In cooperation with the California State Water Resources Control Board

Pesticides in Water and Suspended Sediment of the Alamo and New Rivers, Imperial Valley/Salton Sea Basin, California, 2006–2007

Data Series 365

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

Cover: Photograph of the New River in Imperial County, California.

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By James L. Orlando, Kelly L. Smalling, and Kathryn M. Kuivila

Prepared in cooperation with the California State Water Resources Control Board
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Contents

Figures

Tables

Conversion Factors, Datums, and Abbreviated Water-Quality Units

SI to Inch/Pound

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
kilometer (km)	0.5400	mile, nautical (nmi)
meter (m)	1.094	yard (yd)
	Area	
hectare (ha)	2.471	acre
square kilometer (km^2)	0.3861	square mile (mi^2)
	Volume	
liter (L)	1.057	quart (qt)
	Flow rate	
cubic meter per second (m^3/s)	35.31	cubic foot per second (ft^3/s)
	Mass	
kilogram (kg)	2.205	pound avoirdupois (lb)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F=(1.8\times°C)+32.$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C=(°F-32)/1.8.$$

Datums

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

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

Altitude, as used in this report, refers to distance above the vertical datum.

Concentrations of chemical constituents in water are reported either in milligrams per liter (mg/L) or nanograms per liter (ng/L).

Conversion Factors, Datums, and Abbreviated Water-Quality Units—Continued

Abbreviations

Abbreviations	Meaning
°C/min,degrees	Celsius per minute
DO	dissolved oxygen
G	dimensionless ratio of the acceleration due to centrifugal force divided by the acceleration due to gravity
g	gram
L/min	liter per minute
µg/kg	microgram per kilogram
µg/mL	microgram per milliliter
µL	microliter
µm	micrometer
mg	milligrams
mL	milliliter
mL/min	milliliter per minute
v	volt
USEPA	U.S. Environmental Protection Agency
TMDL	Total Maximum Daily Load
PCBs	polychlorinated biphenyls
VOCs	volatile organic compounds
USGS	U.S. Geological Survey

Pesticides in Water and Suspended Sediment of the Alamo and New Rivers, Imperial Valley/Salton Sea Basin, California, 2006–2007

By James L. Orlando, Kelly L. Smalling, and Kathryn M. Kuivila

Abstract

Water and suspended-sediment samples were collected at eight sites on the Alamo and New Rivers in the Imperial Valley/Salton Sea Basin of California and analyzed for both current-use and organochlorine pesticides by the U.S. Geological Survey. Samples were collected in the fall of 2006 and spring of 2007, corresponding to the seasons of greatest pesticide use in the basin. Large-volume water samples (up to 650 liters) were collected at each site and processed using a flow-through centrifuge to isolate suspended sediments. One-liter water samples were collected from the effluent of the centrifuge for the analysis of dissolved pesticides. Additional samples were collected for analysis of dissolved organic carbon and for suspended-sediment concentrations.

Water samples were analyzed for a suite of 61 current-use and organochlorine pesticides using gas chromatography/mass spectrometry. A total of 25 pesticides were detected in the water samples, with seven pesticides detected in more than half of the samples. Dissolved concentrations of pesticides observed in this study ranged from below their respective method detection limits to 8,940 nanograms per liter (EPTC). The most frequently detected compounds in the water samples were chlorpyrifos, DCPA, EPTC, and trifluralin, which were observed in more than 75 percent of the samples. The maximum concentrations of most pesticides were detected in samples from the Alamo River. Maximum dissolved concentrations of carbofuran, chlorpyrifos, diazinon, and malathion exceeded aquatic life benchmarks established by the U.S. Environmental Protection Agency for these pesticides.

Suspended sediments were analyzed for 87 current-use and organochlorine pesticides using microwave-assisted extraction, gel permeation chromatography for sulfur removal, and either carbon/alumina stacked solid-phase extraction cartridges or deactivated Florisil for removal of matrix interferences. Twenty current-use pesticides were detected in the suspended-sediment samples, including pyrethroid insecticides and fungicides. Fourteen legacy organochlorine pesticides also were detected in the suspended-sediment samples. Greater numbers of current-use and organochlorine pesticides were observed in the Alamo River samples in comparison with the New River samples. Maximum concentrations of current-use pesticides in suspended-sediment samples ranged from below their method detection limits to 174 micrograms per kilogram (pendimethalin). Most organochlorine pesticides were detected at or below their method detection limits, with the exception of p,p’-DDE, which had a maximum concentration of 54.2 micrograms per kilogram. The most frequently detected current-use pesticides in the suspended-sediment samples were chlorpyrifos, permethrin, tetraconazole, and trifluralin, which were observed in more than 83 percent of the samples. The organochlorine degradates p,p’-DDD and p,p’-DDE were detected in all suspended-sediment samples.

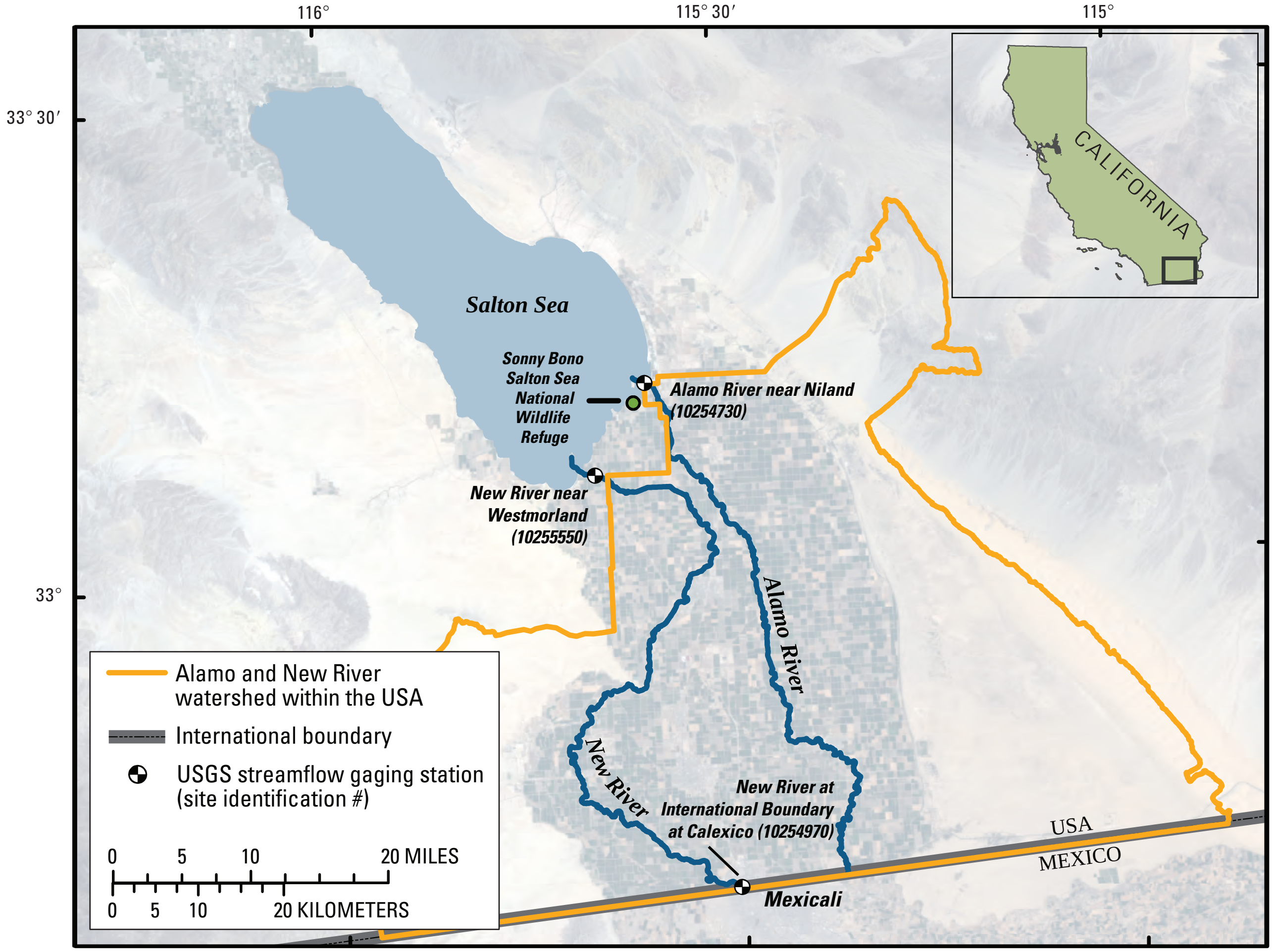
Introduction

The Imperial Valley/Salton Sea Basin in southeastern California is one of the State’s most productive agricultural areas, the result of a year-round growing season and the rich supply of water that is carried from the Colorado River to the region by way of an extensive and complex irrigation network. A wide variety of crops are grown throughout the year in the region, which results in the use of large amounts of multiple pesticides. Previous studies by federal, state, and local agencies have documented elevated levels of both current-use and organochlorine pesticides in water, and associated with suspended and bed sediments, in the Alamo and New Rivers, which drain the majority of the Imperial Valley (Eccles, 1979; Setmire and others, 1984; Schroeder and others, 1988; Setmire and others, 1990; Michel and Schroeder, 1994; Crepeau and others, 2002; and Leblanc and others, 2004a,b). Additional studies have found increased levels of aquatic toxicity in these rivers (de Vlaming and others, 2000; and de Vlaming and others, 2004).

Currently, the Alamo and New Rivers are listed by the U.S. Environmental Protection Agency (USEPA) as impaired, and total maximum daily load (TMDL) criteria currently are being developed and implemented for both rivers. The Alamo River is on the Federal Clean Water Act Section 303(d) list for impairments caused by chlorpyrifos, DDT, dieldrin, PCBs (polychlorinated biphenyls), selenium, and toxaphene. The New River is listed as impaired, due to low dissolved oxygen (DO)-organic enrichment, chlordane, chlorpyrifos, copper, DDT, diazinon, dieldrin, mercury, nutrients, pathogens, PCBs, sediment, selenium, toxaphene, toxicity, trash, and volatile organic compounds (VOCs). In support of the current TMDL development effort, and in cooperation with the California State Regional Water Quality Control Board, the U.S. Geological Survey (USGS) conducted a study, described in this document, to determine concentrations of current-use and organochlorine pesticides in water and suspended sediments in the Alamo and New Rivers.

Hydrologic Setting

The Alamo and New Rivers are located in the Imperial Valley of southeastern California (fig. 1). The area is characterized by an arid, desert-like climate, with normal summer temperatures of up to 41˚C and less than 8 centimeters (cm) of rainfall annually (National Oceanic and Atmospheric Administration, 2002). Despite this harsh climate, the Imperial Valley is one of California's richest agricultural regions, made possible by irrigation water derived from the Colorado River by way of the All-American Canal and supplied to the valley through a nearly 6,000 kilometer (km), complex network of supply and drainage canals. This irrigation network supplies water to over 200,000 hectares (ha) of farmland south of the Salton Sea (Imperial Irrigation District, 2007). Generally, water is gravity-fed onto fields for flood irrigation or pumped and applied using moveable sprinkler systems. Tail water and tile drain water leave the fields through surface and subsurface drains, respectively.



Base map from National Agriculture Imagery Program (2005)

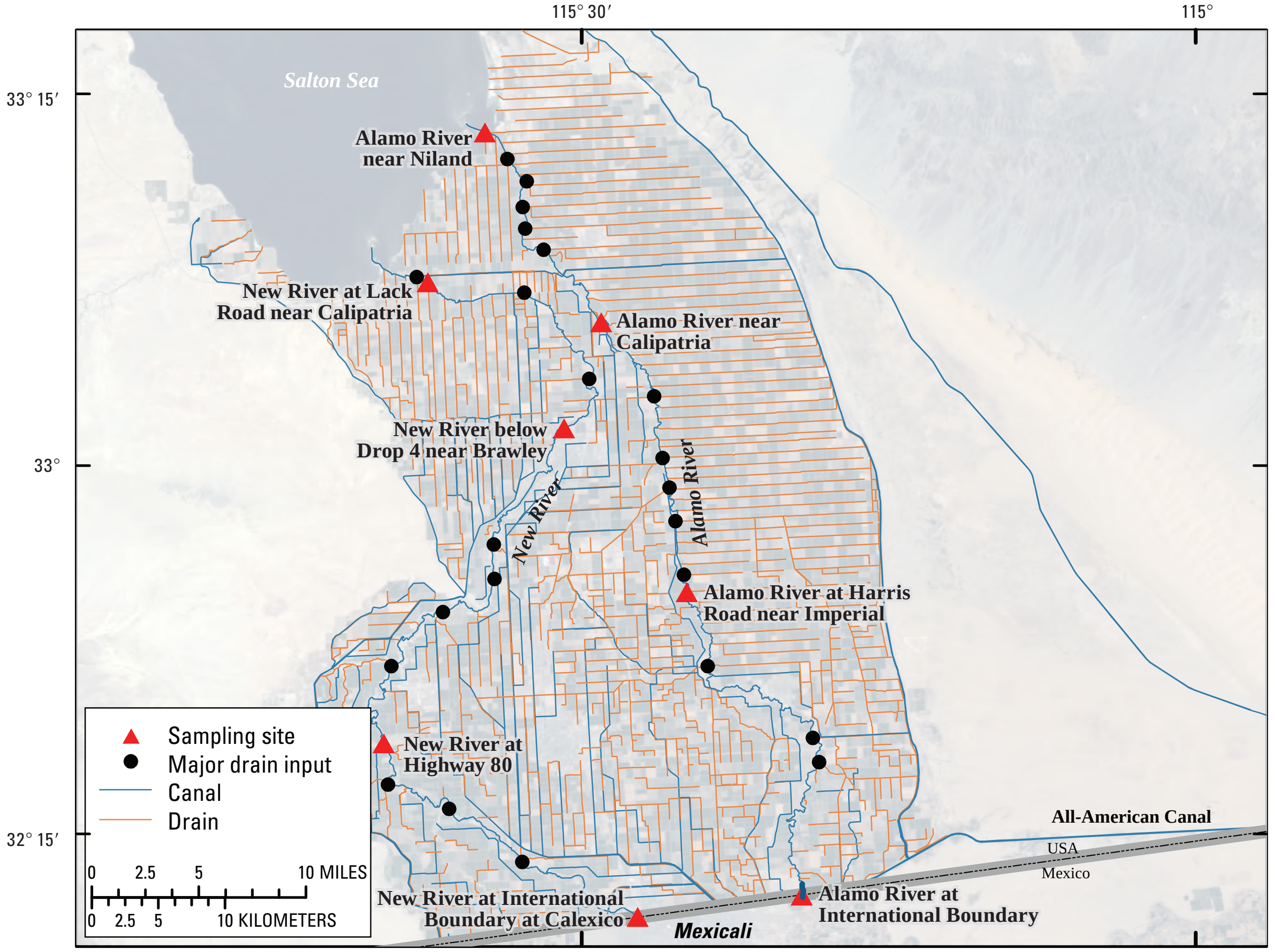
Figure 1. Location map showing study area within the Imperial Valley/Salton Sea basin.

These drains are part of an extensive system and eventually discharge into either the Alamo River, New River, or directly into the Salton Sea (fig. 2).

The Alamo and New Rivers originate near the Colorado River delta in Mexico and flow north approximately 100 km, where they drain into the southern end of the Salton Sea. Flow in both rivers primarily is made up of agricultural drainage waters (Setmire, 1984; Schroeder and others, 1988). The New River also receives treated and untreated municipal and industrial wastewater from Mexicali, Mexico, a city with a population of more than 1 million, located along the international border between the United States and Mexico.

