STUDY 240:
MONITORING GROUND WATER IN SECTIONS WITH REPORTED DETECTIONS OUTSIDE EXISTING GROUND WATER PROTECTION AREAS

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November 17, 2017

ABSTRACT

From January 2007 to June 2008, Environmental Monitoring Branch (EM) staff sampled 176 wells in 11 counties to: (1) determine if previously detected pesticide residues were due to legal agricultural use (LAU), (2) obtain well sampling data on the presence and distribution of pesticide residues in areas outside existing GWPA sections, and (3) identify current CALVUL model factors that may need to be modified or incorporated into the model to encompass all areas of the State that might be vulnerable to pesticide contamination of ground water. This study used a transect sampling design to determine whether previously detected pesticide residues are the result of LAU and provides additional data about what soil types, depths to ground water, and pesticide use patterns allow known pesticide contaminants to reach ground water in areas that are not captured by the current model. Sixty-eight of the 176 sampled wells had at least one of 11 different pesticide residues above its detection limit. All of these pesticide or degradate residues were of pesticides regulated by Title 3 California Code of Regulations (3 CCR) section 6800(a) except hexazinone, which was found in five wells.

The hexazinone detections were investigated further in 2008. A four-section field study (Z573) was conducted around two detections in a single section in Fresno County and an additional well with hexazinone residues was found (Nordmark, 2008). An LAU use determination was conducted and the residues were found not to pollute at the levels detected (Reardon, 2011). DPR has sampled wells near each of the other three wells in this study with hexazinone detections but none of these additional wells had hexazinone residues present.

All pesticides residues detected were at concentrations below known health levels. The maximum concentration for any pesticide residue was 2.14 ppb for DACT in a Fresno County well.

This report presents the results for monitoring ground water in sections with reported detections outside existing ground water protection areas (Study 240). These results include limited analysis. The complete analysis and modeling of the data will be included in a subsequent report when the revised statewide California Vulnerability (CALVUL) analysis and modeling is complete. EM staff will incorporate the results from this study into the CALVUL modeling program. Sampling results from this study will be used to complete 38 four-section surveys (Z-Studies) that DPR would have typically conducted, thus saving DPR resources and making results available more quickly. DPR also plans to use the data to make recommendations for the creation of 70 Ground Water Protection Areas (GWPA) based on verified detections.

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INTRODUCTION

The Pesticide Contamination Prevention Act (Food and Agricultural Code [FAC] section 13141 et seq.) was enacted in 1985 to prevent further pollution of ground water due to the agricultural use of pesticides. FAC section 13150 requires the Department of Pesticide Regulation's (DPR) Director to conduct a formal review of pesticides found in ground water due to agricultural use; it also requires the Director to adopt regulations to modify use of the pesticide if a specific finding allowing continued use is made. Those pesticides are listed in section 6800(a) of Title 3 of the California Code of Regulations (3 CCR) and currently include atrazine, bromacil, diuron, norflurazon, and simazine.

In May 2004, the Director adopted regulations to identify areas sensitive to the movement of pesticides to ground water, denoted as Ground Water Protection Areas (GWPAs). The Director also adopted regulations to modify the use of pesticides listed in 3 CCR section 6800(a) within GWPAs. GWPAs are based on either one of two criteria: (1) detection of a 6800(a)-listed pesticide or a related degradation product in ground water due to legal agricultural use (LAU), or (2) the presence of specified soil types, climate, and depth to ground water that are characteristic of sections where pesticides or their breakdown products have been detected due to LAU (Ross et al., 2011). DPR uses the California Vulnerability Modeling Approach (CALVUL) to identify GWPAs based on the second criteria (Troiano et al., 1999).

Based on additional research EM scientists have done, DPR replaced its Pesticide Management Zones (PMZs) with GWPAs. A PMZ was a section of land established in regulation that contained at least one well with a detection of a pesticide active ingredient or one of its degradation products determined to be due to LAU. By policy, the detection of a pesticide chemical was determined to be due to LAU if:

(1) A pesticide active ingredient contained in a currently registered pesticide, or one of its degradation products, was detected in two wells located within the section with a detection, or one of the three sections most adjacent to the well in the section had a detection (4-adjacent-section area),
(2) There were sites in the section where the pesticide could have been applied, and
(3) There were no point, non-agricultural, or non-pesticidal sources that could have exclusively accounted for the detection.

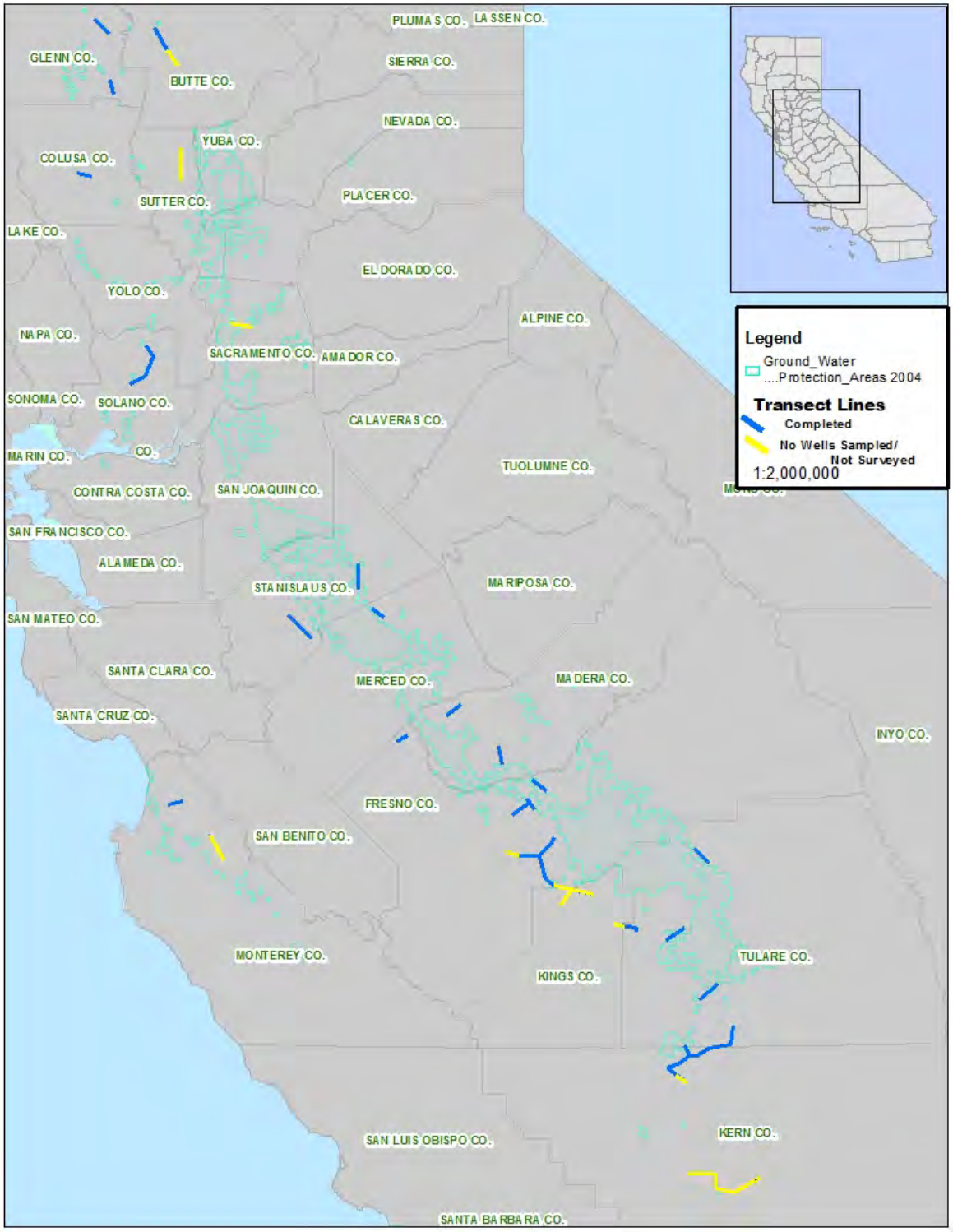
PMZs were pesticide-specific. In contrast, GWPAs can be based on any combination of detections of 6800(a)-listed pesticides or their degradation product(s) in at least two wells in adjacent sections or upon calculated vulnerability of a specific section.

A number of sections outside GWPAs had reported detections of 6800(a)-listed pesticide residues or their degradation products ("known contaminants"). These detections were not included in the original modeling because:

(1) They were sampled after the modeling package was submitted for regulation,
(2) Soil or depth to ground water data were not available for the section,
(3) The ground water depth was deeper than the 70-foot threshold established by the model, or
(4) They were isolated detections for which no agricultural use determination could be made.

This study was conducted to provide data to determine if another well within an adjacent section could be found to contain a known contaminant, facilitating the determination of a GWPA and providing additional data to further calibrate the CALVUL model. The previous sampling design treated each section as a unit and the surrounding three sections closest to the well were identified for potential well sampling locations. A number of the current detections are not located within a Z-Study area; instead they are located relatively close to each other (within a few miles). In order to provide a more efficient method by which to link these detections, transects were drawn between wells with detected 6800(a)-listed pesticides in non-contiguous sections (Figure 1). These transects were predicted to provide more information quicker on well contamination across larger areas than could be achieved using conventional four-section survey (Z-Study) sampling. Wells were to be sampled in sections through which the transect line passed so that detections in adjacent sections would directly link one another, providing evidence for an LAU determination and subsequent listing as a GWPA. Additionally, data collected will be used to update and test the CALVUL model in areas where information is currently lacking.

Figure 1. Well sampling transects planned or completed in Northern and Central California. Detail maps of the transects are located in [Appendix 1](#).



METHODS

The study was conducted using the methods described by Nordmark et al. (2007). Wells were sampled along transects in Butte, Colusa, Fresno, Glenn, Kern, Madera, Merced, Solano, Stanislaus, and Tulare Counties. Target sections were those that the transect line passed through. When possible, two wells were sampled in sections where the transect line passed through more than 20% of the section. In the remaining sections one well was sampled. Crews searched for suitable wells in each target transect section, with a preference for domestic wells since they are generally shallower. Well availability along some transects was very low, which resulted in gaps in the transect lines. To help compensate for the lack of wells, additional wells were sampled in some sections with a goal of having those wells at least 0.5 miles apart to increase the likelihood of obtaining sufficient data for an agricultural use determination. Many sections and some whole transects lacked either wells or well owners willing to grant permission to sample the wells.

Wells were sampled using the standard DPR well sampling procedures outlined by Marade (1996). One primary sample, two backup samples, and one field blank were collected from each well in one-liter amber bottles. Samples were stored on wet ice for transport and were refrigerated until analysis. All primary samples were submitted for analysis.

The California Department of Food and Agriculture (CDFA) laboratory has established analytical methods for atrazine, simazine, and the breakdown products deethyl-atrazine (DEA), deethyl-simazine (ACET), and diaminochlorotriazine (DACT) in well water using liquid chromatography-atmospheric pressure chemical ionization mass spectrometry (APCI/LC/MS/MS). Additionally, the pesticides diuron, prometon, bromacil, hexazinone, norflurazon, and desmethyl-norflurazon (DSMN) are included in the analytical method (CDFA, 2001). The reporting limit for all analytes was 0.05 parts per billion (ppb). If pesticide residues were detected in a primary sample, the corresponding field blank was submitted for analysis. Quality control for this analytical method followed that described by Segawa (1995).

RESULTS

DPR staff sampled 176 wells from 11 counties and detected 6800(a)-listed pesticides or their degradates in 68 wells in eight counties along 33 transects. Eight transects were surveyed but no wells were available for sampling. Eleven transects were not surveyed due to reallocation of study resources.

Table 1 details the results for all sampling for this study by county, section, and well location code. The table also includes the total number of wells and maximum concentration detected for each pesticide residue. The most frequently detected residues were ACET and DACT, appearing in 40 and 48 wells, respectively. All of the pesticide compounds in the pesticide screen were detected in at least two wells. There were five wells in three counties with hexazinone residues present. All pesticide levels reported are below known health levels. The maximum concentration for any pesticide residue was 2.14 ppb for DACT in a Fresno County well.

The counties with the highest percentage of wells with pesticide residues were located in the Central Valley from Solano to Kern County. Of the seven counties sampled in this region, Tulare

County had the highest rate of detection with 19 of 25 wells (76%) having pesticide residues and Madera County had the lowest with three of nine wells (33%) having residues. Sampling crews could locate only four wells to sample in Monterey County along one of two transects and one of these wells had low levels of ACET. No residues were found in the 38 wells sampled in Butte, Colusa, and Glenn Counties. The maximum number of pesticide residues in a single well was five and this occurred in four of the 68 positive wells.

