	---	<.002	<.002	.0206	.0232
Bentazon	<.014	<.014	<.014	<.014	<.014	<.014	<.014	<.014
Bromacil	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Bromoxynil	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Butylate	<.002	<.002	<.002	---	<.002	<.002	<.002	<.002
Carbaryl ²	<.008	<.008	<.008	<.008	<.008	<.008	<.008	<.008
Carbaryl ³	<.003	<.003	<.003	---	<.003	<.003	¹ .0522	¹ .0556
Carbofuran ²	<.028	<.028	<.028	<.028	<.028	<.028	<.12	<.12
Carbofuran ³	<.02	<.003	<.003	---	<.003	<.003	<.003	<.003
Chloramben	<.011	<.011	<.011	<.011	<.011	<.011	<.42	<.42
Chlorothalonil	<.035	<.035	<.035	<.035	<.035	<.035	<.48	<.48
Chlorpyrifos	.0105	.0109	.0176	---	.152	.127	.00678	¹.00356
Clopyralid	<.05	<.05	<.05	<.05	<.05	<.05	<.23	<.23
Cyanazine	.0119	.00886	<.004	---	<.004	.022	<.004	<.004
2,4-D	<.035	<.035	<.035	<.035	<.035	<.035	<.15	<.15
Dacthal	.00414	¹.00381	¹.0194	---	<.002	<.002	.0781	.0812
Dacthal mono-acid	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017
2,4-DB	<.035	<.035	<.035	<.035	<.035	<.035	<.24	<.24
p,p'-DDE	¹.00397	¹.00468	¹.004	---	.0061	¹.00379	.00796	.00996
Deethylatrazine	<.002	<.002	<.002	---	¹.00659	¹.0056	<.002	<.002
Diazinon	.0711	.0665	.0777	---	.0157	.0226	.0418	.0501
Dicamba	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Dichlobenil	<.02	<.02	---	<.02	---	<.02	<1.2	<1.2
Dichlorprop	<.032	<.032	<.032	<.032	<.032	<.032	<.032	<.032
Dieldrin	<.001	<.001	<.001	---	<.001	<.001	<.001	<.001
2,6-Diethylaniline	<.003	<.003	<.003	---	<.003	<.003	<.003	<.003
Dinoseb	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035

See footnotes at end of table.

Table 29. Pesticide and pesticide-degradation compounds detected in split-replicates for surface-water samples, Central Arizona Basins study area, 1996–98—Continued

Constituent	09514000				09517000			
	Split replicate		Split replicate		Split replicate		Split replicate	
Disulfoton	<.017	<.017	<.017	---	<.017	<.017	<.017	<.017
Diuron	<0.02	<0.02	---	<0.02	---	<0.02	¹ 7.61	¹ 7.4
DNOC	<.035	<.035	<.035	<.035	<.035	<.035	<.42	<.42
EPTC	<.002	<.002	<.002	---	<.002	¹ .00239	<.002	<.002
Ethalfuralin	<.004	<.004	<.004	---	<.004	<.004	<.004	<.004
Ethoprop	<.003	<.003	---	---	<.003	<.003	<.003	<.003
Fenuron	<.013	<.013	<.013	<.013	<.013	<.013	<.013	<.013
Fluometuron	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Fonofos	<.003	<.003	<.003	---	<.003	<.003	<.003	<.003
<i>alpha</i> -HCH	<.002	<.002	<.002	---	<.002	<.002	<.002	<.002
<i>gamma</i> -HCH	.0158	.0133	.0194	---	<.004	<.004	<.004	<.004
3-Hydroxycarbofuran	<.014	<.014	<.014	<.014	<.014	<.014	<.014	<.014
Linuron ²	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018
Linuron ³	<.002	<.002	<.002	---	<.002	<.002	<.02	<.02
MCPA	<.05	<.05	<.05	<.05	<.05	<.05	<.17	<.17
MCPB	<.035	<.035	<.035	<.035	<.035	<.035	<.14	<.14
Malathion	<.005	<.005	<.005	---	<.005	<.005	<.005	<.005
Methiocarb	<.026	<.026	<.026	<.026	<.026	<.026	<.026	<.026
Methomyl	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017
Methyl parathion	<.006	<.006	<.006	---	.0253	.0354	<.006	<.006
Metolachlor	<.002	<.002	---	---	<.002	<.002	<.002	<.002
Metribuzin	<.004	<.004	<.004	---	<.004	<.004	<.01	<.004
Molinate	<.004	<.004	<.004	---	<.004	<.004	<.004	<.004
Napropamide	<.003	<.003	<.003	---	<.003	<.003	<.003	<.003
Neburon	<.015	<.015	<.015	<.015	<.015	<.015	<.015	<.015
Norflurazon	<.024	<.024	<.024	<.024	<.024	<.024	<.024	<.024
Oryzalin	<.019	<.019	---	<.019	---	<.019	<.31	<.31
Oxamyl	<.018	<.018	<.018	<.018	<.018	<.018	<.018	<.018
Parathion	<.004	<.004	<.004	---	<.004	<.004	<.004	<.004
Pebulate	<.004	<.004	<.004	---	<.004	<.004	<.004	<.004
Pendimethalin	<.004	<.004	<.004	---	.017	.0136	.0357	.0375
<i>cis</i> -Permethrin	<.005	<.005	<.005	---	<.005	<.005	<.005	<.005
Phorate	<.002	<.002	<.002	---	<.002	<.002	<.002	<.002
Picloram	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
Prometon	¹ .0178	<.018	<.018	---	<.018	¹ .0102	¹ .00849	¹ .00753
Pronamide	<.003	<.003	<.003	---	<.003	<.003	<.003	<.003
Propachlor	<.007	<.007	<.007	---	<.007	<.007	<.007	<.007
Propanil	<.004	<.004	---	---	<.004	<.004	<.004	<.004
Propargite	<.013	<.013	<.013	---	<.013	<.013	<.013	<.013