The USGS operates streamflow-gaging stations on the Alamo and New Rivers. Gages are located near both river outlets to the Salton Sea, and on the New River at the international boundary (fig. 1). Daily mean flows at the outlet sites during their 46- and 64-year periods of record ranged from 468 to 1,120 cubic feet per second (ft^3/s) for the Alamo River near Niland (10254730), and from 508 to 750 ft^3/s for the New River near Westmorland (10255550) (figs. 1 and 3). Mean flow at the New River at International Boundary at Calexico site (10254970) ranged from 193 to 288 ft^3/s over its 27-year period of record (U.S. Geological Survey, 2007a). Flows in both rivers follow a seasonal pattern, in response to irrigation, with broad peaks in the spring and early fall.

The combined watershed of the Alamo and New Rivers within the United States is approximately 4,140 square kilometers (km^2) (fig. 1). This does not take into consideration the larger watershed of the Colorado River, though it is the primary source of water within the Imperial Valley. Previous studies have shown that source water from the Colorado River to the Imperial Valley rarely contains measurable concentrations of dissolved current-use pesticides (Kelly and others, 2001; U.S. Geological Survey, 2007b). In addition, suspended sediments are removed from Colorado River water by six desilting basins prior to the water entering the All-American Canal; therefore, pesticides associated with suspended sediments in Colorado River water are unlikely to reach the Imperial Valley.



Base map from National Agriculture Imagery Program (2005)

Figure 2. Map of sampling sites and major agricultural drain inputs to the Alamo and New Rivers.

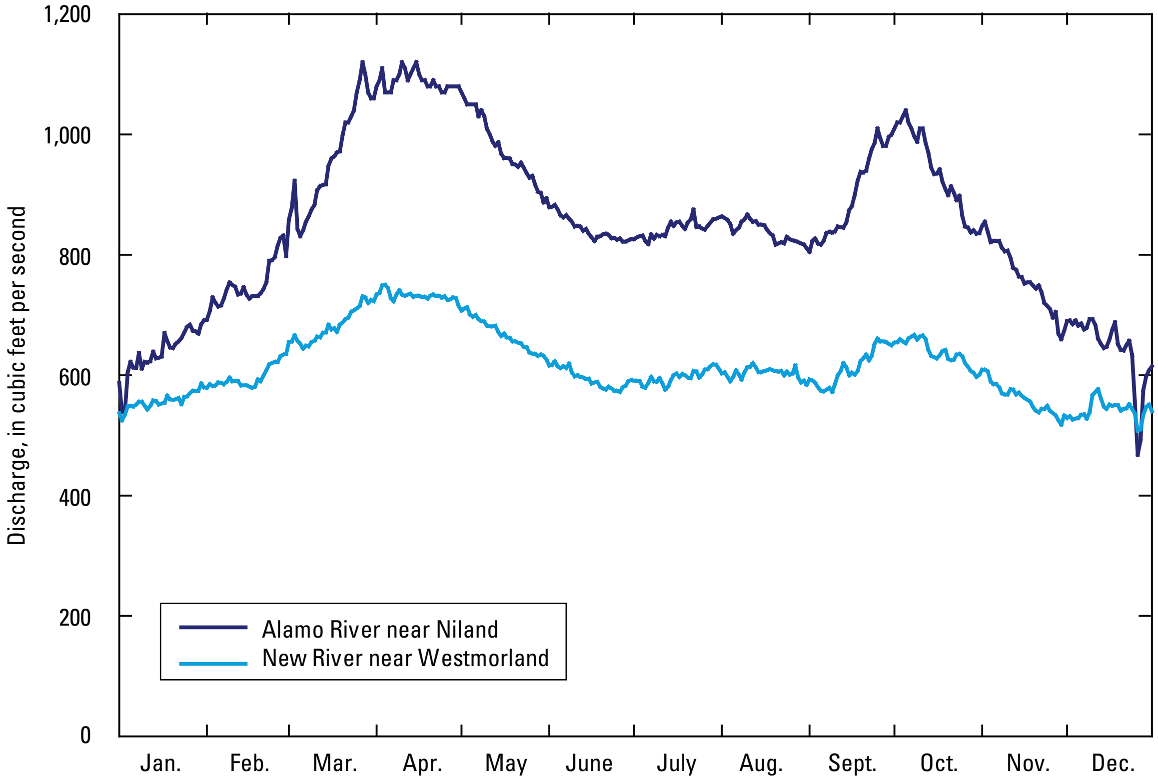


Figure 3. Graph of mean daily flows for the Alamo and New Rivers at their outlets to the Salton Sea.

Pesticide Use

Approximately 1.1 million kilograms of pesticide-active ingredients (excluding sulfur), were applied to over 60 different crops in the Alamo/New River watershed in 2006 (California Department of Pesticide Regulation, 2008). Annual pesticide applications follow a bimodal pattern, with peaks in the spring (February/March) and fall (September/October) (fig. 4). During 2006, over 180 pesticide active ingredients were applied in the basin. The majority (by weight) of these pesticides were applied to six major crops (alfalfa, carrots, lettuce, melons, onions, and sugar beets). Just over 10 percent of the total registered pesticide use in the watershed is for non-agricultural purposes such as structural pest control or roadside maintenance. Applications of pesticides analyzed for during this study totaled just over 250,000 kilograms (kg) in 2006 (the most recent year for which data currently are available), and were dominated by applications of the herbicide trifluralin (table 1). From 2003 to 2006, there was a decrease in the total applications of pesticides analyzed in this study. However, use of 14 of the 49 pesticides increased by varying amounts over the same period (table 1). With the exception of endosulfan, organochlorine pesticides analyzed in suspended sediments during this study no longer are applied in the study area.

Study Design

This study was designed to assess the concentrations of dissolved and sediment-associated pesticides present in the Alamo and New Rivers within the Imperial Valley of California. The study was conducted by the USGS in collaboration with the California State Water Resources Control Board, Colorado River Basin (Region 7), and builds on earlier work done in support of total maximum daily load (TMDL) development for pesticides in the Alamo and New Rivers (Leblanc and others, 2004b).

Sampling was timed to coincide with the peak periods of pesticide application in the basin and was conducted during September, October, and November 2006, and during February, March, and April 2007 (fig. 4). Water and suspended-sediment samples were collected at a total of eight sites in the basin with four sites on each river. Samples were collected only at the two river outlet sites during September, November, February, and April. During October and March, samples were collected from all eight sites. All sampling was conducted during the middle of each month.

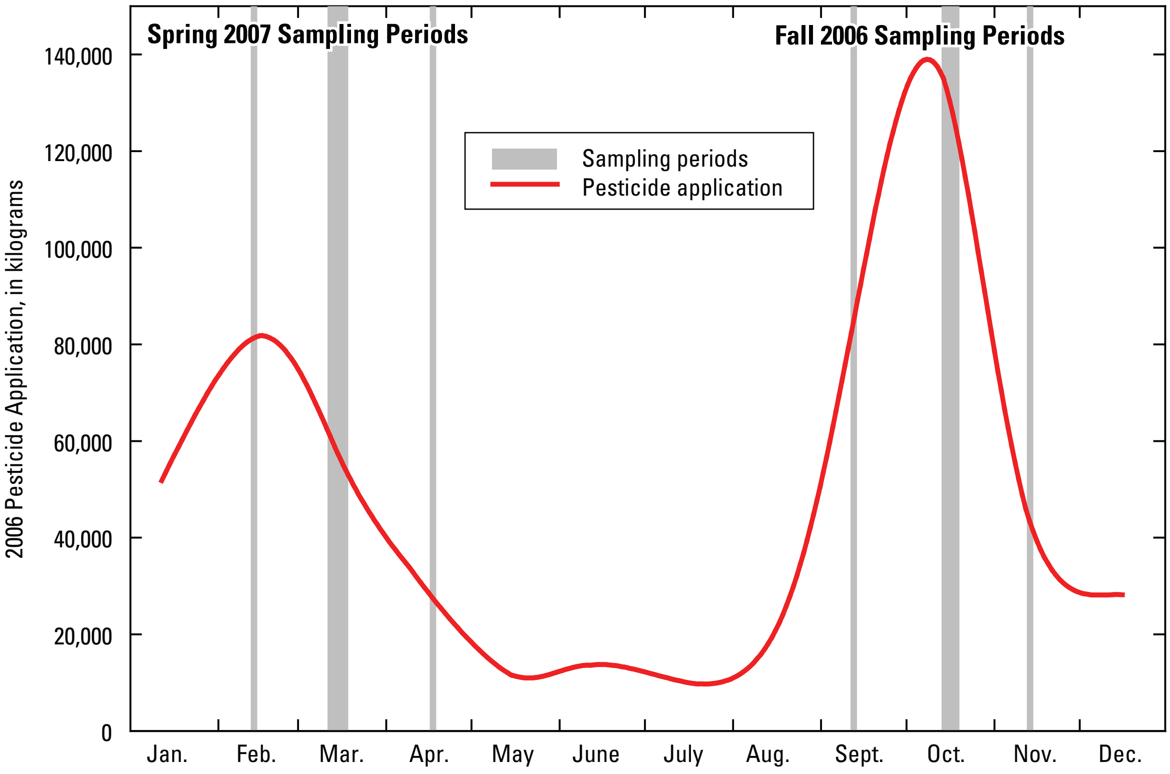


Figure 4. Pesticide application (excluding sulfur) in the combined Alamo/New River watershed in 2006 along with Fall 2006 and Spring 2007 sampling periods. (California Department of Pesticide Regulation, 2008)

Table 1. Pesticide applications of compounds analyzed for in this study 2003–2006.

[Values are reported in kilograms]

Compound	Application			
	2006	2005	2004	2003
Trifluralin	104,505	97,569	95,814	113,658
DCPA	25,256	28,517	23,291	26,425
Malathion	24,263	22,350	25,338	29,285
Chlorpyrifos	22,716	28,056	39,575	36,758
EPTC	17,325	20,193	23,840	15,293
Diazinon	13,334	13,840	17,738	19,054
Pendimethalin	7,852	9,860	10,309	7,941
Atrazine	6,402	7,687	5,281	5,836
Cypermethrin	4,506	5,303	3,540	1,744
Chlorothalonil	4,427	19,450	10,377	13,613
Permethrin	4,307	3,915	3,236	3,309
Oxyfluorfen	3,320	3,021	2,022	1,842
Endosulfan	2,136	2,313	1,543	4,487
Cycloate	1,891	2,257	1,893	955
Diuron[1]	1,730	1,377	7,858	641
Cyfluthrin	1,273	1,204	1,254	1,259
Esfenvalerate	1,005	772	916	1,168
λ-Cyhalothrin	923	801	654	801
Napropamide	582	568	1,076	484
Iprodione	541	1,635	1,101	1,067
Carbaryl	539	1,110	1,450	2,276
Bifenthrin	390	233	211	83
Prometryn	390	81	256	308
Disulfoton	351	299	999	931
Fipronil	315	61	54	0
Piperonyl butoxide	249	67	30	0
Carbofuran	198	1,436	406	2,059
Fenpropathrin	153	425	765	571
Azoxystrobin	147	385	64	105
Myclobutanil	128	155	100	36
Pyrethrins	89	14	8	5
Ethalfluralin	72	79	64	0
Trifloxystrobin	13	16	13	31
Deltamethrin	12	12	16	0
Propiconazole	10	16	26	10
Tebuconazole	2	0	18	132
Methoprene	2	0	0	0
Phosmet	0	22	0	0
Methidathion	0	9	0	84
PCNB	0	3	6	3
Hexazinone	0	0	0	3
Parathion	0	0	23	0
Tralomethrin	0	0	2	8

[1] Diuron is a parent compound of 3,4-DCA.

Descriptions of Sampling Sites

Eight sites were sampled during this study: four sites on the Alamo River and four sites on the New River (table 2). Sites extended from the international border with Mexico to within a few kilometers of each river's outlet to the Salton Sea. Sites were selected by USGS personnel at points downstream of major agricultural drain inputs to each river (fig. 2). Where safety permitted, sites were located at bridges to allow for transect sampling and streamflow measurements.

Alamo River Sites

The furthest upstream site (Alamo River at International Boundary at Calexico) is located adjacent to the All-American Canal and just inside the U.S. border in California. The river emerges from a concrete channel under the canal and spills over a low (0.3-meter high) weir. Samples were collected immediately downstream of the weir at two points spaced equally across the channel. Streamflow at this site was extremely low during all sampling events and was not measured.

The "Alamo River at Harris Road near Imperial" site is located approximately 43 river km downstream of the "Alamo River at International Boundary" site. Water samples were collected at five equally spaced points along the downstream side of the road bridge. Three major and multiple minor agricultural drains enter the Alamo River upstream of this site (fig. 2). Streamflow measurements were conducted at this site at the time of sample collection, following standard USGS procedures (Buchanan and Somers, 1969) (table 3).

The next downstream site (Alamo River near Calipatria) is located approximately 28 river km downstream of the Alamo River at Harris Road near Imperial site. There are five major and many minor agricultural drains that enter the river between these two sites (fig. 2). Samples were collected from the downstream side of a bridge on Kershaw Road, at five equally spaced points across the channel. Streamflow measurements also were made at this site (table 3).

The furthest downstream site on the Alamo River (Alamo River near Niland) is co-located with a USGS real-time streamflow gaging station (site id #10254730). There are five major, and numerous minor, agricultural drains that enter the river between this site and the next site upstream (fig. 2). Samples were collected from the downstream side of a bridge on Sinclair Road, at five equally spaced points across the channel. Real-time stream discharge data are recorded continuously at the gage and are shown in table 3 for each sampling event.

Table 2. Sampling sites located on the Alamo and New Rivers, California

[Horizontal datum: North American Datum 83 (NAD 83); vertical datum: North American Vertical Datum of 1988 (NAVD 88). **Abbreviations:** USGS, U.S. Geological Survey]

Official sampling site name	USGS site identification No.	Latitude	Longitude
Alamo River near Niland	10254730	33°11'56"	115°35’49”
Alamo River near Calipatria	330402115303501	33°04’02”	115°30’35”
Alamo River at Harris Road near Imperial	325259115270801	32°52’59”	115°27’08”
Alamo River at International Boundary	324032115220501	32°40’32”	115°22’08”
New River at Lack Road near Calipatria	330559115385601	33°05’59”	115°38’56”
New River below Drop 4 near Brawley	325951115323501	32°59’51”	115°32’38”
New River at Highway 80	324728115420101	32°47’28”	115°42’04”
New River at International Boundary at Calexico	10254970	32°39’57”	115°30’11”

Table 3. Stream discharge, dissolved organic carbon, and suspended-sediment concentrations at sites located on the Alamo and New Rivers, California.

[Numbers in brackets are U.S. Geological Survey National Water Information System (NWIS) parameter codes. **Abbreviations:** hh:mm, hours minutes; ft^3/s, cubic feet per second; mg/L, milligrams per liter; mm, millimeter; NA, discharge not measured]

Official Site Name	Date	Time (hh:mm)	Stream discharge (ft^3/s) [00060]	Dissolved organic carbon concentration (mg/L) [00681]	Suspended sediment concentration (mg/L) [80154]	Percent finer than .062 mm
Alamo River near Niland	09-12-06	11:45	796	13.0	234	99.2
	10-14-06	13:00	937	8.7	316	87.9
	11-13-06	16:20	656	5.5	213	94.9
	02-13-07	10:55	679	5.9	Sample Lost	Sample Lost
	03-12-07	16:20	978	7.4	437	89.1
	04-17-07	11:00	1,140	7.8	531	71.1
Alamo River near Calipatria	10-16-06	17:00	792	6.7	363	79.9
	03-14-07	12:00	957	9.2	343	87.3
Alamo River at Harris Road near Imperial	10-17-06	08:50	545	6.1	172	80.5
	03-16-07	09:30	459	7.7	349	75.8
Alamo River at International Boundary	10-18-06	07:45	NA	7.7	71	98.9
	03-17-07	08:30	NA	8.3	33	96.7
New River at Lack Road near Calipatria	09-13-06	09:00	496	14.8	242	94.9
	10-14-06	07:00	470	8.5	243	93.2
	11-14-06	09:00	400	6.6	242	80.0
	02-14-07	10:45	600	9.1	190	80.2
	03-13-07	09:45	700	6.3	423	77.6
	04-18-07	10:15	675	7.4	321	84.5
New River below Drop 4 near Brawley	10-15-06	07:30	412	10.3	201	94.7
	03-14-07	07:30	485	8.3	305	86.3
New River at Highway 80	10-16-06	07:35	NA	14.0	105	95.5
	03-15-07	08:00	NA	11.6	87	96.8
New River at International Boundary at Calexico	10-19-06	07:30	123	17.7	48	89.9
	03-18-07	08:30	173	9.2	20	82.7

New River Sites

Stringent safety protocols were followed for samples collected at all sites on New River, as its river water is known to contain high levels of fecal coliforms and other biological contaminants. The New River at International Boundary at Calexico site is located 400 m north of the International Boundary and is co-located with a USGS streamflow gaging station (site id #10254970). Samples were collected from a footbridge at three equally spaced points across the channel. Real-time stream discharge data are recorded continuously at the gage and are presented for each sampling event at this site (table 3).