Quality control results for this study were acceptable. No pesticide detections were reported in any of the 68 field blanks submitted. Blind spike recoveries ranged from 85.2% to 104% of the spiked levels (Table 2). The mean, minimum, and maximum recovery rates of the propazine surrogate added to all primary and field blank samples was 88.8%, 72.5%, and 107% respectively (Table 3). There was no significant difference between the recovery rates for the non-detect samples, detect samples, and field blanks. No problems with the analysis of the primary samples were noted so none of the backup samples were submitted.

Five of the 11 transects not surveyed were located in Southern California in Los Angeles, Orange, San Bernardino, and Riverside Counties (Figure 2). These transects were located in urban areas that have had little or no reported use of the targeted pesticides since 1990. Numerous DPR studies have detected atrazine, simazine, and/or their degradates in numerous wells in this region. Bromacil and diuron have also been detected. The State Water Resources Control Board (SWRCB) Ground Water Ambient Monitoring and Assessment Program (GAMA) also reported numerous wells with these contaminants present (Well Inventory Database, 2016). The most likely source of this ongoing contamination is due to decades-old weed management practices in ground water recharge basins (Rhone, 1987). At one time these infiltration basins were kept weed-free by the use of high levels of herbicides. These practices have since been changed; statewide regulations now prohibit the use of herbicides in recharge basins, but the legacy effects remain. Since there is little current use of these pesticides in this area, further sampling by DPR to create additional GWPAs is a low priority. The remaining six planned transects that were not surveyed were in northern Kings and southern Kern counties. Pesticide use, soil type, and well construction data are common factors that influence the likelihood of finding pesticide residues in a given well (Barbash and Resek, 1996). Table 4 contains the information known about each well and the total pesticide use from 1990-2004 for the section where the well is located and the eight surrounding sections (9-section area). In many of the wells the depth to ground water (DGW) could not be obtained at the time of sampling due to well construction issues. Therefore, the depth to ground water from the DPR DGW database (Spurlock, 2000) derived from Department of Water Resources, Division of Local Planning Assistance, was used. The majority of the well depths listed were from statements by the well owners but DWR well log data was also used where available. The CALVUL model pathway for the section, based on the predominant soil type, is listed for reference. DPR is currently revising the CALVUL model and will be incorporating additional soil data that may provide a contamination pathway for many of the sections currently listed as “unknown.” None of the sections sampled are currently GWPAs.

Figure 2. Southern California transects.

No sampling was done for these transects. Wells sampled by the GAMA program that had atrazine, bromacil, diuron, or simazine (or degradates) residues above 0.04 ppb are shown**.**

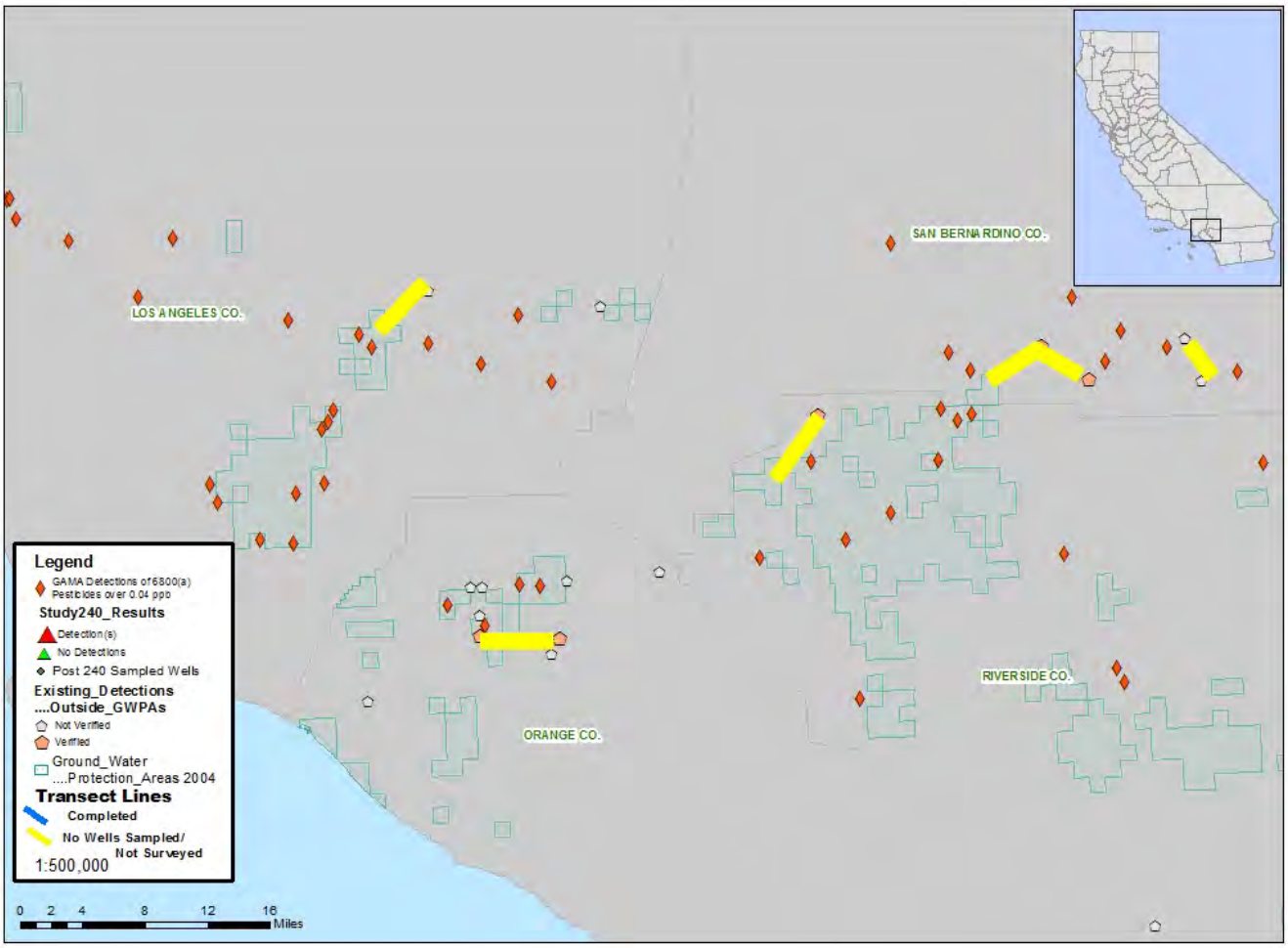


Table 1. Sampling results for Study 240 wells, January 2007-June 2008.

Table 1. cont.			*Chemical Analyzed. Results given in parts per billion (ppb)*										
County	***Section***[1]	***Site Code***	***Atrazine***	***Simazine***	***Diuron***	***Prometon***	***Bromacil***	***Hexazinone***	***Norflurazon***	***DEA***[2]	***ACET***[3]	***DACT***[4]	***DSMN***[5]
Butte	20N/02E-05	04-14	--[6]	--	--	--	--	--	--	--	--	--	--
Butte	20N/02E-06	04-15	--	--	--	--	--	--	--	--	--	--	--
Butte	20N/02E-08	04-11	--	--	--	--	--	--	--	--	--	--	--
Butte	21N/01E-14	04-01	--	--	--	--	--	--	--	--	--	--	--
Butte	21N/01E-23	04-02	--	--	--	--	--	--	--	--	--	--	--
Butte	21N/01E-24	04-03	--	--	--	--	--	--	--	--	--	--	--
Butte	21N/01E-25	04-04	--	--	--	--	--	--	--	--	--	--	--
Butte	21N/02E-19	04-05	--	--	--	--	--	--	--	--	--	--	--
Butte	21N/02E-19	04-06	--	--	--	--	--	--	--	--	--	--	--
Butte	21N/02E-29	04-07	--	--	--	--	--	--	--	--	--	--	--
Butte	21N/02E-30	04-08	--	--	--	--	--	--	--	--	--	--	--
Butte	21N/02E-31	04-09	--	--	--	--	--	--	--	--	--	--	--
Butte	21N/02E-31	04-10	--	--	--	--	--	--	--	--	--	--	--
Butte	21N/02E-32	04-13	--	--	--	--	--	--	--	--	--	--	--
Butte	21N/02E-32	04-12	--	--	--	--	--	--	--	--	--	--	--
Colusa	15N/03W-26	06-02	--	--	--	--	--	--	--	--	--	--	--
Colusa	15N/03W-27	06-03	--	--	--	--	--	--	--	--	--	--	--
Colusa	15N/03W-35	06-01	--	--	--	--	--	--	--	--	--	--	--
Fresno	11S/12E-13	10-01	--	--	--	--	--	--	--	--	--	--	--
Fresno	11S/12E-24	10-04	--	--	--	--	--	--	--	--	--	--	--
Fresno	11S/13E-08	10-08	--	--	--	--	--	--	--	--	--	--	--
Fresno	11S/13E-09	10-09	--	--	--	--	--	--	--	--	--	--	--
Fresno	11S/13E-16	10-10	--	--	--	--	--	--	--	--	--	--	--
Fresno	11S/13E-17	10-06	--	--	--	--	--	--	--	--	--	--	--
Fresno	11S/13E-17	10-07	--	--	--	--	--	--	--	--	--	--	--
Fresno	11S/13E-18	10-03	--	--	--	--	--	--	--	--	--	--	--
Fresno	11S/13E-19	10-05	--	--	--	--	--	--	--	--	--	--	--
Fresno	11S/13E-19	10-02	--	--	--	--	--	--	--	--	--	--	--
Fresno	13S/18E-12	10-12	--	0.073	0.186	--	--	--	--	--	--	0.166	--
Fresno	13S/18E-12	10-11	--	0.095	0.668	--	--	--	--	--	--	--	--
Fresno	13S/19E-17	10-13	--	--	--	--	--	--	--	--	--	--	--
Fresno	13S/19E-17	10-14	--	--	--	--	--	--	--	--	--	0.07	--
Fresno	13S/19E-19	10-22	--	--	--	--	--	--	--	--	--	--	--
Fresno	13S/19E-21	10-20	--	--	--	--	--	--	--	--	--	--	--
Fresno	14S/18E-15	10-19	--	--	--	--	--	--	--	--	0.071	0.268	--
Fresno	14S/18E-15	10-16	--	--	--	--	--	--	--	--	--	0.057	--
Fresno	14S/18E-21	10-15	--	--	--	--	--	--	--	--	--	--	--
Fresno	14S/18E-29	10-18	--	--	--	--	--	--	--	--	--	0.144	--
Fresno	14S/18E-30	10-17	--	--	--	--	--	--	--	--	--	--	--
Fresno	14S/19E-18	10-21	--	--	--	--	--	--	--	--	--	0.429	--
Fresno	15S/19E-25	10-23	--	0.157	--	--	--	--	--	--	0.163	0.117	--
Fresno	15S/19E-25	10-24	--	--	--	--	--	--	--	--	--	--	--
Fresno	15S/19E-35	10-25	--	--	--	--	--	--	--	--	--	--	--
Fresno	15S/19E-35	10-26	--	--	--	--	--	--	--	--	--	--	--
Fresno	16S/18E-23	10-38	--	--	--	--	--	--	--	--	--	--	--
Fresno	16S/18E-23	10-39	--	--	--	--	--	--	--	--	--	--	--
Fresno	16S/18E-25	10-36	--	--	--	--	--	--	--	--	--	--	--
Fresno	16S/19E-02	10-27	--	--	--	--	--	--	--	--	--	--	--
Fresno	16S/19E-02	10-28	--	0.08	--	--	--	--	--	--	0.086	0.131	--
Fresno	16S/19E-03	10-29	--	0.13	--	--	--	--	--	--	0.066	0.053	--
Fresno	16S/19E-10	10-32	--	--	--	--	--	--	--	--	0.062	0.086	--

[1] Section – township/range-section where the well was located, approximately one square mile in area
[2] DEA – deethyl-atrazine, a breakdown product of atrazine
[3] ACET – deethyl-simazine, a breakdown product of atrazine or simazine
[4] DACT – diaminochloro-triazine, a breakdown product of atrazine or simazine
[5] DSMN – desmethyl-norflurazon, a breakdown product of norflurazon
[6] '—' – None Detected: No residues detected above the reporting limit of 0.05 ppb

