12/8-7-95 JSC(1)

UCRL-ID-121236

Assessment of Sediment Monitoring at LLNL

Gretchen Gallegos

March 17, 1994

Work performed under the auspices of the U.S. Department of Energy by the
Lawrence Livermore National Laboratory under Contract W-7405-ENG-48.

DISCLAIMER

This document was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor the University of California nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or the University of California, and shall not be used for advertising or product endorsement purposes.

This report has been reproduced
directly from the best available copy.

Available to DOE and DOE contractors from the
Office of Scientific and Technical Information
P.O. Box 62, Oak Ridge, TN 37831
Prices available from (615) 576-8401, FTS 626-8401

Available to the public from the
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Rd.,
Springfield, VA 22161

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Assessment of Sediment Monitoring at LLNL

Gretchen Gallegos

March 17, 1994

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

MASTER

ga

Table of Contents

Abstract	1
Introduction.....	1
Method Review	2
Annual Sampling.....	2
Special Sampling	2
Data Review.....	3
Surveillance Data	3
1989 Study Data	4
1991 Study Data	4
Conclusion.....	6
Acknowledgments	6
References	20
 Appendix A: Letter Report for 1989 Sediment Study.....	A-1 to A-5
Appendix B: 1991 Sediment Study Sampling Plan.....	B-1 to B-21
Appendix C: Surveillance Soils and Sediment Sampling Procedure.....	C-1 to C-16
Appendix D: Analytical Results from 1991 Sediment Study.....	D-1 to D-9

List of Figures and Tables

Figure 1:	Surveillance Locations.....	7
Figure 2:	Comparisons of ^{232}Th and Tritium data for 1991 study.....	8
Figure 3:	Comparisons of ^{40}K and ^{226}Ra data for 1991 study.....	9
Table 1:	Metals values for sediment samples (mg/L), 1989 to 1992	10
Table 2:	Organic compounds and pesticides values for sediment samples, 1988 to 1992.....	11
Table 3:	Comparison of soils and sediment radionuclide data, 1988 to 1992....	12
Table 4:	California waste extraction analysis metals from 1991 sediments study (mg/L)	12
Table 5:	ICAP metals analysis from 1991 sediments study on liquid samples (mg/L).	12
Table 6:	ICAP metals analysis from 1991 sediments study on solid samples (mg/kg)	13
Table 7:	Radionuclide analysis for 1991 sediment study (pCi/g, unless otherwise noted).....	14
Table 8:	Volatile organic compounds in 1991 study detected by EPA method 8270 and for which there are disposal limits, mg/kg unless otherwise noted	15, 16
Table 9:	Pesticides detected in 1991 study in mg/kg unless otherwise noted ...	17
Table 10:	Volatile organic compounds detected in 1991 study (EPA method 5030/8240) for which there are disposal limits, mg/kg unless otherwise noted	18
Table 11:	Summary of materials found in the sediment studies above hazardous waste disposal limits.....	19

Assessment of Sediment Monitoring at LLNL

Gretchen Gallegos

Abstract

Three separate sediment monitoring studies have been conducted at the Lawrence Livermore National Laboratory (LLNL) Livermore site. "Sediment" is defined here as finely divided solid materials that have settled out of an active stream or standing water. Sediment samples from all three studies were analyzed for a number of contaminants including ^{239}Pu , ^3H , gamma emitting radionuclides, heavy metals, volatile organic compounds and pesticides. The analytical results for metals and organic compounds were compared to limits for disposal of hazardous waste, the tritium values were compared to drinking water standards, and the other radionuclides were compared to soils monitoring values. No tritium values were above (or were greater than 55% of drinking water standards), and no other radionuclides in sediments were above soils values. In all of the studies, only two metals, lead and mercury, and six organic compounds, benzo(a)-pyrene, Dieldrin, p,p'-DDT, Endosulfan I, endosulfan sulfate, and vinyl chloride were above waste disposal limits. Three of the high contaminants, mercury, benzo(a)-pyrene, and vinyl chloride, were found at one sampling location; the others were not connected by drainage channels or physical proximity to each other. Overall, a total of 247 samples were analyzed, and the sporadic identification of materials over disposal limits demonstrates that there is negligible contamination of sediment.

Introduction

Three separate sediment monitoring studies have been conducted at the Lawrence Livermore National Laboratory (LLNL) Livermore site. "Sediment" is used here to mean finely divided solid materials that have settled out of an active stream or standing water (it is not "sediment" in a geologic sense—by the geologic definition, the top 1000 meters at the site is sediment). In 1988, an annual sediment surveillance monitoring program was initiated to assist with environmental restoration efforts at locating areas of contamination (Holland, 1993). Sediment from catch basins, open drainage channels, and manholes were sampled in two other sampling efforts; one in 1989, in which 30 surface soil, drainage channel, and storm drain locations were sampled (see letter report of F. Hoffman to C. DeGrange, May 16, 1989, Appendix A) and one in 1991, in which 89 locations were sampled (see W. Schwartz report, August 1991, Appendix B).

Sediment samples from all three studies were analyzed for a number of contaminants including ^{239}Pu , ^3H , gamma emitting radionuclides, heavy metals, volatile organic compounds and pesticides. These data are reviewed here for significant trends that should be used in determining the need for continued studies of sediments at the LLNL Livermore site.

Method Review

Annual Sampling

Annual surveillance sampling of sediment is conducted according to a written procedure (see Appendix C). Permanent sampling locations were established in the Livermore site drainage channels and are shown on Fig. 1. Sampling locations were chosen to represent points of water flow on to and away from the site, and points where drainage channels met. Sediment is regularly deposited at location CDB, which is a siltation area for the Central Drainage Retention Basin. All other locations are generally scoured by runoff, and the deposition of material does not follow any particular pattern, making any conclusions about the source of deposited material difficult.

Quadruplicate samples were taken at each location in 1988, 1989 and 1990, and triplicate samples were taken in 1991 and 1992; a total of 138 samples were taken from 1988 to 1992. Samples were gathered in the late spring to summer months, between rainy seasons, and were taken 25 cm deep. The samples were submitted for analysis for halogenated volatile organic compounds (annual EPA Method 8010), aromatic volatile organic compounds, (EPA Method 8020), pesticides (EPA Method 8080), heavy metals, ^{239}Pu , gamma emitting radionuclides, and tritium.

Special Sampling

Two special sediment sampling studies have been undertaken in addition to the annual sediment monitoring. The first special study of sediment was in 1989. The locations for sampling were chosen to provide information for the LLNL Ground Water Project Baseline Public Health assessment. Twenty sediment locations were taken in open channel areas of the various drainages throughout the site and 10 surface samples were taken (see Fig. 1). The samples were taken 5 cm deep. They were analyzed for volatile organic compounds (EPA Method 8240), semi-volatile organic compounds, (EPA Method 8270), pesticides (EPA Method 8080), heavy metals, gamma emitting radionuclides, gross alpha radioactivity, gross beta radioactivity, and tritium.

The second special study of sediment took place in 1991. The locations of the second special sampling study were chosen to assess the entire LLNL Livermore storm drainage system. Starting at the highest elevation, sample locations were chosen at the down gradient junction of two intersecting drainage lines or at the junction of a drainage line and a network of drainage lines. Some locations were also chosen on the basis of past practices or known releases near a selected location. The depth of samples was not specified and could be taken to a depth of a "few feet"; the depths appears to have depended upon the depth of material present at any location. The samples were analyzed for volatile organic compounds (EPA Method 5030/8240), semi-volatile organic compounds, (EPA Method 8270), pesticides (EPA Method 8080), heavy metals,

gamma emitting radionuclides, gross alpha radioactivity, gross beta radioactivity, and tritium.

Data Review

Surveillance Data

Surveillance sediment samples were analyzed for three general types of contaminants, metals, organic compounds, and radionuclides. There are no specific standards regulating the amounts of contaminants in soils or sediments. To have some measure of whether the detected levels present any cause for concern, it is useful to compare the levels with standards set for disposal of hazardous waste. Such limits include federal Resource Conservation and Recovery Act regulations, which are also codified in Title 22, California Code of Regulations sections 66261.33 and related section 66268.43. According to section 66261.33 (d): "any residue or contaminated soils, water or other debris resulting from the cleanup of a spill into or on any land or water of any commercial chemical product or manufacturing chemical intermediate having the generic name listed in subsection (e) or (f) of this section, ..." is a hazardous waste. Sections (e) and (f) list acute hazardous wastes and toxic wastes, and include RCRA category P and U wastes; section 66268.43 lists the limits for these wastes.

With one exception, all metals analyses were below the limits for hazardous waste (see Table 1). The one analysis that was above the limits was for lead in 1989; 79 mg/L was found and the limit is 5 mg/L. However, of the quadruplicate samples taken at this location (in accordance with the procedure), only one high value was found, the others were detection limits. Seven samples taken the following year and subsequent routine annual sampling also failed to show high values for lead at that location. This sampling location coincided with a location in for the 1989 special study, which also identified elevated values for chromium, lead, PCE, and Freon 11. This location was cleaned up (Thorpe et al., 1990).

Similarly, there have been no detections of organic chemicals or pesticides above waste limits (see Table 2). In fact, most chemicals were only detected sporadically and at levels barely above detection limits. Only one material was detected at above 40% of the standard for disposal of waste and only three were above 5% of the disposal standard.

There are no specific waste limits for radionuclides, so there is no convenient limit against which to compare the levels of radionuclides in sediments. However, the sediment samples are analyzed for almost the same radionuclides as the soil samples that are taken as part of the routine soils surveillance monitoring program. Both sets of samples are analyzed for ^{239}Pu and for gamma emitters (data are reported in Brekke et al. 1989; Gallegos et al., 1992, 1993; Sims et al. 1990, 1991. (Sediment samples are also analyzed for tritium.) A comparison of the results for routine soils and sediment samples shows that the data are not significantly different except for ^{239}Pu and ^{137}Cs , which are higher for soils than for sediment (see Tables 3 and 4). This result is not unexpected because soils samples are taken 5 cm deep and sediment samples are taken 25 cm deep and ^{239}Pu and ^{137}Cs arise from surface deposition.

The surveillance soils samples were not analyzed for tritium, so sediment values cannot be compared to soils values. However, there is a California drinking water standard (22 California Code of Regulations Section 64443) for tritium of 20,000 pCi/L,

and the values for tritium present in the moisture of the sediment can be compared to that standard (although a drinking water standard could be expected to be more stringent than a standard for materials present in soil). The highest value found for tritium was 4320 pCi/L at location ASE in 1989; this value is only 22% of the standard for drinking water.

1989 Study Data

The data from the 1989 study were summarized in a letter report (all results from this study are reported in Thorpe et al. 1990, Appendix N). Of the 20 sediment samples taken, only two showed levels above limits for hazardous waste for metals. These samples were both taken in a storm drain culvert just east of Building 438 (the location was sampled in duplicate). The only metal detected above the limits for disposal of hazardous waste was lead. The values detected were 18 mg/L and 14 mg/L and the limit for disposal of hazardous waste is 5 mg/L. As stated previously, this location was cleaned up (Thorpe et al., 1990). The location (near Building 438) was sampled as part of the surveillance monitoring program in 1990 to 1992, and no high values of lead were found again.

The 10 surface samples from the 1989 study also had one location with results above disposal limits. This sample was taken north of Building 515 and contained 1.4 mg/L cadmium (limit 1.0 mg/L), 29 mg/L copper (limit 25 mg/L), and 8.5 mg/L lead (limit 5 mg/L). It should be noted that this is in the area near waste disposal operations and is not in a drainage channel. Therefore, it should not be used to determine the need for a sediment surveillance monitoring program. The site where this sample was taken has also been cleaned up (Thorpe et al., 1990).

The 1989 study also showed four elevated values for tritium. Two values, 11,000 pCi/g and 3000 pCi/g were at the same sample location where high values for lead were detected. This location also showed one high tritium values in surveillance monitoring, 4100 pCi/g in 1991. Two other locations showed values of 2000 pCi/L. Nonetheless, the highest value still is only 55% of the drinking water standard of 20,000 pCi/L. In addition, this location has been cleaned up (Thorpe et al., 1990).

1991 Study Data

The sampling locations of the 1991 study were chosen to provide an overall understanding of the deposition of contaminants in the drainage system, to that end 89 locations were sampled. Four types of samples were taken, background sediment samples, catch basin (and manhole) sediment samples, open channel sediment samples, and standing liquid samples. Of these sampling types, the open channel sediment samples are most similar to the sediment samples that are taken for surveillance monitoring.

The only metals detected above disposal limits in the 1991 study were lead and mercury, and none of these were detected in the open channel samples. Lead was detected in liquid samples at one location, CB-190T-49, at 3 times the disposal limit (see Tables 5 and D-2; and at one catch basin sampling location, CB-280D-24 (see Tables 6 and D-3), at 25 times the disposal limit. Mercury was only detected at one catch basin location, CB-320F-17, at 1.9 times the disposal limit (see Tables 6 and D-3).

Six organic compounds and pesticides were found above disposal limits in the study; these compounds were benzo(a)pyrene, Dieldrin, p,p'-DDT, Endosulfan I, Endosulfan sulfate, and vinyl chloride (see Tables 8 to 10 and D-5 to D-7). Of these, one pesticide, Dieldrin, was in a background sample, BS-6-6, and was only slightly above the limit, i.e., 0.14 mg/kg was detected and the disposal limit is 0.13 mg/kg. Benzo(a)pyrene, vinyl chloride, and p,p'-DDT were detected in catch basin samples. The first two were 6 times and 8.5 times the disposal limits of 8.2 and 33 mg/kg, respectively, and were found at location CB-320F-17; the p,p'-DDT was found at CB-410E-44 at 2 times the limit of 0.087 mg/kg, and at location CB-190Q-10 1/2 at 0.098 mg/kg, just above the limit. The Endosulfan compounds were both found in open channel samples, at location OCS-460-1-6 at 2.6 times the limit of 0.066 mg/kg and at location OCS-150-1 at 3.3 times the limit of 0.13 mg/kg. Interestingly, location OCS-460-1-6 is near surveillance location CDB and location OCS-150-1 is near surveillance location 4THA, and no endosulfan compounds have been detected at those locations in surveillance sampling before the 1991 study nor in the 1 year of surveillance sampling after. One reason for the difference in detections could be the difference in sampling depth. However overall, it can be seen that detections of any organic compound was sporadic, with the highest number of detections overall being for toluene with 16 detections, followed by fluoranthene and total xylene isomers with 15 detections. In addition, most detections were in the catch basin and liquid samples. The open channel samples were generally lower than the other sample types.

Because there are no standards available for easy comparison for radionuclides in hazardous waste, the radiological data from the 1991 study were compared to surveillance data for soils and sediments samples collected from 1988 to 1992. The data that were compared were ^{40}K , ^{226}Ra , ^{232}Th , and tritium. Gross alpha and gross beta data were collected during the 1991 study, but not for surveillance samples, so there were no data for comparison. However, the results for gross alpha and gross beta were not very high; the highest gross alpha value was 18 pCi/L in a liquid sample and the highest gross beta value was 29 pCi/g in an open channel sample. The ^{137}Cs values were not compared because most of the ^{137}Cs values in the 1991 study were non-detects (see Table 7). The other nondetection values (i.e., those with more than 100% counting error) for the 1991 study were divided by 2 for the statistical comparison. In addition, three locations with particularly high detection limits for gamma-emitting radionuclides were excluded because they would dominate the resulting analysis; these locations were CB-410D-014, CB-510B-30, and CB-510D-20. An average value for each surveillance sediment location for each year was used so the surveillance locations would not be over represented.

The comparisons of the data show no differences among sampling location types for ^{232}Th or tritium (see Figure 2), and show the catch basins results to be significantly less for ^{40}K and ^{226}Ra (see Figure 3). The lower values in the catch basins may reflect the greater solubility of ^{40}K and ^{226}Ra compared to ^{232}Th , i.e., these radionuclides may have flowed past the sediments in the water, rather than remain in the sediments. In any case, there appears to be no cause for concern that radionuclides are being selectively deposited in sediments. (In addition, all tritium values were well below the drinking water standard of 20,000 pCi/L; the highest open channel value was 6182

pCi/L; the highest catch basin value was 2719 pCi/L, and the highest liquid sample value was 6268 pCi/L.)

Conclusion

LLNL has conducted three separate studies, including one a multi-year surveillance study and two single-year studies, and analyzed 247 samples of materials in surface drainages at the Livermore site. These studies were not based on the same approaches, and two were designed specifically to detect any interrelated contamination of the surface drainage at the site. The data for metals and organic compounds were compared to limits for disposal of hazardous waste, the tritium values were compared to drinking water standards, and the other radionuclides were compared to soils monitoring values. No tritium values were greater than 55% of drinking water standards, and no other radionuclides in sediments were greater soils values. In all of the studies, only two metals and six organic compounds were above waste disposal limits; these are presented in Table 11.

Although some sporadic contamination by lead and a few organic compounds was detected, overall it can be concluded that there is no systematic contamination of the surface drainage at the LLNL Livermore site, and, in fact, there is very little contamination at all. In view of these results and the fact that there is no regulatory requirement to monitor nonradiological materials in sediments, it is recommended that the nonradiological surveillance monitoring be discontinued. LLNL personnel will follow the development of the EPA Contaminated Sediment Management Strategy to determine the applicability of that strategy to LLNL sediments.

Acknowledgements

The author would like to acknowledge the work of William Schwartz in the development of the data analyzed in this paper. He was responsible for the extensive 1991 special study of sediment from planning, through sampling, to data acquisition. The completeness of the 1991 study has enabled this author to examine data that would otherwise have been unavailable. The author would also like to acknowledge the work of the sampling technicians who conducted the various sampling efforts including, but not limited to, Donald Ramsey, David Graves, Paris Althouse, Marion Heaton, and Rebecca Ward.

● Surveillance locations
1991 Study

1989 water

○ 1989 storm drain

1989 Soil

REV	DESCRIPTION	DATE
1	REDRAWN AND UPDATED	4/7
2	UPDATED BY FIELD SURVEY	6/7

STORM DRAIN LEGEND	
SURVEYED DATA	MACROGRAPHIC DATA
MANHOLES (SEE NOTE 1)	3000'
CATCH BASINS (SEE NOTE 2)	3000'
DRAINS UNKNOWN	3000'
SEWER LINES	
DRAIN SWALES	
CLP CORRUGATED METAL PIPE	
VCP VITRIFIED CLAY PIPE	
RCP REINFORCED CONCRETE PIPE	
CIP CAST IRON PIPE	
ACP ASBESTOS CEMENT PIPE	
S SLOPE OF PIPE (FT./FT.)	
N ROUGHNESS COEFFICIENT OF PIPE	
Q FLOW CAPACITY OF PIPE (CU.FT./SEC.)	

