CONCENTRATIONS OF SELECTED RADIONUCLIDES AND CHEMICALS IN FISH, SEDIMENT, AND WATER COLLECTED FROM THE PUTAH CREEK NEAR THE FORMER LABORATORY FOR ENERGY-RELATED HEALTH RESEARCH, DAVIS, CA

Prepared by:

Clinton Cox, PhD
USEPA-NAREL
540 South Morris Avenue
Montgomery, AL 36115-2601

Reviewed by:

Scott Telofski, PE
USEPA-NAREL

Prepared for:

Agency for Toxic Substances and Disease Registry
1600 Clifton Road, NE
Atlanta, GA 30333

NAREL

National Air and Radiation Environmental Laboratory

31 March 1997

T32.4

CONCENTRATIONS OF SELECTED RADIONUCLIDES AND CHEMICALS IN FISH, SEDIMENT, AND WATER COLLECTED FROM THE PUTAH CREEK NEAR THE FORMER LABORATORY FOR ENERGY-RELATED HEALTH RESEARCH DAVIS, CA

Prepared by:
Clinton Cox, PhD
USEPA-NAREL
540 South Morris Avenue
Montgomery, AL 36115-2601

Reviewed by:
Scott Telofski, PE
USEPA-NAREL

Prepared for:

Agency for Toxic Substances and Disease Registry
1600 Clifton Road, NE
Atlanta, GA 30333

NAREL

National Air and Radiation Environmental Laboratory

31 March 1997

INTRODUCTION

The Laboratory for Energy-Related Health Research (LEHR) was a research facility located on the University of California-Davis campus from 1958 to 1988. The Department of Energy (DOE) and its predecessor, the Atomic Energy Commission (AEC), funded the operation of the LEHR primarily to research the long-term effects of low exposure doses of Ra-226 and Sr-90 in beagles. Today, the University of California-Davis operates the Institute of Toxicology and Environmental Health at the location of the former LEHR site.

In December 1995, The Agency for Toxic Substances and Disease Registry (ATSDR) released a report entitled "Site Summary, Laboratory for Energy-Related Health Research, Davis, California." In this report, ATSDR recommended that "the fish in Putah Creek should be sampled." In January 1996, ATSDR asked NAREL to conduct a study of fish collected from Putah Creek which flows east about 250 ft from the southern boundary of the former LEHR site (see Figure 1).

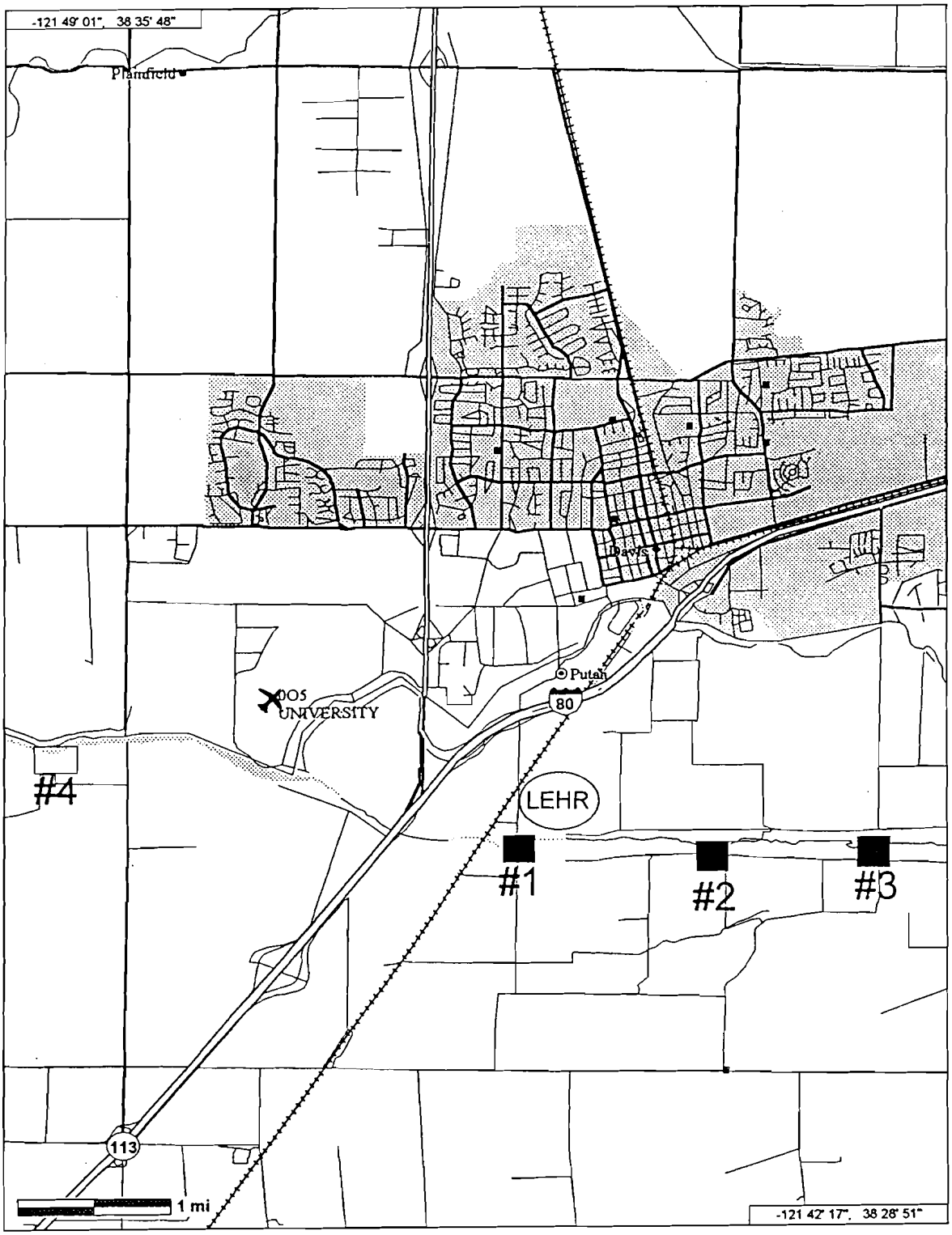
BACKGROUND

During August 1996, NAREL in conjunction with ATSDR, USEPA Region 9, and other stakeholders authored sampling and analysis guidelines entitled "Sampling and Analysis Guidelines for Fish, Sediment, and Water Samples from the Putah Creek Adjacent to the Former Laboratory for Energy-Related Health Research, Davis, CA" with the final version dated August 24, 1996. These Guidelines are included herein as Appendix A. Within these Guidelines selected radionuclides, pesticides, polychlorinated biphenyls (PCBs), and metals were identified for analysis. During the period from August 27, 1996 to September 12, 1996, USEPA Region 9 field personnel collected fish, sediment, and water samples from three locations downstream from the former LEHR site. Also, background samples were collected from one location upstream from the site. Table 1 shows the latitude and longitude for each sampling site, and Figure 1 shows the geographical locations of the sampling sites.

Table 1. Sampling Locations in Putah Creek Adjacent to the LEHR Site, Aug 27-Sep 12, 1996

Sampling Locations for Fish, Sediment , and Water		
Sampling Location	Latitude	Longitude
1	N 38° 31' 2.0"	W 121° 45' 22.1"
2	N 38° 31' 1.6"	W 121° 43' 58.0"
3	N 38° 31' 0.7"	W 121° 42' 46.8"
4 (background)	N 38° 31' 34.4"	W 121° 48' 42.9"

Figure 1. Map of LEHR Site and Putah Creek with Locations of the Four Sampling Sites



Precision Mapping, Copyright 1995,96, Just Softworks Inc., Portions Copyright 1992-1996 TRIUS,Inc.

For the above sampling locations, the species and weights of fish collected are presented in Table 2. Putah Creek is a small creek with a limited fish population that is in close proximity to the former LEHR site. Because of the limited fish population, the large number of analyses requiring separate aliquots, and the low detection limits required, it was necessary to composite many of the fish samples to obtain an analytical sample large enough to perform all requested analyses. Even with compositing, it was not possible to perform all the requested analyses on some fish samples. Although it is preferable to composite only the same species of fish within a length (i.e., age) range, it was not possible to do so in this study for the reasons stated above. The fish species and composited samples with whole and fillet wet weights are shown in Table 2.

Table 2. Fish Collected from Putah Creek near the Former LEHR Facility, Aug 27-Sep 12, 1996

Location	Fish Species (#)	Whole Wet Weight (g)	Fillet Wet Weight (g)
1	Black Crappie (2)	489	168
	Bluegill (1)	136	37
	Large Mouth Bass (2)	1122	421
	Composite 1 (5)	1747	626
	Crayfish (10)	413	38
	Black Bullhead (4)	1115	209
	White Catfish (2)	1492	262
	Composite 2 (16)	3020	509
2	Carp (1)	1564	367
	Black Bullhead (1)	212	46
	Composite (2)	1776	413
	Large Month Bass (1)	650	188
3	Black Crappie (2)	364	92
	Large Mouth Bass (1)	1234	362
	Composite 1 (3)	1598	454
	Crayfish (9)	289	26
	Carp (1)	1696	495
	Composite 2 (10)	1985	521
	White Catfish (1)	2624	670
4(background)	Bluegill (78)	1906	394
	Green Sunfish (13)	627	127
	Large Month Bass (3)	192	45
	Crayfish (8)	221	42
	White Catfish (1)	89	12
	Composite (103)	3035	620

METHODOLOGY

Fish, water, and sediment samples were collected and shipped under chain-of-custody following the above referenced Guidelines (see Appendix A and B). Samples were received, analyzed, and subsequent results reported following the above referenced Guidelines (see Appendix A), NAREL standard operating procedures (SOPs), and the NAREL Quality Assurance Plan (QAP). The definition of terms and acronyms used in the SOPs and the reporting of the results are located in Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories (8).

RESULTS

The results for this study are reported in the following tables. These tables were generated from Data Quality Packages (DQPs) produced from the radiological and chemical analyses performed for this study. The DQPs (9, 10, 11, 12, 13, 14, 15, 16, 17) noted only minor quality assurance exceptions, which did not affect the reported data values, e.g., not enough sample to perform analysis. For specific exceptions, qualifiers, and QA/QC results, see DQP references 9, 10, 11, 12, 13, 14, 15, 16, 17. [NOTE: These DQPs can be obtained from NAREL by contacting Dr. John Griggs at 334-270-3450.] General information regarding gamma spectrometry and gross alpha/beta results is presented in Appendix C. Tables 3 through 5 present the analytical results for the water samples. Tables 6 through 8 present the analytical results for the sediment samples. Tables 9 through 11 present the analytical results for the fish samples.

