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Prepared in cooperation with the Wyoming Department of Agriculture on behalf of the Wyoming Ground-water and Pesticides Strategy Committee

Pesticides in Wyoming Groundwater, 2008–10

Scientific Investigations Report 2013–5064

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

Cover. Bighorn Basin geographic area. Photograph by Cheryl Eddy-Miller, U.S. Geological Survey.

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KEN SALAZAR, Secretary

U.S. Geological Survey
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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)

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

°F=(1.8×°C)+32

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

Concentrations of chemical constituents in water are given in micrograms per liter (µg/L).

Abbreviations

CAL	common assessment level
CSAL	compound-specific assessment level
E	estimated
GPSC	Ground-water and Pesticides Strategy Committee
KSOCRL	U.S. Geological Survey Organic Chemistry Research Laboratory in Lawrence, Kansas
LHA	Lifetime Health Advisory
LRL	laboratory reporting level
LT-MDL	long-term method detection level
MCL	Maximum Contaminant Level
MDL	method detection limit
MRL	minimum reporting level
NAL	no assessment level
NLCD	National Land Cover Data
NWQL	National Water Quality Laboratory of U.S. Geological Survey
QA	quality assurance
QC	quality control
RPD	relative percentage difference
SMP	State of Wyoming Generic Management Plan for Pesticides in Ground Water
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WDA	Wyoming Department of Agriculture
WDEQ	Wyoming Department of Environmental Quality

Pesticides in Wyoming Groundwater, 2008–10

By Cheryl A. Eddy-Miller, Timothy T. Bartos, and Michelle L. Taylor

Abstract

Groundwater samples were collected from 296 wells during 1995–2006 as part of a baseline study of pesticides in Wyoming groundwater. In 2009, a previous report summarized the results of the baseline sampling and the statistical evaluation of the occurrence of pesticides in relation to selected natural and anthropogenic (human-related) characteristics.

During 2008–10, the U.S. Geological Survey, in cooperation with the Wyoming Department of Agriculture, resampled a subset (52) of the 296 wells sampled during 1995–2006 baseline study in order to compare detected compounds and respective concentrations between the two sampling periods and to evaluate the detections of new compounds. The 52 wells were distributed similarly to sites used in the 1995–2006 baseline study with respect to geographic area and land use within the geographic area of interest.

Because of the use of different types of reporting levels and variability in reporting-level values during both the 1995–2006 baseline study and the 2008–10 resampling study, analytical results received from the laboratory were recensored. Two levels of recensoring were used to compare pesticides—a compound-specific assessment level (CSAL) that differed by compound and a common assessment level (CAL) of 0.07 microgram per liter. The recensoring techniques and values used for both studies, with the exception of the pesticide 2,4–D methyl ester, were the same. Twenty-eight different pesticides were detected in samples from the 52 wells during the 2008–10 resampling study. Pesticide concentrations were compared with several U.S. Environmental Protection Agency drinking-water standards or health advisories for finished (treated) water established under the Safe Drinking Water Act. All detected pesticides were measured at concentrations smaller than U.S. Environmental Protection Agency drinking-water standards or health advisories where applicable (many pesticides did not have standards or advisories).

One or more pesticides were detected at concentrations greater than the CAL in water from 16 of 52 wells sampled (about 31 percent) during the resampling study. Detected pesticides were classified into one of six types: herbicides, herbicide degradates, insecticides, insecticide degradates, fungicides, or fungicide degradates. At least 95 percent of detected pesticides were classified as herbicides or herbicide degradates.

The number of different pesticides detected in samples from the 52 wells was similar between the 1995–2006 baseline study (30 different pesticides) and 2008–2010 resampling study (28 different pesticides). Thirteen pesticides were detected during both studies. The change in the number of pesticides detected (without regard to which pesticide was detected) in groundwater samples from each of the 52 wells was evaluated and the number of pesticides detected in groundwater did not change for most of the wells (32). Of those that did have a difference between the two studies, 17 wells had more pesticide detections in groundwater during the 1995–2006 baseline study, whereas only 3 wells had more detections during the 2008-2010 resampling study.

The difference in pesticide concentrations in groundwater samples from each of the 52 wells was determined. Few changes in concentration between the 1995–2006 baseline study and the 2008–2010 resampling study were seen for most detected pesticides. Seven pesticides had a greater concentration detected in the groundwater from the same well during the baseline sampling compared to the resampling study. Concentrations of prometon, which was detected in 17 wells, were greater in the baseline study sample compared to the resampling study sample from the same well 100 percent of the time.

The change in the number of pesticides detected (without regard to which pesticide was detected) in groundwater samples from each of the 52 wells with respect to land use and geographic area was calculated. All wells with land use classified as agricultural had the same or a smaller number of pesticides detected in the resampling study compared to the baseline study. All wells in the Bighorn Basin geographic area also had the same or a smaller number of pesticides detected in the resampling study compared to the baseline study.

Introduction

In October 1991, the U.S. Environmental Protection Agency (USEPA) completed the “Pesticides and Ground-Water Strategy” that describes, in part, a Federal-State partnership approach to address potential risks posed to groundwater by the use of pesticides (Wyoming Ground-water and Pesticides Strategy Committee, 1999). In response, the State of Wyoming created the Ground-water and Pesticide Strategy

Committee (GPSC) consisting of members of local, State, and Federal government, as well as industry and interest groups, to prepare the State of Wyoming Generic Management Plan for Pesticides in Ground Water (known as the "State Management Plan" (SMP) (Wyoming Ground-water and Pesticides Strategy Committee, 1999). The SMP includes information describing individuals and organizations involved with implementation of the SMP, groundwater contamination prevention, groundwater monitoring, and required responses if pesticides are detected in groundwater.

In Wyoming, little existing information was available describing pesticide occurrence in groundwater. In accordance with the SMP, the GPSC began a program to conduct baseline groundwater sampling to characterize pesticide occurrence in Wyoming's groundwater. In addition, the GPSC identified 20 pesticides (18 parent pesticides and 2 degradates, defined as "focal compounds" and referred to in the present report as "focal pesticides") as being of greatest interest during baseline groundwater sampling).

The U.S. Geological Survey (USGS), in cooperation with the Wyoming Department of Agriculture (WDA), acting on behalf of the GPSC, later with assistance from the Wyoming Department of Environmental Quality (WDEQ), began statewide implementation of this baseline groundwater sampling in 1995. Water samples were collected during fall and spring from 296 wells in Wyoming during 1995–2006 and analyzed for pesticides. Bartos and others (2009) published a report summarizing the occurrence of pesticides in the State of Wyoming, and statistically evaluated the occurrence of pesticides in relation to selected natural and anthropogenic (human-related) characteristics such as geography, soils, hydrogeology, selected water-quality constituents and characteristics, and land use.

During 2008–10, the USGS, in cooperation with the WDA, resampled a subset of 52 of the 296 wells that had been sampled during the 1995–2006 baseline study. The purpose of the 2008–10 resampling was to compare detected compounds and their respective concentrations between the two sampling periods, and evaluate the occurrence of new compounds. The 52 resampled wells were distributed similarly to wells used in the 1995–2006 baseline study with respect to geographic area and land use within the geographic area of interest. In order to help evaluate changes in pesticide occurrence, wells with pesticide detections during the baseline study were given resampling priority.

Purpose and Scope

The purpose of this report is to (1) summarize the occurrence of pesticides in Wyoming groundwater during 2008–10 resampling study, (2) compare the pesticides detections and concentrations during the 2008–10 resampling study with the detections and concentrations found during the 1995–2006 baseline study, and (3) compare relations between pesticide occurrence in groundwater in 2008–10 resampling study and selected natural and anthropogenic factors. The summary of pesticide occurrence includes detection frequencies; detections by action, class, and individual pesticides; concentrations and comparisons to USEPA standards and health advisories; and detections in relation to pesticide use. Natural and anthropogenic factors were evaluated for relations with pesticide occurrence including geographic area and land use, as defined in Bartos and others (2009).

Methods of Investigation

Published methods for the selection of sampling locations, collection of groundwater samples and analysis for pesticides using USGS laboratory analytical methods and reporting conventions, and the collection and analysis of quality-control samples as part of a quality-assurance program were used in this study. The approach used to censor data and assemble final datasets was the same as the 1995–2006 baseline study (Bartos and others, 2009).

Selection of Sampling Locations

Fifty-one of the 52 wells sampled during the 2008–10 resampling study are a subset of the 296 wells sampled during the 1995–2006 baseline study (figs. 1 and 2; appendix 1). Because access to one well located in the Bighorn Basin geographic area was denied, a neighbor's well with similar depth and the same land use was used for the 2008–10 resampling study. Bartos and others (2009) described the site selection process for the 1995–2006 baseline study, including determination of geographic areas and land use. Land use within a 500-m (1,640-ft) radius surrounding each sampled well was classified using an enhanced version of the USGS 1992 National Land Cover Data (NLCD) set (Nakagaki and Wolock, 2005). The NLCD classified land use for each 30-by-30-m area of the United States. Individual land uses classified within the 500-m radius then were used to classify land use into one of four predominant land-use categories using the following criteria: (1) agricultural [greater than (>) 50 percent agricultural land and less than or equal to (≤) 5 percent urban land]; (2) urban (> 25 percent urban land use and ≤ 25 percent agricultural land); (3) rangeland/undeveloped (≤ 5 percent urban land and ≤ 25 percent agricultural land); and (4) mixed (all other combinations of urban, agricultural, and rangeland/undeveloped land). Each sampled well then was assigned to one of these four land-use categories to relate pesticide detections to overlying land use.

Analysis of sample data from the 1995–2006 baseline study indicated that the frequency of pesticide detections in a well was related to the geographic area in which the well was located, and to the land use surrounding the well (Bartos and

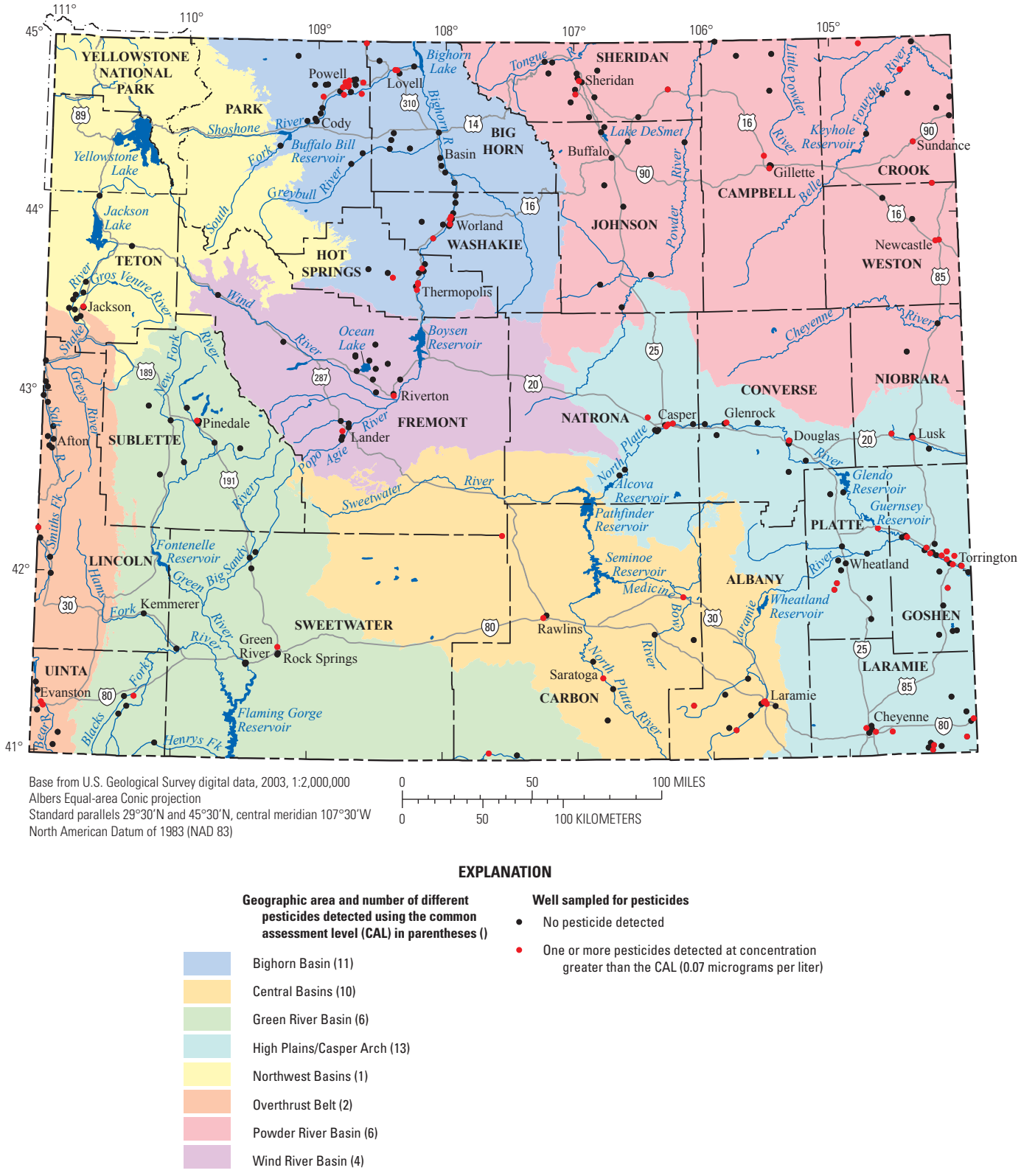

Figure 1. Wells sampled from the eight geographic areas of Wyoming during the 1995–2006 baseline study (from Bartos and others, 2009).

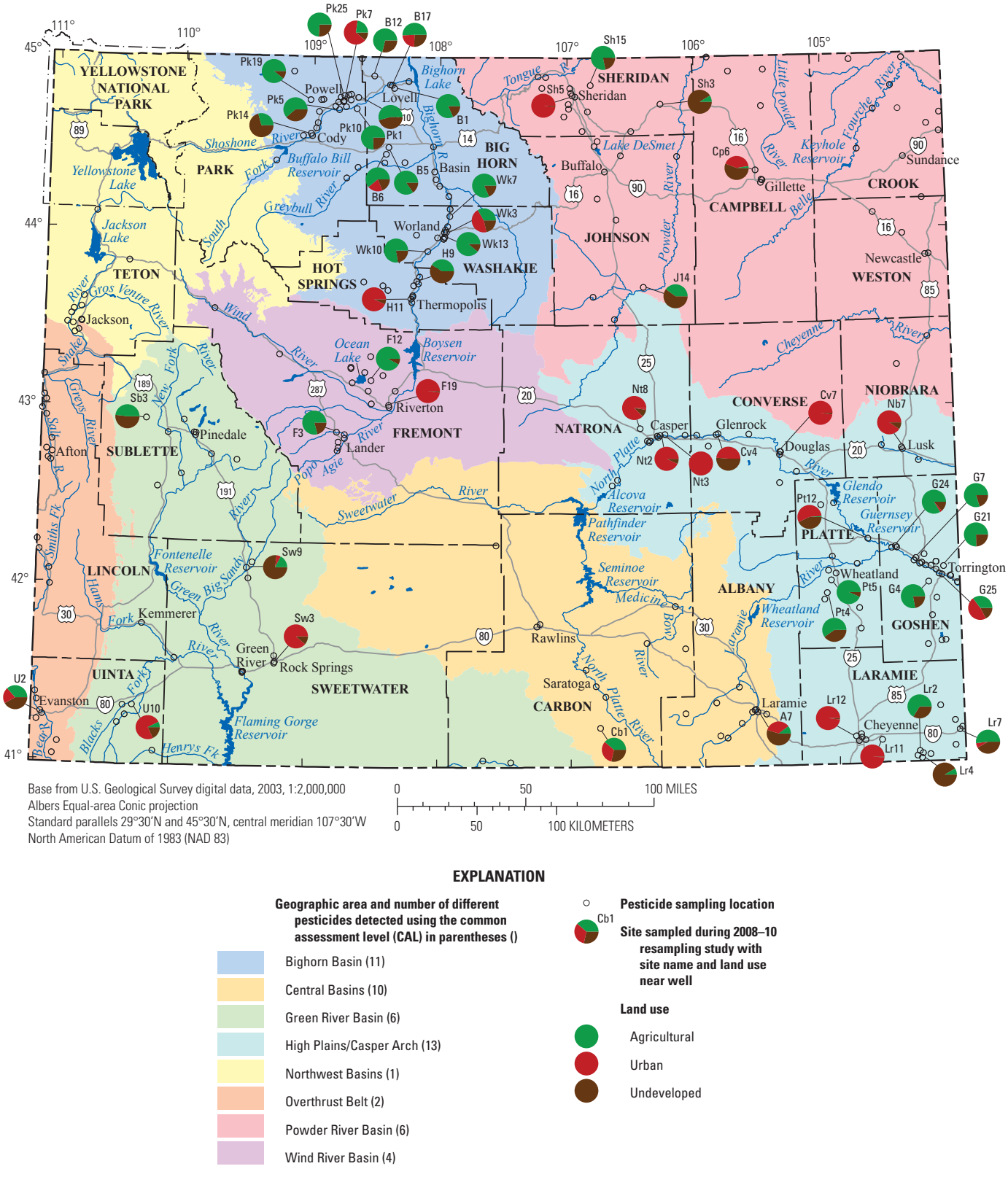

Figure 2. Location of, and land use near, the 52 wells sampled during the 2008–10 resampling study, Wyoming.

others, 2009; Eddy-Miller and others, 2009; fig. 2). Therefore, preference for the 2008–10 resampling was given to the two geographic areas in the baseline study having the highest detection frequencies; the High Plains/Casper Arch and Bighorn Basin, which were resampled in 2008 (19 wells sampled) and 2009 (18 wells sampled), respectively. Samples from the rest of the State (15 wells) were collected during 2010. Because land use also affected the frequency of pesticide detections in a well, 2008–10 resampling sites within each of the eight geographic areas were selected to represent a similar distribution of land use; that is, a similar percentage of wells in each of the four land-use categories was selected for 2008–10 resampling compared to the 1995–2006 baseline sampling.

Because the 1995–2006 baseline study also showed that a larger number of different pesticides were detected in the fall (August–October) than in the spring (March–May), samples were collected in the fall for all three years of the 2008–10 resampling study.

Sample Collection and Chemical Analyses

During the 2008–10 resampling study, groundwater samples were collected and processed in a mobile water-quality laboratory using procedures specified by the USGS National Water-Quality Assessment Program (Koterba and others, 1995; Koterba, 1998) and by the USGS National Field Manual for the Collection of Water-Quality Data (U.S. Geological Survey, variously dated). Samples were sent to the USGS National Water Quality Laboratory (NWQL) in Denver, Colo., for analysis using analytical methods selected to detect the 19 pesticides (17 parent pesticides and 2 pesticide degradates) identified in the SMP as focal pesticides of greatest concern (table 1). (Analysis of one focal pesticide, difenzoquat, was not made, as analytical methods were not available.) The USGS NWQL analytical methods selected to detect focal pesticides in groundwater samples also could detect many additional nonfocal (as many as 136) pesticides (table 1) (Furlong and others, 2001; Madsen and others, 2003; Sandstrom and others, 2001; Zaugg and others, 1995). Additionally during the 2008–10 resampling study, samples were collected and sent to the U.S. Geological Survey Organic Chemistry Research Laboratory in Lawrence, Kansas (KSOCRL) for analysis of glyphosate and its degradates using methods described in Meyer and others (2009).