See footnotes at end of table.

Table 29. Pesticide and pesticide-degradation compounds detected in split-replicates for surface-water samples, Central Arizona Basins study area, 1996–98—Continued

Constituent	09514000				09517000			
	Split replicate		Split replicate		Split replicate		Split replicate	
Propham	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Propoxur	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Silvex	<0.021	<0.021	<0.021	<0.021	<0.021	<0.021	<0.021	<0.021
Simazine	.0123	<.005	<.01	---	<.005	.00835	.0152	.0149
(2,4,5-trichlorophenoxy) acetic acid	<.035	<.035	<.035	<.035	<.035	<.035	<.035	<.035
Tebuthiuron	<.01	<.01	<.01	---	<.01	<.01	<.01	<.01
Terbacil	<.007	<.007	<.007	---	<.007	<.007	<.007	<.007
Terbufos	<.013	<.013	<.013	---	<.013	<.013	<.013	<.013
Thiobencarb	<.002	<.002	---	---	<.002	<.002	<.002	<.002
Triallate	<.001	<.001	---	---	<.001	<.001	<.001	<.001
Triclopyr	<.05	<.05	<.05	<.05	<.05	<.05	<.25	<.25
Trifluralin	.00704	.00684	².00329	---	.0043	.00448	.000265	².00295
Surrogate recoveries, in percent								
BDMC	56	56	57	45	---	65	81	90
Diazinon-D1	98	93	101	---	97	99	90	95
Terbutylazine	198	191	146	---	E 214	203	115	132
Alpha-HCH-D6	97	100	104	---	198	97	100	98

¹Compound analyzed by gas chromatography/mass spectrometry.

²Estimated.

BASIC DATA

Table 30 Data for volatile organic compounds detected in ground-water samples collected April 1996 through September 1996, Central Arizona Basins study area

[Site identifier (see [table 31](#)). Concentrations are in micrograms per liter]

Constituent	Site identifier																					
	SV1	SV8	SV3	SV12	SV4	SV10	SV2	SV9	SV17	SV5	SV13	SV6	SV19	SV15	SV16	SV18	W33	W38	W40	W41	W39	W37
Sample date	6-24-96	6-25-96	6-26-96	6-27-96	7-10-96	7-23-96	7-24-96	7-25-96	8-12-96	8-13-96	8-14-96	8-15-96	8-26-96	8-28-96	9-17-96	9-18-96	4-3-96	4-16-96	4-16-96	4-17-96	4-22-96	4-23-96
Sample time	1459	1059	959	859	959	1059	959	959	1329	1029	1059	959	1259	959	1059	859	1559	1659	1159	1159	1659	1159
Dibromomethane	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100
Bromodichloromethane	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	1.010	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100
Dibromochloromethane	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100
Trichloromethane	.03	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	0.04	<.050	<.050	<.050	<.050	0.008	<.050	<.050	<.050	<.050	<.050
Methylbenzene	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
Chlorobenzene	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	1.002	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
Tetrachloroethene	<.050	<.050	<.050	<.050	<.050	<.050	1.030	0.15	<.050	1.030	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
1,4-Dichlorobenzene	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
Carbon disulfide	<.050	<.050	<.050	<.050	<.050	<.050	1.030	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	1.005	1.010	<.050	<.050	<.050	<.050	<.050
Bromochloromethane	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100
Tetrachloromethane	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
1,2-Dichloroethane	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
Tribromomethane	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	1.010	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200
Benzene	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	1.020	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
2-Propenal	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200
2-Propenenitrile	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200
Chloroethane	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100
Ethylbenzene	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
1,1,1,2,2,2-Hexachloroethane	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
Bromomethane	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100
Chloromethane	<.200	<.200	<.200	<.200	<.200	<.270	<.280	<.280	1.010	<.200	<.200	<.200	<.200	<.200	<.200	1.010	<.200	1.030	<.200	1.020	1.030	1.020
Dichloromethane	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100
Trichlorofluoromethane	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100
1,1-Dichloroethane	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
1,1-Dichloroethene	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100
1,1,1-Trichloroethane	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050