New River at Highway 80 is located 33 river km downstream of the International Boundary site. There are three major and multiple minor agricultural drains that enter the river upstream of this site (fig. 2). Due to safety considerations, this site could not be sampled from a bridge; therefore, samples were collected from the downstream side of a large concrete culvert passing under Highway 80. Water was collected from two equally spaced points across the stream channel. Stream discharge measurements could not be conducted at this site.

The next downstream site (New River below Drop 4 near Brawley) is located 42 river km downstream of the Highway 80 site. Four major and many minor drains enter the New River between these sites (fig. 2). Samples were collected from the downstream side of the bridge at the site, at five equally spaced points across the stream channel. Streamflow measurements were made at this site during each sample collection (table 3).

"New River at Lack Road near Calipatria" is the furthest downstream site sampled on the New River. The site is located at a road bridge approximately 1.5 km upstream of a USGS gaging station (New River near Westmorland, site id #10255550) (fig. 1). Samples were collected at the Lack Road site rather than at the Westmorland site due to the recent removal of the cableway at the gaging station. The Lack Road site was the nearest location upstream of the gaging station where a complete stream transect measurement could be conducted safely. Two major and many smaller agricultural drains discharge into the New River between this site and the "New River below Drop 4 near Brawley" site (fig. 2). Water samples were collected at five equally spaced points across the stream channel on the downstream side of the bridge. Streamflow measurements were conducted at the Lack Road site during each sampling event (table 3).

Purpose and Scope

This report describes the methods and procedures used in determining dissolved and sediment-associated pesticide concentrations in 24 samples collected at 8 sites located on the Alamo and New Rivers in the fall of 2006 and spring of 2007. Results are presented for 61 current-use and organochlorine pesticides analyzed for in water and 87 current-use and organochlorine pesticides analyzed for in suspended sediments. Concentrations of dissolved organic carbon, and suspended-sediment in water samples, as well as percent particulate organic carbon and nitrogen in sediment, also are presented. In addition, stream-discharge measurements made at selected sites and river cross-sectional measurements of dissolved oxygen, specific conductance, temperature, pH, turbidity are reported.

Acknowledgments

The authors express their sincere gratitude to the U.S. Fish and Wildlife Service, Sonny Bono Salton Sea National Wildlife Refuge, and to Roy Schroeder (USGS retired) for invaluable support throughout this project.

Sample Collection and Processing Methods

Large-Volume Water Samples

All water samples were collected using a large, peristaltic pump powered by a portable generator and equipped with a single, stainless steel and Teflon inlet hose. Sample water was pumped directly into pre-cleaned, 20-L stainless steel kegs. The stainless steel kegs were cleaned with deionized water, methanol, and acetone prior to each use. Immediately prior to sample collection, each keg was rinsed three times with water from the sampling site. At each site, water was collected from multiple points spaced equally across the stream channel (from two to five points, depending on stream width) and from multiple vertical points in the water column. Total sample volumes varied, ranging from 200 to 600 L, depending on the suspended-sediment concentration at each site at the time of sampling. Time required to collect a sample generally was less than 30 minutes. Following collection, samples were transported to the Sonny Bono Salton Sea National Wildlife Refuge for initial processing.

Sample Processing

Water and suspended sediments for pesticide analysis were isolated by pumping the large-volume water samples through a flow-through centrifuge (Westfalia model KA-2, Westfalia Corporation, Odele, Federal Republic of Germany). Water (200–600 L) was pumped at a flow rate of 2 L/min through the centrifuge, which operated at 9,500 G (G is the dimensionless ratio of the acceleration due to centrifugal force divided by the acceleration due to gravity). The 2 L/min flow rate has been shown to be within the range of optimal influent rate for efficient capture of a wide variety of grain sizes and suspended sediment concentrations (Horowitz and others, 1989). During the processing of each 20-L sample keg, sample water was collected from the effluent of the centrifuge directly into 1-L baked amber glass bottles. In the Westfalia model KA-2, sediment was collected in a series of four nested, stainless steel bowls. Following centrifugation of an entire water sample, sediment was removed carefully from each of the concentric centrifuge bowls using precleaned Teflon and stainless steel spatulas. Sediment was placed directly into 500-mL precleaned, amber glass jars and frozen. All samples were transported on ice within 48 hours of collection to the U.S. Geological Survey Organic Chemistry Research Laboratory in Sacramento, California.

Dissolved Organic Carbon and Suspended-Sediment Concentration Sample Collection

Water samples for the analysis of DOC and SSC were collected immediately prior to or following collection of the large-volume water samples. Samples were collected from a single stream transect at multiple vertical points using an isokinetic depth-integrating sampler (USGS DH-95) equipped with a 1-L Teflon bottle at six of the eight sampling sites. At the remaining two sites (Alamo River at International Boundary and New River at Highway 80), samples were collected concurrently with the large-volume water samples using the peristaltic pump, due to safety considerations. Samples collected using the DH-95 were shaken vigorously and then poured from the 1-L Teflon collection bottle into a single 125-mL baked, amber glass bottle (DOC) and a 500-mL clear glass bottle (SSC). Samples collected using the peristaltic pump were pumped directly into their respective containers.

Samples for DOC analysis were processed immediately after collection, by gravity filtering through a baked, 0.7-µm (Whatman GF/F; Florham Park, New Jersey) glass fiber filter into a 125-mL precleaned, amber glass bottle. The pH was adjusted to approximately 1.9 in each DOC sample using 4–7 drops of concentrated hydrochloric acid. Samples were refrigerated and shipped on ice to the U.S. Geological Survey Organic Chemistry Research Laboratory in Sacramento, California.

Samples collected for suspended-sediment concentration analysis were not processed in the field. Samples were refrigerated following collection and shipped to the U.S. Geological Survey Sediment Laboratory in Marina, California.

Water-Quality Parameters

Water-quality parameters (temperature, specific conductance, pH, dissolved oxygen, and turbidity) were measured at each site at the time of sample collection using a Hydrolab Surveyor 4 multiparameter meter (Hach Environmental, Loveland, Colorado) calibrated daily during each field deployment. Measurements were made at multiple points along the stream transect and at multiple depths at each site and recorded in field notebooks. Mean values for each water-quality parameter were calculated and recorded as the final field value for the respective water samples collected for pesticide analyses.

Analytical Methods

Dissolved Pesticides

Water collected from the continuous-flow centrifuge effluent was extracted onto solid phase extraction (SPE) cartridges within 24 hours of collection. Prior to extraction, samples were spiked with ring-$^{13}C_3$-atrazine and diethyl-d_{10} diazinon as recovery surrogates (Cambridge Isotopes Lab, Andover, Massachusetts). The 1-L water sample was pumped at a flow rate of 10 mL/min through an Oasis® HLB extraction cartridge (6 cc, 500 mg, 60 µm; Waters Corporation, Milford, Massachusetts) that had been preconditioned with 10 mL of ethyl acetate, 10 mL methanol and 5 mL of deionized water. The cartridges were dried manually using a syringe and frozen at -40°C. The syringe was used to dry the cartridge in the field since carbon dioxide, typically used as the drying agent, was not available. Prior to analysis, the cartridges were thawed, eluted with 12 mL of ethyl acetate, and concentrated under nitrogen. After extraction, ~1 g of sodium sulfate (Na_2SO_4) was added to sample bottles to remove any residual water, and the bottles were rinsed three times with approximately 5 mL of dichloromethane (DCM). The bottle rinses were reduced to 1 mL under nitrogen and then added to the ethyl acetate fraction. The entire sample (bottle rinse plus SPE elution) was reduced to a final volume of 200 µL for analysis. Deuterated polycyclic aromatic hydrocarbon (PAH) compounds were used as internal standards and included acenaphthene- d_{10}, phenanthrene- d_{10}, and pyrene- d_{10}. All extracts were analyzed for 61 current-use and organochlorine pesticides by gas chromatography/mass spectrometry (GC/MS). Details of the analytical method are described in Hladik and others (2008).

Sediment-Associated Pesticides

Sediment samples were extracted based on methods described by LeBlanc and others (2004b), Smalling and others (2005), and Smalling and Kuivila (USGS, written commun., 2008). Prior to extraction, sediment samples were spiked with chlorpyrifos- diethyl-d_{10}, trifluralin- d_{10}, ring-$^{13}C_{12}$-*p,p'*-DDE, phenoxy-$^{13}C_6$-*cis*-permethrin and dibromooctofluorobiphenyl (DBOFB), used as recovery surrogates. Wet sediments (~50 percent moisture) were extracted two times using a MSP 1000 (CEM Corporation, Mathews, North Carolina) microwave-assisted extraction (MAE) with dichloromethane (DCM) and methanol (9:1 v/v) at 100°C and 120°C. Following extraction, sample extracts were dried over Na_2SO_4 and reduced to 0.5 mL using a Turbovap II (Zymark Corporation, Hopkinton, Massachusetts). Sulfur was removed using a gel-permeation/high-performance liquid chromatography system (GPC/HPLC) with DCM and methanol (98:2 v/v) as the carrier solvent. Samples were again reduced to 0.5 mL, split in half, and subjected to two different clean-up methods, depending on compounds of interest.

The first clean-up method was for all compounds except the fungicides and the organochlorine pesticides. Interfering matrix was removed by passing the sample extract through two, stacked SPE cartridges containing 500-mg of nonporous, graphitized carbon (Restek Corporation, Bellefonte, Virginia) and 500-mg alumina (Varian Inc., Palo Alto, California). The cartridges were washed in tandem with 10 mL of DCM prior to the addition of sample extract. Compounds of interest were eluted off both SPE cartridges with 10 mL of DCM and collected as fraction 1 (F1). The carbon SPE was removed and the alumina SPE was eluted with 10 mL of ethyl acetate and DCM (50:50 v/v) and collected as fraction 2 (F2) (Smalling and others, 2005). Both fractions were evaporated separately under a gentle stream of purified nitrogen gas (N-evap, Organomation Associates, Berlin, Massachusetts) to 0.2 mL and the deuterated PAH internal standard mixture was added.

The second clean-up method was designed for the fungicides and the organochlorine pesticides. The interfering matrix was removed using a 200-mL glass column (400 mm L × 10 mm i.d.) dry packed with 10 percent water (v/w) deactivated Florisil (60–100 mesh chromatographic grade, Thermo-Fisher Scientific, Waltham, Massachusetts). The Florisil had been treated previously at 550°C in a muffle furnace for 16 hours. The organochlorine pesticides were eluted with 100 mL of 20 percent DCM in hexane (fraction 1, F1) and the fungicides were eluted using 100 mL of 60 percent ethyl acetate in hexane (fraction 2, F2). Following Florisil clean-up and fractionation, both the F1 and F2 extracts were reduced to ~0.2 mL under a gentle stream of nitrogen gas and exchanged to hexane and ethyl acetate, respectively. Prior to instrumental analysis, the deuterated PAH internal standard mixture was added to each extract.

Instrumental Analysis

Water and suspended-sediment extracts (1-μL injection volume) were analyzed for pesticides on a Varian Saturn 2000 (Walnut Creek, California) gas chromatograph/ion trap mass spectrometer (GC/MS). Analyte separation on the GC/MS was achieved using a 30 m × 0.25 mm i.d. × 0.25 μm DB-5 ms fused silica column (Agilent Technologies, Folsom, California) with helium as the carrier gas. The temperature of the splitless injector was held constant at 275ºC. Because of the number of compounds and instrument limitations, samples were injected in two separate aliquots using two different oven programs: a short (30-min) and a long (61-min) gas chromatograph (GC) oven program. The nine fungicides and the organochlorine pesticides (in sediment only) were run on the shorter program while the rest of the compounds were run on the longer program. The fungicides and organochlorines were separated analytically from the other compounds because of greater ease in setting selected-ion-storage (SIS) windows.

The short-oven program was 80ºC (hold 1 min) with an increase to 300ºC at 10ºC/min (hold 10 min). The long oven program was 80ºC (hold 0.5 min.) with an increase to 120ºC at 10ºC/min, an increase to 200ºC at 3ºC/min (hold 5 min), followed by a third increase to 219ºC at 3ºC/min, and a final increase to 300ºC at 10ºC/min (hold 10 min). The transfer line and ion trap temperatures were 280ºC and 220ºC, respectively. The MS was operated in electron ionization (EI) mode with an emission current of 15 μA and no offset when run in full scan mode, and an emission current of 45 μA with a multiplier offset of 300 volts when using SIS windows. Data were collected in the full scan and SIS modes. More detailed information on the GC/MS method parameters can be found in Hladik and others (2007).

Sample extracts (1μL injection volume) were analyzed for organochlorine pesticides on an Agilent 6890 GC (Agilent Technologies, Palo Alto, California) coupled to a micro-electron capture detector (GC-μECD) with GC/MS confirmation. Analyte separation on the GC-μECD was achieved using a 30 m × 0.25 mm i.d. × 0.25 μm DB-XLB fused silica capillary column (Agilent Technologies, Folsom, California) with helium as the carrier gas. The flow was constant at 1.5 mL/min with an average linear velocity of 35 cm/s. Nitrogen was used as the makeup gas with a total flow of 64 mL/min. The temperature of the splitless injector and the detector were 250°C and 330°C, respectively. The GC oven program was 75°C (hold 0.5 min) and increase to 300°C at 10°C/min (hold 10 min).

Sediment Organic Carbon and Nitrogen

Suspended sediments were analyzed for organic carbon content using a Perkin Elmer CHNS/O analyzer (Perkin Elmer Corporation, Norwalk, Connecticut). Sediments were combusted at 925°C in silver boats after being exposed to concentrated hydrochloric acid (HCl) fumes in a desiccator for 24 hours to remove inorganic carbon. Before analysis, sediments were dried to a constant weight at 100°C for 3 hours. Acetanilimide was used for instrument calibration of elemental carbon and nitrogen.

Dissolved Organic Carbon

Samples were analyzed for DOC using a Shimadzu TOC-5000A total organic carbon analyzer (Shimadzu Scientific Instruments, Columbia, Maryland). The instrument was calibrated using potassium hydrogen phthalate standards prepared in organic-free water with concentrations ranging from 0.0 to 4.0 mg/L. All standards and blanks were acidified prior to analysis using approximately four drops of concentrated HCl to lower the pH to 1.9. The samples were diluted with acidified organic free water prior to analysis by a factor of three or four to insure that sample concentrations would fall into the linear range of the instrument. Approximately 5 mL of the diluted, acidified sample was sparged for 3 minutes using N_2 to remove inorganic carbon as CO_2. The non-purgeable organic carbon (NPOC) was combusted at 680°C and the CO_2 produced by oxidation of the NPOC was detected using a non-dispersive infrared photometric cell. Blanks, replicate samples, and mid-level calibration check standards were analyzed every six samples to monitor the response of the instrument. Additional details about the analytical method can be found in Bird and others (2003).

Suspended-Sediment Concentration and Grain Size

Whole-water samples were analyzed for suspended-sediment concentration and grain size at the U.S. Geological Survey Sediment Laboratory in Marina, California. Details of the analytical method can be found in Guy (1969). Analytical results of single-blind quality control samples provided by the USGS Sediment Laboratory Quality Assurance Project show that laboratory performance during the period of this study was satisfactory (U.S. Geological Survey, 2007c).

