CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

Monitoring of Sediment-bound Contaminants In the Lower Sacramento River Watershed

Surface Water Ambient Monitoring Program (SWAMP) Lower Sacramento River Watershed

FINAL REPORT

July 2004

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EXECUTIVE SUMMARY

To investigate the occurence and possible sources of sediment bound contaminants, sediment samples were collected in April 2003 from three agricultural (Main Drainage Canal, Wadsworth Canal, Jack Slough) and one urban (Dry Creek) influenced waterways in the lower Sacramento River Watershed. Since funding was limited this was a one-time sampling event from six sites. Samples in the Main Canal were collected at three sites to reflect a gradient of agricultural land use. Samples from all other sites were collected from near the downstream reaches of each watershed. Sediment samples were analyzed for metals, polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides (OCs), pyrethroid pesticides, and organophosphate pesticides (OPs). Sediment bound mercury analyses were not conducted.

The Dry Creek sampling site had elevated, relative to lower Sacramento River bed sediments (Alpers et al., 2000), sediment bound concentrations of Pb, Cd, Zn, and Ag. The downstream most sampling site at the Main Canal (Main Canal at Farris Rd.) also had elevated concentrations of metals, as compared to background lower Sacramento River bed, in the sediments including Pb, Cd, Ni, and Zn. Nickel exceeded the effects range-low (ERL) at all agricultural sites (Main Canal, Jack Slough, Wadsworth Canal). However, with the exception of nickel, metals were not measured above probable effects concentrations (PECs; MacDonald et al., 2000) as reported in the literature for freshwater ecosystems.

Total concentrations of PAHs varied from 99 to 2395 ng/g (dry wt.). Selected PAH ratios and PAH distribution patterns indicated both pyrogenic and petrogenic sources in sediment samples. PAHs were not measured above any reported PECs at any sampling location.

Total DDTs exceeded effects range-median (ERM; Long and Morgan, 1991) by four - fold at the Main Canal at Farris. Undegraded DDT concentrations in sediments reflected a gradient of agricultural land use, and increased moving from upstream to downstream in the Main Canal. Generally, DDT and its metabolites were more abundant than other organochlorine pesticides in the agricultural site samples. However, chlordane was the most abundant organochlorine compound measured in sediment from the urban site, Dry Creek, and exceeded the probable effects level (PEL; Smith et al., 1996).

Permethrin was the only pyrethroid pesticide detected, and was measured at the upstream most sampling site in the Main Canal and at Dry Creek at 112 ng/g and 8.1 ng/g, respectively. Lambda-cyhalothrin, cypermethrin, and esfenvalerate pyrethroids were not detected in any samples. Organophosphate pesticides were not detected in any sediment samples. Chlorpyrifos, the most likely OP to be in sediment, had poor laboratory spike recovery. Further studies using direct measures of biological effect, such as sediment toxicity testing, are needed to determine if beneficial uses are being impacted.

INTRODUCTION

This study was conducted as a follow-up to a Surface Water Ambient Monitoring Program (SWAMP) project in the lower Sacramento River Basin from fiscal years 00/01 and 01/02. The SWAMP study identified low biotic index scores of the resident benthic macroinvertebrate communities and poor habitat conditions in effluent dominated and agriculture dominated waterways of the lower Sacramento River watershed (Markiewicz et al., 2004). Low biotic index scores were correlated with many habitat variables and some water quality variables. Unknown was the possible relationship of low biotic index scores and poor sediment quality, as sediment chemistry and sediment toxicity data were not available.

The current study was funded from a portion of the fiscal year 02/03 SWAMP allocation of the lower Sacramento River Basin. Due to the limited funding only sediment chemistry analyses were conducted in this study. Sediment chemistry data will provide information about concentrations of sediment bound contaminants and will be useful for follow up studies using sediment toxicity, if future funding is available. Although sediment toxicity testing provides a direct biological measure of beneficial use impairment, funding was not sufficient for such analyses in this study.

METHODS

Sampling Site Selection

Sediment samples were collected April 16-17, 2003 from three agricultural dominated waterways and one urban waterway in the lower Sacramento River Watershed (Table 1, Figure 1). Generally, all waterways were sampled at the lower reaches of the watershed to reflect potential contaminant inputs within each larger watershed basin. Dry Creek, the urban waterway, was sampled adjacent to the Southern Pacific Railyard in Roseville. Sampling sites within the Main Canal were selected to reflect a gradient of agricultural land use. The Main Canal @ Phil/Fran is the most upstream site in the Main Canal system and is within 50 meters of the supply water diversion from the Sutter Butte Canal. The Main Canal @ Rio Bonito is approximately 1.5 kilometers downstream from Phil/Fran. The Main Canal @ Farris is approximately 10 kilometers downstream of Phil/Fran. Jack Slough and Wadsworth Canal were sampled downstream of all agricultural land use within each sub-watershed.

Table 1. Sampling site information.

Site Code	Site Name	Dominant Land Use	County	Latitude	Longitude
1	Dry Creek @ Atkinson	Urban	Placer	38.73415	121.30750
2	Jack Slough @ Doc Adams	Agriculture	Yuba	39.16145	121.59619
3	Wadsworth Canal @ Franklin	Agriculture	Sutter	39.13018	121.75288
4	Main Canal @ Phil/Fran	Agriculture	Butte	39.43585	121.67890
5	Main Canal @ Rio Bonito	Agriculture	Butte	39.42521	121.68613
6	Main Canal @ Farris	Agriculture	Butte	39.38539	121.78172

Sample Collection and Storage

Samples were collected from depositional zones within stream channel. Fine grain sediments were targeted. The upper 2.0 cm of sediment was collected using a large stainless steel spoon and placed into a 1.0 liter glass amber jar. Samples were immediately placed on wet ice and transported to the University of California, Davis Department of Environmental Engineering Laboratory. Upon delivery at the laboratory, samples were stored at 4 C^0 in temperature controlled environmental chambers until extraction and analysis.

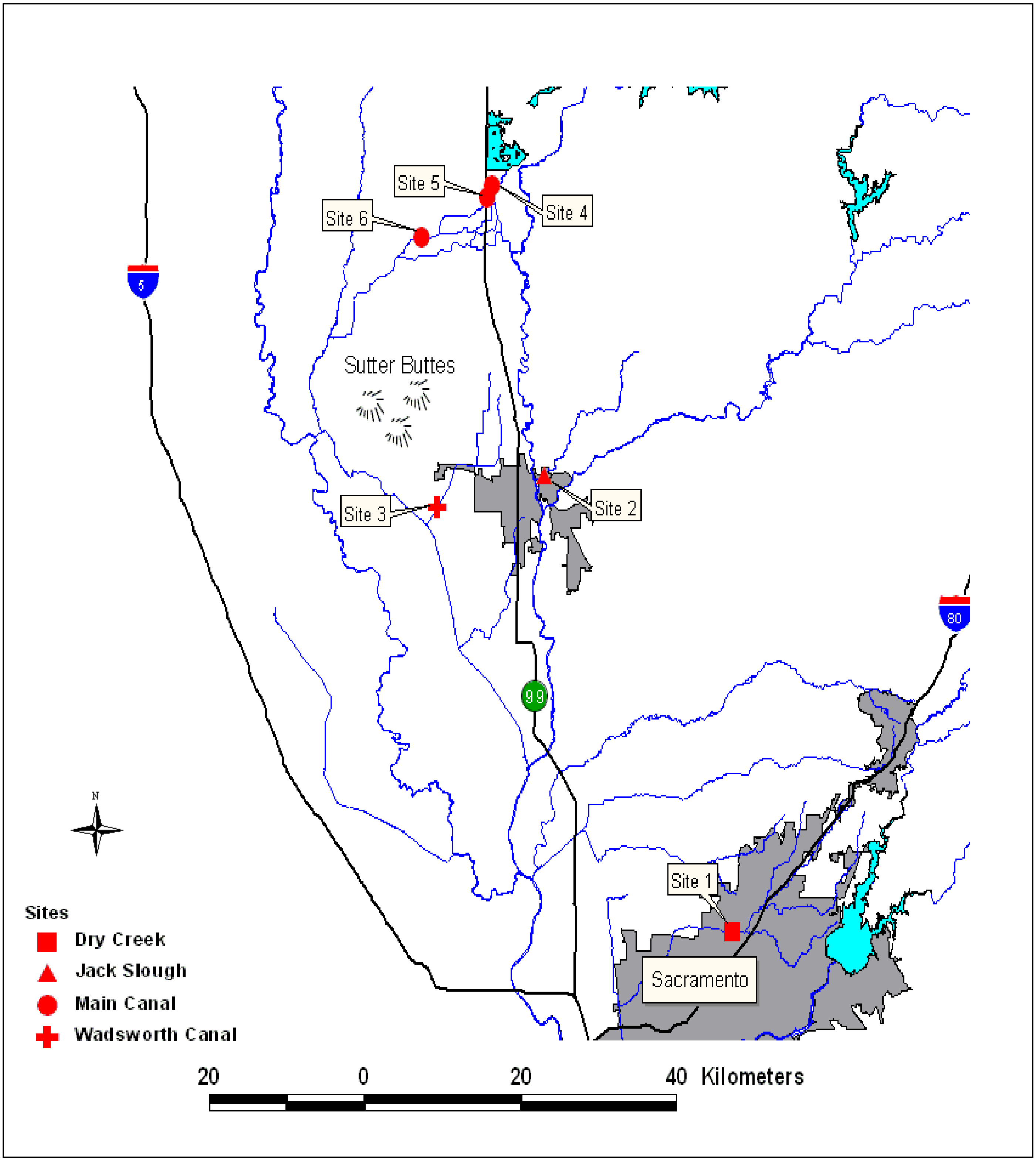

Figure 1. Sampling sites for sediment bound contaminants in the lower Sacramento River Watershed (April 16-17, 2003).