Table 1. cont.			*Chemical Analyzed. Results given in parts per billion (ppb)*										
County	***Section[1]***	***Site Code***	***Atrazine***	***Simazine***	***Diuron***	***Prometon***	***Bromacil***	***Hexazinone***	***Norflurazon***	***DEA[2]***	***ACET[3]***	***DACT[4]***	***DSMN[5]***
Fresno	16S/19E-10	10-31	--	0.063	--	--	--	--	--	--	0.122	0.125	--
Fresno	16S/19E-11	10-30	--	--	--	--	--	--	--	--	--	--	--
Fresno	16S/19E-16	10-33	--	--	--	--	--	--	--	--	0.077	0.063	--
Fresno	16S/19E-16	10-34	--	--	--	--	--	--	--	--	0.062	0.105	--
Fresno	16S/19E-20	10-35	--	--	--	--	--	--	--	--	0.053	0.062	--
Fresno	17S/19E-09	10-37	--	--	--	--	--	--	--	--	--	--	--
Fresno	17S/19E-21	10-40	--	--	--	--	--	--	--	--	--	--	--
Fresno	17S/19E-22	10-43	--	--	--	--	--	--	--	--	--	--	0.075
Fresno	17S/19E-23	10-44	--	--	--	--	--	--	--	--	--	--	--
Fresno	17S/19E-36	10-41	--	--	0.083	--	--	0.081	--	--	--	--	--
Fresno	17S/19E-36	10-42	--	--	0.154	--	--	0.247	--	--	0.64	2.14	--
Glenn	18N/02W-01	11-17	--	--	--	--	--	--	--	--	--	--	--
Glenn	18N/02W-02	11-18	--	--	--	--	--	--	--	--	--	--	--
Glenn	18N/02W-12	11-19	--	--	--	--	--	--	--	--	--	--	--
Glenn	18N/02W-12	11-20	--	--	--	--	--	--	--	--	--	--	--
Glenn	19N/02W-23	11-11	--	--	--	--	--	--	--	--	--	--	--
Glenn	19N/02W-23	11-12	--	--	--	--	--	--	--	--	--	--	--
Glenn	19N/02W-35	11-14	--	--	--	--	--	--	--	--	--	--	--
Glenn	19N/02W-35	11-15	--	--	--	--	--	--	--	--	--	--	--
Glenn	19N/02W-36	11-16	--	--	--	--	--	--	--	--	--	--	--
Glenn	19N/02W-36	11-13	--	--	--	--	--	--	--	--	--	--	--
Glenn	21N/02W-04	11-05	--	--	--	--	--	--	--	--	--	--	--
Glenn	21N/02W-05	11-04	--	--	--	--	--	--	--	--	--	--	--
Glenn	21N/02W-09	11-06	--	--	--	--	--	--	--	--	--	--	--
Glenn	21N/02W-15	11-07	--	--	--	--	--	--	--	--	--	--	--
Glenn	22N/02W-31	11-02	--	--	--	--	--	--	--	--	--	--	--
Glenn	22N/02W-31	11-01	--	--	--	--	--	--	--	--	--	--	--
Glenn	22N/02W-32	11-03	--	--	--	--	--	--	--	--	--	--	--
Kern	25S/25E-23	15-07	--	--	--	--	--	--	--	--	--	--	--
Kern	25S/25E-26	15-14	--	--	--	--	--	--	--	--	--	--	--
Kern	25S/25E-27	15-08	--	--	--	--	0.096	--	--	--	0.117	0.268	--
Kern	25S/25E-30	15-10	--	--	--	--	--	--	--	--	--	--	--
Kern	25S/25E-31	15-09	--	--	--	--	--	--	--	--	--	--	--
Kern	25S/25E-31	15-11	--	--	--	--	--	--	--	--	--	0.075	--
Kern	25S/25E-32	15-13	--	--	--	--	--	--	--	--	--	--	--
Kern	25S/26E-02	15-01	--	--	--	--	--	--	--	--	--	--	--
Kern	25S/26E-10	15-03	--	--	--	--	--	--	--	--	--	0.078	--
Kern	25S/26E-10	15-02	--	--	--	--	--	--	--	--	--	--	--
Kern	25S/26E-16	15-04	--	0.118	0.148	--	0.053	--	--	--	0.192	0.16	--
Kern	25S/26E-18	15-05	--	--	--	--	--	--	--	--	0.053	0.139	--
Kern	25S/26E-18	15-06	--	0.194	--	--	--	--	--	--	0.257	0.343	--
Kern	26S/25E-09	15-12	--	--	--	--	--	--	--	--	--	--	--
Madera	10S/15E-02	20-02	--	--	--	--	--	--	--	--	--	--	--
Madera	10S/15E-09	20-03	--	--	0.068	--	--	--	--	--	--	0.092	--
Madera	10S/15E-10	20-01	--	--	--	--	--	--	--	--	--	--	--
Madera	11S/17E-28	20-11	--	--	--	--	--	--	--	--	--	--	--
Madera	12S/17E-03	20-13	--	--	0.086	--	--	--	--	--	0.067	0.161	--
Madera	12S/17E-04	20-12	--	--	0.118	--	--	--	--	--	--	--	--
Madera	12S/17E-04	20-16	--	--	--	--	--	--	--	--	--	--	--
Madera	12S/17E-09	20-14	--	--	--	--	--	--	--	--	--	--	--
Madera	12S/17E-15	20-15	--	--	0.087	--	--	--	--	0.07	0.144	0.324	--
Merced	05S/11E-25	24-02	--	--	--	--	--	--	0.169	--	0.053	0.153	0.272
Merced	05S/11E-26	24-01	--	--	--	--	--	--	--	--	--	--	--
Merced	05S/11E-35	24-03	--	--	--	--	--	--	--	--	--	--	--
Merced	05S/12E-30	24-06	--	--	--	--	--	--	--	--	--	--	--
Merced	05S/12E-31	24-05	--	--	--	--	--	--	--	--	--	0.051	--
Merced	06/S11E-01	24-04	0.096	--	--	--	--	--	--	0.099	--	0.065	0.069
Merced	06S/12E-06	24-08	--	--	--	--	--	--	--	--	--	--	--
Merced	06S/12E-06	24-07	--	--	--	--	--	--	--	--	--	--	--
Monterey	14S/03E-08	27-03	--	--	--	--	--	--	--	--	0.056	--	--
Monterey	14S/03E-10	27-02	--	--	--	--	--	--	--	--	--	--	--
Monterey	14S/03E-10	27-01	--	--	--	--	--	--	--	--	--	--	--
Monterey	14S/03E-18	27-04	--	--	--	--	--	--	--	--	--	--	--

Table 1. cont.			*Chemical Analyzed. Results given in parts per billion (ppb)*										
County	***Section[1]***	***Site Code***	***Atrazine***	***Simazine***	***Diuron***	***Prometon***	***Bromacil***	***Hexazinone***	***Norflurazon***	***DEA[2]***	***ACET[3]***	***DACT[4]***	***DSMN[5]***
Solano	06N/01E-10	48-21	0.061	--	--	--	--	--	--	--	--	--	--
Solano	06N/01E-14	48-20	--	--	--	--	--	--	--	--	0.053	0.323	--
Solano	06N/01E-14	48-22	--	--	--	--	--	--	--	--	--	--	--
Solano	06N/01E-21	48-02	0.101	--	--	--	--	--	--	0.145	--	--	--
Solano	06N/01E-22	48-01	--	--	--	--	--	--	--	--	--	--	--
Solano	06N/01E-23	48-23	0.07	--	0.151	--	--	0.126	--	--	--	0.114	--
Solano	06N/01E-28	48-03	--	--	--	--	--	--	--	--	--	--	--
Solano	06N/01E-29	48-04	--	--	--	--	--	--	--	--	--	--	--
Solano	06N/01E-29	48-09	--	--	--	--	--	--	--	--	--	--	--
Solano	06N/01E-31	48-06	--	--	--	--	--	--	--	--	--	--	--
Solano	06N/01E-31	48-07	--	--	--	--	--	--	--	--	--	--	--
Solano	06N/01W-36	48-08	0.158	--	--	--	--	--	--	0.082	0.051	--	--
Solano	06N/01W-36	48-05	--	--	--	--	--	--	--	--	--	--	--
Solano	07N/01E-23	48-25	--	--	--	--	--	--	--	--	--	--	--
Solano	07N/01E-23	48-26	--	0.094	--	--	--	--	--	--	0.083	--	--
Solano	07N/01E-25	48-28	--	--	--	--	--	--	--	--	--	--	--
Solano	07N/01E-25	48-27	0.066	--	--	--	--	--	--	0.059	--	--	--
Solano	07N/01E-26	48-29	--	--	--	--	--	--	--	--	--	--	--
Solano	07N/01E-35	48-30	--	--	--	--	--	--	--	--	--	0.083	--
Stanislaus	03S/11E-30	50-01	--	--	0.069	--	--	--	--	--	--	--	--
Stanislaus	03S/11E-31	50-02	--	--	0.65	--	--	--	0.468	--	0.403	0.363	0.703
Stanislaus	03S/11E-31	50-03	--	--	--	--	--	--	--	--	0.278	1	0.112
Stanislaus	03S/11E-31	50-05	0.599	0.113	--	--	--	--	--	0.429	0.249	0.181	--
Stanislaus	04S/11E-06	50-04	--	--	0.099	--	--	--	--	--	0.059	0.149	--
Stanislaus	04S/11E-07	50-06	--	--	--	--	--	--	--	--	--	--	--
Stanislaus	04S/11E-07	50-07	--	--	--	--	--	--	--	--	--	--	0.225
Stanislaus	06S/08E-05	50-19	--	--	--	--	--	--	--	--	--	--	--
Stanislaus	06S/08E-15	50-14	--	0.232	--	0.064	--	--	--	--	--	--	--
Stanislaus	06S/08E-22	50-16	--	--	--	--	--	--	--	--	--	--	--
Stanislaus	06S/08E-25	50-11	--	--	--	--	--	--	--	--	--	--	--
Stanislaus	06S/08E-26	50-12	--	--	--	--	--	--	--	--	--	--	--
Stanislaus	06S/08E-26	50-15	--	--	--	--	--	0.062	--	--	0.052	0.091	--
Stanislaus	06S/08E-26	50-13	--	--	--	--	--	--	--	--	--	--	--
Stanislaus	06S/09E-31	50-08	--	--	--	--	--	--	--	--	--	--	--
Stanislaus	07S/08E-01	50-10	--	--	--	--	--	--	--	--	--	--	--
Stanislaus	07S/09E-06	50-09	--	--	0.092	--	--	0.094	--	--	--	--	--
Tulare	16S/26E-26	54-10	--	--	--	--	--	--	--	0.125	--	--	--
Tulare	16S/26E-35	54-11	--	--	--	--	--	--	--	--	0.451	0.77	--
Tulare	16S/26E-35	54-12	--	0.074	--	--	--	--	--	--	0.919	0.835	--
Tulare	19S/23E-21	54-06	--	--	0.068	--	--	--	--	--	0.275	0.628	--
Tulare	19S/23E-27	54-04	--	0.091	--	--	--	--	--	--	0.119	0.362	--
Tulare	19S/23E-27	54-03	--	0.07	--	--	--	--	--	--	0.089	0.083	--
Tulare	19S/23E-28	54-05	--	0.123	--	--	--	--	--	--	0.102	--	--
Tulare	19S/23E-34	54-02	--	--	--	--	--	--	--	--	0.055	--	--
Tulare	19S/23E-34	54-01	--	--	--	--	--	--	--	--	0.065	--	--
Tulare	19S/25E-26	54-07	--	--	--	--	--	--	--	--	--	--	--
Tulare	19S/25E-27	54-108	--	--	--	--	--	--	--	--	--	--	--
Tulare	19S/25E-27	54-107	--	0.171	--	--	--	--	--	--	0.358	0.365	0.067
Tulare	19S/25E-33	54-106	--	--	--	--	--	--	--	--	--	--	--
Tulare	19S/25E-33	54-105	--	--	--	--	--	--	--	--	--	--	--
Tulare	19S/25E-35	54-09	--	0.249	0.107	--	--	--	--	--	0.412	0.469	--
Tulare	19S/25E-35	54-08	--	--	--	--	--	--	--	--	--	--	--
Tulare	20S/25E-06	54-104	--	--	0.237	--	--	--	--	--	--	--	--
Tulare	20S/25E-06	54-103	--	0.052	--	--	--	--	--	--	0.113	0.235	--
Tulare	20S/25E-07	54-102	--	--	--	--	--	--	--	--	--	0.122	--
Tulare	20S/25E-07	54-101	--	--	--	--	--	--	--	--	--	--	--
Tulare	22S/26E-23	54-	--	0.084	0.124	--	--	--	--	--	0.148	0.157	0.062

Table 1. cont.			*Chemical Analyzed. Results given in parts per billion (ppb)*										
County	***Section[1]***	***Site Code***	***Atrazine***	***Simazine***	***Diuron***	***Prometon***	***Bromacil***	***Hexazinone***	***Norflurazon***	***DEA[2]***	***ACET[3]***	***DACT[4]***	***DSMN[5]***
		109											
Tulare	22S/26E-23	54-110	--	--	0.118	--	--	--	--	--	0.078	0.12	--
Tulare	22S/26E-33	54-112	--	--	0.069	--	--	--	--	--	--	0.072	--
Tulare	22S/26E-33	54-111	--	--	0.057	--	--	--	--	--	--	--	--
Tulare	24S/25E-35	54-31	--	--	--	--	--	--	--	--	--	--	--
Tulare	24S/25E-35	54-30	--	--	--	--	--	--	--	--	0.128	0.199	--
TOTAL DETECTIONS			7	19	21	1	2	5	2	7	40	48	8
MAXIMUM CONCENTRATION			0.599	0.249	0.668	0.064	0.096	0.247	0.468	0.429	0.919	2.14	0.703

Table 2. Blind spike recoveries.