See footnotes at end of table.

Table 30. Data for volatile organic compounds detected in ground-water samples collected April 1996 through September 1996, Central Arizona Basins study area—Continued

Constituent	Site identifier																						
	SV1	SV8	SV3	SV12	SV4	SV10	SV2	SV9	SV17	SV5	SV13	SV6	SV19	SV15	SV16	SV18	W33	W38	W40	W41	W39	W37	
1,1,2-Trichloroethane	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	
1,1,2,2-Tetrachloroethane	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	
1,2-Dichlorobenzene	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	
1,2-Dichloropropane	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	
trans-1,2-Dichloroethene	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	
1,2,4-Trichlorobenzene	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	
1,3-Dichlorobenzene	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	
Dichlorodifluoromethane	<200	<200	<200	<200	<200	<200	<200	1,170	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	
Naphthalene	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	
trans-1,3-Dichloropropene	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	
cis-1,3-Dichloropropene	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	
Chloroethene	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	
Trichloroethene	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	
Hexachlorobutadiene	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	
Methyl acrylate	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	
1,2,3,4-Tetramethylbenzene	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	
1,2,3,5-Tetramethylbenzene	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	
Bromoethene	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	
Ethyl tert-butyl ether	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	
tert-Amyl methyl ether	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	
trans-1,4-Dichloro-2-butene	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	
Ethyl methacrylate	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	
Vinyl acetate	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	
cis-1,2-Dichloroethene	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	
2-Hexanone	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	
Ethynylbenzene	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	
1,2-Dimethylbenzene	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	
1,1-Dichloropropene	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	
2,2-Dichloropropane	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	<050	

See footnotes at end of table.

Table 30. Data for volatile organic compounds detected in ground-water samples collected April 1996 through September 1996, Central Arizona Basins study area—Continued

Constituent	Site identifier															
	SV1	SV8	SV3	SV12	SV4	SV10	SV2	SV9	SV17	SV5	SV13	SV6	SV19	SV15	SV16	SV18
1,3-Dichloropropane	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
2-Ethyltoluene	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
1,2,3-Trimethylbenzene	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
1,2,4-Trimethylbenzene	<.050	<.050	1.030	1.050	<.050	<.050	<.050	<.050	1.090	<.079	1.090	<.050	1.030	0.17	<.050	2.110
(1-Methylethyl)benzene	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
n-Propylbenzene	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
1,3,5-Trimethylbenzene	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
1-Chloro-2-methylbenzene	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
1-Chloro-4-methylbenzene	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
n-Butylbenzene	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
(1-Methylpropyl)benzene	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
(1,1-Dimethylethyl)benzene	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
1-Isopropyl-4-methylbenzene	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
Iodomethane	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
1,2,3-Trichloropropane	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200
1,1,1,2-Tetrachloroethane	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
1,2,3-Trichlorobenzene	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200
1,2-Dibromomethane	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100
1,1,2-Trichloro-1,2,2-trifluoroethane	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
Methyl tert-butyl ether	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100
3-Chloro-1-propene	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100
4-Methyl-2-pentanone	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Xylenes, Total	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Acetone	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
Bromobenzene	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100
Diethyl ether	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100
Diisopropyl ether	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200	<.200
Methyl acrylonitrile	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
2-Butanone	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100	<.100

See footnotes at end of table.

Table 30. Data for volatile organic compounds detected in ground-water samples collected April 1996 through September 1996, Central Arizona Basins study area—Continued

Constituent	Site identifier																					
	SV1	SV8	SV3	SV12	SV4	SV10	SV2	SV9	SV17	SV5	SV13	SV6	SV19	SV15	SV16	SV18	W33	W38	W40	W41	W39	W37
Methyl methacrylate	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	3.3	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Tetrahydrofuran	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
1,2-Dibromo-3-chloro-propane	<.064	<.064	<.064	<.064	<.064	<.064	<.064	<.064	<.064	<.064	<.064	<.064	<.064	<.064	<.064	<.064	<.064	<.050	<.050	<.050	<.050	<.050

¹Estimated.