Table 3. Radiological Results for Water Collected from Putah Creek near the Former LEHR Facility

Analyte	Site #1 LEHR96.05001/X (pCi/L)		Site #2 LEHR96.05000/X (pCi/L)		Site #3 LEHR96.05005 (pCi/L)	Site #4 LEHR96.04998 (pCi/L)
Gross Alpha	2.57±1.93	3.18±2.19	5.71±2.75	NA	4.57±2.54	1.76±1.73
Gross Beta	3.63±2.20	5.29±2.46	4.41±2.39	NA	6.87±2.67	2.76±2.22
U-238	0.2709±0.0699	NA	0.3430±0.0798	0.3819±0.0813	0.3737±0.0698	0.2737±0.0678
U-234	0.6306±0.1101	NA	0.5139±0.0984	0.6414±0.1075	0.6465±0.0937	0.6238±0.1055
Th-230	0.0414±0.0289	NA	0.0624±0.0340	0.0456±0.0326	0.0480±0.0267	0.0411±0.0282
Ra-226 (γ)	≤77.5	≤74.3	≤78.0	NA	≤79.2	≤85.6
Ra-226	0.26±0.03	0.22±0.05	0.07±0.01	NA	0.09±0.02	0.11±0.02
U-235	0.0463±0.0310	ND	0.0423±0.0309	0.0209±0.0221	0.0835±0.0350	0.0599±0.0361
Th-227	0.0095±0.0291	NA	0.0090±0.0275	0.0639±0.0635	0.0123±0.0214	0.0364±0.0364
Th-232	0.0238±0.0238	NA	0.0101±0.0156	0.0118±0.0182	0.0455±0.0268	0.0103±0.0158
Ra-228 (γ)	≤17.0	≤17.1	≤16.8	NA	≤16.2	≤24.0
Ra-228	2.9±1.0	1.0±1.0	0.35±0.75	NA	-0.12±0.78	0.88±0.73
Th-228	0.0202±0.0680	NA	0.0240±0.0651	0.0284±0.0718	0.0231±0.0555	-0.0330±0.0518
Tl-208	ND	ND	1.67±3.06	NA	ND	ND
Pu-238	0.0072±0.0131	NA	0.0286±0.0317	-0.0077±0.0292	0.0640±0.0564	0.0263±0.0358
Pu-239/240	-0.0012±0.0024	NA	0.00136±0.0090	0.0124±0.0164	0.0021±0.0137	0.0000±0.0101
K-40	≤51.6	≤54.9	≤51.6	NA	≤51.9	33.2±62.8
C-14	-80±82	-72±82	-96±81	NA	-77±82	NA
Ba-140	≤99.9	≤101	≤96.2	NA	≤99.0	≤161
Co-60	≤5.84	≤5.28	≤6.43	NA	≤5.62	≤8.44
Cs-137	≤4.52	≤4.31	≤4.16	NA	≤4.48	≤6.58
I-131	≤79.7	≤79.0	≤79.4	NA	≤80.2	≤101
Sr-89	-3.01±4.76	NA	3.78±4.80	NA	2.08±4.80	1.90±4.41*
Sr-90	0.571±0.717	NA	-0.400±0.755	NA	0.0112±0.757	-0.134±0.667*

(γ) -- measured by gamma spectrometry with a corresponding radiochemical analysis. ND -- not detected.
NA -- not available or not analyzed. X -- designates a replicate analysis.
* Replicate analysis: Sr-89, 7.47±4.96 pCi/L; Sr-90, -0.750±0.740 pCi/L.
Note: Values in this table were extracted from LEHR Data Quality Packages (9, 10, 11, 12, 13, 14, 17). "Less than value" is equal to the Minimum Detectable Concentration (MDC); see Appendix C.

Table 4. Inorganic Results For Water Collected From Putah Creek Near The Former LEHR Facility

Analyte	CAS Number	Site #1 LEHR96.05001[X] (μg/L or ppb)		Site #2 LEHR96.05000 (μg/L or ppb)	Site #3 LEHR96.05005 (μg/L or ppb)	Site #4 LEHR96.04998 (μg/L or ppb)
Antimony	7440-36-0	2.48[B]	4.43[B]	2.24[B]	2.52[B]	1.94[B]
Arsenic	7440-38-2	3.08[B]	2.03[B]	2.29[B]	3.08[B]	1.31[B]
Barium	7440-39-3	190.0[B]	260.0[B]	530.0[B]	570.0[B]	400.0[B]
Cadmium	7440-43-9	≤0.36	≤0.36	≤0.36	≤0.36	≤0.36
Chromium	7440-47-3	60.0[B]	60.0[B]	30.0[B]	50.0[B]	30.0[B]
Cobalt	7440-48-4	≤2.5	≤2.5	≤2.5	2.6[B]	≤2.5
Lead	7439-92-1	3.02	1.57[B]	≤1.26	1.52[B]	≤1.26
Mercury	7439-97-6	≤0.05	≤0.05	≤0.05	≤0.05	≤0.05
Nickel	7440-02-0	7.1[B]	8.07[B]	≤5.5	17.8[B]	≤5.5
Selenium	7782-49-2	≤1.07	≤1.07	≤1.07	≤1.07	≤1.07
Silver	7440-22-4	≤0.18	≤0.18	≤0.18	≤0.18	0.21[B]
Thallium	7440-28-0	≤0.80	≤0.80	2.01[B]	≤0.80	≤0.80
Vanadium	7440-62-2	7.8[B]	7.5[B]	7.2[B]	12.5[B]	6.1[B]
Zinc	7440-66-6	70.0	80.0	60.0	70.0	60.0

[B] The value is less than the Reporting Limit but greater than or equal to the Instrument Detection Limit (IDL).
[X] The values in the second column are from a replicate analysis.
Note: The "less than value" is the IDL, i.e., analyte was analyzed for but not detected. Values in this table were extracted from LEHR Data Quality Packages (15, 17).

Table 5. Organic Results For Water Collected From Putah Creek Near The Former LEHR Facility

Analyte	CAS Number	Site #1 LEHR96.05001 (μg/L or ppb)	Site #2 LEHR96.05000 (μg/L or ppb)	Site #3 LEHR96.05005 (μg/L or ppb)	Site #4 LEHR96.04997 (μg/L or ppb)
Chlordane (Total)	57-74-9	≤0.05	≤0.05	≤0.05	≤0.05
4,4"-DDT	50-29-3	≤0.10	≤0.10	≤0.10	≤0.10
Dicofol	115-32-2	≤0.20	≤0.20	≤0.20	≤0.20
Dieldrin	60-57-1	≤0.10	≤0.10	≤0.10	≤0.10
Endosulfan I	959-98-8	≤0.05	≤0.05	≤0.05	≤0.05
Endosulfan II	33213-65-9	≤0.10	≤0.10	≤0.10	≤0.10
Endrin	72-20-8	≤0.10	≤0.10	≤0.10	≤0.10
Heptachlor Epoxide	1024-57-3	≤0.05	≤0.05	≤0.05	≤0.05
Hexachlorobenzene	118-74-1	≤0.05	≤0.05	≤0.05	≤0.05
Lindane	58-89-9	≤0.05	≤0.05	≤0.05	≤0.05
Toxaphene	8001-35-2	≤5.0	≤5.0	≤5.0	≤5.0
Aroclor 1016	12674-11-2	≤1.0	≤1.0	≤1.0	≤1.0
Aroclor 1221	11104-28-2	≤2.0	≤2.0	≤2.0	≤2.0
Aroclor 1232	11141-16-5	≤1.0	≤1.0	≤1.0	≤1.0
Aroclor 1242	53469-21-9	≤1.0	≤1.0	≤1.0	≤1.0
Aroclor 1248	12672-29-6	≤1.0	≤1.0	≤1.0	≤1.0
Aroclor 1254	11097-69-1	≤1.0	≤1.0	≤1.0	≤1.0
Aroclor 1260	11096-82-5	≤1.0	≤1.0	≤1.0	≤1.0

Note: The "less than value" is the Reporting Limit, i.e., analyte was analyzed for but not detected. Values in this table were extracted from LEHR Data Quality Packages (16, 17).

Table 6. Radiological Results for Sediment Collected from Putah Creek near the Former LEHR Facility

Analyte	Site #1 LEHR96.05002/X (pCi/g-dry)		Site #2 LEHR96.05003 (pCi/g-dry)	Site #3 LEHR96.05004 (pCi/g-dry)	Site #4 LEHR96.04999/X (pCi/g-dry)	
Gross Alpha	7.17±5.25	5.91±5.01	8.00±5.21	10.2±5.70	7.42±5.53	NA
Gross Beta	14.8±3.31	13.4±3.16	17.1±3.38	12.6±3.06	12.4±3.19	NA
U-238	0.343±0.0779	0.435±0.0904	0.631±0.102	0.459±0.0727	0.523±0.0971	NA
Th-234	ND	NA	0.399±0.150	ND	ND	ND
U-234	0.555±0.101	0.544±0.101	0.627±0.100	0.565±0.0810	0.431±0.088	NA
Th-230	0.369±0.0707	0.387±0.0682	0.576±0.0843	0.488±0.0753	0.549±0.0863	NA
Ra-226 (γ)	0.698±0.145	NA	1.30±0.223	0.860±0.207	1.06±0.216	1.24±0.201
Ra-226	0.43±0.04	0.41±0.03	0.92±0.04	0.59±0.03	0.71±0.04	NA
Pb-214	0.314±0.0158	NA	0.481±0.0214	0.385±0.0198	0.484±0.0219	0.561±0.0209
Bi-214	0.286±0.0169	NA	0.458±0.0230	0.369±0.0212	0.445±0.0238	0.518±0.0219
U-235	0.0285±0.0275	0.0684±0.0400	0.0806±0.0400	0.0483±0.0250	0.0698±0.0392	0.0755±0.0122
U-235 (γ)	ND	NA	0.0799±0.0134	ND	ND	ND
Th-227	0.0183±0.0254	0.0414±0.0308	0.0256±0.0248	0.0207±0.0207	0.0502±0.0366	NA
Ra-223	ND	NA	0.0681±0.0448	ND	ND	ND
Th-232	0.290±0.0624	0.326±0.0624	0.587±0.0851	0.545±0.0795	0.477±0.0802	NA
Ra-228 (γ)	0.296±0.0210	NA	0.594±0.0316	0.420±0.0296	0.483±0.0313	0.532±0.0295
Ra-228	1.1±0.56	0.99±0.52	1.7±0.54	0.94±0.56	0.99±0.65	NA
Th-228	0.314±0.0654	0.332±0.0638	0.676±0.0919	0.414±0.0699	0.510±0.0831	NA
Ra-224	0.223±0.155	NA	0.470±0.218	0.276±0.219	0.477±0.230	0.578±0.207
Pb-212	0.304±0.0165	NA	0.675±0.0236	0.432±0.0202	0.562±0.0230	0.574±0.0217
Bi-212	0.349±0.0901	NA	0.627±0.126	0.488±0.105	0.591±0.121	0.501±0.117
Tl-208	0.113±0.00936	NA	0.216±0.0127	0.154±0.0117	0.173±0.0128	0.199±0.0127
Pu-238	-0.00486±0.0335	-0.00272±0.0265	0.00475±0.0369	0.0000±0.0075	0.0224±0.0416	NA
Pu-239/240	0.0227±0.0215	0.00818±0.0147	0.00317±0.0098	0.00606±0.0084	0.00203±0.0132	NA
K-40	8.35±0.193	NA	13.7±0.271	9.83±0.253	9.87±0.266	9.92±0.239
Cs-137	0.0140±0.0057	NA	≤0.0167	0.0245±0.0079	≤0.0186	≤0.0179
Ba-140	≤0.308	NA	≤0.360	≤0.337	≤0.405	≤3.64
Co-60	≤0.0171	NA	≤0.0211	≤0.0194	≤0.0224	≤0.0201
I-131	≤0.250	NA	≤0.292	≤0.246	≤0.330	≤11.6
Sr-89	6.38±4.78+	NA	1.29±3.76	1.70±4.14	0.673±4.01	2.35±3.84
Sr-90	-0.662±0.659	NA	-0.128±0.561	-0.329±0.656	0.0351±0.612	0.187±0.561