Quality Assurance/Quality Control

Pesticide concentrations in water and suspended sediments were validated against a comprehensive set of performance-based quality control criteria including field and laboratory blanks, replicate samples, surrogate recovery, certified reference materials, matrix spikes and matrix spike replicates. All QC results met or exceeded QC guidelines established by the Surface Water Ambient Monitoring Program (SWAMP) (California State Water Resources Control Board, 2002). Therefore, results for the target constituents that were analyzed under the same conditions were of acceptable quality.

Dissolved Pesticides

Two field blanks and two laboratory blanks were analyzed as part of the established SWAMP criteria. No pesticides were detected in any of the laboratory or field blanks during the study. Ring-$^{13}C_3$-atrazine and diethyl-d_{10} diazinon were used as recovery surrogates to assess the efficiency of sample extraction. Mean (± standard deviation) percent recoveries of ring-$^{13}C_3$-atrazine and diethyl-d_{10} diazinon for all samples analyzed (including QC samples) were 97 ± 12 percent and 100 ± 8 percent, respectively. Sample data were excluded if percent recovery was less than 75 percent; since all samples had recoveries greater than 75 percent, all data points were reported. Replicate samples (3) were analyzed constituting approximately 10 percent of the samples and were within 25 percent agreement for all pesticides detected. Relative percent differences for all pesticides detected in replicate sample pairs ranged from 1.4 to 24 percent. Matrix spikes (2) were analyzed in approximately 10 percent of all samples as part of the method validation. The percent recoveries of pesticides in the matrix-spiked samples ranged from 79 to 115 percent. Matrix-spike replicates were analyzed every 20 samples as part of the established SWAMP guidelines. The relative percent differences were calculated for the pesticides analyzed, which ranged from 0.1 to 24 percent, depending on the compound. The USGS National Water Quality Laboratory’s Schedule 2003/2033 field spike added to sample water was used as an appropriate certified reference material to assess the accuracy and precision of the method and was analyzed every 20 samples. Percent recoveries of the certified reference material ranged from 58–122 percent, depending on compound with an average of 102 ± 14 percent.

Calibration of the GC/MS was achieved using calibration standards that spanned the linear range of environmental sample concentrations. An eight-point calibration standard was developed with concentrations ranging from 0.025 to 5.0 µg/mL. Calibration curves were considered acceptable if the coefficient of determination, R^2, for each individual compound was greater than 0.995. The response of the instrument also was monitored every 6–8 samples with mid-level check standards. The instrument was considered to be stable if the recoveries of the check standards fell within the range of 80–115 percent of the nominal standard concentration.

Sediment-Associated Pesticides

Laboratory blanks consisting of baked Na_2SO_4 as a sediment substitute, were analyzed after the analysis of every 10 environmental samples. No pesticides were detected in any of the laboratory blank samples run with the sediment samples. Mean (± standard deviation) recoveries of chlorpyrifos- diethyl-d^{10}, trifluralin-d^{10}, ring-$^{13}C_{12}$-*p,p’* DDE, phenoxy-$^{13}C_6$-*cis*-permethrin and dibromooctofluorobiphenyl (DBOFB), used as recovery surrogates were 89 ± 9 percent, 89 ± 9 percent, 105 ± 11 percent, 93 ± 9 percent, and 91 ± 14 percent, respectively. Two replicate samples were analyzed, constituting approximately 10 percent of the total number of samples analyzed. The relative-percent differences for the two replicate pairs for all pesticides detected were less than 25 percent and ranged from 2.9 to 21.4 percent for the individual compounds. Two matrix spikes were analyzed and the percent recoveries ranged from 75 to 119 percent for all compounds. One additional replicate sample was analyzed as a matrix spike/matrix spike duplicate (MS/MSD) pair to monitor for recovery (compared to the respective unspiked sample) and variability (between spiked samples) as part of established SWAMP guidelines. The percent recoveries for this MS/MSD pair ranged from 76 to 117 percent and the relative-percent differences ranged from 0.02 to 22 percent. Standard reference material 1941b, Organics in Marine Sediment (NIST, Gaithersburg, Maryland), was chosen as an appropriate reference material for this study. Since no standard reference material is available for the current-use pesticides, SRM 1941b was chosen because it contains eight organochlorine pesticides that were compounds of interest in the study (hexachlorobenzene, α-chlordane, γ-chlordane, *cis*-nonachlor, *trans*-nonachlor, p,p’-DDD, p,p’-DDE, and p,p’-DDT) (National Institute of Standards and Technology, 2004). The average percent recovery of the organochlorine pesticides present in SRM 1941b was 100 ± 7 percent. Calculated concentrations for all compounds fell within the 95-percent confidence intervals for the certified values.

Calibration of the GC/MS and GC-μECD was achieved using calibration standards that spanned the linear range of environmental sample concentration (0.025 to 5.0 μg/mL and 0.1 to 100 pg/μL, respectively). Calibration curves for the GC/MS and GC-μECD were considered acceptable if the R^2 for each individual compound was greater than 0.995 and 0.998, respectively. The responses of the instruments were monitored every six to eight samples with mid-level check standards. The instruments were considered to be stable if the recovery of the check standards fell within the range of 80–115 percent of the nominal standard concentration.

Method Detection Limits

Surface-water and suspended-sediment method detection limits (MDLs) were validated in previous studies (Hladik and others, 2007; and Smalling and Kuivila (USGS, written commun., 2008) using the EPA procedure described in 40 CFR Part 136 (U.S. Environmental Protection Agency, 1992). Water samples used to determine MDLs were collected in 2005 from the Sacramento River at Miller Park and suspended-sediment samples were collected in 2004 from the Cache Creek inflow to the settling basin near Woodland (USGS site id # 384340121434401). The MDLs were calculated for each compound using the following equation:

$$MDL = S \cdot t\ (n-1,\ 1-\alpha=0.99),$$

where

MDL is the method detection limit,
S is the standard deviation of replicate samples,
n is the number of replicates ($n = 7$), and
t is the value of the student's *t* statistic at 6 degrees of freedom and 99-percent confidence interval.

MDLs for surface water ranged from 0.9 to 18.0 ng/L (table 4) and suspended sediment MDLs ranged from 0.6 to 4.4 μg/kg (table 5). Analytes can be identified at concentrations less than the MDL with a lower confidence in the actual value; therefore, concentrations of compounds detected below the MDLs are reported as estimates.

Table 4. Method detection limits and U.S. Geological Survey National Water Information System (NWIS) parameter codes for dissolved pesticides in water.

[Values are reported in nanograms per liter. **Abbreviations:** IGR, Insect Growth Regulator]

Compound	Use type	Method detection limit	Parameter code
3,4-DCA	Degradate	8.3	66584
Alachlor	Herbicide	1.7	65064
Allethrin	Insecticide	18.0	66586
Atrazine	Herbicide	2.3	65065
Azoxystrobin	Fungicide	9.3	66589
Bifenthrin	Insecticide	4.7	65067
Butylate	Herbicide	1.8	65068
Carbaryl	Insecticide	6.5	65069
Carbofuran	Insecticide	[1]3.1	65070
Chlorothalonil	Fungicide	12.1	65071
Chlorpyrifos	Insecticide	2.1	65072
Cycloate	Herbicide	1.1	65073
Cyfluthrin	Insecticide	5.2	65074
Cypermethrin	Insecticide	5.6	65075
Cyproconazole	Fungicide	11.2	66593
DCPA	Herbicide	2.0	65076
Deltamethrin	Insecticide	3.5	65077
Diazinon	Insecticide	0.9	65078
EPTC	Herbicide	1.5	65080
Esfenvalerate	Insecticide	3.9	65081
Ethalfluralin	Herbicide	3.0	65082
Fenpropathrin	Insecticide	4.1	65083
Fipronil	Insecticide	2.9	66604
Fipronil disulfinyl	Degradate	1.6	66607
Fipronil sulfide	Degradate	1.8	66610
Fipronil sulfone	Degradate	3.5	66613
Hexazinone	Herbicide	[1]8.4	65085
Iprodione	Fungicide	8.7	66617
λ-cyhalothrin	Insecticide	2.0	65086
Malathion	Insecticide	3.7	65087
Metconazole	Fungicide	11.5	66620
Methidathion	Insecticide	7.2	65088
Methoprene	IGR	8.4	66623
Methylparathion	Insecticide	3.4	65089
Metolachlor	Herbicide	1.5	65090
Molinate	Herbicide	3.2	65091
Myclobutanil	Fungicide	9.2	66632
Napropamide	Herbicide	11.3	65092
Oxyfluorfen	Herbicide	3.1	65093
p,p'-DDD	Degradate	3.6	65094
p,p'-DDE	Degradate	4.1	65095
p,p'-DDT	Insecticide	4.0	65096
Pentachloroanisole (PCA)	Insecticide	4.7	66637
Pentachloronitrobenzene (PCNB)	Insecticide	3.1	66639
Pebulate	Herbicide	2.3	65097
Pendimethalin	Herbicide	2.3	65098
Permethrin	Insecticide	3.4	65099
Phenothrin	Insecticide	5.1	65100
Phosmet	Insecticide	4.4	65101
Piperonyl butoxide	Synergist	2.3	65102
Prometryn	Herbicide	1.8	65103
Propiconazole	Fungicide	8.8	66643
Resmethrin	Insecticide	5.7	65104
Simazine	Herbicide	5.0	65105
τ-fluvalinate	Insecticide	5.3	65106
Tebuconazole	Fungicide	10.2	66649
Tetraconazole	Fungicide	8.2	66654
Tetramethrin	Insecticide	2.9	66657
Thiobencarb	Herbicide	1.9	65107
Trifloxystrobin	Fungicide	3.9	66660
Trifluralin	Herbicide	2.1	65108

[1] Compound detected in unspiked water.

Table 5. Method detection limits and U.S. Geological Survey National Water Information System (NWIS) parameter codes for pesticides associated with suspended sediment

[Values are reported in micrograms per kilogram. **Abbreviations:** IGR, Insect Growth Regulator]

Compound	Use type	Method detection limit	Parameter code
Anilines			
3,4-DCA	Degradate	2.5	63400
Ethalfluralin	Herbicide	1.3	65130
Pendimethalin	Herbicide	1.0	65142
Propanil	Herbicide	Not detectable	63481
Trifluralin	Herbicide	1.7	04019
Azoles/Triazoles			
Cyproconazole	Fungicide	3.3	66594
Fipronil	Insecticide	1.9	66605
Fipronil desulfinyl	Degradate	2.8	66608
Fipronil sulfide	Degradate	2.2	66611
Fipronil sulfone	Degradate	1.1	66614
Metconazole	Fungicide	2.4	66621
Myclobutanil	Fungicide	3.3	66633
Propiconazole	Fungicide	2.2	66644
Tebuconazole	Fungicide	2.9	63492
Tetraconazole	Fungicide	3.4	66655
Carbamates			
Carbaryl	Insecticide	1.8	65117
Carbofuran	Insecticide	1.5	65118
Chloroacetanilides			
Alachlor	Herbicide	1.0	04021
Metolachlor	Herbicide	1.3	04002
Organochlorines			
α-Chlordane	Insecticide	2.0	63122
α-HCH	Insecticide	0.9	63133
Aldrin	Insecticide	1.2	63121
β-HCH	Insecticide	1.2	63134
cis-Nonachlor	Insecticide	1.8	66635
δ-HCH	Insecticide	1.3	66616
Dieldrin	Insecticide	1.3	63127
Endosulfan I	Insecticide	1.7	63128
Endosulfan II	Insecticide	1.0	66601
Endolsulfan sulfate	Degradate	1.4	66602
Endrin	Insecticide	2.0	63129
Endrin aldehyde	Degradate	1.0	66603
γ-Chlordane	Insecticide	1.6	63123
Heptachlor	Insecticide	0.7	63130
Heptachlor epoxide	Degradate	1.6	63131
Hexachlorobenzene	Insecticide	0.8	63132
γ-HCH (Lindane)	Insecticide	1.3	63135
Isodrin	Insecticide	1.7	66619
Methoxychlor	Insecticide	1.4	63136
Oxychlordane	Degradate	1.8	65140
Pentachloroanisole (PCA)	Insecticide	1.4	66638
Pentachloronitrobenzene (PCNB)	Insecticide	1.2	66640
p,p'-DDD	Degradate	1.4	63124
p,p'-DDE	Degradate	1.4	63125
p,p'-DDT	Insecticide	1.3	63126
trans-Nonachlor	Insecticide	1.8	63138
Organophosphates			
Chlorpyrifos	Insecticide	2.0	65120
Diazinon	Insecticide	2.0	65126
Disulfoton	Insecticide	1.9	63432
Malathion	Insecticide	1.1	65135
Methidathion	Insecticide	2.9	65136
Methylparathion	Insecticide	1.2	65137
Phosmet	Insecticide	1.4	65145
Pyrethroids			
Allethrin	Insecticide	1.5	66587
Bifenthrin	Insecticide	2.2	63415
Cyfluthrin	Insecticide	2.0	65122
λ-Cyhalothrin	Insecticide	2.4	65134
Cypermethrin	Insecticide	2.6	65123
Deltamethrin	Insecticide	2.5	65125
Esfenvalerate	Insecticide	2.1	65129
Fenpropathrin	Insecticide	2.1	65131
τ-Fluvalinate	Insecticide	2.6	65148
Permethrin	Insecticide	1.0	65143
Phenothrin	Insecticide	1.3	65144
Resmethrin	Insecticide	1.9	65147
Tefluthrin	Insecticide	1.1	63496
Tetramethrin	Insecticide	1.4	66658
Thiocarbamates			
Butylate	Herbicide	1.6	65116
Cycloate	Herbicide	1.0	65121
EPTC	Herbicide	0.9	65128
Molinate	Herbicide	1.1	65138
Pebulate	Herbicide	1.4	65141
Thiobencarb	Herbicide	0.6	65149
Triazines/Triazones			
Atrazine	Herbicide	1.7	04017
Hexazinone	Herbicide	1.2	65133
Prometryn	Herbicide	2.8	04010
Simazine	Herbicide	1.5	04008
Terbuthylazine	Herbicide	1.7	66652
Strobilurins			
Azoxystrobin	Fungicide	4.4	66590
Trifloxystrobin	Fungicide	3.3	66661
Pyraclostrobin	Fungicide	Not detectable	66647
Miscellaneous			
Chlorothalonil	Fungicide	1.6	65119
DCPA	Herbicide	2.5	65124
Iprodione	Fungicide	2.6	63457
Methoprene	IGR	2.4	66624
Napropamide	Herbicide	1.3	65139
Oxyfluorfen	Herbicide	3.6	63468
Piperonyl butoxide	Synergist	1.6	65146

Results

Dissolved Pesticides

A total of 25 pesticides were detected in the 24 water samples, with detection frequencies as high as 83 percent and concentrations up to 8,900 ng/L (table 6). Overall, detection frequencies of those pesticides observed in the water samples ranged from 4 to 83 percent. The most frequently detected compounds were chlorpyrifos, DCPA, EPTC, and trifluralin, each of which were detected in more than 75 percent of the samples. In contrast, seven compounds (alachlor, azoxystrobin, bifenthrin, cyproconazole, λ-cyhalothrin, myclobutanil, and tebuconazole) were detected only in a single water sample. The compounds with the highest detected maximum concentrations were carbofuran, diazinon, and EPTC, each with maximum concentrations greater than 3,200 ng/L (table 6).

Table 6. Dissolved pesticide concentrations measured in samples collected at sites located on the Alamo and New Rivers, California, September 2006 to April 2007.