Spiked Pesticide	***Spike Level (ppb)***	***Recovery Level (ppb)***	***Recovery %***	***Propazine Surrogate Recovery %***
Simazine	0.25	0.213	85.2%	85.5
Bromacil	0.2	0.178	89.0%	85.5
Diuron	0.15	0.137	91.3%	74.5
Bromacil	0.4	0.416	104.0%	98
DACT	0.15	0.154	102.7%	101
Diuron	0.35	0.33	94.3%	95.5
Average Recovery			94.4%	90.0%

Table 3. Propazine surrogate recoveries. Propazine is added to each sample before analysis.

	Non-Detect Samples	***Detect Samples***	***Field Blank***	***All Samples***
AVG	89.7%	89.0%	87.0%	88.7%
MEAN	89.5%	88.8%	85.5%	88.8%
Maximum	105.0%	107.0%	102.0%	107.0%
Minimum	77.0%	75.0%	72.5%	72.5%

Table 4. Well location data.

Data includes the depth to ground water, reported well depth, contamination pathway according to the 2004 CALVUL model, and total pesticide use for the section in which the well was located and the eight surrounding sections (9-section area) for the years 1990-2004.

Table 4					Pesticide Use for the 9-Section Area (LBS AI) 1990-2004[7]					
LOC[8]	Results[9]	DGW[10]	Well Depth[11]	CALVUL Pathway[12]	Atrazine	Bromacil	Diuron	Hexaz-inone	Norflur-azon	Simazine
04-01		35		Unknown	0	0	1601	168	3974	7494
04-03		35	105	Unknown	0	0	1009	0	5427	12595
04-05		36		Unknown	0	0	385	0	2550	10345
04-07		27	70	Runoff	0	0	129	0	1921	5537
04-09		22	200	Unknown	0	0	1305	0	1786	1693
04-11		8	110	Runoff	0	0	477	0	351	402
04-13		19	280	Runoff	0	0	36	0	1543	1062
04-15		13	270	Runoff	0	0	1589	0	905	3125
06-02		24	75	Runoff	0	0	294	0	0	0
10-01		5	20	No Data	0	0	4744	172	0	0
10-03		4	140	No Data	0	0	6783	18	31	0
10-05		4	50	Runoff	0	0	7242	809	55	0
10-07		5		Runoff	0	0	9220	18	99	0
10-09		6	150	Runoff	0	0	7320	403	151	0
10-11	SIM DIU	61	95	Leaching	0	0	4966	0	8634	33036
10-13		74	120	Runoff	0	0	1692	0	1284	10339
10-15		87	160	Leaching	0	0	1890	31	2744	18247

[7] This use does not include rights-of-way applications. Rights-of-way use can be a significant portion of the total use of some pesticides. No significant use of prometon (over 2 lbs total) was reported so this column was omitted.
[8] LOC – Location code for the well. The first 2 digits are the county number.
[9] Abbreviated pesticide residues found during this study shown for comparison to the pesticide use. Parent residues are shown in CAPS, degradates are shown in lower case versions of the standard acronyms. The parent residues are: ATR=atrazine, BRO=bromacil, DIU=diuron, HEX=hexazinone, NOR=norflurazon, PRO=prometon, SIM=simazine.
[10] DGW – Depth to ground water in feet derived from DWR data
[11] Well Depth – Well owner reported depth for the sampled well in feet.
[12] California Vulnerability Model predicted contamination pathway based on 2012 compiled soil data. There was insufficient data for the model to classify sections marked Unknown. No data was available for sections marked No Data.

Table 4 — ***Pesticide Use for the 9-Section Area (LBS AI) 1990-2004[7]***

LOC	Results	DGW	Depth	Pathway	Atrazine	Bromacil	Diuron	inone	azon	Simazine
10-16	dact	77		Leaching	0	0	3443	216	3583	23310
10-17		115	263	Leaching	0	0	1511	74	3662	18363
10-18	dact	104		Leaching	0	0	1468	150	3608	16394
10-19	acet dact	77		Leaching	0	0	3443	216	3583	23310
10-20		80	150	Runoff	0	0	662	0	347	3767
10-21	dact	65		Leaching	0	0	4149	668	1402	11170
10-22		67	220	Runoff	0	3	3955	0	3534	20193
10-23	SIM acet dact	94	175	Leaching	0	0	3512	0	6362	55510
10-24		94	300	Leaching	0	0	3512	0	6362	55510
10-25		119	220	Leaching	0	0	2264	0	7439	24930
10-26		119	291	Leaching	0	0	2264	0	7439	24930
10-27		125	340	Leaching	0	0	828	0	7894	24256
10-28	SIM acet dact	125	325	Leaching	0	0	828	0	7894	24256
10-29	SIM acet dact	140		Leaching	0	0	864	0	6061	21387
10-30		123	240	Leaching	0	0	309	0	7558	26211
10-31	SIM acet dact	138	400	Leaching	0	0	891	23	7545	26561
10-32	acet dact	138	300	Leaching	0	0	891	23	7545	26561
10-33	acet dact	156	175	Leaching	0	0	694	23	12121	45253
10-34	acet dact	156	256	Leaching	0	0	694	23	12121	45253
10-35	acet dact	161		Leaching	0	0	550	23	13335	41233
10-36		159		Leaching	0	0	4233	1035	5877	18005
10-37		127		Unknown	0	0	5472	2394	973	2986
10-38		168	450	Leaching	0	0	6343	501	5648	24181
10-39		168	400	Leaching	0	0	6343	501	5648	24181
10-40		107		Unknown	0	0	3466	1127	746	1400
10-41	DIU HEX	40	205	Unknown	0	0	4074	1851	1231	167
10-42	DIU HEX acet dact	40		Unknown	0	0	4074	1851	1231	167
10-43	dsmn	95	280	Unknown	0	0	3790	1437	773	1431
10-44		84	275	Unknown	0	0	4792	1545	335	67
11-01		14		Unknown	0	94	5292	281	6305	5913
11-02		14		Unknown	0	94	5292	281	6305	5913
11-03		13		Unknown	79	94	4397	556	6538	6880
11-04		17	180	Unknown	1688	214	3894	1220	5982	5897
11-05		17	120	Unknown	2064	197	2389	2321	8851	3675
11-06		21	140	Unknown	2361	197	2663	2660	7356	3901
11-07		19	120	Unknown	2313	0	1741	6494	11217	1266
11-11		8	80	Runoff	0	0	183	202	0	118
11-12		8	170	Runoff	0	0	183	202	0	118
11-13		7	160	Runoff	0	0	1061	228	31	115
11-14		6	60	Runoff	0	0	0	202	0	0
11-15		6	142	Runoff	0	0	0	202	0	0
11-16		7		Runoff	0	0	1061	228	31	115
11-17		6		Runoff	0	0	1125	26	0	72
11-18		7	148	Runoff	0	0	0	0	0	0
11-19		7		Runoff	0	0	275	82	0	0
11-20		7		Runoff	0	0	275	82	0	0
15-01		169		Runoff	0	6257	16209	0	411	21266
15-02		157	570	Runoff	0	1467	10704	0	501	27114
15-03	dact	157		Runoff	0	1467	10704	0	501	27114

Table 4					Pesticide Use for the 9-Section Area (LBS AI) 1990-2004[7]					
LOC[8]	Results[9]	DGW[10]	Well Depth[11]	CALVUL Pathway[12]	Atrazine	Bromacil	Diuron	Hexaz-inone	Norflur-azon	Simazine
15-04	SIM DIU BRO acet dact	127	400	Runoff	0	416	9980	0	667	36048
15-05	acet dact	102	270	Leaching	0	293	3971	0	344	20571
15-06	SIM acet dact	102	300	Leaching	0	293	3971	0	344	20571
15-07		89	600	Unknown	0	0	1899	0	279	3193
15-08	BRO acet dact	114		Unknown	0	0	1056	64	547	1629
15-09		161	1007	Unknown	0	0	1209	99	228	2931
15-10		147	623	Unknown	0	0	302	54	48	2817
15-11	dact	161		Unknown	0	0	1209	99	228	2931
15-12		160	500	Unknown	0	0	7663	76	3089	5570
15-13		132	400	Unknown	0	0	2408	163	229	884
15-14		105	600	Unknown	0	0	679	0	546	3792
20-01		90		Leaching	0	0	6605	1276	2438	1802
20-02		116	430	Leaching	0	0	2195	2024	2334	1620
20-03	DIU dact	87	320	Leaching	0	0	7030	1392	3313	1914
20-11		89	320	Leaching	0	0	3581	0	4993	19045
20-12	DIU	81	216	Leaching	0	0	3100	0	8967	27586
20-13	DIU acet dact	85	200	Leaching	0	0	4835	31	5594	27788
20-14		75	320	Unknown	0	0	4282	0	10064	29714
20-15	DIU dea acet dact	71		Runoff	0	0	5433	114	5999	26728
20-16		81	175	Leaching	0	0	3100	0	8967	27586
24-01		81	300	Leaching	0	0	246	0	2356	1996
24-02	NOR acet dact dsmn	92	200	Leaching	0	0	271	0	2220	1930
24-03		63	300	Leaching	0	0	72	0	2933	2380
24-04	ATR dea dact dsmn	69	132	Leaching	0	0	74	0	4476	1202
24-05	dact	83	270	Leaching	0	0	6	0	2674	2181
24-06		98	105	Leaching/ Runoff	0	0	33	0	1435	1614
24-07		77	260	Leaching	0	0	288	56	3812	1237
24-08		77		Leaching	0	0	288	56	3812	1237
27-01		192	675	Unknown	0	0	184	0	0	173
27-02		192	499	Unknown	0	0	184	0	0	173
27-03	acet	158	100	Unknown	0	0	521	0	0	141
27-04		0	142	Unknown	0	0	762	0	0	2504
48-01		8	160	Unknown	0	0	2636	5604	112	0
48-02	ATR dea	8	40	Unknown	1818	0	864	3746	172	0
48-03		9	120	Unknown	1450	0	915	2771	60	0
48-04		9	160	Unknown	2111	0	554	4663	60	0
48-05		14	870	Unknown	2362	0	470	4138	334	0
48-06		12		Unknown	1748	0	613	4656	334	0
48-07		12		Unknown	1748	0	613	4656	334	0
48-08	ATR dea acet	14		Unknown	2362	0	470	4138	334	0
48-09		9		Unknown	2111	0	554	4663	60	0
48-20	acet dact	8	105	Unknown	0	0	3583	6763	381	0
48-21	ATR	10		Unknown	0	0	63	4275	976	0
48-22		8	90	Unknown	0	0	3583	6763	381	0
48-23	ATR DIU HEX dact	7	90	Unknown	234	0	3849	7568	100	0