Inorganics Analyses

For elemental analysis by ICP-MS, samples were digested with nitric acid and hydrogen peroxide followed by dilution, following a modified version of EPA's Acid Digestion Of Sediments, Sludges, And Soils (Method 3050B). The modification to EPA 3050B consisted of substituting open heating in glassware to pressurized sonication in new plasticware (EQL SOP E-10.1 and D-16.1). Normalization to Iron was used to compare environmental concentrations of metals with those reported in past studies of lower Sacramento River sediments (Colusa to Freeport).

Organics Analyses

For organic chemical analyses, Environmental Quality Laboratory Standard Operating Procedures (EQL, 2003) and EPA Method 8141A were adopted. Standard Operating Procedures can be found at the Environmental Quality Laboratory, Department of Civil and Environmental Engineering, University of California, Davis.

Homogenized wet sediment samples (~ 20g) were mixed with sodium sulfate and extracted with acetone and hexane sequentially for 24 hours using Soxhlet extraction apparatus (EQL SOP E-01.1). Surrogate standard solutions were added before extraction for quantification. Deuterated PAHs (naphthalene-d_8, acenanaphthene-d_{10}, phenanthrene-d_{10}, crysene-d_{12}, and perylene-d_{10}) were used for PAHs. TCMX and PCB 103 were used for OC pesticides and pyrethroid pesticides. Extracts were then concentrated using a rotary evaporator to reduce the volume (EQL SOP C-01.1). After concentration to 1 mL of hexane, the extracts were cleaned using Florisil column chromatography to remove interferences (EQL SOP P-01.1). Identification and quantification of organic contaminants were accomplished using a Hewlett-Packard 6890 gas chromatography equipped with a J&W DB-5MS fused-silica capillary column (30 m × 0.25 mm ID, 0.25 μm film thickness) and a Hewlett-Packard 5973 mass selective detector (MSD). The MSD was operated in the electron ionization (EI, 70 eV) and the selected ion monitoring (SIM) modes.

The oven temperature for PAHs was programmed to start initially at 60 °C, increased to 150 °C at 15 °C/min, increased to 220 °C at 5 °C/min, increased to 300 °C at 10 °C/min, and held for 10 min (EQL SOP D-01.1). The oven temperature for OC pesticides was programmed to start initially at 80 °C, increased to 170 °C at 12 °C/min, increased to 210 °C at 1 °C/min, increased to 300 °C at 20 °C/min, and held for 8 min (EQL SOP D-03.1). The oven temperature for pyrethroid pesticides was programmed to start initially at 80 °C, increased to 150 °C at 15 °C/min, increased to 220 °C at 5 °C/min, increased to 310 °C at 7 °C/min, and held for 5 min (EQL SOP D-05.1). The oven temperature for OP pesticides was programmed to start initially at 50 °C for 1 minute, ramp 25 °C/min up to 100 °C, then ramp up 5 °C/min to 300°C and hold for 5 minutes (EPA Method 8141A). Method detection limits and reporting limits are presented in Table 3, Table 4, Table 5, Table 6, and Table 7.

QA/QC

All monitoring included adequate quality assurance/quality control measures consistent with the State of California Surface Water Ambient Monitoring Program (SWAMP) Quality Assurance Project Plan (QAPP; Puckett, 2001). Laboratory procedural blanks, split samples, matrix spikes, and surrogate recovery were the types of quality-control data collected (Table 8, Table 9, Table 10, Table 11, Table 12). Laboratory blank and split samples were processed in a manner identical to environmental samples. Concentrations reported are dry weight basis (ng/g dry wt. for organics and µg/g dry wt. for metals). To measure water contents in sediment, an aliquot (~ 1 g) of homogenized wet sediments was dried in the oven (60 °C) for 24 hours.

Laboratory procedural blanks were processed with each batch of sample analytes. None of the inorganics, organochlorine pesticides, or pyrethroid pesticides was detected in the equipment blanks. Four PAHs (naphthalene, biphenyl, phenanthrene, and C1-phe/ant) of the thirty-seven included in the scan were detected above the method detection limit (MDL) in the laboratory blanks.

Percent difference in split sample analyses of inorganics ranged between 1 percent and 14 percent. The average percent difference was 4 percent with standard deviation of 3.7 for the split sample analysis of the fifteen inorganics. Percent difference in split sample analyses of detected organochlorine pesticides ranges between 7 percent and 18% (n = 4, average = 12%, standard deviation = 4.4). Split sample analyses were not conducted on PAHs and pyrethroid pesticides.

Matrix spikes were only conducted with PAHs and organophosphate pesticides. The recovery rates of 19 PAHs were measured using a sediment sample from Jack Slough. The recovery rates of all spiked PAHs (except acenaphthylene and anthracene) were between 75 and 125%. Nine organophosphate pesticides were determined for the matrix spike: three (dimethoate, monocroptophos, TEPP) were not detected (though two of them are not used in California), chlorpyrifos had poor recovery (~15%), and five (diazinon, EPN, malathion, parathion, sulfotepp) were acceptable between 72% and 137%.

The recovery rates of surrogate standards ranged from 54 to 109% for deuterated PAHs and 72 to 89% for TCMX and PCB 103. Triphenylphosphate was used as the surrogate for organophosphate pesticides and showed recovery between 100% and 129% for all samples except Dry Creek. Surrogate recoveries were 102% for lab blank, 121% for duplicate sample, and 123% for matrix spike (for a sub-sample of the same field sample).

Sediment Particle Size and Organic Carbon

Relative masses of sediment particle size were determined by sieving after drying to constant weight, followed by gentle crushing by mortar and pestle. Organic carbon was not measured due to lack of funding.

Sediment Quality

Numerical sediment quality guidelines for contaminants in freshwater ecosystems were used to estimate the potential for adverse effects to aquatic life (MacDonald et al., 2000).

RESULTS

Inorganics

Iron normalized concentrations of metals were relatively low compared to regional waterway sediment in Sacramento River, CA (Figure 2; Alpers et al., 2000). Minor exceptions to the low concentrations of metals (Pb, Ni, Cu, and Zn) in the sediments were the samplings sites at Dry Creek, and the Main Canal at Farris, which had the highest number metals constituents that were elevated in comparison to Sacramento River bed sediments. Lead was detected at approximately 7 to 8 times the concentration of lead in the Sacramento River bed at the Dry Creek and Main Canal at Farris. Further, copper was detected at approximately 3 to 5 times the concentration of copper in the Sacramento River Bed at all downstream agricultural sites, and at the Dry Creek site.

Of the metals measured in sediments, only nickel was found at levels exceeding aquatic life concern thresholds. Nickel concentration exceeded the ERM (51.6 ppm) in sediment from Main Canal at Farris (99.8 ppm) and at Wadsworth Canal (83.4 ppm; Figure 3). In addition, the ERL for nickel was exceeded at all other agricultural sites.

Organics

The concentrations of organochlorine pesticides in sediment samples are given in Appendix A. Total DDT (DDT + DDD + DDE) concentrations were highest in the Main Canal (Figure 4) and exceeded the ERL (1.6 ppb) at all sites (Figure 5). DDT levels in samples from Main Canal reflected the upstream to downstream gradient in agricultural land use. Further, total DDT concentration (194 ng/g) exceeded the ERM (46 ppb) by 4 times at the downstream Main Canal sampling site (Main Canal at Farris). In this sediment, DDT was dominant over DDD and DDE, suggesting possible fresh input of DDT (Figure 5; Figure 6; Figure 7). Chlordanes in sediment from the Dry Creek site exceeded the PEL (4.7 ppb). Sixteen and seventeen PAHs were measured less than the MDL and not detected in the thirty-seven chemical scan, respectively. The concentrations of total PAHs in sediments ranged from 99 to 2395 ng/g (Figure 8). Distribution patterns of PAHs in sediments from the Dry Creek and Main Canal at Farris are distinct, indicating different sources (Figure 9). The PAH sample from the Main Canal was dominated by petroleum originated PAHs (e.g., petroleum oil as a pesticide, gasoline to burn rice straws), while PAHs in the Dry Creek sample had primarily a pyrogenic input. However, none of the samples had PAHs above the ERM values.

Permethrin was the only pyrethroid pesticide detected, and was measured at the upstream-most site in the Main Canal and at Dry Creek at 112 ng/g and 8.1 ng/g, respectively. Lambda-cyhalothrin, cypermethrin, and esfenvalerate were not detected in any samples. It should be noted that QA/QC data were limited with pyrethroid pesticides.