DO NOT REUSE THIS DRAWING
ALL MODIFICATIONS AND REVISIONS
THIS DOCUMENT SHALL BE REVIEWED
EXTENSION 2-4-88
PE.MOLSTO

SITE PLAN

Lawrence Livermore National Lab
Livermore, CA
PLANT ENGINE

**LLNL
SITE 200
STORM DRAIN
SYSTEM**

DESIGN	DATE
DRAWN	DATE
CHECK	DATE
PE/A	DATE
PE/M	DATE
SECURITY	DATE
NOV	DATE
P.C.	DATE

SHEET
M-1
PLC78-099-C

NOTES:
1. MANHOLE AND CATCH BASIN NUMBERS ARE DERIVED FROM THE SITE BLOCK NUMBER AND A LETTER DESIGNATION. ONLY THE LETTER DESIGNATION IS SHOWN ON THE PLAN NEXT TO THE MANHOLE OR CATCH BASIN. REFER TO BLOCK GRID FOR PREFIX NUMBER. MANHOLES THAT FALL CLOSE OR ON GRID LINES HAVE THEIR LETTER DESIGNATION WITHIN THE GRID BLOCK THEY ARE ASSOCIATED WITH.
2. SEE SHEET M-2 FOR MANHOLE AND CATCH BASIN COORDINATE LIST.

PLAN VIEW
SCALE: 1" = 200'

Figure 2. Comparisons of ^{232}Th and tritium data for 1991 study (BS = background samples, CB = catch basin samples, and OCS = open channel samples), surveillance sediment samples (SD), and surveillance soil samples (SO). The diamonds show the 95% confidence interval for the means; the line bisecting the diamond shows the mean for the group of data. The circles show significant differences; those that do not intersect, or for which the angle intersection is less than 90° , are significantly different.

Figure 3. Comparisons of ^{40}K and ^{226}Ra data for 1991 study (BS = background samples, CB = catch basin samples, and OCS = open channel samples), surveillance sediment samples (SD), and surveillance soil samples (SO). The diamonds show the 95% confidence interval for the means; the line bisecting the diamond shows the mean for the group of data. The circles show significant differences; those that do not intersect, or for which the angle intersection is less than 90° , are significantly different.

Table 1. Metals values for sediment samples (mg/L), 1989 to 1992.

	Ba	Cd	Co	Total Cr	Cu	Ni	Pb	V	Zn	As	Se	Hg	Ag	Mo	Sb
No. of detections	124	45	124	101	102	124	54	120	120	119	2	50	7	3	7
Maximum value detected	17	0.41	0.79	0.37	3.8	1.7	79	1.1	26	0.47	0.02	0.058	0.06	0.09	0.15
Minimum value detected	2.3	0.04	0.11	0.05	0.05	0.2	0.2	0.1	0.03	0.02	0.02	0.002	0.02	0.08	0.06
Average detected value	8.08	0.065	0.40	0.10	0.28	0.56	2.0	0.31	1.2	0.043	0.02	0.004	0.036	0.087	0.10
Limit for disposal of hazardous waste	100	0.75	80	5	25	20	5	24	250	5	1	0.2	5	350	15
Maximum value as a percent of disposal limit	17	54.7	0.99	7.4	15.2	8.5	156	4.6	10.4	9.4	2	29	1.2	0.03	1

Note: Values for 1988 are not included because a different analytical method was used.

Table 2. Organic compounds and pesticides values for sediment samples, 1988 to 1992.

	1,1,1-TCA	1,1-DCE	1,1-DCA	Chloro- form	Methylene chloride	TCE	Trichlorofluoro- methane	PCE
No. of detections	18	3	9	38	28	45	8	46
Maximum value detected	0.0022	0.0027	0.0013	0.0076	0.0066	0.0035	0.0076	0.0096
Minimum value detected	0.0002	0.0004	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Average detected value	0.00066	0.0013	0.00041	0.0012	0.00083	0.0007 3	0.00124	0.0021
Limit for disposal of hazardous waste	5.6	33	7.2	5.6	33	5.6	N/A	5.6
Maximum value as a % of disposal limit	0.039	0.0082	0.018	0.136	0.02	0.063		0.17
	Benzene	Toluene	Xylene isomers	cis-1,2- DCE	1,2-DCE	p,p'-DDT	Endosulfan I	Chloro- methane
No. of detections	37	114	10	8	9	1	2	1
Maximum value detected	0.03	0.26	0.035	0.0009	0.0009	0.009	0.03	0.0021
Minimum value detected	0.0002	0.0003	0.0003	0.0002	0.0002	0.009	0.002	0.0021
Average detected value	0.00571	0.02653	0.006	0.00048	0.0005	0.009	0.016	0.0021
Limit for disposal of hazardous waste	36	28	28	33	33	0.087	0.066	33
Maximum value as a % of disposal limit	0.083	0.93	0.13	0.0027	0.0027	10.3	45.5	0.0064
	BHC, alpha isomer	BHC, beta isomer	Endrin aldehyde	p,p'-DDE	Dieldrin	Carbon tetrachloride	Endrin	
No. of detections	3	1	1	4	2	2	2	
Maximum value detected	0.003	0.002	0.003	0.007	0.008	0.0002	0.005	
Minimum value detected	0.002	0.002	0.003	0.003	0.004	0.0002	0.003	
Average detected value	0.0023	0.002	0.003	0.0043	0.006	0.0002	0.004	
Limit for disposal of hazardous waste	0.066	0.066	0.13	0.087	0.13	5.6	0.13	
Maximum value as a % of disposal limit	4.54	3.03	2.31	8.05	6.15	0.0036	3.85	

Table 3. Comparison of soils and sediment radionuclide data, 1988 to 1992.

Analyte	Sediment		Soils		ANOVA Prob > F	Significantly different
	Mean	Std error	Mean	Std error		
^{239}Pu (Bq/L)*	0.000095	0.00002	0.000246	0.00004	0.0010	Yes
^{137}Cs (Bq/L)	0.000662	0.00018	0.0041	0.00028	0.0000	Yes
^{40}K (Bq/L)	0.492	0.007	0.479	0.010	0.2879	No
^{235}U ($\mu\text{g/g}$)	0.0212	0.0007	0.0203	0.0011	0.4399	No
^{238}U ($\mu\text{g/g}$)	2.44	0.126	2.56	0.196	0.6065	No
^{232}Th ($\mu\text{g/g}$)	6.91	0.123	6.87	0.191	0.8557	No
^{226}Ra (Bq/L)	0.0232	0.0005	0.238	0.0008	0.4928	No
^{228}Ra (Bq/L)	0.0252	0.00055	0.0242	0.00085	0.3600	No

*Logarithms of ^{239}Pu were also significantly different.

Table 4. California waste extraction analysis metals from 1991 sediments study (mg/L).

	Barium	Cadmium	Copper	Lead	Nickel	Vanadium	Zinc
Catch basins							
No. of detections	11	11	13	16	14	4	14
Maximum value detected	7.4	0.26	7	63	1.7	0.65	80
Minimum value detected	3.3	0.08	0.39	0.6	0.02	0.15	8.5
Average detected value	5.2	0.126	1.64	6.81	0.57	0.32	35
Limit for disposal of hazardous waste	100	1	25	5	20	24	250
Maximum value as a percent of disposal limit	7.4	26	28	1260	8.5	2.71	32
Open channels							
No. of detections	7	2	4	6	7	7	3
Maximum value detected	8.9	0.17	5.7	3.6	0.9	0.59	82
Minimum value detected	5.2	0.05	1.2	0.3	0.6	0.24	18
Average detected value	7.59	0.11	2.68	1.13	0.71	0.36	43.3
Limit for disposal of hazardous waste	100	1	25	5	20	24	250
Maximum value as a percent of disposal limit	8.9	17	22.8	72	4.5	2.46	32.8

Table 5. ICAP metals analysis from 1991 sediments study on liquid samples (mg/L).

	As	Ba	Be	Cd	Cr	Co	Cu	Pb	Hg	Mo	Ni	Se	Th	V	Zn
No. of detections	4	4	1	2	3	2	7	3	5	1	2	1	1	2	7
Maximum value detected	0.043	11	0.01	0.47	1.4	1.2	5.4	15	0.073	8.2	1.4	0.01	0.2	1.9	62
Minimum value detected	0.006	0.07	0.01	0.45	0.05	0.27	0.025	0.2	0.0009	8.2	1.2	0.01	0.2	1.1	0.24
Average detected value	0.016	2.9	0.01	0.46	0.95	0.74	1.58	5.8	0.034	8.2	1.3	0.01	0.2	1.5	12.2
Limit for disposal of hazardous waste	5	100	0.75	1	5	80	25	5	0.2	350	20	1	7	24	250
Maximum value as a % of disposal limit	0.86	11	1.33	47	28	1.5	21.6	300	36.5	2.34	7	1	2.86	7.92	24.8

Table 6. ICAP metals analysis from 1991 sediments study on solid samples (mg/kg).

	Sb	As	Ba	Be	Cd	Cr	Co	Cu	Pb	Hg	Mo	Ni	Ag	Th	V	Zn
Background																
No. of detections	0	7	8	7	8	8	8	8	7	3	1	8			8	8
Maximum value detected		3.8	520	0.6	15	75	15	160	320	0.14	9	110			77	290
Minimum value detected		1.4	130	0.2	6	18	5	15	6	0.05	9	16			28	27
Average detected value		2.3	258	0.4	9.75	39.8	9.25	40.1	56.3	0.103	9	43.5			43.8	78.1
Limit for disposal of hazardous waste	500	500	10000	75	100	2500	8000	2500	1000	20	3500	2000	500	700	2400	5000
Maximum value as a percent of disposal limit		0.76	5.2	0.8	15	3	0.19	6.4	32	0.7	0.26	5.5			3.2	5.8
Catch basin																
No. of detections	3	39	41	24	42	42	42	42	42	29	6	42	7	5	42	42
Maximum value detected	120	43	250	0.3	22	340	54	480	25000	38	15	200	21	7	61	3000
Minimum value detected	4	0.05	50	0.2	3	14	3	2.3	4.8	0.05	4	15	1	2	9	65
Average detected value	43	4.28	113.4	0.22	7.14	49.0	9.57	67.5	676.5	1.75	7.67	47.1	7	4	23.5	420
Limit for disposal of hazardous waste	500	500	10000	75	100	2500	8000	2500	1000	20	3500	2000	500	700	2400	5000
Maximum value as a percent of disposal limit	24	8.6	2.5	0.4	22	13.6	0.68	19.2	2500	190	0.43	10	4.2	1	2.54	60
Open channel																
No. of detections	2	16	18	16	27	27	27	27	25	8	0	27	0	3	27	27
Maximum value detected	5	7.3	330	0.7	13	66	14	54	80	1.2	0	70	0	6	54	1500
Minimum value detected	4	0.06	38	0.2	2	15	2	7	4	0.06	0	13	0	4	9	34
Average detected value	4.5	3.1	172	0.35	7.77	31.5	9.05	22.7	15.2	0.393		32		4.67	32.8	165
Limit for disposal of hazardous waste	500	500	10000	75	100	2500	8000	2500	1000	20	3500	2000	500	700	2400	5000
Maximum value as % of disposal limit	1	1.46	3.3	0.93	13	2.64	0.18	2.16	8	6	0	3.5	0	0.86	2.25	30

Table 7. Radionuclide analysis for 1991 sediment study (pCi/g, unless otherwise noted).

Locations	Gross alpha	Gross beta	³ H (pCi/L)	% moisture	40K	¹³⁷ Cs	²²⁶ Ra	²²⁸ Th	²³² Th
<u>Background</u>									
No. of detections	4	8	5	8	8	0	7	7	6
Maximum value detected	8	19	1302	8.8	18.99		0.9029	1.114	1.121
Minimum value detected	4	13	245	1.5	8.097		0.3623	0.5109	0.5342
Average detected value	6.5	15.6	711	4.3	13.59		0.5612	0.8294	0.8099
<u>Catch basin</u>									
No. of detections	37	43	41	34	45	8	29	39	24
Maximum value detected	11	20	2719	54.2	528	0.7091	0.6985	1.226	3.681
Minimum value detected	0.5	5	12	0.4	0.4453	0.09741	0.1961	0.05515	0.3531
Average detected value	3.4	13	654	13.5	20.72	0.3256	0.3870	0.6029	0.8641
<u>Open channel</u>									
No. of detections	26	28	28	27	28	9	25	26	24
Maximum value detected	10	29	6182	49.8	105	0.726	1.407	7.122	3.33
Minimum value detected	0.5	10	1.5	0.7	0.642	0.0724	0.1627	0.468	0.1235
Average detected value	4.8	16	782	9.0	16.8	0.2264	0.5823	1.057	0.8641
<u>Liquid (mg/L)</u>									
No. of detections	5	6	6	0	2	1	1	2	1
Maximum value detected	18	25	6268		11.62	0.4909	0.4984	0.9726	0.5581
Minimum value detected	0.5	10	236		9.173	0.4909	0.4984	0.6237	0.5581
Average detected value	5.6	15	1737		10.3965	0.4909	0.4984	0.79815	0.5581

Table 8. Volatile organic compounds in 1991 study detected by EPA method 8270 and for which there are disposal limits, mg/kg unless otherwise noted.

	1,3-Di- chloro- benzene	1,4-Di- chloro- benzene	2-Chloro- phenol	4-Methyl- phenol (p- Cresol)	4-Nitro- phenol	Benzo- (a)anthra- cene	Benzo- (a)pyrene
Background							
No. of detections	0	0	0	0	0	1	1
Maximum value detected						0.5	0.7
Minimum value detected						0.5	0.7
Average detected value						0.5	0.7
Limit for disposal of hazardous waste	6.2	6.2	5.7	3.2	29	8.2	8.2
Maximum value as a % of disposal limit						6.1	8.5
Catch basin							
No. of detections	0	0	0	0	0	5	7
Maximum value detected						4	50
Minimum value detected						0.3	0.2
Average detected value						1.82	9.4
Limit for disposal of hazardous waste	6.2	6.2	5.7	3.2	29	8.2	8.2
Maximum value as % of disposal limit						48.8	610
Open channel							
No. of detections	1	1	1	0	1	1	1
Maximum value detected	0.03	0.03	0.03	0	1	0.26	0.2
Minimum value detected	0.03	0.03	0.03	0	1	0.26	0.2
Average detected value	0.03	0.03	0.03		1	0.26	0.2
Limit for disposal of hazardous waste	6.2	6.2	5.7	3.2	29	8.2	8.2
Maximum value as % of disposal limit	0.48	0.48	0.53		3.4	3.2	2.4
Liquid (µg/L)							
No. of detections	0	0	0	1	0	1	1
Maximum value detected				70		17	21
Minimum value detected				70		17	21
Average detected value				70		17	21
Limit for disposal of hazardous waste	36	90	44	770	120	59	61
Maximum value as % of disposal limit				9.1		28.8	34.4

Table 8. Volatile organic compounds in 1991 study detected by EPA method 8270 and for which there are disposal limits, mg/kg unless otherwise noted. (continued)

	Chrysene	Dibenzo-(a,h)anthracene	Fluoranthene	Indeno(1,2,3-c,d)-pyrene	Phenol	Bis-(2-chloro-ethyl)ether
Background						
No. of detections	1	0	2	0	0	0
Maximum value detected	0.6		1.1			
Minimum value detected	0.6		0.6			
Average detected value	0.6		0.85			
Limit for disposal of hazardous waste	8.2	8.2	8.2	8.2	6.2	7.2
Maximum value as % of disposal limit	7.3		13.4			
Catch basin						
No. of detections	6	0	8	2	0	0
Maximum value detected	4.6		8	1.6		
Minimum value detected	0.3		0.3	0.5		
Average detected value	2.3		2.9	1.1		
Limit for disposal of hazardous waste	8.2	8.2	8.2	8.2	6.2	7.2
Maximum value as % of disposal limit	56.1		97.6	19.5		
Open channel						
No. of detections	3	1	3	1	1	1
Maximum value detected	0.3	0.22	0.54	0.2	0.03	0.03
Minimum value detected	0.09	0.22	0.09	0.2	0.03	0.03
Average detected value	0.20	0.22	0.28	0.2	0.03	0.03
Limit for disposal of hazardous waste	8.2	8.2	8.2	8.2	6.2	7.2
Maximum value as % of disposal limit	3.66	2.68	6.59	2.44	0.48	0.42
Liquid (µg/L)						
No. of detections	1	1	2	0	0	0
Maximum value detected	17	12	27			
Minimum value detected	17	12	20			
Average detected value	17	12	23.5			
Limit for disposal of hazardous waste	59	55	68	5.5	39	33
Maximum value as % of disposal limit	28.8	21.8	39.7			

Table 9. Pesticides detected in 1991 study in mg/kg unless otherwise noted.

	Dieldrin	p,p'-DDE	p,p'-DDT	Endo-sulfan I	Endo-sulfan II	Endo-sulfan sulfate	Hepta-chlor epoxide	Meth-oxy-chlor	BHC, beta isomer	BHC, delta isomer
Background										
No. of detections	1	1	0	0	0	0	0	0	0	0
Value detected	0.14	0.006								
Limit for disposal of hazardous waste	0.13	0.087	0.087	0.066	0.13	0.13	0.066	0.18	0.066	0.066
Maximum value as % of disposal limit	108	6.9								
Catch basin										
No. of detections	2	0	3	0	2	0	1	2	1	0
Maximum value detected	0.07		0.19		0.12		0.04	0.3	0.006	
Minimum value detected	0.02		0.02		0.01		0.04	0.1	0.006	
Average detected value	0.045		0.10267		0.065		0.04	0.2	0.006	
Limit for disposal of hazardous waste	0.13	0.087	0.087	0.066	0.13	0.13	0.066	0.18	0.066	0.066
Maximum value as % of disposal limit	53.8		218		92.3		60.6	167	9.1	
Open channel										
No. of detections	0	0	0	1	0	1	0	0	1	0
Value detected				0.17		0.43			0.006	
Limit for disposal of hazardous waste	0.13	0.087	0.087	0.066	0.13	0.13	0.066	0.18	0.066	0.066
Maximum value as % of disposal limit				258		331			9.1	
Liquid (µg/L)										
No. of detections	0	0	0	0	0	0	0	0	0	1
Value detected										0.09
Limit for disposal of hazardous waste	17	31	3.9	23	29	29	16	250	0.14	23
Maximum value as % of disposal limit										0.39

Table 10. Volatile organic compounds detected in 1991 study (EPA method 5030/8240) for which there are disposal limits, mg/kg unless otherwise noted.

