Is The University of California Polluting Strawberry Creek? A Water Quality Analysis of Selected Drains Flowing into Strawberry Creek

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Introduction

Strawberry Creek adds a distinct natural flavor to the academic setting of the lower Berkeley campus. The Creek meanders from the east end of campus following a man-made channel toward the west, where it disappears beneath Oxford Street.

The quality of the water in Strawberry Creek has been the focus of many previous investigations that are relevant to this study. Frazier(1983) studied dissolved oxygen and reported values for the concentrations of cadmium, lead and mercury. Carlson (1971) also focused his efforts on determining the concentrations of hexavalent chromium, cadmium, mercury and lead in the Creek. Phillips (1986) noted that some abnormally high pH values (above 8.0) have been detected on various occasions in the Creek, and that the dissolved oxygen content generally complies with the Regional Water Quality Control Board's (RWQCB) suggested specifications. In 1987 the U.C. Berkeley Office of Environmental Health and Safety investigated heavy metal concentrations flowing into the creek from various drains (EH&S, 1988).

This report presents the results of a water quality assessment program which seeks to duplicate the EH&S (1988) summer investigation. The study will attempt to determine if the concentrations of contaminants change in response to the increased campus activity in the fall when the University population is larger than in the summer session.

Background

Strawberry Creek flows onto campus at two locations (Figure 1). The south fork, which originates in Strawberry Canyon, flows from an underground culvert behind the Women's Faculty Club and winds its way west through campus. The north fork drains the residential area immediately northeast of the lower campus, emerging from underground culverts behind the University House. The two forks join below the Life Science Building Annex (Figure 1). The creek flows from campus in an underground culvert which begins just south of the west entrance crescent on Oxford Street.