[Numbers in brackets are U.S. Geological Survey National Water Information System (NWIS) parameter codes.Values are reported in nanograms per liter. Results in parentheses ( ) are below method detection limits and are estimates. The following compounds were analyzed but were not detected in any samples: allethrin, butylate, cycloate, cyfluthrin, cypermethrin, deltamethrin, disulfoton, esfenvalerate, ethalfluralin, fenpropathrin, fipronil, fipronil disulfinyl, fipronil sulfide, fipronil sulfone, hexazinone, metconazole, methidathion, methoprene, methylparathion, metolachlor, molinate, napropamide, *p,p*'-DDD, *p,p*'-DDT, pentachloroanisole (PCA), pentachloronitrobenzene (PCNB), pebulate, permethrin, phenothrin, phosmet, propiconazole, resmethrin, simazine, τ-fluvalinate, tetramethrin, thiobencarb, and trifloxystrobin. **Abbreviations:** hh:mm, hours minutes; ND, not detected]

Official site name	Sample date	Sample time (hh:mm)	Analysis date	3,4-DCA [66584]	Alachlor [65064]	Atrazine [65065]	Azoxy-strobin [66589]	Bifenthrin [65067]	Carbaryl [65069]	Carbo-furan [65070]
Alamo River near Niland	09-12-06	11:45	09-19-06	ND	ND	114	ND	ND	ND	ND
	10-14-06	13:00	11-14-06	ND	ND	129	ND	ND	42.7	ND
	11-13-06	16:20	11-17-06	ND	ND	ND	ND	ND	ND	ND
	02-13-07	10:55	02-20-07	(5.8)	ND	ND	ND	9.2	ND	ND
	03-12-07	16:20	03-21-07	15.2	137	323	(3.2)	ND	ND	1,500
	04-17-07	11:00	05-03-07	(4.8)	ND	166	ND	ND	ND	108
Alamo River near Calipatria	10-16-06	17:00	11-14-06	ND	ND	99.0	ND	ND	ND	ND
	03-14-07	12:00	03-21-07	10.9	ND	ND	ND	ND	ND	4,020
Alamo River at Harris Road near Imperial	10-17-06	08:50	11-14-06	ND	ND	ND	ND	ND	ND	ND
	03-16-07	09:30	03-21-07	15.5	ND	146	ND	ND	ND	2,330
Alamo River at International Boundary	10-18-06	07:45	11-14-06	ND	ND	ND	ND	ND	ND	ND
	03-17-07	08:30	03-21-07	ND	ND	ND	ND	ND	ND	ND
New River at Lack Road near Calipatria	09-13-06	09:00	09-19-06	ND	ND	ND	ND	ND	ND	ND
	10-14-06	07:00	11-14-06	87.2	ND	ND	ND	ND	ND	ND
	11-14-06	09:00	11-17-06	64.4	ND	ND	ND	ND	ND	ND
	02-14-07	10:45	02-20-07	27.0	ND	ND	ND	ND	ND	ND
	03-13-07	09:45	03-21-07	19.2	ND	ND	ND	ND	ND	65.0
	04-18-07	10:15	05-03-07	9.6	ND	438	ND	ND	ND	ND
New River below Drop 4 near Brawley	10-15-06	07:30	11-14-06	70.0	ND	ND	ND	ND	21.4	ND
	03-14-07	07:30	03-21-07	17.4	ND	ND	ND	ND	ND	ND
New River at Hwy 80	10-16-06	07:35	11-14-06	106	ND	ND	ND	ND	ND	ND
	03-15-07	08:00	03-21-07	35.2	ND	ND	ND	ND	ND	ND
New River at International Boundary at Calexico	10-19-06	07:30	11-14-06	ND	ND	ND	ND	ND	ND	ND
	03-18-07	08:30	03-21-07	21.4	ND	ND	ND	ND	ND	ND

Table 6. Dissolved pesticide concentrations measured in samples collected at sites located on the Alamo and New Rivers, California, September 2006 to April 2007.—Continued

[Numbers in brackets are U.S. Geological Survey National Water Information System (NWIS) parameter codes. Values are reported in nanograms per liter. Results in parentheses ( ) are below method detection limits and are estimates. The following compounds were analyzed but were not detected in any samples: allethrin, butylate, cycloate, cyfluthrin, cypermethrin, deltamethrin, disulfoton, esfenvalerate, ethalfluralin, fenpropathrin, fipronil, fipronil disulfinyl, fipronil sulfide, fipronil sulfone, hexazinone, metconazole, methidathion, methoprene, methylparathion, metolachlor, molinate, napropamide, *p,p*’-DDD, *p,p*’-DDT, pentachloroanisole (PCA), pentachloronitrobenzene (PCNB), pebulate, permethrin, phenothrin, phosmet, propiconazole, resmethrin, simazine, τ-fluvalinate, tetramethrin, thiobencarb, and trifloxystrobin. **Abbreviations:** hh:mm, hours minutes; ND, not detected]

Official site name	Sample date	Sample time (hh:mm)	Analysis date	Chlorothalonil [65071]	Chlorpyrifos [65072]	Cyproconazole [66593]	DCPA [65076]	Diazinon [65078]	EPTC [65080]
Alamo River near Niland	09-12-06	11:45	09-19-06	ND	2.6	ND	39.4	12.4	1,030
	10-14-06	13:00	11-14-06	ND	51.8	ND	444	713	8,940
	11-13-06	16:20	11-17-06	ND	34.4	ND	689	240	146
	02-13-07	10:55	02-20-07	ND	120	ND	197	20.2	148
	03-12-07	16:20	03-21-07	ND	43.2	17.6	94.4	ND	6,020
	04-17-07	11:00	05-03-07	ND	6.0	ND	141	ND	3,788
Alamo River near Calipatria	10-16-06	17:00	11-14-06	ND	123	ND	581	3,240	2,230
	03-14-07	12:00	03-21-07	(1.4)	54.7	ND	176	ND	1,164
Alamo River at Harris Road near Imperial	10-17-06	08:50	11-14-06	ND	58.4	ND	854	485	3,340
	03-16-07	09:30	03-21-07	ND	44.3	ND	170	ND	17.3
Alamo River at International Boundary	10-18-06	07:45	11-14-06	ND	ND	ND	ND	ND	15.6
	03-17-07	08:30	03-21-07	ND	ND	ND	2.6	ND	ND
New River at Lack Road near Calipatria	09-13-06	09:00	09-19-06	ND	7.5	ND	3.8	15.5	10.3
	10-14-06	07:00	11-14-06	ND	21.6	ND	102	333	770
	11-14-06	09:00	11-17-06	ND	10.6	ND	120	64.8	716
	02-14-07	10:45	02-20-07	ND	68.2	ND	22.4	ND	56.6
	03-13-07	09:45	03-21-07	(5.6)	30.4	ND	58.8	ND	61.4
	04-18-07	10:15	05-03-07	ND	5.6	ND	25.2	ND	3,848
New River below Drop 4 near Brawley	10-15-06	07:30	11-14-06	ND	26.0	ND	ND	260	455
	03-14-07	07:30	03-21-07	ND	15.2	ND	7.2	ND	18.6
New River at Hwy 80	10-16-06	07:35	11-14-06	ND	65.4	ND	ND	206	ND
	03-15-07	08:00	03-21-07	ND	ND	ND	ND	ND	ND
New River at International Boundary at Calexico	10-19-06	07:30	11-14-06	ND	ND	ND	ND	249	556
	03-18-07	08:30	03-21-07	ND	ND	ND	ND	ND	ND

Table 6. Dissolved pesticide concentrations measured in samples collected at sites located on the Alamo and New Rivers, California, September 2006 to April 2007.—Continued

[Numbers in brackets are U.S. Geological Survey National Water Information System (NWIS) parameter codes.Values are reported in nanograms per liter. Results in parentheses ( ) are below method detection limits and are estimates. The following compounds were analyzed but were not detected in any samples: allethrin, butylate, cycloate, cyfluthrin, cypermethrin, deltamethrin, disulfoton, esfenvalerate, ethalfluralin, fenpropathrin, fipronil, fipronil disulfinyl, fipronil sulfide, fipronil sulfone, hexazinone, metconazole, methidathion, methoprene, methylparathion, metolachlor, molinate, napropamide, *p,p*'-DDD, *p,p*'-DDT, pentachloroanisole (PCA), pentachloronitrobenzene (PCNB), pebulate, permethrin, phenothrin, phosmet, propiconazole, resmethrin, simazine, τ-fluvalinate, tetramethrin, thiobencarb, and trifloxystrobin. **Abbreviations:** hh:mm, hours minutes; ND, not detected]

Official site name	Sample date	Sample time (hh:mm)	Analysis date	Iprodione [66617]	λ-Cyhalothrin [65086]	Malathion [65087]	Myclobutanil [66632]	Oxyfluorfen [65093]	*p,p'*-DDE [65095]
Alamo River near Niland	09-12-06	11:45	09-19-06	ND	ND	ND	ND	ND	(2.8)
	10-14-06	13:00	11-14-06	ND	ND	ND	ND	ND	ND
	11-13-06	16:20	11-17-06	ND	32.4	ND	ND	5.4	(1.2)
	02-13-07	10:55	02-20-07	ND	ND	16.6	ND	22.4	(2.0)
	03-12-07	16:20	03-21-07	ND	ND	214	19.0	11.2	ND
	04-17-07	11:00	05-03-07	14.0	ND	ND	ND	13.6	ND
Alamo River near Calipatria	10-16-06	17:00	11-14-06	ND	ND	ND	ND	ND	ND
	03-14-07	12:00	03-21-07	ND	ND	186	ND	33.9	ND
Alamo River at Harris Road near Imperial	10-17-06	08:50	11-14-06	ND	ND	ND	ND	6.2	(2.4)
	03-16-07	09:30	03-21-07	ND	ND	129	ND	12.4	ND
Alamo River at International Boundary	10-18-06	07:45	11-14-06	ND	ND	ND	ND	ND	ND
	03-17-07	08:30	03-21-07	ND	ND	ND	ND	ND	ND
New River at Lack Road near Calipatria	09-13-06	09:00	09-19-06	ND	ND	ND	ND	ND	ND
	10-14-06	07:00	11-14-06	ND	ND	ND	ND	ND	ND
	11-14-06	09:00	11-17-06	ND	ND	ND	ND	ND	ND
	02-14-07	10:45	02-20-07	ND	ND	ND	ND	27.4	ND
	03-13-07	09:45	03-21-07	ND	ND	113	ND	15.8	ND
	04-18-07	10:15	05-03-07	32.4	ND	ND	ND	4.6	ND
New River below Drop 4 near Brawley	10-15-06	07:30	11-14-06	ND	ND	ND	ND	ND	ND
	03-14-07	07:30	03-21-07	ND	ND	25.4	ND	ND	ND
New River at Hwy 80	10-16-06	07:35	11-14-06	ND	ND	ND	ND	ND	ND
	03-15-07	08:00	03-21-07	ND	ND	ND	ND	ND	ND
New River at International Boundary at Calexico	10-19-06	07:30	11-14-06	ND	ND	ND	ND	ND	ND
	03-18-07	08:30	03-21-07	ND	ND	ND	ND	ND	ND

Table 6. Dissolved pesticide concentrations measured in samples collected at sites located on the Alamo and New Rivers, California, September 2006 to April 2007.—Continued

[Numbers in brackets are U.S. Geological Survey National Water Information System (NWIS) parameter codes. Values are reported in nanograms per liter. Results in parentheses ( ) are below method detection limits and are estimates. The following compounds were analyzed but were not detected in any samples: allethrin, butylate, cycloate, cyfluthrin, cypermethrin, deltamethrin, disulfoton, esfenvalerate, ethalfluralin, fenpropathrin, fipronil, fipronil disulfinyl, fipronil sulfide, fipronil sulfone, hexazinone, metconazole, methidathion, methoprene, methylparathion, metolachlor, molinate, napropamide, *p,p*'-DDD, *p,p*'-DDT, pentachloroanisole (PCA), pentachloronitrobenzene (PCNB), pebulate, permethrin, phenothrin, phosmet, propiconazole, resmethrin, simazine, τ-fluvalinate, tetramethrin, thiobencarb, and trifloxystrobin. **Abbreviations:** hh:mm, hours minutes; ND, not detected]

Official site name	Sample date	Sample time (hh:mm)	Analysis date	Pendi-methalin [65098]	Piperonyl butoxide [65102]	Prometryn [65103]	Tebuco-nazole [66649]	Tetraco-nazole [66654]	Trifluralin [65108]
Alamo River near Niland	09-12-06	11:45	09-19-06	6.0	ND	ND	ND	ND	12.2
	10-14-06	13:00	11-14-06	7.8	ND	6.0	ND	ND	7.6
	11-13-06	16:20	11-17-06	ND	ND	8.4	ND	ND	15.0
	02-13-07	10:55	02-20-07	182	ND	ND	ND	ND	111
	03-12-07	16:20	03-21-07	233	ND	ND	ND	8.6	517
	04-17-07	11:00	05-03-07	90.8	ND	ND	ND	(3.2)	238
Alamo River near Calipatria	10-16-06	17:00	11-14-06	8.0	ND	ND	ND	ND	37.8
	03-14-07	12:00	03-21-07	360	ND	ND	ND	ND	554
Alamo River at Harris Road near Imperial	10-17-06	08:50	11-14-06	5.4	ND	ND	ND	ND	19.2
	03-16-07	09:30	03-21-07	264	ND	ND	29.3	ND	338
Alamo River at International Boundary	10-18-06	07:45	11-14-06	ND	ND	ND	ND	ND	ND
	03-17-07	08:30	03-21-07	ND	ND	ND	ND	ND	2.8
New River at Lack Road near Calipatria	09-13-06	09:00	09-19-06	10.8	ND	ND	ND	ND	(2.0)
	10-14-06	07:00	11-14-06	ND	ND	ND	ND	ND	12.8
	11-14-06	09:00	11-17-06	ND	15.6	ND	ND	ND	11.6
	02-14-07	10:45	02-20-07	245	ND	ND	ND	ND	ND
	03-13-07	09:45	03-21-07	174	ND	ND	ND	(1.4)	153
	04-18-07	10:15	05-03-07	41.4	ND	ND	ND	(2.0)	98.2
New River below Drop 4 near Brawley	10-15-06	07:30	11-14-06	ND	16.6	ND	ND	ND	(1.0)
	03-14-07	07:30	03-21-07	ND	ND	ND	ND	ND	134
New River at Hwy 80	10-16-06	07:35	11-14-06	ND	30.6	ND	ND	ND	6.6
	03-15-07	08:00	03-21-07	ND	18.2	ND	ND	ND	74.9
New River at International Boundary at Calexico	10-19-06	07:30	11-14-06	ND	61.6	ND	ND	ND	ND
	03-18-07	08:30	03-21-07	ND	ND	ND	ND	ND	ND

There were noticeable differences in pesticide occurrence between the Alamo and New Rivers. Twenty-four pesticides were detected in the Alamo River while only 16 pesticides were detected in the New River (table 7). Nine pesticides were detected only in the Alamo River, while the synergist piperonyl butoxide was detected only in the New River. Four compounds (atrazine, DCPA, oxyfluorfen, and pendimethalin) were detected frequently in the Alamo River but were detected infrequently in the New River, while 3,4-DCA was detected frequently in New River samples but detected only rarely in Alamo River samples (fig. 5). Fifteen compounds were detected in both rivers and maximum concentrations of 11 of these compounds were detected in Alamo River samples.

The occurrence and concentrations of pesticides showed distinct seasonal differences (fig. 6). More pesticides were detected in the spring months (February, March, and April) than in the fall months (September, October, and November). Eleven compounds were detected only during the spring, while three others were detected only during the fall (fig. 6, table 7). The pesticides that were detected most frequently in the spring were 3,4-DCA and DCPA. In the fall, chlorpyrifos and diazinon were detected most frequently. Two additional pesticides (EPTC and trifluralin) were detected in more than 75 percent of the samples in both seasons (fig. 6). Concentrations followed a similar seasonal pattern to detection frequency with the maximum concentrations of 15 pesticides occurring in the spring months and only 10 pesticides in the fall.