	1,2-Di-chloro-ethene	Ace-tone	Chloro-form	TCA	TCE	Trichloro-fluoro-methane	Tolu-ene	PCE	Total xylene isomers	cis-1,2-dichloroethene	Vinyl chlor-ide
Background											
No. of detections	0	0	0	0	0	0	5	0	2	0	0
Maximum value detected							0.03		0.039		
Minimum value detected							0.005		0.008		
Average detected value							0.0112		0.0235		
Limit for disposal of hazardous waste	33	160	5.6	5.6	5.6	33	28	5.6	28	33	33
Maximum value as % of disposal limit							0.11		0.14		
Catch basin											
No. of detections	1	1	0	0	1	1	7	6	6	1	2
Maximum value detected	0.03	0.067			0.005	0.005	0.35	0.27	0.089	0.03	280
Minimum value detected	0.03	0.067			0.005	0.005	0.009	0.007	0.005	0.03	0.011
Average detected value	0.03	0.067			0.005	0.005	0.0819	0.089	0.031	0.03	140
Limit for disposal of hazardous waste	33	160	5.6	5.6	5.6	33	28	5.6	28	33	33
Maximum value as % of disposal limit	0.091	0.042			0.089	0.015	1.25	4.82	0.32	0.091	848
Open channel											
No. of detections	0	1	1	0	0	0	2	0	6	0	0
Maximum value detected		0.1	0.023				0.038		0.026		
Minimum value detected		0.1	0.023				0.016		0.008		
Average detected value		0.1	0.023				0.027		0.0175		
Limit for disposal of hazardous waste	33	160	5.6	5.6	5.6	33	28	5.6	28	33	33
Maximum value as % of disposal limit		0.063	0.41				0.14		0.093		
Liquid (µg/L)											
No. of detections		3	3	1	1	1	2	1	1	1	0
Maximum value detected		26	5.7	32	0.7	1.5	67	4.9	2.1	0.9	
Minimum value detected		0.11	1.3	32	0.7	1.5	0.036	4.9	2.1	0.9	
Average detected value		13.0	2.83	32	0.7	1.5	33.5	4.9	2.1	0.9	
Limit for disposal of hazardous waste	54	280	46	54	54	20	80	56	320	54	270
Maximum value as % of disposal limit		9.3	12.3	59.3	1.3	7.5	83.8	8.75	0.66	1.67	

Table 11. Summary of materials found in the sediment studies above hazardous waste disposal limits.

Study	Contaminant	Waste limit	Value detected	Location
Surveillance	Lead	5 mg/L	79 mg/L	ASE
1989 Study	Lead	5 mg/L	18 mg/L	B438
		5 mg/L	14 mg/L	Duplicate at B 438
1991 Study	Lead	5 mg/L	15 mg/L	CB-190T-49
		5 mg/L	25000 mg/L	CB-280D-24
	Mercury	20 mg/L	38 mg/L	CB-320F-17
	Benzo(a)-pyrene	8.2 mg/kg	50 mg/kg	CB-320F-17
	Dieldrin	0.14 mg/kg	0.13 mg/kg	BS-6-6
	p,p'-DDT	0.087 mg/kg	0.19 mg/kg	CB-410E-044
		0.087 mg/kg	0.098 mg/kg	CB-190Q-10 1/2
	Endosulfan I	0.066 mg/kg	0.17 mg/kg	OCS-460-1-6
	Endosulfan sulfate	0.13 mg/kg	0.43 mg/kg	OCS-150-1
	Vinyl chloride	33 mg/kg	280 mg/kg	CB-320F-17

References

- Brekke, D. D., R. C. Holland, M. G. Brown, and T. M. Carlsen (1989), *Environmental Monitoring at the Lawrence Livermore National Laboratory, 1988 Annual Report*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-50027-88).
- Gallegos, G. M., B. K. Balke, K. A. Surano, W. G. Hoppes, P. J. Tate, J. C. Steenhoven, B. C. Fields, L. M. Garcia, and K. C. Lamson (1992), *Environmental Report for 1991*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-50027-91).
- Gallegos, G. M., S. M. Wander, B. K. Balke, E. Christofferson, P. J. Tate, K. A. Surano, R. J. Harrach, L. M. Garcia, B. C. Fields, W. G. Hoppes, and R. A. Failor (1993), *Environmental Report for 1992*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-50027-92).
- Holland, R. (1993), SAIC, Inc., Pleasanton, CA, personal communication.
- Sims, J. M., K. A. Surano, K. C. Lamson, and M. G. Brown (1990), *Environmental Report for 1989*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-50027-89).
- Sims, J. M., K. A. Surano, K. C. Lamson, B. K. Balke, and J. C. Steenhoven (1991), *Environmental Report for 1990*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-50027-90).
- Thorpe, R. K., W. F. Isherwood, M. D. Dresen, and C. P. Webster-Scholten (1990), *CERCLA Remedial Investigation Report for the LLNL Livermore Site*, Lawrence Livermore National Laboratory, Livermore, CA (UCAR-10299, Volumes 1 to 5).
- U.S. Department of Energy (1991), *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*, U.S. Department of Energy, Washington, DC (DOE/EH-0173T).

Appendix A

Letter Report for 1989 Sediment Study

May 16, 1989

Ext: 3-6745

To: Connie Degrange
 From: F. Hoffman
 Re: Storm Drain Remediation Issues

As a result of the LLNL Ground Water Project Baseline Public Health Assessment (BPHA) a series of samples were collected from storm drain sediments, surface waters, and surface sediments. See the attached summary of Baseline Public Health Assessment Site Sampling protocols and sampling location map. We have provided copies of the results of these sampling and analyses to Robert Holland and Robert Fisher of your division. The results of several samples taken from the south west portion of the Laboratory are notable. Below I have provided the results of the analyses of these samples and indicated analytes that are elevated relative to background.

1. Sediments from the storm drain culvert just east of Bldg 438 were found to have elevated concentrations of the following analytes (this storm drain location was sampled in duplicate):

Sample code:	SSD-008	SSD-009	Units
Analyte:			
Tritium	11,000	3,000	pCi/l
Arochlor 1254	1.3	0.7	mg/kg
Lindane	ND	0.088	mg/kg
C20-C35 Hydrocarbons (Bunker Oils?)	5,000	3,000	mg/kg
Lead (STLC)	18*	14*	mg/l

*(note: the Lead STLC limit for hazardous waste is 5 mg/l).

2. A surface water sample collected from the Bldg 438 storm drain was found to contain elevated concentrations of the following analytes:

Sample code:	SDW-002	Units
Analyte:		
Chromium	70*	µg/l
Lead	15	µg/l
PCE	5	µg/l
Freon 11	4	µg/l

*(note: the drinking water limits for Chromium is 50 µg/l).

University of California

Lawrence Livermore
National Laboratory

Baseline Public Health Assessment Site Sampling Protocol

Samples collected for organic compound and radionuclide analyses were collected into steam cleaned 1.5 inch diameter steel core tubes, the ends of the core tubes were covered with clean teflon sheets and sealed with plastic caps and duct tape. Samples were collected at a depth of 5 cm. Areas with fine grain materials were selected for sampling. Leaves, twigs, pieces of plastic, etc. were omitted from the sample. Soil samples collected for metal analyses were collected directly into clean zip-lock baggies. Surface water samples were bailed and transferred to or collected directly into appropriate sample containers. Brown and Caldwell analyzed for the organic compounds and coliform bacteria. Clayton Environmental Consultants analyzed for metals. TMA/ Norcal analyzed for radionuclides. The surface soils in both the arroyos were each sampled in triplicate. Analyses requested for each soil or water sample are summarized in Table 1. The number of samples collected and sample codes used are summarized in Tables 2 and 3, below. Sampling locations for the Baseline Public Health Assessment Site Sampling are shown in draft Figures 2 and 23, both taken from the Baseline Public Health Assessment, in preparation. Copy of the analytical result sheets for Baseline Public Health Assessment Site Sampling are attached.

Table 1. Analyses requested for each soil or water sample

	Organic Compounds			Metals		Radionuclides			
Analyses (soils):	8240	8270	8080	TTLc	STLC	Tritium	Alpha	Beta	Gamma Spec
Sample container	Steel Core Tube			Baggie		Steel Core Tube			
Sample size	100g			100g		200g			
Analyses (water):	624	625	608	Coli ^a	DWM	Tritium	Alpha	Beta	Gamma Spec
Sample container	VOA	Glass	Glass	Plastic ^b	Plastic	Plastic	Plastic	Plastic	Plastic
Sample size, ml	2x40	2x1000	2x1000	200	2000	250	1000	1000	1000

^a Coliform bacteria

^b Sterile

Table 2. Number of samples collected and sample code formats for public health assessment site sampling

	Locations	Replicates ^a	Total	Code ^b
Arroyo Seco	1	3	3	SAS-Location #-0.5U
Arroyo Los Positias	1	3	3	SAP-Location #-0.5U
Storm drain ditches	14	1	14	SSD-Location #-0.5U
Surface soil locations	10	1	10	SSS-Location #-0.5U
Surface water ^c	11	1	11	SDW-Location #-Date
Total			41	

^a Arroyo replicates collected 5 feet apart.

^b Sample #s assigned sequentially in a general clockwise direction starting in the southwest most sample.

^c Including the Retention Basin.

Table 3. Summary of public health assessment site sampling codes

Arroyo Seco Sediments: Collected February 7, 1989.

Location:	Sample Code:	Comments:
1	SAS-011-0.5u-1	Note: SAS-011 was originally identified as SAS-001.
2	SAS-011-0.5u-2	
3	SAS-011-0.5u-3	

Arroyo Las Positias Sediments: Collected February 7, 1989.

Location:	Sample Code:	Comments:
1	SAP-001-0.5u-1	
2	SAP-001-0.5u-2	
3	SAP-001-0.5u-3	

Storm Drain Sediments: Collected February 7, 1989 and February 15, 1989.

Location:	Sample Code:	Comments:
1	SSD-001-0.5u	Sandy silt
2	SSD-002-0.5u	Dark brown soft silt
3	SSD-003-0.5u	Brown silty clay
4	SSD-004-0.5u	Silty sand
5	SSD-005-0.5u	Silty sand
6	SSD-006-0.5u	Silty sand
7	SSD-007-0.5u	Silty sand
8	SSD-008-0.5u	Darkly stained fine silt
9	SSD-009-0.5u	Replicate of location 8
10	SSD-010-0.5u	Silty sand with gravel
11	SSD-011-0.5u	Fine silt
12	SSD-012-0.5u	Fine silt
13	SSD-013-0.5u	Very fine clay (Drilling mud?)
14	SSD-014-0.5u	Fine silt

Storm Drain Waters: Collected February 9, 1989.

Location:	Sample Code:	Comments:
1	SDW-001	
2	SDW-002	
3	SDW-003	
4	SDW-004	
5	SDW-005	
6	SDW-006	
7	SDW-007	
8	SDW-008	DDW Trip blank
9	SDW-009	Collected in duplicate for RAD only
10	SDW-010	
11	SDW-011	

Table 3 (cont.). Summary of public health assessment site sampling codes

Surface sediments: Collected April 11, 1989.

Location:	Sample Code:	Comments:
1	SSS-001	Fine clat
2	SSS-002	Near helipad
3	SSS-003	Next to ball field
4	SSS-004	Rubble piles
5	SSS-005	Near LN gas tanks
6	SSS-006	Behind DWTF
7	SSS-007	Dirt piles
8	SSS-008	Old solar ponds
9	SSS-009	Next B-514 yard
10	SSS-010	Next to B-518

STORM SEWER LEGEND

REVISIONS

- MANHOLE
- CLAY TILE
- SEWER LINES
- COMBUSTIBLE MATERIAL
- STANDARD CLAY PIPE
- REINFORCED CONCRETE PIPE
- CAST IRON PIPE
- ADJUSTABLE STREET PIPE
- SEWER OF PIPE (STREET)
- SEWER OF PIPE (STREET)
- FLOW CAPACITY OF PIPE (CFS)

- MANHOLE
- MANHOLE
- PARALLEL LOTS
- ADJACENT LOTS
- ADJACENT LOTS
- ADJACENT LOTS

○① = Surface sediment collected from storm Drain.

□① Surface water collected from storm Drain.

See Attached Sheet for complete Sample List

Appendix B

1991 Sediment Study Sampling Plan

**LLNL Storm Drain Sampling Plan
and
Follow-Up Cleanout and
Maintenance Proposal**

August 1991

W. W. Schwartz, Project Engineer

Operations and Regulatory Affairs Division

Contents

Acronyms	iv
Background	1
LLNL Storm Drain Grading and Drainage	1
Storm Drain System at LLNL	2
LLNL Storm Drain Sampling Plan	2
Purpose for Sampling	2
Sampling Strategy	3
Initial Sampling	3
Additional Sampling	3
QA Sampling	3
Applicable Regulations and Methods	4
Media to be Sampled and Sample Types	4
Target Constituents	4
Area to be Sampled	5
Sampling Procedure	5
Quality Assurance/Quality Control	5
Duplicate Samples	5
Blank Samples	5
Background Samples	5
Documentation and Reporting	5
QA/QC Policy and Procedures	6
Sampling Method	6
Sample Labeling	7
Sample Transportation, Treatment, and Storage	7
Chain-of-Custody Forms and Field Tracking Forms	7
Sampling Locations	7
Analytical Laboratories	10
Sampling Materials, Equipment, and Supplies	10
Follow-Up Activities	11
Remediation of LLNL Storm Drain System	11
LLNL Storm Drain Cleanout and Disposal Recommendations	11
Future and Ongoing Monitoring of the LLNL Storm Drain System	11
Documentation of LLNL Storm Drain System	11
Appendix A. LLNL Storm Drain Site Map	A-1
Appendix B. Sampling Location Site Map	B-1
Appendix C. Sampling Location Data Sheet	C-1

Acronyms

ACP	asbestos-impregnated cement pipe
Ag	silver
As	arsenic
Ba	barium
BCA	Brown and Caldwell Analytical Laboratory
Be	beryllium
BF	background field sample
BPHA	Baseline Public Health Assessment
BS	background sample
CB	catch basin
CCR	California Code of Regulations
Cd	cadmium
CEC	Clayton Environmental Consultants Analytical Laboratory
CFR	Code of Federal Regulations
CIP	cast iron pipe
CMP	corrugated metal pipe
CMPA	corrugated metal pipe-arched
Co	cobalt
Cr	chromium
Cu	copper
DP	duplicate sample
EAS	LLNL Environmental-Analytical Sciences Laboratory
EPA	U.S. Environmental Protection Agency
EPD	LLNL Environmental Protection Department
FAX	facsimile
FB	field blank
FS	field sample
Hg	mercury
ID	identification
L	liquid
LCS	laboratory control standards
LLNL	Lawrence Livermore National Laboratory
MDL	minimum detection limit
MH	manhole
Mo	molybdenum
N	no
NA	not applicable
Ni	nickel
O	other
OCS	open channel site
Pb	lead
PCB	polychlorinated biphenyl
PE	Plant Engineering
QA	quality assurance
QC	quality control
RCP	reinforced concrete pipe
RDL	reporting detection limit
REAL	LLNL Radiological Environmental Analytical Laboratory

Acronyms (Continued)

S	solid
Sb	antimony
SDS	storm drain system
Se	selenium
SE	sediment
SO	soil
STLC	soluble threshold limit concentration
TCL	target compound list
Tl	thallium
TTLC	total threshold limit concentration
V	vanadium
VCP	vittrified clay pipe
Y	yes
Zn	zinc

LLNL Storm Drain Sampling Plan and Follow-Up Cleanout and Maintenance Proposal

Background

In 1989, an LLNL Ground Water Project Baseline Public Health Assessment (BPHA) was conducted. The BPHA included the collection of an initial series of samples from selected storm drain catch basin sediments, storm drain surface water, and storm drain surface sediments. The BPHA Storm Drain Sampling Plan report listed the sampling protocol, sampling methods, analyses performed, and the sample results. An LLNL site map showing the sample locations was also included. Several samples with elevated contaminant levels are noted in the March 16, 1989 "Storm Drain Remediation Issues" memorandum by F. Hoffman. Recommendations resulting from this initial Storm Drain sampling effort and BPHA were to: (1) develop an ongoing program to monitor the LLNL storm drain system for potential contaminants; (2) develop and implement remediation of contaminated storm drain sediment; and (3) develop and implement a storm drain cleanout program.

The LLNL Storm Drain Sampling Plan and Follow-up Cleanout and Maintenance Proposal is being carried out as a best management practice and includes the following activities: (1) sample the Lawrence Livermore National Laboratory (LLNL) storm drain system (SDS) at the Livermore Site; (2) remediate all local sites found to be contaminated; (3) develop and implement an ongoing storm drain cleanout program; (4) develop an ongoing program to monitor the LLNL storm drain system for potential contaminants; and (5) document the LLNL storm drain system and assign responsibility for documenting changes and additions to the storm drain system. Items 2 through 5 are recommended follow-up activities to the sampling of the SDS. Activities 1 through 5 are an expanded summation of the recommended follow-up activities resulting from the initial sampling performed as part of the 1989 LLNL Ground Water Project BPHA.

LLNL Storm Drain Grading and Drainage

At the LLNL Livermore site, the natural slope of 1.5% grade toward the northwest is the controlling feature for all site grading and drainage. Since 1940, the natural drainage has been redirected and controlled as necessary in order to accommodate existing and new facilities.

The surface area of the Laboratory site is presently drained with a combination of subsurface drainage pipe networks, open surface channels, and swales (see LLNL Storm Drain System Site Map, LLNL drawing PLC78-099-052E, in Appendix A).

Portions of the southwest quadrant of the site are drained by a network of underground storm drain pipes and open surface channels that discharge through one of the two site outfalls into the Arroyo Seco drainage channel at the southwest corner of the site. The storm drains that discharge into the Arroyo Seco channel are sized to accommodate drainage generated by a "10-year-storm," which is standard municipal engineering practice. The Arroyo Seco channel has adequate flow capacity to accept anticipated flows generated by a "100-year-storm," and does not constitute a potential flood hazard to the LLNL Livermore site.

The other areas of the site (northwest, northeast, and southeast quadrants and a portion of the southwest quadrant) are drained by a network of underground storm drain pipes and open surface channels that drain into secondary channels that, in turn, drain into the relocated Arroyo Los Positas

drainage channel that runs along the northern border of the site. The relocated Arroyo Los Positas drainage channel discharges into the Arroyo Los Positas drainage channel at the site's northwest outfall. The secondary channels generally have adequate flow capacity to accept anticipated flows generated by a "25-year-storm." Open channel improvements along the LLNL reach of the relocated Arroyo Los Positas channel have upgraded the flow capacity to accommodate drainage generated by a "100-year-storm"; but various storm drain structures along the channel have not yet been upgraded.

A shallow surface swale along the southern border of the site (north side of East Avenue) drains surface storm runoff westward to the Arroyo Seco drainage channel. An open surface channel along the eastern border of the site (west side of Greenville road) drains surface storm runoff northward to the relocated Arroyo Los Positas drainage channel. The relocated Arroyo Los Positas drainage channel then runs westward along the northern border of the site to the outfall at the Northwest corner of the site.