Organophosphate pesticides of regional concern, including chlorpyrifos, one of the highest used organophosphate pesticides in the region, was not detected in sediments. However, chlorpyrifos had poor spike recovery (~15%). Based upon method detection limits and associated quality assurance results OPs were not present in any of the samples above 20 ng/g, with a somewhat higher cut-off of 60 ng/g for chlorpyrifos.

Inorganic and organic sediment bound chemistry data are presented in Appendices A (inorganics), Appendix B (organochlorine pesticides), Appendix C (polyaromatic hydrocarbons), Appendix D (pyrethroid pesticides), and Appendix E (organophosphate pesticides). Ambient water quality data are presented in Appendix F. Site pictures are presented in Appendix G.

Sediment Particle Size

Sediment samples had varying particle sizes with highest relative masses of finer particles in sizes <0.032 to <0.6 mm (Table 2). Generally, particle sizes less than 1 mm are considered silts and clays. Samples with percentages of the coarser materials will not typically reveal the occurrence of sediment bound contaminants associated with fine sediments.

Table 2. Relative masses of sediment samples.

	Dry Creek	Jack Slough	Wadsworth Canal	Main Canal @ Phil/Fran	Main Canal @Rio Bonito	Main Canal @ Farris
>2 mm	0	0	0	0	0	0
>0.6 mm	0.013	0.310	0.011	0.364	0.252	0.193
>0.25 mm	0.425	0.308	0.652	0.173	0.179	0.260
>0.1 mm	0.470	0.228	0.316	0.194	0.184	0.281
>0.32 mm	0.081	0.141	0.018	0.238	0.325	0.222
<0.32 mm	0.011	0.012	0.003	0.030	0.060	0.043

DISCUSSION

This study included evaluation of sediment bound contaminants from a one time screening-level sampling event (April 2003) at six sites in the Lower Sacramento River Watershed. Each sampling site consisted of one sample collected from a depositional area in each waterway. Overall, poor sediment quality was found at each sampling site as indicated by multiple exceedances of sediment quality guidelines and associated probable effects levels for freshwater aquatic life. Direct biological effects of sediments were not investigated in this study, as funding was limited. However, of all the sediment bound contaminants measured in this study, only one inorganic (nickel), and two organics - organochlorine (DDT), and pyrethroid (permethrin) pesticides were found to be of potential concern for aquatic life, and may need further investigation. Direct measures of biological effects of sediment-bound contaminants, such as sediment toxicity tests, are recommended as follow up.

A sediment quality guideline approach was used in this investigation as a way to explore possible need for follow up evaluation using direct measures of biological effects. Because there is no relationship established between sediment quality guidelines and an adverse impact on beneficial uses of the waterway in which the sediments originated the utility of such an approach is limited. Lee and Jones-Lee (2002b) question the reliability of the sediment quality approaches and caution the use of such approaches for evaluating sediment quality. Lee and Jones-Lee (2002a) point out that the sediment quality approaches are based upon a number of “inherent and invalid” assumptions. One such assumption is that the sediment quality approach presumes that there is a direct causal relationship between the concentration of each contaminant in sediment and the water quality impact of that sediment. Therefore, comparisons of the sediment quality guidelines and measured sediment-bound contaminants in this study do not allow for establishment of a link between measured sediment contaminant concentrations and beneficial use impairment. However, the sediment chemistry concentrations measured in this limited screening-level study will be useful for planning follow up studies.

A goal of SWAMP investigations in the lower Sacramento River Basin is to compare and contrast current monitoring data with data collected by other stakeholders. However, published data of sediment bound contaminant chemistry in the lower Sacramento River Watershed are limited. Most published water quality studies in the lower Sacramento River Watershed have not included sediment chemistry analyses, but instead water column chemistry, water column toxicity, fish tissue contaminant concentrations, and more recently sediment toxicity. For example, the Sacramento River Watershed Program (SRWP) collects and reports water quality data as part of a coordinated multi-agency collaborative stakeholder approach. The SRWP water quality monitoring component has included analyses of mercury (in water and fish tissue), trace metals in water, drinking water parameters of concern, aquatic toxicity, sediment toxicity, organochlorine compounds and PCBs in fish tissue, and bioassessment (Larry Walker Associates, 2003). The current SRWP water quality monitoring program does not include analyses of sediment bound contaminants. Therefore, the SRWP data could not be directly compared and/or contrasted with the results of this study.

Sediment-bound contaminants have been measured in Central Valley waterways by other investigators. MacCoy and Domagalski (1999) measured organochlorine pesticides in sediments and biota of the Sacramento River Basin. Further, MacCoy and Domagalski (1999) observed a gradient of organochlorine pesticide concentrations in sediments and biota with the highest concentrations found in downriver samples. The authors suggest the concentration gradient of organochlorine pesticides reflects a gradient of agricultural land use. These results are similar to the current study, in which increased concentrations of organochlorine pesticides were detected at the lower more agriculturally dominated reaches of the Main Drain (at Farris Rd.). The Main Canal was the only waterway in this study in which sediment samples were collected at various reaches reflecting increasing agricultural land use.

Brown (1998) reported both sediment and tissue bound contaminants at 18 sites in the Valley Floor Region of the San Joaquin River Watershed. Organochlorine compounds were the most frequently detected compounds in both media, and the highest concentrations were detected in the west side San Joaquin River tributaries. Further, Brown (1998) reported that concentrations of chlorinated organic compounds in biota, and possibly sediments, have decreased from concentrations measured in the 1970s and 1980s. The same trend would be expected in the Sacramento River Basin. Although, such a hypothesis is difficult to explore with the current limited data set. However, whether decreasing or remaining constant, data from the current study indicate that organochlorine pesticides are still detectable in the sediments at some locations, some three decades after being banned. Recent studies have reported organochlorine pesticides existing in fish tissue from the Sacramento River Watershed and downstream Delta (Davis et al., 2003). Lee and Jones-Lee (2002b) have prepared a management guidance document, which includes management guidance for organochlorine pesticides in waterways of the Central Valley.

Permethrin was the only pyrethroid insecticide measured in sediment samples from the current study, and was detected at the upper Main Canal site. Weston et al., (2004) reported sediment bound pesticides, particularly pyrethroid insecticides, as being linked to test organism mortality in freshwater sediment toxicity tests using agricultural waterway sediments from throughout the Central Valley. Further, Weston et al., (2004) detected permethrin in 75 percent of all toxic chemistry samples, with a maximum concentration of 129 ng/g. Similarly, permethrin was measured in the current study, at a concentration of 112 ng/g in the Main Canal. Weston et al., (2004) reported a *hyalella*, a common aquatic toxicity testing and resident benthic species, LC50 for permethrin ranging between 60-90 ng/g. Weston et al., (2004) also reported that the potential for sediment bound pyrethroid pesticide toxicity is greatest during or near the application time period of the pyrethroid pesticide (July – August in the Central Valley). The measured concentration of permethrin in sediments from the Main Canal is greater than the reported LC50 for *hyalella* suggesting possible adverse biological effects and indicating a need for follow up with sediment toxicity testing.

In addition to organochlorine and pyrethroid pesticides, organophosphate pesticides, PAHs, and metals were also measured in sediments in the current study. Organophosphate pesticides were not detected in any samples. However, QAQC results for chlorpyrifos, the most likely organophosphate pesticide to be sediment-bound, were not acceptable. Since this was a one-time limited screening-level sampling event there was not a chance to correct QAQC recovery levels for chlorpyrifos. Although not reported above any toxicological thresholds, PAHs were measured at most sites, and based upon chemistry patterns suggested differing origins in Dry Creek (urban) versus agricultural sites. Of the metals bound to sediment, nickel concentrations from all agricultural sites exceeded thresholds for aquatic life. However, it is not known if the source of the nickel is related to agricultural practices, geology, or other factors. Ambient water quality monitoring programs from other regions of the state have also reported elevated nickel in sediments. The source of elevated nickel in sediments is considered geological from two such monitoring programs, one in San Francisco Estuary (Karen Taberski, personnal communication; Regional Monitoring Program data at www.sfei.org), and one on the California Central Coast Region (Karen Worchester, personnal communication; 1998 Coastal Confluences Sediment Chemistry Assessment).

In summary, follow up studies are recommended using sediment toxicity tests particularly at sites where pyrethroid pesticides were measured. Fish tissue analyses may be useful for examining bioaccumulation of organochlorine compounds at sites with elevated DDT. It is also recommended that further work examine the origin(s) of the undegraded DDT in the Main Canal watershed.