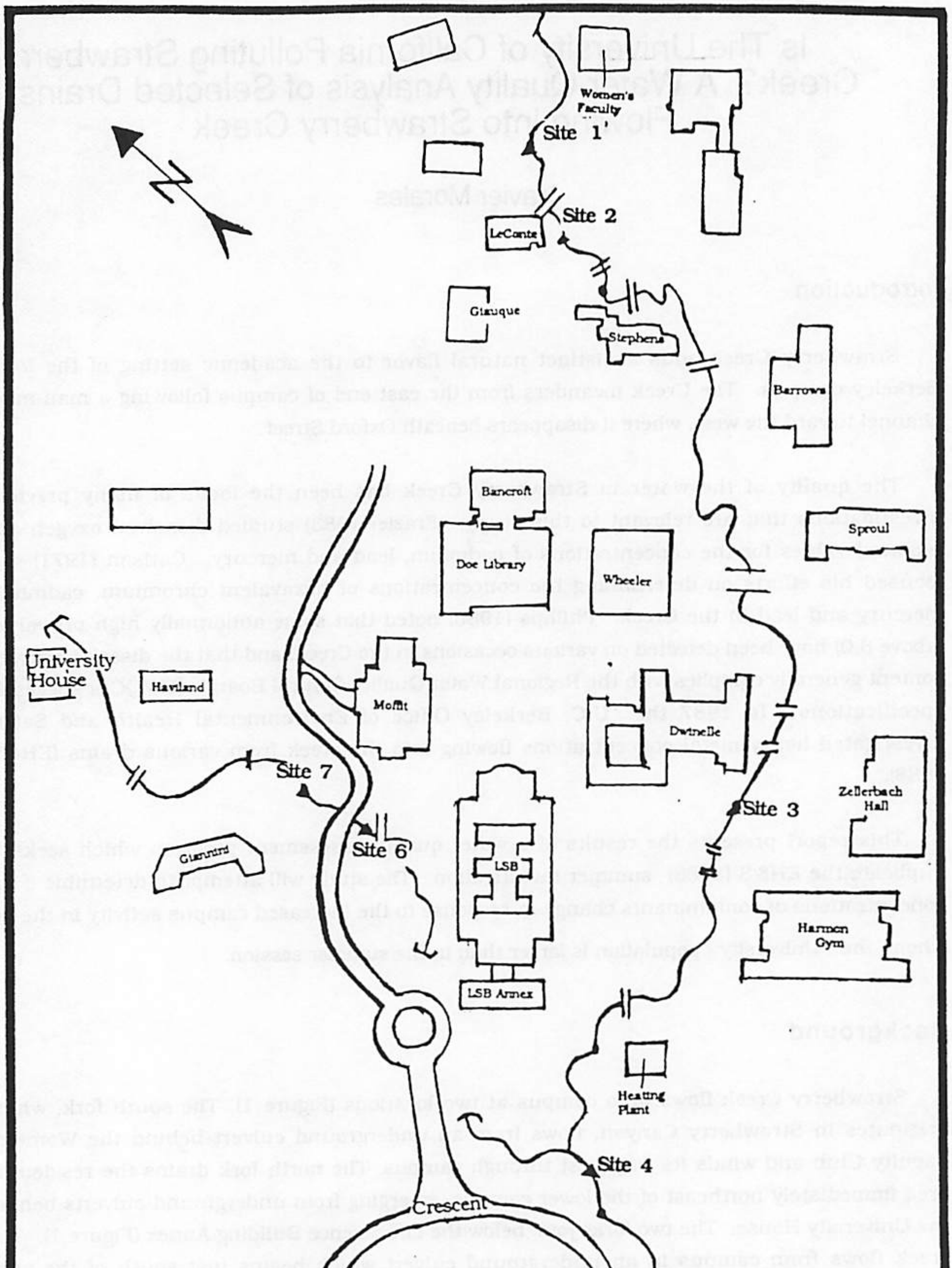

Figure 1: Strawberry Creek, Sampling Sites

Over 100 drains, many of which are inactive or partially active, open into Strawberry Creek from various campus buildings and planted areas (Charbonneau, pers. comm., Oct. 1987). Many of these drains originate as storm, catchbasin and roof drains; however, some of the drains begin in laboratories where water is used as a cooling agent. Direct laboratory discharge is a possibility, as many drain sources have not been identified (Phillips, 1986).

The lack of faunal diversity in Strawberry Creek has been attributed to periodic temperature extremes and abnormally high chemical concentrations in the discharge water from some of the drains (Phillips, 1986). The following heavy metals have been found in varying concentrations: cadmium, lead, mercury, copper, sodium, silicon, zinc, barium, calcium, iron, magnesium and strontium (EH&S, 1988). Infrequently, the Creek has exhibited a greenish tint, sometimes a milky white color and many times a frothy texture in areas of high turbulence. These occasional abnormalities have not been explained.

Methodology

This study duplicates the methods used in the EH&S (1988) study to ensure comparability of test results between the two studies. The drain-monitoring phase of the EH&S study tested seven sites. Because of changing drain conditions, this report only monitored six locations. Site 5, the Mulford Hall and adjacent grounds drain, was not sampled because of its low discharge rate.

The sampling protocol and laboratory analysis were identical to the EH&S (1988) study in order to decrease the possibility of sampling and testing error. The six locations sampled were chosen for analysis on the basis of continuous flow and their potential for polluted effluent (Charbonneau, pers. comm., Oct. 1987). The sample locations are shown on Figure 1 and described in Table 1.

Site 1:	12" reinforced concrete pipe originating in the Giauque low temperature laboratory
Site 2:	8" clay pipe from LeConte Hall
Site 3:	30" reinforced concrete pipe beginning in Zellerbach hall
Site 4:	10" clay pipe draining the steam plant and Edwards field
Site 5:	Mulford drain (not sampled due to low effluent discharge)
Site 6:	12" PVC pipe originating at Moffit and Doe Libraries and adjacent storm drains
Site 7:	27" reinforced concrete pipe, the cross-campus culvert