Storm Drain System at LLNL

Underground pipe in the LLNL storm drain system consists of corrugated metal pipe (CMP), corrugated metal pipe-arched (CMPA), vitrified clay pipe (VCP), reinforced concrete pipe (RCP), some cast iron pipe (CIP), and some asbestos-impregnated cement pipe (ACP). Pipe diameters range from 6 inches to about 5 feet. Catch basins and manholes are located along each run of underground pipe in the network and act as access points to the system. They are generally installed where (1) two or more lines connect, (2) a line diameter changes, or (3) the grade or direction of flow changes. Since about 1980, installed catch basins have been of the self-flushing type that do not have sumps. These precast, reinforced concrete catch basins are nominally 16 cubic feet (approximately 120 gallons). Older (pre-1980) catch basins may have sumps that are approximately 6-inches deep. Manholes are larger access points and are also constructed of precast reinforced concrete. There are approximately 740¹ catch basins and approximately 94¹ manholes that connect the underground pipe and open channels in the LLNL storm drain system. In areas of the site where there are no underground lines, open shallow surface swales and drainage channels direct the flow. LLNL drawing PLC78-099-052E, LLNL Storm Drain System Site Map, shows the existing underground storm drain lines, drainage channels, catch basins, and storm drain manholes.¹

LLNL Storm Drain Sampling Plan

Purpose for Sampling

The purpose for sampling the LLNL storm drain system is to determine if any elevated contaminant levels of regulated hazardous and/or radioactive constituents may be present. The LLNL storm drain system will be sampled and characterized as a best management practice follow-up activity to the initial sampling that was conducted as part of the 1989 LLNL Ground Water Project BPHA.

Although waste is not intentionally discharged into the LLNL storm drain system, anecdotal information suggests that past discharges may have occurred. Some constituents may have become concentrated in catch basins or open channel sediment over time, even if they originally entered with runoff at nonhazardous concentrations, since the LLNL storm drain system is currently not cleaned out on a regular basis. Results from this sampling program and investigation will be useful in determining if there have been or continue to be any inappropriate discharges.

¹ The catch basins, manholes, underground lines, drainage channels, and surface swales shown on LLNL drawing PLC78-099-052E, LLNL Storm Drain System Site Map, are current as of August 5, 1991.

This sampling plan describes the procedures for adequate environmental sampling of the LLNL storm drain system. In the event that any constituents at hazardous concentrations are found, appropriate action will be taken which will include notification of regulators, clean-up and restoration, additional sampling, and cessation of any inappropriate ongoing discharges that might be found to exist.

Sampling Strategy

This sampling plan requires the possible collection and analyses of two different sample media type: (1) samples of the liquid component from some catch basins, if any standing liquid is present, and (2) samples of solids (including samples from catch basins, manholes, and open channel sites; and background samples from selected locations). Samples will be taken that adequately represent the spatial variations that may exist at each sample location.

Initial Sampling

This plan is a hierarchical sampling plan that consists of initially sampling selected sample locations on a one-time basis to preliminarily assess the entire LLNL storm drain system while limiting the number of sample locations. Starting at the highest elevation, the LLNL storm drain system was reviewed and sample locations were selected at the down gradient junction of two intersecting lines or at the junction of a line and a network of lines. In addition, some sample locations were selected on the basis of past practices or known releases near a selected location. Each collected sample is considered to represent the sediment at that location and, furthermore, may represent sediment that is up gradient. If the sample results show that hazardous waste and/or radioactive constituents at levels above background are present, then appropriate remediation will be conducted and follow-up sampling will be performed. If any elevated contaminant levels of regulated hazardous and/or radioactive constituents are found, then on a case-by-case basis, additional sampling may be done to further characterize that portion of the SDS. If the sample results show that regulated hazardous and/or radioactive constituents either are nonexistent or are at background levels, then no further sampling will be done unless other information indicates that additional sampling may be required.

Storm drain influent flow varies temporally with respect to volume and content. Sediment in catch basins, manholes, and open channel sites that was deposited over time may have elevated concentrations resulting from accumulation. If open channel site sediment depth is relatively deep, it may be necessary to take sequential samples at various depths. If the sediment depth is shallow due to sediment being washed down gradient, then it will be necessary to take only one single or composite sample. Since catch basin and manhole sediment may have been laid down in uneven patterns that are unlikely to be uniformly mixed, constituent concentrations may vary over the accumulation area. Therefore, a systematic random composite sample may be required. This type of sampling involves dividing the accumulation area into sections, and then randomly sampling within each section. This sampling method provides more uniform coverage of the area than does random sampling, and further ensures that the accumulation area is more fully characterized.

Additional Sampling

If the results from sampling a particular sample location in the Initial Sampling indicate elevated contaminate levels, then on a case-by-case basis additional upgradient sample locations will be selected for sampling in subsequent sampling events.

QA Sampling

Off-site background samples will be taken to establish a basis for comparison between the collected field samples and the surrounding area. The Quality Assurance/Quality Control (QA/QC) protocol described in the "Sampling Procedure" outlines the necessary QA sampling to ensure the integrity of the sampling plan and procedures.

Applicable Regulations and Methods

The following is a list of regulations and methods that are applicable to sampling activities.

CCR Title 22	Division 4, Environmental Health
40 CFR Part 136	Guidelines for Establishing Test Procedures for the Analysis of Pollutants
40 CFR Part 261	Identification and Listing of Hazardous Waste
EPA-SW-846	Test Methods for Evaluating Solid Waste
EPA-600/4-79-020	Methods for Chemical Analysis of Water and Wastes
EPA-600/4-82-029	Handbook for Sampling and Sample Preservation of Water and Wastewater
EPA-600/4-82-057	Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater

Media to be Sampled and Sample Types

All field samples (FS) will consist of either solid (S) or liquid (L) samples. Solid samples will be either sediment (SE) or soil (SO) media. Liquid samples that result from storm runoff or area runoff due to LLNL standard operating procedures (i.e., irrigation, steam cleaning, etc.) will contain varying percentages of solids.² Collected Quality Assurance (QA) samples, including duplicate samples (DP) and field blank (FB) samples, may be either solid or liquid samples. QA background field samples (BF) will be taken to establish a basis for comparison between the collected field samples and the surrounding area.

Target Constituents

The target constituents for solid samples and liquid samples are listed in Table 1.

² The analytical method for liquid samples that contain varying percentages of solids will be determined by the analytical laboratory after the percent of solids has been determined.

Table 1. Target constituents for solid and liquid^a samples.

Metals ^b (TTL and STLC)
Volatile TCL organics
Semi-volatile TCL organics
Pesticides and PCBs ^c
Radionuclides
Gross alpha
Gross beta
Gamma
Tritium

^a The determination of whether a sample that contains varying percentages of solids is a liquid or solid sample will be determined by the analytical laboratory after the percent of solids has been determined.

^b California Assessment Manual (CAM) Metals - (17 metals): Sb, As, Ba, Be, Cd, Cr, Co, Cu, Pb, Hg, Mo, Ni, Se, Ag, Ti, V, Zn.

^c Organochlorine pesticides and polychlorinated biphenyls.

Area to be Sampled

The area to be sampled consists of the entire LLNL storm drain system that is located within the LLNL Livermore site. Refer to LLNL drawing PLC78-099-052E, LLNL Storm Drain System Site Map in Appendix A, which shows the LLNL Site and the LLNL storm drain system. Field samples will be taken from selected catch basins, manholes, open channel sites, and other locations that are within the LLNL storm drain system. Quality assurance samples will be taken from areas within and outside the LLNL Livermore site.

Sampling Procedure

Quality Assurance/Quality Control

Quality Assurance (QA) and Quality Control (QC) shall be integrated throughout the Storm Drain Sampling Program. LLNL policies and procedures, including those outlined in the Health and Safety Manual, shall be followed.

Duplicate Samples. Duplicate samples provide information on the precision of the sampling, sample preservation, shipping, and analytical techniques and procedures. The total number of duplicate samples shall be equal to or greater than 10 percent of the total number of samples. A minimum of one duplicate sample shall be included for every 10 samples collected (one duplicate sample shall be taken even when fewer than 10 samples are collected).

Blank Samples. A minimum of one liquid field blank sample shall be used for every daily set of liquid samples collected. Liquid field blanks shall be carbon-filtered distilled water.

Background Samples. Background field samples shall be taken to establish a basis for comparison between the collected field samples and the surrounding area. Background field samples shall be solid samples of undisturbed native soil taken from selected locations. Background samples shall be taken from areas outside the SDS and/or from off-site locations.

Documentation and Reporting. If the sample does not require expedited analyses, then written and signed analytical reports, with accompanying chain-of-custody documentation and QA/QC data, shall be received by the designated LLNL representative within 20 calendar days of sample submittal. If the sample does require expedited analyses, then preliminary sample results of analyses are to be reported verbally, by FAX, and/or by electronic data transfer to the designated LLNL representative immediately upon completion of the analyses. The preliminary results are to be followed within 5 working days by a written and signed analytical report that contains complete QA/QC data and chain-of-custody documentation.

Written analytical reports, at a minimum, are to include the following:

Sample data

- LLNL sample ID number or unique sample identifier
- sample collection date
- date the laboratory received the sample
- sample analysis date
- requested analyses method number(s)
- date of sample digestion
- sample dilution values
- laboratory's sample log number
- sample description
- chain-of-custody form number
- analytical results

- QA/QC data
- signature of lab director or responsible lab representative

QA/QC data (for each analyte)

- Laboratory control standards (LCS) data: batch number, method number, date of analysis, instrument ID number, analyst's ID number, and percent recovery
- Matrix QC precision (lab split/duplicate sample) data: batch number, method number, date of analysis, instrument ID number, analyst's ID number, and percent relative difference
- Matrix QC accuracy (spike) data: batch number, method number, date of analysis, instrument ID number, analyst's ID number, and percent recovery
- Method blank data: batch number, method number, date of analysis, instrument ID number, analyst's ID number, and method blank results
- Reporting detection limit (RDL)
- Minimum detection limit (MDL)

The analytical laboratory must provide the designated LLNL representative with the control limits or acceptance criteria used for LCS, matrix QC precision and accuracy, method blanks, and reporting detection limit data used to determine acceptance. If the control limits are unacceptable to the LLNL representative, the analytical laboratory shall use contract RDL limits based on EPA or Contract Laboratory Program recommendations. All analyses shall be reported in units specified by the designated LLNL representative. Chain-of-custody forms shall be required for all samples collected for analyses under the Storm Drain Sampling Program. Each set of sample results received from an analytical laboratory shall be accompanied by the applicable QC data.

QA/QC Policy and Procedures. Policies and procedures that shall be used for QC include the following:

- Personnel shall be trained and knowledgeable of appropriate LLNL Health and Safety issues.
- Personnel shall be trained and shall follow standard operating procedures for the collection, handling, and preservation of environmental samples that may exhibit hazardous waste characteristics.
- Only certified analytical laboratories shall be used to conduct nonradionuclide analyses of samples.
- All activities shall be done in accordance with EPA regulations for sampling and analysis.
- All work activities shall be done in accordance with LLNL Health and Safety Manual requirements.
- All work activities shall be done in accordance with LLNL policies and procedures.
- All required documentation, including chain-of-custody forms, shall be created and organized for ease of review.

Sampling Method

Solid samples from storm drain catch basins and manholes will consist of two samples that are collected in squat widemouth glass jars and one sample that will be collected in a stainless steel tube. The sample in the stainless steel tube will be analyzed for volatile TCL organics and semi-volatile TCL organics. The two samples in the glass jars will be analyzed for the other target constituents listed in Table 1. These samples will be collected with stainless steel tools or disposable plastic scoops. Due to the variety of materials that potentially will be sampled by this method, the selection of sampling equipment will occur on a sample-specific basis. Liquid that may be standing in a storm drain catch basin or manhole will be collected in glass jars.

Solid samples from open channel sites will consist of two samples that are collected in squat widemouth glass jars and one core sample that will be collected with a stainless steel core sampler from a hand-excavated boring. Borings may extend from the surface to a depth of a few feet. Core samples

will be collected with a hammer-driven, stainless steel core barrel. The core barrel will be fitted with a stainless steel tube that will retain the sample. Analyses will be the same as for those collected from catch basins and manholes.

After collection of the samples in stainless steel tubes, the ends of each tube will be covered with clean Teflon sheeting and capped with plastic end caps. Each plastic end cap will be sealed with duct tape that will extend to the sample label placed on the side of the tube.

Sample collection equipment shall be thoroughly cleaned and decontaminated prior to taking a sample and between each sampling event. Sufficient sampling equipment will be provided to minimize field cleaning of equipment. All stainless steel sleeves will be cleaned and protected prior to being transported to the field. All other sample containers will be pre-cleaned or supplied by the analytical laboratory; therefore, no field cleaning of any sample containers will be necessary.

All ice chests shall be washed with laboratory detergent (interior and exterior), rinsed with tap water, and air dried before storage or use.

The method(s) for sample collection, equipment cleaning, sample container cleaning, sampling equipment use and operation, vehicle use and cleaning, and other sampling method considerations shall be in accordance with the EPD Field Sampling Training Manual, 92044.01.

Sample Labeling

Each sample that is collected shall be labeled with at least the following information:

- unique sample ID number
- sample collection date
- time sample was taken
- sample location
- requested analyses
- identity of the sampler(s)

Sample Transportation, Treatment, and Storage

All environmental samples and QA samples will be protected by appropriate protective coverings and isolated from external contaminants. Samples will be stored in ice chests, with ice when appropriate, and transported to an analytical laboratory as soon as practical and within the minimum hold time for the specified analysis. A courier service will be used to transport samples between LLNL and the analytical laboratory.

Chain-of-Custody Forms and Field Tracking Forms

The sampler(s) shall fill out a chain-of-custody form at the time the sample is collected. The chain-of-custody form shall remain with the sample at all times. The chain-of-custody form shall be signed and dated each time a sample is transferred from one individual to another.

Sampling Locations

The individual sampling locations may consist of catch basins, manholes, open channel sites, selected background locations, and other locations. Sampling locations are listed in Table 2 and also shown on the Sampling Location Site Map (Appendix B). A copy of the LLNL Storm Drain System Site Map (LLNL drawing PLC78-099-052E) has been marked up to indicate the locations of all the sample locations. Triangles indicate field sample locations and asterisks indicate background field sample locations. LLNL drawing PLC78-099-052E shows all documented manholes, catch basins, and open channel swales. The manholes are indicated by solid circles, the catch basins are indicated by open circles, and the open channel swales are indicated by solid lines with flow indication arrows. This drawing has a grid that divides the LLNL site into grid blocks. The vertical axis is divided from 10 through 90 and the horizontal axis is divided from 0 through 600. Each block has a unique grid block

Table 2. Sampling Locations in the LLNL Storm Drain System.

10s		100s		200s		300s		400s		500s		600s	
10	BS-6	100	BS-7									610	BS-1
70	BS-5	190	BS-4									690	BS-2
												690	BS-3
OCS	10-1	CB	110-C	CB	210-C	CB	310-C	CB	410-D	CB	510-B	CB	610-A
		CB	110-G	CB	220-A	CB	310-M	CB	410-E	CB	510-D	CB	610-B
		MH	120-G	CB	220-F	CB	320-C	CB	420-D	CB	510-F	OCS	610-1
		CB	120-M	CB	220-U	CB	320-F	MH	420-F	CB	520-F	CB	620-I
		CB	120-S	CB	230-B	CB	320-K	CB	430-T	OCS	530-1	CB	620-N
		CB	130-Y	CB	230-P	CB	320-M	MH	440-A1	OCS	540-1	CB	620-O
		CB	140-J	CB	230-S	CB	330-G	CB	460-C	CB	550-A	OCS	660-1
		CB	150-F	CB	240-F	CB	330-D1	OCS	460-1	CB	550-K	OCS	670-1
		CB	150-U	CB	250-A	CB	340-A	CB	470-P	CB	560-G	OCS	690-1
		OCS	150-1	CB	250-G	MH	340-C	CB	490-X	OCS	570-1	OCS	690-2
		CB	160-C	CB	260-G	CB	350-E	OCS	490-1	CB	590-Q1	OCS	690-3
		CB	170-B	CB	260-Q	CB	360-G	OCS	490-2	OCS	590-1		
		CB	170-P	CB	270-G	CB	360-J			OCS	590-2		
		OCS	170-1	CB	270-I	CB	390-R						
		OCS	180-1	CB	280-D	CB	390-Y						
		CB	190-Q	CB	280-J								
		CB	190-T	OCS	280-1								
		CB	190-W	CB	290-A								
		OCS	190-1	CB	290-F								
		OCS	190-2	CB	290-J								
		OCS	190-3	CB	290-M								
		OCS	190-4	CB	290-N								
				OCS	290-1								
				OCS	290-2								
BS	(2)	BS	(2)	BS	(0)	BS	(0)	BS	(0)	BS	(0)	BS	(3)
CB	(0)	CB	(14)	CB	(21)	CB	(14)	CB	(7)	CB	(8)	CB	(5)
MH	(0)	MH	(1)	MH	(0)	MH	(1)	MH	(2)	MH	(0)	MH	(0)
<u>OCS</u>	<u>(1)</u>	<u>OCS</u>	<u>(7)</u>	<u>OCS</u>	<u>(3)</u>	<u>OCS</u>	<u>(0)</u>	<u>OCS</u>	<u>(3)</u>	<u>OCS</u>	<u>(5)</u>	<u>OCS</u>	<u>(6)</u>
TOT	(3)	TOT	(24)	TOT	(24)	TOT	(15)	TOT	(12)	TOT	(13)	TOT	(14)

- (7) Number of background field sampling locations.
- (69) Number of catch basin field sampling locations.
- (4) Number of manhole field sampling locations.
- (25) Number of open channel site field sampling locations.

(105) Total number of sampling locations.

number. Manholes and catch basins, within each grid block, are uniquely labeled A, B, C, etc. A combination of the grid block number and the letter designation provides a unique label for each manhole or catch basin, e.g., catch basin 190-W. Open Channel Site sample locations, within each grid block, have been sequentially numbered 1, 2, 3, etc. A combination of the grid block number and the sequence number provides a unique label for each Open Channel Site sample location, e.g., 190-1. Background field sample locations are sequentially numbered and have the prefix BS, e.g., BS-1.

The Location Number, Location Type, Location Type ID, and Sample Purpose for each sampling location will be entered on a Sampling Location Data Sheet (Appendix C) prior to sampling. The Sample Media, Bottom information, Sampler, Time, Date, and Sample ID will be entered at the time the sample is taken. An example of a completed Sampling Location Data Sheet is shown in Table 3.

Table 3. Sampling location data sheet for the LLNL storm drain system.