Data Reporting and Treatment

Groundwater samples were analyzed using USGS analytical methods with laboratory reporting levels much smaller than typically used in routine pesticide monitoring of public drinking-water supplies. Consequently, it is likely that much more frequent rates of detection were obtained than would have been possible with less sensitive analytical methods. Reporting levels during the 1995–2006 baseline study varied by pesticide, and many reporting levels changed during the 12 years of the baseline study. Therefore, Bartos and others (2009) recensored pesticide detections to two different assessment levels to account for (1) variations in reporting levels for the same compound and (2) variations in reporting levels among the different compounds. The assessment levels were determined for all analytical results before data were summarized and analyzed.

Laboratory Reporting Levels

During the 1995–2006 baseline study (Bartos and others, 2009) and the 2008–10 resampling study, the USGS NWQL reported analytical results for pesticides relative to three types of reporting levels, referred to as "original NWQL censoring." Very small concentrations are censored and reported as "less than" values by the NWQL to avoid false-positive detections (reporting detections when the analytes are not actually present in the sample). Censoring levels, generally known as "reporting levels," are specific to analytical methods and can change over time as methods change. During analysis of the 1995–2006 baseline data, extensive evaluation of the three types of reporting levels was performed and documented (Bartos and others, 2009). The three types of reporting levels used by the NWQL during 1995–2006 included (1) the oldest and most basic of the three types, the minimum reporting level (MRL), which is defined as the minimum concentration of a constituent that can be reliably measured using a given analytical method (Timme, 1995); (2) the method detection limit (MDL), which is defined as the minimum concentration of a constituent that can be identified, measured, and reported with 99-percent confidence to be significantly greater than zero (Childress and others, 1999); and (3) the laboratory reporting level (LRL), a reporting level used to minimize both false-positive and false-negative detections (reporting a nondetection when the actual concentration in the sample is greater than the MDL; Childress and others, 1999). The reporting level during the 2008–10 resampling study was the LRL.

NWQL also calculates a long-term method detection level (LT-MDL), which is determined from the standard deviation of long-term laboratory spike samples (Bartos and others, 2009). NWQL qualifies detections less than the LRL, but greater than the LT-MDL as an estimated or "E" value. For this study, detections qualified with an "E" remark code were treated as quantified values. This approach preserves all of the information provided by the laboratory and acknowledges that values with an "E" remark code have concentrations greater than true nondetections.

Table 1. Pesticides analyzed in 1995–2006 baseline and 2008–10 resampling studies, with trade names, pesticide actions, pesticide classes, laboratory reporting levels, and U.S. Environmental Protection Agency drinking-water standards.

[Pesticides detected during 2008–10 resampling study are in **bold** type. Focal pesticides, as determined by the Ground-water and Pesticides Strategy Committee, are shown with a grey background. USGS, U.S. Geological Survey; µg/L, micrograms per liter; USEPA, U.S. Environmental Protection Agency; --, not applicable; USGS analytical method: 1 = USGS laboratory schedule 2001, 2 = USGS laboratory schedule 2050, 3 = USGS laboratory schedule 1379, 4 = USGS laboratory schedule 2060, 5 = USGS laboratory schedule 2033, 6 = USGS Organic Chemistry Research Laboratory in Lawrence, Kansas schedule LCGY; USEPA standard or health advisory: LHA = USEPA Lifetime Health Advisory Level (U.S. Environmental Protection Agency, 2012), MCL = USEPA Maximum Contaminant Level (U.S. Environmental Protection Agency, 2012), RSD4 = USEPA Risk-Specific Dose at 10^{-4} Cancer Risk (U.S. Environmental Protection Agency, 2012); DCPA, dimethyl tetrachloroterephthalate; HCH, hexachlorocyclohexane; EPTC, S-ethyl dipropylthiocarbamate; MCPA, (4-Chloro-2-methylphenoxy)acetic acid; MCPB, 4-(4-chloro-2-methylphenoxy)butanoic acid; U, chemical was analyzed for, but not detected]

Pesticide	Trade name	Pesticide action	Pesticide class (or parent compound class)	USGS laboratory parameter code	USGS analytical method (see headnote)	Laboratory reporting level (µg/L)		USEPA standard or health advisory (µg/L)
						Minimum	Maximum	
1-Naphthol	Fourrine	Insecticide	Carbamate	49295	2, 5	0.036	0.09	--
2,4,5–T[1]	Dacamine, Emulsavert, Line Rider	Herbicide	Chlorophenoxy	39742	2, 4	0.01	0.32	70 (LHA)
2,4–D methyl ester	--	Herbicide	Chlorophenoxy	50470	4	0.009	0.2	--
2,4–D	Dacamine, Weed-B-Gon	Herbicide	Chlorophenoxy	39732	2, 4	0.01	0.73	70 (MCL)
2,4–DB	Butoxone, Butyrac	Selective herbicide	Chlorophenoxy	38746	2, 4	0.01	0.25	--
2,6-Diethylaniline	Alachlor degradate	--	Amide/acetanilide	82660	1, 5	0.002	0.006	--
2-Chloro-2',6'-diethylacetanilide	Butenachlor degradate	--	Amide	61618	5	0.005	0.01	--
2-Chloro-4-isopropylamino-6-amino-*s*-triazine (CIAT)	Atrazine degradate	--	Triazine	04040	1, 3, 4, 5	0.002	0.06	--
2-Chloro-6-ethylamino-4-amino-*s*-triazine (CEAT)	Atrazine/cyanazine/Simazine degradate	--	Triazine	04038	3, 4	0.01	0.08	--
2-Ethyl-6-methylaniline	Metolachlor degradate	--	Amide	61620	5	0.004	0.01	--
2-Hydroxy-4-isopropylamino-6-ethylamino-*s*-triazine (OIET)	Atrazine degradate	--	Triazine	50355	4	0.008	0.06	--
2-Methyl-4,6-dinitrophenol (DNOC)[1]	Dinitro-o-cresol, Elgetol	Herbicide	Miscellaneous	49299	2	0.01	0.42	--
3,4-Dichloroaniline	Propanil degradate	--	Urea	61625	5	0.004	0.006	--
3,5-Dichloroaniline	Iprodione degradate	--	Miscellaneous	61627	5	0.004	0.012	--
3-Hydroxycarbofuran	Carbofuran degradate	--	Carbamate	49308	2, 4	0.006	0.57	--
3-keto-Carbofuran[1]	Carbofuran degradate	--	Carbamate	50295	4	0.01	0.02	--
4-Chloro-2-methylphenol	MCPA degradate	--	Urea	61633	5	0.005	0.008	--

Table 1. Pesticides analyzed in 1995–2006 baseline and 2008–10 resampling studies, with trade names, pesticide actions, pesticide classes, laboratory reporting levels, and U.S. Environmental Protection Agency drinking-water standards.—Continued

[Pesticides detected during 2008–10 resampling study are in **bold** type. Focal pesticides, as determined by the Ground-water and Pesticides Strategy Committee, are shown with a grey background. USGS, U.S. Geological Survey; µg/L, micrograms per liter; USEPA, U.S. Environmental Protection Agency; --, not applicable; USGS analytical method: 1 = USGS laboratory schedule 2001, 2 = USGS laboratory schedule 2050, 3 = USGS laboratory schedule 1379, 4 = USGS laboratory schedule 2060, 5 = USGS laboratory schedule 2033, 6 = USGS Organic Chemistry Research Laboratory in Lawrence, Kansas schedule LCGY; USEPA standard or health advisory: LHA = USEPA Lifetime Health Advisory Level (U.S. Environmental Protection Agency, 2012), MCL = USEPA Maximum Contaminant Level (U.S. Environmental Protection Agency, 2012), RSD4 = USEPA Risk-Specific Dose at 10^{-4} Cancer Risk (U.S. Environmental Protection Agency, 2012); DCPA, dimethyl tetrachloroterephthalate; HCH, hexachlorocyclohexane; EPTC, S-ethyl dipropylthiocarbamate; MCPA, (4-Chloro-2-methylphenoxy)acetic acid; MCPB, 4-(4-chloro-2-methylphenoxy)butanoic acid; U, chemical was analyzed for, but not detected]

Pesticide	Trade name	Pesticide action	Pesticide class (or parent compound class)	USGS laboratory parameter code	USGS analytical method (see headnote)	Laboratory reporting level (µg/L)		USEPA standard or health advisory (µg/L)
						Minimum	Maximum	
Acetochlor	Guardian, Harness, Relay	Preplant herbicide	Amide/ chloroacetamide	49260	1, 3, 5	0.002	0.05	--
Acifluorfen	Blazer, Tackle 2S, Astic	Herbicide	Miscellaneous acid	49315	2, 4	0.007	0.24	100 (RSD4)
Alachlor	Alanex, Lasso, Shroud	Herbicide	Amide/ acetanilide	46342	1, 3, 5	0.002	0.05	2 (MCL)
Aldicarb	Temik	Insecticide, nematicide, acaricide	Carbamate	49312	2, 4	0.02	1.86	3 (MCL)[2]
Aldicarb sulfone	Standak, aldoxycarb, aldicarb metabolite	Insecticide	Carbamate	49313	2, 4	0.02	1.31	2 (MCL)[2]
Aldicarb sulfoxide	Aldicarb degradate	--	Carbamate	49314	2, 4	0.008	0.27	4 (MCL)[2]
***alpha*-Endosulfan**	Endosulfan degradate	--	Organochlorine	34362	5	0.005	0.011	--
alpha-HCH[1]		Insecticide	Organochlorine	34253	1, 3, 5	0.002	0.007	--
Ametryn[1]	Evik	Herbicide	Triazine	38401	3	0.05	--	60 (LHA)
Aminomethylphosphonic acid[3]	Glyphosate degradate	--		62649	6	0.02	--	--
Atrazine	Aatrex, Atranex	Herbicide	Triazine	39632	1, 3, 4, 5	0.001	0.05	3 (MCL)
Azinphos-methyl	Guthion, Crysthyon	Insecticide	Organophosphate	82686	1, 5	0.001	0.12	--
Azinphos-methyl-oxon				61635		0.12	--	
Bendiocarb	Ficam, Garrox, Turcam	Insecticide	Carbamate	50299	4	0.02	0.04	--
Benfluralin	Balan, Benefin	Herbicide	Dinitroaniline	82673	1, 5	0.002	0.014	--
Benomyl	Benlate, Benex	Fungicide	Carbamate	50300	4	0.004	0.06	--
Bensulfuron, methyl	Escuri, Londax	Herbicide	Urea/sulfonyurea	61693	4	0.02	0.06	--
Bentazon	Basagram, Bentzone	Herbicide	Miscellaneous	38711	2, 4	0.01	0.06	200 (LHA)
Bromacil	Hyvar X	Herbicide	Miscellaneous	04029	2, 3, 4	0.01	1.1	70 (LHA)
Bromoxynil	Buctril, Brominal, Agristar	Herbicide	Miscellaneous	49311	2, 4	0.01	1.6	--

Table 1. Pesticides analyzed in 1995–2006 baseline and 2008–10 resampling studies, with trade names, pesticide actions, pesticide classes, laboratory reporting levels, and U.S. Environmental Protection Agency drinking-water standards.—Continued

[Pesticides detected during 2008–10 resampling study are in **bold** type. Focal pesticides, as determined by the Ground-water and Pesticides Strategy Committee, are shown with a grey background. USGS, U.S. Geological Survey; µg/L, micrograms per liter; USEPA, U.S. Environmental Protection Agency; --, not applicable; USGS analytical method: 1 = USGS laboratory schedule 2001, 2 = USGS laboratory schedule 2050, 3 = USGS laboratory schedule 1379, 4 = USGS laboratory schedule 2060, 5 = USGS laboratory schedule 2033, 6 = USGS Organic Chemistry Research Laboratory in Lawrence, Kansas schedule LCGY; USEPA standard or health advisory: LHA = USEPA Lifetime Health Advisory Level (U.S. Environmental Protection Agency, 2012), MCL = USEPA Maximum Contaminant Level (U.S. Environmental Protection Agency, 2012), RSD4 = USEPA Risk-Specific Dose at 10^{-4} Cancer Risk (U.S. Environmental Protection Agency, 2012); DCPA, dimethyl tetrachloroterephthalate; HCH, hexachlorocyclohexane; EPTC, S-ethyl dipropylthiocarbamate; MCPA, (4-Chloro-2-methylphenoxy)acetic acid; MCPB, 4-(4-chloro-2-methylphenoxy)butanoic acid; U, chemical was analyzed for, but not detected]

Pesticide	Trade name	Pesticide action	Pesticide class (or parent compound class)	USGS laboratory parameter code	USGS analytical method (see headnote)	Laboratory reporting level (µg/L)		USEPA standard or health advisory (µg/L)
						Minimum	Maximum	
Butachlor[1]	Butanex, Lambast, Machete	Herbicide	Amide	04026	3	0.05	--	--
Butylate[1]	Sutan+, Genate Plus	Herbicide	Carbamate	04028	1, 3	0.002	0.05	400 (LHA)
Carbaryl	Carbatox, Sevin	Insecticide	Carbamate	49310	2, 4	0.008	0.08	4,000 (RSD4)
Carbaryl	Carbatox, Sevin	Insecticide	Carbamate	82680	1, 5	0.003	0.06	4,000 (RSD4)
Carbofuran	Furadan, Futura	Insecticide	Carbamate	49309	2, 4	0.006	3.33	40 (MCL)
Carbofuran	Furadan, Futura	Insecticide	Carbamate	82674	1, 5	0.003	0.06	40 (MCL)
Carboxin[1]	Kisvax, Oxatin, Vitavax	Fungicide	Miscellaneous	04027	3	0.05	--	700 (LHA)
Chloramben, methyl ester	Chloramben	Herbicide	Miscellaneous acid	61188	2, 4	0.01	0.42	100 (LHA)
Chlorimuron	Classic, Darban, Lory	Herbicide	Urea/sulfonyurea	50306	4	0.01	0.08	--
Chlorodiamino-*s*-triazine (CAAT)[1]	Atrazine degradate	--	Triazine	04039	4	0.04	--	--
Chlorothalonil[1]	Bravo	Fungicide	Organochlorine	49306	2, 4	0.01	0.48	150 (RSD4)
Chlorpyrifos	Dursban, Lorsban	Insecticide	Organophosphate	38933	1, 5	0.0036	0.006	2 (LHA)
***cis*–Permethrin**	Ambush, Pounce	Insecticide	Pyrethroid	82687	1, 5	0.005	0.016	--
cis-Propiconazole		--	Miscellaneous	79846	5	0.008	0.013	--
Clopyralid	Stinger, Lontrel	Herbicide	Pyridinecarboxylic acid	49305	2, 4	0.01	1.82	--
Cyanazine	Bladex	Selective herbicide	Triazine	04041	1, 3, 5	0.004	0.022	1 (LHA)
Cycloate	Ro-Neet	Selective herbicide	Carbamate/ thiocarbamate	04031	3, 4	0.01	0.05	--
Cyfluthrin	Aztec, Bug-b-gon, Laser, Raid, Tempo	Insecticide	Pyrethroid	61585	5	0.016	0.053	--
Cypermethrin	Barricade, Cymbush	Insecticide	Pyrethroid	61586	5	0.009	0.046	--
Dacthal mono-acid	Dacthal degradate	--	Organochlorine	49304	2, 4	0.01	0.15	--
DCPA	Dacthal	Herbicide	Organochlorine	82682	1, 5	0.002	0.0076	70 (LHA)

Table 1. Pesticides analyzed in 1995–2006 baseline and 2008–10 resampling studies, with trade names, pesticide actions, pesticide classes, laboratory reporting levels, and U.S. Environmental Protection Agency drinking-water standards.—Continued

[Pesticides detected during 2008–10 resampling study are in **bold** type. Focal pesticides, as determined by the Ground-water and Pesticides Strategy Committee, are shown with a grey background. USGS, U.S. Geological Survey; µg/L, micrograms per liter; USEPA, U.S. Environmental Protection Agency; --, not applicable; USGS analytical method: 1 = USGS laboratory schedule 2001, 2 = USGS laboratory schedule 2050, 3 = USGS laboratory schedule 1379, 4 = USGS laboratory schedule 2060, 5 = USGS laboratory schedule 2033, 6 = USGS Organic Chemistry Research Laboratory in Lawrence, Kansas schedule LCGY; USEPA standard or health advisory: LHA = USEPA Lifetime Health Advisory Level (U.S. Environmental Protection Agency, 2012), MCL = USEPA Maximum Contaminant Level (U.S. Environmental Protection Agency, 2012), RSD4 = USEPA Risk-Specific Dose at 10^{-4} Cancer Risk (U.S. Environmental Protection Agency, 2012); DCPA, dimethyl tetrachloroterephthalate; HCH, hexachlorocyclohexane; EPTC, S-ethyl dipropylthiocarbamate; MCPA, (4-Chloro-2-methylphenoxy)acetic acid; MCPB, 4-(4-chloro-2-methylphenoxy)butanoic acid; U, chemical was analyzed for, but not detected]

Pesticide	Trade name	Pesticide action	Pesticide class (or parent compound class)	USGS laboratory parameter code	USGS analytical method (see headnote)	Laboratory reporting level (µg/L)		USEPA standard or health advisory (µg/L)
						Minimum	Maximum	
Desulfinylfipronil amide	Fipronil degradate	--	Pyrazole	62169	1, 5	0.009	0.029	--
Desulfinylfipronil	Fipronil degradate	--	Pyrazole	62170	1, 5	0.004	0.012	--
Diazinon	Basudin, Spectracide, Knoxout	Insecticide, nematicide	Organophosphate	39572	1, 5	0.002	0.008	1 (LHA)
Dicamba	Banvel, Banex	Herbicide	Miscellaneous acid	38442	2, 4	0.01	0.35	4,000 (LHA)
Dichlobenil[1]	Barrier, Casoron, Rootx	Herbicide	Organochlorine	49303	2	0.02	1.2	--
Dichloroprop	Weedone, Polymone	Herbicide	Chlorophenoxy	49302	2, 4	0.01	0.13	--
Dichlorvos	DDVP, Vapona	Insecticide	Organophosphate	38775	5	0.04	--	--
Dicrotophos	Bidrin, Penetrex	Insecticide	Organophosphate	38454	5	0.08	--	--
Dieldrin	Panoram D-31, Octalox	Insecticide	Organochlorine	39381	1, 5	0.001	0.009	0.2 (RSD4)
Dimethoate	Cygon, Defend, Rogor	Insecticide	Organophosphate	82662	1, 5	0.006	0.01	--
Dinoseb	Premerge	Herbicide	Miscellaneous	49301	2, 4	0.01	0.21	7 (MCL)
Diphenamid	Dymid, Enide	Selective herbicide	Amide	04033	3, 4	0.01	0.05	200 (LHA)
Disulfoton sulfone	Disyston sulfone	Insecticide	Organophosphate	61640	5	0.01	0.014	--
Disulfoton	Di-Syston	Insecticide, acaricide	Organophosphate	82677	1, 5	0.02	0.06	0.7 (LHA)
Diuron	Durashield, Karmex	Herbicide	Urea	49300	2, 4	0.01	0.42	200 (RSD4)
Endosulfan Sulfate	Endosulfan degradate	--	Organochlorine	61590	5	0.014	0.022	--
EPTC	Eptam, Eradicane	Herbicide	Carbamate	82668	1, 5	0.002	0.015	--
Ethalfluralin[1]	Eptam, Eradicane	Herbicide	Dinitroaniline	82663	1	0.004	0.013	--
Ethion monoxon	Ethion degradate	--	Organophosphate	61644	5	0.002	0.021	--
Ethion	Klear-all, Rhodocide	Insecticide	Organophosphate	82346	5	0.004	0.016	--
Ethoprop (Ethoprophos)	Mocap, Prophos	Insecticide, nematicide	Organophosphate	82672	1, 5	0.003	0.016	--
Fenamiphos sulfone	Fenamiphos degradate	--	Organophosphate	61645	5	0.049	0.054	--
Fenamiphos sulfoxide	Fenamiphos degradate	--	Organophosphate	61646	5	0.04	0.08	--
Fenamiphos	Nemacur	Insecticide	Organophosphate	61591	5	0.03	--	0.7 (LHA)