Note: Values in this table were extracted from LEHR Data Quality Packages (9, 10, 11, 12, 13, 14, 17). "Less than value" is equal to the Minimum Detectable Concentration (MDC); see Appendix C. γ – measured by gamma spectrometry. ND - not detected. NA - not analyzed. + -- less than MDC; see Appendix C. X - designates replicate analysis.

Table 7. Inorganic Results for Sediment Collected from Putah Creek near the Former LEHR Facility

Analyte	CAS Number	Site #1 LEHR96.05002[X] (mg/kg or ppm)		Site #2 LEHR96.05003 (mg/kg or ppm)	Site #3 LEHR96.05004 (mg/kg or ppm)	Site #4 LEHR96.04999[X] (mg/kg or ppm)	
Antimony	7440-36-0	0.64[B]	0.54[B]	1.11[B]	0.92[B]	1.36	NA
Arsenic	7440-38-2	6.19	NA	10.12	5.92	12.09	12.35
Barium	7440-39-3	≤49.36	57.22[B]	98.05[B]	82.77[B]	127.01[B]	NA
Cadmium	7440-43-9	≤0.09	NA	≤0.09	≤0.10	0.48	0.19[B]
Chromium	7440-47-3	239.94	292.32	89.79	220.18	173.32	NA
Cobalt	7440-48-4	20.9	20.91	15.0	16.2	21.3	NA
Lead	7439-92-1	7.22	NA	9.93	9.06	9.27	9.52
Mercury	7439-97-6	0.15	0.18	≤0.03	≤0.03	≤0.03	NA
Nickel	7440-02-0	248	247.69	65.1	175	177	NA
Selenium	7782-49-2	0.29[B]	NA	0.31[B]	0.37[B]	0.40[B]	0.33[B]
Silver	7440-22-4	0.42	NA	0.07[B]	0.25[B]	0.11[B]	0.05[B]
Thallium	7440-28-0	≤0.21	NA	0.23[B]	≤0.22	0.22[B]	0.22[B]
Vanadium	7440-62-2	42.00	42.02	56.9	43.1	59.3	NA
Zinc	7440-66-6	102.45	150.32	162.04	116.99	105.32	NA

[B] The value is less than the Reporting Limit but greater than or equal to the Instrument Detection Limit (IDL).
[X] The values in the second column are from a replicate analysis. NA -- not analyzed.
Note: Units are on a dry basis. The "less than value" is the IDL, i.e., analyte was analyzed for but not detected. Values in this table were extracted from LEHR Data Quality Packages (15, 17).

Table 8. Organic Results for Sediment Collected from Putah Creek near the Former LEHR Facility

Analyte	CAS Number	Site #1 LEHR96.05002 (μg/kg or ppb)	Site #2 LEHR96.05003 (μg/kg or ppb)	Site #3 LEHR96.05004 (μg/kg or ppb)	Site #4 LEHR96.04999 (μg/kg or ppb)
Chlordane (Total)	57-74-9	≤2.2	≤2.2	≤2.3	≤2.2
4,4"-DDT	50-29-3	≤4.3	≤4.2	≤4.5	≤4.4
Dicofol	115-32-2	≤8.6	≤8.4	≤9.0	≤8.7
Dieldrin	60-57-1	≤4.3	≤4.2	≤4.5	≤4.4
Endosulfan I	959-98-8	≤2.2	≤2.2	≤2.3	≤2.2
Endosulfan II	33213-65-9	≤4.3	≤4.2	≤4.5	≤4.4
Endrin	72-20-8	≤4.3	≤4.2	≤4.5	≤4.4
Heptachlor Epoxide	1024-57-3	≤2.2	≤2.2	≤2.3	≤2.2
Hexachlorobenzene	118-74-1	≤2.2	≤2.2	≤2.3	≤2.2
Lindane	58-89-9	≤2.2	≤2.2	≤2.3	≤2.2
Toxaphene	8001-35-2	≤220	≤220	≤230	≤220
Aroclor 1016	12674-11-2	≤43	≤42	≤45	≤43
Aroclor 1221	11104-28-2	≤86	≤84	≤92	≤88
Aroclor 1232	11141-16-5	≤43	≤42	≤45	≤43
Aroclor 1242	53469-21-9	≤43	≤42	≤45	≤43
Aroclor 1248	12672-29-6	≤43	≤42	≤45	≤43
Aroclor 1254	11097-69-1	≤43	≤42	≤45	≤43
Aroclor 1260	11096-82-5	≤43	≤42	≤45	≤43

Note: Units are on a dry basis. The "less than value" is the Reporting Limit, i.e., analyte was analyzed for but not detected. Values in this table were extracted from LEHR Data Quality Packages (16, 17).

Table 9. Radiological Results for Fish Collected from Putah Creek near the Former LEHR Facility

Analyte	Site #1, Comp 1/Comp 1/Comp 2 LEHR96.05987/7X/8 (pCi/g-wet)			Site #2, Comp/LMB LEHR96.05989/73 (pCi/g-wet)		Site #3, Comp 1, Comp 2, WCF LEHR96.05990/91/81 (pCi/g-wet)			Site #4, Comp LEHR96.05992 (pCi/g-wet)
Gross Alpha	0.0933±0.0792	NA	0.0917±0.0859	0.00825±0.0547	NA	0.000±0.0580	-0.00285±0.0403	0.0207±0.0408	0.0476±0.0732
Gross Beta	3.36±0.142	NA	3.13±0.143	3.12±0.135	NA	3.44±0.149	3.13±0.135	3.29±0.128	3.14±0.165
U-238	0.000524±0.000349	NA	0.00122±0.000521	0.000646±0.000421	0.000540±0.000473	0.000863±0.000490	0.000876±0.000471	0.000102±0.000187	0.00131±0.000528
Th-234	ND	ND	ND	ND	ND	ND	ND	ND	ND
U-234	0.000475±0.000353	NA	0.00110±0.000500	0.000855±0.000475	0.000731±0.000546	0.00177±0.000639	0.00170±0.000636	0.000408±.0.000314	0.00150±0.000570
Th-230	0.000099±0.000114	NA	0.00177±0.000554	0.000812±0.000334	0.000222±0.000216	0.000711±0.000379	0.000562±0.000308	0.000546±0.000368	0.00113±0.000674
Ra-226 (γ)	≤0.0907	≤0.0891	≤0.198	≤0.181	≤0.279	≤0.354	≤0.108	≤0.0799	≤0.0910
Ra-226	0.03±0.01	NA	0.03±0.01	0.07±0.01	0.03±0.01	-0.01±0.01	0.01±0.01	0.04±0.01*	0.02±0.01
Pb-214	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bi-214	ND	ND	ND	ND	ND	ND	ND	ND	ND
U-235	ND	ND	ND	ND	ND	ND	ND	ND	ND
U-235 (γ)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Th-227	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ra-223	ND	ND	ND	ND	ND	ND	ND	ND	ND
Th-232	0.000154±0.000149	NA	0.00475±0.000907	0.00410±0.000753	0.000±0.000110	0.000152±0.000211	0.000288±0.000217	-0.0000494±0.000262	0.000354±0.000391
Ra-228 (γ)	≤0.0203	≤0.0317	≤0.0506	≤0.0469	≤0.0619	≤0.0685	≤0.0340	≤0.0289	≤0.0223
Ra-228	0.18±0.15	NA	0.07±0.15	0.06±0.13	0.10±0.18	0.19±0.18	0.16±0.17	0.40±0.20	0.20±0.19
Th-228	-0.00195±0.000263	NA	0.00348±0.00102	0.00351±0.000902	-0.00290±0.000538	-0.000510±0.000633	0.000679±0.000414	-0.000368±0.000639	0.000607±0.00121
Ra-224	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pb-212	ND	ND	ND	ND	ND	0.0209±0.0216	ND	ND	ND
Bi-212	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tl-208	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pu-238	-0.000387±0.000415	0.0000362±0.000114	-0.000169±0.000313	0.0000107±0.000126	NA	0.0000516±0.000103	0.000387±0.000485	0.000192±0.000339	0.000215±0.000625
Pu-239/240	0.000±0.000141	0.0000362±0.000114	0.0000563±0.000172	0.0000321±0.0000641	NA	0.0000861±0.000150	0.0000738±0.000165	0.000±0.000	-0.0000537±0.0000760
K-40	3.11±0.101	3.04±0.147	2.54±0.224	2.84±0.174	3.41±0.229	2.94±0.211	2.99±0.166	3.01±0.137	2.62±0.0948
C-14	4.9±1.8	NA	5.4±1.7	3.9±1.9	2.4±2.1	3.6±2.8	4.8±1.6	3.8±1.6*	20±14
Cs-137	≤0.00538	≤0.00739	≤0.0157	≤0.0132	≤0.0175	≤0.0192	≤0.00929	≤0.00657	≤0.00571
Ba-140	≤0.251	≤0.594	≤0.565	≤1.13	≤0.268	≤0.861	≤0.356	≤0.0907	≤0.398
Co-60	≤0.00665	≤0.0100	≤0.0129	≤0.0151	≤0.0221	≤0.0248	≤0.0131	≤0.0106	≤0.00802
Hg-203	0.0137±0.00431	0.0109±0.0054	ND	ND	ND	ND	ND	ND	ND
I-131	≤0.298	≤0.989	≤0.711	≤2.45	≤0.188	≤1.08	≤0.387	≤0.0550	≤0.575
Sr-89	0.0824±0.0691+	0.0561±0.0954	-0.00365±0.0625	-0.0208±0.0477	NA	0.0369±0.0664	-0.0123±0.0634	0.000216±0.0537	-0.0537±0.113
Sr-90	-0.00903±0.00954	-0.00366±0.0133	0.00217±0.0103	0.00618±0.00686	NA	-0.00717±0.0111	0.00417±0.0107	0.00300±0.00882	0.0139±0.0163

γ -- measured by gamma spectrometry with a corresponding radiochemical analysis. ND -- not detected. NA -- not analyzed. + -- less than Minimum Detectable Concentration (MDC); see Appendix C. X -- designates a replicate analysis. *-- Replicate analysis, C-14, 15±1.8; Ra-226, 0.03±0.01; Ra-228, 0.64±0.28. Note: Values in this table were extracted from LEHR Data Quality Packages (9, 10, 11, 12, 13, 14, 17). "Less than value" is equal to the MDC; see Appendix C.