Table 4					Pesticide Use for the 9-Section Area (LBS AI) 1990-2004[7]					
LOC[8]	Results[9]	DGW[10]	Well Depth[11]	CALVUL Pathway[12]	Atrazine	Bromacil	Diuron	Hexaz-inone	Norflur-azon	Simazine
48-25		20		Unknown		0	1003	471	405	128
48-26	SIM acet	20	308	Unknown	0	0	1003	471	405	128
48-27	ATR dea	20	136	Unknown	0	0	2520	2173	115	17
48-28		20	125	Unknown	0	0	2520	2173	115	17
48-29		18		Unknown	0	0	1027	821	114	4
48-30	dact	18	349	Unknown	0	0	1390	2547	377	4
50-01	DIU	68	200	Leaching	0	0	1873	147	4850	11347
50-02	DIU NOR acet dact dsmn	74	150	Leaching	0	0	1998	37	4267	11837
50-03	acet dact dsmn	74	144	Leaching	0	0	1998	37	4267	11837
50-04	DIU acet dact	74	144	Leaching	0	0	2089	62	6328	14744
50-05	ATR SIM dea acet dact	74	125	Leaching	0	0	1998	37	4267	11837
50-06		72	210	Leaching	0	0	1033	25	5607	11571
50-07	dsmn	72	180	Leaching	0	0	1033	25	5607	11571
50-08		18	100	Unknown	0	0	7970	1042	896	1584
50-09	DIU HEX	24	50	Unknown	0	0	11531	1041	943	1351
50-10		29	145	Unknown	0	0	5079	539	1716	2251
50-11		18	210	Unknown	0	0	4818	624	879	2039
50-12		19	185	Unknown	0	0	3086	616	1417	2488
50-13		19		Unknown	0	0	3086	616	1417	2488
50-14	SIM PRO	17		Runoff	0	0	6805	650	2091	1670
50-15	HEX acet dact	19	100	Unknown	0	0	3086	616	1417	2488
50-16		22		Unknown	0	0	4627	767	1017	623
50-19		35	380	Unknown	0	0	4284	483	700	850
54-01	acet	55	236	Unknown	0	0	6943	354	1913	208
54-02	acet	55	270	Unknown	0	0	6943	354	1913	208
54-03	SIM acet dact	57		Unknown	0	23	5838	419	3859	208
54-04	SIM acet dact	57		Unknown	0	23	5838	419	3859	208
54-05	SIM acet	63		Unknown	0	23	6617	676	4143	269
54-06	DIU acet dact	71	200	Unknown	0	23	4936	432	4770	716
54-07		44	220	Unknown	0	0	12152	69	1800	13158
54-08		48	150	Unknown	0	0	7703	149	1581	6581
54-09	SIM DIU acet dact	48		Unknown	0	0	7703	149	1518	2313
54-10	dea	25.9		Unknown	0	621	3483	0	130	4143
54-11	acet dact	25.9		Runoff	0	621	6689	0	175	9686
54-12	SIM acet dact	25.9		Runoff	0	621	6689	0	175	9686
54-30	acet dact	65	350	Leaching	0	0	521	0	52	2472
54-31		65		Leaching	0	0	521	0	52	2472
54-101		54	175	Unknown	0	0	6315	181	2409	7940
54-102	dact	54	128	Unknown	0	0	6315	181	2409	7940
54-103	SIM acet dact	52	130	Unknown	0	0	11319	191	3322	14081
54-104	DIU	52	400	Unknown	0	0	11319	191	3322	14081
54-105		44	400	Unknown	0	0	10034	0	2981	17531
54-106		44	503	Unknown	0	0	10034	0	2981	17531

Table 4					Pesticide Use for the 9-Section Area (LBS AI) 1990-2004[7]					
LOC[8]	Results[9]	DGW[10]	Well Depth[11]	CALVUL Pathway[12]	Atrazine	Bromacil	Diuron	Hexaz-inone	Norflur-azon	Simazine
54-107	SIM acet dact dsmn	42		Unknown	0	0	11171	0	1971	14941
54-108		42		Unknown	0	0	11171	0	1971	14941
54-109	SIM DIU acet dact dsmn	99	350	Runoff	0	0	9261	570	2454	10594
54-110	DIU acet dact	99	200	Runoff	0	0	9261	570	2454	10594
54-111	DIU	145	600	Runoff	0	0	2416	77	5194	3599
54-112	DIU dact	145		Runoff	0	0	2416	77	5194	3599

DISCUSSION

This study's well sampling addressed 38 four-section surveys (Z-Studies) (Table 5). Sampled well results are counted towards completing the Z-Study if they are within or adjacent to the section containing the original positive well that initiated the study. Normally, only wells within the original section and the three sections closest to the positive well are counted. The number of sampled wells applicable to each study ranged from none (no wells available) to seven. Currently, the establishment of new GWPAs not created by the CALVUL model are based on detections of pesticide residues on the 6800(a) list or their degradates in ground water due to the LAU of that pesticide (Oshima, 1987). A residue found in a well can be determined to result from LAU if: (1) an additional well with pesticide residues can be located within or adjacent to the section with the original detection, and (2) actual or probable use of that pesticide in the area can be determined or (3) by the preponderance of evidence if additional wells cannot be located (CDPR, 1996). Once a section is determined to be a GWPA, any detection of a 6800(a)-listed pesticide or degradate in a well is assumed to have resulted from LAU. Adjacent sections containing wells with pesticide residues are listed as additional GWPAs.

Twenty-one of the 38 Z-Studies had additional detections of 6800(a)-listed pesticides or degradates in wells sampled as part of this study either in the same section or an adjacent section. Two of the 38 Z-Studies were based on verified detections from a study conducted by Weaver and Nordmark (2003) in adjacent sections so they could mutually qualify as GWPAs based on the original detections alone.

Eight Z-Studies had wells sampled within or adjacent to the target section but no additional residues were reported. For six of these eight Z-Studies, only a single well was sampled near the original well, limiting the confidence that the original reported detection was isolated or erroneous. These studies will be considered completed.

No suitable wells could be located adjacent to nine of the Z-Studies areas. These studies are considered completed even though no conclusions can be drawn due to the lack of additional testing.

Three of the 17 verified original detections in the last two categories were located in sections adjacent to one or more existing GWPAs. By policy, this alone recommends these sections as

GWPAs (Ross et al., 2011). In all, 28 of these Z-Study primary sections and a number of the sections adjacent to them are recommended as GWPAs based on these data. A total of 70 sections can be recommended as GWPAs based on data collected during this study (Table 6).

Not all pesticides were detected at the same frequency or at the same levels (Table 7). Only two wells had bromacil residues while 56 wells had simazine and/or its degradates present. Logically this number of detections should be related to pesticide use and, for the most part, such a relationship is shown. Bromacil had the least reported use around wells with detections while simazine had the most use. Factors such as Koc, solubility, and the half-life of the pesticides also influence detection rates.

Two-thirds of the atrazine/DEA detections were in areas where there has been reported use of the pesticide since 1990. Crop applications of atrazine have been declining in California; it is no longer a significant rights-of-way use pesticide. (Rights-of-way pesticide application locations are typically only reported by the county of application.) These detections are likely the result of applications before 1990. Studies have shown that atrazine and its degradates can persist for decades in water and soil (Jablonowski et al., 2010). The two bromacil detections also occurred in areas of little or no reported use; however, bromacil is used for rights-of-way applications.

The soil type is also a factor in the probability of pesticides reaching ground water. Table 8 details the detections broken out by the CALVUL-assigned soil properties (leaching, runoff, unassigned, no soil data) based on the most current data DPR has. These assignments are tentative and are subject to change as the model is refined. About half of the wells sampled were in areas where the soil data for the section did not fit into either the leaching or runoff pathways. The highest detection rate was in leaching sections with 58% of the wells having detections and the lowest in runoff sections with detections in 16% of the wells. Pesticide use is also broken out by soil type. Table 8 also shows the average use for all sections sampled as well as the average use for sections containing wells with residues of that pesticide or degradate. These comparisons show that reported applications of atrazine and bromacil cannot explain the detections regardless of soil type. For the other four pesticides, there is reported pesticide use around the wells with detections but that use is not necessarily significantly higher than the average reported use for all sections and may actually be lower.

The results of this study are consistent with results from previous DPR ground water studies. Additional areas were sampled which will help refine the CALVUL model. Using this sampling design rather than doing individual four-section Z Studies allowed DPR to complete 38 potential field studies (Z-Studies), saving DPR resources and time over doing the studies individually. Identification of additional areas in California that have the potential for pesticide movement to ground water and regulating the use of pesticides known to reach ground water there-in will aid in DPR's goal of preventing future contamination.

Table 5. Four-section surveys (Z-Studies) completed by work on Study 240.

Table 5. Cont.

Z Study	County	Section	Additional Sections	Initial Pesticide Detections Reported	New Wells Sampled / Positive in Nine Section	Pesticides Detected in Study 240 Wells	Notes
Z169	Tulare	19S23E34		SIM (unverified)	2/2	SIM acet dact	Recommend LAU and GWPA
Z170	Fresno	14S18E11	14S18E15	SIM (unverified)	2/2	acet dact	Recommend LAU and GWPA
Z277	Fresno	11S13E09		DIU	5/0	-	Close out study. No other positive wells.
Z312	Fresno	13S19E27		SIM acet	1/0	-	Close out study. No additional positive wells. Recommend LAU and GWPA based on verified detection adjacent to 3 GWPAs
Z320	Fresno	14S18E02		DIU (verified) SIM (unverified)	0/0	-	Close out study. No wells available. Recommend LAU and GWPA based on verified detection adjacent to 2 GWPAs
Z321	Fresno	14S19E19	14S19E19	DIU	1/1	dact	Recommend LAU and GWPA
Z344	Fresno	16S18E21		BRO DIU	0/0	-	Close out study. No wells available.
Z345	Fresno	16S19E02	16S19E03 16S19E10	SIM acet	7/4	SIM acet dact	Recommend LAU and GWPA
Z362	Fresno	17S19E22		DIU	3/1	dsmn	Recommend LAU and GWPA
Z367	Tulare	16S26E07		DIU SIM acet	0/0	-	Close out study. No wells available
Z368	Tulare	16S26E35	16S26E26	DIU SIM acet	3/3	SIM acet dact dea	Recommend LAU and GWPA
Z380	Tulare	24S27E01		BRO DIU acet	0/0	-	Close out study. No wells available
Z381	Tulare	24S27E35		BRO DIU SIM acet	0/0	-	Close out study. No wells available
Z383	Kern	26S25E24		BRO DIU	0/0	-	Close out study. No wells available
Z387	Tulare	19S25E26	19S26E35	BRO	5/2	DIU SIM acet dact dea dsmn	Recommend LAU and GWPA
Z405	Fresno	13S18E12		acet	2/2	SIM DIU dact	Recommend LAU and GWPA
Z423	Kern	25S26E18		acet	2/2	SIM acet	Recommend LAU

Table 5.

Z Study	County	Section	Additional Sections	Initial Pesticide Detections Reported	New Wells Sampled / Positive in Nine Section	Pesticides Detected in Study 240 Wells	Notes
						dact	and GWPA
Z425	Merced	05S11E26	05S11E25	acet	3/1	NOR acet dact dsmn	Recommend LAU and GWPA
Z449	Fresno	16S17E14		DIU	0/0	-	Close out study. No wells available.
Z454	Solano	07N01E25	07N01E23 07N01E35	dea	6/3	ATR SIM acet dact dea	Additional positive well in adjacent section. Recommend LAU and GWPA
Z456	Stanislaus	07S09E06		DIU	1/0	DIU HEX	Original well resampled, diuron and hexazinone detected. One additional well sampled, no residues detected. No additional wells available. Close out study
Z458	Tulare	19S23E27	19S23E21 19S23E28	SIM acet	6/6	DIU SIM acet dact	Recommend LAU and GWPA
Z468	Stanislaus	03S11E30	03S11E31	ATR acet dea	4/4	ATR DIU NOR SIM acet dact dea dsmn	Recommend LAU and GWPA
Z471	Merced	06S12E05	05S12E31	BRO	3/1	dact	Recommend LAU and GWPA
Z474	Madera	11S17E28		ATR BRO acet dact dea	1/0	-	Close out study. No additional positive wells.
Z475	Madera	12S17E22	12S17E15	ATR BRO DIU SIM acet dact dea	1/1	DIU acet dact dea	Recommend LAU and GWPA
Z476	Fresno	14S18E30	14S18E29	acet dact	3/1	dact	Recommend LAU and GWPA
Z482	Fresno	15S19E25		SIM	4/1	SIM acet dact	Recommend LAU and GWPA
Z492	Kern	25S25E31		DIU	4/1	dact	Recommend LAU and GWPA
Z493	Kern	25S26E01		DIU acet	1/0	-	Close out study. No additional positive wells.

Table 5.

Z Study	County	Section	Additional Sections	Initial Pesticide Detections Reported	New Wells Sampled / Positive in Nine Section	Pesticides Detected in Study 240 Wells	Notes
Z494	Kern	25S26E16	25S26E10	BRO DIU SIM acet dact	2/1	dact	Original well resampled and all pesticide residues still present. Recommend LAU and GWPA
Z495	Kern	26S25E09		DIU	0/0	-	Original well resampled. No residues detected. No additional wells available. Close out study
Z536	Glenn	18N02W12		DIU SIM	4/0	-	Close out study. No additional positive wells.
Z538	Glenn	21N02W14		ATR dea	1/0		Recommend LAU and GWPA based on atrazine and DEA residues reported from GW03 and GW05 in section 21N02W23
Z539	Glenn	21N02W23		ATR dea	0/0		Recommend LAU and GWPA based on atrazine and DEA residues reported from GW03 in section 21N02W14
Z544	Solano	06N01E22	06N01E14 06N01E21 06N01E23	ATR dea	6/3	ATR DIU HEX dact dea	Additional positive wells in adjacent two sections. Recommend LAU and GWPA
Z569	Tulare	20S24E12	20S25E06 20S25E07	DIU acet	4/3	DIU SIM acet dact	Recommend LAU and GWPA
Z570	Tulare	22S27E08		BRO	0/0	-	Close out study. No wells. Recommend LAU and GWPA based on verified detection adjacent to 2 GWPAs.