Table 1. Pesticides analyzed in 1995–2006 baseline and 2008–10 resampling studies, with trade names, pesticide actions, pesticide classes, laboratory reporting levels, and U.S. Environmental Protection Agency drinking-water standards.—Continued

[Pesticides detected during 2008–10 resampling study are in **bold** type. Focal pesticides, as determined by the Ground-water and Pesticides Strategy Committee, are shown with a grey background. USGS, U.S. Geological Survey; µg/L, micrograms per liter; USEPA, U.S. Environmental Protection Agency; --, not applicable; USGS analytical method: 1 = USGS laboratory schedule 2001, 2 = USGS laboratory schedule 2050, 3 = USGS laboratory schedule 1379, 4 = USGS laboratory schedule 2060, 5 = USGS laboratory schedule 2033, 6 = USGS Organic Chemistry Research Laboratory in Lawrence, Kansas schedule LCGY; USEPA standard or health advisory: LHA = USEPA Lifetime Health Advisory Level (U.S. Environmental Protection Agency, 2012), MCL = USEPA Maximum Contaminant Level (U.S. Environmental Protection Agency, 2012), RSD4 = USEPA Risk-Specific Dose at 10^{-4} Cancer Risk (U.S. Environmental Protection Agency, 2012); DCPA, dimethyl tetrachloroterephthalate; HCH, hexachlorocyclohexane; EPTC, S-ethyl dipropylthiocarbamate; MCPA, (4-Chloro-2-methylphenoxy)acetic acid; MCPB, 4-(4-chloro-2-methylphenoxy)butanoic acid; U, chemical was analyzed for, but not detected]

Pesticide	Trade name	Pesticide action	Pesticide class (or parent compound class)	USGS laboratory parameter code	USGS analytical method (see headnote)	Laboratory reporting level (µg/L)		USEPA standard or health advisory (µg/L)
						Minimum	Maximum	
Fenuron	Fenuron	Herbicide	Urea	49297	2, 4	0.01	1.0	--
Fipronil sulfide	Fipronil degradate	--	Pyrazole	62167	1, 5	0.005	0.013	--
Fipronil sulfone	Fipronil degradate	--	Pyrazole	62168	1, 5	0.005	0.024	--
Fipronil	Combat, Frontline, Maxforce, Regent	Insecticide	Pyrazole	62166	1, 5	0.007	0.018	--
Flumetsulam	Broadstrike, Python	Herbicide	Miscellaneous	61694	4	0.01	0.08	--
Fluometuron	Cotoran	Herbicide	Urea	38811	2, 4	0.01	0.36	90 (LHA)
Fonofos	Dyfonate	Insecticide	Organophosphate	04095	1, 5	0.003	0.008	10 (LHA)
Glufosinate[3]	Glyphosate degradate	--		62721	6	0.02	--	--
Glyphosate[3]	Roundup	Herbicide	Organophosphate	62722	6	0.02	--	700 (MCL)
Hexazinone	Buckshot, Pronone, Velpar	Herbicide	Triazine	04025	3, 5	0.012	0.05	400 (LHA)
Imazaquin	Scepter	Herbicide	Miscellaneous	50356	4	0.02	0.1	--
Imazethapyr	New Path, Pursuit	Herbicide	Miscellaneous	50407	4	0.02	0.08	--
Imidacloprid	Admire, Provado	Insecticide	Miscellaneous	61695	4	0.007	0.08	--
Iprodione	Chipco, Rovral	Fungicide	Dicarboximide	61593	5	0.014	0.538	--
Isofenphos	Amaze, Pryfon	Insecticide	Organophosphate	61594	5	0.003	0.011	--
lambda-Cyhalothrin	Commodore, Icon	Insecticide	Pyrethroid	61595	5	0.009	0.014	--
Lindane (*gamma*-HCH)[1]	Lindane, Isotoz	Insecticide	Organochlorine	39341	1	0.004	0.011	0.2 (MCL)
Linuron	Linurex, Lorox	Herbicide	Urea	38478	2, 4	0.01	1.47	--
Linuron[1]	Linurex, Lorox	Herbicide	Urea	82666	1	0.002	0.039	--
Malaoxon	Malathion degradate	--	Organophosphate	61652	5	0.022	0.039	--
Malathion	Cythion, Malaspray	Insecticide	Organophosphate	39532	1, 5	0.005	0.031	500 (LHA)
MCPA	Solve, MCP	Herbicide	Chlorophenoxy	38482	2, 4	0.01	0.20	30 (LHA)
MCPB	Butoxone M40, Thistrol	Herbicide	Chlorophenoxy	38487	2, 4	0.01	0.26	--

Table 1. Pesticides analyzed in 1995–2006 baseline and 2008–10 resampling studies, with trade names, pesticide actions, pesticide classes, laboratory reporting levels, and U.S. Environmental Protection Agency drinking-water standards.—Continued

[Pesticides detected during 2008–10 resampling study are in **bold** type. Focal pesticides, as determined by the Ground-water and Pesticides Strategy Committee, are shown with a grey background. USGS, U.S. Geological Survey; µg/L, micrograms per liter; USEPA, U.S. Environmental Protection Agency; --, not applicable; USGS analytical method: 1 = USGS laboratory schedule 2001, 2 = USGS laboratory schedule 2050, 3 = USGS laboratory schedule 1379, 4 = USGS laboratory schedule 2060, 5 = USGS laboratory schedule 2033, 6 = USGS Organic Chemistry Research Laboratory in Lawrence, Kansas schedule LCGY; USEPA standard or health advisory: LHA = USEPA Lifetime Health Advisory Level (U.S. Environmental Protection Agency, 2012), MCL = USEPA Maximum Contaminant Level (U.S. Environmental Protection Agency, 2012), RSD4 = USEPA Risk-Specific Dose at 10^{-4} Cancer Risk (U.S. Environmental Protection Agency, 2012); DCPA, dimethyl tetrachloroterephthalate; HCH, hexachlorocyclohexane; EPTC, S-ethyl dipropylthiocarbamate; MCPA, (4-Chloro-2-methylphenoxy)acetic acid; MCPB, 4-(4-chloro-2-methylphenoxy)butanoic acid; U, chemical was analyzed for, but not detected]

Pesticide	Trade name	Pesticide action	Pesticide class (or parent compound class)	USGS laboratory parameter code	USGS analytical method (see headnote)	Laboratory reporting level (µg/L)		USEPA standard or health advisory (µg/L)
						Minimum	Maximum	
Metalaxyl	Apron, Ridamil, Subdue	Fungicide	Miscellaneous	50359	4	0.01	0.04	--
Metalaxyl	Apron, Ridamil, Subdue	Fungicide	Miscellaneous	61596	5	0.005	0.018	--
Methidathion	Somanil, Supracide	Insecticide	Organophosphate	61598	5	0.006	0.012	--
Methiocarb	Mesurol	Insecticide	Carbamate	38501	2, 4	0.008	1.99	--
Methomyl	Lannate, Nudrin	Insecticide	Carbamate	49296	2, 4	0.004	1.09	200 (LHA)
Methyl paraoxon	Methyl parathion degradate	--	Organophosphate	61664	5	0.014	0.03	--
Methyl parathion	Penncap-M, Paratox	Insecticide	Organophosphate	82667	1, 5	0.006	0.035	1 (LHA)
Metolachlor	Bicep, Dual	Herbicide	Amide	39415	1, 3, 5	0.002	0.05	700 (LHA)
Metribuzin	Lexone, Sencor	Herbicide	Triazine	82630	1, 3, 5	0.004	0.05	70 (LHA)
Metsulfuron-methyl	Ally, Escort	Herbicide	Urea/sulfonyurea	61697	4	0.03	0.14	--
Molinate	Hydram, Ordram	Herbicide	Carbamate	82671	1, 5	0.002	0.007	--
Myclobutanil	Rally, Systhane	Fungicide	Miscellaneous	61599	5	0.008	0.033	--
N-(4-Chlorophenyl)-*N*'-methylurea	Diuron degradate	--	Urea	61692	4	0.02	0.1	--
Napropamide[1]	Devrinol	Herbicide	Amide	82684	1	0.003	0.01	--
Neburon	Granurex, Propuron	Herbicide	Urea	49294	2, 4	0.01	0.41	--
Nicosulfuron	Accent, OneHope	Herbicide	Urea/sulfonyurea	50364	4	0.01	0.32	--
Norflurazon	Zorial, Solicam	Herbicide	Miscellaneous	49293	2, 4	0.02	0.32	--
Oryzalin	Surflan	Herbicide	Dinitroaniline	49292	2, 4	0.01	1.25	--
Oxamyl	Vydate	Insecticide, acaricide, nematicide	Carbamate	38866	2, 4	0.01	0.68	200 (MCL)
Oxyfluorfen	Goal	Herbicide	Miscellaneous	61600	3	0.007	0.017	--
Parathion[1]	Alkron, Bladan, Fighter	Insecticide	Organophosphate	39542	1	0.004	0.022	--
Pebulate[1]	Tillam	Herbicide	Carbamate	82669	1	0.002	0.009	--
Pendimethalin	Prowl, Stomp	Herbicide	Dinitroaniline	82683	1, 5	0.004	0.012	--

Table 1. Pesticides analyzed in 1995–2006 baseline and 2008–10 resampling studies, with trade names, pesticide actions, pesticide classes, laboratory reporting levels, and U.S. Environmental Protection Agency drinking-water standards.—Continued

[Pesticides detected during 2008–10 resampling study are in **bold** type. Focal pesticides, as determined by the Ground-water and Pesticides Strategy Committee, are shown with a grey background. USGS, U.S. Geological Survey; µg/L, micrograms per liter; USEPA, U.S. Environmental Protection Agency; --, not applicable; USGS analytical method: 1 = USGS laboratory schedule 2001, 2 = USGS laboratory schedule 2050, 3 = USGS laboratory schedule 1379, 4 = USGS laboratory schedule 2060, 5 = USGS laboratory schedule 2033, 6 = USGS Organic Chemistry Research Laboratory in Lawrence, Kansas schedule LCGY; USEPA standard or health advisory: LHA = USEPA Lifetime Health Advisory Level (U.S. Environmental Protection Agency, 2012), MCL = USEPA Maximum Contaminant Level (U.S. Environmental Protection Agency, 2012), RSD4 = USEPA Risk-Specific Dose at 10^{-4} Cancer Risk (U.S. Environmental Protection Agency, 2012); DCPA, dimethyl tetrachloroterephthalate; HCH, hexachlorocyclohexane; EPTC, S-ethyl dipropylthiocarbamate; MCPA, (4-Chloro-2-methylphenoxy)acetic acid; MCPB, 4-(4-chloro-2-methylphenoxy)butanoic acid; U, chemical was analyzed for, but not detected]

Pesticide	Trade name	Pesticide action	Pesticide class (or parent compound class)	USGS laboratory parameter code	USGS analytical method (see headnote)	Laboratory reporting level (µg/L)		USEPA standard or health advisory (µg/L)
						Minimum	Maximum	
Phorate oxon	Phorate degradate	--	Organophosphate	61666	5	0.027	0.10	--
Phorate	Thimet, Rampart	Insecticide	Organophosphate	82664	1, 5	0.02	0.10	--
Phosmet oxon[3]	Phosmet degradate	--	Organophosphate	61668	5	0.05	0.0511	--
Phosmet[3]	Imidan, Percolate, Prolate	Insecticide	Organophosphate	61601	5	0.008	0.08	--
Picloram	Tordon	Herbicide	Pyridinecarboxylic acid	49291	2, 4	0.02	0.26	500 (MCL)
Prometon	Pramitol, Gesafram	Herbicide	Triazine	04037	1, 3, 5	0.01	0.05	400 (LHA)
Prometryn	Caparol, Selectin	Herbicide	Triazine	04036	3, 5	0.005	0.05	--
Propachlor[1]	Ramrod, Prolex	Herbicide	Amide	04024	1, 3	0.007	0.05	100 (RSD4)
Propanil	Stamp	Herbicide	Amide	82679	1, 5	0.004	0.016	--
Propargite	Comite, Omite	Insecticide, acaricide	Miscellaneous	82685	1, 5	0.01	0.06	--
Propazine[1]	Milogard, Tritol	Herbicide	Triazine	38535	3	0.05	--	10 (LHA)
Propham	Chem Hoe	Herbicide	Carbamate	49236	2, 4	0.01	7.9	100 (LHA)
Propiconazole	Banner	Fungicide	Miscellaneous	50471	4	0.01	0.038	--
Propoxur	Baygone, Suncide	Fungicide	Carbamate	38538	2, 4	0.008	0.71	--
Propyzamide (Pronamide)	Kerb	Herbicide	Amide	82676	1, 5	0.003	0.009	100 (RSD4)
Siduron	Tupersan	Herbicide	Urea	38548	4	0.02	0.04	--
Silvex[1] (2,4,5–TP)	Silvex, Weed-B-Gon	Herbicide	Chlorophenoxy	39762	2	0.02	0.25	50 (MCL)
Simazine	Aquazine, Princep	Herbicide	Triazine	04035	1, 3, 5	0.005	0.05	4 (MCL)
Simetryn[1]	Cymetrin, Gy-bon	Herbicide	Triazine	04030	3	0.05	--	--
Sulfometruron-methyl	Oust	Herbicide	Urea/sulfonyurea	50337	4	0.009	0.091	--
Tebuconazole	Elite, Folicur, Raxil	Fungicide	Azole	62852	5	0.02	--	--
Tebuthiuron	Graslan, Spike	Herbicide	Urea	82670	1, 4, 5	0.01	0.06	500 (LHA)
Tefluthrin	Demand, Force, Karate	Insecticide	Pyrethroid	61606	5	0.003	0.014	--
Terbacil[1]	Sinbar, Herbicide 732	Herbicide	Miscellaneous	82665	1	0.007	0.034	90 (LHA)

Table 1. Pesticides analyzed in 1995–2006 baseline and 2008–10 resampling studies, with trade names, pesticide actions, pesticide classes, laboratory reporting levels, and U.S. Environmental Protection Agency drinking-water standards.—Continued

[Pesticides detected during 2008–10 resampling study are in **bold** type. Focal pesticides, as determined by the Ground-water and Pesticides Strategy Committee, are shown with a grey background. USGS, U.S. Geological Survey; µg/L, micrograms per liter; USEPA, U.S. Environmental Protection Agency; --, not applicable; USGS analytical method: 1 = USGS laboratory schedule 2001, 2 = USGS laboratory schedule 2050, 3 = USGS laboratory schedule 1379, 4 = USGS laboratory schedule 2060, 5 = USGS laboratory schedule 2033, 6 = USGS Organic Chemistry Research Laboratory in Lawrence, Kansas schedule LCGY; USEPA standard or health advisory: LHA = USEPA Lifetime Health Advisory Level (U.S. Environmental Protection Agency, 2012), MCL = USEPA Maximum Contaminant Level (U.S. Environmental Protection Agency, 2012), RSD4 = USEPA Risk-Specific Dose at 10^{-4} Cancer Risk (U.S. Environmental Protection Agency, 2012); DCPA, dimethyl tetrachloroterephthalate; HCH, hexachlorocyclohexane; EPTC, S-ethyl dipropylthiocarbamate; MCPA, (4-Chloro-2-methylphenoxy)acetic acid; MCPB, 4-(4-chloro-2-methylphenoxy)butanoic acid; U, chemical was analyzed for, but not detected]

Pesticide	Trade name	Pesticide action	Pesticide class (or parent compound class)	USGS laboratory parameter code	USGS analytical method (see headnote)	Laboratory reporting level (µg/L)		USEPA standard or health advisory (µg/L)
						Minimum	Maximum	
Terbacil	Sinbar, Herbicide 732	Herbicide	Miscellaneous	04032	3, 4	0.01	0.05	90 (LHA)
Terbufos	Counter, Contraven	Insecticide	Organophosphate	82675	1, 5	0.01	0.02	0.4 (LHA)
Terbuthylazine	Gardoprim	Herbicide	Triazine	04022	1, 3, 5	U	0.01	--
Thiobencarb	Bolero, Saturn	Herbicide	Carbamate	82681	1, 5	0.002	0.016	--
trans-Propiconazole	--	--	Miscellaneous	79847	5	0.01	0.03	--
Triallate[1]	Far-Go, Avadex BW	Herbicide	Carbamate	82678	1	0.001	0.008	--
Tribenuron[1]	Express, Urgent	Herbicide	Urea/sulfonyurea	61159	4	0.009	--	--
Tribuphos	Def, Easy off-D, Folex	Herbicide	Organophosphate	61591	5	0.004	0.035	--
Triclopyr	Garlon	Herbicide	Chlorophenoxy	49235	2, 4	0.02	0.36	--
Trifluralin	Treflan, Trim	Herbicide	Dinitroaniline	82661	1, 5	0.002	0.018	10 (LHA)
Trifluralin[1]	Treflan, Trim	Herbicide	Dinitroaniline	04023	3	0.05	--	10 (LHA)
Vernolate[1]	Surpass, Vernam	Herbicide	Carbamate	04034	2	0.05	--	--

[1]Pesticide was not on analytical schedules 2008–10.

[2]The MCL for any combination of two or more of these three chemicals (aldicarb, aldicarb sulfoxide, and aldicarb sulfone) is 7 µg/L.

[3]Pesticide was not on analytical schedules 1995–2008.

Recensoring and Assessment Levels

Because of the use of three different types of reporting levels and variability in reporting-level values during the 1995–2006 baseline study, analytical results received from the NWQL with original censoring were recensored. The recensoring techniques and all but one value used for the data during the 1995–2006 baseline study (Bartos and others, 2009) were also used to recensor the 2008–10 resampling study data. During the 1995–2006 baseline study, recensoring was necessary to account for different types of reporting levels (MRL, MDL, or LRL) and (or) variable laboratory reporting levels either for a specific pesticide or between individual pesticides. The reporting levels typically vary over time due to changes in analytical methods, differences in laboratory equipment, equipment sensitivity, experience and skill of equipment operators, and laboratory conditions. Recensoring to a common value (referred to herein as the assessment level) allows for accurate calculation and comparison of detection frequencies and concentrations between individual pesticides or groups of pesticides with different types and values of reporting levels, as well as the use of quantitative statistical methods to examine pesticide occurrence.