Table 10. Inorganic Results for Fish Collected from Putah Creek near the Former LEHR Facility

Analyte	CAS Number	Site #1, Comp 1/2 LEHR96.05987/8 (mg/kg-wet or ppm-wet)		Site #2, LMB/Comp LEHR96.05973/89 (mg/kg-wet or ppm-wet)		Site #3, WCF/WCF/Comp 1/Comp 2 LEHR96.05981/81[X]/90/91 (mg/kg-wet or ppm-wet)				Site #4, Comp LEHR96.05992 (mg/kg-wet or ppm-wet)
Antimony	7440-36-0	0.38[B]	0.49[B]	0.70	0.44[B]	0.75	0.52	0.53	0.41[B]	0.84
Arsenic	7440-38-2	≤0.06	≤0.06	≤0.06	≤0.06	≤0.06	≤0.06	≤0.06	0.11[B]	≤0.06
Barium	7440-39-3	≤12.0	≤12.0	≤12.0	≤12.0	≤12.0	≤12.0	≤12.0	≤12.0	≤12.0
Cadmium	7440-43-9	≤0.02	≤0.02	≤0.02	≤0.02	≤0.02	≤0.02	≤0.02	≤0.02	≤0.02
Chromium	7440-47-3	≤9.10	≤9.10	≤9.10	≤9.10	≤9.10	≤9.10	≤9.10	≤9.10	≤9.10
Cobalt	7440-48-4	≤0.25	≤0.25	≤0.45	≤0.25	≤0.25	≤0.25	≤0.25	0.29[B]	≤0.25
Lead	7439-92-1	0.28[B]	1.06	0.20[B]	0.17[B]	0.17[B]	≤0.08	0.24[B]	0.19[B]	≤0.08
Mercury	7439-97-6	0.69	0.15	0.25	0.16	0.48	0.46	0.24	0.13	0.13
Nickel	7440-02-0	≤0.55	0.90[B]	≤0.55	≤0.55	≤0.55	≤0.55	≤0.55	≤0.55	≤0.55
Selenium	7782-49-2	0.27[B]	≤0.08	0.25[B]	0.25[B]	≤0.08	≤0.08	0.23[B]	0.36[B]	0.33[B]
Silver	7440-22-4	0.04[B]	0.03[B]	0.65	0.02[B]	0.03[B]	0.03[B]	0.01[B]	0.01[B]	0.01[B]
Thallium	7440-28-0	≤0.06	≤0.06	≤0.06	≤0.06	0.12[B]	0.10[B]	≤0.06	≤0.06	≤0.06
Vanadium	7440-62-2	≤0.17	≤0.17	≤0.17	≤0.17	≤0.17	≤0.17	≤0.17	≤0.17	≤0.17
Zinc	7440-66-6	9.80	8.70	12.0	13.4	6.10	11.6	8.70	15.3	17.60

[B] The value is less than the Reporting Limit but greater than or equal to the Instrument Detection Limit (IDL).
[X] The values in the second column are from a replicate analysis.
Note: The "less than value" is the IDL, i.e., analyte was analyzed for but not detected. Values in this table were extracted from LEHR Data Quality Packages (15, 17).

Table 11. Organic Results for Fish Collected from Putah Creek near the Former LEHR Facility

Analyte	CAS Number	Site #1, Comp 1/2 LEHR96.05987/8 (μg/kg-wet or ppb-wet)		Site #2, LMB/Comp LEHR96.05973/89 (μg/kg-wet or ppb-wet)		Site #3, WCF/ Comp 1/Comp 2 LEHR96.05981/90/91 (μg/kg-wet or ppb-wet)			Site #4, Comp LEHR96.05992 (μg/kg-wet or ppb-wet)
Chlordane (Total)	57-74-9	≤5.1	≤5.1	≤5.1	≤5.1	≤5.1	≤5.1	≤5.1	≤5.1
4,4"-DDT	50-29-3	≤10.0	≤10.0	≤10.0	≤10.0	≤20.0	≤10.0	≤10.0	≤10.0
Dicofol	115-32-2	≤20.0	≤20.0	≤20.0	≤20.0	≤20.0	≤20.0	≤20.0	≤20.0
Dieldrin	60-57-1	≤10.0	≤10.0	≤10.0	≤10.0	≤10.0	≤10.0	≤10.0	≤10.0
Endosulfan I	959-98-8	≤5.0	≤5.0	≤5.0	≤5.0	≤5.1	≤5.0	≤5.0	≤5.0
Endosulfan II	33213-65-9	≤10.0	≤10.0	≤10.0	≤10.0	≤10.0	≤10.0	≤10.0	≤10.0
Endrin	72-20-8	≤10.0	≤10.0	≤10.0	≤10.0	≤10.0	≤10.0	≤10.0	≤10.0
Heptachlor Epoxide	1024-57-3	≤5.1	≤5.1	≤5.1	≤5.1	≤5.1	≤5.1	≤5.1	≤5.1
Hexachlorobenzene	118-74-1	≤5.1	≤5.1	≤5.1	≤5.1	≤5.1	≤5.1	≤5.1	≤5.1
Lindane	58-89-9	≤5.1	≤5.1	≤5.1	≤5.1	≤5.1	≤5.1	≤5.1	≤5.1
Toxaphene	8001-35-2	≤510	≤510	≤510	≤510	≤510	≤510	≤510	≤510
Aroclor 1016	12674-11-2	≤100	≤100	≤100	≤100	≤100	≤100	≤100	≤100
Aroclor 1221	11104-28-2	≤200	≤200	≤200	≤200	≤200	≤200	≤200	≤200
Aroclor 1232	11141-16-5	≤100	≤100	≤100	≤100	≤100	≤100	≤100	≤100
Aroclor 1242	53469-21-9	≤100	≤100	≤100	≤100	≤100	≤100	≤100	≤100
Aroclor 1248	12672-29-6	≤100	≤100	≤100	≤100	≤100	≤100	≤100	≤100
Aroclor 1254	11097-69-1	≤100	≤100	≤100	≤100	≤100	≤100	≤100	≤100
Aroclor 1260	11096-82-5	≤100	≤100	≤100	≤100	≤100	≤100	≤100	≤100

Note: The "less than value" is the Reporting Limit, i.e., analyte was analyzed for but not detected. Values in this table were extracted from LEHR Data Quality Packages (16, 17).

DISCUSSION OF RESULTS

In Table 3, radionuclide concentrations for water samples collected from Putah Creek downstream from the LEHR are presented. When compared to the radionuclide concentrations for the background location (Site #4), the radionuclide concentrations for the downstream sample locations are not appreciably greater than those for the background location. Also, when the radionuclide concentrations for downstream and the background location are compared to relevant standards and guidelines presented in Table 12 below, the radionuclide concentrations for the samples are not greater than the standards and guidelines.

Table 12. Relevant Standards and Guidelines for Acceptable Radionuclide Concentrations in Water

Analyte	USEPA Drinking Water Standards (1)	Other Standards and Guidelines
Gross Alpha	15 pCi/L	
Gross Beta	30 pCi/L	
U-238	30 pCi/L (7 pCi/L) (total U)+	
U-234	30pCi/L (7 pCi/L) (total U)+	
Th-230		7000 pCi/L (2)
Ra-226	20 pCi/L	
U-235	30 pCi/L (7 pCi/L) (total U)+	
Th-227		
Th-232		2000 pCi/L (2)
Ra-228	20 pCi/L	
Th-228		2000 pCi/L (2)
Tl-208		
Pu-238 (soluble)		5 pCi/L (2)
Pu-239/240 (soluble) each		5 pCi/L (2)
K-40		
C-14		
Ba-140	90 pCi/L	
Co-60	100 pCi/L	
Cs-137	200 pCi/L	
I-131	3 pCi/L	
Sr 89/90	8 pCi/L	

+ In the 1991 USEPA Proposed Drinking Water Regulations for Radionuclides, the Minimum Concentration Limit (MCL) allowed for total U is 20 μg/L which is equivalent to 7 pCi/L; however, in Figure 2 (of the proposed regulations) to determine compliance, the total U MCL is 30 pCi/L.

In Table 4, metal concentrations for water samples collected from Putah Creek downstream from the LEHR are presented. When compared to the metal concentrations for the background location (Site #4), metal concentrations for the downstream sample locations are not appreciably greater than those for the background location except for lead at Site #1, 3.02 ppb compared to ≤1.26 ppb. However, when the metal concentrations for downstream and the background location are compared to relevant standards and guidelines presented in Table 13, the metal concentrations for the samples are not greater than the standards and/or guidelines including the comparison action level for lead, 3.02 ppb compared to 15 ppb.

Table 13. Relevant Standards and Guidelines for Acceptable Metal Concentrations in Water

Analyte	CAS Number	USEPA Drinking Water Standard (1)	Other Standards and Guidelines
Antimony	7440-36-0	6 ppb	
Arsenic	7440-38-2	50 ppb	
Barium	7440-39-3	2000 ppb	
Cadmium	7440-43-9	5 ppb	
Chromium	7440-47-3	100 ppb	
Cobalt	7440-48-4		
Lead	7439-92-1	15 ppb (action level)	
Mercury	7439-97-6	2 ppb	
Nickel	7440-02-0		100 ppb (3)
Selenium	7782-49-2	50 ppb	
Silver	7440-22-4		50 ppb (4)
Thallium	7440-28-0	2 ppb	
Vanadium	7440-62-2		
Zinc	7440-66-6	5000 ppb	

In Table 5, organic concentrations for water samples collected from Putah Creek downstream from the LEHR are presented. No concentrations were detected above the Reporting Limit for all analytes at all sample locations. In addition, the organic concentrations for downstream and the background locations are not greater than the relevant standards and guidelines presented in Table 14 below. [Note: The Reporting Limits for 4,4"-DDT, Endosulfan II, and total PCBs are not adequate to determine if concentrations are below respective standards and/or guidelines.]