²Value may be higher than actual value.

Table 31. Site information for wells sampled, Central Arizona Basins study area, 1996–98

[unsurv, unsurveyed]

Site identifier	Well number	Site identifier	Well number	Site identifier	Well number	Site identifier	Well number
Sierra Vista subbasin sub-unit survey							
SV1	(D-23-22)31dda	SV6	(D-21-21)33bda	SV11	(D-20-22)16ddb	SV16	(D-17-21)29dca
SV2	(D-23-20)01acc2	SV7	(D-21-23)33aaa	SV12	(D-19-18)33aaa2	SV17	(D-17-19)17ddd2
SV3	(D-23-23)06bcc2	SV8	(D-21-19) 06cc unsurv	SV13	(D-19-22)27acc	SV18	(D-17-20)18bbb
SV4	(D-22-21)33aaa	SV9	(D-20-20)32dcb2	SV14	(D-18-23)32abc	SV19	(D-15-20)21bda
SV5	(D-22-18)13bbd	SV10	(D-20-20)18ccc	SV15	(D-18-21)33bbb		
Upper Santa Cruz Basin sub-unit survey							
SC1	(D-10-14)06dca	SC9	(D-15-14)02ddc	SC16	(D-17-14)21bba	SC23	(D-19-13)22ddd
SC2	(D-11-13)34add	SC10	(D-15-16)06aad	SC17	(D-17-15)09bac	SC24	(D-21-13)19cdb
SC3	(D-11-14)10dab2	SC11	(D-15-16)34cba	SC18	(D-17-15)23add	SC25	(D-21-13)30cda
SC4	(D-12-12)01cda	SC12	(D-16-14)06cdc	SC19	(D-18-16)01bcc	SC26	(D-22-13)09cad
SC5	(D-13-13)18acb	SC13	(D-16-14)11bca	SC20	(D-19-12)36cbb	SC27	(D-23-14)26cca
SC6	(D-13-13)18cbd	SC14	(D-16-16)04dab	SC21	(D-19-13)07cba	SC28	(D-23-14)30baa
SC7	(D-13-14)35aad3	SC15	(D-17-13)11dcd2	SC22	(D-19-13)22ccc	SC29	(D-23-15)31cbb
SC8	(D-14-13)23aca						
Agricultural land-use study							
AG1	(B-01-02)14cac	AG4	(B-01-03)34cdd	AG7	(C-01-03)07bbd		
AG2	(B-01-02)32cbb	AG5	(B-01-04)33cad	AG8	(C-01-04)04caa		
AG3	(B-01-03)25ccb	AG6	(C-01-03)02dcc	AG9	(C-01-04)20baa		
West Salt River Valley sub-unit survey							
W10	(A-01-01)14bab2	W20	(A-03-02)16aaa	W30	(B-02-01)01bbb	W40	(B-05-03)24ada
W11	(A-01-01)22dcc	W21	(A-03-02)26dcb	W31	(B-02-01)36add	W41	(B-06-03)36ddd
W12	(A-01-01)28bba	W22	(A-04-01)05acc	W32	(B-02-02)28bca	W42	(C-01-02)19ccc
W13	(A-01-02)21bcd	W23	(A-05-02)35acb2	W33	(B-02-02)33ada	W43	(C-01-04)20bab
W14	(A-01-02)34ada	W24	(B-01-01)14dbd	W34	(B-03-01)02dcc	W44	(D-01-02)10aca
W15	(A-02-02)36cba	W25	(B-01-02)09cbd	W35	(B-03-01)09ccc	¹ W45	(B-01-02)22dba2
W16	(A-02-03)13dac2	W26	(B-01-02)32add	W36	(B-03-01)34bbb	¹ W47	(C-01-03)05bbd
W17	(A-02-04)21ccb	W27	(B-01-03)13dba	W37	(B-04-01)07aaa	¹ W61	(B-01-04)32dbb
W18	(A-03-01)25abb	W28	(B-01-03)30cdc	W38	(B-04-03)04bdb	¹ W63	(B-02-02)24baa
W19	(A-03-01)34ddd2	W29	(B-01-03)34bbb	W39	(B-05-03)15aaa	¹ W65	(C-01-02)06dbb

¹Well was not used for interpretation of sub-unit survey results