Typically, recensoring is conducted by comparing concentrations of reported detections to all LRLs; all detections less than the largest LRL are recoded as nondetections, and all detections greater than the largest LRL are retained as detections at the originally reported laboratory concentrations. Unfortunately, pesticide reporting levels varied widely during the baseline study (table 1), and selection of the largest LRL for recensoring would result in many, if not most, detections being recoded as nondetections. Consequently, an approach was used to recensor the data in an attempt to retain as many pesticide detections as possible while still adhering to a rigorous and defensible procedure for assembly of the final dataset. In order to be able to compare data from the 1995–2006 baseline study to the 2008–10 resampling study, the laboratory reported pesticide concentrations from the 2008–10 resampling study were recensored in the same manner as the 1995–2006 baseline study data.

During the 1995–2006 baseline study data analyses, two levels of recensoring were developed to compare pesticides—a compound-specific assessment level (CSAL) that differed by compound, and a common assessment level (CAL) of 0.07 microgram per liter (µg/L) (Bartos and others, 2009). During the analysis of the 2008–10 resampling study data, the CSAL for all pesticides and the CAL were evaluated to determine if adjustments were needed based on the LRL reported by the NWQL during 2008–10. All pesticide CSALs remained the same as the level determined during the baseline study, with the exception of 2,4–D methyl ester, for which the CSAL increased from 0.009 to 0.02 µg/L (table 2). The CAL (0.07 µg/L) remained the same for the 2008–2010 resampling data as the value used during the 1995–2006 baseline study. In addition to the two levels of recensoring, no assessment level (NAL) also was used to compare pesticide results. The NAL is the value the NWQL or the KSOCRL determined and reported for the sample.

Quality-Control Samples and Quality Assurance

In addition to collection of environmental groundwater-quality samples, three types of quality-control (QC) samples were collected as part of the overall quality-assurance (QA) program—field-blank samples, replicate samples, and field-matrix spike samples. The QC samples were collected, preserved, and analyzed using the same methods and equipment as for environmental samples. Collection and evaluation of QC samples, in addition to strict sample collection, processing, and analysis procedures, composed the field QA program. Results for the QC samples can be found in appendix 1.

Field-Blank Samples

Field-blank samples were collected to evaluate bias from the potential introduction of contamination to environmental samples during sample collection, sampling equipment cleaning, and laboratory analytical procedures. Specially prepared water that is certified to be free of organic constituents was used as the source-water for blank samples. No detections of pesticides were found in the one field-blank sample (site number 410817104470201) that was collected in conjunction with another project, using the same sampling equipment and procedures as the 2008–10 resampling study. This result indicated that decontamination procedures were adequate and that field and laboratory contamination of environmental samples by pesticides was minimal, and was consistent with results of field-blank samples collected during 1995–2006 baseline sampling.

Replicate Samples

A replicate sample (duplicate) is a sample collected immediately after the primary environmental sample to assess combined effects of sample-collection and laboratory procedures on measurement variability (precision). Two replicate samples were collected for analysis at sites 410108104223501 (Lr4) and 444603108383401 (Pk1) (appendix 2). The replicate and environmental samples had a total of 274 pairs of individual analyses, of which six pairs had detections of a pesticide in both the replicate and the environmental samples. Two sample pairs had detections in only one set of samples (either the replicate or the environmental sample); however, it should be noted that the detections in the one sample for both pesticides were estimated (“E”) values at 6 and 25 percent of the LRL. All reported detections were used in analysis of the replicate data, including the values assigned an “E” remark code (85 percent of reported detections). All replicate data were used without recensoring.

Table 2. Pesticides detected in groundwater samples collected from 52 wells sampled during both 1995–2006 baseline study[1] and 2008–10 resampling study.

[Pesticides in **bold** were not included on the analytical schedules used during the 1995–2006 baseline study. NAL, no assessment level; CSAL, compound-specific assessment level; CAL, common assessment level; µg/L, micrograms per liter; I, insecticide; H, herbicide; HD, herbicide degradate; FD, fungicide degradate; ID, insecticide degradate; F, fungicide; BF, detected during 1995–2006 baseline study fall sampling; BS, detected during 1995–2006 baseline study spring sampling; RF, detected during 2008–10 resampling study fall sampling; NS, not on analytical schedule]

Pesticide	Pesticide action	Detection with original laboratory censoring (NAL)			Laboratory reporting level range (µg/L)		Assigned assessment level (µg/L)	
		Baseline spring	Baseline fall	Resampling fall	1995–2006	2008–10	CSAL	CAL
1-Napthol	I	--	--	RF	0.09	0.036–0.04	0.02	0.07
2,4-D methyl ester	H	--	BF	--	0.009–0.016	0.02	[2]0.02	0.07
2,4-D	H	--	BF	--	0.01–0.73	0.03	0.15	0.07
2-Chloro-4-isopropyl-amino-6-amino-*s*-triazine (CIAT)	HD	BS	BF	RF	0.002–0.05	0.006–.014	0.05	0.07
2-Chloro-6-ethylamino-4-amino-*s*-triazine (CEAT)	HD	BS	--	RF	0.01–0.08	0.06–0.08	0.04	0.07
2-Hydroxy-4-isopropylamino-6-ethylamino-*s*-triazine (OIET)	HD	--	--	RF	0.008–0.032	0.003	0.016	0.07
3,4-Dichloroanaline	HD	--	--	RF	0.004	0.02–0.03	0.004	0.07
3,5-Dichloroaniline	FD	--	--	RF	0.004–0.012	0.003–0.003	0.003	0.07
Aldicarb sulfone	ID	BS	BF		0.02–1.31	0.04	0.11	0.07
Aldicarb sulfoxide	ID	BS	BF	RF	0.008–0.27	0.03	0.14	0.07
Aminomethylphosphonic acid	HD	--	--	RF	NS	0.02	0.02	0.07
Atrazine	H	BS	BF	RF	0.001–0.05	0.004	0.004	0.07
Benfluralin	H	--	BF	--	0.002–0.013	0.007	0.013	0.07
Bentazon	H	--	--	RF	0.01–0.06	0.03	0.06	0.07
Bromacil	H	BS	BF	RF	0.01–1.1	0.01–0.03	0.06	0.07
Bromoxynil	H	--	BF	--	0.01–1.6	0.06	0.07	0.07
Carbaryl	I	--	BF	--	0.003–0.046	0.01–0.02	0.05	0.07
Carbofuran	I	--	BF	--	0.003–0.02	0.02	0.02	0.07
Chlorimuron	H	--	--	--	0.01–0.046	0.04	0.046	0.07
cis-Permethrin	I	--	BF	--	0.005–0.016	0.005–0.007	0.016	0.07
Clopyralid	H	BS	BF	--	0.01–1.82	0.03	0.26	0.07
Cyanazine	H	BS	BF	--	0.004–0.2	0.011	0.013	0.07
Cypermethrin	I	--	--	RF	0.009–0.046	0.014–0.020	0.01	0.07
DCPA	H	--	--	--	0.002–0.004	0.004	0.004	0.07
Diazinon	I	BS	--	--	0.002–0.008	0.003	0.008	0.07
Dicamba	H	--	--	--	0.01–0.35	0.02–0.03	0.13	0.07
Dichloroprop	H	--	--	--	0.01–0.13	0.02	0.06	0.07
Dieldrin	I	--	BF	--	0.001–0.009	0.004	0.008	0.07
Diuron	H	BS	BF	RF	0.01–0.42	0.02	0.06	0.07
Fipronil	I	--	--	RF	0.004–0.012	0.018–0.040	0.02	0.07
Fipronil sulfide	ID	--	BF	--	0.005–0.013	0.006	0.006	0.07

Table 2. Pesticides detected in groundwater samples collected from 52 wells sampled during both 1995–2006 baseline study[1] and 2008–10 resampling study.—Continued

[Pesticides in **bold** were not included on the analytical schedules used during the 1995–2006 baseline study. NAL, no assessment level; CSAL, compound-specific assessment level; CAL, common assessment level; µg/L, micrograms per liter; I, insecticide; H, herbicide; HD, herbicide degradate; FD, fungicide degradate; ID, insecticide degradate; F, fungicide; BF, detected during 1995–2006 baseline study fall sampling; BS, detected during 1995–2006 baseline study spring sampling; RF, detected during 2008–10 resampling study fall sampling; NS, not on analytical schedule]

Detected pesticide	Pesticide action	Detection with original laboratory censoring (NAL)			Laboratory reporting level range (µg/L)		Assigned assessment level (µg/L)	
		Baseline spring	Baseline fall	Resampling fall	1995–2006	2008–10	CSAL	CAL
Fipronil sulfone	ID	--	BF	--	0.005–0.024	0.012	0.012	0.07
Flumetsulam	H	--	--	--	0.01–0.06	0.03	0.06	0.07
Fluometuron	H	--	--	RF	0.01–0.36	0.04	0.02	0.07
Glyphosate	H	--	--	RF	NS	0.02	0.02	0.07
Hexazinone	H	--	--	RF	0.013–0.05	0.005–0.007	0.05	0.07
Imidacloprid	I	--	--	RF	0.007–0.241	0.03–0.1	0.02	0.07
Metalaxyl	F	--	--	RF	0.01–0.02	0.007–0.018	0.02	0.07
Metolachlor	H	BS	BF	RF	0.002–0.05	0.01	0.009	0.07
Metribuzin	H	BS	BF	RF	0.004–0.05	0.006	0.05	0.07
Metsulfuron-methyl	H	--	--	RF	0.03–0.07	0.07	0.07	0.07
Norflurazon	H	BS	BF	RF	0.02–0.32	0.02	0.06	0.07
Oryzalin	H	--	BF	--	0.01–1.25	0.02	0.31	0.07
Picloram	H	BS	BF	RF	0.02–0.26	0.06	0.06	0.07
Prometon	H	BS	BF	RF	0.01–0.05	0.006	0.05	0.07
Simazine	H	BS	BF	RF	0.005–0.05	0.005	0.05	0.07
Suflometuron-methyl	H	--	BF	RF	0.009–0.091	0.03	0.09	0.07
Tebuthiuron	H	BS	BF	RF	0.01–0.026	0.01–0.14	0.01	0.07
Triallate	H	BS	BF	--	0.001–0.008	NS	0.003	0.07
Triclopyr	H	BS	BF	--	0.02–0.36	0.04	0.36	0.07
Trifluralin	H	--	BF	--	0.002–0.012	0.006–0.009	0.012	0.07

[1]Bartos and others (2009).

[2]The CSAL for 2,4–D methyl ester for the 2008–10 resampling study was modified from the assigned CSAL for the 1995–2006 baseline study because of a statistical change in the long-term method detection level.

The relative percentage difference (RPD) was calculated to compare the pesticide concentrations measured in both the environmental (sample1) and replicate (sample2) samples using the following equation:

$$RPD = \text{absolute value}\left(\frac{sample1 - sample2}{\left(\frac{sample1 + sample2}{2}\right)}\right) \times 100 \qquad (1)$$

RPDs were not calculated for pairs where one value was reported as less than the LRL and not as an estimated value.

Evaluation of the two pairs of individual results with detections (six pesticides detected in both environmental and replicate samples) indicated five pesticide pairs had an RPD of less than 13 percent, and the remaining pesticide pair had an RPD of 29 percent. The differences generally were attributable to small concentration differences that resulted in relatively large RPDs because both environmental and replicate sample concentrations were estimated and small. These results were considered acceptable for this resampling study, generally were similar to the in-depth replicate sampling conducted during the 1995–2006 baseline study, and consequently, no detections were qualified or deleted on the basis of calculated RPDs.

Field-Matrix Spike Samples

Field-matrix spike samples were analyzed to evaluate bias and variability from the environmental groundwater matrix or potential degradation of the constituent during sample processing, storage, and analysis. Field-matrix spike samples were collected in the same manner as the environmental samples, immediately following collection of the environmental samples. The samples then were injected with a known concentration of selected pesticides. Forty-five spike samples were collected during the 1995–2006 baseline study, and laboratory recoveries of most field-matrix spike samples ranged from 60 to 120 percent of the pesticide or degradate known to be in the sample during that time (Bartos and others, 2009). Because the same analytical methods were used during the 2008–10 resampling study, spike samples were collected at only one well, site number 41101910405130 (Lr 7) (appendix 3).

Overall recoveries of pesticides and degradates during the 2008-2010 resampling study averaged about 90 percent, which indicates a possible slight low bias in reported concentrations. Analysis of a subset of field-matrix spike data that included only pesticides and degradates detected in environmental samples showed about the same average recovery (93 percent). Two pesticides and degradates detected in environmental samples (1-napthol and bentazon), however, had low field-matrix spike recoveries indicating a general low bias (average recoveries less than 60 percent). Concentrations of aldicarb sulfoxide, fipronil, and sulfometuron-methyl may have been biased slightly high, as the calculated recoveries were 123, 127, and 158 percent, respectively. These results were considered acceptable for this study, and consequently, no detections were qualified or deleted on the basis of poor recoveries.

Pesticide Occurrence during 2008–10 Resampling Study

The occurrences of pesticides in the samples collected from 52 wells during the 2008–10 resampling study are summarized and described in relation to pesticide action. Water-quality analyses for each well can be accessed at *http://nwis.waterdata.usgs.gov/wy/nwis/qwdata* (U.S. Geological Survey, 2012), by using the site number shown in appendix 4. In general, the NAL is used when describing any indication that the pesticide was detected. The CSAL is the level of assessment used when comparing detections of the same pesticide over time or between wells. The CAL is the level of assessment used when comparing detections that include different pesticides. In selected tables and figures, results for all assessment levels are shown for interpretive purposes.

Pesticides Detected during 2008–10 Resampling Study

Twenty-eight different pesticides were detected using NAL from the 52 wells resampled in 2008–10 (fig. 3; table 2). Concentrations of detected pesticides generally were small (less than 1 µg/L). Three different pesticides (bromacil, glyphosate, and picloram) were detected at concentrations greater than 1 µg/L one time each (table 3; fig. 3), and in groundwater from three different wells. Bromacil was detected at 1.87 µg/L (table 3) in water from well Nt8 (fig. 2) in the High Plains/Casper Arch geographic area. Glyphosate was detected at 1.6 µg/L (table 3) in water from well Sh3 (fig. 2) in the Powder River Basin geographic area. Picloram was detected at 9.88 µg/L (table 3) in water from well Sh5 (fig. 2), also in the Powder River Basin geographic area.

The USEPA has established standards for physical properties and chemical constituents in drinking water that may have adverse effects on human health or that may cause cosmetic effects (for example, skin or tooth discoloration) or aesthetic effects (for example, color, taste, or odor). The Maximum Contaminant Level (MCL) is a legally enforceable and health-based standard and is the maximum permissible level for a constituent in drinking water that is delivered to a user of a public-water system (U.S. Environmental Protection Agency, 2012). A health advisory is a nonenforceable level that establishes acceptable constituent concentrations for different exposure periods (1 day, 10 days, long-term, and lifetime). A Lifetime Health Advisory Level is the concentration of a chemical that would not result in any known or anticipated adverse noncarcinogenic health effects over a lifetime of exposure (70 years) (U.S. Environmental Protection Agency, 2012). The Risk-Specific Dose is a concentration of a chemical with a specific risk level under certain exposure conditions over a lifetime (70 years) (U.S. Environmental Protection Agency, 2012). The USEPA drinking-water standards and health advisory levels serve as technical guidance to evaluate the suitability of water collected from private wells for human consumption.

Pesticide concentrations detected during the 2008–10 resampling study were evaluated by comparing the levels of these concentrations with several USEPA standards for drinking water or health advisories for finished (treated) water established under the Safe Drinking Water Act. In addition, pesticide detections were evaluated by the GPSC and compared to Wyoming groundwater-quality standards in accordance with the SMP (Wyoming Ground-water and Pesticides Strategy Committee, 1999).

All detected concentrations of pesticides during 2008–10 resampling study were lower than USEPA drinking-water standards or health advisories, where applicable (many pesticides did not have standards or advisories) (table 3). Most pesticide concentrations were at least an order of magnitude smaller

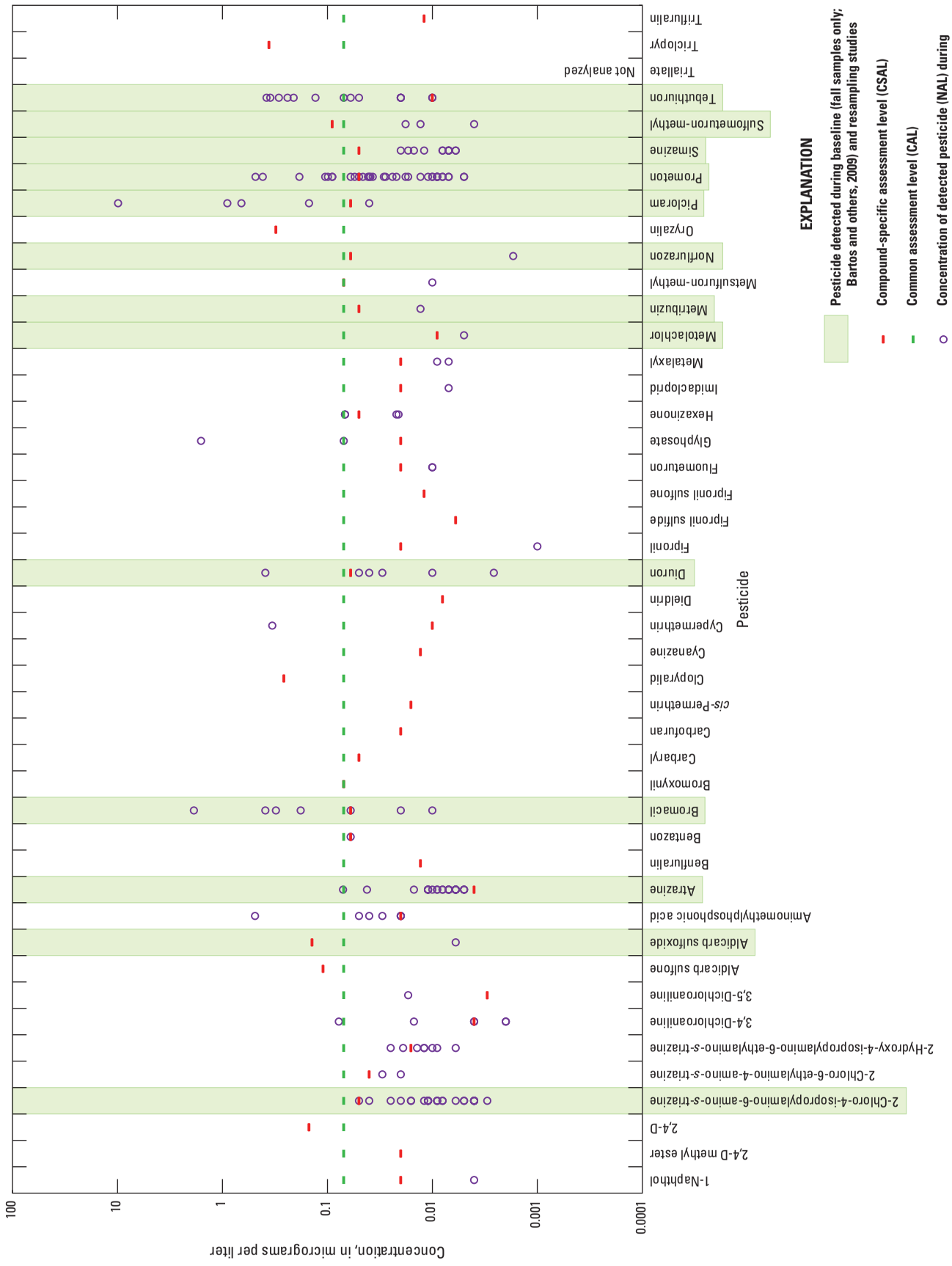

Figure 3. Pesticide detections and concentrations (using no assessment level) in groundwater samples collected from 52 wells during the 2008–10 resampling study, Wyoming.

than USEPA drinking-water standards or health advisories. The largest pesticide or degradate concentration relative to a drinking-water standard was bromacil, at a concentration slightly less than 3 percent of the Lifetime Health Advisory Level (table 3).