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Figures

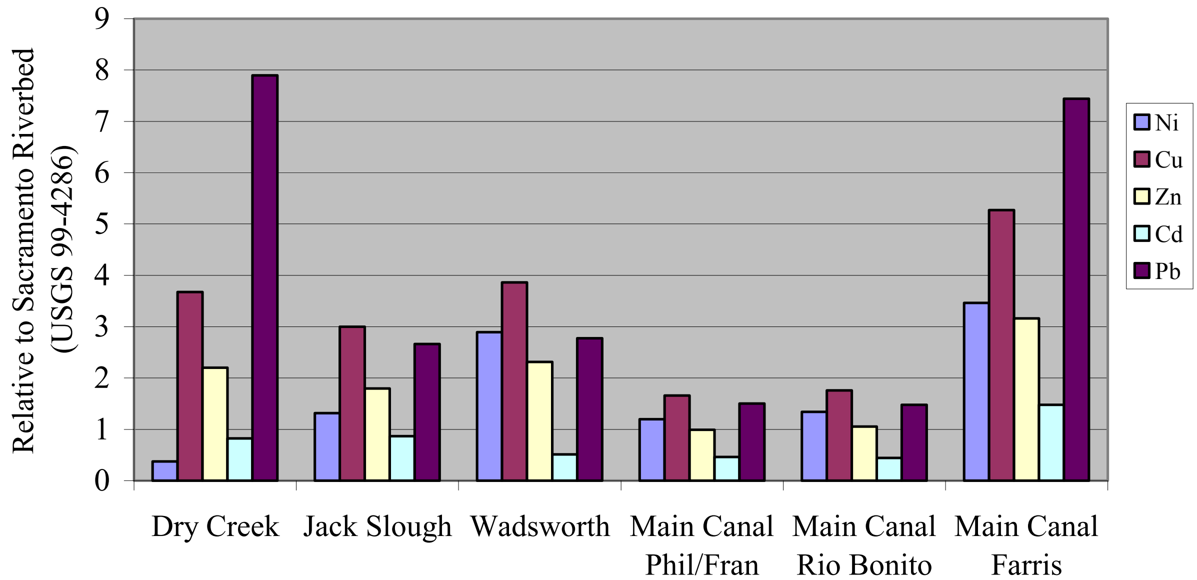

Figure 2. Metals in sediments (normalized to iron, by dry inorganic weight) relative to Sacramento Riverbed (USGS 99-4286).

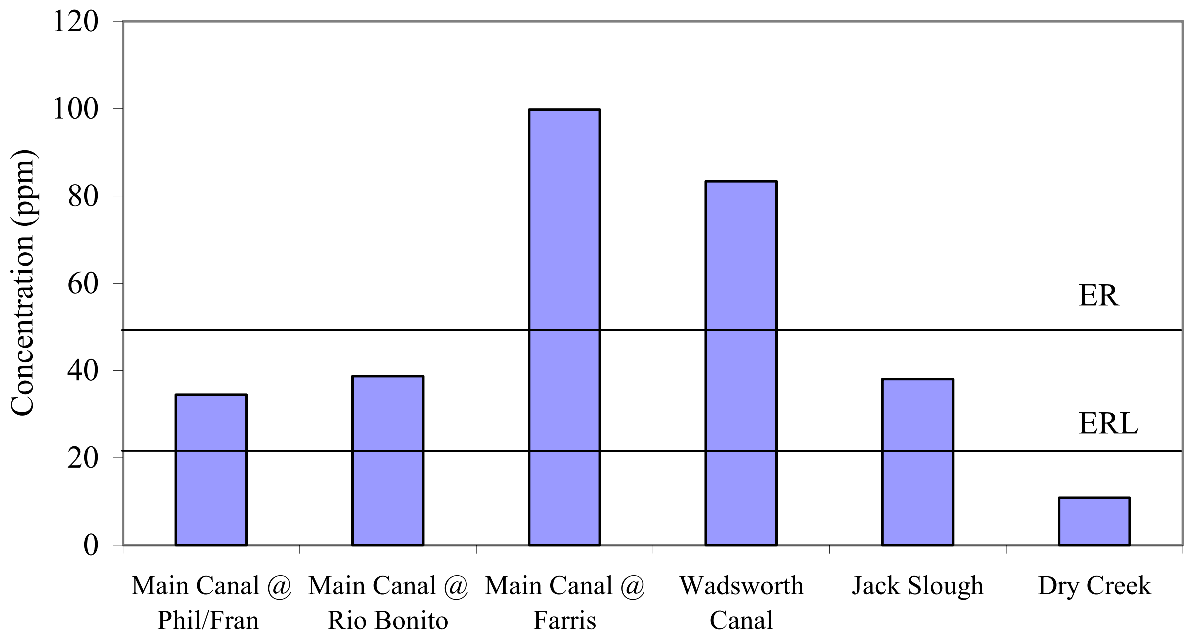

Figure 3. Nickel concentrations in sediments by dry weight (ug/g).

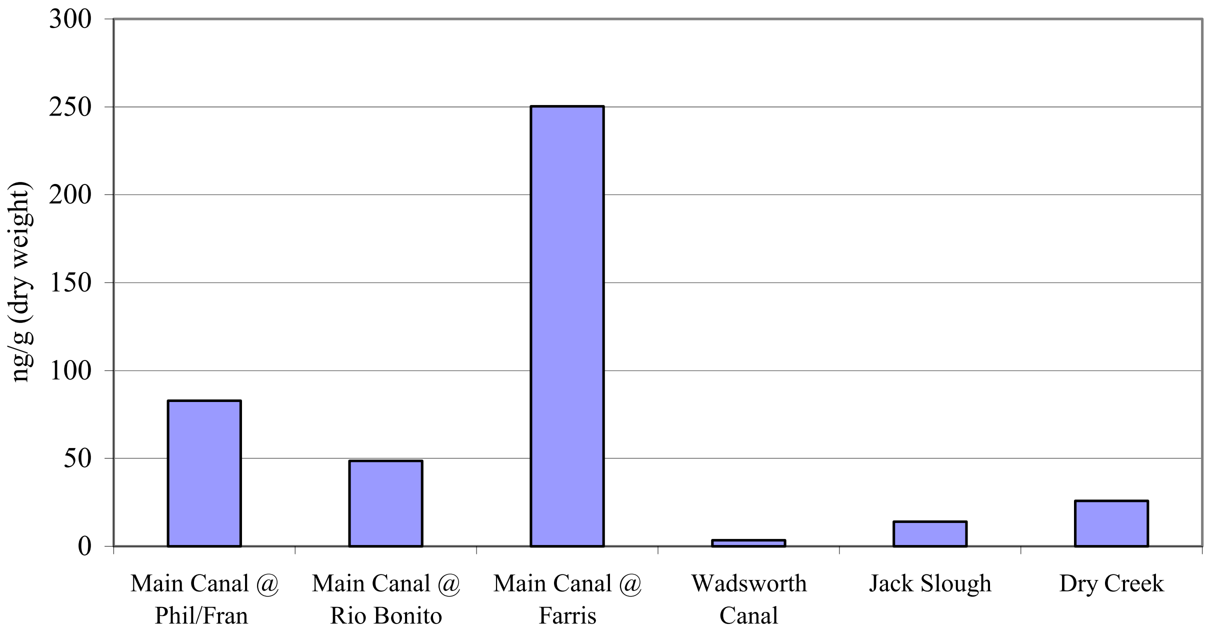

Figure 4. Total organochlorine pesticides by dry weight (ppm).

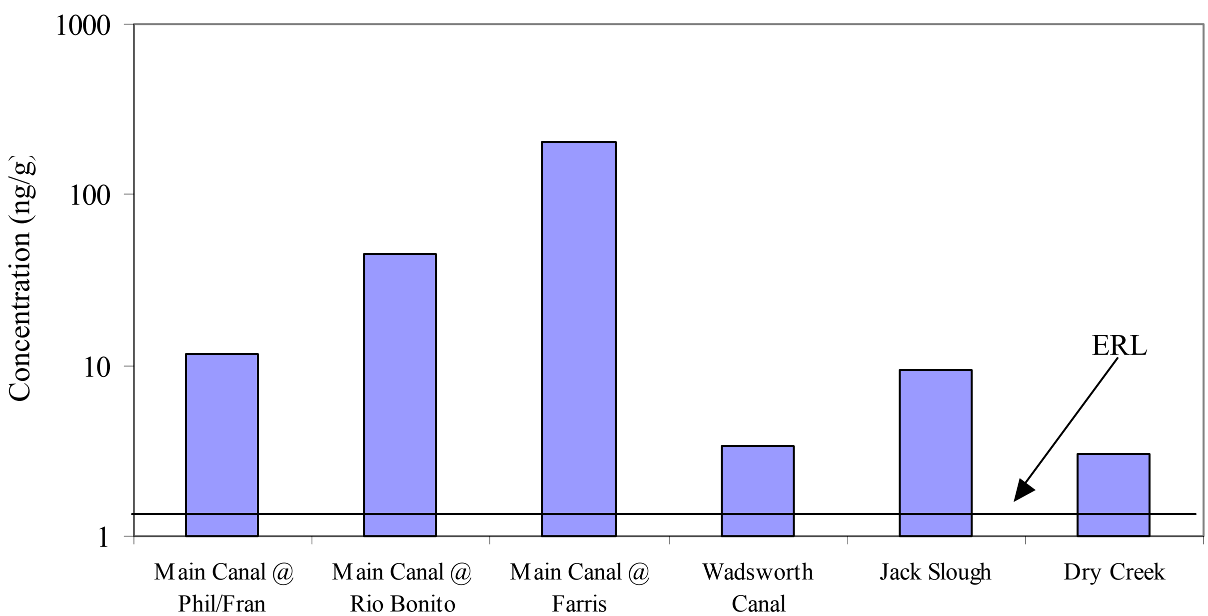

Figure 5. Concentrations of total DDTs in sediments (ng/g).