Table 14. Relevant Standards and Guidelines for Acceptable Organic Concentrations in Water

Analyte	CAS Number	USEPA Drinking Water Standard (1)	Other Standards and Guidelines
Chlordane (Total)	57-74-9	2 ppb	
4,4"-DDT	50-29-3		0.59 ppt (5)
Dicofol	115-32-2		
Dieldrin	60-57-1		
Endosulfan I (total)	959-98-8		56 ppt (6)
Endosulfan II (total)	33213-65-9		56 ppt (6)
Endrin	72-20-8	2 ppb	
Heptachlor Epoxide	1024-57-3	0.2 ppb	
Hexachlorobenzene	118-74-1	1 ppb	
Lindane	58-89-9	0.2 ppb	
Toxaphene	8001-35-2	3 ppb	
PCBs (total aroclors)		0.5 ppb	

In Table 6, radionuclide concentrations for sediment samples collected from Putah Creek downstream from the LEHR are presented. When compared to the radionuclide concentrations for the background location (Site #4), radionuclide concentrations for the downstream sample locations are not appreciably greater than those for the background location except for Th-234, Ra-226, Pb-212 and K-40 at Site #2 and Cs-137 at Site #1 and #3. However, these slightly elevated concentrations when compared to respective typical radionuclide concentrations in soil are not appreciably different. The typical soil concentrations (7) for Th-234, Ra-226, Pb-212, K-40, and Cs-137 are 1.0 (based on U-238), 1.0, 1.0 (based on Th-228), 10, 0.7 pCi/g, respectively.

In Table 7, metal concentrations for sediment samples collected from Putah Creek downstream from the LEHR are presented. When compared to the metal concentrations for the background location (Site #4), metal concentrations for the downstream sample locations are not appreciably greater than those for the background location except for chromium, mercury, nickel, silver, and zinc at Site #1, zinc at Site #2, and chromium at Site #3. However, the chromium, nickel, silver, and zinc concentrations were only slightly elevated; all of these metals are present naturally in soil. Mercury, however, is not normally present in soil except where mercury-containing minerals are found. The elevated concentrations of mercury found at Site#1 could result in bioconcentration of mercury in fish and other aquatic animals and plants.

In Table 8, organic concentrations for sediment samples collected from Putah Creek downstream

from the LEHR are presented. No concentrations were detected above the Reporting Limit for all analytes at all sample locations. Based on these organic analyses, there is no indication of elevated organic concentrations in the Putah Creek sediment.

In Table 9, radionuclide concentrations for fish samples collected from Putah Creek downstream from the LEHR are presented. When compared to the radionuclide concentrations for the background location (Site #4), radionuclide concentrations for the downstream sample locations are not appreciably greater than those for the background location except for Hg-203 measured in Composite 1 and 2 at Site #1, and Th-232 and Th-228 measured in Composite 2 at Site #1 and the Composite at Site #2. Th-232 and Th-228 are naturally occurring radionuclides, and these concentrations are not appreciably elevated. However, Hg-203 is a man-made radionuclide and does not appear naturally in the environment. The half-life for Hg-203 is 46.61 days; therefore, the Hg-203 release(s) would have had to occurred within about one year or less before September 1996. Note that elevated mercury concentrations were also found in the sediment collected from Site #1; this was the only sediment location with elevated mercury concentrations. However, dose calculations based on the highest Hg-203 concentration plus two standard deviations resulted in 0.0011, 0.0024, and 0.0013 mrem/y for adult-residential, adult-recreational, and child-(5-9y), respectively. These Hg-203 dose concentrations are orders of magnitude below any radiological dose standards such as the USEPA drinking water regulations (1) for gamma emitters of 4 mrem/y. The potential Hg-203 dose from eating fish taken from Putah Creek is of no biological significance and presents no health hazard.

In Table 10, metal concentrations for fish samples collected from Putah Creek downstream from the LEHR are presented. When compared to the metal concentrations for the background location (Site #4), metal concentrations for the downstream sample locations are not appreciably greater than those for the background location except for mercury and lead at Site #1, #2 and #3 and silver at Site #2. The highest mercury concentration, 0.69 ppm, and the highest lead concentration, 1.06 ppm, were measured in fish collected from Site #1. It was noted above that mercury found in the sediment at Site #1 could result in bioconcentration of mercury in fish and other aquatic animals and plants. These results support that statement. Also, when the metal concentrations for downstream and the background location are compared to the relevant USEPA screening values for fish (8) presented in Table 15, the metal concentrations for the samples are not greater except for the comparison for mercury -- 0.69 ppm compared to 0.6 ppm, and lead -- 1.06 ppm compared to 0.3 ppm. It appears that potential doses of mercury and lead from eating fish taken from some areas of Putah Creek could present a health hazard.

In Table 11, organic concentrations for fish samples collected from Putah Creek downstream from the LEHR are presented. No concentrations were detected above the Reporting Limit for all analytes at all sample locations. In addition, when the organic concentrations for downstream and the background locations are compared to the relevant USEPA screening values for fish (8) presented in Table 15, the organic concentrations for the samples are not greater than those screening values except for dicofol, dieldrin, toxaphene and total PCBs. However, this is an artifact of the NAREL analytical method since the Reporting Limit for each of these three contaminants is

Table 15. Screening Values for Selected Metal and Organic Contaminants in Fish

Analyte	CAS Number	Screening Values from Table 5-2 (8) (ppm)	Calculated Screening Values by Equation 5-4 (8) (ppm)
Arsenic (inorganic)	7440-36-0	3	
Cadmium	7440-43-9	10	
Mercury	7439-97-6	0.6	
Lead	7439-92-1		0.3 (18) [see Appendix D]
Selenium	7782-49-2	50	
Silver	7440-22-4		32 (19)
Chlordane (total)	57-74-9	0.08	
4,4"-DDT	50-29-3	0.3	
Dicofol	115-32-2	10	
Dieldrin	60-57-1	0.007	
Endosulfan I and II (total)	959-98-8 33213-65-9	60	
Endrin	72-20-8	3	
Heptachlor Epoxide	1024-57-3	0.01	
Hexachlorobenzene	118-74-1	0.07	
Lindane	58-89-9	0.08	
Toxaphene	8001-35-2	0.1	
PCBs (total aroclors)		0.01	

greater than the respective screening value. The dicofol, dieldrin, toxaphene, and PCBs Reporting Limits are 20, 0.01, 0.51, and 0.8 ppm compared to the screening values of 10, 0.007, 0.1, and 0.01 ppm, repectively. Nevertheless, based on these organic analyses, there is no indication of elevated organic concentrations in the fish collected from Putah Creek.

CONCLUSIONS

The radionuclide, metal, and organic concentrations in the water collected from Putah Creek are not appreciably elevated as compared to background concentrations or relevant standards and guidelines.

The radionuclide, metal, and organic concentrations in the sediment collected from Putah Creek are

not appreciably elevated as compared to background concentrations or typical radionuclide concentrations in soil except for mercury found at Site #1 which could be the source for bioconcentrated mercury in fish and other aquatic animals and plants.

The radionuclide, metal, and organic concentrations in the fish collected from Putah Creek are not appreciably elevated as compared to background concentrations and screening values except for Hg-203 at Site #1 and mercury and lead at Site #1, #2, and #3. Bioconcentrated Hg-203, mercury, and lead are present in the collected fish. The potential radiation doses from Hg-203 by eating fish taken from Putah Creek present no health hazard. However, potential doses of mercury and lead from eating fish taken from Putah Creek present a possible health hazard.

RECOMMENDATIONS

We recommend that the appropriate agency:

Conduct an additional fish study to define the concentration of lead and mercury in different fish species within selected length ranges, i.e., age ranges, so as to determine which fish species should be in a fish advisory, if any, for Putah Creek. [Note: Unlike this initial screening study which investigated many different contaminants (i.e., requires a large number of different analyses and large sample weights), the next study should only address mercury and lead contamination which requires only one aliquot of 50 g-wet for the lead/mercury analysis. Even with a small fish population, a study is then possible based on individual species and length ranges.]

In the interim, consider addressing the possible health hazard associated with the elevated concentrations of lead and mercury found in the fish collected from areas of Putah Creek near the former LEHR site.

Consider investigating whether Hg-203, mercury, and lead are presently being released and, if so, that the releases meet applicable environmental regulations.

REFERENCES

(1) United States Environmental Protection Agency. Code of Federal Regulations. 40 CFR 141.

(2) Nuclear Regulatory Commission. Code of Federal Regulations. 10 CFR 20.

(3) Food and Drug Administration. Federal Register. 58 FR 41612 (1993).

(4) United States Environmental Protection Agency. Federal Register. 45 FR 79318-79319 (1980).

(5) United States Environmental Protection Agency. Code of Federal Regulations. 40 CFR 261, Appendix VIII.

(6) United States Environmental Protection Agency. Ambient Water Quality Criteria Document: Endosulfan. Washington, DC: USEPA, OWRS, CSD. EPA 440/5-80-046 (1980).

(7) United States Environmental Protection Agency. Technical Support Document for the Development of Radionuclide Cleanup Levels for Soil. Washington, DC: USEPA, ORIA. EPA 402-R-96-011A (1994).

(8) United States Environmental Protection Agency. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1, Fish Sampling and Analysis, 2nd ed. Washington, DC: USEPA, OW. EPA 823-R-95-007 (1995).

(9) United States Environmental Protection Agency. National Air and Radiation Environmental Laboratory, LEHR, Gamma Spectrometry Results (fish--NB#96-00067, sediment--NB#96-00052, and water--NB#96-00051). Montgomery, AL: USEPA, OAR, ORIA, NAREL, MASB (1997).

(10) United States Environmental Protection Agency. National Air and Radiation Environmental Laboratory, LEHR, Gross Alpha and Beta Analytical Results (fish--NB#96-00067, sediment--NB#96-00052, and water--NB#96-00051). Montgomery, AL: USEPA, OAR, ORIA, NAREL, MASB (1997).

(11) United States Environmental Protection Agency. National Air and Radiation Environmental Laboratory, LEHR, Plutonium Radiochemical Analytical Results (fish--NB#96-00067, sediment--NB#96-00052, and water--NB#96-00051). Montgomery, AL: USEPA, OAR, ORIA, NAREL, MASB (1997).

(12) United States Environmental Protection Agency. National Air and Radiation Environmental Laboratory, LEHR, Strontium Radiochemical Analytical Results (fish--NB#96-00067, sediment--NB#96-00052, and water--NB#96-00051). Montgomery, AL: USEPA, OAR, ORIA, NAREL, MASB (1997).