Pesticide Detection Frequency by Well During the 2008–10 Resampling Study

The number of pesticides detected (pesticide detection frequencies) in groundwater from each of the 52 wells sampled during the 2008–10 resampling study was examined using the NAL, CSAL, and CAL. Pesticide detection frequencies varied, as expected, based on the assessment level used. One or more pesticides were detected at concentrations greater than the CAL in water from 16 of 52 wells sampled (about 31 percent) during the resampling study (fig. 4). As many as nine pesticides per well were detected using the NAL.

Pesticide Detections by Action During the 2008–10 Resampling Study

Detected pesticides were classified into one of six actions: herbicides, herbicide degradates, insecticides, insecticide degradates, fungicides, or fungicide degradates (fig. 5, table 2). At least 95 percent of detected pesticides were classified as herbicides or herbicide degradates regardless of whether data were examined with original censoring (NAL), or with assessment levels CSAL or CAL. Pesticides classified as insecticides, insecticide degradates, fungicides, or fungicide degradates were detected much less frequently. The prevalence of pesticides classified as herbicides was expected because herbicide use is more common than insecticide use in Wyoming, and the eight most distributed pesticides in Wyoming are herbicides (Hank Uhden, Wyoming Department of Agriculture, written commun., 2010; appendix 5).

Differences in Pesticide Occurrence between 1995–2006 Baseline and 2008–10 Resampling Studies

One purpose of the 2008–10 resampling study was to determine whether the pesticides detected in groundwater differed over time, and whether the concentrations of pesticides detected during the baseline study differed. Because the 2008–10 resampling study collected its samples only during the fall, the data from the samples collected from 52 wells were compared only to fall samples collected during the 1995–2006 baseline study. Observed changes are described in terms of pesticides (or their degradates) detected, the concentrations of detected pesticides, and the detections in relation to surrounding land use and geographic area.

Differences in Pesticides Detected

The number of different pesticides detected in samples from the 52 wells was similar between 2008–10 resampling study (28 different pesticides) (fig. 3) and the 1995–2006 baseline study (30 pesticides) (table 4; fig. 6). Thirteen pesticide detections were common to both sampling periods. Fifteen pesticides were detected during the 2008–10 resampling study that had not been detected in fall samples collected during the baseline study from the 52 wells; three of these pesticides were not on the analytical schedules used during the baseline study. Sixteen pesticides were not detected during the 2008–10 resampling study that had been detected previously during the 1995–2006 baseline study. Most of the pesticides detected in only one study, but not the other, were only detected one or two times, with the exception of hexazinone that was detected three times during the resampling study.

Differences in Pesticide Detections

The change in the number of pesticides detected (without regard to which pesticide was detected) in groundwater samples between the 1995–2006 baseline study and 2008–10 resampling study from each of the 52 sampled wells is shown in figure 7. Most of the wells (32) had no changes in the number of pesticides detected in groundwater samples. Of the wells that did have a difference between the two sampling studies, 17 wells had more pesticide detections during the 1995–2006 baseline study, whereas only 3 wells had more pesticide detections during the 2008–10 resampling study.

Differences in Pesticide Concentrations

Pesticide concentration changes in groundwater samples collected from the 52 wells was determined by evaluating pesticides with at least 50 analyses during both studies, and with at least one concentration greater than the CSAL (table 5). Most pesticides (11 of the 19 evaluated) with detections had little change in concentration between the 1995–2006 baseline study and 2008–10 resampling study. Seven pesticides generally had greater concentrations in the groundwater from the same well during the 1995–2006 baseline study than during the 2008-2010 resampling study. Concentrations of atrazine, which was detected in 33 wells, and concentrations of the atrazine degradate 2-chloro-4-isopropylamino-6-amino-*s*-traizine, were greater in the 1995–2006 baseline study sample than in the 2008–10 resampling study sample about 80 percent of the time. Concentrations of prometon, detected in 17 wells, were greater in the 1995–2006 baseline study sample than in the 2008–10 resampling study sample 100 percent of the time. Only one pesticide, diuron, detected in only four wells at concentrations greater than the CSAL, generally had greater concentrations in the 2008–10 resampling study sample than in the 1995–2006 baseline study sample.

Table 3. Summary of pesticide detections and concentrations in groundwater sampled during the 2008–10 resampling study, Wyoming.

[Pesticides highlighted in yellow were analyzed for, but not detected during the 1995–2006 baseline study;[1] pesticides highlighted in orange were not analyzed for during the 1995–2006 baseline study.[1] NAL, no assessment level; CSAL, compound-specific assessment level; CAL, common assessment level; µg/L, micrograms per liter; USEPA, U.S. Environmental Protection Agency; USEPA standard or health advisory: MCL = USEPA Maximum Contaminant Level (U.S. Environmental Protection Agency, 2012), LHA = USEPA Lifetime Health Advisory Level (U.S. Environmental Protection Agency, 2012), RSD4 = USEPA Risk-Specific Dose at 10^{-4} Cancer Risk (U.S. Environmental Protection Agency, 2012); --, not applicable]

Pesticide	CSAL (µg/L)	Number of wells with detections			Number of analyses	Percent of wells with detections		
		NAL	CSAL	CAL		NAL	CSAL	CAL
1-Naphthol	0.02	1	0	0	52	1.9	0.0	0.0
2-Chloro-4-isopropylamino-6-amino-*s*-triazine	0.05	26	1	0	52	50.0	1.9	0.0
2-Chloro-6-ethylamino-4-amino-*s*-triazine	0.04	2	0	0	52	3.8	0.0	0.0
2-Hydroxy-4-isopropylamino-6-ethylamino-*s*-triazine	0.016	8	2	0	52	15.4	3.8	0.0
3,4-Dichloroaniline	0.004	6	4	1	52	11.5	7.7	1.9
3,5-Dichloroaniline	0.003	1	1	0	52	1.9	1.9	0.0
Aldicarb sulfoxide	0.11	1	0	0	52	1.9	0.0	0.0
Aminomethylphosphonic acid	0.02	7	7	1	52	13.5	13.5	1.9
Atrazine	0.004	24	24	1	52	46.2	46.2	1.9
Bentazon	0.06	1	1	0	52	1.9	1.9	0.0
Bromacil	0.06	7	5	4	52	13.5	9.6	7.7
Cypermethrin	0.01	1	1	1	52	1.9	1.9	1.9
Diuron	0.06	6	1	1	52	11.5	1.9	1.9
Fipronil	0.02	1	0	0	52	1.9	0.0	0.0
Fluometuron	0.02	2	0	0	52	3.8	0.0	0.0
Glyphosate	0.02	2	2	2	52	3.8	3.8	3.8
Hexazinone	0.05	4	2	0	52	7.7	3.8	0.0
Imidacloprid	0.02	1	0	0	52	1.9	0.0	0.0
Metalaxyl	0.02	2	0	0	52	3.8	0.0	0.0
Metolachlor	0.009	1	0	0	52	1.9	0.0	0.0
Metribuzin	0.05	1	0	0	52	1.9	0.0	0.0
Metsulfuron-methyl	0.07	1	0	0	52	1.9	0.0	0.0
Norflurazon	0.06	1	0	0	52	1.9	0.0	0.0
Picloram	0.06	5	4	4	52	9.6	7.7	7.7
Prometon	0.05	35	10	7	52	67.3	19.2	13.5
Simazine	0.05	12	0	0	52	23.1	0.0	0.0
Sulfometuron-methyl	0.09	3	0	0	52	5.8	0.0	0.0
Tebuthiuron	0.01	14	14	7	52	26.9	26.9	13.5

[1]Bartos and others (2009).

Table 3. Summary of pesticide detections and concentrations in groundwater sampled during the 2008–10 resampling study, Wyoming.—Continued

[Pesticides highlighted in yellow were analyzed for, but not detected during the 1995–2006 baseline study;[1] pesticides highlighted in orange were not analyzed for during the 1995–2006 baseline study.[1] NAL, no assessment level; CSAL, compound-specific assessment level; CAL, common assessment level; µg/L, micrograms per liter; USEPA, U.S. Environmental Protection Agency; USEPA standard or health advisory: MCL = USEPA Maximum Contaminant Level (U.S. Environmental Protection Agency, 2012), LHA = USEPA Lifetime Health Advisory Level (U.S. Environmental Protection Agency, 2012), RSD4 = USEPA Risk-Specific Dose at 10^{-4} Cancer Risk (U.S. Environmental Protection Agency, 2012); --, not applicable]

Detected concentration range (µg/L)						Median of detected concentrations (µg/L)			USEPA standard or health advisory (µg/L)
NAL		CSAL		CAL					
minimum	maximum	minimum	maximum	minimum	maximum	NAL	CSAL	CAL	
0.004	0.004	--	--	--	--	--	--	--	--
0.003	0.05	0.05	0.05	--	--	0.009	--	--	--
0.02	0.03	--	--	--	--	0.025	--	--	--
0.006	0.025	0.019	0.025	--	--	0.012	0.022	--	--
0.002	0.078	0.004	0.078	0.078	0.078	0.004	0.0095	--	--
0.017	0.017	0.017	0.017	--		--	--	--	--
0.006	0.006	--	--	--		--	--	--	4 (MCL)
0.02	0.49	0.02	0.49	0.49	0.49	0.03	0.03	--	--
0.005	0.071	0.005	0.071	0.071	0.071	0.0075	0.0075	--	3 (MCL)
0.06	0.06	0.06	0.06	--		--	--	--	200 (LHA)
0.01	1.87	0.06	1.87	0.18	1.87	0.18	0.31	0.35	70 (LHA)
0.335	0.335	0.335	0.335	0.335	0.335	--	--	--	--
0.0026	0.39	0.39	0.39	0.39	0.39	0.035	--	--	200 (RSD4)
0.001	0.001	--	--	--	--	--	--	--	--
0.01	0.01	--	--	--	--	0.01	--	--	90 (LHA)
0.07	1.6	0.07	1.6	0.07	1.6	0.835	0.835	0.835	70 (MCL)
0.021	0.68	0.068	0.068	--	--	0.045	0.068	--	400 (LHA)
0.007	0.007	--	--	--	--	--	--	--	--
0.007	0.009	--	--	--	--	0.008	--	--	--
0.005	0.005	--	--	--	--	--	--	--	700 (LHA)
0.013	0.013	--	--	--	--	--	--	--	70 (LHA)
0.01	0.01	--	--	--	--	--	--	--	--
0.0017	0.0017	--	--	--	--	--	--	--	--
0.04	9.88	0.15	9.88	0.15	9.88	0.66	0.78	0.78	500 (MCL)
0.005	0.484	0.05	0.484	0.09	0.484	0.024	0.09	0.105	100 (LHA)
0.006	0.02	--	--	--	--	0.0075	--	--	4 (MCL)
0.004	0.018	--	--	--	--	0.013	--	--	--
0.01	0.38	0.01	0.38	0.07	0.38	0.065	0.065	0.24	500 (LHA)

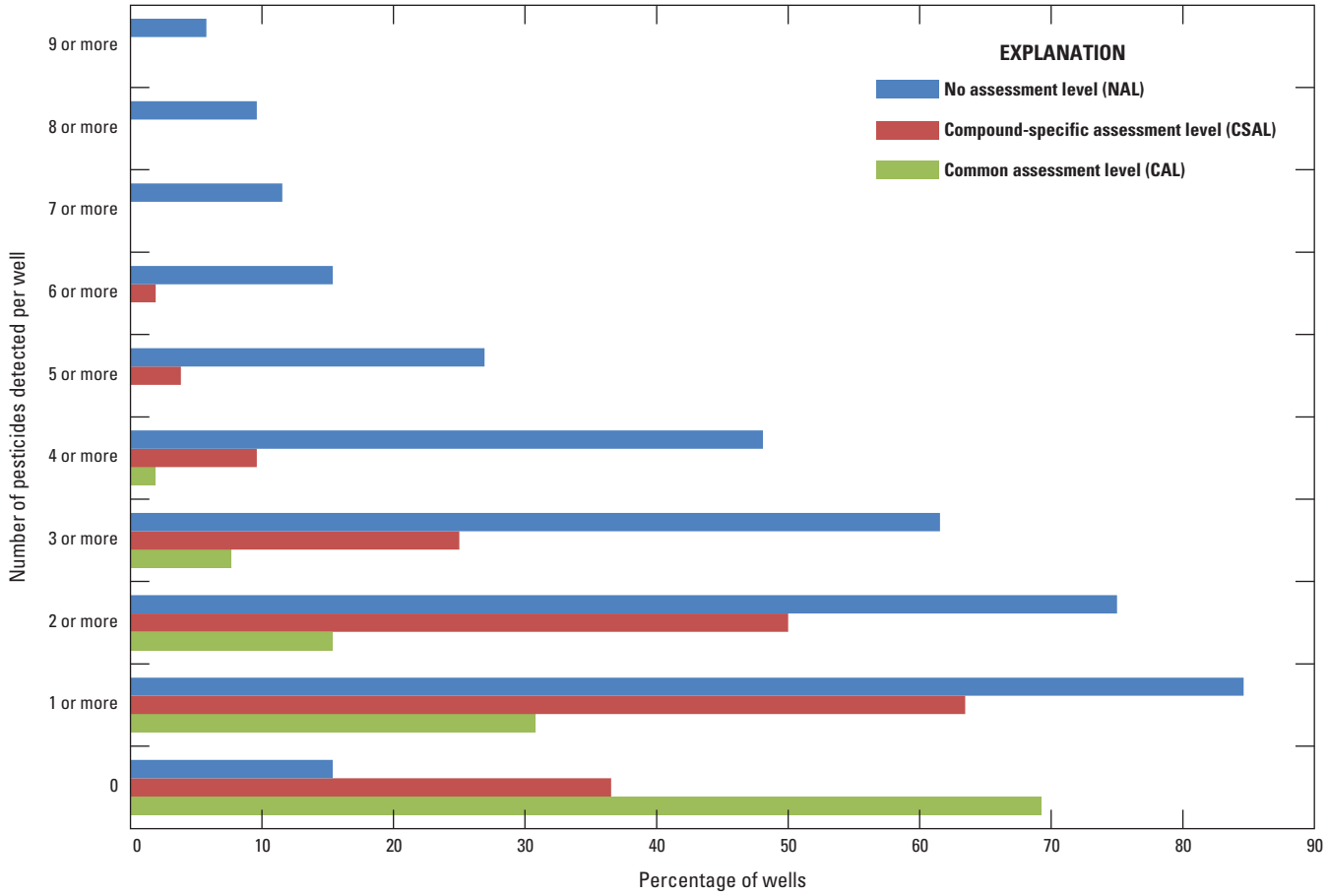

Figure 4. Number of pesticides detected in groundwater samples collected from 52 wells sampled during the 2008–10 resampling study using no assessment level, compound-specific assessment level, and common assessment level, Wyoming.

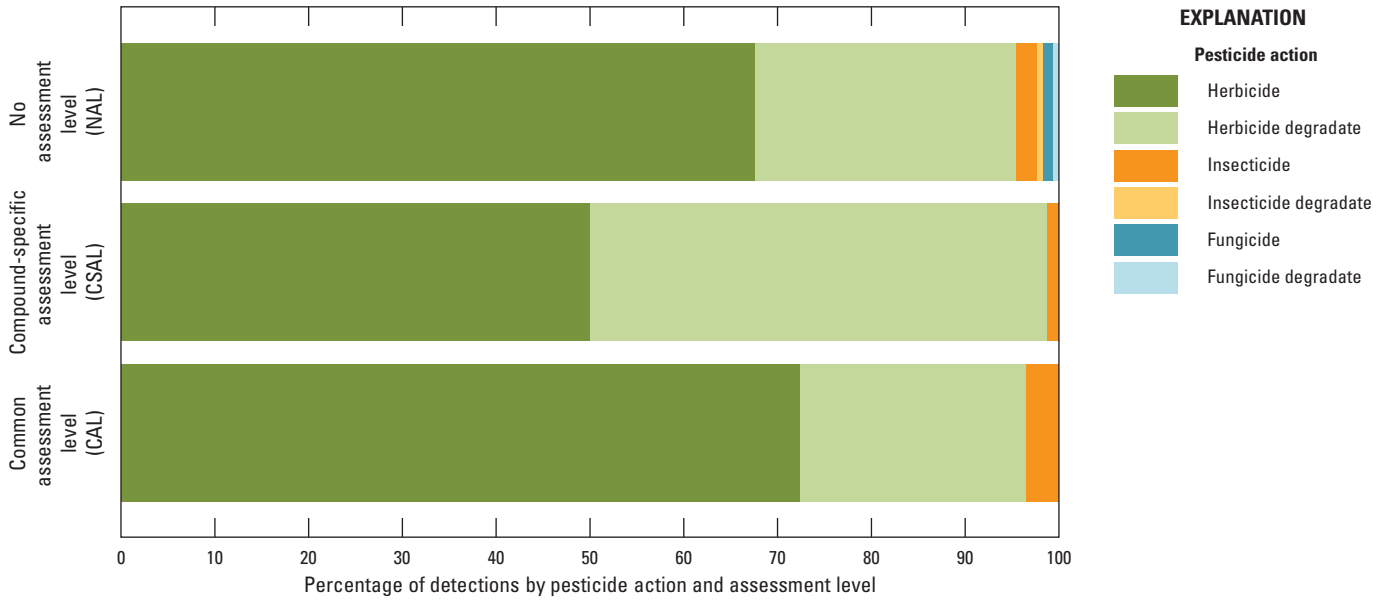

Figure 5. Pesticide detections relative to pesticide action in groundwater samples collected from 52 wells sampled during the 2008–10 resampling study, Wyoming.

Table 4. Pesticides detected in the 52 wells sampled during 1995–2006 baseline study[1] and (or) 2008–10 resampling study, Wyoming.