Dissolved concentrations of four insecticides (carbofuran, chlorpyrifos, diazinon, and malathion) exceeded aquatic life benchmarks established by the U.S. Environmental Protection Agency (U.S. Environmental Protection Agency, 2007). Carbofuran concentrations exceeded the benchmark for acute toxicity to invertebrates (1,115 ng/L) in three samples collected from the Alamo River in March 2007 (table 6). Chlorpyrifos concentrations were greater than the benchmark for acute invertebrate toxicity (50 ng/L) in five samples from the Alamo River and in two samples from the New River, with four of these seven samples collected during the October 2006 sampling event. Concentrations of diazinon exceeded the acute invertebrate toxicity benchmark (100 ng/L) in six samples and the chronic toxicity benchmark for fish (550 ng/L) in two additional samples. All diazinon exceedances occurred in samples collected in the fall. Malathion concentrations in four samples collected during March 2007 were above the chronic invertebrate toxicity benchmark (60 ng/L). Concentrations of nine pesticides detected during this study (alachlor, atrazine, carbaryl, chlorothalonil, DCPA, EPTC, oxyfluorfen, pendimethalin, and trifluralin) were below aquatic life benchmarks, while the other 12 compounds detected do not have benchmarks.

Table 7. Numbers of detections of dissolved pesticides by season and river system.

[ND, not detected]

Compound	Alamo River		New River	
	Fall 2006	Spring 2007	Fall 2006	Spring 2007
3,4-DCA	ND	5	4	6
Alachlor	ND	1	ND	ND
Atrazine	3	3	ND	1
Azoxystrobin	ND	1	ND	ND
Bifenthrin	ND	1	ND	ND
Carbaryl	1	ND	1	ND
Carbofuran	ND	4	ND	1
Chlorothalonil	ND	1	ND	1
Chlorpyrifos	5	5	5	4
Cyproconazole	ND	1	ND	ND
DCPA	5	6	3	4
Diazinon	5	1	6	ND
EPTC	6	5	5	4
Iprodione	ND	1	ND	1
λ-Cyhalothrin	1	ND	ND	ND
Malathion	ND	4	ND	2
Myclobutanil	ND	1	ND	ND
Oxyfluorfen	2	5	ND	3
p-p'-DDE	3	1	ND	ND
Pendimethalin	4	5	1	3
Piperonyl butoxide	ND	ND	4	1
Prometryn	2	ND	ND	ND
Tebuconazole	ND	1	ND	ND
Tetraconazole	ND	2	ND	2
Trifluralin	5	6	5	4

Sediment-Associated Pesticides

Thirty-four pesticides were detected in suspended-sediment samples at detection frequencies up to 100 percent and with concentrations as high as 174 µg/kg. Pesticides detected included 5 fungicides, 5 herbicides, 19 insecticides (current-use and organochlorines), 4 pesticide degradates, and 1 synergist (tables 5, 8, and 9). The nine most frequently detected pesticides were chlorpyrifos, DCPA, dieldrin, permethrin, p,p’-DDD, p,p’-DDE, p,p’-DDT, tetraconazole, and trifluralin, which were detected in greater than 75 percent of the samples. Pendimethalin and trifluralin had the highest maximum concentrations at 174 and 87.4 µg/kg, respectively. The majority of the organochlorine pesticides detected were at or below their method detection limits, except for p,p’-DDE, for which measured concentrations ranged from 2 to 54 µg/kg.

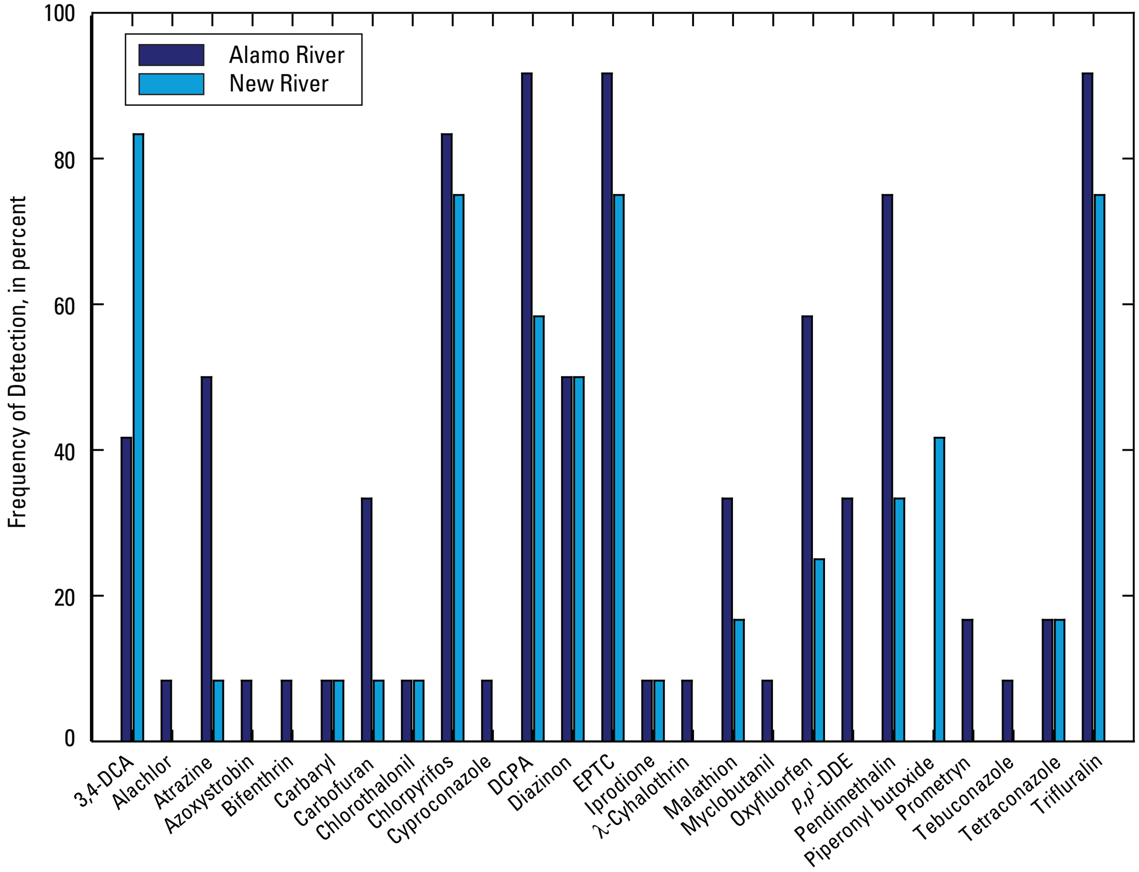


Figure 5. Detection frequencies of dissolved pesticides, as a percentage of the total number of samples collected, by river system.

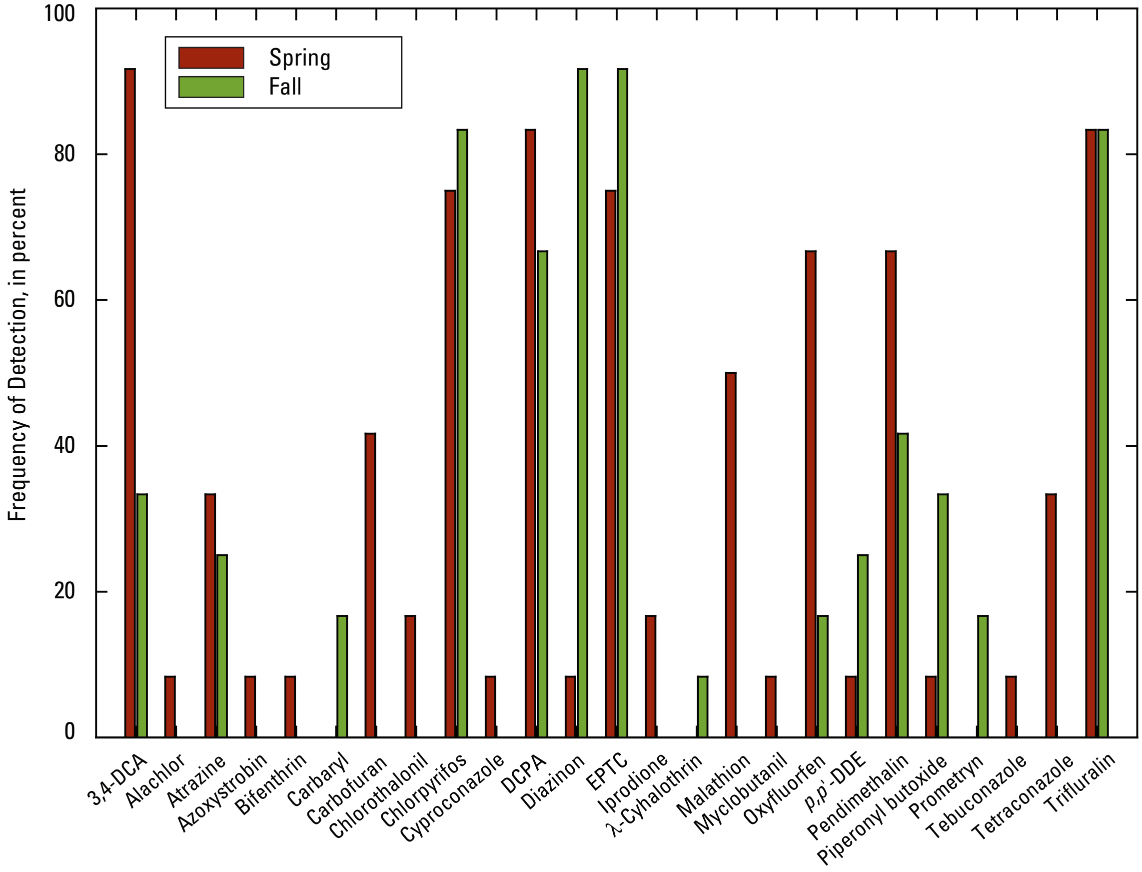


Figure 6. Detection frequencies of dissolved pesticides, as a percentage of the total number of samples collected, by season.

Table 8. Pesticide concentrations in suspended sediments collected at sites located on the Alamo and New Rivers, California, September 2006 to April 2007.

[Numbers in brackets are U.S. Geological Survey National Water Information System (NWIS) parameter codes.Values are reported in micrograms per kilogram. Results in parentheses ( ) are below method detection limits and are estimates. The following compounds were analyzed but were not detected in any samples: alachlor, allethrin, atrazine, azoxystrobin, butylate, carbaryl, cycloate, cyfluthrin, deltamethrin, ethalfluralin, fenpropathrin, fipronil, fipronil desulfinyl, fipronil sulfide, fipronil sulfone, iprodione, hexazinone, malathion, metconazole, methidathion, methoprene, methylparathion, metolachlor, molinate, napropamide, pentachloroanisole (PCA), pentachloronitrobenzene (PCNB), pebulate, phenothrin, phosmet, prometryn, resmethrin, simazine, τ-fluvalinate, tebuconazole, tetramethrin, thiobencarb and trifloxystrobin. **Abbreviations:** hh:mm, hours minutes; ND, not detected]

Official site name	Sample date	Sample time (hh:mm)	Analysis date	3,4-DCA [63400]	Bifenthrin [63415]	Carbofuran [65118]	Chloro-thalonil [65119]	Chlor-pyrifos [65120]
Alamo River near Niland	09-12-06	11:45	08-31-07	ND	ND	ND	ND	ND
	10-14-06	13:00	08-31-07	ND	ND	ND	ND	10.4
	11-13-06	16:20	09-05-07	ND	(0.5)	ND	ND	8.1
	02-13-07	10:55	09-05-07	ND	ND	ND	ND	29.5
	03-12-07	16:20	09-05-07	ND	ND	ND	ND	4.9
	04-17-07	11:00	09-10-07	ND	ND	ND	ND	(1.6)
Alamo River near Calipatria	10-16-06	17:00	08-31-07	ND	ND	ND	ND	20.0
	03-14-07	12:00	09-05-07	ND	(1.0)	(0.9)	(1.5)	6.6
Alamo River at Harris Road near Imperial	10-17-06	08:50	08-31-07	(1.0)	(0.4)	ND	ND	11.0
	03-16-07	09:30	09-05-07	(1.1)	(1.4)	ND	ND	16.0
Alamo River at International Boundary	10-18-06	07:45	08-31-07	ND	ND	ND	ND	ND
	03-17-07	08:30	09-10-07	ND	ND	ND	ND	ND
New River at Lack Road near Calipatria	09-13-06	09:00	08-31-07	ND	ND	ND	ND	2.2
	10-14-06	07:00	08-31-07	ND	ND	ND	ND	5.2
	11-14-06	09:00	08-31-07	3.2	ND	ND	ND	4.0
	02-14-07	10:45	09-05-07	ND	ND	ND	ND	12.5
	03-13-07	09:45	09-05-07	ND	ND	ND	(1.4)	10.7
	04-18-07	10:15	09-10-07	ND	ND	ND	ND	ND
New River below Drop 4 near Brawley	10-15-06	07:30	08-31-07	ND	ND	ND	ND	9.1
	03-14-07	07:30	09-05-07	ND	ND	ND	ND	4.6
New River at Hwy 80	10-16-06	07:35	08-31-07	3.1	ND	ND	ND	18.3
	03-15-07	08:00	09-05-07	37.7	ND	ND	ND	13.4
New River at International Boundary at Calexico	10-19-06	07:30	09-10-07	ND	ND	ND	ND	13.1
	03-18-07	08:30	09-05-07	ND	ND	ND	ND	(1.6)

Table 8. Pesticide concentrations in suspended sediments collected at sites located on the Alamo and New Rivers, California, September 2006 to April 2007.—Continued

[Numbers in brackets are U.S. Geological Survey National Water Information System (NWIS) parameter codes. Values are reported in micrograms per kilogram. Results in parentheses ( ) are below method detection limits and are estimates. The following compounds were analyzed but were not detected in any samples: alachlor, allethrin, atrazine, azoxystrobin, butylate, carbaryl, cycloate, cyfluthrin, deltamethrin, ethalfluralin, fenpropathrin, fipronil, fipronil desulfinyl, fipronil sulfide, fipronil sulfone, iprodione, hexazinone, malathion, metconazole, methidathion, methoprene, methylparathion, metolachlor, molinate, napropamide, pentachloroanisole (PCA), pentachloronitrobenzene (PCNB), pebulate, phenothrin, phosmet, prometryn, resmethrin, simazine, τ-fluvalinate, tebuconazole, tetramethrin, thiobencarb and trifloxystrobin. **Abbreviations:** hh:mm, hours minutes; ND, not detected]

Official site name	Sample date	Sample time (hh:mm)	Analysis date	Cyper-methrin [65123]	Cyproco-nazole [66594]	DCPA [65124]	Diazinon [65126]	EPTC [65128]	Esfen-valerate [65129]
Alamo River near Niland	09-12-06	11:45	08-31-07	ND	ND	(2.0)	ND	ND	ND
	10-14-06	13:00	08-31-07	ND	ND	26.8	5.7	12.4	ND
	11-13-06	16:20	09-05-07	ND	ND	46.8	2.9	2.3	ND
	02-13-07	10:55	09-05-07	13.4	ND	28.3	ND	2.6	ND
	03-12-07	16:20	09-05-07	ND	ND	5.3	ND	7.9	ND
	04-17-07	11:00	09-10-07	ND	ND	18.0	ND	4.9	ND
Alamo River near Calipatria	10-16-06	17:00	08-31-07	ND	(1.5)	31.2	11.7	ND	ND
	03-14-07	12:00	09-05-07	ND	ND	13.0	ND	4.7	ND
Alamo River at Harris Road near Imperial	10-17-06	08:50	08-31-07	ND	ND	58.1	3.7	5.7	(1.9)
	03-16-07	09:30	09-05-07	ND	ND	30.5	ND	1.1	5.3
Alamo River at International Boundary	10-18-06	07:45	08-31-07	ND	ND	ND	ND	ND	ND
	03-17-07	08:30	09-10-07	ND	ND	ND	ND	ND	ND
New River at Lack Road near Calipatria	09-13-06	09:00	08-31-07	ND	ND	(0.8)	ND	ND	ND
	10-14-06	07:00	08-31-07	ND	ND	9.4	2.1	ND	ND
	11-14-06	09:00	08-31-07	ND	ND	56.1	ND	2.7	ND
	02-14-07	10:45	09-05-07	ND	ND	4.4	ND	1.8	ND
	03-13-07	09:45	09-05-07	ND	ND	7.0	ND	ND	ND
	04-18-07	10:15	09-10-07	ND	ND	(1.3)	ND	1.5	ND
New River below Drop 4 near Brawley	10-15-06	07:30	08-31-07	ND	ND	3.5	ND	2.8	ND
	03-14-07	07:30	09-05-07	ND	ND	(0.7)	ND	ND	ND
New River at Hwy 80	10-16-06	07:35	08-31-07	ND	ND	ND	ND	ND	ND
	03-15-07	08:00	09-05-07	ND	ND	ND	ND	ND	ND
New River at International Boundary at Calexico	10-19-06	07:30	09-10-07	ND	ND	ND	ND	ND	ND
	03-18-07	08:30	09-05-07	ND	ND	ND	ND	ND	ND