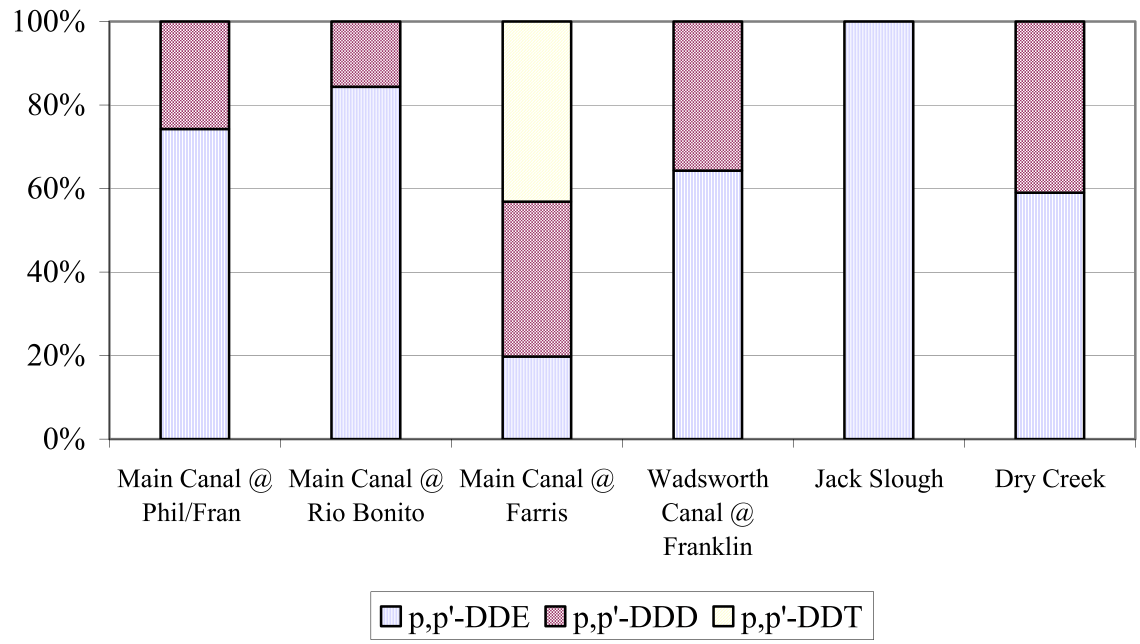

Figure 6. Distribution patterns of DDTs in sediments

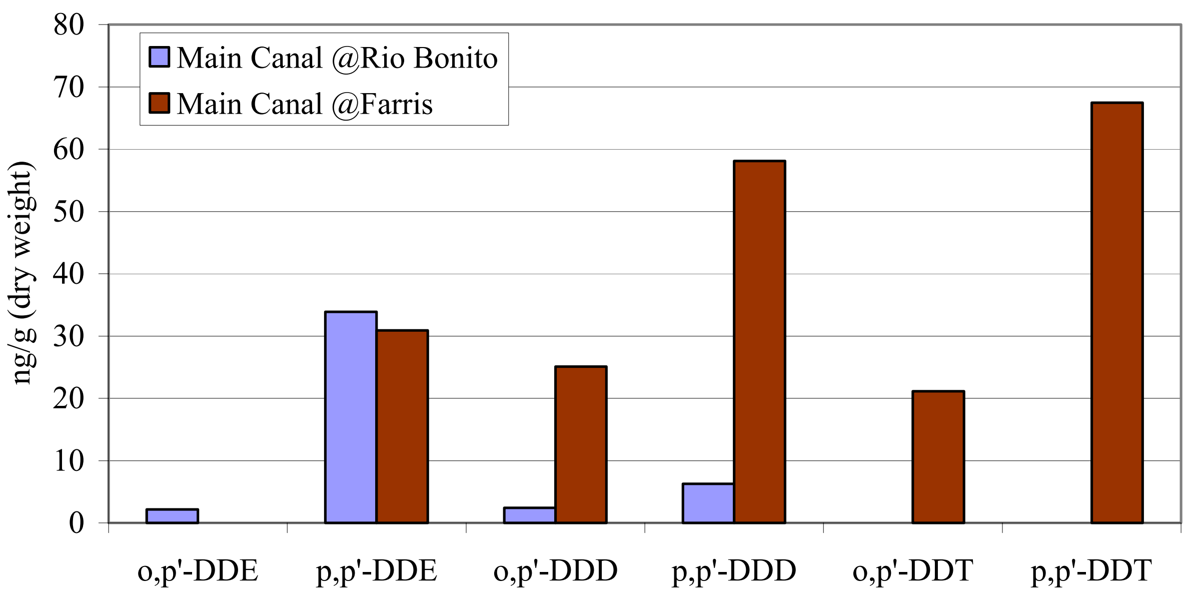

Figure 7. DDE, DDD, DDT in sediments from two Main Canal sites by dry weight (ppm).

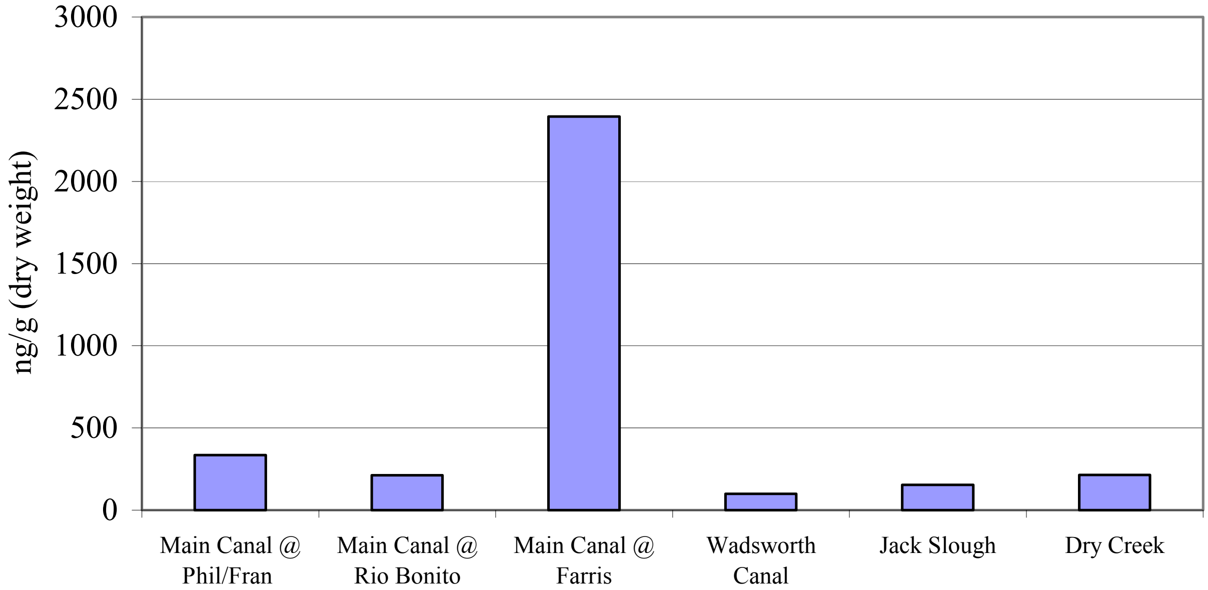

Figure 8. Total polycylic aromatic (PAHs) hydrocarbons in sediment by dry weight (ppm).

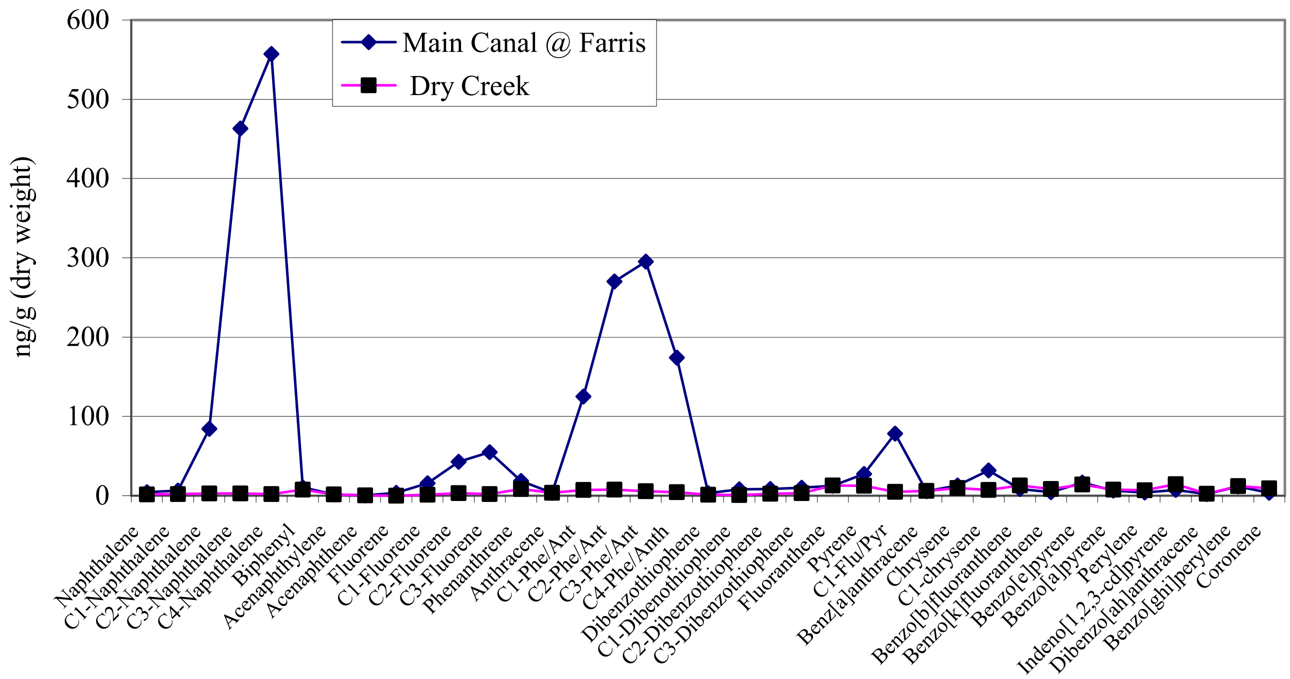

Figure 9. Total polycyclic aromatic (PAHs) hydrocarbons detected at Main Canal (Farris) and at Dry Creek by dry weight (ppm).