Table 6. Potential new GWPAs based on Study 240 and historical detections of pesticides.

Table 6			Detections in Potential GWPA Sections[13]		Detections in Adjacent Section		
County	Section[14]	Site Code	New Wells[15]	Historical Wells[16]	Section	New Wells	Historical Wells
Butte	21N/01E-02			ATR dea	21N/01E-11		DIU NOR SIM
Butte	21N/01E-11			DIU NOR SIM	21N/01E-02		ATR dea
Butte	21N/01E-12			NOR	21N/01E-11		DIU NOR SIM
Colusa	15N/03W-36			SIM	15N/02W-31		SIM acet
Colusa	15N/02W-31			SIM acet	15N/03W-36		SIM
Fresno	13S/18E-12	10-11 10-12	10-11-SIM DIU[17] 10-12-SIM DIU dact	acet	Detection adjacent to 2 GWPAs		
Fresno	13S/19E-17	10-14	dact				
Fresno	13S/19E-27			SIM acet	Detection adjacent to 3 GWPAs		
Fresno	14S/18E-02			DIU SIM	14S/18E-02		SIM
Fresno	14S/18E-11			SIM	14S/18E-15	10-16-dact 10-19-acet dact	
Fresno	14S/18E-15	10-16 10-19	10-16-dact 10-9-acet dact		14S/18E-11		SIM
Fresno	14S/18E-29	10-18	dact		14S/18E-30		acet dact
Fresno	14S/18E-30	10-17		acet dact	14S/18E-29	dact	
Fresno	14S/19E-18	10-21	dact		14S/19E-19		DIU
Fresno	14S/19E-19			DIU	14S/19E-18	dact	
Fresno	15S/19E-25	10-23	SIM acet dact	SIM			
Fresno	16S/19E-02	10-28	SIM acet dact	SIM acet	16S/19E-03	SIM acet dact	
Fresno	16S/19E-03	10-29	SIM acet dact		16S/19E-02	SIM acet dact	
Fresno	16S/19E-10	10-31 10-32	SIM acet dact acet dact		16S/19E-03	SIM acet dact	
Fresno	16S/19E-14			SIM acet	16S/19E-10	SIM acet dact acet dact	
Fresno	16S/19E-16	10-33 10-34	acet dact acet dact		16S/19E-10	SIM acet dact acet dact	
Fresno	16S/19E-20	10-35	acet dact	SIM	16S/19E-16	acet dact acet dact	
Fresno	16S/19E-22			SIM acet dact	16S/19E-16	acet dact acet dact	
Fresno	16S/19E-23			SIM acet	16S/19E-22		SIM acet dact
Fresno	17S/19E-36 Previously recommended by Z573	10-41 10-42 Z573-1 Z573-2	10-41-DIU HEX 10-42-DIU HEX acet dact 1-DIU 2-HEX dact	DIU	Kings Co. 18S/19E-01	DIU	
Glenn	21N/02W-14			ATR dact dea	21N/02W-23		ATR dea
Glenn	21N/02W-23			ATR dea	21N/02W-14		ATR dact dea
Kern	25S/25E-27	15-08	BRO acet dact	BRO			
Kern	25S/25E-31	15-11	dact	DIU			
Kern	25S/26E-10	15-03	dact		25S/26E-16	BRO DIU SIM acet dact t	

[13] Abbreviated pesticide residues found during this study shown for comparison to the pesticide use. Parent residues are shown in CAPS, degradates are shown in lower case versions of the standard acronyms. The parent residues are: ATR=atrazine, BRO=bromacil, DIU=diuron, HEX=hexazinone, NOR=norflurazon, PRO=prometon, SIM=simazine. A number preceding the residue list refers to the Site Code number of the well with the residues.

[14] Township/Range-Section

[15] New wells include wells with pesticide detections sampled by DPR for Study 240 and four-section survey Z573.

[16] Historical wells are wells with pesticide detections sampled by DPR prior to Study 240.

[17] Numbers preceding the pesticide codes correspond to the location number with the detection when multiple wells with detections exist in the section.

Table 6			Detections in Potential GWPA Sections[13]		Detections in Adjacent Section		
County	Section[14]	Site Code	New Wells[15]	Historical Wells[16]	Section	New Wells	Historical Wells
Kern	25S/26E-16	15-04	BRO DIU SIM acet dact	Same well	25S/26E-10	dact	
Kern	25S/26E-18	15-05 15-06	15-05-acet dact 15-06-SIM acet dact	acet			
Madera	12S/17E-03	20-13	DIU acet dact		12S/17E-04	DIU	
Madera	12S/17E-04	20-12	DIU		12S/17E-03	DIU acet dact	
Madera	12S/17E-15	20-15	DIU dea acet dact		12S/17E-22		ATR BRO DIU SIM dea dact
Madera	12S/17E-22			ATR BRO DIU SIM dea dact	12S/17E-15	DIU dea acet dact	
Merced	05S/11E-25	24-02	NOR acet dact dsmn		05S/11E-26		acet
Merced	05S/11E-26			acet	05S/11E-25	NOR acet dact dsmn	
Merced	05S/12E-31	24-05	dact		06/S11E-01	ATR dea dact dsmn	
Merced	06S/12E-05			BRO	05S/12E-31	dact	
Solano	06N/01E-10	48-21	ATR		06N/01E-14	acet dact	
Solano	06N/01E-14	48-20	acet dact		06N/01E-23	ATR DIU HEX dact	
Solano	06N/01E-21	48-02	ATR dea		06N/01E-22		ATR dea
Solano	06N/01E-23	48-23	ATR DIU HEX dact		06N/01E-14	acet dact	
Solano	06N/01W-36	48-08	ATR dea acet	ATR HEX PRO dea			
Solano	07N/01E-23	48-26	SIM acet		07N/01E-25	ATR dea	dea
Solano	07N/01E-25	48-27	ATR dea	dea	07N/01E-23	SIM acet	
Solano	07N/01E-35	48-30	dact		07N/01E-25	ATR dea	dea
Stanislaus	03S/11E-30	50-01	DIU	ATR dea acet	03S/11E-31	50-02-DIU NOR acet dact dsmn 50-03-acet dact dsmn 50-05-ATR SIM dea acet dact	
Stanislaus	03S/11E-31	50-02 50-03 50-05	50-02-DIU NOR acet dact dsmn 50-03-acet dact dsmn 50-05-ATR SIM dea acet dact		03S/11E-30	DIU	ATR dea acet
Stanislaus	04S/11E-06	50-04	ATR DIU SIM acet dact		03S/11E-31	50-02-DIU NOR acet dact dsmn 50-03-acet dact dsmn 50-05-ATR SIM dea acet dact	
Stanislaus	04S/11E-07	50-07	dsmn		04S/11E-06	ATR DIU SIM acet dact	
Tulare	16S/26E-07	-		DIU acet	Detection adjacent to 2 GWPAs		
Tulare	16S/26E-26	54-10	dea		16S/26E-35	54-11-acet dact 54-12-SIM acet dact	DIU SIM acet

Table 6			Detections in Potential GWPA Sections[13]		Detections in Adjacent Section		
County	Section[14]	Site Code	New Wells[15]	Historical Wells[16]	Section	New Wells	Historical Wells
Tulare	16S/26E-35	54-11 54-12	54-11-acet dact 54-12-SIM acet dact	DIU SIM acet	16S/26E-26	dea	
Tulare	19S/23E-21	54-06	DIU acet dact		19S/23E-28	SIM acet	
Tulare	19S/23E-27	54-03 54-04	54-03-SIM acet dact 54-04-SIM acet dact	SIM acet dact	19S/23E-28	SIM acet	
Tulare	19S/23E-28	54-05	SIM acet		19S/23E-27	54-03-SIM acet dact 54-04-SIM acet dact	SIM acet dact
Tulare	19S/23E-34	54-01 54-02	1-acet 2-acet		19S/23E-27	54-03-SIM acet dact 54-0 4-SIM acet dact	
Tulare	19S/25E-26			BRO	19S/25E-27	SIM acet dact dsmn	
Tulare	19S/25E-27	54-107	SIM acet dact dsmn		19S/25E-35	DIU SIM acet dact	
Tulare	19S/25E-35	54-09	DIU SIM acet dact		19S/25E-27	SIM acet dact dsmn	
Tulare	20S/24E-12			DIU acet	20S/25E-06	54-103-SIM acet dact 54-104-DIU	
Tulare	20S/25E-06	54-103 54-104	103-SIM acet dact 104-DIU		20S/25E-07	dact	
Tulare	20S/25E-07	54-102	dact				
Tulare	20S/24E-12			DIU acet	20S/25E-06	54-103-SIM acet dact 54-104-DIU	
Tulare	22S/26E-23	54-109 54-110	54-109-DIU SIM acet dact dsmn 54-110-DIU acet dact		22S/26E-24		DIU
Tulare	22S/26E-33	54-111 54-112	54-111-DIU 54-112-DIU dact	DIU			
Tulare	22S/27E-08	-	-	BRO	Detection adjacent to 5 GWPAs		
Tulare	24S/25E-35	54-30	54-30-acet dact	SIM	Detection adjacent to 4 GWPAs		

Table 7. Summary of results by pesticide detected for Study 240.

The table includes the number of wells with detections, the minimum, maximum, and average concentrations reported (in ppb), the total pounds of active ingredient (AI) applied in nine sections surrounding each detection, and the average use around each detection. Pesticide use is totaled for the period 1990-2004.

Table 7	Detections		Concentrations (ppb)			9-Section Use[18]	
Analyte	Wells	Sections	Mini-mum[19]	Maxi-mum	Average.	Total for All Detections	Average for All Detections
Atrazine	7	7	0.061	0.599	0.164	4,414	631
DEA	7	7	0.059	0.429	0.144	4180	597
Atrazine & Degradate[20] (SUM)	5	5	0.125	1.03	0.367	4,180	836
Atrazine OR Degradate[21] (SUM)	9	9	0.061	1.03	0.24	4,414	490
Bromacil	2	2	0.053	0.096	0.075	416	208
Diuron	21	17	0.057	0.668	0.164	117,110	5,577
Hexazinone	5	4	0.062	0.247	0.122	12,927	2,585
Norflurazon	2	2	0.169	0.465	0.319	6,487	3,244
DSMN	8	7	0.062	0.703	0.198	26,035	3,254
Norflurazon & Degradate[21]	2	2	0.441	1.17	0.086	6,487	3,244
Simazine	19	17	0.052	0.249	0.119	316,340	16,649
ACET	40	31	0.051	0.919	0.172	573,952	14,349
DACT	48	39	0.051	2.14	0.263	714,132	14,878
Simazine & Degradate(s)[21] (SUM)	17	16	0.177	1.83	0.54	28,1634	16,567
Simazine OR Degradate(s)[22] (SUM)	56	45	0.051	2.14	0.398	749,792	13,389

[18] Total pounds of AI applied in the nine-sections surrounding the detection from 1990 -2004
[19] The Reporting Level for all analytes was 0.05 ppb
[20] Wells where both the parent pesticide and at least one of the degradates of that parent were detected. Concentrations listed are summed totals for the parent and degradates present.
[21] Wells where either the parent pesticide or at least one of the degradates of that parent were detected. Concentrations listed are summed totals for the parent and/or degradates present.

Table 8. Summary of detections by CALVUL soil type, pesticide, and reported pesticide use.