(13) United States Environmental Protection Agency. National Air and Radiation Environmental Laboratory, LEHR, Thorium Radiochemical Results (fish--NB#96-00067, sediment--NB#96-00052, and water--NB#96-00051). Montgomery, AL: USEPA, OAR, ORIA, NAREL, MASB (1997).

(14) United States Environmental Protection Agency. National Air and Radiation Environmental Laboratory, LEHR, Urainium Radiochemical Analytical Results (fish--NB#96-00067, sediment--NB#96-00052, and water--NB#96-00051). Montgomery, AL: USEPA, OAR, ORIA, NAREL, MASB (1997).

(15) United States Environmental Protection Agency. National Air and Radiation Environmental Laboratory, LEHR, Inorganic Analytical Results (fish--NB#96-00067, sediment--NB#96-00052, and water--NB#96-00051). Montgomery, AL: USEPA, OAR, ORIA, NAREL, MASB (1997).

(16) United States Environmental Protection Agency. National Air and Radiation Environmental Laboratory, LEHR, Organic Analytical Results (fish--NB#96-00067, sediment--NB#96-00052, and water--NB#96-00051). Montgomery, AL: USEPA, OAR, ORIA, NAREL, MASB (1997).

(17) Sanford Cohen and Associates, Inc. LEHR Analytical Report -- Ra-226, Ra-228, C-14, Co, Ni, and V (fish, sediment, and water). Montgomery, AL: Sanford Cohen and Associates Southeastern Regional Laboratory (1997).

(18) United States Environmental Protection Agency. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Supplement Guidance "Standard Default Exposure Factors" (Interim Final). Washington, DC: USEPA, OERR, TIB. OSWER Directive 9285.6-03 (1991).

(19) United States Environmental Protection Agency. Integrated Risk Information System (IRIS). Cincinnati, OH: USEPA (1989).

APPENDIX A

Sampling and Analysis Guidelines for the LEHR Site

SAMPLING AND ANALYSIS GUIDELINES FOR FISH, SEDIMENT, AND WATER SAMPLES FROM THE PUTAH CREEK ADJACENT TO THE FORMER LABORATORY FOR ENERGY-RELATED HEALTH RESEARCH DAVIS, CA

Prepared by:

Clinton Cox, PhD
USEPA-NAREL
540 South Morris Avenue
Montgomery, AL 36115-2601

Prepared for:

Agency for Toxic Substances and Disease Registry
1600 Clifton Road, NE
Atlanta, GA 30333

NAREL

National Air and Radiation Environmental Laboratory

August 24, 1996

1.0 Purpose

In a Site Summary Report entitled "Laboratory for Energy-Related Health Research, Davis, California" dated December 1995, prepared by the Agency for Toxic Substances and Disease Registry (ATSDR), a recommendation was made to conduct a screening analysis survey of fish from the Putah Creek. This document provides guidance in the selection, collection, and analysis of fish samples (and collocated sediment and water samples) to be collected from the Putah Creek. It is intended to provide general guidance to personnel who are familiar with and have procedures in place for the collection of fish, sediment and water samples from streams such as that being studied. Directions for packing and shipping of the samples obtained are included. Further, it identifies the radiological and chemical analyses to be performed on the collected and processed samples.

2.0 Potential Contamination of Concern

ATSDR has requested the National Air and Radiation Environmental Laboratory (NAREL) to collect biota (e.g., fish and crayfish) that is present in Putah Creek near the former Department of Energy (DOE) Laboratory for Energy-Related Health Research (LEHR) at Davis, CA. We anticipate that the samples [projected to be 8 fish, 4 crayfish plus collocated waters (and possibly water filters) and sediments of 4 samples each] will be collected during the week of 26 August 1996. Analyses for the fish and crayfish will be performed on fillets and tails, respectively. We anticipate that the samples will be available for analysis on about 3 September 1996. The following analyses will be performed on all samples.

<u>Metals</u>

1. Antimony
2. Arsenic (inorganic)*+
3. Barium+
4. Cadmium*+
5. Chromium (total)+
6. Lead+
7. Mercury*+
8. Selenium*+
9. Silver+
10. Thallium
11. Zinc
12. Vanadium
13. Cobalt
14. Nickel

* USEPA Fish Advisories Metal

\+ USEPA RCRA Metal

Organochlorine Pesticides

1. Chlordane, total
2. DDT, total
3. Dicofol (kelthane)
4. Dieldrin
5. Endosulfan (I and II)
6. Endrin
7. Heptachlor Epoxide
8. Hexachlorobenzene
9. Lindane
10. Toxaphene

PCBs

1. Total Aroclors (reported as seven individual aroclors, i.e., Aroclor 1016, 1221, 1232, 1242, 1248, 1254, and 1260)

Radionuclides

1. Sr
2. C-14
2. Ra, Th, U, Pu
3. Gross Alpha
4. Gross Beta
5. Gamma Spectrometry

Analytes From EPA's Fish Advisories' Recommended Target Analytes List NOT NEEDED:

1. Metal: Tributyl Tin*
2. Organochlorine Pesticide: Mirex
3. Organophosphate Pesticides
4. Chlorophenoxy Herbicides
5. Dioxins/furans
6. PAHs

The Reporting Limits for the non-rad analytes are presented in Table 1, and the Minimum Detectable Concentrations (MDCs) for the radionuclides of interest are presented in Tables 2 and 3.

TABLE 1. Reporting Limits of Mixed Waste Analytes for LEHR Environmental Samples

Metals	Water (100-mL)	SW-846 Method #'s	Soil (1-g)	SW-846 Method #'s	Fish/Crayfish (1-g)	SW-846 Method #'s
Antimony	60 µg/L	3015/7041	12 mg/Kg*	3051/7041	12 mg/Kg*	3051/7041
Arsenic	10 µg/L	3015/7060A	2 mg/Kg*	3051/7060A	2 mg/Kg*	3051/7060A
Barium	200 µg/L	3015/7080A	40 mg/Kg*	3051/7080A	40 mg/Kg*	3051/7080A
Cadmium	5 µg/L	3015/7131A	1 mg/Kg*	3051/7131A	1 mg/Kg*	3051/7131A
Chromium	10 µg/L	3015/7190	2 mg/Kg*	3051/7190	2 mg/Kg*	3051/7190
Lead	3 µg/L	3015/7421	0.6 mg/Kg*	3051/7421	0.6 mg/Kg*	3051/7421
Mercury	0.2 µg/L	7470A	0.1 mg/Kg*	7471A	0.1 mg/Kg*	7471A
Selenium	5 µg/L	3015/7740	1 mg/Kg*	3051/7740	1 mg/Kg*	3051/7740
Silver	10 µg/L	3015/7761	2 mg/Kg*	3051/7761	2 mg/Kg*	3051/7761

Metals	Water (100-mL)	SW-846 Method #'s	Soil (1-g)	SW-846 Method #'s	Fish/Crayfish (1-g)	SW-846 Method #'s
Thallium	10 µg/L	3015/7841	2 mg/Kg*	3051/7841	2 mg/Kg*	3051/7841
Zinc	20 µg/L	3015/7950	4 mg/Kg*	3051/7950	4 mg/Kg*	3051/7950
Pesticides/PCBs	Water (1-L)	SW-846 Method #'s	Soil (30-g)	SW-846 Method #'s	Fish/Crayfish (10-g)	SW-846 Method #'s
Chlordane (total)	0.05 µg/L	3510B/3640A/8081	1.7 µg/Kg*	3550A/3640A/8081	5.1 µg/Kg*	3550A/3640A/8081
4,4' - DDT	0.10 µg/L	3510B/3640A/8081	3.3 µg/Kg*	3550A/3640A/8081	10.0 µg/Kg*	3550A/3640A/8081
Dicofol	0.20 µg/L	3510B/3640A/8081	6.6 µg/Kg*	3550A/3640A/8081	20.0 µg/Kg*	3550A/3640A/8081
Dieldrin	0.10 µg/L	3510B/3640A/8081	3.3 µg/Kg*	3550A/3640A/8081	10.0 µg/Kg*	3550A/3640A/8081
Endosulfan I	0.05 µg/L	3510B/3640A/8081	1.7 µg/Kg*	3550A/3640A/8081	5.1 µg/Kg*	3550A/3640A/8081
Endosulfan II	0.10 µg/L	3510B/3640A/8081	3.3 µg/Kg*	3550A/3640A/8081	10.0 µg/Kg*	3550A/3640A/8081
Endrin	0.10 µg/L	3510B/3640A/8081	3.3 µg/Kg*	3550A/3640A/8081	10.0 µg/Kg*	3550A/3640A/8081
Heptachlor Epoxide	0.05 µg/L	3510B/3640A/8081	1.7 µg/Kg*	3550A/3640A/8081	5.1 µg/Kg*	3550A/3640A/8081
Hexachlorobenzene	0.05 µg/L	3510B/3640A/8081	1.7 µg/Kg*	3550A/3640A/8081	5.1 µg/Kg*	3550A/3640A/8081
Lindane	0.05 µg/L	3510B/3640A/8081	1.7 µg/Kg*	3550A/3640A/8081	5.1 µg/Kg*	3550A/3640A/8081
Toxaphene	5.0 µg/L	3510B/3640A/8081	170 µg/Kg*	3550A/3640A/8081	510.0 µg/Kg*	3550A/3640A/8081
Aroclor 1016	1.0 µg/L	3510B/3640A/8081	33.0 µg/Kg*	3550A/3640A/8081	100.0 µg/Kg*	3550A/3640A/8081
Aroclor 1221	2.0 µg/L	3510B/3640A/8081	67.0 µg/Kg*	3550A/3640A/8081	200.0 µg/Kg*	3550A/3640A/8081
Aroclor 1232	1.0 µg/L	3510B/3640A/8081	33.0 µg/Kg*	3550A/3640A/8081	100.0 µg/Kg*	3550A/3640A/8081
Aroclor 1242	1.0 µg/L	3510B/3640A/8081	33.0 µg/Kg*	3550A/3640A/8081	100.0 µg/Kg*	3550A/3640A/8081
Aroclor 1248	1.0 µg/L	3510B/3640A/8081	33.0 µg/Kg*	3550A/3640A/8081	100.0 µg/Kg*	3550A/3640A/8081
Aroclor 1254	1.0 µg/L	3510B/3640A/8081	33.0 µg/Kg*	3550A/3640A/8081	100.0 µg/Kg*	3550A/3640A/8081
Aroclor 1260	1.0 µg/L	3510B/3640A/8081	33.0 µg/Kg*	3550A/3640A/8081	100.0 µg/Kg*	3550A/3640A/8081

* All soil and fish/crayfish units are based on wet weight. Soil samples will be reported on a dry weight basis. Fish/crayfish samples will be reported on a wet weight basis.