Method Detection Limits (MDLs)

And

Reporting Limits (RLs)

Table 3. Method detection limits and reporting limits for metals in sediments.

Metals	MDL ug/g (dry wt)	RL ug/g (dry wt)
Fe	0.1	1
Be	0.002	0.02
V	0.002	0.02
Cr	0.01	0.1
Mn	0.01	0.1
Co	0.002	0.02
Ni	0.002	0.02
Cu	0.002	0.02
Zn	0.01	0.1
As	0.002	0.02
Se	0.002	0.02
Ag	0.002	0.02
Cd	0.002	0.02
Tl	0.002	0.02
Pb	0.002	0.02

Table 4. Method detection limits and reporting limits for organochlorine pesticides in sediments.

OC pesticides	MDL ng/g	RL ng/g
α-HCH	0.95	0.95
HCB	0.61	0.61
Pentachloroanisole	0.33	0.33
β-HCH	0.78	0.78
γ-HCH	0.88	0.88
δ-HCH	0.85	0.85
Heptachlor	0.13	0.13
Aldrin	0.72	0.72
Dicofol(Kelthane)	0.78	0.78
Heptachlor epoxide	0.50	0.50
Oxychlordane	0.35	0.35
Captane	0.98	0.98
trans-Chlordane	0.26	0.26
o,p'-DDE	0.39	0.39
Endosulfan I	0.39	0.39
cis-Chlordane	0.38	0.38
trans-Nonachlor	0.23	0.23
Dieldrin	0.48	0.48
p,p'-DDE	0.84	0.84
o,p'-DDD	1.04	1.04
Endrin	0.57	0.57
Endosulfan II	0.56	0.56
cis-Nonachlor	0.13	0.13
p,p'-DDD	0.45	0.45
o,p'-DDT	0.38	0.38
Endrin aldehyde	0.50	0.50
Endosulfan sulfate	0.32	0.32
p,p'-DDT	0.69	0.69
Captafol	0.69	0.69
Endrin ketone	0.54	0.54
Methoxychlor	0.59	0.59
Mirex	0.21	0.21

Table 5. Method detection limits and reporting limits for polycyclic aromatic hydrocarbons (PAHs) in sediments.

PAHs	MDL ng/g	RL ng/g
Naphthalene	0.96	0.96
C1-Naphthalene	1.89	1.89
C2-Naphthalene	1.14	1.14
C3-Naphthalene	0.60	0.60
C4-Naphthalene	0.60	0.60
Acenaphthylene	0.69	0.69
Acenaphthene	1.23	1.23
Fluorene	1.11	1.11
C1-Fluorene	1.05	1.05
C2-Fluorene	1.05	1.05
C3-Fluorene	1.05	1.05
Phenanthrene	0.33	0.33
Anthracene	0.42	0.42
4,5-Methylenephenanthrene	0.33	0.33
C1-Phenanthrene	0.36	0.36
C2-Phenanthrene	0.36	0.36
C3-Phenanthrene	0.36	0.36
C4-Phenanthrene	0.36	0.36
Retene	0.33	0.33
Dibenzothiophene	0.72	0.72
C1-Dibenzothiophene	0.72	0.72
C2-Dibenzothiophene	0.72	0.72
C3-Dibenzothiophene	0.72	0.72
Fluoranthene	0.42	0.42
Pyrene	0.45	0.45
C1-Fluo/Pyr	0.66	0.66
Benz[a]anthracene	0.84	0.84
Chrysene	0.81	0.81
C1-Chrysene	0.81	0.81
Benzo[b]fluoranthene	0.24	0.24
Benzo[k]fluoranthene	0.15	0.15
Benzo[e]pyrene	0.63	0.63
Benzo[a]pyrene	0.51	0.51
Perylene	0.81	0.81
Indeno[1,2,3-cd]pyrene	0.84	0.84

Table 5 (cont.). Method detection limits and reporting limits for polycyclic aromatic hydrocarbons (PAHs) in sediments.

PAHs	MDL ng/g	RL ng/g
Dibenzo[ah]anthracene	0.78	0.78
Benzo[ghi]perylene	0.92	0.92
Coronene	1.32	1.32

Table 6. Method detection limits for organophosphate pesticides in sediments.

OP Pesticides	MDL (ng/g)	RL (ng/g)
azinphos, ethyl	48	240
azinphos, methyl	36	180
chlorpyrifos	12	60
diazinon	12	60
dichlorvos (DDVP)	12	60
dimethoate	12	60
disulfoton	12	60
ethoprop	12	60
fonofos	12	60
malathion	24	120
parathion	24	120
parathion, methyl	12	60
phorate (Thimet)	12	60
phosmet	24	120
Mevinphos	36	180
Tributyl phosphate	24	120
Sulfotepp	12	60
Coumaphos	48	240
Chlorpyrifos, methyl	36	180
Ronnel	12	60
Fenthion	12	60
Fensulfothion	24	120
EPN	36	180

Table 7. Method detection limits and reporting limits for pyrethroid pesticides in sediments.

Pyrethroid Pesticides	MDL (ng/g)	RL (ng/g)
Lambda-cyhalothrin	0.31	0.31
Permethrin	0.25	0.25
Cypermethrin	0.41	0.41
Esfenvalerate	0.72	0.72

Calibration Standards Results

Table 8. Calibration results of standard solutions for polycyclic aromatic hydrocarbons (PAHs).

	CAL 1	CAL 2	CAL 3	CAL 4	CAL 5	CAL 6
	2000	1000	500	250	125	62.5
			ng/mL			
Naphthalene	2000	1002	498	249	125	64.2
Acenaphthylene	2001	987	525	235	121	67.6
Acenaphthene	2000	1002	498	249	124	65.0
Fluorene	1999	1004	496	244	126	68.2
Phenanthrene	2000	1003	498	246	125	65.9
Anthracene	1999	1006	496	240	124	73.1
Dibenzothiophene	1999	1004	496	246	125	66.9
Fluoranthene	1999	1006	497	240	125	72.4
Pyrene	1999	1003	498	246	124	67.1
Benz[a]anthracene	1999	1005	499	235	124	76.5
Chrysene	2000	100	496	249	126	65.3
Benzo[b]fluoranthene	2001	993	516	239	118	71.7
Benzo[k]fluoranthene	1999	1007	493	243	125	71.6
Benzo[e]pyrene	1999	1007	497	230	124	80.9
Benzo[a]pyrene	1999	1007	497	230	124	80.9
Perylene	2000	1007	496	230	124	80.9
Indeno[1,2,3-cd]pyrene	1997	1021	469	230	130	87.8
Dibenzo[ah]anthracene	2000	1012	484	242	125	75.5
Benzo[ghi]perylene	1999	1010	489	242	127	70.1
Coronene	1998	1012	485	240	127	73.5

Table 9. Calibration results of standard solutions for organochlorine pesticides.