Table 8		*CALVUL Preliminary Soil Classification*				
		Leaching	**Runoff**	**Unclassified**	**No Soil Data**	**All Sections**
Total Wells Sampled		50	44	80	3	176
Total Wells with Detections		29	7	30	0	68
% with Detections		58%	16%	38%	0%	39%
Pesticide	**Condition**					
Atrazine	Average Use[22]	0	0	309	0	140
	Average Use - Residues [23]	0	0	735	0	490
	Total Detections / Detections in Areas with No Use[24]	2/2	1/1	6/3	0	9/6
Bromacil	Average Use	13	247	20	0	74
	Average Use - Residues	none	416	0	none	208
	Total Detections / Detections in Areas with No Use	0/0	1/0	1/1	0/0	2/1
Diuron	Average Use	2,272	3,828	3,825	5,386	3,433
	Average Use - Residues	3,857	8,484	5,813	none	5,577
	Total Detections / Detections in Areas with No Use	8/0	4/0	9/0	0/0	21/0
Hexazinone	Average Use	174	132	1,351	629	707
	Average Use - Residues	none	none	2,585	none	2,585
	Total Detections / Detections in Areas with No Use	0/0	0/0	5/0	0/0	5/0
Norflurazon	Average Use	5,160	846	2,094	10	2,628
	Average Use - Residues	4,167	2,454	1,372	none	3,254
	Total Detections / Detections in Areas with No Use	5/0	1/0	2/0	0/0	8/0
Simazine	Average Use	18,741	5,699	3,935	0	8,528
	Average Use - Residues	21,352	15,829	2,484	none	13,389
	Total Detections / Detections in Areas with No Use	26/0	9/0	21/3	0/0	56/3

[22] The total pounds of AI applied 1990-2004 in the nine sections surrounding each sampled well divided by the number of wells sampled. Two wells sampled in the same section will count that section twice.
[23] The total pounds of AI applied 1990-2004 in the nine sections surrounding each well with residues of the parent or any degradates of that parent. Wells with detections of both parent and degradate(s) are counted only once.
[24] Wells with detections of both parent and degradate(s) are counted only once.

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APPENDIX 1

Detail maps of the Study 240 transects and wells sampled for Study 240 and for additional DPR studies sampling for 6800(a)-listed pesticides conducted post Study 240 through 2014.

Figure A1-1. Transects and wells sampled in Butte, Colusa, and Glenn Counties.
Figure A1-2. Transects and wells sampled in Solano and Sacramento Counties.
Figure A1-3. Transects and wells sampled in Stanislaus and Merced Counties.
Figure A1-4. Transects and wells sampled in Fresno, Kings, and Madera Counties.
Figure A1-5. Transects and wells sampled in Tulare, Kings, and northern Kern Counties.
Figure A1-6. Transects and wells sampled in southern Tulare and Kern Counties.
Figure A1-7. Transects and wells sampled in Monterey County.

Figure A1-1. Transects and wells sampled in Butte, Colusa, and Glenn Counties.
No wells were sampled along the yellow transect sections.

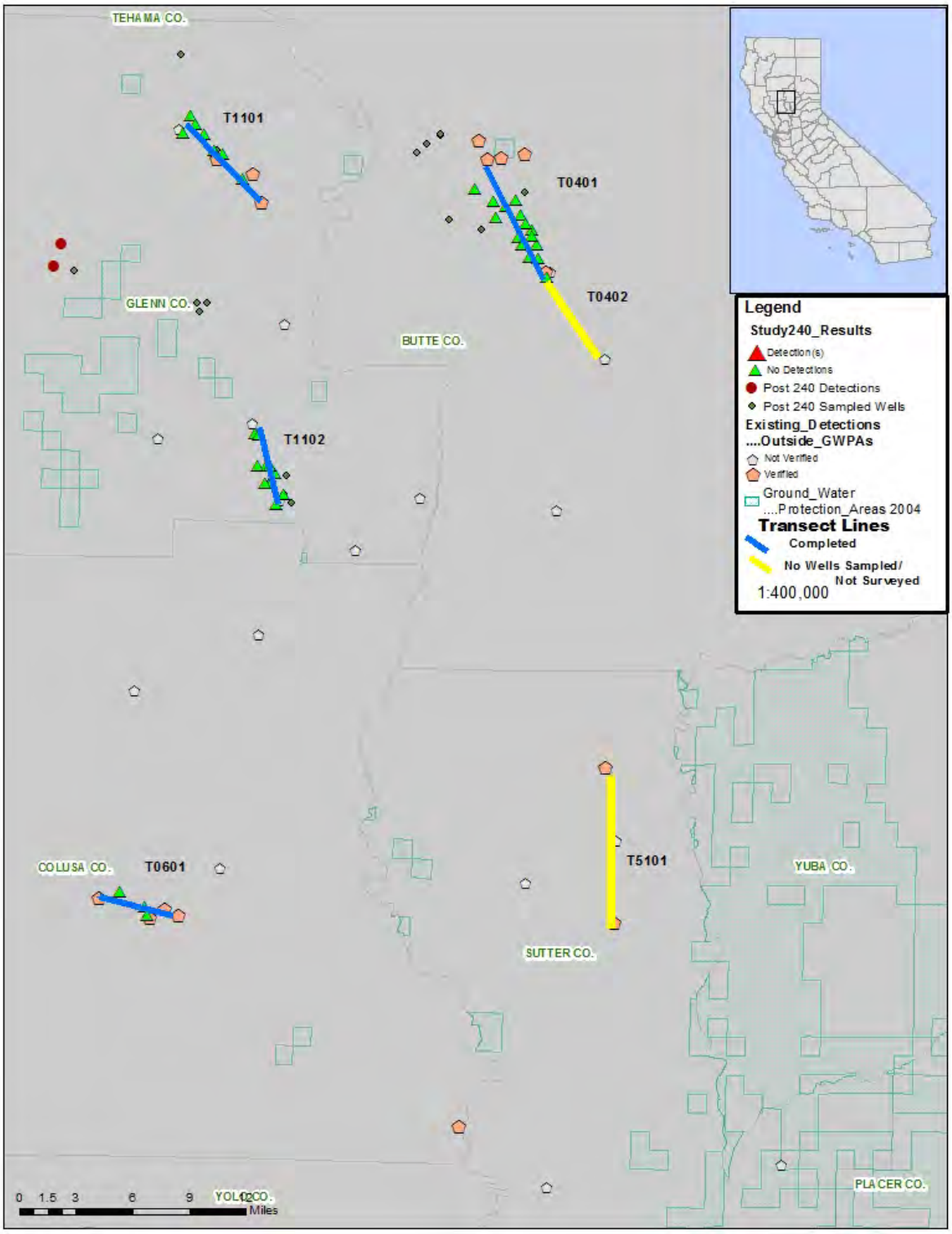

Figure A1-2. Transects and wells sampled in Solano and Sacramento Counties.
No wells were sampled along the yellow transects.

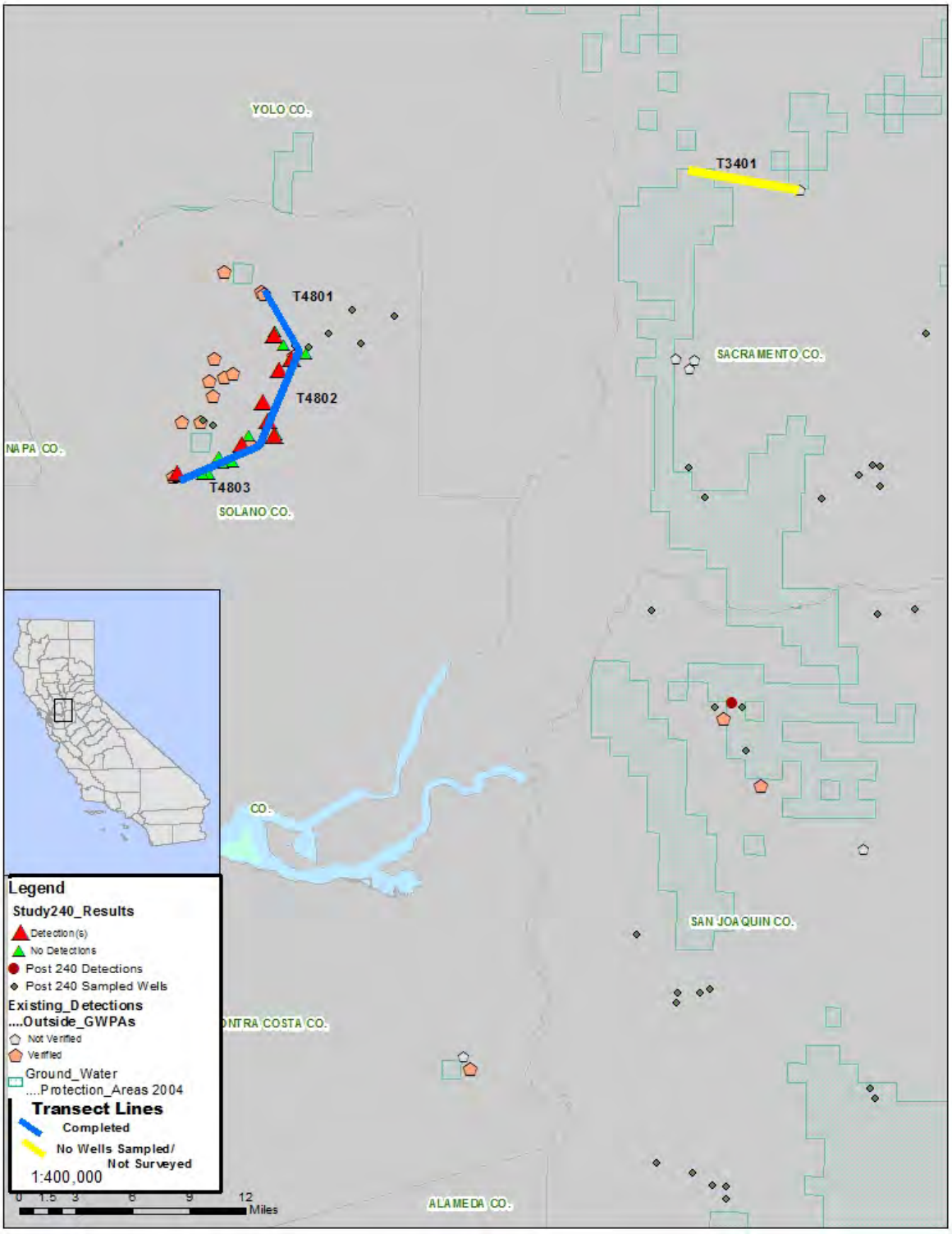

Figure A1-3. Transects and wells sampled in Stanislaus and Merced Counties.

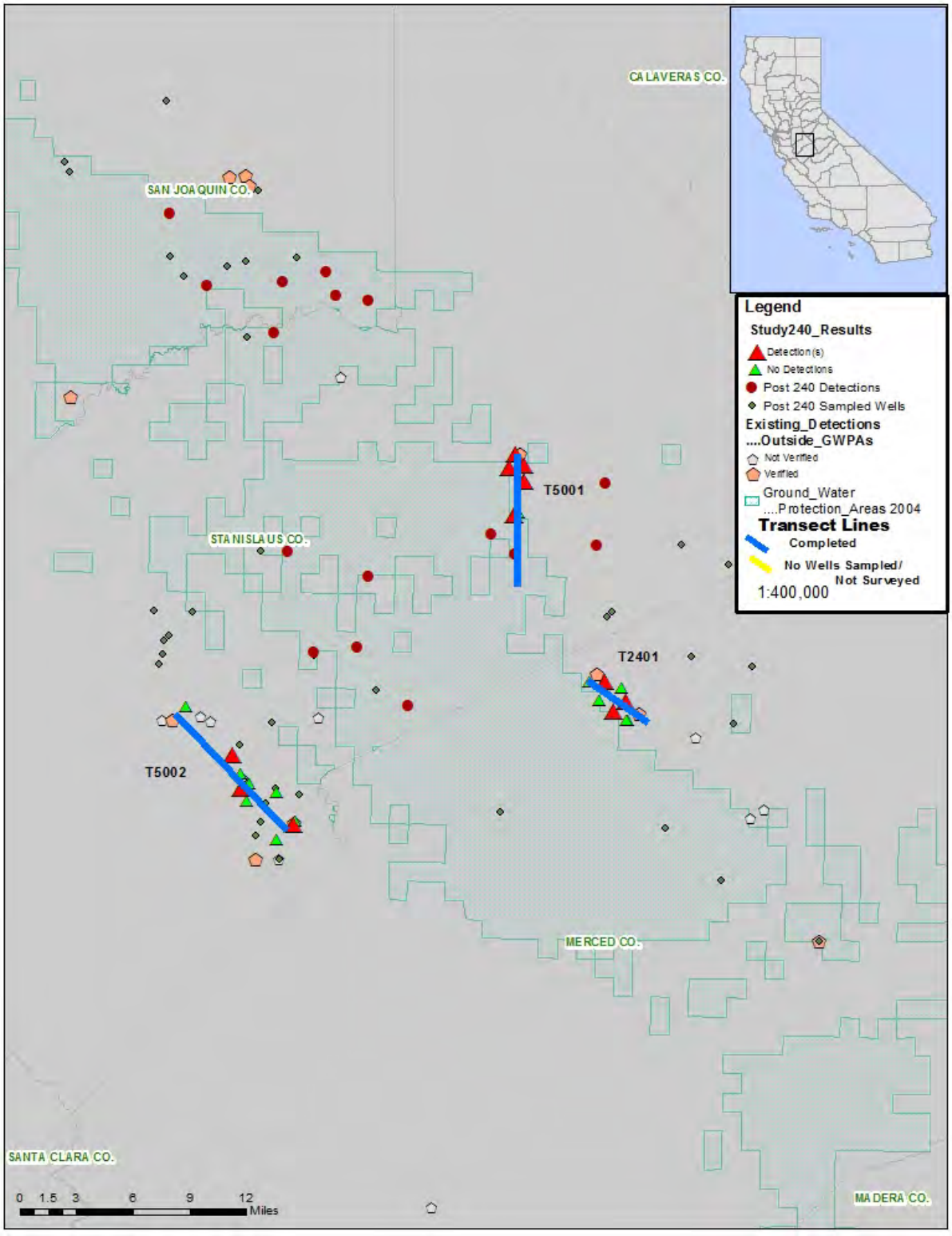

Figure A1-4. Transects and wells sampled in Fresno, Kings, and Madera Counties.
No wells were sampled along the yellow sections of the transects.