TABLE 2. Minimum Detectable Concentration (MDC) for Gamma Emitters Using Gamma Spectrometry with a Ge Detector

Selected Gamma Emitters	MDC (pCi/L) 1 L of Water, 1000 min Count	MDC (pCi/gwet) 1500 g of Sediment, 1000 min Count	MDC (pCi/gwet) 100 g of Sediment, 1000 min Count	MDC (pCi/gwet) 40 g of Sediment, 1000 min Count	MDC (pCi/gwet) 1000 g of Biota, 1000 min Count
Am-241	17.7	0.0179	0.0842	0.168	0.0177
Cd-109	83.0	0.0749	0.424	0.901	0.0830
Th-234	52.5	0.0468	0.270	0.578	0.0525
U-235	56.7	0.0470	0.294	0.684	0.0567
Ra-226	86.1	0.0710	0.446	1.05	0.0861
Th-229	65.6	0.0540	0.340	0.799	0.0656
Pb-212	8.45	0.00689	0.0439	0.104	0.00845
Ra-224	91.0	0.0742	0.473	1.12	0.0910
Ra-223	26.7	0.0216	0.139	0.329	0.0267
Pb-214	11.4	0.00919	0.0601	0.143	0.0114
I-131	5.84	0.00468	0.0307	0.0730	0.0584
Rn-219	69.6	0.0556	0.367	0.873	0.0696
Be-7	45.4	0.0360	0.241	0.574	0.0454
Ba-140	22.2	0.0175	0.119	0.282	0.0222
Rn-220	7110	5.6	38.0	90.4	7.11
Tl-208	6.42	0.00504	0.0344	0.0818	0.00642
Cs-134	6.67	0.00523	0.0357	0.0850	0.00667
Bi-214	13.1	0.0103	0.0704	0.167	0.0131
Cs-137	7.26	0.00567	0.0391	0.0929	0.00726
Bi-212	89.4	0.0696	0.483	1.15	0.0894
Pb-211	188	0.145	1.02	2.42	0.188
Mn-54	7.03	0.00543	0.0382	0.0909	0.00703
Ra-228	24.4	0.0188	0.133	0.317	0.0244
Pa-234m	950	0.728	5.20	12.4	0.950
Co-60	10.3	0.00782	0.0566	0.135	0.0103
Na-22	9.38	0.00712	0.0519	0.123	0.00938
K-40	99.3	0.0749	0.552	1.31	0.0993

NOTE: MDCs will vary depending on activity in the sample, density of sample matrix, efficiency of detector, and other counting parameters. The above MDCs were calculated based on a 1000-min count of a 1.0-L Marinelli of deionized water.

Table 3. NAREL Minimum Detectable Concentration (MDC) for Selected Radionuclides Using Various Radiochemical Analyses

Radionuclide	Matrix	Typical Aliquot Size	Count Time (min)	Method	MDC
Carbon-14	Solid	0.5 g	100	LS	3 pCi/g
	Water	10 mL	100	LS	250 pCi/L
Gross Alpha	Water	250 mL	100	GFP	6 pCi/L
Gross Beta	Water	250 mL	100	GFP	3 pCi/L
Radium-226	Water	1 L	1000	SC	0.02 pCi/L
	Solids	0.5 g	1000	SC	0.04 pCi/g
Radium-228	Water	1 L	100	GFP	1 pCi/L
	Solids	0.5 g	100	GFP	2 pCi/g
Uranium-234, 235, 238 Thorium-230, 232 Plutonium-238, 239/240	Water	1L	1000	AS	0.1 pCi/L
	Solids	0.5 g	1000	AS	0.2 pCi/g
Thorium-227	Water	1L	1000	AS	0.2 pCi/L
	Solids	0.5 g	1000	AS	0.35 pCi/g
Thorium-228	Water	1L	1000	AS	0.15 pCi/L
	Solids	**0.5 g**	**1000**	**AS**	**0.3 pCi/g**

AS Alpha Spectrometry GFP Gas-Flow Proportional Counting
LS Liquid Scintillation Counting SC Scintillation Counting

3.0 Sample Collection

3.1 Fish Species

Putah Creek contains an excellent collection of both native and introduced species. There are trout in the upper reaches of Putah Creek, but the LEHR site is low down in the system and the water is warmer. As a result, a background site, where the same warm-water fish may be captured, will be selected near the site. The fish categories and target species are as follows:

Game Fish Category
1) Bluegill, Lepomis Macrochirus
2) Largemouth Bass, Micropterus Salmoides

Bottom-Feeders Category
1) Common Carp, Cyprinus Carpio
2) Catfish, Ictalurus Species

Other Category
1) Crayfish, Astacidae

3.2 Sample Sites

Presently, there is a lot of water in the creek which continues to flow several miles downstream of the site. In recent years, this was not the case during late summer months. Two locations on the South Fork, one at the site and one downstream one or two miles are easily accessible. The North Fork is really not connected to the South Fork (only at high water and by a storm water culvert) or related to it from a contamination standpoint - it is actually a stagnant, ponded stretch. The North Fork was not identified for sampling.

For background sampling, the creek is accessible for several miles upstream. The background site selected is above all influence from the University which is several miles downstream. Several potential sources of pollution are at or near the site including: the UC Davis waste water treatment plant which discharges immediately upstream of the site at the Old Davis Road bridge crossing, a storm channel which cuts through the old landfill which is part of the site on the downstream side (it is usually dry), other departments of the University located upstream, and the University landfill located near the County Road 98 crossing of Putah Creek.

The following four sampling locations (one a background location) were selected:

Location #1 - South Fork Putah Creek - downstream of Old Davis Road and adjacent to the site.

Location #2 - South Fork Putah Creek - 1 mile downstream of Old Davis Road and 0.6 miles downstream of storm drain on eastern edge of LEHR site.

Location #3 - South Fork Putah Creek - 2 mile downstream of Old Davis Road and 1.6 miles downstream of storm drain on eastern edge of LEHR site.

Location #4 - South Fork Putah Creek - a background site located upstream, west of Davis off Putah Creek Road near Stevenson Bridge Road crossing.

3.3 Sampling Method

Fish, sediment and water samples will be collected and shipped, under chain-of-custody, by documented procedures currently in use by USEPA Region 9. The fish samples may be, depending upon availability, composites of different species from a single sample location. However, identifiers and records of individual species should be maintained during sampling and on the chain-of-custody form. If composites are necessary, they will be performed at the laboratory. If possible, it is desirable to have 1 kg of each fish species collected to be included in the composites.

3.3.1 Fish Sampling

Sampling for fish will be accomplished with a seine. If seining success is poor due to snags, a backpack electroshocker will be used from a 13-ft boat. Seining should work well upstream, but habitat at the site and downstream may make seining difficult. Crayfish will be captured in baited crayfish traps. A minimum of 2 kg of each fish category will be required. The level of effort, gear used, and fish sampling information will be recorded in field logbooks.

3.3.2 Water Sampling

Grab surface water samples will be collected directly into sample container (at least 2 L for metals, 2 L for pesticides/PCBs, and 8 L for rad) near the stream center in proximity of the locations where the crayfish samples were collected. Field duplicates and collocated samples will also be collected at Sample Location #1. If particulate is visible in the metal or rad water samples, the particulate will be removed with a 0.45-μm filter. Each container (and 0.45-μm filter, if present) will be clearly marked as to the analysis to be performed. Filters will not be analyzed unless greater than 5 g of particulate is present. Nitric acid will be used to adjust the pH of the metal and rad water samples (after filtering) to 2. Water sampling information will be recorded in field logbooks.

3.3.3 Sediment Sampling

Grab sediment samples (at least 800 g for metals, 400 g for pesticides/PCBs, and 2000 g for rad) will be collected to a sediment depth of about 15 cm using a dredge such as an Eckman, Ponar, or Petersen dredge or, if appropriate, a coring device can be used. The sediment samples will be collected in proximity of the locations where the crayfish and water samples were collected. Sediment samples will be transferred to the appropriate container and clearly marked as to the analysis to be performed. Field duplicates and collocated samples will also be collected at Sample Location #1. Sediment sampling information will be recorded in field logbooks.

3.3.4 Sample Containers, Storage, and Shipment

Sample containers, acid preservative, and packaging will be selected to suit the analytical needs and to follow sampling and analysis procedures. Samples should be maintained at 4±2°C and shipped to NAREL for next day delivery. Peter Husby, John Griggs, and Mike Clark will coordinate the sample volumes, containers, preservative, storage, and shipping requirements for this survey.

4.0 Analyses

The fish collected from Putah Creek will be analyzed per NAREL standard analytical procedures for radioactive and target analytes listed in *Guidance for Assessing Chemical Contamination Data For Use in Fish Advisories, Volume 1, Fish Sampling and Analysis, Second Edition, September 1995* and Section 2.0 Potential Contamination of Concern above. Analyses will be performed on the fish fillets and crayfish tails. The QAPP applicable to this project is *Quality Assurance Project Plan for Radiochemical Measurements to Provide Technical Support for NAREL Environmental Evaluation at Department of Energy Sites.*

5.0 Shipping Instructions

The samples are to be maintained at 4±2°C while waiting for shipment to NAREL. Sediment and water samples will be shipped in picnic coolers, along with chain-of-custody forms. Each fish sample obtained should be placed whole in labeled, zip-lock freezer bags, along with the chain-of-custody forms, packed in ice inside a picnic cooler of sufficient size and shipped via overnight delivery to:

USEPA-NAREL
540 South Morris Avenue
Montgomery, AL 3611-2601
Contact: Susan Baker, Sample Prep
(334) 270-7052

Sample Prep at NAREL should be informed a minimum of three days in advance of the impending arrival of the samples. If needed, NAREL will provide shipping containers, survey supplies, and shipping invoices.

6.0 Data Reporting

NAREL will produce a data quality package which includes the QA/QC data for the project. Also, a NAREL Technical Report will be written that includes the survey results in table form, a discussion of the results, conclusions and recommendations, as appropriate.

Appendix B

Field Sampling Summary for Sampling from Putah Creek Adjacent to the Former Laboratory for Energy-Related Health Research

FIELD SAMPLING SUMMARY FOR SAMPLING FROM PUTAH CREEK ADJACENT TO THE FORMER LABORATORY FOR ENERGY-RELATED HEALTH RESEARCH DAVIS, CA

Prepared by:

Peter Husby
USEPA Region 9 Laboratory
1337 S. 46th St.; Building 201
Richmond, CA 94804

INTRODUCTION

Background

This sampling event near the Former Laboratory for Energy-Related Health Research (LEHR) Site in Davis, CA was performed to assist the USEPA-National Air and Radiation Environmental Laboratory (NAREL) in conducting a screening analysis survey of fish from Putah Creek. The sampling was performed by personnel from the USEPA Region 9 Laboratory. Sampling was performed in accordance with the Sampling and Analysis Guidelines (see Appendix A) document dated August 24, 1996. These Guidelines provided general guidance in the selection, collection, and analysis of fish samples (and collocated sediment and water samples) to be collected from the Putah Creek. This document outlines the specific methods used and the dates and times of all collections. Sampling occurred between August 27 and September 12, 1996.