	CAL 1	CAL 2	CAL 3	CAL 4	CAL 5	CAL 6
	62.5	125	250	500	1000	2000
	ng/mL					
alpha-Hexachlorocyclohexane	64.9	124	240	492	1003	2049
Hexachlorobenzene						
Pentachloroanisole						
beta-Hexachlorocyclohexane	63.7	121	226	471	981	2032
gamma-Hexachlorocyclohexane	60.9	119	239	490	986	1932
delta-Hexachlorocyclohexane	67.1	120	238	492	1006	2061
Heptachlor	66.7	125	237	471	984	2136
Aldrin	64.4	125	243	487	994	2065
Dicofol(Kelthane)						
Heptachlor epoxide	65.7	123	240	484	999	2076
Oxychlordane						
Captan						
trans-Chlordane	66.0	122	240	487	1007	2059
o,p'-DDE						
Endosulfan I	67.6	122	232	482	1011	2087
cis-Chlordane	64.3	125	240	494	1011	2028
trans-Nonachlor						
Dieldrin	64.2	126	241	489	996	2059
p,p'-DDE	63.6	127	241	489	1007	2037
o,p'-DDD(Mitotane)						
Endrin	59.9	135	256	476	948	2085
Endosulfan II	68.0	127	225	468	993	2156
cis-Nonachlor						
p,p'-DDD	67.2	123	234	479	1004	2098
o,p'-DDT						
Endrin aldehyde	66.7	123	240	471	1004	2101
Endosulfan sulfate	68.4	124	227	474	1005	2125
p,p'-DDT	69.9	121	229	467	1003	2145
Captafol						
Endrin ketone	68.4	120	235	481	1013	2085
Methoxychlor	71.5	123	224	453	999	2196
Mirex						

Sample Splits Results

Table 10. Metals split sample results and percent difference.

ug/g (dry wt)	Blank	Main Canal @ Rio Bonito	Split - Main Canal @ Rio Bonito		Percent difference (high-low/high)
Fe	ND	16710	16890		1
Be	ND	0.153	0.167		8
V	ND	36.130	36.550		1
Cr	ND	35.18	36.45		3
Mn	ND	720.9	700.1		3
Co	ND	10.190	10.090		1
Ni	ND	38.740	39.210		1
Cu	ND	23.220	23.620		2
Zn	ND	30.39	31.67		4
As	ND	2.758	2.545		8
Se	ND	0.451	0.390		14
Ag	ND	0.032	0.031		3
Cd	ND	0.064	0.065		1
Tl	ND	0.048	0.051		5
Pb	ND	4.264	4.292		1
				Average	4
				StDev	3.7

Table 11. Organochlorine pesticide split sample results and percent difference.

Ng/g dry wt	Blank	MC @ Rio Bonito	Duplicate (MC @ Rio)	Percent Difference
alpha-Hexachlorocyclohexane	ND	ND	ND	
Hexachlorobenzene	ND	ND	ND	
Pentachloroanisole	ND	ND	ND	
beta-Hexachlorocyclohexane	ND	ND	ND	
gamma-Hexachlorocyclohexane	ND	ND	ND	
delta-Hexachlorocyclohexane	ND	ND	ND	
Heptachlor	ND	ND	ND	
Aldrin	ND	ND	ND	
Dicofol(Kelthane)	ND	6.03	5.26	12.7
Heptachlor epoxide	ND	ND	ND	
Oxychlordane	ND	ND	ND	
Captan	ND	ND	ND	
trans-Chlordane	ND	ND	ND	
o,p'-DDE	ND	< MDL	< MDL	
Endosulfan I	ND	ND	ND	
cis-Chlordane	ND	ND	ND	
trans-Nonachlor	ND	< MDL	< MDL	
Dieldrin	ND	ND	ND	
p,p'-DDE	ND	33.88	29.79	12.1
o,p'-DDD(Mitotane)	ND	2.41	2.59	6.9
Endrin	ND	< MDL	< MDL	
Endosulfan II	ND	ND	ND	
cis-Nonachlor	ND	ND	ND	
p,p'-DDD	ND	6.29	5.18	17.6
o,p'-DDT	ND	ND	ND	
Endrin aldehyde	ND	ND	ND	
Endosulfan sulfate	ND	ND	ND	
p,p'-DDT	ND	< MDL	< MDL	
Captafol	ND	ND	ND	
Endrin ketone	ND	ND	ND	
Methoxychlor	ND	ND	ND	
Mirex	ND	ND	ND	
			Average	12.3
			Stdev	4.4

Matrix Spike and Surrogate Recovery Results

Table 12. Organophosphate pesticide surrogate and matrix spike recovery data.

Samples	Dry sample wt (g)	Surrogate (1) (ppm)
Dry Creek @Atkinson	20.35	4.19
Jack Slough @ Doc Adams	11.20	2.22
Wadsworth Canal	18.22	2.40
Main canal @ Phil-Franklin	6.80	2.21
Main canal @ Rio Bonito-S1	11.73	2.57
Main canal @ Farris	16.72	2.00
Rio Bonito-Duplicate	8.01	2.42
Rio Bonito-Matrix spike	7.96	2.45
Lab Blank		2.03
Rio Bonito-Matrix spike		(ppm)
Chlorpyrifos		0.3
Diazinon		1.72
Dimethoate		ND
EPN		2.06
Malathion		2.73
Monocrotophos		ND
Parathion		1.97
Sulfotepp		1.44
TEPP		ND

Notes

ND not detected

(1) triphenylphosphate

Appendices A - E

Sediment-bound Contaminant Data

Appendix A. Sediment bound metals data.

ug/g (dry wt)	Blank	Main Canal @ Phil/Fran	Main Canal @ Rio Bonito	Main Canal @ Farris	Wadsworth Canal @ Franklin	Jack Slough @ Doc Adams	Dry Creek @ Atkinson
Date Sampled		4/17/03	4/17/03	4/17/03	4/16/03	4/16/03	4/16/03
Date Received		4/18/03	4/18/03	4/18/03	4/18/03	4/18/03	4/18/03
Digest Extract Date		5/5/03	5/5/03	5/5/03	5/5/03	5/5/03	5/5/03
Date analyzed		5/12/03	5/12/03	5/12/03	5/12/03	5/12/03	5/12/03
Fe	ND	14420	16710	32940	35940	35010	14420
Be	ND	0.150	0.153	0.398	0.342	0.385	0.151
V	ND	35.250	36.130	124.000	84.640	85.440	36.060
Cr	ND	34.94	35.18	78.91	75.14	57.7	18.58
Mn	ND	194.1	720.9	589.3	1360	3139	473.2
Co	ND	7.436	10.190	26.120	24.750	36.830	6.946
Ni	ND	34.480	38.740	99.770	83.380	38.020	10.860
Cu	ND	24.460	23.220	60.700	35.930	33.910	16.010
Zn	ND	28.69	30.39	91.18	66.78	51.86	63.53
As	ND	1.935	2.758	5.722	6.591	5.093	2.880
Se	ND	0.367	0.451	1.332	0.953	0.858	0.503
Ag	ND	0.032	0.032	0.072	0.051	0.033	0.064
Cd	ND	0.067	0.064	0.213	0.074	0.125	0.119
Tl	ND	0.044	0.048	0.074	0.135	0.086	0.063
Pb	ND	4.342	4.264	21.460	8.000	7.677	22.770
Sb, estimated		0.004	0.005	0.007	0.004	0.000	0.060
Hg, estimated		0.004	0.005	0.007	0.004	0.000	0.060
%org		79.7	76.5	53.6	49.4	50.7	79.7

Appendix B. Sediment bound organchlorine pesticide data.

(ng/g dry wt.)	Blank	MC @ Phil/Fran	MC @ Rio Bonito	MC @ Farris	Wadsworth Canal	Jack Slough	Dry Creek
Date Sampled		4/17/03	4/17/03	4/17/03	4/16/03	4/16/03	4/16/03
Date Received		4/18/03	4/18/03	4/18/03	4/18/03	4/18/03	4/18/03
Date Extracted	4/28/03	4/28/03	4/28/03	4/28/03	4/28/03	4/28/03	4/28/03
Date Analyzed	7/29/03	7/29/03	7/29/03	7/29/03	7/29/03	7/29/03	7/29/03
alpha-Hexachlorocyclohexane	ND	ND	ND	ND	ND	ND	ND
Hexachlorobenzene	ND	ND	ND	ND	ND	ND	ND
Pentachloroanisole	ND	ND	ND	17.38	ND	ND	< MDL
beta-Hexachlorocyclohexane	ND	ND	ND	ND	ND	ND	ND
gamma-Hexachlorocyclohexane	ND	ND	ND	ND	ND	ND	ND
delta-Hexachlorocyclohexane	ND	ND	ND	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND	ND	ND	ND
Aldrin	ND	ND	ND	ND	ND	ND	ND
Dicofol(Kelthane)	ND	9.53	6.03	8.37	< MDL	4.55	ND
Heptachlor epoxide	ND	ND	ND	ND	ND	ND	ND
Oxychlordane	ND	ND	ND	ND	ND	ND	ND
Captan	ND	ND	ND	ND	ND	ND	ND
trans-Chlordane	ND	ND	ND	< MDL	< MDL	ND	8.56
o,p'-DDE	ND	ND	< MDL	2.14	ND	ND	ND
Endosulfan I	ND	ND	ND	ND	ND	ND	ND
cis-Chlordane	ND	ND	ND	< MDL	ND	ND	7.09
trans-Nonachlor	ND	ND	< MDL	< MDL	ND	ND	5.40
Dieldrin	ND	ND	ND	ND	ND	ND	ND
p,p'-DDE	ND	8.72	33.88	30.88	2.18	9.44	1.80
o,p'-DDD(Mitotane)	ND	ND	2.41	25.07	< MDL	ND	< MDL
Endrin	ND	< MDL	< MDL	< MDL	< MDL	< MDL	ND
Endosulfan II	ND	58.82	ND	ND	ND	ND	ND
cis-Nonachlor	ND	ND	ND	ND	ND	ND	1.76
p,p'-DDD	ND	3.02	6.29	58.11	1.21	< MDL	1.25
o,p'-DDT	ND	ND	ND	21.14	ND	ND	ND
Endrin aldehyde	ND	ND	ND	ND	ND	ND	ND
Endosulfan sulfate	ND	ND	ND	ND	ND	ND	ND
p,p'-DDT	ND	ND	< MDL	67.43	< MDL	< MDL	ND
Captafol	ND	ND	ND	ND	ND	ND	ND
Endrin ketone	ND	ND	ND	ND	ND	ND	ND
Methoxychlor	ND	2.69	ND	19.76	ND	ND	< MDL
Mirex	ND	ND	ND	ND	ND	ND	ND

Appendix C. Sediment bound polycyclic aromatic hydrocarbon (PAHs) data.