Sampling Location Data Sheet									
Location Number ^a	Location Type ^b	Location Type ID ^c	Sample Purpose ^d	Sample Media ^e	Bottom ^f	Sampler ^g	Time ^h	Date ⁱ	Sample ID ^j
001	CB	510-D	FS	L S	Y N NA	PK/BJ	8:30	08/15/91	
002	MH	520-F	FS	L S	Y N NA	PK/BJ	9:15	08/15/91	
003	OCS	150-1	FS	L S	Y N NA	PK	10:00	08/15/91	
004	O	O-1	FS	L S	Y N NA	PK/BJ	10:45	08/15/91	
005	BS	BS-1	FS	L S	Y N NA	PK	11:30	08/15/91	
006	CB	420-D	FS	L S	Y N NA	PK/BJ	13:30	08/15/91	
006	CB	420-D	DP	L S	Y N NA	PK/BJ	13:40	08/15/91	
QA	QA	—	FB	L S	Y N NA	PK/BJ	14:15	08/15/91	

- ^a Enter the Location Number. Also note Location Number on the Sampling Location Site Map. Enter QA for field blanks.
- ^b Enter the appropriate Location Type: BS = Background Sample; CB = Catch Basin; MH = Manhole; O = Other; OCS = Open Channel Site; QA = Quality Assurance.
- ^c Enter the appropriate Location Type ID: CB and MH Location Type IDs refer to catch basins or manholes that are shown on LLNL drawing PLC78-099-052E, LLNL Storm Drain System Site Map. OCS Location Type IDs refer to the grid block location and a sequence # shown on the Sampling Location Site Map (Appendix B). BS and O Location Type IDs refer to background sample sites or other locations shown on the Sampling Location Site Map (Appendix B).
- ^d Enter the appropriate Sample Purpose: BF = Background Field; DP = Duplicate; FS = Field Sample; FB = Field Blank.
- ^e Circle appropriate Sample Media that was taken: L = Liquid; S = Solid.
- ^f Circle Y (Yes) or N (No) to indicate if there is a bottom in the sampled catch basin. Circle NA (Not Applicable) if the Sample Location is not a catch basin or manhole.
- ^g Enter the initials of the person or persons who took the sample, e.g., PK/BJ.
- ^h Enter the time that the sample was taken. Use 24-hour notation.
- ⁱ Enter the date that the sample was taken. Use MM/DD/YY notation.
- ^j Enter the unique Sample ID.

Analytical Laboratories

The following list of analytical laboratories will be considered to process and analyze the collected samples. Only laboratories that are State certified for specified nonradionuclide analytical method will be used.

<u>Laboratory</u>	<u>Contact Person(s)</u>	
Brown and Caldwell Analytical Laboratory (BCA)	Larry Penfold	(415) 428-2300
Clayton Environmental Consultants (CEC) Analytical Laboratory	Maryann Gambino	(415) 426-2600
LLNL Environmental-Analytical Sciences Laboratory (EAS)	Price Russ	(415) 422-6671 Pager # 6197
	Dave Silberman	(415) 422-2100 Pager # 5661
	Susan Gagner	(415) 423-6008
	Rod Dougan	(415) 422-6648 Building Page 2-8151
LLNL Radiological Environmental Analytical Laboratory (REAL)		
TMA Norcal Analytical Laboratory (TMA/Norcal)	Dinkar Kharkar	(415) 235-2633

Sampling Materials, Equipment, and Supplies

Table 4 provides the descriptions of necessary sampling materials, equipment, and supplies, including the stock numbers for ordering. Equivalent items may be substituted as necessary.

Table 4. Sampling materials, equipment, and supplies.

<u>General Quantity</u>	<u>Item</u>	<u>Stock Number</u>
4 pair	Leather gloves, M	8415-49220
	Leather gloves, L	8415-49219
	Leather gloves, XL	8415-50328
4 each	Hand trowel, ss	Fabricated
1 roll	Teflon tape - 3 mil x 4" x 60'	Order
8 rolls	Vinyl tape, red - 1/2" wide	5970-56200
4 rolls	Duct tape, black - 1" wide	7510-53251
4 rolls	Acetate tape, see through - 2" wide	7510-12334
4 each	Marker pen, black - Sharpie	7520-62156
as req	Distilled water, 5 gal each	6810-13280
3 each	Filter cartridge, rinsewater	4180-63126
2 boxes	Detergent, Tide	7930-30299
as req	Wipes—Kay Dry	7999-63447
2 each	Ice chest—various sizes	Order
as req	Ice, crushed	NA
as req	Preservative	NA
as req	Chain-of-custody form	NA
as req	Radiation analyses form	7600-69183
as req	EAS waste analysis request form	LL-6267
as req	Field tracking form	NA

<u>Per Sample Location Quantity</u>	<u>Item</u>	<u>Stock Number</u>
2 pair	Vinyl gloves (disposable), S	8415-64993
	Vinyl gloves (disposable), M	8415-64994
	Vinyl gloves (disposable), L	8415-64995
1 each	Tube, 0.049"tk ss - 1.5" OD, x 6" l	Order
2 each	Tube caps, polyethylene - 1.5" OD	Order
2 each	Glass jar, squat widemouth - 4 oz	8125-27799
3 each	Labels, self adhesive - 1.5" x 2.75"	7530-53182
3 each	Plastic bag, sealable - 6" x 8"	8105-60398
1 each	Plastic bag, nonsealable - 6" x 12"	8105-27699

Follow-Up Activities

The following are recommended follow-up activities to sampling the LLNL storm drain system.

Remediation of LLNL Storm Drain System

If necessary, appropriate remediation and cleanup of all contaminated locations will be performed by the Environmental Restoration Division.

LLNL Storm Drain Cleanout and Disposal Recommendations

The Maintenance Operations Division in the Maintenance/Operations Department of Plant Engineering has the responsibility for cleanout of the LLNL storm drain system and disposal of nonhazardous debris. Cleanout has been performed on an "as needed" basis, and no set frequency has been established. It is recommended that the Maintenance/Operations Department review the results of the LLNL Storm Drain Sampling Program, inspect the SDS, and then decide if a set schedule for cleanout is required or if the current "as needed" basis is appropriate. The Maintenance/Operations Department will continue to have the primary responsibility for cleanout of the LLNL storm drain system, and LLNL emergency response personnel would respond if a spill of hazardous material to the SDS were to occur.

Future and Ongoing Monitoring of the LLNL Storm Drain System

Future and ongoing inspections, surveillance, and monitoring of the LLNL storm drain system will be conducted by the Environmental Monitoring Group of the Environmental Protection Department. A sampling plan that addresses the necessary sampling protocol, parameters, analytes, and frequency to adequately sample the LLNL storm drain system on a regular and ongoing basis will be developed as part of the overall LLNL Storm Drain Monitoring Program.

Documentation of LLNL Storm Drain System

The Utilities Division in the Maintenance/Operations Department of Plant Engineering has the responsibility for maintenance of the LLNL storm drain system and for documenting and updating the LLNL Storm Drain System Site Map, LLNL drawing PLC78-099-052E.

Appendix A

LLNL Storm Drain System Site Map
(LLNL drawing PLC78-099-052E)

STORM DRAIN LEGEND

[illegible]

DO NOT REVISE THIS DRAWING

DATE: 10/1/68 BY: J. L. B. (J. L. B. is the initials of the drafter)

PROJECT: MONSTORM 5112

SITE PLAN

**Lawrence Livermore
National Laboratory**
Livermore, CA 94550

LLNL
SITE 200
STORM DRAIN
SYSTEM

NAME	DATE	TIME	SCORE
1. NAME	1. DATE	1. TIME	1. SCORE
2. NAME	2. DATE	2. TIME	2. SCORE
3. NAME	3. DATE	3. TIME	3. SCORE
4. NAME	4. DATE	4. TIME	4. SCORE
5. NAME	5. DATE	5. TIME	5. SCORE
6. NAME	6. DATE	6. TIME	6. SCORE
7. NAME	7. DATE	7. TIME	7. SCORE
8. NAME	8. DATE	8. TIME	8. SCORE
9. NAME	9. DATE	9. TIME	9. SCORE
10. NAME	10. DATE	10. TIME	10. SCORE
11. NAME	11. DATE	11. TIME	11. SCORE
12. NAME	12. DATE	12. TIME	12. SCORE
13. NAME	13. DATE	13. TIME	13. SCORE
14. NAME	14. DATE	14. TIME	14. SCORE
15. NAME	15. DATE	15. TIME	15. SCORE
16. NAME	16. DATE	16. TIME	16. SCORE
17. NAME	17. DATE	17. TIME	17. SCORE
18. NAME	18. DATE	18. TIME	18. SCORE
19. NAME	19. DATE	19. TIME	19. SCORE
20. NAME	20. DATE	20. TIME	20. SCORE
21. NAME	21. DATE	21. TIME	21. SCORE
22. NAME	22. DATE	22. TIME	22. SCORE
23. NAME	23. DATE	23. TIME	23. SCORE
24. NAME	24. DATE	24. TIME	24. SCORE
25. NAME	25. DATE	25. TIME	25. SCORE
26. NAME	26. DATE	26. TIME	26. SCORE
27. NAME	27. DATE	27. TIME	27. SCORE
28. NAME	28. DATE	28. TIME	28. SCORE
29. NAME	29. DATE	29. TIME	29. SCORE
30. NAME	30. DATE	30. TIME	30. SCORE
31. NAME	31. DATE	31. TIME	31. SCORE
32. NAME	32. DATE	32. TIME	32. SCORE
33. NAME	33. DATE	33. TIME	33. SCORE
34. NAME	34. DATE	34. TIME	34. SCORE
35. NAME	35. DATE	35. TIME	35. SCORE
36. NAME	36. DATE	36. TIME	36. SCORE
37. NAME	37. DATE	37. TIME	37. SCORE
38. NAME	38. DATE	38. TIME	38. SCORE
39. NAME	39. DATE	39. TIME	39. SCORE
40. NAME	40. DATE	40. TIME	40. SCORE
41. NAME	41. DATE	41. TIME	41. SCORE
42. NAME	42. DATE	42. TIME	42. SCORE
43. NAME	43. DATE	43. TIME	43. SCORE
44. NAME	44. DATE	44. TIME	44. SCORE
45. NAME	45. DATE	45. TIME	45. SCORE
46. NAME	46. DATE	46. TIME	46. SCORE
47. NAME	47. DATE	47. TIME	47. SCORE
48. NAME	48. DATE	48. TIME	48. SCORE
49. NAME	49. DATE	49. TIME	49. SCORE
50. NAME	50. DATE	50. TIME	50. SCORE
51. NAME	51. DATE	51. TIME	51. SCORE
52. NAME	52. DATE	52. TIME	52. SCORE
53. NAME	53. DATE	53. TIME	53. SCORE
54. NAME	54. DATE	54. TIME	54. SCORE
55. NAME	55. DATE	55. TIME	55. SCORE
56. NAME	56. DATE	56. TIME	56. SCORE
57. NAME	57. DATE	57. TIME	57. SCORE
58. NAME	58. DATE	58. TIME	58. SCORE
59. NAME	59. DATE	59. TIME	59. SCORE
60. NAME	60. DATE	60. TIME	60. SCORE
61. NAME	61. DATE	61. TIME	61. SCORE
62. NAME	62. DATE	62. TIME	62. SCORE
63. NAME	63. DATE	63. TIME	63. SCORE
64. NAME	64. DATE	64. TIME	64. SCORE
65. NAME	65. DATE	65. TIME	65. SCORE
66. NAME	66. DATE	66. TIME	66. SCORE
67. NAME	67. DATE	67. TIME	67. SCORE
68. NAME	68. DATE	68. TIME	68. SCORE
69. NAME	69. DATE	69. TIME	69. SCORE
70. NAME	70. DATE	70. TIME	70. SCORE
71. NAME	71. DATE	71. TIME	71. SCORE
72. NAME	72. DATE	72. TIME	72. SCORE
73. NAME	73. DATE	73. TIME	73. SCORE
74. NAME	74. DATE	74. TIME	74. SCORE
75. NAME	75. DATE	75. TIME	75. SCORE
76. NAME	76. DATE	76. TIME	76. SCORE
77. NAME	77. DATE	77. TIME	77. SCORE
78. NAME	78. DATE	78. TIME	78. SCORE
79. NAME	79. DATE	79. TIME	79. SCORE
80. NAME	80. DATE	80. TIME	80. SCORE
81. NAME	81. DATE	81. TIME	81. SCORE
82. NAME	82. DATE	82. TIME	82. SCORE
83. NAME	83. DATE	83. TIME	83. SCORE
84. NAME	84. DATE	84. TIME	84. SCORE
85. NAME	85. DATE	85. TIME	85. SCORE
86. NAME	86. DATE	86. TIME	86. SCORE
87. NAME	87. DATE	87. TIME	87. SCORE

PLC70-099-052EN

1. NAME, ADDRESS AND CATCH BASIN NUMBER ARE DERIVED FROM THE SITE BLOCK NUMBER AND LETTER DESIGNATION. ONLY THE LETTER DESIGNATION IS SHOWN ON THE PLAN NEXT TO THE NAME OF THE CATCH BASIN. REFER TO BLOCK 610 FOR SPECIFIC NUMBER. REMEMBER THAT EACH CLUST OR ON CATCH LINES HAVE THEIR LETTER DESIGNATION WITHIN THE GRID BLOCK THEY ARE ASSOCIATED WITH.
2. SEE SHEET 6-2 FOR NAME AND CATCH BASIN COORDINATE LIST.

Appendix B

Sampling Location Site Map

B-1

Appendix C

Sampling Location Data Sheet

Sampling Location Data Sheet

Location Number ^a	Location Type ^b	Location Type ID ^c	Sample Purpose ^d	Sample Media ^e	Bottom ^f	Sampler ^g	Time ^h	Date ⁱ	Sample ID ^j
_____	_____	_____	_____	L S	Y N NA	_____	_____	_____	_____
_____	_____	_____	_____	L S	Y N NA	_____	_____	_____	_____
_____	_____	_____	_____	L S	Y N NA	_____	_____	_____	_____
_____	_____	_____	_____	L S	Y N NA	_____	_____	_____	_____
_____	_____	_____	_____	L S	Y N NA	_____	_____	_____	_____
_____	_____	_____	_____	L S	Y N NA	_____	_____	_____	_____
_____	_____	_____	_____	L S	Y N NA	_____	_____	_____	_____
_____	_____	_____	_____	L S	Y N NA	_____	_____	_____	_____

- ^a Enter the Location Number. Also note Location Number on the Sampling Location Site Map. Enter QA for field blanks.
- ^b Enter the appropriate Location Type: BS = Background Sample; CB = Catch Basin; MH = Manhole; O = Other; OCS = Open Channel Site; QA = Quality Assurance.
- ^c Enter the appropriate Location Type ID: CB and MH Location Type IDs refer to catch basins or manholes that are shown on LLNL drawing PLC78-099-052E, LLNL Storm Drain System Site Map. OCS Location Type IDs refer to the grid block location and a sequence # shown on the Sampling Location Site Map (Appendix B). BS and O Location Type IDs refer to background sample sites or other locations that are shown on the Sampling Location Site Map (Appendix B).
- ^d Enter the appropriate Sample Purpose: BF = Background Field; DP = Duplicate; FS = Field Sample; FB = Field Blank.
- ^e Circle appropriate Sample Media that was taken: L = Liquid; S = Solid.
- ^f Circle Y (Yes) or N (No) to indicate if there is a bottom in the sampled catch basin. Circle NA (Not Applicable) if the Sample Location is not a catch basin or manhole.
- ^g Enter the initials of the person or persons who took the sample, e.g., PK/BJ.
- ^h Enter the time that the sample was taken. Use 24-hour notation.
- ⁱ Enter the date that the sample was taken. Use MM/DD/YY notation.
- ^j Enter the unique Sample ID.

Appendix C

Surveillance Soils and Sediment Sampling Procedure

EMP-S-S

SOIL & ARROYO SEDIMENT SAMPLING

Prepared by:

Kris Surano
Group Leader, SMG
12/3/92
date

Duke Ramsey
Environmental Technician, TSG
12-4-92
date

Reviewed by:

David Graves
Environmental Technician, TSG
12-4-92
date

Paris Althouse
Environmental Technician, TSG
12-4-92
date

Approved by:

Rebecca A. Failor
Section Leader, EMS
12/7/92
date

Kris Surano
Group Leader, SMG
12/3/92
date

Lucinda Garcia
Quality Assurance Coordinator, EMS
12/8/92
date

1. PURPOSE

This procedure describes the methods to be used in collecting surface soil and arroyo sediment samples for EMS environmental surveillance activities at LLNL, in the Livermore Valley, and at Site 300. This procedure applies to both routine and non-routine sampling unless the non-routine sampling plan specifically states otherwise.

2. DISCUSSION

Soil is an integrating medium that can contain pollutants originally released directly to the ground, to the air, or through liquid effluents. Reference 1, on which much of EMS monitoring is based, states that "Periodic sampling and analysis of indicator materials, such as soil ... should be performed to determine if there is measurable long-term buildup of radionuclides in the terrestrial environment." Since 1972, surface soil sampling in the vicinity of LLNL and Site 300 has been part of a continuing LLNL monitoring program designed to measure any changes in environmental levels of radioactivity and to evaluate any increase in radioactivity that might have resulted from LLNL operations. Surface soil samples are also analyzed for beryllium, a potentially toxic metal used at LLNL and Site 300.

EMS soil sampling locations are chosen to coincide with air sampling locations or to give coverage to areas of special concern, including areas of known past contamination (Reference 2). The use of constant sampling locations allows better trending of data and closer monitoring of areas of concern. All soil sampling is conducted according to this procedure.

According to Reference 1, "The sampling of sedimentary material from streams or ponds can provide an indication of the accumulation of undissolved radionuclides in the aquatic environment. The accumulation of radioactive materials in sediment can lead to exposure of humans through ingestion of aquatic species, through sediment resuspension into drinking water supplies, or as an external radiation source..." Sediments also have the potential to concentrate nonradioactive constituents present in storm water runoff. Sediment sampling, followed by radiological and chemical analyses, helps EMS determine if significant buildups of pollutants have occurred in nearby arroyos.

Annual sediment samples have been collected from selected arroyos and other drainages at and around LLNL since 1988. Sediments from 11 major LLNL drainages currently are sampled. The sediment sampling locations coincide with storm water runoff sampling locations so results from the sampling of these two related media can be compared (Reference 3). Analyses have been conducted on both radioactive and nonradioactive constituents of sediment samples every year since the inception of sediment monitoring. All sediment sampling is conducted according to this procedure.

3. REFERENCES

1. DOE/EH-0173T, *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*
2. EMP-S-L, *Soil and Arroyo Sampling Locations*
3. EMP-RO-L, *Storm Water Runoff Sampling Locations*
4. EMP-QA-CD, *Design Change Packages*
5. EMP-QA-NCR, *Nonconformance Reports*
6. EMP-QA-D, *Data Analysis*
7. EMP-QA-AER, *Annual Environmental Report*
8. EMP-QA-SL, *Sample Location Designators*
9. EMP-QA-SA, *Self Assessments*
10. EMP-QA-SD, *Sample Tracking Documentation*
11. EMP-QA-DC, *Document Retention Center*

REVISION 3 FINAL	EMP-S-S Soil & Arroyo Sediment Sampling	Effective date: 01/04/93 Page 3 of 16
---------------------	--	--

12. EMP-HS-300, *Site 300 Health and Safety Work Procedure*
13. EMP-QA-S, *Quality Assurance Samples*
14. EMP-QA-DM, *Data Management*
15. EMP-QA-CS, *Courier Service Protocol*
16. Sims, et al., *Environmental Report for 1990* (UCRL-50027-90)

4. DEFINITIONS

Arroyo: A deep gully cut by an intermittent stream.

Auger: Tool used to bore holes in the ground. Soil/sediment samples can be collected from the auger bit after it is withdrawn from the ground.

Core Sampler: An impact-driven soil sampling device for collecting an intact, undisturbed cylinder of surface soil from the ground.