[CSALs and CALs shown in **bold** indicate pesticide detected at concentration equal to or greater than the assessment level in at least one well in resampling study. NAL, no assessment level; CSAL, compound-specific assessment level; CAL, common assessment level; µg/L, micrograms per liter; ND, not detected; D, detected; NA, not analyzed]

Pesticide	Number of analyses		Detection of pesticide during study (NAL)		Pesticide assessment level[1] (µg/L)	
	1995–2006	2008–10	1995–2006	2008–10	CSAL	CAL
1-Naphthol	1	52	ND	D	0.02	0.07
2,4–D methyl ester	9	52	D	ND	0.02	0.07
2,4–D	51	52	D	ND	0.15	0.07
2-Chloro-4-isopropylamino-6-amino-*s*-triazine	52	52	D	D	**0.05**	0.07
2-Chloro-6-ethylamino-4-amino-*s*-triazine	0	52	NA	D	0.04	0.07
2-Hydroxy-4-isopropylamino-6-ethylamino-*s*-triazine	8	52	ND	D	**0.016**	0.07
3,4-Dichloroaniline	1	52	ND	D	**0.004**	**0.07**
3,5-Dichloroaniline	1	52	ND	D	**0.003**	0.07
Aldicarb sulfone	52	52	D	ND	0.11	0.07
Aldicarb sulfoxide	51	52	D	D	0.14	0.07
Aminomethylphosphonic acid	0	52	NA	D	**0.02**	**0.07**
Atrazine	52	52	D	D	**0.004**	**0.07**
Benfluralin	52	52	D	ND	0.013	0.07
Bentazon	50	52	ND	D	**0.06**	0.07
Bromacil	51	52	D	D	**0.06**	**0.07**
Bromoxynil	51	52	D	ND	0.07	0.07
Carbaryl	52	52	D	ND	0.05	0.07
Carbofuran	52	52	D	ND	0.02	0.07
cis-Permethrin	52	52	D	ND	0.016	0.07
Clopyralid	51	52	D	ND	0.26	0.07
Cyanazine	52	52	D	ND	0.013	0.07
Cypermethrin	1	52	ND	D	**0.01**	**0.07**
Dieldrin	52	52	D	ND	0.008	0.07
Diuron	51	52	D	D	**0.06**	**0.07**
Fipronil	9	52	ND	D	0.02	0.07
Fipronil sulfide	9	52	D	ND	0.006	0.07
Fipronil sulfone	9	52	D	ND	0.012	0.07
Fluometuron	9	52	ND	D	0.02	0.07
Glyphosate	0	52	NA	D	**0.02**	**0.07**
Hexazinone	1	52	ND	D	**0.05**	0.07
Imidacloprid	9	52	ND	D	0.02	0.07
Metalaxyl	9	52	ND	D	0.02	0.07
Metolachlor	52	52	D	D	0.009	0.07
Metribuzin	52	52	D	D	0.05	0.07
Metsulfuron-methyl	9	52	ND	D	0.07	0.07
Norflurazon	51	52	D	D	0.06	0.07
Oryzalin	51	52	D	ND	0.31	0.07
Picloram	51	52	D	D	**0.06**	**0.07**
Prometon	52	52	D	D	**0.05**	**0.07**
Simazine	52	52	D	D	0.05	0.07
Sulfometuron-methyl	9	52	D	D	0.09	0.07
Tebuthiuron	52	52	D	D	**0.01**	**0.07**
Triallate	52	0	D	NA	0.003	0.07
Triclopyr	51	52	D	ND	0.36	0.07
Trifluralin	52	52	D	ND	0.012	0.07

[1]Bartos and others (2009), fall samples only.

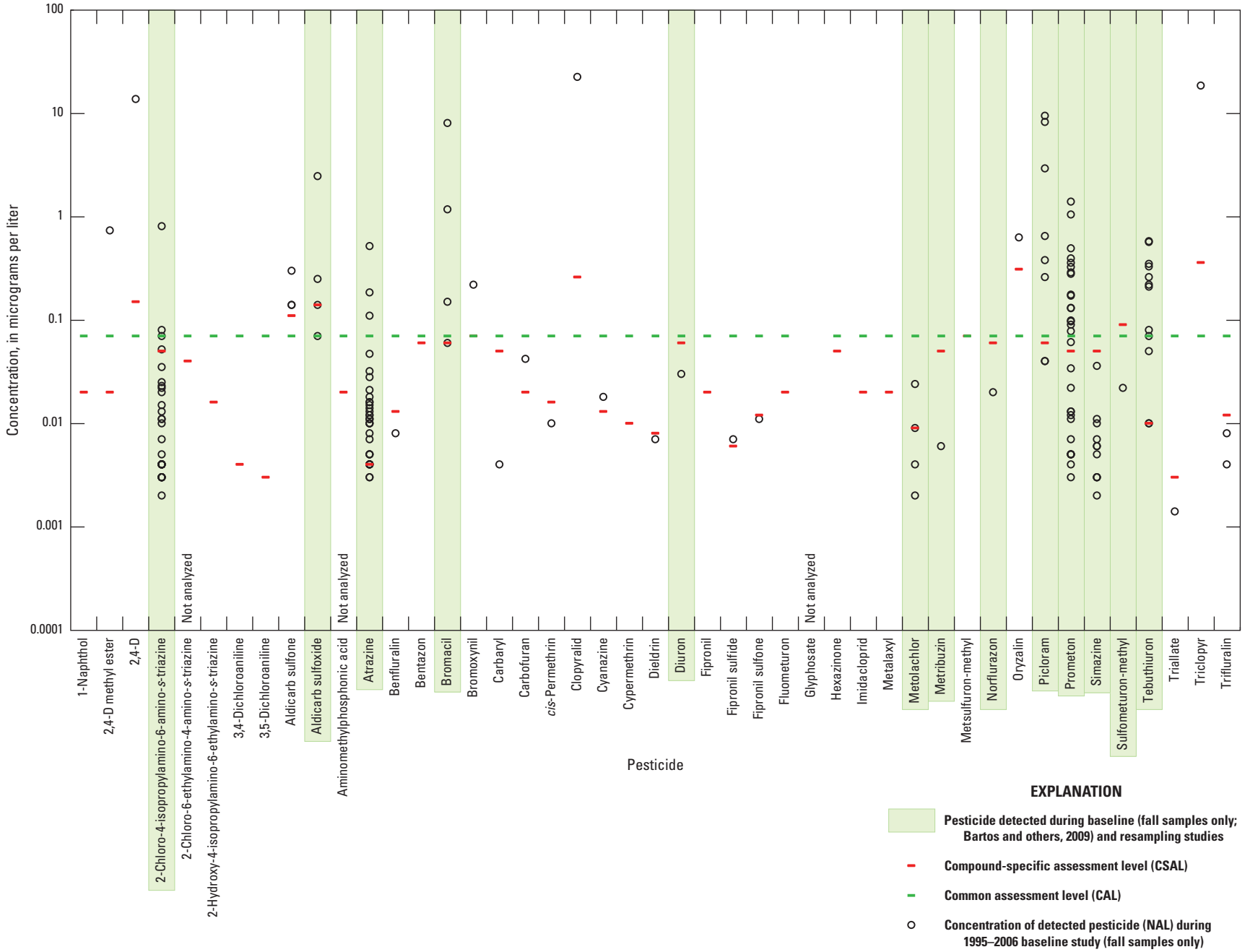

Figure 6. Pesticide detections and concentrations (using no assessment level) in groundwater samples collected from 52 wells during the 1995–2006 baseline study (fall samples only; Bartos and others, 2009).

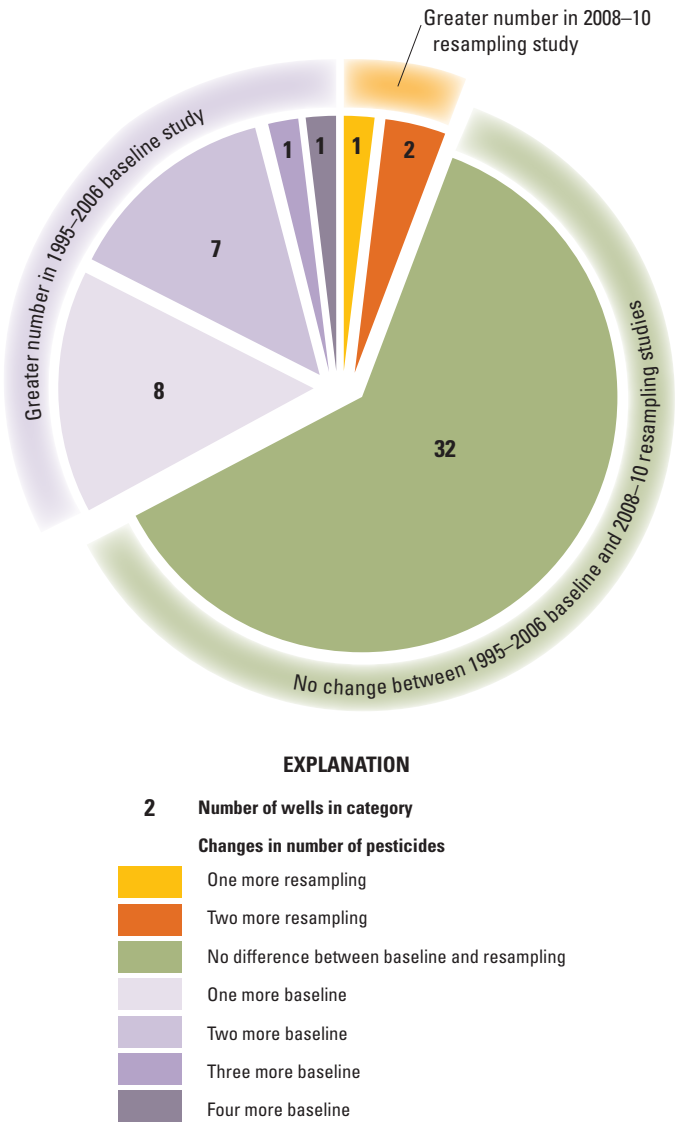

Figure 7. Difference in number of pesticides detected in the same well between the 1995–2006 baseline (fall samples only; Bartos and others, 2009) and 2008–10 resampling studies. Pesticide detection is based on the common assessment level.

Differences in Pesticide Detections and Detection Frequency Relative to Land Use and Geographic Area

The change in the number of pesticides detected and the detection frequency relative to land use and geographic area between the baseline and resampling studies was determined. Concentrations of pesticides detected during the baseline and resampling studies by assessment levels, including land use, are shown in figure 8.

The overall frequency of pesticide detections in groundwater from the 52 wells was examined by calculating the percentage of wells with at least one pesticide detected at concentrations greater than the CAL with respect to land use near the well and geographic area (fig. 9). The detection frequency of at least one pesticide in groundwater from a well decreased or remained unchanged, regardless of land use or geographic area, between the 1995–2006 baseline and 2008–10 resampling studies. The detection frequency within the agricultural land-use category had the largest change from the 1995–2006 baseline study to the 2008–10 resampling study, changing from 38 percent detection frequency to zero. The detection frequency within the Bighorn Basin geographic area had the largest change from the 1995–2006 baseline study to the 2008–10 resampling study, changing from 56 percent to 17 percent.

The change in the number of pesticides detected (without regard to which pesticide was detected) between the 1995–2006 baseline study and the 2008–10 resampling study in groundwater samples from each of the 52 wells with respect to land use and geographic area was calculated and is shown in figure 10. Results shown in figure 10 are a refinement of figure 7, and indicate as expected, that most wells had no change in the number of pesticides detected, regardless of land use or geographic area. This refinement shows that all wells with nearby land use classified as agricultural had the same or a smaller number of pesticides in the 2008–10 resampling study compared to the 1995–2006 baseline study. Figure 10 also shows that all wells in the Bighorn Basin geographic area had the same or a smaller number of pesticides detected in the 2008–10 resampling study compared to the 1995–2006 baseline study.

USGS hydrologist measuring the water level in a well in the Bighorn Basin geographic area. Photograph by Seth L. Davidson, September 2009.

Table 5. Differences in pesticide detections between the 1995–2006 baseline study[1] and the 2008–10 resampling study, Wyoming. Differences were calculated on a well by well basis for pesticides with at least 50 analyses during both sampling studies and with at least one concentration greater than the compound-specific assessment level (CSAL).

[Pesticides highlighted in green indicate minimal change between baseline study and resampling study (one well or fewer with a concentration difference); pesticides highlighted in purple indicate generally greater concentrations detected in baseline study than in resampling study from same well; pesticides highlighted in tan indicate generally greater concentrations detected in resampling study than in baseline study from same well]

Pesticide	Number of analyses		Pesticide not detected above CSAL in either sample	Concentration greater than CSAL in at least one sample					
				Concentrations greater in baseline study		Concentrations equal in baseline and resampling studies		Concentrations greater in resampling study	
	1995–2006 baseline study[2]	2008–10 resampling study		Number of wells	Percentage	Number of wells	Percentage	Number of wells	Percentage
2,4-D	51	52	50	1	100	0	0	0	0
2-Chloro-4-isopropylamino-6-amino-*s*-triazine	52	52	47	4	80	0	0	1	20
Aldicarb sulfone	51	52	48	3	100	0	0	0	0
Aldicarb sulfoxide	51	52	47	4	100	0	0	0	0
Atrazine	52	52	19	25	76	1	3	7	21
Bentazon	50	52	49	0	0	0	0	1	100
Bromacil	51	52	44	4	57	0	0	3	43
Bromoxynil	51	52	50	1	100	0	0	0	0
Carbaryl	52	52	51	1	100	0	0	0	0
Carbofuran	52	52	51	1	100	0	0	0	0
Clopyralid	51	52	50	1	100	0	0	0	0
Cyanazine	52	52	51	1	100	0	0	0	0
Diuron	51	52	47	1	25	0	0	3	75
Metolachlor	52	52	50	2	100	0	0	0	0
Oryzalin	51	52	50	1	100	0	0	0	0
Picloram	51	52	44	4	57	0	0	3	43
Prometon	52	52	35	17	100	0	0	0	0
Tebuthiuron	52	52	36	9	56	1	6	6	38
Triclopyr	51	52	50	1	100	0	0	0	0

[1]Bartos and others (2009), fall samples only.

[2]Number of samples used for comparison.

Well with primarily urban land use nearby, in the High Plains/Casper Arch geographic area. Photograph by Cheryl A. Eddy-Miller, September 2008.

Sugar beet field in the Bighorn Basin geographic area. The pesticide detection frequency within the Bighorn Basin geographic area had the largest change from the 1995–2006 baseline study to the 2008–10 resampling study, changing from 56 percent to 17 percent. Photograph by Cheryl A. Eddy-Miller, September 2009.

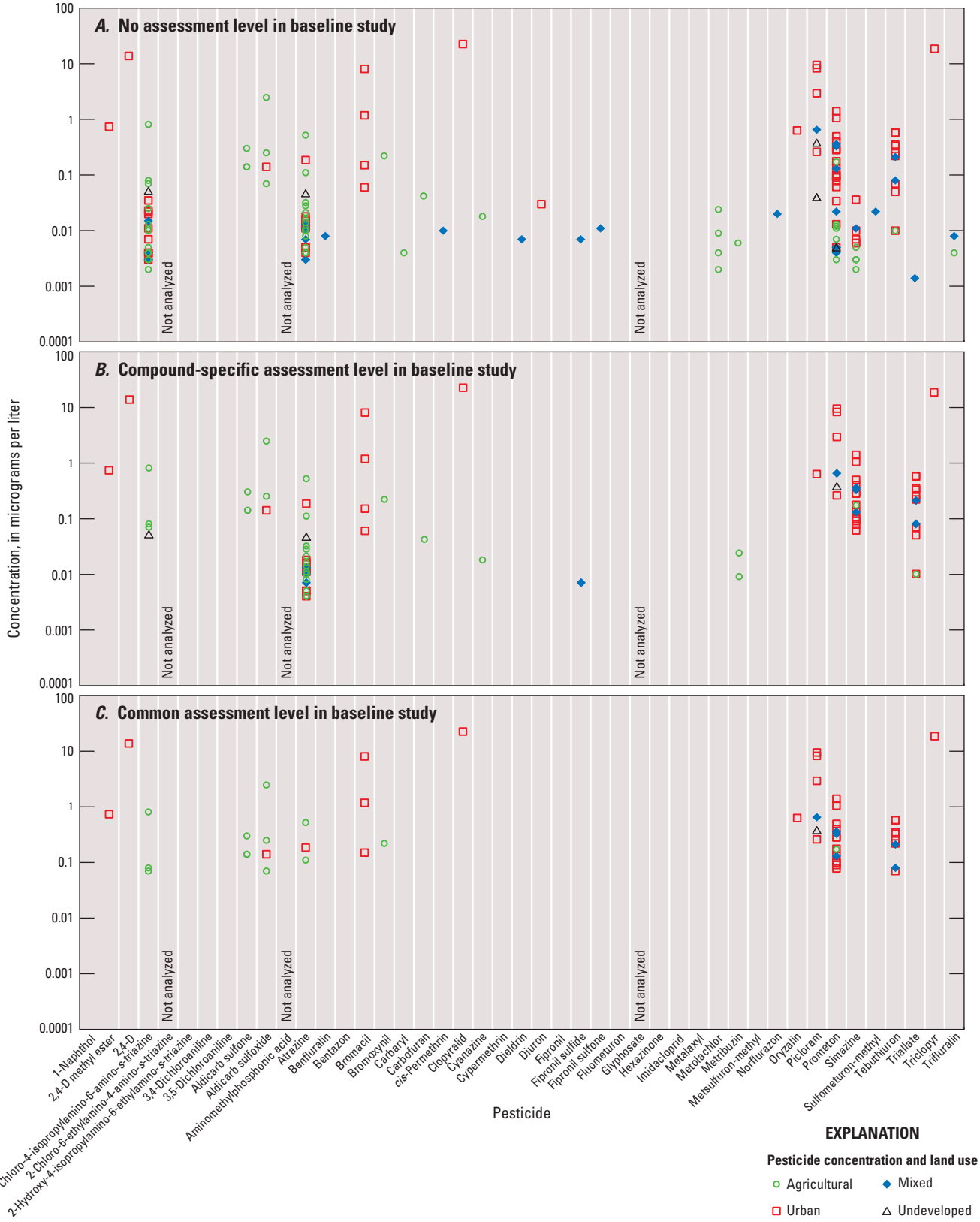

Figure 8. Pesticide detections and concentrations in groundwater samples collected from 52 wells during 1995–2006 baseline study (fall samples only; Bartos and others, 2009) and 2008–10 resampling study, Wyoming.