(ng/g dry wt.)	Blank	MC @ Phil/Fran	MC @ Rio Bonito	MC @ Farris	Wadsworth Canal	Jack Slough	Dry Creek
Date Sampled		4/17/03	4/17/03	4/17/03	4/16/03	4/16/03	4/16/03
Date Received		4/18/03	4/18/03	4/18/03	4/18/03	4/18/03	4/18/03
Date Extracted	4/28/03	4/28/03	4/28/03	4/28/03	4/28/03	2/17/04	4/28/03
Date Analyzed	5/26/03	5/26/03	5/26/03	5/26/03	5/26/03	2/27/04	5/26/03
Naphthalene	3.40	7.28	9.61	4.32	1.80	3.78	1.81
C1-Naphthalene	< MDL	6.38	8.26	6.52	1.91	4.92	1.92
C2-Naphthalene	ND	8.31	9.35	84.3	1.93	10.23	2.66
C3-Naphthalene	ND	5.92	6.94	463	1.14	3.35	2.84
C4-Naphthalene	ND	4.82	3.91	557	< MDL	<MDL	2.04
Biphenyl	1.56	14.0	27.9	10.5	5.85	1.50	7.79
Acenaphthylene	< MDL	4.95	1.23	1.48	< MDL	2.29	1.69
Acenaphthene	< MDL	1.12	< MDL	0.55	< MDL	<MDL	0.42
Fluorene	< MDL	4.60	3.69	3.75	< MDL	3.13	< MDL
C1-Fluorene	ND	6.46	3.20	15.8	< MDL	2.72	1.31
C2-Fluorene	ND	15.1	11.1	42.7	2.38	3.54	3.15
C3-Fluorene	ND	5.54	4.90	54.9	1.25	0.92	1.95
Phenanthrene	0.56	16.9	12.1	18.6	2.74	13.3	8.39
Anthracene	< MDL	8.22	1.81	3.83	< MDL	3.64	3.53
C1-Phe/Ant	1.86	13.6	11.2	125	5.05	8.49	7.25
C2-Phe/Ant	< MDL	20.3	15.8	270	7.06	7.47	7.83
C3-Phe/Ant	ND	6.65	4.95	295	5.42	3.27	5.50
C4-Phe/Anth	ND	< MDL	< MDL	174	2.93	0.69	4.40
Dibenzothiophene	< MDL	1.57	1.50	3.09	0.38	0.81	1.09
C1-Dibenothiophene	< MDL	1.25	1.50	8.04	< MDL	0.89	0.96
C2-Dibenzothiophene	ND	1.54	2.52	8.49	1.63	0.86	2.25
C3-Dibenzothiophene	ND	2.67	3.38	10.2	1.83	1.65	3.35
Fluoranthene	< MDL	38.2	11.5	12.4	2.11	18.7	12.9
Pyrene	< MDL	19.6	6.42	27.5	3.33	14.8	12.4
C1-Flu/Pyr	ND	7.95	3.93	78.2	5.73	6.22	4.97
Benz[a]anthracene	< MDL	8.59	4.16	5.78	4.69	4.28	6.20
Chrysene	< MDL	16.6	5.81	12.8	4.84	9.23	9.70
C1-chrysene	ND	3.40	2.04	31.8	13.7	4.17	7.08
Benzo[b]fluoranthene	ND	19.5	5.71	8.64	2.52	4.09	12.9
Benzo[k]fluoranthene	ND	11.5	3.51	4.44	1.06	4.84	8.38
Benzo[e]pyrene	ND	17.0	6.56	16.7	7.17	4.38	14.2
Benzo[a]pyrene	ND	2.21	1.65	6.34	< MDL	0.97	7.86
Perylene	ND	2.00	1.73	3.93	< MDL	<MDL	6.89
Indeno[1,2,3-cd]pyrene	< MDL	16.1	7.36	7.16	1.99	3.11	14.7
Dibenzo[ah]anthracene	< MDL	3.54	< MDL	1.94	1.34	<MDL	2.50
Benzo[ghi]perylene	< MDL	6.15	2.48	11.9	2.34	2.20	12.1
Coronene	< MDL	5.24	2.93	3.77	< MDL	<MDL	9.45
Total PAHs		335	212	2395	99	154	215

Appendix D. Sediment bound pyrethroid pesticide data.

(ng/g dry wt.)	Blank	MC @ Phil/Fran	MC @ Rio Bonito	MC @ Farris	Wadsworth Canal	Jack Slough	Dry Creek
Date Sampled		4/17/03	4/17/03	4/17/03	4/16/03	4/16/03	4/16/03
Date Received		4/18/03	4/18/03	4/18/03	4/18/03	4/18/03	4/18/03
Date Extracted	4/28/03	4/28/03	4/28/03	4/28/03	4/28/03	4/28/03	4/28/03
Date Analyzed	6/11/03	6/11/03	6/11/03	6/11/03	6/11/03	6/11/03	6/11/03
Lambda-cyhalothrin	ND	ND	ND	ND	ND	ND	ND
Permethrin	ND	112	ND	ND	ND	ND	8.15
Cypermethrin	ND	ND	ND	ND	ND	ND	ND
Esfenvalerate	ND	ND	ND	ND	ND	ND	ND

Appendix E. Sediment bound organphosphate pesticide data.

(ng/g dry wt.)	Blank	MC @ Phil/Fran	MC @ Rio Bonito	MC @ Farris	Wadsworth Canal	Jack Slough	Dry Creek
Date Sampled		4/17/03	4/17/03	4/17/03	4/16/03	4/16/03	4/16/03
Date Received		4/18/03	4/18/03	4/18/03	4/18/03	4/18/03	4/18/03
Date Extracted	4/28/03	4/28/03	4/28/03	4/28/03	4/28/03	4/28/03	4/28/03
Date Analyzed	5/21/03	5/21/03	5/21/03	5/21/03	5/21/03	5/21/03	5/21/03
azinphos, ethyl	ND	ND	ND	ND	ND	ND	ND
azinphos, methyl	ND	ND	ND	ND	ND	ND	ND
chlorpyrifos	ND	ND	ND	ND	ND	ND	ND
diazinon	ND	ND	ND	ND	ND	ND	ND
dichlorvos (DDVP)	ND	ND	ND	ND	ND	ND	ND
dimethoate	ND	ND	ND	ND	ND	ND	ND
disulfoton	ND	ND	ND	ND	ND	ND	ND
ethoprop	ND	ND	ND	ND	ND	ND	ND
fonofos	ND	ND	ND	ND	ND	ND	ND
malathion	ND	ND	ND	ND	ND	ND	ND
parathion	ND	ND	ND	ND	ND	ND	ND
parathion, methyl	ND	ND	ND	ND	ND	ND	ND
phorate (Thimet)	ND	ND	ND	ND	ND	ND	ND
phosmet	ND	ND	ND	ND	ND	ND	ND
Mevinphos	ND	ND	ND	ND	ND	ND	ND
Tributyl phosphate	ND	ND	ND	ND	ND	ND	ND
Sulfotepp	ND	ND	ND	ND	ND	ND	ND
Coumaphos	ND	ND	ND	ND	ND	ND	ND
Chlorpyrifos, methyl	ND	ND	ND	ND	ND	ND	ND
Ronnel	ND	ND	ND	ND	ND	ND	ND
Fenthion	ND	ND	ND	ND	ND	ND	ND
Fensulfothion	ND	ND	ND	ND	ND	ND	ND
EPN	ND	ND	ND	ND	ND	ND	ND

Appendix F

Ambient Water Quality Data

Appendix F. Ambient water quality data on day of sampling.

Site	Date	Time	Temp. C^{o}	Dissolved Oxygen mg/L	Spec. Cond. us/cm	pH
Dry Creek @ Atkinson	4/16/03	0930	20.5	5.7	174	7.6
Jack Slough @ Doc Adams	4/16/03	1120	22.7	5.1	165	7.8
Wadsworth Canal	4/16/03	1315	23.0	6.4	538	8.2
Main Canal @ Phil/Fran	4/17/03	1025	19.0	2.1	190	7.3
Main Canal @ Rio Bonito	4/17/03	1045	21.0	5.7	279	7.5
Main Canal @ Farris	4/17/03	1200	22.6	3.2	484	7.7

Appendix G

Site Pictures

Dry Creek @ Atkinson Avenue looking upstream from under bridge .

Jack Slough @ Doc Adams Road looking upstream.

Wadsworth Canal upstream of Franklin Rd. bridge looking upstream.

Main Canal @ Phil/Fran Drive looking upstream towards Sutter Butte Canal.

Main Canal @ Rio Bonito Rd. looking upstream from bridge.

Main Canal @ Farris Rd. looking downstream from bridge.