Table 8. Pesticide concentrations in suspended sediments collected at sites located on the Alamo and New Rivers, California, September 2006 to April 2007.—Continued

[Numbers in brackets are U.S. Geological Survey National Water Information System (NWIS) parameter codes.Values are reported in micrograms per kilogram. Results in parentheses ( ) are below method detection limits and are estimates. The following compounds were analyzed but were not detected in any samples: alachlor, allethrin, atrazine, azoxystrobin, butylate, carbaryl, cycloate, cyfluthrin, deltamethrin, ethalfluralin, fenpropathrin, fipronil, fipronil desulfinyl, fipronil sulfide, fipronil sulfone, iprodione, hexazinone, malathion, metconazole, methidathion, methoprene, methylparathion, metolachlor, molinate, napropamide, pentachloroanisole (PCA), pentachloronitrobenzene (PCNB), pebulate, phenothrin, phosmet, prometryn, resmethrin, simazine, τ-fluvalinate, tebuconazole, tetramethrin, thiobencarb and trifloxystrobin. **Abbreviations:** hh:mm, hours minutes; ND, not detected]

Official site name	Sample date	Sample time (hh:mm)	Analysis date	λ-Cyhalothrin [65134]	Myclobutanil [66633]	Oxyfluorfen [63468]	Pendimethalin [65142]	Permethrin [65143]
Alamo River near Niland	09-12-06	11:45	08-31-07	ND	ND	ND	3.5	ND
	10-14-06	13:00	08-31-07	ND	ND	ND	4.5	4.1
	11-13-06	16:20	09-05-07	ND	ND	2.4	ND	2.7
	02-13-07	10:55	09-05-07	ND	ND	17.5	174	5.1
	03-12-07	16:20	09-05-07	ND	(0.6)	ND	46.5	(0.7)
	04-17-07	11:00	09-10-07	ND	ND	(1.9)	9.7	(0.6)
Alamo River near Calipatria	10-16-06	17:00	08-31-07	ND	(1.1)	ND	6.2	75.1
	03-14-07	12:00	09-05-07	ND	ND	3.9	52.7	1.4
Alamo River at Harris Road near Imperial	10-17-06	08:50	08-31-07	(1.1)	ND	7.5	8.0	3.3
	03-16-07	09:30	09-05-07	2.6	ND	11.4	96.0	51.3
Alamo River at International Boundary	10-18-06	07:45	08-31-07	ND	ND	ND	ND	ND
	03-17-07	08:30	09-10-07	ND	ND	ND	ND	ND
New River at Lack Road near Calipatria	09-13-06	09:00	08-31-07	ND	ND	ND	2.2	6.2
	10-14-06	07:00	08-31-07	ND	ND	ND	ND	3.4
	11-14-06	09:00	08-31-07	ND	ND	ND	3.5	17.4
	02-14-07	10:45	09-05-07	ND	ND	ND	58.9	2.8
	03-13-07	09:45	09-05-07	ND	ND	ND	56.1	2.7
	04-18-07	10:15	09-10-07	ND	ND	ND	1.8	ND
New River below Drop 4 near Brawley	10-15-06	07:30	08-31-07	ND	(1.4)	ND	ND	5.1
	03-14-07	07:30	09-05-07	ND	ND	ND	7.2	3.7
New River at Hwy 80	10-16-06	07:35	08-31-07	ND	ND	ND	ND	29.4
	03-15-07	08:00	09-05-07	ND	ND	ND	36.0	1.6
New River at International Boundary at Calexico	10-19-06	07:30	09-10-07	ND	ND	ND	ND	13.9
	03-18-07	08:30	09-05-07	ND	ND	ND	ND	4.7

Table 8. Pesticide concentrations in suspended sediments collected at sites located on the Alamo and New Rivers, California, September 2006 to April 2007.—Continued

[Numbers in brackets are U.S. Geological Survey National Water Information System (NWIS) parameter codes.Values are reported in micrograms per kilogram. Results in parentheses ( ) are below method detection limits and are estimates. The following compounds were analyzed but were not detected in any samples: alachlor, allethrin, atrazine, azoxystrobin, butylate, carbaryl, cycloate, cyfluthrin, deltamethrin, ethalfluralin, fenpropathrin, fipronil, fipronil desulfinyl, fipronil sulfide, fipronil sulfone, iprodione, hexazinone, malathion, metconazole, methidathion, methoprene, methylparathion, metolachlor, molinate, napropamide, pentachloroanisole (PCA), pentachloronitrobenzene (PCNB), pebulate, phenothrin, phosmet, prometryn, resmethrin, simazine, τ-fluvalinate, tebuconazole, tetramethrin, thiobencarb and trifloxystrobin. **Abbreviations:** hh:mm, hours minutes; ND, not detected]

Official site name	Sample date	Sample time (hh:mm)	Analysis date	Piperonyl butoxide [65146]	Propiconazole [66644]	Tetraconazole [66655]	Trifluralin [04019]
Alamo River near Niland	09-12-06	11:45	08-31-07	ND	ND	(0.3)	2.7
	10-14-06	13:00	08-31-07	ND	ND	(0.2)	3.8
	11-13-06	16:20	09-05-07	ND	ND	(0.2)	6.0
	02-13-07	10:55	09-05-07	ND	ND	(0.2)	47.6
	03-12-07	16:20	09-05-07	ND	(0.3)	(0.4)	33.1
	04-17-07	11:00	09-10-07	ND	ND	(0.2)	12.9
Alamo River near Calipatria	10-16-06	17:00	08-31-07	ND	ND	(0.8)	10.4
	03-14-07	12:00	09-05-07	ND	ND	(0.2)	36.8
Alamo River at Harris Road near Imperial	10-17-06	08:50	08-31-07	ND	(0.4)	(0.2)	7.3
	03-16-07	09:30	09-05-07	ND	ND	ND	87.4
Alamo River at International Boundary	10-18-06	07:45	08-31-07	ND	ND	(0.3)	ND
	03-17-07	08:30	09-10-07	ND	ND	(0.2)	ND
New River at Lack Road near Calipatria	09-13-06	09:00	08-31-07	ND	ND	(0.8)	(1.5)
	10-14-06	07:00	08-31-07	ND	ND	(0.5)	6.3
	11-14-06	09:00	08-31-07	ND	ND	ND	12.5
	02-14-07	10:45	09-05-07	ND	ND	(0.1)	12.2
	03-13-07	09:45	09-05-07	ND	ND	(0.2)	50.9
	04-18-07	10:15	09-10-07	ND	ND	(0.3)	5.0
New River below Drop 4 near Brawley	10-15-06	07:30	08-31-07	ND	ND	(0.9)	(1.2)
	03-14-07	07:30	09-05-07	ND	ND	(0.8)	28.8
New River at Hwy 80	10-16-06	07:35	08-31-07	(0.7)	ND	(0.2)	7.1
	03-15-07	08:00	09-05-07	ND	ND	(0.5)	65.0
New River at International Boundary at Calexico	10-19-06	07:30	09-10-07	ND	ND	ND	ND
	03-18-07	08:30	09-05-07	ND	ND	(1.1)	ND

Table 9. Organochlorine pesticide concentrations in suspended sediments collected at sites located on the Alamo and New Rivers, California, September 2006 to April 2007.

[Numbers in brackets are U.S. Geological Survey National Water Information System (NWIS) parameter codes.Values are reported in micrograms per kilogram. Results in parentheses ( ) are below method detection limits and are estimates. The following compounds were analyzed but were not detected in any samples: α-HCH, endosulfan sulfate, endrin aldehyde, hepatchlor, hepatchlor epoxide, hexachlorobenzene, isodrin, methoxychlor, oxychlordane, pentachloroanisole (PCA) and pentachloronitrobenzene (PCNB). **Abbreviations:** hh:mm, hours minutes; ND, not detected]

Official site name	Sample date	Sample time (hh:mm)	Analysis date	α-Chlordane [63122]	β-HCH [63134]	*cis*-Nonachlor [66635]	δ-HCH [66616]	Dieldrin [63127]
Alamo River near Niland	09-12-06	11:45	09-05-07	(0.3)	ND	ND	ND	1.5
	10-14-06	13:00	09-05-07	(0.2)	ND	(1.4)	ND	2.7
	11-13-06	16:20	09-05-07	(0.2)	(0.5)	ND	(0.2)	1.7
	02-13-07	10:55	09-05-07	(0.2)	(0.7)	ND	ND	2.3
	03-12-07	16:20	09-12-07	ND	ND	ND	ND	(1.2)
	04-17-07	11:00	09-12-07	ND	ND	ND	ND	(1.0)
Alamo River near Calipatria	10-16-06	17:00	09-05-07	ND	ND	ND	ND	ND
	03-14-07	12:00	09-12-07	(0.2)	ND	ND	ND	(1.0)
Alamo River at Harris Road near Imperial	10-17-06	08:50	09-05-07	(0.3)	(0.4)	(0.1)	ND	2.3
	03-16-07	09:30	09-05-07	(0.3)	(0.6)	ND	ND	2.5
Alamo River at International Boundary	10-18-06	07:45	09-05-07	ND	ND	ND	ND	(0.4)
	03-17-07	08:30	09-12-07	ND	ND	ND	ND	(0.3)
New River at Lack Road near Calipatria	09-13-06	09:00	09-05-07	ND	ND	ND	ND	(0.4)
	10-14-06	07:00	09-05-07	ND	ND	ND	ND	(0.6)
	11-14-06	09:00	09-05-07	ND	ND	ND	ND	(0.8)
	02-14-07	10:45	09-05-07	ND	(0.4)	ND	(0.1)	(0.8)
	03-13-07	09:45	09-12-07	ND	ND	ND	ND	(0.8)
	04-18-07	10:15	09-12-07	ND	ND	ND	ND	(0.7)
New River below Drop 4 near Brawley	10-15-06	07:30	09-05-07	ND	1.8	ND	ND	(0.6)
	03-14-07	07:30	09-05-07	ND	(0.7)	ND	(0.1)	(0.5)
New River at Hwy 80	10-16-06	07:35	09-05-07	(0.3)	ND	(0.6)	ND	(0.5)
	03-15-07	08:00	09-05-07	ND	ND	ND	ND	1.9
New River at International Boundary at Calexico	10-19-06	07:30	09-12-07	ND	ND	ND	ND	ND
	03-18-07	08:30	09-12-07	(0.9)	ND	ND	ND	(0.5)

Table 9. Organochlorine pesticide concentrations in suspended sediments collected at sites located on the Alamo and New Rivers, California, September 2006 to April 2007.—Continued

[Numbers in brackets are U.S. Geological Survey National Water Information System (NWIS) parameter codes.Values are reported in micrograms per kilogram. Results in parentheses ( ) are below method detection limits and are estimates. The following compounds were analyzed but were not detected in any samples: α-HCH, endosulfan sulfate, endrin aldehyde, hepatchlor, hepatchlor epoxide, hexachlorobenzene, isodrin, methoxychlor, oxychlordane, pentachloroanisole (PCA) and pentachloronitrobenzene (PCNB). **Abbreviations:** hh:mm, hours minutes; ND, not detected]

Official site name	Sample date	Sample time (hh:mm)	Analysis date	Endosulfan I [63128]	Endolusfan II [66601]	γ-Chlordane [63123]	γ-HCH [63135]
Alamo River near Niland	09-12-06	11:45	09-05-07	(0.2)	ND	(0.6)	ND
	10-14-06	13:00	09-05-07	(0.3)	2.2	(0.2)	ND
	11-13-06	16:20	09-05-07	(0.3)	ND	(0.7)	ND
	02-13-07	10:55	09-05-07	(0.3)	(0.2)	(0.9)	ND
	03-12-07	16:20	09-12-07	ND	ND	(0.6)	ND
	04-17-07	11:00	09-12-07	(0.1)	ND	(0.3)	ND
Alamo River near Calipatria	10-16-06	17:00	09-05-07	ND	ND	ND	ND
	03-14-07	12:00	09-12-07	(0.1)	ND	(0.5)	ND
Alamo River at Harris Road near Imperial	10-17-06	08:50	09-05-07	(0.3)	ND	(0.1)	ND
	03-16-07	09:30	09-05-07	(0.2)	ND	(0.2)	ND
Alamo River at International Boundary	10-18-06	07:45	09-05-07	ND	ND	ND	ND
	03-17-07	08:30	09-12-07	ND	ND	(0.3)	ND
New River at Lack Road near Calipatria	09-13-06	09:00	09-05-07	(0.3)	ND	ND	ND
	10-14-06	07:00	09-05-07	(0.2)	ND	ND	ND
	11-14-06	09:00	09-05-07	(0.5)	ND	ND	ND
	02-14-07	10:45	09-05-07	ND	ND	(0.3)	(0.1)
	03-13-07	09:45	09-12-07	(0.1)	ND	ND	ND
	04-18-07	10:15	09-12-07	(0.1)	ND	ND	ND
New River below Drop 4 near Brawley	10-15-06	07:30	09-05-07	ND	ND	ND	(0.2)
	03-14-07	07:30	09-05-07	ND	ND	ND	(0.1)
New River at Hwy 80	10-16-06	07:35	09-05-07	(0.1)	ND	ND	1.3
	03-15-07	08:00	09-05-07	ND	ND	ND	ND
New River at International Boundary at Calexico	10-19-06	07:30	09-12-07	ND	ND	ND	ND
	03-18-07	08:30	09-12-07	ND	ND	(0.3)	ND

Table 9. Organochlorine pesticide concentrations in suspended sediments collected at sites located on the Alamo and New Rivers, California, September 2006 to April, 2007.—Continued

[Numbers in brackets are U.S. Geological Survey National Water Information System (NWIS) parameter codes.Values are reported in micrograms per kilogram. Results in parenthesis ( ) are below method detection limits and are estimates. The following compounds were analyzed but were not detected in any samples: α-HCH, endosulfan sulfate, endrin aldehyde, hepatchlor, hepatchlor epoxide, hexachlorobenzene, isodrin, methoxychlor, oxychlordane, pentachloroanisole (PCA) and pentachloronitrobenzene (PCNB). **Abbreviations:** hh:mm, hours minutes; ND, not detected]