Sample Identifier: The four-field code that identifies an individual sample to an analytical laboratory. It is made up of the sample location designator (two fields), a sample number, and a media code (L-ZON7-01-SO, for example).

Sediment: Finely divided solid material that settles to the bottom of a liquid.

Sediment sample: A aliquot of arroyo sediment taken with a split-spoon sampler driven into the sediment to a depth of 2 ft.

Slide Hammer: A device used to pound soil/sediment sampling equipment into the ground. It is made of a heavy weight which slides up and down on a smooth rod, striking the soil sampling equipment with a descending blow. Repetitive blows can drive sampling equipment to the necessary depths even when the ground has hardened.

Soil: The top layer of earth, suitable for the growth of plants.

Soil sample: An aliquot of surface soil collected to a depth of 5 cm because surface deposition from the air is the primary pathway for potential soil contamination.

Split-Spoon Sampler: A specialized soil sampling device which can be pounded into the ground and extracted with the soil core intact. The sampler can be opened longitudinally to reveal the intact soil core, which can then be collected untouched for analysis.

5. RESPONSIBILITIES

5.1. EMS ENVIRONMENTAL ANALYST (SOILS)

The Environmental Analyst assigned responsibility for the soil and sediment monitoring networks will decide when and where samples are to be collected. Sampling locations are described in Reference 2. The Analyst must periodically review the network sampling locations, the sample collection schedule, soil and sediment collection methods, quality assurance (QA) sampling, and sample analytes for technical suitability in the context of EMS goals and missions. Furthermore, the Analyst is responsible for assessing the need to sample newly discovered areas of known or suspected contamination. The Analyst is responsible for submitting design changes regarding the network sampling locations, schedules, and sampling methods (Reference

REVISION 3 FINAL	EMP-S-S Soil & Arroyo Sediment Sampling	Effective date: 01/04/93 Page 4 of 16
---------------------	--	--

4). The Analyst should also discuss analytical procedures, detection limits, and data delivery schedules with analytical laboratory personnel. The Analyst is also responsible for keeping this procedure updated, for participating in nonconformance report activities (Reference 5), for conducting data analysis (Reference 6), reporting results (Reference 7) and for communicating changes, as needed, to other EMS staff members.

5.2. EMS QUALITY ASSURANCE COORDINATOR

The QA Coordinator is responsible for keeping lists of all present and past sampling locations, evaluating the need for and reviewing/approving soil sampling method design changes (Reference 4), and for assigning new soil sampling location designators as needed (Reference 8). The QA Coordinator is also responsible for inspecting and evaluating sample collection methods and documentation (References 9 and 10), participating in nonconformance report activities (Reference 5), and for archiving all design changes and revisions of this procedure (Reference 11).

5.3. EMS TECHNICIANS

The EMS Technicians are responsible for collecting soil and sediment samples according to methods detailed in this procedure at locations described in Reference 2. They must complete appropriate Field Tracking Forms (FTF) and Chain-of-Custody Record Forms (COCs) and must make detailed notes (on FTFs) as pertinent information regarding soil and sediment samples is acquired (see References 8 and 10). In particular, they must record the distance and direction from permanent location markers to the actual sampling locations. Technicians are also responsible for providing input to the Analyst regarding the suitability of sampling locations and sampling methods, the availability of samples, and any problems associated with the monitoring networks (Reference 5).

REVISION 3 FINAL	EMP-S-S Soil & Arroyo Sediment Sampling	Effective date: 01/04/93 Page 5 of 16
---------------------	--	--

6. PROCEDURE

Equipment Required:

SURFACE SOIL SAMPLING

Stainless steel soil core sampler (custom fabricated by EMS Technicians; B-596)
 Resin striking surface
 Sledge hammer, 5 to 8 lb. (LLNL Stores Stock #5120-26051)
 Plastic sample collection bags (LLNL Stores Stock #8105-27696)
 Yellow tie-on sample tags (LLNL Stores Stock #8135-27958)
 Indelible marking pens (LLNL Stores Stock #7520-62156)
 Tape measure, 50 ft. (LLNL Stores Stock #5185-27672)
 Magnetic compass (LLNL Stores Stock #6650-18471)
 Plastic vial for soil subsample, Be analysis (LLNL Stores Stock #8125-48618)
 Adhesive labels (LLNL Stores Stock #7530-46221)
 Field Tracking Form
 Chain-of-Custody Record Forms (2 each)
 Ice chest (no ice required; Transportainer TY-165, end of 6th St., LLNL)

ARROYO SEDIMENT SAMPLING

Hand auger w/extensions (Environmental Instruments Co., Concord CA; B-596)
 Split-spoon sampler (Environmental Instruments Co., Concord CA; B-596)
 Stainless-steel tubes (Building 596)
 Slide hammer (Building 596)
 Pipe wrenches (2 each; LLNL Stores Stock #5120-26390)
 Large screwdriver (LLNL Stores Stock #5120-26241)
 Ice chest w/ double-bagged ice (Transportainer TY-165, end of 6th St., LLNL)
 Wide-mouth glass sample collection containers (LLNL Stores Stock #8125-27800)
 Adhesive labels (LLNL Stores Stock #7530-46221)
 Indelible markers (LLNL Stores Stock #7520-62156)
 Teflon sheets, 4 inches by 4 inches (LLNL Pipe Shop, B-511)
 Protective caps (LLNL Pipe Shop, B-511)
 Duct tape
 Tape measure, 50 ft. (LLNL Stores Stock #5185-27672)
 Wooden stakes (LLNL Carpenter Shop, B-511)
 Trowel
 Field Tracking Form
 Chain-of-Custody Record Form

DECONTAMINATION AND PERSONAL PROTECTIVE EQUIPMENT

Disposable vinyl gloves (LLNL Stores Stock #8415-64995)
 Deionized water and detergent (LLNL Stores Stock #7930-30299)
 Large test tube brush (LLNL Stores Stock #7920-30233)
 Large rinse tray (photo developing, LLNL Stores Stock #6750-29166)
 Kimwipes or equivalent (LLNL Stores Stock #7999-63447)
 Garbage bags (LLNL Stores Stock #8105-58929)
 Leather protective gloves (LLNL Stores Stock #8415-50328)
 Safety shoes (boots; LLNL Supervisor controlled)
 Safety glasses (LLNL Stores Stock #4270-34827)

All soil and sediment samples must be collected according to the methods described in this procedure. All sampling activities must take place at designated sampling locations (Reference 2). FTFs and COCs must be completed for all samples, in accordance with References 8 and 10.

6.1. SURFACE SOIL SAMPLING (LIVERMORE VALLEY/SITE 300)

The soil sampling methods are identical for the Livermore Valley and Site 300 soil monitoring networks. Site 300 access and safety procedures must be strictly followed when performing all sampling activities (Reference 12). Soil samples shall be collected annually, usually in the months of April and May. The collection of surface soils requires only nominal personal protective equipment (disposable vinyl gloves, safety glasses, safety boots).

6.1.1. SELECTION OF SOIL SAMPLE MATERIAL

6.1.1.1. Locate the permanent soil sample location marker (red and white fence post with metal identification tag attached; Reference 2). Select an undisturbed area, free of rocks and not sheltered by trees or buildings, in the vicinity of the permanent location marker.

6.1.1.2. Choose a 1 m² area from which to collect the sample. The sample will consist of five subsamples, collected at the four corners and the center of the square. If a 1 m² area is not available (such as along a roadside or a fence) the sample will be collected in a line, with each subsample being taken 1 m apart.

6.1.1.3. Using the tape measure and the compass for measurements, note the distance and direction of the actual sampling location from the permanent identification marker (Reference 2). Record this distance and direction on the FTF.

6.1.2. SOIL SAMPLE VOLUME

The total sample should weigh between 0.5 and 1.0 kg. A 10-g aliquot is taken from the sample for beryllium analysis.

6.1.3. OBTAINING THE SOIL SAMPLE

Note: Prior to the actual collection of the samples, it is vital that the sampler be aware of EMS sampling hygiene. This includes wearing disposable gloves when collecting samples and discarding the gloves between locations. Take special precautions not to introduce any external contamination. This includes keeping the work area clean.

6.1.3.1. If necessary, carefully clip surface vegetation at the soil surface from the five subsampling areas. Do not disturb the soil surface.

6.1.3.2. Place the clean, decontaminated core sampler, resin striking surface at the top, on the first subsample site. With a sledge hammer, drive the core sampler into the ground until the ground surface is level with the bottom of the steel band welded to the outside of the core sampler. (At some locations, the soil may be loose enough so you can merely twist the core sampler into the ground by hand.)

6.1.3.3. Remove the resin striking surface. Twist the core sampler in order to break off the core it contains. If the soil sample is loose within the

corer, capture the soil sample by slipping a newly gloved hand under the base of the core sampler as it is removed. Be careful not to lose or contaminate any part of the sample. Should loss of subsample integrity occur, the subsample shall be discarded and another shall be collected.

6.1.3.4. Shake the contents of the core sampler into the plastic sample collection bag. If the sample is not easily shaken out, place two plastic bags over the handle of the sledge hammer and gently tap the core sample into the sample collection bag.

6.1.3.5. Repeat the collection steps 6.1.3.1 through 6.1.3.4 at the four remaining subsample sites, combining the five subsamples into the same sample bag.

6.1.3.6. Make sure the subsamples are adequately mixed. Then obtain an approximately 10-g aliquot from the sample and place it in a plastic vial. Place a white, self-stick label on the vial (Attachment A). Record the following information on the label: the sample identifier (including sample location designator), the type of sample, the date and year of collection, the type of analysis required (Be), the analytical laboratory, "LLNL", and the collector's initials.

6.1.3.7. Secure the sampling collection bag with a rubber band. Mark the outside of the bag with the sampling location using a waterproof, indelible marking pen. Place this bag inside another plastic bag and secure the second bag with a rubber band. Attach a yellow sample identification tag to the outside bag (Attachment B). The tag shall contain, at a minimum, the sample identifier (including sample location designator), the type of sample, the date and year of collection, the analyses required (gamma, plutonium), the analytical laboratory, and the collectors initials.

6.1.4. SOIL SAMPLE FIELD DOCUMENTATION

Record the appropriate information on the FTF (References 2 and 10). Be sure to record the distance and direction from the permanent sampling location to the location at which the sample was obtained. Record any other pertinent information about the sample.

6.1.5. SOIL SAMPLE PRESERVATION

No special preservation measures are required for soil samples. However, samplers must ensure the integrity of sample containers to avoid cross-contamination.

6.1.6. SOIL QUALITY ASSURANCE SAMPLES

QA samples will be submitted with each batch of samples, in accordance with Reference 13. Duplicate samples are the only QA samples authorized for the soil sampling networks. Two duplicate samples are required for the Livermore Valley soil sampling network and two duplicate samples are required for the Site 300 soil sampling network. At locations chosen for duplicate samples, two samples are to be collected. Each sample will consist of five subsamples. At each corner and at the center of the sampling square, two cores will be collected and processed separately. Duplicate 10-g sample aliquots for beryllium analyses will also be produced. The sampling locations of QA samples are not to be identified on the bags, sample identification tags, or vial labels (References 8 and 10). However, this information is required on FTFs, and the QA sample must be assigned a temporary identification number (References 8 and 10).

6.1.7. SOIL SAMPLING EQUIPMENT DECONTAMINATION

Gloves must be discarded after collecting each sample, and must not be reused. After all subsamples are collected from a location, decontaminate the core sampler by washing it thoroughly with deionized water and a low-phosphate detergent. The large test tube brush should be used to clean the inside of the corer and to remove any particles adhering to the outside. The core sampler must then be thoroughly rinsed with deionized water. Rinse any other equipment that has come into contact with soil, using the same procedures. Dry the core sampler with a Kimwipe and place it in a plastic bag to prevent contamination.

6.1.8. CHAIN OF CUSTODY

Chain-of-custody procedures (Reference 10) must be followed. After all samples have been collected from a soil network, use the information from the FTF to complete a COC for each analytical laboratory. In addition to sample identification information, each COC must specify the laboratory name and the analyses to be completed.

6.1.9. SOIL SAMPLE DELIVERY

Deliver the samples in the plastic sampling bags to the Radiation Analytical Sciences Laboratory (RASL), Building 151, Room 2143. If the samples cannot be delivered on the day of collection, they must be kept secure (Reference 10) until they can be delivered. Samples going to a contract analytical laboratory for beryllium analyses must be delivered, in accordance with Reference 15, to the sample courier. Chain-of-custody procedures must be followed whenever samples are delivered to laboratory personnel or to couriers.

Plutonium content of samples is determined by alpha spectroscopy of sample aliquots. Other sample aliquots are analyzed by gamma spectroscopy using a Ge(Li) detector (Reference 16). Beryllium content is determined by graphite-furnace atomic absorption spectroscopy.

6.1.10. SOIL DATA REVIEW, ANALYSIS, MANAGEMENT, ARCHIVING

The Analyst will review and analyze data promptly after receipt, in accordance with Reference 6. Chain-of-custody procedures will be followed for data (Reference 10), and QA samples will be identified by the Analyst when signing and returning COCs, following receipt of data, to the analytical laboratory. Data will be given to the Data Manager promptly for entry into the EMS Monitoring Database (References 10 and 14), and will be archived according to Reference 11.

6.1.11. SOIL DATA REPORTING

The monitoring results will be reported in the Site Annual Environmental Report (Reference 7).

6.2. ARROYO SEDIMENT SAMPLING

Arroyo sediment samples shall be collected annually, during the months of June and July, after seasonal rains have ceased. The collection of sediment samples requires the use of personal protective equipment (disposable vinyl gloves, leather gloves, safety glasses, safety shoes). An individual sediment sample is collected as two subsamples, of varying depths, in two steps. The first subsample is collected with the hand auger and is submitted for radiological analyses. The second subsample is

collected from the bottom of the same hole, using the split-spoon sampler, and is analyzed for metals and organic compounds.

Note: The sediment sampling procedure involves the use of heavy equipment. Care should be exercised to avoid injury when using the sampling equipment. The normally high daytime temperatures during the sampling period, combined with the strenuous physical activity required to operate the slide hammer and auger, make it mandatory that a team consisting of no less than three qualified persons perform the sampling.

6.2.1. SELECTION OF ARROYO SEDIMENT SAMPLE MATERIAL

6.2.1.1. Locate the permanent sediment sampling location marker at the sampling location. A culvert/bridge or other permanent marker, described in Reference 2, serves as a reference point for that sampling location. Drive a wooden stake into the ground at the permanent location marker.

6.2.1.2. The Analyst will have supplied three random numbers on the Field Tracking Form. Samples are to be collected at distances (in feet) from the permanent marker corresponding to those numbers. Using the tape measure, measure from the permanent sampling location marker and place stakes at the sampling locations. Samples should be collected from the middle of the drainage channel at the most "down stream" number first, working upstream for each successive sample.

6.2.2. ARROYO SEDIMENT SAMPLE VOLUME

Sediment samples are obtained with various devices. The auger should provide enough sample to fill the glass sample container that will be submitted to RASL. The split-spoon sampler is designed to place samples directly into sample containers, which are merely sealed and sent to the analytical laboratory.

6.2.3. OBTAINING THE ARROYO SEDIMENT SAMPLE

Note: Prior to the actual collection of the samples, it is vital that the sampler be aware of EMS sampling hygiene. This includes wearing disposable gloves when collecting samples and discarding the gloves between samples. Take special precautions not to introduce any external contamination. This includes keeping the work area clean.

6.2.3.1. Remove any loose impediments from the sediment surface at the exact location where the sample is to be collected.

6.2.3.2. Using the hand auger, dig to a depth of 1 ft from ground level. Remove and discard all loose sediment from the hole and the auger. Once the hole and auger are clean, continue to dig to a total depth of 1.5 feet.

6.2.3.3. Remove the auger from hole and place the sediment that is attached to the auger bit into a glass sample container. In the event that the sediment is dry and will not remain attached to the auger, use a trowel to fill the glass sample container with sediment from the hole.

6.2.3.4. Using the indelible marking pen, prepare an adhesive label. The label should include the sample identifier (including the sample location designator), the sample collector's initials, the type of sample, the analyses required (tritium, gamma), the analytical laboratory (RASL), and the sampling date (Attachment C). Secure the lid to the jar with duct tape, attach the label to the jar, and place the sample container into the ice chest. This portion of the sample goes to RASL for tritium and other radiological analyses, and must be kept cool prior to analyses.

6.2.3.5. Clear all loose sediment from the hole to prepare for collecting the second subsample, which will be collected using the split-spoon sampler.

6.2.3.6. Place two clean, decontaminated stainless-steel tubes into the split-spoon sampler, and assemble the sampler/slide hammer.

6.2.3.7. Place the sampler/slide hammer into the hole. Use the slide hammer to drive the sampler into the ground far enough to fill the bottom six inch tube (usually about eight to ten inches).

6.2.3.8. Remove the sampler from the hole by rotating the sampler, and disassemble the split-spoon sampler.

6.2.3.9. With freshly gloved hands, remove the bottom tube, making sure that the sediment sample is flush with both ends of the tube. Place a square Teflon sheet over each end of the sample tube and cover the Teflon sheets with plastic caps. Tape the plastic caps to the sample tube (use duct tape; do not use vinyl tapes, because they contain volatile organic compounds, which can contaminate the sample).

6.2.3.10. Using the indelible marking pen, prepare an adhesive label. The label should include the sample identifier (including the sample location designator), the sample collector's initials, the type of sample (sediment), the analyses required (CAM metals, EPA 8010, EPA 8020, EPA 8080), the analytical laboratory (usually a contract laboratory), "LLNL", and the sampling date (Attachment D). Attach the label to the sample tube and place the tube into the ice chest.

6.2.4. ARROYO SEDIMENT SAMPLE FIELD DOCUMENTATION

Record appropriate information on the FTF (References 2 and 10). Record any pertinent information about the sample.

6.2.5. ARROYO SEDIMENT SAMPLE PRESERVATION

All sediment samples must be kept cool until analysis, and must be kept on ice while in the field. Upon returning to LLNL, samples for radiological analyses that are in glass sample containers should be kept in a refrigerator, and sediment samples for metals and organic analyses that are in the stainless-steel tubes should be kept in a freezer. The samples must still be refrigerated/frozen when delivered to analytical laboratories.

6.2.6. ARROYO SEDIMENT QUALITY ASSURANCE SAMPLES

QA samples are to be submitted with each batch of samples, in accordance with Reference 13. In reality, the three samples taken at each sediment sampling locations are duplicate samples. However, blind duplicates are also required. A fourth sample is to be taken from each of three designated sampling locations and submitted blind, as a QA sample, to analytical laboratories. For locations chosen for duplicate sampling, a fourth random number is generated and a sample is collected using identical methods. The sampling locations of QA samples are not to

REVISION 3 FINAL	EMP-S-S Soil & Arroyo Sediment Sampling	Effective date: 01/04/93 Page 11 of 16
---------------------	--	---

be identified on the sample containers or COCs (References 8 and 10). However, this information is required on FTFs.