Sample Locations

The following four locations were sampled:

Site #1 - South Fork Putah Creek - downstream of Old Davis Road and adjacent to the site.
Lat/Lon - N 38° 31'2.0" W 121° 45'22.1"

Site #2 - South Fork Putah Creek - 1 mile downstream of Old Davis Road and 0.6 miles downstream of storm drain on eastern edge of LEHR site. Lat/Lon - N 38° 31' 1.6" W 121° 43'58.0"

Site #3 - South Fork Putah Creek - 2 mile downstream of Old Davis Road and 1.6 miles downstream of storm drain on eastern edge of LEHR site. Lat/Lon - N 38° 31' 0.7" W 121° 42'46.8"

Site #4 - South Fork Putah Creek - a background site located upstream, west of Davis upstream of Pedrick Road crossing. Lat/Lon - N 38° 31'34.4" W 121° 48'42.9"

SAMPLING METHODS

Fish Sampling

Fish collection occurred over several days and involved various methods, as required by the habitats and conditions encountered at each site. Electrofishing occurred over larger reaches, while netting was limited to specific locations, near the crayfish traps and sediment and water collection points. The fish which were collected or trapped were stored on ice during the day in the field and placed in the freezer upon return to the Region IX Lab. Identifications were made in the field and verified in the lab prior to shipment. See Table B-1 for dates of sampling, and Table B-2 for a summary of the fish species collected and the total lengths and weights of the specimens collected. Specific information on collection methods used at each site is outlined below:

Site #1 - Due to the depth of the reach, seining was not possible. Electroshocking was attempted, using a backpack shocker mounted on a 13-foot boat, with no success. Finally, sufficient sample was collected with two Fyke nets. The nets were set on 9/11 and the fish collected on 9/12.

Site #2 - Due to the depth and width of the reach, seining was not possible. Electroshocking was attempted using a backpack shocker mounted on a 13-foot boat. Although success was limited, minimum tissue for both game and bottom-fish was collected.

Site #3 - This site was also too deep and wide for seining or backpack electroshocking. In addition, there was no access point for a boat and access upstream and downstream of the location was obstructed by thick brush. Therefore, a large mesh (6 inch) gill net and a hoop net were set. These nets were set on 9/10 and checked on 9/11 and 9/12. Adequate sample of both game and bottom fish were obtained in that time frame.

Site #4 - This background site was initially sampled by seine on 8/27 with no success. As a result of the shallow, fast moving nature of most of the reach, backpack electroshocking was the easiest method of collection and was used exclusively at this site. The upper end of the reach was too deep and wide for electroshocking on foot and no boat access was available. Adequate game fish sample was collected after several days effort (8/27-28 and 9/3-4), but sufficient bottom-feeder tissue was not collected.

Crayfish were captured in baited crayfish traps. One trap was set at each site on 8/27. An additional trap was set at Sites 1 and 4. The two traps at Site 4 were removed on 9/4 and placed at Sites 2 & 3. All traps at Sites 1, 2 & 3 were removed on 9/12. Traps were baited with canned cat food and were checked each day samplers were on site. All crayfish collected were live and were placed on ice while in the field, then frozen at the Region 9 Lab until shipment to NAREL.

Surface Water Sampling

Grab surface water samples were collected directly into the sample containers. The samples were collected in the stream flow near the locations where the crayfish traps were set, and the sediment samples were collected. Field duplicates were collected at Site #1. As no visible particulate matter was noted in the samples, filtration was performed. All samples were kept on ice until shipment to NAREL. See Table B-1 for dates and times.

Sediment Sampling

A hand core was used to collect multiple sediment cores which were composited and then placed in sample containers. The sediments collected were soft sediments in close proximity to the crayfish traps and water sample locations. Field duplicates and collocated samples were collected at Site #1. All samples were kept on ice until shipment to NAREL. See Table B-1 for dates and times.

TABLE B-1

Sample Collection Summary

Location	Fish Date	Crayfish Date	Sediment Date/Time	Water Date/Time
Site # 1	9/11-12/96	8/27 - 9/12/96	8/28/96 13:30	8/28/96 13:30
Site # 2	9/9/96	8/27 - 9/12/96	8/28/96 15:30	8/28/96 15:30
Site # 3	9/10-12/96	8/27 - 9/12/96	8/29/96 11:45	8/29/96 11:15
Site # 4	8/27-28, 9/3-4/96	8/27 - 9/4/96	8/27/96 11:10	8/27-28/96 10:35

TABLE B-2

Fish Species Summary

Location	Common Name	Scientific Name	Number Collected	Total Length (cm)	Weight (g)
Site # 1	Black crappie	*Pomoxis nigromaculatus*	2	23.6 26.9	191 280
	Largemouth bass	*Micropterus salmoides*	2	27.2 35.0	312 764
	Bluegill	*Lepomis macrochirus*	1	17.0	118
	White catfish	*Ameiurus catus*	2	33.5 38.9	638 783
	Black bullhead	*Ameiurus melas*	4	22.1 22.4 26.9 27.7	204 219 362 312
	Crayfish		10	---	394
Site # 2	Largemouth bass	*Micropterus salmoides*	1	33	580
	Black bullhead	*Ameiurus melas*	1	22.9	194
	Carp	*Cyprinus carpio*	1	---	1500
	Crayfish		9	---	288

Location	Common Name	Scientific Name	Number Collected	Total Length (cm)	Weight (g)
Site # 3	Largemouth bass	*Micropterus salmoides*	3	27.9 29.0 31.8	308 346 520
	Black crappie	*Pomoxis nigromaculatus*	2	22.4 23.4	172 173
	Carp	*Cyprinus carpio*	1	52.1	1621
	White catfish	*Ameiurus catus*	1	60.4	2538
	Crayfish		9	---	265
Site # 4	Largemouth bass	*Micropterus salmoides*	3	6.1 14.2 20.6	3 49 120
	Bluegill	*Lepomis macrochirus*	78	---	1845
	Green Sunfish	*Lepomis cyanellus*	43	---	578
	White catfish	*Ameiurus catus*	1	17.0	67
	Crayfish		8	---	203

Appendix C

General Information for Various NAREL Analytical Methods

Gamma Spectrometry:

The reporting format in the NAREL Data Quality Packages lists the gamma emitters in alphabetical order. The activity and 2-sigma uncertainty for radionuclides measured by gamma spectroscopy are reported only if the nuclide is detected. Nuclides that are not detected do not appear in the report, with the exception of Ba-140, Co-60, Cs-137, I-131, K-40, Ra-226 and Ra-228. If one of these seven nuclides is undetected, NAREL reports it as "Not Detected" or "ND" and provides a sample-specific estimate of the Minimum Detectable Concentration (MDC).

Due to potential spectral interferences and other possible problems associated with the determination of the activity of certain radionuclides, the activities for Th-234, Pa-234m, Ra-226, and U-235 are subject to greater possible error than other commonly reported radionuclides. Note that this potential error is not included in the 2-sigma counting error which is reported with each activity. Although in NAREL reports, the calculated activities for these radionuclides are provided, it is recommend that the results be used only as a qualitative means of indicating the presence of these radionuclides and not as a quantitative measure of their concentration. The results for these nuclides are not used in the evaluation of quality control samples. Furthermore, because of mutual interference between Ra-226 and U-235, NAREL's gamma analysis software tends to overestimate the amounts of these nuclides whenever both are present in a sample. Lower estimates for Ra-226 activities can be obtained from the reported activities of its decay products, Pb-214 and Bi-214, which are likely to be somewhat less than the Ra-226 activity because of the potential escape of radon gas.

NAREL's gamma spectroscopy software corrects activities and MDCs for decay between collection and analysis, but only up to a limit of ten half-lives. So, if the decay time for a sample is more than ten half-lives of a radionuclide, that nuclide will almost always be undetected and the reported MDC will be meaningless. This is usually a problem only for short-lives radionuclides, such as I-131 and Ba-140, when there is a long delay between collection and analysis.

Gross Alpha and Beta Analysis:

In comparison to the methods employed to determine radionuclide-specific activities, the method employed by NAREL to determine gross alpha and beta activity in water samples has the potential for greater analytical bias. It should be noted that this potential analytical error is not included in the 2-sigma counting error term. Therefore, gross alpha and beta results should be used as gross approximations of the alpha and beta activity present.

Thorium Radiochemical Analysis:

In analyzing samples for U-234 and U-238, U-232 is used as a tracer to determine the chemical recovery. Th-228 is produced from the radioactive decay of U-232 and since it is one of the thorium isotopes of concern, the small amount of Th-228 present once the tracer has been prepared for use, along with its ingrowth from the time of preparation to its use, is substracted from the Th-228 activity measured. Occasionally, our estimate of the Th-228 originally present in the tracer is too high. If the sample Th-228 activity is very low, overestimation of the Th-228 present in the tracer may result in a negative Th-228 activity for the sample.

Appendix D

Screening Value Calculation for Consumption of Lead-Contaminated Fish

The USEPA has established a safe action level of lead in drinking water of 0.015 mg_{Pb}/L (1) using default values of 2.0 L/day for water intake and 70 kg for the weight of an adult male. Within the USEPA Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories (8), a Screening Value (SV_{Pb}) for lead was not specified. Presented below are the assumptions and calculations used to estimate a SV_{Pb} for comparative use in this study.

Assumptions:

(1) The same Reference Dose (R_fD) is applicable regardless whether the lead intake is from drinking water or eating contaminated fish. [Note: This assumption is conservative toward the protection of the public.]

(2) The most sensitive sub-population is children 9-12 yr of age who are likely to fish a small creek and eat the fish taken (parents and siblings may do the same for the family).

(3) The weight of 9-12 yr old children is 36 kg (8).

(4) The daily intake for locally caught fish is 54 g/day (18). [Note: This assumption is conservative toward the protection of the public.]

Calculations:

(1) $R_fD = (0.015\ mg_{Pb}/L \times 2.0\ L/day)/70\ kg_m = 0.00043\ mg_{Pb}/kg_m\text{-day}$

(2) $SV_{Pb} = (0.00043\ mg_{Pb}/kg_m\text{-day} \times 36\ kg_m)/(54\ g_f/day \times kg_f/1000\ g_f) = 0.3\ mg_{Pb}/kg_f$