Official site name	Sample date	Sample time (hh:mm)	Analysis date	PCA [66638]	*p,p*'-DDD [63124]	*p,p*'-DDE [63125]	*p,p*'-DDT [63126]	*trans*-Nonachlor [63138]
Alamo River near Niland	09-12-06	11:45	09-05-07	ND	(0.7)	15.7	(0.3)	ND
	10-14-06	13:00	09-05-07	(0.2)	1.9	48.6	1.4	(0.2)
	11-13-06	16:20	09-05-07	ND	(1.0)	26.0	(0.8)	(0.3)
	02-13-07	10:55	09-05-07	ND	1.7	54.2	1.3	(0.3)
	03-12-07	16:20	09-12-07	ND	4.2	34.5	7.0	ND
	04-17-07	11:00	09-12-07	ND	(0.6)	14.2	1.8	ND
Alamo River near Calipatria	10-16-06	17:00	09-05-07	ND	(1.3)	34.9	(0.5)	ND
	03-14-07	12:00	09-12-07	ND	(0.4)	12.3	(0.4)	ND
Alamo River at Harris Road near Imperial	10-17-06	08:50	09-05-07	ND	(1.1)	33.6	(0.4)	(0.2)
	03-16-07	09:30	09-05-07	ND	1.8	50.9	1.5	(0.2)
Alamo River at International Boundary	10-18-06	07:45	09-05-07	ND	(0.3)	9.2	ND	ND
	03-17-07	08:30	09-12-07	ND	(0.3)	3.6	(0.3)	ND
New River at Lack Road near Calipatria	09-13-06	09:00	09-05-07	ND	(0.7)	12.7	(0.7)	ND
	10-14-06	07:00	09-05-07	ND	(0.6)	6.4	(1.0)	ND
	11-14-06	09:00	09-05-07	ND	(1.1)	12.5	ND	ND
	02-14-07	10:45	09-05-07	ND	(0.3)	5.7	1.3	ND
	03-13-07	09:45	09-12-07	ND	(0.7)	9.0	(1.0)	ND
	04-18-07	10:15	09-12-07	ND	(0.8)	3.4	(1.0)	ND
New River below Drop 4 near Brawley	10-15-06	07:30	09-05-07	ND	(1.3)	3.7	ND	ND
	03-14-07	07:30	09-05-07	ND	(0.1)	2.7	(0.5)	ND
New River at Hwy 80	10-16-06	07:35	09-05-07	(0.1)	(0.4)	2.8	(0.6)	ND
	03-15-07	08:00	09-05-07	ND	(0.9)	20.0	2.9	ND
New River at International Boundary at Calexico	10-19-06	07:30	09-12-07	ND	(1.0)	1.9	ND	ND
	03-18-07	08:30	09-12-07	ND	(0.7)	5.3	(0.8)	ND

Sediment-associated pesticides were detected most frequently, and generally at higher concentrations, in samples from the Alamo River. Thirty-two pesticides were detected in samples collected from the Alamo River, and 24 pesticides were detected in New River samples (table 10). The synergist, piperonyl butoxide, and the organochlorine pesticide, γ-HCH, were detected only in New River samples. The pesticides detected most frequently (greater than 75 percent) in the Alamo River were chlorpyrifos, DCPA, dieldrin, γ-chlordane, pendimethalin, permethrin, *p,p*'-DDD, *p,p*'-DDE, *p,p*'-DDT, tetraconazole, and trifluralin. Except for DCPA, pendimethalin, and γ-chlordane, these same compounds also were detected in greater than 75 percent of New River samples (fig. 7). Twenty-two compounds were detected in both rivers and maximum concentrations of 16 of these compounds were detected in Alamo River samples.

The numbers of pesticides detected in suspended sediments, their frequencies of detection, and maximum concentrations showed limited variation between seasons. Twenty-nine pesticides were detected in the spring, compared with 31 pesticide detections in the fall. Carbofuran and chlorothalonil were detected only in the spring, while *cis*-nonachlor, cyproconazole, diazinon, and piperonyl butoxide were detected only in the fall. Ten pesticides were detected in more than 75 percent of spring samples, while eight of these pesticides also were detected as frequently in the fall. The maximum concentrations of 18 pesticides occurred in the spring, while the maximum concentrations of 16 occurred in the fall.

Table 10. Numbers of detections of sediment associated pesticides by season and river system.

[ND, not detected]

Compound	Alamo River		New River	
	Fall 2006	Spring 2007	Fall 2006	Spring 2007
3,4-DCA	1	1	2	1
α-Chlordane	4	3	1	1
β-HCH	2	2	1	2
Bifenthrin	2	2	ND	ND
Carbofuran	ND	1	ND	ND
Chlorothalonil	ND	1	ND	1
Chlorpyrifos	4	5	6	5
cis-Nonachlor	2	ND	1	ND
Cypermethrin	ND	1	ND	ND
Cyproconazole	1	ND	ND	ND
DCPA	5	5	4	4
δ-HCH	1	ND	ND	2
Diazinon	4	ND	1	ND
Dieldrin	5	6	5	6
Endosulfan I	4	4	4	2
Endosulfan II	1	1	ND	ND
EPTC	3	5	2	2
Esfenvalerate	1	1	ND	ND
γ-Chlordane	4	6	ND	2
γ-HCH (Lindane)	ND	ND	2	2
λ-Cyhalothrin	1	1	ND	ND
Myclobutanil	1	1	1	ND
Oxyfluorfen	2	3	ND	ND
p,p'-DDD	6	6	6	6
p,p'-DDE	6	6	6	6
p,p'-DDT	6	5	3	6
Pentachloroanisole (PCA)	1	ND	1	ND
Pendimethalin	4	5	2	5
Permethrin	4	5	6	5
Piperonyl butoxide	ND	ND	1	ND
Propiconazole	1	1	ND	ND
Tetraconazole	6	5	4	6
trans-Nonachlor	3	2	ND	ND
Trifluralin	5	5	5	5

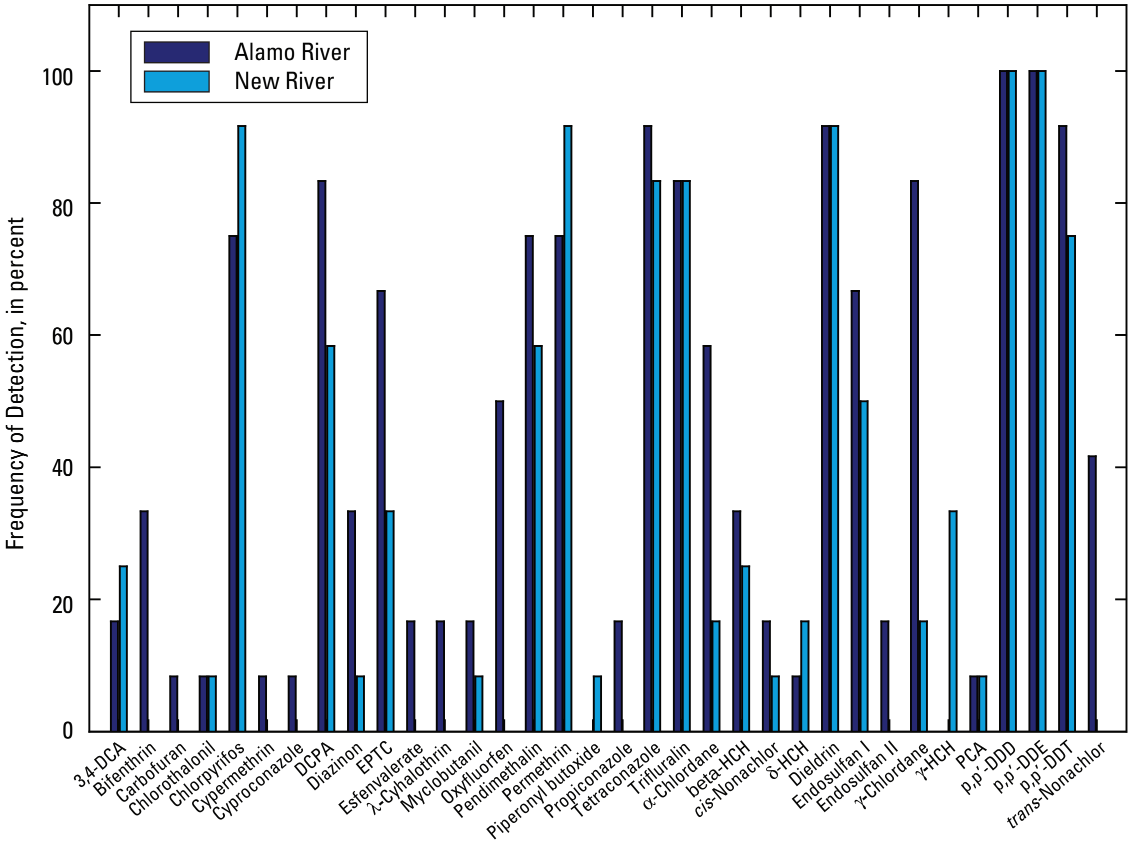


Figure 7. Frequency of detection, as a percentage of the total number of samples collected, by river system, for sediment-associated pesticides.

Sediment Organic Carbon and Nitrogen

Organic carbon and nitrogen are measured to better understand the source of a sediment sample. Normalizing pesticide concentrations to sediment organic carbon is useful in comparing different sediments with varying carbon contents.

The percentages of organic carbon and nitrogen (POC and PON) in suspended sediments generally were higher in New River samples, compared with Alamo River samples. Percent organic carbon values ranged from 1.30 to 27.97 for New River samples and ranged from 0.97 to 4.92 for Alamo River samples. Percent organic nitrogen ranged from 0.19 to 3.36 for New River samples and ranged from 0.11 to 1.00 for Alamo River samples (table 11). POC and PON values showed no significant seasonal patterns.

Table 11. Percent organic carbon and nitrogen in suspended sediment samples collected in the Alamo and New Rivers.

[**Abbreviations:** hh:mm, hours minutes]

Official site name	Sample date	Sample time (hh:mm)	Percent organic carbon	Percent organic nitrogen
Alamo River near Niland	09-12-06	11:45	1.21	0.15
	10-14-06	13:00	0.97	0.11
	11-13-06	16:20	1.13	0.13
	02-13-07	10:55	1.12	0.18
	03-12-07	16:20	1.01	0.14
	04-17-07	11:00	0.97	0.14
Alamo River near Calipatria	10-16-06	17:00	1.08	0.14
	03-14-07	12:00	1.08	0.17
Alamo River at Harris Road near Imperial	10-17-06	08:50	1.38	0.15
	03-16-07	09:30	1.40	0.20
Alamo River at International Boundary	10-18-06	07:45	4.92	1.00
	03-17-07	08:30	3.71	0.72
New River at Lack Road near Calipatria	09-13-06	09:00	1.80	0.28
	10-14-06	07:00	1.60	0.24
	11-14-06	09:00	1.50	0.21
	02-14-07	10:45	2.30	0.35
	03-13-07	09:45	1.48	0.20
	04-18-07	10:15	1.30	0.19
New River below Drop 4 near Brawley	10-15-06	07:30	2.24	0.32
	03-14-07	07:30	1.71	0.26
New River at Hwy 80	10-16-06	07:35	5.69	0.84
	03-15-07	08:00	6.89	1.22
New River at International Boundary at Calexico	10-19-06	07:30	27.97	3.36
	03-18-07	08:30	9.51	1.97

Dissolved-Organic-Carbon and Suspended-Sediment Concentrations

Many of the pesticides detected in surface waters tend to associate with DOC. The higher the DOC the less bioavailable certain compounds may be to aquatic organisms. Therefore, measuring the DOC in water samples can aid in understanding the fate and transport of pesticides in the environment.

Dissolved organic carbon (DOC) concentrations ranged from 5.5 to 13.0 mg/L in Alamo River samples and 6.3 to 17.7 mg/L in New River samples (table 3). The average DOC concentration for samples collected from the New River (10.3 mg/L) was higher than for samples collected on the Alamo River (7.8 mg/L). The average concentration for samples collected in the fall (10.0 mg/L) was higher than for samples collected in the spring (8.2 mg/L).

Suspended sediment concentrations (SSC) ranged from 33 to 531 mg/L for samples collected from the Alamo River and ranged from 20 to 423 mg/L for New River samples (table 3). The average suspended-sediment concentration for Alamo River samples (278 mg/L) was slightly higher than the average for New River samples (202 mg/L). The average SSC concentration was higher for samples collected in the spring (276 mg/L) than for samples collected in the fall (204 mg/L). The percentage of suspended sediment finer than 0.062 mm ranged from 71.1 to 99.2 in Alamo River samples and ranged from 77.6 to 96.8 in New River samples (table 3). Considering all samples collected, the average values for the percent of fine sediment were similar for the Alamo River and the New River (87.4 and 88.0 percent, respectively). However, the average for fall samples (90.8 percent) was slightly higher than for spring samples (84.4 percent).

Water-Quality Parameters

Water-quality parameters (temperature, specific conductance, pH, dissolved oxygen, and turbidity) measured in stream cross-sections during each sampling event showed that the water columns were well mixed at all sites, both laterally and vertically. Mean values of water-quality parameters, based on cross-sectional measurements for each sampling event, are shown in table 12.

Table 12. Mean water-quality parameter values calculated from measured stream cross-sections at sites located on the Alamo and New Rivers, California, September 2006 to April 2007.

[Numbers in brackets are U.S. Geological Survey National Water Information System (NWIS) parameter codes. **Abbreviations:** hh:mm, hours minutes; ft, feet; °C, degrees Celisus; µS/cm, microsiemens per centimeter; NTU, nephelometric turbidity units; mg/L, milligrams per liter]

Official site name	Sample date	Sample time (hh:mm)	Temperature (°C) [00010]	Specific conductance (µS/cm) [00094]	Turbidity (NTU) [61028]	pH [00400]	Dissolved oxygen (mg/L) [00300]
Alamo River near Niland	09-12-06	11:45	28.0	3,419	290	7.6	5.3
	10-14-06	13:00	21.5	3,268	282	8.1	6.9
	11-13-06	16:20	17.5	4,325	223	7.3	8.0
	02-13-07	10:55	14.5	3,314	245	7.1	8.5
	03-12-07	16:20	19.0	2,813	681	7.6	7.2
	04-17-07	11:00	18.0	2,710	349	7.7	9.5
Alamo River near Calipatria	10-16-06	17:00	22.0	3,165	252	8.3	7.4
	03-14-07	12:00	19.0	2,945	483	7.4	7.6
Alamo River at Harris Road near Imperial	10-17-06	08:50	20.0	3,338	127	8.1	9.1
	03-16-07	09:30	19.0	2,857	351	7.6	8.2
Alamo River at International Boundary	10-18-06	07:45	22.5	5,376	125	8.0	2.2
	03-17-07	08:30	20.0	5,267	105	7.7	7.3
New River at Lack Road near Calipatria	09-13-06	09:00	27.5	4,572	215	7.6	4.0
	10-14-06	07:00	21.0	4,595	196	7.8	5.1
	11-14-06	09:00	17.0	5,950	191	7.2	6.8
	02-14-07	10:45	14.5	3,967	197	7.0	5.8
	03-13-07	09:45	18.5	4,360	372	7.5	5.5
	04-18-07	10:15	18.0	4,435	228	7.5	8.2
New River below Drop 4 near Brawley	10-15-06	07:30	20.5	4,592	191	7.8	5.4
	03-14-07	07:30	20.0	5,256	458	7.4	6.7
New River at Hwy 80	10-16-06	07:35	21.5	4,659	145	8.4	1.3
	03-15-07	08:00	21.0	5,302	254	7.3	0.7
New River at International Boundary at Calexico	10-19-06	07:30	21.0	4,463	141	7.8	0.2
	03-18-07	08:30	21.0	5,660	59	7.6	4.9

Summary and Conclusions

This project was designed to provide the State Water Resources Control Board with data for an initial assessment and characterization of current-use and organochlorine pesticides present in the water column and suspended sediments of the Alamo and New Rivers. In samples collected between September 2006 and April 2007, 25 pesticides were detected in water and 34 pesticides were detected in suspended sediments. Maximum dissolved pesticide concentrations ranged from below the method detection limits to 8,900 ng/L (EPTC). Maximum dissolved concentrations for most pesticides were observed in samples from the Alamo River. A greater number of dissolved pesticides were detected during the spring than the fall, and concentrations were more often at their maximum during this season. Four current-use pesticides (carbofuran, chlorpyrifos, diazinon and malathion) were detected in water samples at concentrations above established U.S. Environmental Protection Agency aquatic life benchmarks. Pesticide concentrations in suspended-sediment samples were as high as 174 µg/kg (pendimethalin). For the organochlorine pesticides detected in sediment, only *p,p*'-DDE concentrations consistently were above the method detection limits. In the Alamo River, greater numbers of sediment-associated pesticides were detected and at higher detection frequencies than in the New River. Maximum concentrations of 16 of the 22 pesticides detected in suspended sediments in both rivers were found in Alamo River samples. In general, no significant seasonal differences were observed for pesticides detected in suspended sediments.

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