6.2.7. ARROYO SEDIMENT SAMPLING EQUIPMENT DECONTAMINATION

Gloves must be discarded after collecting each sample, and must not be reused. Before collecting additional samples, either at the same location or at another location, the auger, split-spoon sampler, and other sampling equipment must be decontaminated.

Wash the equipment thoroughly with deionized water and a low-phosphate detergent. The large test tube brush should be used to clean the inside of the samplers and to remove any sediment adhering to the outside of the samplers. Rinse all equipment thoroughly with deionized water. Dry the samplers with Kimwipes and place the samplers in a plastic bag to prevent subsequent contamination.

6.2.8. CHAIN OF CUSTODY

Chain-of-custody procedures (Reference 10) must be followed. Using information from the FTF, complete the COCs after all samples have been collected from the arroyo sediment sampling network. Two COCs are required for each set of samples because the subsamples are sent to different laboratories for processing. In addition to sample identification information, the COC must specify the laboratory name and the analyses required. Be sure to include the COC numbers on the FTF as a cross-reference.

6.2.9. ARROYO SEDIMENT SAMPLE DELIVERY

On the same day that they are collected, deliver the radiological subsamples to the RASL, Building 151, Room 2143. If the samples cannot be delivered on the day of collection, they must be kept secure (Reference 10) and refrigerated until they can be delivered. Chain-of-custody procedures must be followed when delivering samples (Reference 10).

Tritium content is determined by liquid scintillation counting of water recovered from the samples by using freeze-drying techniques (lyophilization). Plutonium content is determined by alpha spectroscopy, and other radionuclides are determined by gamma spectroscopy (Reference 16).

Samples submitted for organic analyses have "holding times," (the period following sampling in which analyses must be completed) so timely processing and submittal of sediment samples is essential. Frozen subsamples contained in sampling tubes are to be sent to analytical laboratories via courier as soon as possible, preferably on the day of collection (Reference 15). Chain-of-custody and sample-preservation procedures must be observed.

The sediment samples are analyzed for metals by inductively-coupled plasma emission spectroscopy (ICP). The samples are analyzed for organic compounds by using standard EPA methods (8010 for halogenated volatile organic compounds, method 8020 for aromatic volatile organic compounds, and method 8080 for pesticides and PCBs).

6.2.10. SEDIMENT DATA REVIEW, ANALYSIS, MANAGEMENT, ARCHIVING

The Analyst will review and analyze data promptly after receipt, in accordance with Reference 6. Chain-of-custody procedures will be followed for data (Reference 10), and QA samples will be identified by the Analyst when signing and returning COCs, following receipt of data, to the analytical laboratory. Data will be given to the Data Manager promptly for entry into the EMS

Monitoring Database (References 10 and 14), and will be archived according to Reference 11.

6.2.11. SEDIMENT DATA REPORTING

The sediment sampling results will be reported in the Site Annual Environmental Report (Reference 7).

7. DOCUMENTATION

Samplers must complete FTFs and COCs when collecting soil and arroyo sediment samples, in accordance with Reference 10. FTFs must contain current location designators (Reference 8). FTFs and COCs become QA records and must be archived in the Document Retention Center, along with final sample data (Reference 11). Any deviations from this procedure must be documented in Nonconformance Reports (Reference 5). Any changes to this procedure must be documented in an approved Design Change Package (Reference 4). All Nonconformance Reports and Design Change Packages are QA records and must be archived (Reference 11).

8. ACCEPTANCE CRITERIA

Only samples taken at official sampling locations will be used in the assessments of LLNL impacts on the environment, unless special samples are authorized in an approved sampling plan. Samples will not be deemed acceptable if the proper collection and preservative methods have not been followed, if the chain-of-custody has been broken or compromised, if the documentation has not been properly completed, or if the sample label or tag is illegible. Samples must be identified with authorized location designators (References 8 and 10) and documentation must include pertinent information as required by this procedure. Furthermore, samples will not be deemed acceptable if the sample containers are not properly labeled, dated, and initialed by the sample collector, if sample contamination is suspected, or if sampling schedules have not been met.

9. ATTACHMENTS

- A. Soil Sample Label (Beryllium Analysis)
- B. Soil Sample Tag
- C. Arroyo Sediment Sample Label (Radiological Analyses)
- D. Arroyo Sediment Sample label (Metals/Organic Compounds Analyses)

REVISION 3
FINAL

EMP-S-S
Soil & Arroyo Sediment Sampling

Effective date: 01/04/93
Page 13 of 16

ATTACHMENT A. SOIL SAMPLE LABEL
(BERYLLIUM ANALYSIS)

LLNL

10-3-91

L-MESQ-01-50

ANNUAL
SOIL

TMA-NORCAL

Be

DR, DG

REVISION 3
FINAL

EMP-S-S
Soil & Arroyo Sediment Sampling

Effective date: 01/04/93
Page 14 of 16

ATTACHMENT B. SOIL SAMPLE TAG

LLNL

10-3-91

L-CAFE-01-SO
ANNUAL SOIL

NCD-ERL

Pu, GAMMA

DR, DG

LLNL
10-3-91
7-CDB-01-A5
ANNUAL SEDIMENT
NCD-ERL
TRIT, Pu, GAMMA DR, DG

ATTACHMENT C, ARROYO SEDIMENT SAMPLE LABEL
(RADIOLOGICAL ANALYSES)

REVISION 3 FINAL	EMP-S-S Soil & Arroyo Sediment Sampling	Effective date: 01/04/93 Page 15 of 16
---------------------	--	---

REVISION 3
FINAL

EMP-S-S
Soil & Arroyo Sediment Sampling

Effective date: 01/04/93
Page 16 of 16

ATTACHMENT D. ARROYO SEDIMENT SAMPLE LABEL
(METALS/ORGANIC COMPOUNDS ANALYSES)

LLNL

10-3-91

2-CDB-01-AS
ANNUAL SEDIMENT

BCA

CAN METALS, 7010, 7020, 7080

Dr. DK

Appendix D

Analytical Results from 1991 Sediment Study

Appendix D

Analytical Results from 1991 Sediment Study

Table D-1. Soluble metals analysis from 1991 sediments study (mg/L).

Locations	Barium	Cadmium	Copper	Lead	Nickel	Vanadium	Zinc
Catch basin							
CB-140J-13	5.4	0.08	1.1	4.5	0.4	0.23	30
CB-170B-18	4.4	≤0.05		0.6	0.4		
CB-190Q-10 1/2	5.4	0.1	2.2	2.4	0.4	0.22	30
CB-270G-29		≤0.05	0.88	3.5	0.5		45
CB-290A-96	3.7	≤0.05		0.8	0.5		48
CB-290F-38	7.4	0.12	1.4	1.9	1	0.65	
CB-290J-82		≤0.05	0.47	1.2			17
CB-290N-19		0.1	0.39	1.5			78
CB-350E-44	6.1	0.1	0.83	11	0.6		80
CB-360G-20 1/2	5.6	0.14	7	2.4	1.7		31
CB-360J-48	3.3	≤0.05	0.48	2.5	0.4		40
CB-410D-014	5.3	0.12		3.7	0.6		28
CB-410E-044	4	0.12	3.2	63	0.4	0.15	14
CB-420D-024	6.6	0.12	1.4	4.7	0.7		15
CB-620J-01-34		0.26	1.3	4.1	0.4		26
CB-620J-34		0.13	0.71	1.1	0.02		8.5
Open channel							
OCS-150-1	8.1	0.17	1.9	3.6	0.7	0.48	82
OCS-170-1	8.9	≤0.05		0.6	0.7	0.24	30
OCS-180-1	8.6	≤0.05		0.5	0.9	0.34	18
OCS-190-1	8.1	≤0.05	1.2	0.6	0.9	0.59	
OCS-190-2		≤0.05	5.7				
OCS-190-4	7.2	0.05		0.3	0.6	0.36	
OCS-290-1	7	≤0.05			0.6	0.29	
OCS-290-2	5.2	≤0.05	1.9	1.2	0.6	0.24	

Table D-2. ICAP metals analysis from 1991 sediments study on liquid samples (mg/L).

Locations	Sb	As	Ba	Be	Cd	Cr	Co	Cu	Pb	Hg	Mo	Ni	Se	Ag	Th	V	Zn
CB-160C-30	≤0.2	0.007	0.46	≤0.01	≤0.05	≤0.05	≤0.05	1.6	≤0.2	0.01	≤0.2	≤0.1	≤0.002	≤0.05	≤0.2	≤0.05	3.4
MH-340A-71	≤0.2	0.043	0.08	≤0.01	≤0.05	≤0.05	≤0.05	0.025	≤0.2	≤0.0005	≤0.2	≤0.1	≤0.002	≤0.05	≤0.2	≤0.05	0.38
CB-190T-49	≤0.2	0.006	11	0.01	0.45	1.4	0.27	5.4	15	0.073	≤0.2	1.2	≤0.002	≤0.05	≤0.2	1.1	62
CB-290M-26	≤0.2	≤0.002	0.07	≤0.01	≤0.05	≤0.05	≤0.05	1.6	≤0.2	0.032	≤0.2	≤0.1	≤0.002	≤0.05	≤0.2	≤0.05	1.9
CB-390Y-84					0.47	1.4	1.2	2.1	2.2	0.054	≤0.2	1.4	0.01	≤0.05	≤0.2	1.9	17
CB-130Y-24	≤0.2	0.006	≤0.05	≤0.01	≤0.05	0.05	≤0.05	0.09	≤0.2	≤0.0005	8.2	≤0.1	≤0.002	≤0.05	≤0.2	≤0.05	0.24
CB-220A-33					≤0.05	≤0.05	≤0.05	0.26	0.2	0.0009	≤0.2	≤0.1	≤0.002	≤0.05	0.2	≤0.05	0.72

Table D-3. ICAP metals analysis from 1991 sediments study on solid samples (mg/kg).

Locations	Sb	As	Ba	Be	Cd	Cr	Co	Cu	Pb	Hg	Mo	Ni	Se	Ag	Th	V	Zn
Background																	
BS-1-01-6	≤4	1.4	170	0.4	7	28	8	15	6	≤0.05	≤4	32 ≤0.4	≤1	≤4	39	30	
BS-1-02-6	≤4	1.8	200	0.4	7	28	10	17	≤4	≤0.05	≤4	32 ≤0.4	≤1	≤4	40	27	
BS-2-8	≤4	1.7	260	0.3	6	20	5	31	6	≤0.05	≤4	16 ≤0.4	≤1	≤4	28	49	
BS-3-6	≤4	1.8	210	0.4	6	18	7	28	11	≤0.05	≤4	18 ≤0.4	≤1	≤4	33	32	
BS-4-6	≤4	3.7	260	0.6	13	48	10	24	8	0.05	≤4	39 ≤0.4	≤1	≤4	52	57	
BS-5-6			520		15	64	10	160	320	0.12	9	62 ≤0.4	≤1	≤4	77	290	
BS-6-6	≤4	1.9	310	0.5	14	75	15	31	30	0.14	≤4	110 ≤0.4	≤1	≤4	53	80	
BS7-6	≤4	3.8	130	0.2	10	37	9	15	13	≤0.05	≤4	39 ≤0.4	≤1	≤4	28	60	
Catch basin																	
CB-120M-21	≤4	3.5	90	≤0.2	11	36	4	99	120	0.6	≤4	25 ≤0.4	10	2	18	1800	
CB-120S-01-17	≤4	7.9	110	0.3	7	43	7	120	69	0.73	4	26 ≤0.4	5	≤4	22	430	
CB-120S-02-17	≤4	10	140	0.2	7	31	5	46	47	0.64	≤4	18 ≤0.4	21	≤4	20	280	
CB-140J-13	≤4	16	140	0.3	8	44	11	37	43	0.37	≤4	43 ≤0.4	≤1	≤4	34	460	
CB-150F-18			250		14	39	12	24	16	≤0.05	≤4	41 ≤0.4	≤1	≤4	46	65	
CB-150U-21	≤4	1.4	76	≤0.2	4	14	4	15	38	0.19	≤4	15 ≤0.4	≤1	≤4	18	150	
CB-170B-18	≤4	2.8	100	0.2	5	29	12	23	18	0.06	≤4	43 ≤0.4	1	≤4	24	140	
CB-190Q-10 1/2	≤4	2.8	110	0.2	6	38	8	52	23	0.37	≤4	38 ≤0.4	≤1	≤4	31	390	
CB-260G-38	≤4	3.2	110	0.2	10	31	28	42	25	0.28	≤4	39 ≤0.4	≤1	≤4	30	290	
CB-270G-29	≤4	1.4								≤0.05	≤4	30 ≤0.4	≤1	≤4	10	280	
CB-280D-24	120	2.9	86	0.2	8	60	10	420	25000	0.24	≤4	66 ≤0.4	6	≤4	23	560	
CB-290A-96	≤4	1.4	110	0.2	4	36	6	15	17	≤0.05	≤4	29 ≤0.4	≤1	≤4	19	410	
CB-290F-38	4	2.7	130	0.3	7	34	9	30	14	≤0.05	≤4	41 ≤0.4	≤1	≤4	29	220	
CB-290J-82	≤4	1.3	69	≤0.2	3	23	6	28	30	0.06	≤4	19 ≤0.4	≤1	≤4	16	250	
CB-290N-19	≤4	1.8	85	≤0.2	4	19	8	29	22	0.09	≤4	17 ≤0.4	≤1	≤4	20	810	
CB-310C-24	≤4	0.8	50	≤0.2	5	340	6	13	570	0.07	≤4	140 ≤0.4	≤1	≤4	9	240	
CB-310M-30			180		13	33	11	24	6	≤0.05	≤4	46 ≤0.4	≤1	≤4	40	120	
CB-320-M	≤4	2.4	80	≤0.2	7	62	8	68	76	0.07	10	69 ≤0.4	≤1	≤4	21	170	
CB-320-M2	≤4	2.5	100	≤0.2	8	78	10	35	270	0.17	5	200 ≤0.4	≤1	≤4	21	140	
CB-320F-17	5	3.9	120	0.2	22	97	15	290	400	38	15	91 ≤0.4	3	≤4	20	3000	
CB-340C-35	≤4	2.6	110	0.2	4.7	32	9.4	17	4.8	≤0.05	≤4	44 ≤0.4	≤1	≤4	22	100	
CB-350E-44	≤4	2.7	100	0.2	5	28	8	73	34	0.1	≤4	30 ≤0.4	≤1	≤4	16	560	
CB-360G-20 1/2	≤4	4.3	110	0.2	6	34	54	52	24	0.24	≤4	59 ≤0.4	≤1	≤4	21	400	
CB-360J-48	≤4	3.6	110	0.2	5	120	9	34	100	0.05	≤4	70 ≤0.4	≤1	≤4	23	940	
CB-390R-14 1/2					9.2	28	9.6	96	36	0.13	≤4	31 ≤0.4	≤1	≤4	21	390	
CB-410D-014	≤4	2.3	160	≤0.2	4	21	6	2.3	80	0.13	≤4	27 ≤0.4	≤1	≤4	15	460	
CB-410E-044	≤4	3.8	110	0.2	7	66	8	120	640	1.3	≤4	54 ≤0.4	≤1	≤4	28	390	
CB-420D-024	≤4	0.9	150	≤0.2	4	40	6	41	68	0.34	≤4	44 ≤0.4	≤1	≤4	19	400	
CB-420F-27	≤4	3.1	94	0.2	9	93	12	44	120	0.35	≤4	69 ≤0.4	≤1	≤4	29	710	
CB-430T-86.5	≤4	3.3	88	≤0.2	3	21	3	19	24	0.3	≤4	20 ≤0.4	≤1	≤4	15	440	
CB-460-C	≤4	3.9	160	0.3	8	45	10	25	15	0.1	≤4	52 ≤0.4	≤1	7	35	86	
CB-470-P	≤4	3.2	130	0.2	9	35	10	19	7	0.08	≤4	43 ≤0.4	≤1	≤4	30	240	
CB-470-P2	≤4	3.6	120	0.2	8	40	9	17	6	0.06	≤4	44 ≤0.4	≤1	5	31	150	
CB-490-X-36	≤4	0.05	76	≤0.2	8	33	8	15	8		≤4	51 ≤0.4	≤1	4	18	78	
CB-510B-30	≤4	3.9	70	0.2	3	33	3	18	25	≤0.05	≤4	24 ≤0.4	≤1	≤4	13	130	

Table D-3. ICAP metals analysis from 1991 sediments study on solid samples (mg/kg)
(continued).

Locations	Sb	As	Ba	Be	Cd	Cr	Co	Cu	Pb	Hg	Mo	Ni	Se	Ag	Th	V	Zn
CB-520F-76			72	0.2	3	21	4	98	32								
CB-560G-14	≤4	3.2	71	≤0.2	5	61	8	29	15	0.11	≤4	52	≤0.4	≤1	≤4	17	150
CB-590-Q1-12	≤4	0.05	160	0.2	8	37	7	49	44		≤4	32	≤0.4	≤1	≤4	28	180
CB-610A-54	≤4	43	240	0.3	11	29	9	26	54	≤0.05	≤4	43	≤0.4	≤1	≤4	61	98
CB-610B-16	≤4	2.5	100	≤0.2	5	36	6	73	59	≤0.05	≤4	44	≤0.4	≤1	≤4	21	210
CB-620J-01-34	≤4	2.3	85	≤0.2	6	22	7	48	64	≤0.05	6	30	≤0.4	≤1	≤4	14	420
CB-620J-34	≤4	2.2	68	≤0.2	6	27	5	30	38	≤0.05	≤4	30	≤0.4	≤1	≤4	20	270
MH-110G-93	≤4	3.6	130	0.2	10	67	11	480	110	5.5	6	50	≤0.4	3	2	21	640
Open channel																	
OCB-620-28	≤4	2.5	38	≤0.2	2	16	2	7	8	≤0.05	≤4	17	≤0.4	≤1	≤4	9	140
OCS-10-1-6			180		10	36	10	23	22	0.18	≤4	40	≤0.4	≤1	≤4	35	92
OCS-150-1	≤4	7.3	160	0.4	9	43	12	50	80	1.2	≤4	44	≤0.4	≤1	≤4	38	1500
OCS-170-1	≤4	4.6	180	0.4	7	39	12	23	53	0.1	≤4	42	≤0.4	≤1	≤4	36	400
OCS-180-1	≤4	3.8	180	0.4	7	30	12	22	10	≤0.05	≤4	36	≤0.4	≤1	≤4	37	280
OCS-190-1	≤4	2.4	170	0.3	5	30	8	48	33	0.78	≤4	26	≤0.4	≤1	≤4	28	160
OCS-190-2	≤4	3.7	87	0.2	3	15	5	30	4	0.2	≤4	13	≤0.4	≤1	4	20	57
OCS-190-3-6	≤4	3.9	330	0.7	12	47	13	27	7	0.06	≤4	47	≤0.4	≤1	≤4	54	62
OCS-190-4	≤4	4.8	150	0.4	6	28	10	19	6	≤0.05	≤4	30	≤0.4	≤1	≤4	34	130
OCS-280-1					10	33	10	23	16	≤0.05	≤4	42	≤0.4	≤1	≤4	30	410
OCS-290-1	≤4	2.2	130	0.3	5	27	11	15	≤4	≤0.05	≤4	25	≤0.4	≤1	6	33	90
OCS-290-2	≤4	3	130	0.3	5	27	10	54	18	0.37	≤4	27	≤0.4	≤1	≤4	30	160
OCS-460-1-6					12	41	8.9	18	8	≤0.05	≤4	38	≤0.4	≤1	≤4	41	77
OCS-490-1					7	21	8.2	14	6	≤0.05	≤4	32	≤0.4	≤1	≤4	26	46
OCS-490-2					7.9	27	7.2	14	≤4	≤0.05	≤4	25	≤0.4	≤1	≤4	36	77
OCS-530-1-8	≤4	0.44	130	0.2	10	66	9	20	13		≤4	48	≤0.4	≤1	4	28	120
OCS-540-1-12	≤4	0.06	180	0.3	9	41	12	17	6		≤4	35	≤0.4	≤1	≤4	40	52
OCS-590-1					7	20	7.4	9.6	6	≤0.05	≤4	19	≤0.4	≤1	≤4	24	63
OCS-590-2					4	15	6	7.2	4	≤0.05	≤4	15	≤0.4	≤1	≤4	17	70
OCS-610-1-6	≤4	4	220	0.4	10	38	14	19	16	≤0.05	≤4	39	≤0.4	≤1	≤4	40	45
OCS-660-1-6	≤4	≤0.05	150	0.2	8	50	10	14	24		≤4	70	≤0.4	≤1	≤4	29	160
OCS-670-1-8	5	2	210	0.5	7	26	7	12	12	0.25	≤4	23	≤0.4	≤1	≤4	36	34
OCS-690-1-6	≤4	2.4	250	0.3	10	20	6	42	5	≤0.05	≤4	22	≤0.4	≤1	≤4	35	57
OCS-690-2-6	4	2	220	0.3	8	18	6	44	6	≤0.05	≤4	19	≤0.4	≤1	≤4	27	51
OCS-690-2A-10					10	35	9.2	14	7	≤0.05	≤4	30	≤0.4	≤1	≤4	46	38
OCS-690-2B-10					13	43	7.5	18	5	≤0.05	≤4	27	≤0.4	≤1	≤4	54	45
OCS-690-3-8					6	19	11	10	5	≤0.05	≤4	35	≤0.4	≤1	≤4	22	35

Table D-4. Radionuclide analysis for 1991 sediment study in pCi/g, unless otherwise noted.