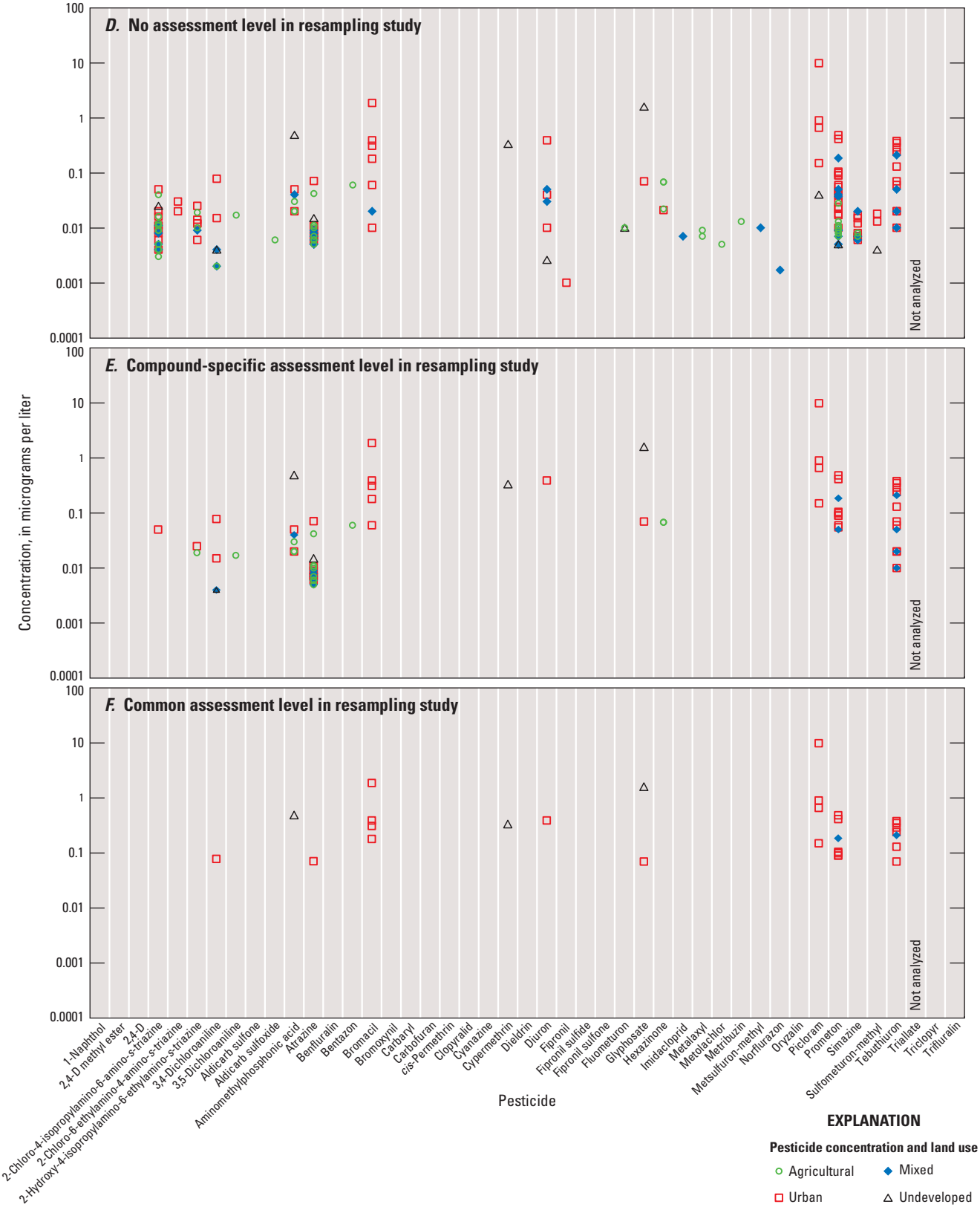

Figure 8. Pesticide detections and concentrations in groundwater samples collected from 52 wells during 1995–2006 baseline study (fall samples only; Bartos and others, 2009) and 2008–10 resampling study, Wyoming.—Continued

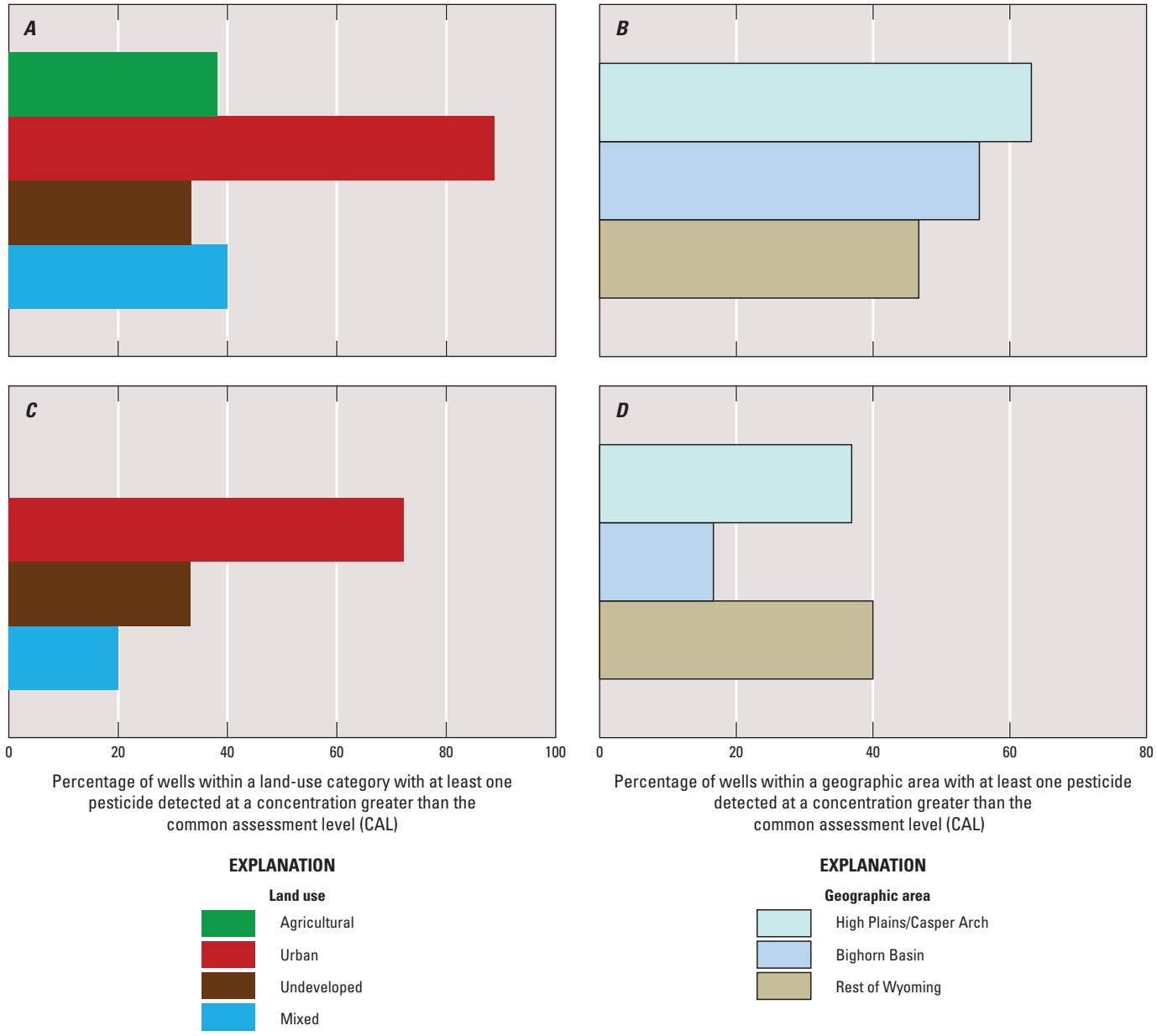

Figure 9. Percentage of wells with at least one pesticide detected in groundwater samples collected from 52 wells relative to land use and geographic area during the 1995–2006 baseline study (fall samples only; Bartos and others, 2009) and the 2008–10 resampling study, Wyoming. *A*, Detections relative to land use, 1995–2006 baseline study. *B*, Detections relative to geographic area, 1995–2006 baseline study. *C*, Detections relative to land use, 2008–10 resampling study. *D*, Detections relative to geographic area, 2008–10 resampling study.

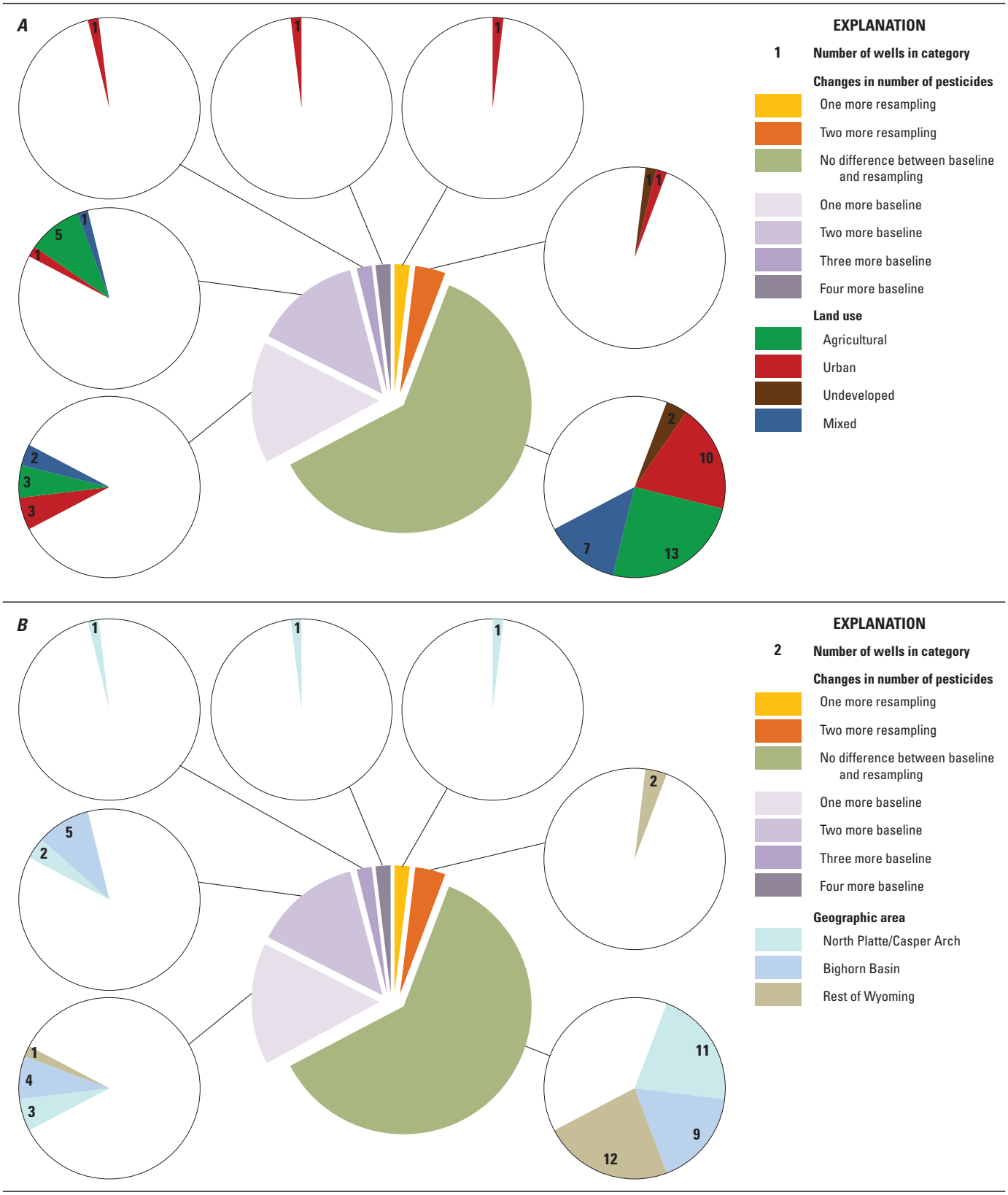

Figure 10. Difference in number of pesticides detected in the same well between 1995–2006 baseline (fall samples only; Bartos and others, 2009) and 2008–10 resampling studies. *A*, Land use near wells. *B*, Geographic area of well in each category. Pesticide detection is based on the common assessment level (CAL).

Summary

The Ground-water and Pesticide Strategy Committee (GPSC) consisting of members of local, State, and Federal government, as well as industry and interest groups, prepared the State of Wyoming Generic Management Plan for Pesticides in Ground Water. A key component of this plan was to conduct baseline groundwater sampling to characterize pesticide occurrence in Wyoming's groundwater.

The U.S. Geological Survey (USGS), in cooperation with the Wyoming Department of Agriculture (WDA), acting on behalf of the GPSC, later with assistance from the Wyoming Department of Environmental Quality (WDEQ), began statewide implementation of this baseline groundwater sampling in 1995. During 1995–2006, samples were collected from 296 wells in Wyoming. Results of this study were previously summarized to describe the occurrence of pesticides in the State of Wyoming, and were statistically evaluated to determine occurrence of pesticides in relation to selected natural and anthropogenic characteristics. During 2008–10, the USGS, in cooperation with the WDA, resampled a subset of 52 wells that were sampled during the 1995–2006 baseline study in order to compare detected compounds and respective concentrations between the two sampling periods, and to evaluate the occurrence of new pesticides. The 52 wells were distributed similarly to sites used in the 1995–2006 baseline study with respect to geographic area and land use within the geographic area of interest. In order to help evaluate changes in pesticide occurrence, wells with previous detections of pesticides were given priority for resampling.

Because of the use of different types of "reporting levels" and variability in reporting-level values during the 1995–2006 baseline study and the 2008–10 resampling study, analytical results received from the laboratory were recensored. The recensoring techniques and values used for the resampling study were the same as used during the baseline study. In addition to using no assessment level, two levels of recensoring were used to compare pesticides—a compound-specific assessment level (CSAL) that differed by compound and a common assessment level (CAL) of 0.07 microgram per liter.

Twenty eight different pesticides were detected using no assessment level in samples from the 52 wells during the 2008–10 resampling study. Concentrations of detected pesticides generally were small (less than 1 microgram per liter), although three pesticides—bromacil, glyphosate, and picloram—were measured at concentrations greater than 1 microgram per liter one time each in groundwater from three different wells.

Pesticide concentrations were compared with several U.S. Environmental Protection Agency (USEPA) drinking-water standards or health advisories for finished (treated) water established under the Safe Drinking Water Act. All detected pesticide concentrations were smaller than USEPA drinking-water standards or health advisories where applicable (many pesticides did not have standards or advisories). Most pesticide concentrations were at least an order of magnitude smaller than USEPA standards or health advisories.

The overall detection frequency of pesticides in groundwater from the 52 wells was examined by calculating the percentage of wells with at least one pesticide detected at concentrations greater than the CAL. One or more pesticides were detected at concentrations greater than the CAL in water from 16 of 52 wells sampled (about 31 percent) during the resampling study.

Detected pesticides were classified into one of six actions: herbicides, herbicide degradates, insecticides, insecticide degradate, fungicides, or fungicide degradates. At least 95 percent of detected pesticides were classified as herbicides or herbicide degradates.

The purpose of the 2008–10 resampling study was to determine if the specific pesticides detected in groundwater changed over time, and if the concentrations of previously detected pesticides changed as well. The data from the 52 wells sampled during the 2008–10 resampling study were compared to fall samples collected during the 1995–2006 baseline study.

The number of different pesticides detected in samples from the 52 wells was similar between the baseline study (30 different pesticides) and the resampling study (28 different pesticides). Thirteen pesticides were common to both sampling periods. During the baseline study, 16 additional pesticides were detected that were not detected during the resampling study. Fifteen pesticides were detected during the resampling study that had not been detected in the fall samples from the 52 wells sampled in the baseline study; however, three of these pesticides were not on the analytical schedules used during the baseline study. Most pesticides detected in one of the studies, but not the other, were only detected in one or two samples.

The change in the number of pesticides detected (without regard to which pesticide was detected) in groundwater samples from each of the 52 wells was calculated, and most of the wells (32) had no changes in the number of pesticides detected. Of those wells that did have a difference between the two studies, 17 wells had more pesticide detections in groundwater during the baseline study, whereas only 3 wells had more detections during the resampling study.

The change in concentration over time in groundwater samples from the 52 wells was determined by evaluating pesticides with at least 50 analyses during both sampling studies, and with at least one concentration greater than the CSAL. Most pesticides with detections had little change in concentration between the baseline study and resampling study. Seven pesticides had a greater concentration detected in groundwater from the same well during the baseline study than during the resampling study. Concentrations of atrazine,

which was detected in 33 wells, and the atrazine degradate 2-chloro-4-isopropylamino-6-amino-*s*-triazine were greater in the baseline study sample than in the resampling study sample about 80 percent of the time. Concentrations of prometon, detected in 17 wells, were greater in the baseline study sample than in the resampling study sample 100 percent of the time.

The overall detection frequency of pesticides in groundwater from the 52 wells was examined by calculating the percentage of wells with at least one pesticide detected at concentrations greater than the CAL with respect to land use near the well and geographic area. The detection frequency of at least one pesticide in groundwater from a well decreased or remained unchanged, regardless of land use or geographic area, between the 1995–2006 baseline and 2008–10 resampling study. The detection frequency within the agricultural land-use category had the largest change between the 1995–2006 baseline and 2008–10 resampling studies, decreasing from 38 percent to zero. The detection frequency within the Bighorn Basin geographic area had the largest change between the 1995–2006 baseline and 2008–10 resampling studies, decreasing from 56 percent to 17 percent.

The change in the number of pesticides detected (without regard to which pesticide was detected) between the 1995–2006 baseline study and the 2008–10 resampling study in groundwater samples from each of the 52 wells with respect to land use and geographic area was calculated. All wells with land use classified as agricultural had the same or a smaller number of pesticides detected in the resampling study compared to the baseline study. All wells in the Bighorn Basin geographic area also had the same or a smaller number of pesticides detected in the resampling study compared to the baseline study.

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Appendixes

Appendix 1. Blank data for sample collected at site 410817104470201, November 2009.

[µg/L, micrograms per liter; <, less than]

Pesticide	Concentration (µg/L)
Acrylonitrile	<0.80
Bromacil	<0.36
Bromomethane	<0.2
Carbaryl	<0.38
Carbazole	<0.030
Carbon disulfide	<0.04
Chlorpyrifos	<0.16
cis-1,3-Dichloropropene	<0.10
DEET	<0.06
Diazinon	<0.16
Iodomethane	<0.26
Metalaxyl	<0.12
Metolachlor	<0.080
Prometon	<0.12
trans-1,3-Dichloropropene	<0.14

Appendix 2. Replicate sample data for detected pesticides from samples collected at sites 4108108104223501 (September 2009) and 444603108383401 (September 2010). All other pesticides analyzed for had no detection in either the environmental or replicate sample.

[RPD, relative percent difference; µg/L, micrograms per liter; E, estimated value; <, less than; NC, not calculated]

Pesticide	Samples for site 410108104223501 (Lr4)			Samples for site 444603108383401 (Pk1)		
	Environmental (µg/L)	Replicate (µg/L)	RPD percent	Environmental (µg/L)	Replicate (µg/L)	RPD percent
2-Chloro-4-isopropylamino-6-amino-*s*-triazine	E0.025	E0.022	13	<0.014	<0.014	NC
3,4-Dichloroaniline	E0.004	E0.0035	13	<0.004	<0.004	NC
Atrazine	0.015	0.014	7	<0.007	<0.007	NC
Diuron	E0.0026	<0.04	NC	<0.04	<0.04	NC
Fluometuron	E0.01	<0.04	NC	E0.01	E0.01	0
Picloram	E0.04	E0.04	0	<0.12	<0.12	NC
Sulfometuron-methyl	E0.004	E0.003	29	<0.060	<0.060	NC

Appendix 3. Spike recovery data from sample collected from site 41101910405130 (Lr7), September 2008.