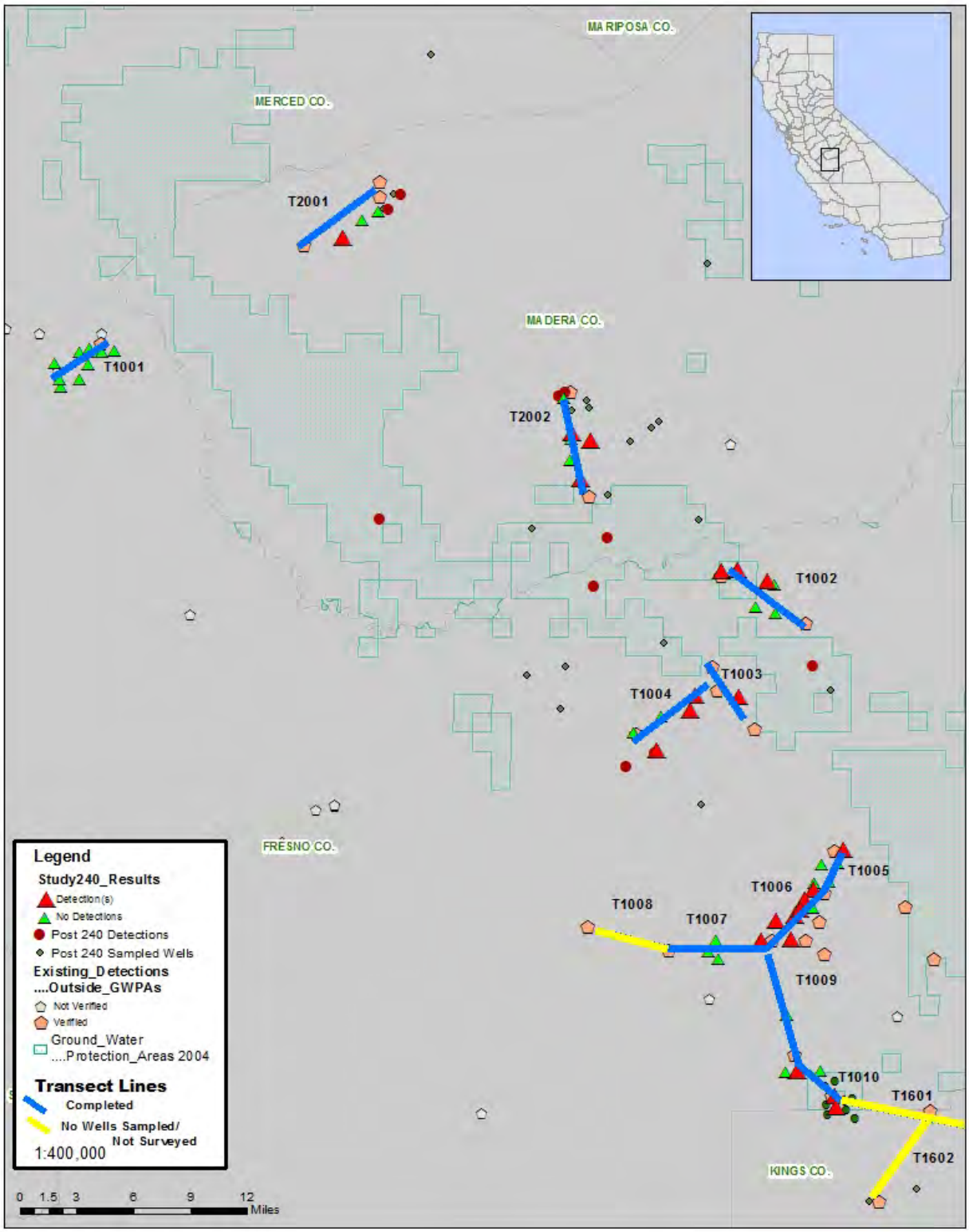

Figure A1-5. Transects and wells sampled in Tulare, Kings, and Kern Counties.
No wells were sampled along the yellow sections of the transects.

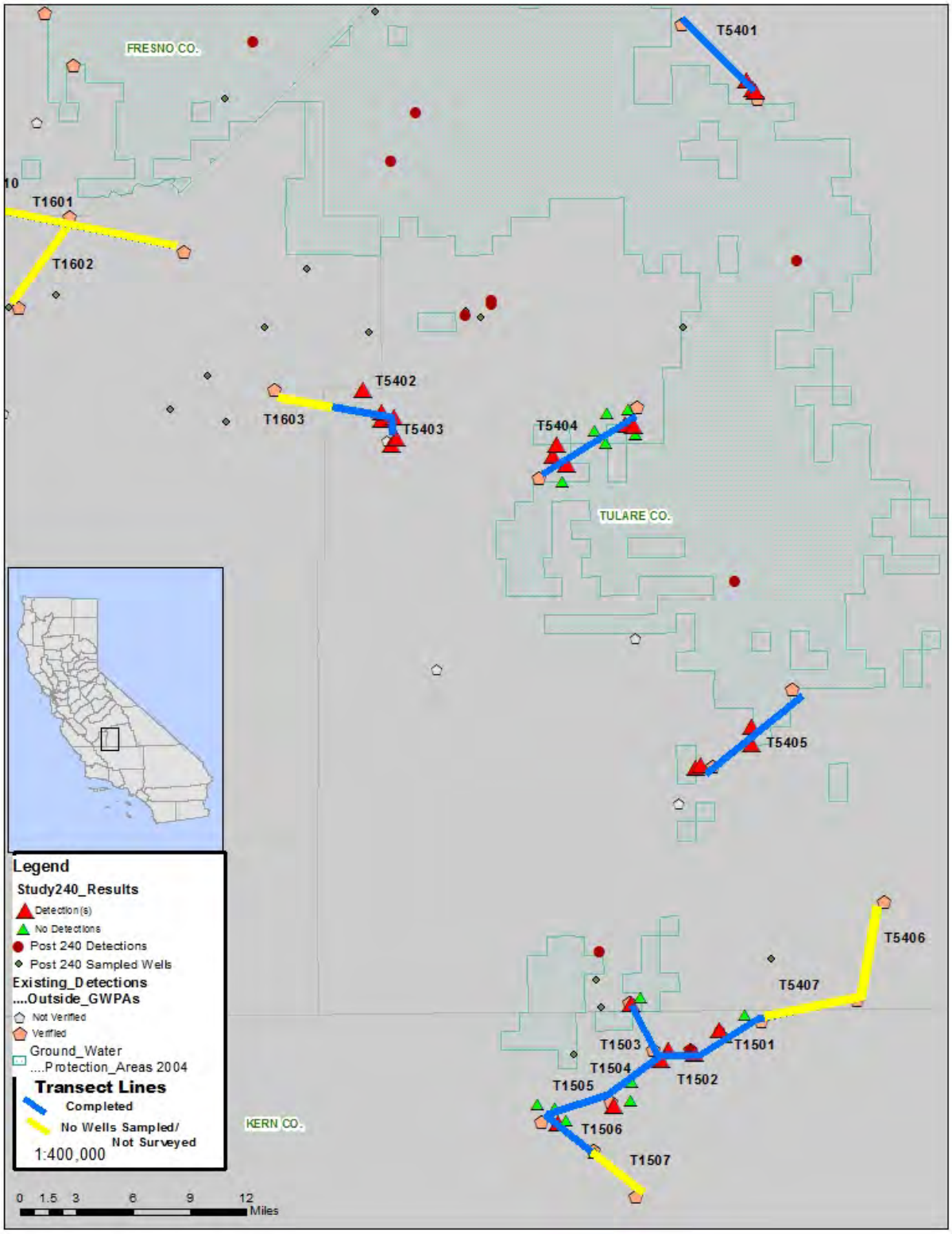

Figure A1-6. Transects and wells sampled in Tulare and Kern Counties.
No wells were sampled along the yellow sections of the transects.

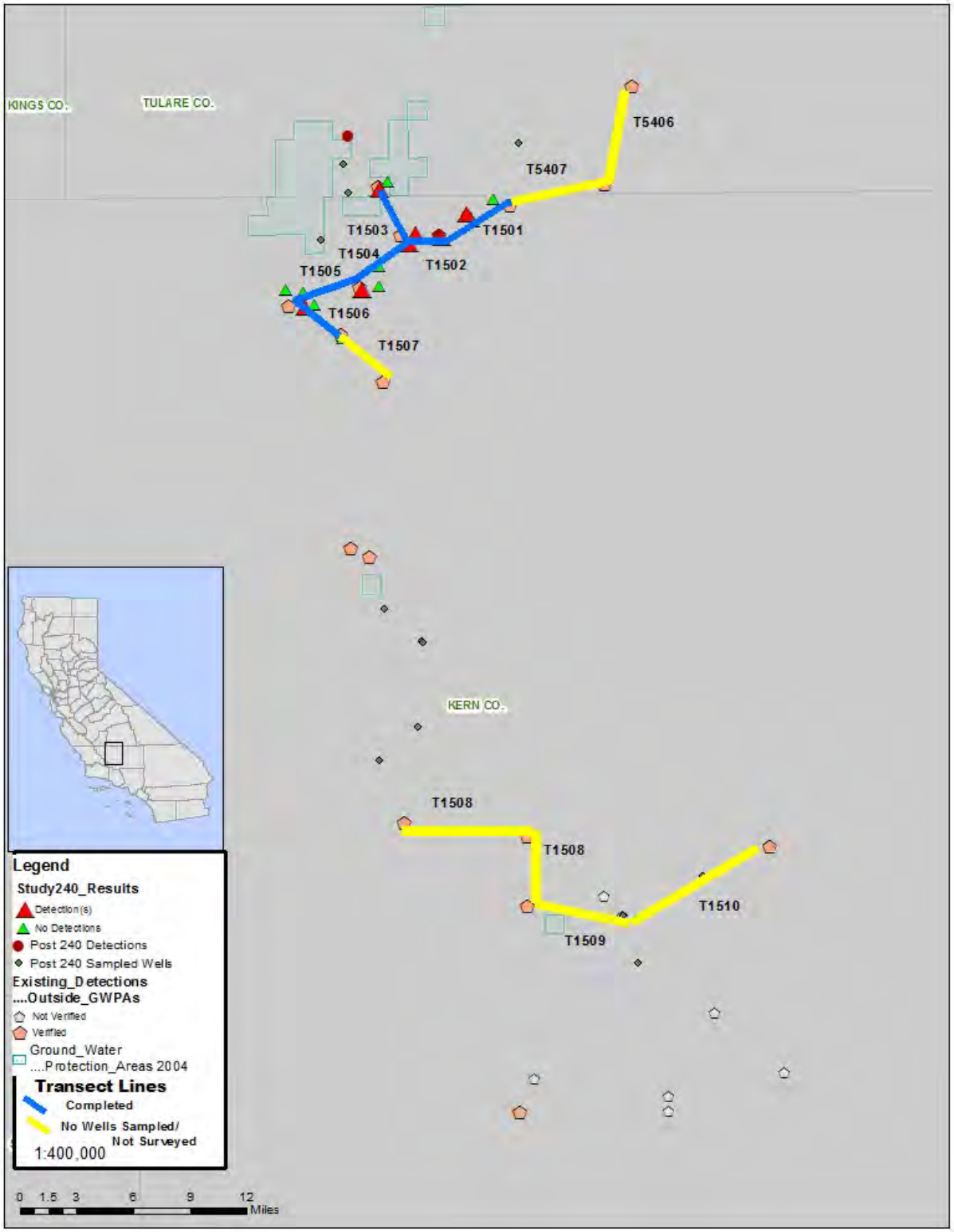

Figure A1-7. Transects and wells sampled in Monterey County.
No wells were sampled along the yellow sections of the transects.