Locations	Gross α	Gross β	^3H (pCi/L)	% moisture	40K	^{137}Cs	^{226}Ra	^{228}Th	^{232}Th
Background									
BS-1-01-5	7	19	1302	5.6	11.84	≤ 0.1924	≤ 0.7144	1.099	≤ 0.9536
BS-1-02-6	7	15	881	5.5	12.09	≤ 0.1408	0.7126	0.7008	0.9569
BS-2-8	≤ 2	16	245	5.2	15.62	≤ 0.06996	0.5086	0.7361	0.5719
BS-3-6	≤ 3	13	≤ 32	1.6	18.99	≤ 0.1716	0.4097	1.114	1.121
BS-4-6	8	16	367	2.9	15.38	≤ 0.1734	0.9029	1.028	≤ 1.288
BS-5-6	≤ 1	16	≤ 32	8.8	15.32	≤ 0.156	0.5612	0.6171	0.9448
BS-6-6	4	14	762	2.9	8.097	≤ 0.13	0.4709	0.5109	0.7306
BS7-6	≤ 3	13	≤ 451	1.5	11.38	≤ 0.118	0.3623	≤ 2.352	0.5342
Catch basin									
CB-120M-21	≤ 2	18	263		11.33	≤ 0.103	0.2929	0.308	0.3531
CB-120S-01-17	≤ 1	14	334	4.1	13.37	0.1791	0.2026	0.3865	0.5896
CB-120S-02-17	11	18	333	4.66	12.78	≤ 0.1758	≤ 0.529	0.6395	0.6565
CB-140J-13	9	10	75	1.4	10.68	≤ 0.278	0.5049	0.3429	0.8454
CB-150F-18	≤ 2	16	133	17.1	11.44	≤ 0.1186	0.2425	0.8766	0.6371
CB-150U-21	8	11		44.6	12.7	≤ 0.2432	0.5691	1.174	≤ 1.474
CB-170B-18	1.5	10	19.5	0.7	8.666	≤ 0.1676	0.4502	0.3466	≤ 0.8956
CB-190Q-10 1/2	2.5	11	25.5	12.9	6.266	0.1353	0.4753	0.7748	0.64
CB-260G-38	0.5	14	173	12.8	14.92	≤ 0.2012	0.3891	0.7137	≤ 0.9498
CB-270G-29	6	11	196		5.278	≤ 0.1194	0.3604	0.3844	≤ 0.643
CB-280D-24	1.5	11	17.5	0.4	7.404	≤ 0.2498	0.6985	≤ 0.4816	≤ 1.27
CB-290A-96	9	17	314	40	6.27	≤ 0.6572	≤ 1.286	1.226	3.681
CB-290F-38	6	10	2548	1.9	9.12	≤ 0.1038	0.3888	0.4896	0.7721
CB-290J-82		20	358		11.65	≤ 0.09658	0.2986	0.4162	0.6464
CB-290N-19	1	20	2719		8.616	≤ 0.1092	0.5357	0.5175	0.7712
CB-310C-24	1	5	12.5		6.667	≤ 0.175	0.3104	0.4717	0.6294
CB-310M-30	1.5	11	478	14.8	7.203	≤ 0.2056	0.4701	0.5105	≤ 0.7798
CB-320-M	1	9	1467	14	7.965	≤ 0.1686	≤ 0.4128	0.6847	≤ 0.8444
CB-320-M2	1.5	16	799	11.2	9.7	≤ 0.1546	0.4656	0.4592	0.7326
CB-320F-17	2	14	1408	54.2	7.568	0.7091	≤ 0.7434	0.8066	1.033
CB-340C-35		15	115	1.2	9.655	≤ 0.1048	0.3888	0.5192	0.612
CB-350E-44	1	8		1	10.48	≤ 0.1296	0.6235	0.6247	≤ 0.7556
CB-360G-20 1/2	5	19	292	9.1	3.879	≤ 0.6596	≤ 0.658	0.9487	1.856
CB-360J-48	1	6	12	1.4	7.462	≤ 0.1296	0.3914	0.5067	0.527
CB-390R-14 1/2	1.5	13	373	17	8.318	≤ 0.1488	0.2551	0.4065	≤ 0.7122
CB-410D-014	1	9	349	37.9	19.08	≤ 0.6238	≤ 1.422	≤ 1.18	≤ 3.302
CB-410E-044	5	17	880	1.4	8.376	0.2907	≤ 0.2902	0.5089	≤ 0.6262
CB-420D-024	2.5	7	440	18.7	5.09	≤ 0.4194	≤ 0.812	0.7301	≤ 2.072
CB-420F-27	2	9	671	18.1	6.308	0.3697	≤ 0.3634	0.578	≤ 0.8412
CB-430T-86.5	8	15	1378	4.3	6.044	≤ 0.1986	0.291	0.5742	≤ 0.8478
CB-460-C	1	18	86	2.3	11.62	≤ 0.1744	0.4526	≤ 0.3564	≤ 0.9554
CB-470-P	6	17	235	3.5	11.74	≤ 0.1146	0.3833	0.8328	0.9668
CB-470-P2	1.5	17	165	3.1	10.51	≤ 0.09006	0.3832	0.76	0.7909
CB-490-X-36		11	117	17	6.354	0.09741	0.207	0.4165	0.4888
CB-510B-30	1	14	2403	16.39	34.5	≤ 0.7756	≤ 1.526	≤ 1.28	≤ 2.726
CB-510D-20	6	10	1542		≤ 1056	≤ 66.61	≤ 120.2	≤ 84.87	≤ 235.6
CB-520F-76					0.607	≤ 0.085	≤ 0.154	≤ 0.1406	≤ 0.3312
CB-560G-14	2	12	361	9.8	9.552	≤ 0.1414	≤ 0.3362	0.7006	≤ 0.9168
CB-590-Q1-12	7	19	2026	12.8	13.4	0.4185	0.372	0.7338	0.9922
CB-610A-54	7	12	18	12.1	8.682	0.405	≤ 0.7869	0.8647	0.829
CB-610B-16	1	8	1067		4.401	≤ 0.05254	0.1961	0.3499	≤ 0.374
CB-620J-01-34	0.5	12	892		6.366	≤ 0.0702	0.325	0.4738	0.4028
CB-620J-34	1	10	1329		5.536	≤ 0.05042	0.2995	0.4691	0.5174
CB-943					0.4453	≤ 0.07238	≤ 0.1319	0.05515	≤ 0.3376

Table D-4. Radionuclide analysis for 1991 sediment study in pCi/g, unless otherwise noted (continued).

Locations	Gross α	Gross β	^3H (pCi/L)	% moisture	40K	^{137}Cs	^{226}Ra	^{228}Th	^{232}Th
<u>Open channel</u>									
OCB-620-28	1.5	10	235	24.1	24.28	0.726	1.407	1.077	3.33
OCS-10-1-6	0.5	14	763	1.3	13.39	0.0725	0.404	0.6718	1.038
OCS-150-1	5	16	285	13.4	12.28	0.1826	0.7133	1.113	0.7535
OCS-170-1	5	14	26	1	12.14	≤ 0.148	0.3911	≤ 0.2806	≤ 0.7756
OCS-180-1	2.5	15	36	1.5	13.55	≤ 0.1078	0.4866	0.5548	0.5511
OCS-190-1	2.5	16	179	19.9	16.19	≤ 0.4164	≤ 1.005	0.7411	≤ 2.034
OCS-190-2	7	14	3.5	2.1	13.87	0.1307	0.5567	0.998	0.8882
OCS-190-3-6	10	18	383	8.9	14	0.0724	0.8613	1.216	0.8165
OCS-190-4	10	19	49	5.8	13.91	≤ 0.3038	0.6486	0.9492	1.604
OCS-280-1		16	179	1.9	13.33	≤ 0.101	0.4183	0.7715	0.7895
OCS-290-1	5	14	10.5	0.7	14.52	≤ 0.9038	0.4852	0.4695	0.45
OCS-290-2	10	10	6182	49.8	11.37	≤ 0.3056	0.7411	7.122	0.1235
OCS-290-2A	2.5	14	5240		0.642	≤ 0.07365	≤ 0.1243	≤ 0.1827	≤ 0.3045
OCS-460-1-6	2.5	19	1224	4.8	13.91	≤ 0.1222	0.5733	1.058	1.49
OCS-490-1	1	19	1.5	10.5	8.547	≤ 0.1136	0.4294	0.7108	0.594
OCS-490-2	6	17	315	10.6	14.78	≤ 0.1434	0.5011	1.125	0.6636
OCS-530-1-8	9	15	757	4.1	105	≤ 0.09766	0.3804	0.5914	0.4605
OCS-540-1-12	6	16	674	9	13.24	≤ 0.1318	0.291	0.9886	0.6551
OCS-590-1	6	17	188	13.2	18.43	≤ 0.2566	≤ 0.544	0.5572	0.6152
OCS-590-2	2	25	40.5	10.7	14.82	≤ 0.145	0.5034	0.468	0.7002
OCS-610-1-6	1.5	14	1325	3	13.04	0.1719	0.6726	0.9412	≤ 0.829
OCS-660-1-6	2.5	11	476	5.9	12.7	≤ 0.185	0.7139	0.8054	0.8705
OCS-670-1-8	7	15	851	4.6	13.82	0.2058	0.4928	0.6423	0.4931
OCS-690-1-6		17	486	5.2	13.88	≤ 0.121	0.6415	0.5382	0.6539
OCS-690-2-6	1.5	16	551	8.3	13.78	≤ 0.133	0.1627	0.665	0.5661
OCS-690-2A-10	10	16	546	8.4	12.67	0.0871	0.6656	0.9976	1.382
OCS-690-2B-10	6	16	695	9.7	13.58	≤ 0.1134	0.8942	1.092	1.103
OCS-690-3-8	1	29	193	3.3	13.38	0.3882	0.523	0.6079	0.1479
<u>Liquid (mg/L)</u>									
CB-160C-30		14	236		9.173	≤ 0.0949	0.4984	0.6237	0.5581
MH-340A-71	18	25	971		≤ 0.72	≤ 0.04636	≤ 0.1104	≤ 0.1306	≤ 0.211
CB-190T-49	0.5	12	310		11.62	0.4909	≤ 0.6372	0.9726	≤ 1.446
CB-290M-26	1	10	6268		≤ 335.4	≤ 20.06	≤ 40.87	≤ 25.74	≤ 84.85
CB-390Y-84	8	15	2016		≤ 594	≤ 41.03	≤ 91.02	≤ 86.21	≤ 190.1
CB-130Y-24	0.5				≤ 0.6551	≤ 0.04571	≤ 0.09247	≤ 0.08773	≤ 0.01812
CB-220A-33		14	621		≤ 162	≤ 9.324	≤ 17.59	≤ 12.8	≤ 38.43

Table D-5. Organic compounds detected by EPA Method 8270 in 1991 study, mg/kg unless otherwise noted.

Locations	1,3-Di-chloro-ben-zene	1,4-Di-chloro-ben-zene	2-Chlor-ophe-nol	4-Methyl phenol (p-Cre-sol)	4-Nitro-phenol	Acen-aph-thene	Anthra-cene	Benzo (a)an-thra-cene	Benzo (a)py-rene	Benzo (b)fluor-an-thene	Benzo (g,h,i)-perylene
<u>Background</u>											
BS-5-6								0.5	0.7	0.8	
BS-6-6											
BS7-6											
<u>Catch basin</u>											
CB-120M-21											
CB-120S-01-17								0.3	0.2	0.5	
CB-120S-02-17											
CB-290F-38								2	3	5	
CB-290J-82									0.5	0.4	
CB-320F-17									50		
CB-360G-20 1/2								4	6	10	
CB-390R-14 1/2						0.6	0.7	1.9	5.4	4.4	1.9
MH-110G-93								0.9	0.7	1.5	0.6
<u>Open channel</u>											
OCS-170-1								0.26	0.2	0.46	0.24
OCS-190-2										0.08	
OCS-190-3-6	0.03	0.03	0.03								
OCS-280-1											
OCS-660-1-6					1						
<u>Liquid (µg/L)</u>											
CB-510D-20				70							
CB-943											
MH-340A-71							2	17	21		16
CB-390Y-84										20	

Table D-5. Organic compounds detected by EPA Method 8270 in 1991 study, mg/kg unless otherwise noted. (continued)

Locations	Benzo (k)fluor an- thene	Chry- sene	Di- benzo- (a,h)- anthra- cene	Fluor- an- thene	Fluo- rene	Indeno (1,2,3- c,d)- pyrene	N- Nitroso dime- thyl- amine	Phen- an- threne	Phenol	Py- rene	Bis(2- chloro ethyl-)ether
<u>Background</u>											
BS-5-6	0.8	0.6		1.1				1.2		1.1	
BS-6-6				0.6				0.6		0.6	
BS7-6											
<u>Catch basin</u>											
CB-120M-21											
CB-120S-01-17	0.5	0.3		0.3				0.3		0.4	
CB-120S-02-17				0.5						0.5	
CB-290F-38	5	4		6				4		7	
CB-290J-82	0.4	0.3		0.4				0.4		0.4	
CB-320F-17				2						2	
CB-360G-20 1/2	10	4		8				4		7	
CB-390R-14 1/2	4.4	4.6		4.8	0.4	1.6		5		5.4	
MH-110G-93	1.5	0.8		1.3		0.5		0.7		1.2	
<u>Open channel</u>											
OCS-170-1	0.46	0.3	0.22	0.54		0.2		0.29		0.49	
OCS-190-2	0.08	0.09		0.09				0.08			
OCS-190-3-6							0.03		0.03		0.03
OCS-280-1		0.2		0.2						0.2	
OCS-660-1-6											
<u>Liquid (µg/L)</u>											
CB-510D-20											
CB-943											
MH-340A-71		17	12	27				21		24	
CB-390Y-84	20			20				20		20	

Table D-6. Pesticides detected in 1991 study (EPA Method 8080), mg/kg unless otherwise noted.

Locations	Dieldrin	p,p'-DDE	p,p'-DDT	Endo-sulfan I	Endo-sulfan II	Endo-sulfan sulfate	Hepta-chlor epoxide	Meth-oxy-chlor	BHC, beta isomer	BHC, delta isomer
<u>Background</u>										
BS-6-6	0.14									
BS7-6		0.006								
<u>Catch basin</u>										
CB-140J-13							0.04			
CB-190Q-10 1/2			0.098							
CB-350E-44								0.1		
CB-360G-20 1/2					0.01				0.006	
CB-410E-044	0.07		0.19							
CB-420D-024	0.02									
CB-590-Q1-12			0.02							
MH-110G-93					0.12			0.3		
<u>Open channel</u>										
OCS-150-1						0.43				
OCS-460-1-6				0.17						
OCS-660-1-6									0.006	
<u>Liquid (µg/L)</u>										
CB-390Y-84										0.09

Table D-7. Volatile organic compounds detected in 1991 study, values in mg/kg unless otherwise noted.

Locations	1,2-Di-chloro-ethene	Ace-tone	Chloro-form	Ethyl ben-zene	Freon 113	TCA	TCE	Tri-chloro-fluoro-methane	Tolu-ene	PCE	Total xylene iso-mers	cis-1,2-di-chloro ethene	Vinyl chlor-ide
Background													
BS-1-02-6									0.005				
BS-2-8				0.01					0.03		0.039		
BS-3-6									0.006				
BS-4-6									0.006				
BS-6-6									0.009		0.008		
Catch basin													
CB-120S-02-17										0.017			
CB-170B-18									0.012				
CB-280D-24										0.007			
CB-290F-38				0.016					0.027		0.064		
CB-290J-82									0.045				
CB-310C-24													0.011
CB-320F-17	0.03	0.067								0.007	0.005	0.03	280
CB-350E-44									0.03		0.012		
CB-360J-48									0.009		0.007		
CB-410E-044				0.03					0.1		0.089		
CB-430T-86.5				0.013	0.015		0.005	0.005	0.35	0.011	0.01		
CB-620J-01-34										0.27			
CB-620J-34										0.22			
Open channel													
OCS-190-2				0.008					0.038		0.026		
OCS-290-2		0.1											
OCS-460-1-6											0.01		
OCS-590-2			0.023										
OCS-660-1-6				0.006							0.024		
OCS-670-1-8									0.016		0.008		
OCS-690-2B-10											0.016		
OCS-690-3-8											0.021		
Liquid (µg/L)													
CB-510D-20		0.11							0.036				
CB-520F-76			1.3		0.6		0.7			4.9		0.9	
CB-943			1.5			32		1.5					
MH-340A-71			5.7										
CB-290M-26		26									2.1		
CB-390Y-84		13											
CB-220A-33									67				