Pesticide	Spike recovery percent
1-Naphthol	35
2,4-D	58
2,4-DB	44
2,6-Diethylaniline	94
2-Chloro-2',6'-diethylacetanilide	110
2-Chloro-4-isopropylamino-6-amino-*s*-triazine	61
2-Chloro-6-ethylamino-4-amino-*s*-triazine	99
2-Ethyl-6-methylaniline	94
2-Hydroxy-4-isopropylamino-6-ethylamino-*s*-triazine	88
3,4-Dichloroaniline	78
3,5-Dichloroaniline	84
3-Hydroxy carbofuran	105
4-Chloro-2-methylphenol	60
Acetochlor	119
Acifluorfen	38
Alachlor	118
Aldicarb sulfone	99
Aldicarb sulfoxide	123
alpha-Endosulfan	82
Atrazine	109
Azinphos-methyl	81
Azinphos-methyl oxygen analog	28
Bendiocarb	34
Benfluralin	83
Benomyl	158
Bensulfuron-methyl	143
Bentazon	41
Bromacil	92
Bromoxynil	20
Carbaryl	78
Carbaryl	109
Carbofuran	106
Carbofuran	116
Chloramben methyl ester	82
Chlorimuron-ethyl	179
Chlorpyrifos	93
cis-Permethrin	62
cis-Propiconazole	119
Clopyralid	51
Cyanazine	100
Cycloate	54
Cyfluthrin	64
Cypermethrin	61
DCPA	115
DCPA monoacid	51
Desulfinylfipronil	122
Desulfinylfipronil amide	110
Diazinon	107
Dicamba	51
Dichlorprop	68
Dichlorvos	8
Dicrotophos	40
Dieldrin	104
Dimethoate	43
Dinoseb	24
Diphenamid	116
Disulfoton	66
Disulfoton sulfone	94
Diuron	105
Endosulfan sulfate	88
EPTC	90
Ethion	90
Ethion monoxon	89
Ethoprop	103
Fenamiphos	111
Fenamiphos sulfone	102
Fenamiphos sulfoxide	16
Fenuron	116
Fipronil	128
Fipronil sulfide	119
Fipronil sulfone	88
Flumetsulam	143
Fluometuron	99
Fonofos	98
Hexazinone	70
Imazaquin	204
Imazethapyr	187
Imidacloprid	106
Iprodione	51
Isofenphos	107
lambda-Cyhalothrin	28
Linuron	85
Malaoxon	59
Malathion	94

Appendix 3. Spike recovery data from sample collected from site 41101910405130 (Lr7), September 2008.—Continued

Pesticide	Spike recovery percent
MCPA	61
MCPB	41
Metalaxyl	99
Metalaxyl	129
Methidathion	100
Methiocarb	68
Methomyl	108
Methyl paraoxon	53
Methyl parathion	101
Metolachlor	113
Metribuzin	108
Metsulfuron-methyl	61
Molinate	98
Myclobutanil	97
N-(4-Chlorophenyl)-*N*'-methylurea	119
Neburon	92
Nicosulfuron	337
Norflurazon	112
Oryzalin	78
Oxamyl	68
Oxyfluorfen	76
Pendimethalin	101
Phorate	76
Phorate oxygen analog	113
Picloram	61
Prometon	104
Prometryn	119
Propanil	111
Propargite	59
Propham	74
Propiconazole	85
Propoxur	109
Propyzamide	115
Siduron	136
Simazine	99
Sulfometuron-methyl	158
Tebuthiuron	119
Tefluthrin	57
Terbacil	96
Terbufos	88
Terbufos oxygen analog sulfone	65
Terbuthylazine	114
Thiobencarb	106
trans-Propiconazole	114
Tribuphos	62
Triclopyr	58
Trifluralin	94

Appendix 4. Name, number, and ancillary information for 52 wells sampled during 1995–2006 baseline study[1] and 2008–10 resampling study, Wyoming.

Site name (shown on fig. 2)	Site number	County	Geographic area	Land use	Well depth (feet)	Years fall sample was collected
A7	411842105362901	Albany	Central Basins	Urban	12	2003, 2010
B1	444914108214101	Big Horn	Bighorn Basin	Agricultural	22	1999, 2009
B5	442912108240601	Big Horn	Bighorn Basin	Agricultural	27	1999, 2009
B6	442650108251501	Big Horn	Bighorn Basin	Mixed	23	1999, 2009
B12	445324108310601	Big Horn	Bighorn Basin	Agricultural	7	1999, 2009
B17	445014108224301	Big Horn	Bighorn Basin	Mixed	22	1999, 2009
Cb1	411303106464201	Carbon	Central Basins	Mixed	13	2004, 2010
Cp6	442055105315801	Campbell	Powder River Basin	Urban	20	2004, 2010
Cv4	425154105513101	Converse	High Plains/Casper Arch	Urban	20	2003, 2008
Cv7	424536105231801	Converse	High Plains/Casper Arch	Urban	20	2003, 2008
F3	425242108465301	Fremont	Wind River Basin	Agricultural	40	1998, 2010
F12	431202108254401	Fremont	Wind River Basin	Agricultural	50	1998, 2010
F19	430119108225701	Fremont	Wind River Basin	Urban	60	1998, 2010
G4	420029104170601	Goshen	High Plains/Casper Arch	Agricultural	142	1995, 2008
G7	420836104223501	Goshen	High Plains/Casper Arch	Agricultural	42	1995, 2008
G21	420531104100201	Goshen	High Plains/Casper Arch	Agricultural	23	1995, 2008
G24	421219104310401	Goshen	High Plains/Casper Arch	Agricultural	25	1995, 2008
G25	420241104105301	Goshen	High Plains/Casper Arch	Mixed	36	1995, 2008
H9	434358108102901	Hot Springs	Bighorn Basin	Mixed	45	2003, 2009
H11	433843108122001	Hot Springs	Bighorn Basin	Urban	20	2003, 2009
J14	434143106250901	Johnson	Powder River Basin	Mixed	27	2000, 2010
Lr2	410327104232301	Laramie	High Plains/Casper Arch	Agricultural	100	1998, 2008
Lr4	410108104223501	Laramie	High Plains/Casper Arch	Undeveloped	80	1998, 2008
Lr7	411019104051301	Laramie	High Plains/Casper Arch	Mixed	243	1998, 2008
Lr11	410834104491601	Laramie	High Plains/Casper Arch	Urban	20	1998, 2008
Lr12	410906104515101	Laramie	High Plains/Casper Arch	Urban	20	1998, 2008
Nb7	424526104271101	Niobrara	High Plains/Casper Arch	Urban	17.5	2005, 2008
Nt2	425137106180401	Natrona	High Plains/Casper Arch	Urban	15	2001, 2008
Nt3	425101106185701	Natrona	High Plains/Casper Arch	Urban	14	2001, 2008
Nt8	425400106272101	Natrona	High Plains/Casper Arch	Urban	24	2001, 2008
Pk1	444603108383401	Park	Bighorn Basin	Agricultural	35	1997, 2009
Pk5	444147108472802	Park	Bighorn Basin	Agricultural	40	1997, 2009
Pk7	444453108452301	Park	Bighorn Basin	Urban	18	1997, 2009
Pk10	444212108390801	Park	Bighorn Basin	Agricultural	94	1997, 2009
Pk14	443254109000601	Park	Bighorn Basin	Mixed	80	1997, 2009
Pk19	444514108545401	Park	Bighorn Basin	Agricultural	90	1997, 2009
Pk25	444633108450401	Park	Bighorn Basin	Agricultural	20	1997, 2009
Pt4	415733105030901	Platte	High Plains/Casper Arch	Agricultural	68	2000, 2008
Pt5	420151105011401	Platte	High Plains/Casper Arch	Agricultural	100	2000, 2008
Pt12	421532104441001	Platte	High Plains/Casper Arch	Urban	25	2000, 2008

Appendix 4. Name, number, and ancillary information for 52 wells sampled during 1995–2006 baseline study[1] and 2008–10 resampling study, Wyoming.—Continued

Site name (shown on fig. 2)	Site number	County	Geographic area	Land use	Well depth (feet)	Years fall sample was collected
Sb3	425633110142401	Sublette	Green River Basin	Mixed	90	2004, 2010
Sh3	444338106161001	Sheridan	Powder River Basin	Undeveloped	30	1999, 2010
Sh5	444645106574001	Sheridan	Powder River Basin	Urban	24	1999, 2010
Sh15	445014106490701	Sheridan	Powder River Basin	Agricultural	50	1999, 2010
Sw3	413454109133501	Sweetwater	Green River Basin	Urban	19	2001, 2010
Sw9	420635109270101	Sweetwater	Green River Basin	Undeveloped	80	2001, 2010
U2	411643110583401	Uinta	Overthrust Belt	Mixed	35	2002, 2010
U10	411937110172801	Uinta	Green River Basin	Urban	13	2002, 2010
Wk3	440031107573701	Washakie	Bighorn Basin	Urban	30	1997, 2009
Wk7	440232107561201	Washakie	Bighorn Basin	Agricultural	125	1997, 2009
Wk10	435402108052101	Washakie	Bighorn Basin	Agricultural	27	1997, 2009
Wk13	435819107580601	Washakie	Bighorn Basin	Agricultural	30	1997, 2009

[1]Bartos and others (2009).

Appendix 5. Summary of pesticides distributed within Wyoming, 2007.[1]

[NAL, no assessment level; H, Herbicide; F, Fungicide; I, Insecticide; R, Rodenticide; L, Larvicide; S, Soil fumigant; ST, Seed treatment; CP, Crop protectant; GR, Growth regulator; B, Bactericide, Algaecide; MCPA, (4-chloro-2-methylphenoxy)acetic acid; EPTC, S-ethyl dipropylthiocarbamate; DCPA, dimethyl tetrachloroterephthalate; MSMA, monosodium methyl arsenate; PCNB, pentachloronitrobenzene; --, not on analytical schedule]

Pesticide	Pesticide action	Distribution rank[2]	Number of detections (NAL)	
			1995–2006 baseline study (598 samples)[3]	2008–10 resampling study (52 samples)
Dicamba	H	1	1	0
2,4–D amine	H	2	3	--
Glyphosate	H	3	--	2
Diuron	H	4	17	6
Mecoprop-p	H	5	--	--
2,4–D methyl ester	H	6	1	0
Clopyralid	H	7	9	0
Triclopyr	H	8	2	0
Copper compounds	F	9	--	--
Piperonyl butoxide	I	10	--	--
Permethrin	I	11	1	--
Malathion	I	12	2	0
MCPA	H	12	0	0
Fluroxypyr	H	14	--	--
Bromacil	H	15	21	6
Metsulfuron-methyl	H	15	1	1
Imazapyr	H	17	--	--
Chlorpyrifos	I	18	0	0
Bacillus thuringiensis	I	19	--	--
Carbaryl	I	19	2	0
Pendimethalin	H	19	0	0
Prometon	H	22	177	35
Diflufenzopyr	H	23	--	--
Bromoxynil	H	24	1	0
Mancozeb	F	24	--	--
Bentazon	H	26	4	1
Chlorsulfuron	H	27	--	--
Diquat dibromide	H	27	--	--
2,4–D	H	29	3	0
B-Cyfluthrin	I	29	0	--
Tebuthiuron	H	29	67	14
Chlorophacinone	R	32	--	--
Hexazinone	H	32	1	4
EPTC	H	34	0	0
Metolachlor	H	34	16	1
Clethodim	H	36	--	--
Metribuzin	H	36	3	1
Simazine	H	36	48	12
Sodium chlorate	H	36	--	--
Sodium metaborate	H	36	--	--

Appendix 5. Summary of pesticides distributed within Wyoming, 2007.[1]—Continued

[NAL, no assessment level; H, Herbicide; F, Fungicide; I, Insecticide; R, Rodenticide; L, Larvicide; S, Soil fumigant; ST, Seed treatment; CP, Crop protectant; GR, Growth regulator; B, Bactericide, Algaecide; MCPA, (4-chloro-2-methylphenoxy)acetic acid; EPTC, S-ethyl dipropylthiocarbamate; DCPA, dimethyl tetrachloroterephthalate; MSMA, monosodium methyl arsenate; PCNB, pentachloronitrobenzene; --, not on analytical schedule]

Pesticide	Pesticide action	Distribution rank[2]	Number of detections (NAL)	
			1995–2006 baseline study (598 samples)[3]	2008–10 resampling study (52 samples)
Imidacloprid	I	41	2	1
Picloram	H	41	43	5
Atrazine	H	43	190	24
Bromadiolone	R	43	--	--
Desmedipham	H	43	--	--
Ethofumesate	H	43	--	--
Flumioxazin	H	43	--	--
S-Methoprene	I	43	--	--
Dichlobenil	H	49	0	0
Terbufos	I	49	0	0
Acetochlor	H	51	0	0
Sulfometuron-methyl	H	51	3	3
Dimethoate	I	53	0	0
Paraquat dichloride	H	53	--	--
2,4–DB	H	56	0	0
Bifenthrin	I	56	--	--
Carfentrazone-ethyl	H	56	--	--
Dimethenamid-P	H	56	--	--
Aldicarb	I	60	0	--
Dithiopyr	H	60	--	--
Mineral oil	I, F	60	--	--
Prodiamine	H	60	--	--
Pyrethrins	I	60	--	--
Trifluralin	H	60	2	0
Benefin	H	66	--	--
Hydramethylnon	I	66	--	--
Tefluthrin	I	66	0	0
Triallate	H	66	2	--
Trichlorfon	I	66	--	--
Chlorothalonil	F	71	0	0
Cypermethrin	I	71	0	1
Imazamox	H	71	--	--
Imazapic	H	71	--	--
Metalaxyl	F	71	0	2
Thifensulfuron	H	71	--	--
Tribenuron	H	71	0	0
Bacillus sphaericus	L	78	--	--
Dinotefuran	I	78	--	--
d-Phenothrin	I	80	--	--
Ethalfluralin	H	81	0	0

Appendix 5. Summary of pesticides distributed within Wyoming, 2007.[1]—Continued

[NAL, no assessment level; H, Herbicide; F, Fungicide; I, Insecticide; R, Rodenticide; L, Larvicide; S, Soil fumigant; ST, Seed treatment; CP, Crop protectant; GR, Growth regulator; B, Bactericide, Algaecide; MCPA, (4-chloro-2-methylphenoxy)acetic acid; EPTC, S-ethyl dipropylthiocarbamate; DCPA, dimethyl tetrachloroterephthalate; MSMA, monosodium methyl arsenate; PCNB, pentachloronitrobenzene; --, not on analytical schedule]

Pesticide	Pesticide action	Distribution rank[2]	Number of detections (NAL)	
			1995–2006 baseline study (598 samples)[3]	2008–10 resampling study (52 samples)
Fludioxonil	F	82	--	--
Hydrotreated paraffinic oil	I	82	--	--
Rimsulfuron	H	82	--	--
Strychnine	R	82	--	--
Thiophanate-methyl	F	82	--	--
Triflusulfuron methyl	H	82	--	--
Azoxystrobin	F	88	--	--
Esfenvalerate	I	88	--	--
Quinclorac	H	88	--	--
Resmethrin	I	88	--	--
Sulfentrazone	H	88	--	--
Tebuconazole	F	88	--	--
1,3-Dichloropropene	S	94	0	--
Aluminum phosphide	I	94	--	--
Captan	I	94	--	--
Carbofuran	I	94	2	0
Carboxin	ST	94	0	0
Isoxaben	H	94	--	--
Kaolin	CP	94	--	--
Methidathion	I	94	0	0
Naled	I	94	--	--
Oxydemeton-methyl	I	94	--	--
Phenmedipham	H	94	--	--
Phorate	I	94	0	0
Phosmet	H	94	0	0
Pronamide	H	94	--	--
Propionic acid	F	94	--	--
Sodium methyldithiocarbamate	S	94	--	--
Sulfur	F	94	--	--
Tebupirimfos	I	94	--	--
Zinc phosphide	R	94	--	--
Acephate	I	113	--	--
Boscalid	F	113	--	--
Carbon	R	113	--	--
Clodinafop-propargyl	H	113	--	--
Cycloate	H	113	0	0
Diphacinone	R	113	--	--
Endothall	H	113	--	--
Fenoxaprop-*p*-ethyl	H	113	--	--
Fluazifop-*P*-butyl	H	113	--	--

Appendix 5. Summary of pesticides distributed within Wyoming, 2007.[1]—Continued

[NAL, no assessment level; H, Herbicide; F, Fungicide; I, Insecticide; R, Rodenticide; L, Larvicide; S, Soil fumigant; ST, Seed treatment; CP, Crop protectant; GR, Growth regulator; B, Bactericide, Algaecide; MCPA, (4-chloro-2-methylphenoxy)acetic acid; EPTC, S-ethyl dipropylthiocarbamate; DCPA, dimethyl tetrachloroterephthalate; MSMA, monosodium methyl arsenate; PCNB, pentachloronitrobenzene; --, not on analytical schedule]

Pesticide	Pesticide action	Distribution rank[2]	Number of detections (NAL)	
			1995–2006 baseline study (598 samples)[3]	2008–10 resampling study (52 samples)
Fluridone	H	113	--	--
Flurprimidol	GR	113	--	--
Flutolanil	F	113	--	--
Foramsulfuron	H	113	--	--
lambda-Cyhalothrin	I	113	0	0
Lindane	I	113	0	0
Mesotrione	H	113	--	--
MSMA	H	113	--	--
Myclobutanil	F	113	0	0
Nicosulfuron	H	113	0	0
Novaluron	I	113	--	--
Oryzalin	H	113	1	0
Pinoxaden	H	113	--	--
Poly(oxy-1,2-ethanediyl), α-isoctadecyl-ω-hydroxyl	I	113	--	--
Prallethrin	I	113	--	--
Propargite	I	113	0	0
Pyraclostrobin	F	113	--	--
Pyrazon	H	113	--	--
Sethoxydim	H	113	--	--
Siduron	H	113	0	0
Sodium nitrate	R	113	--	--
Streptomycin	B	113	--	--
Sulfosulfuron	H	113	--	--
Sulfur	R	113	--	--
Temephos	I	113	--	--
Terbacil	H	113	0	0
Tetraconazole	F	113	--	--
Tralkoxydim	H	113	--	--
Triphenyltin hydroxide	F	113	--	--
Abamectin	I	151	--	--
Aminopyralid	H	151	--	--
Bifenazate	I	151	--	--
Butoxypolypropylene glycol	I	151	--	--
DCPA	H	151	5	0
Diazinon	I	151	1	0
Difenoconazole	I	151	--	--
Ethephon	GR	151	--	--
Fipronil	H	151	0	1

Appendix 5. Summary of pesticides distributed within Wyoming, 2007.[1]—Continued

[NAL, no assessment level; H, Herbicide; F, Fungicide; I, Insecticide; R, Rodenticide; L, Larvicide; S, Soil fumigant; ST, Seed treatment; CP, Crop protectant; GR, Growth regulator; B, Bactericide, Algaecide; MCPA, (4-chloro-2-methylphenoxy)acetic acid; EPTC, S-ethyl dipropylthiocarbamate; DCPA, dimethyl tetrachloroterephthalate; MSMA, monosodium methyl arsenate; PCNB, pentachloronitrobenzene; --, not on analytical schedule]

Pesticide	Pesticide action	Distribution rank[2]	Number of detections (NAL)	
			1995–2006 baseline study (598 samples)[3]	2008–10 resampling study (52 samples)
Imazethapyr	H	151	0	0
Iprodione	F	151	0	0
Oxyfluorfen	H	151	1	0
Paclobutrazol	GR	151	--	--
PCNB	F	151	--	--
Propiconazole	F	151	0	0
Pyraflufen ethyl	H	151	--	--
Quizalofop-*P*-ethyl	H	151	--	--
Spiromesifen	I	151	--	--
Triadimefon	F	151	--	--

[1]Data from Wyoming Department of Agriculture (Hank Uhden, Wyoming Department of Agriculture, written commun., 2010). Summary includes pesticides that were distributed in Wyoming in 2007. This does not necessarily mean the pesticide was sold or used during 2007.

[2]A ranking of 1 represents the active ingredient distributed most frequently. Progressively higher ranking numbers represent progressively lower distribution.

[3]Bartos and others (2009).

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U.S. Geological Survey
521 Progress Circle, Suite 6
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(307) 778-2931

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