Table 1: Sample locations

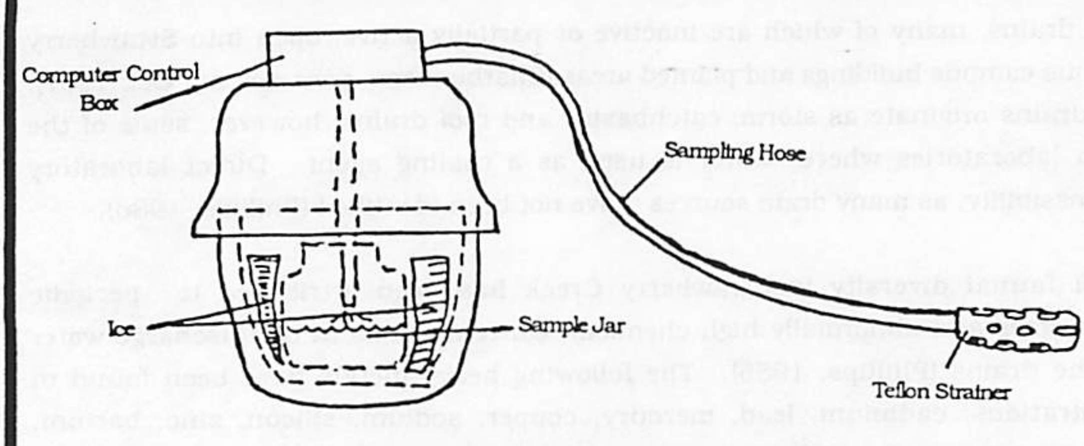

Figure 2: Isco Model 2100 Sampler with accessories

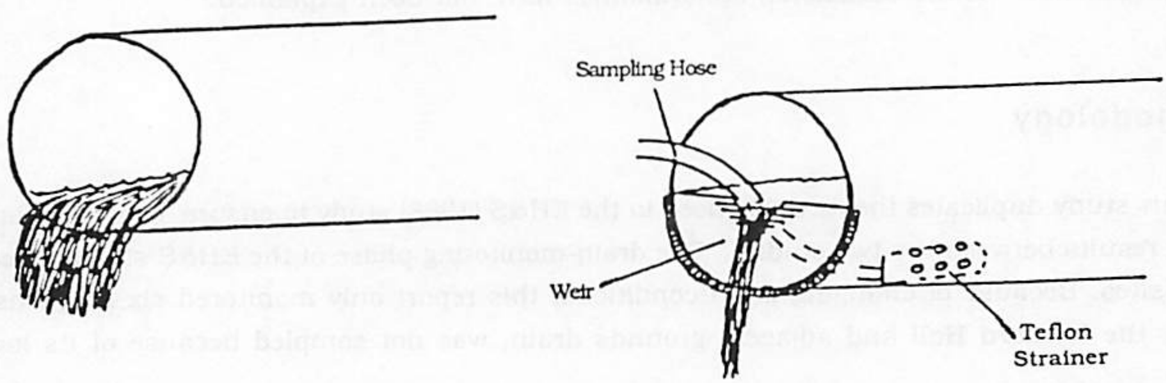

Figure 3A: Pipe without the weir -vs- Pipe with weir

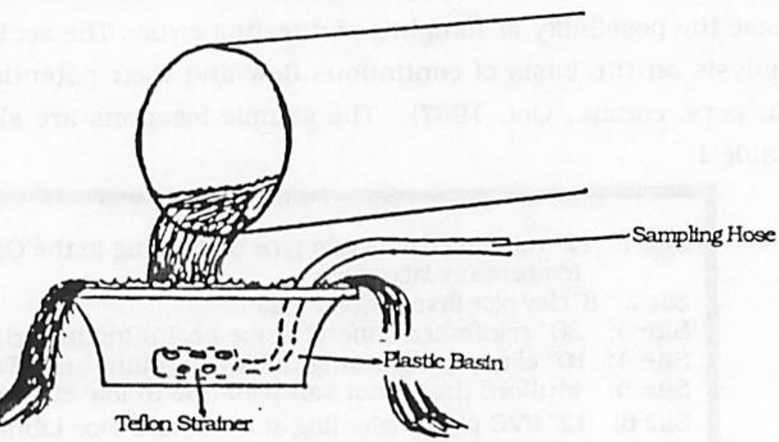

Figure 3B: Sampling Equipment at a Large Diameter Pipe

At each location an Isco model 2100 computerized sampler was used to take 24-hour composite samples. The sampler was programmed to draw between 50ml and 100ml of effluent every 1/2 hour into a glass sample jar. The sample was kept cold throughout the sampling period by placing ice packs alongside the jar in the sample compartment (Figure 2). Before sampling at each site, the sampling hose and jar were flushed with the effluent to be sampled. This reduced the possibility of cross-site contamination.

The discharge water was sampled at the mouth of the drainpipes. Expandable weirs were used where the effluent discharge level was too low to permit the complete submergence of the teflon strainer attached to the end of the sampling hose (Figure 3A). This wasn't possible at Sites 3 and 7 because the diameter of the pipes was too wide for the weirs. At these two locations a plastic basin was placed under the drain to serve as a pool in which the teflon strainer could be submerged (Figure 3B).

At the end of the 24-hour period, clean plastic sample jars, which were supplied by the analytical laboratory, were filled from the composite sample jar. Temperature, pH readings, weather and a visual description of the sample were also recorded. The samples were delivered on ice to the laboratory within 4 hours of sampling. No preservative was used as 4 hours is considered a reasonable period in which no degradation should occur (Larson, pers. comm., Oct. 1987). Records indicating the time sampled, sampling personnel and analyses to be performed (Chain-of-Custody Records) were completed when the samples were delivered to the laboratory. Six samples were submitted to Brown and Caldwell Analytical Laboratories in Emeryville, California.

All samples were designated for three types of analyses. The Environmental Protection Agency (EPA) has standardized test methods used by analytical laboratories. The tests requested for the water samples, are listed in Table 2.

- o Toxic Metal Scan (includes arsenic (As), cadmium (Cd), hexavalent chromium (Cr. hex), copper (Cu), lead (Pb) mercury (Hg), nickel (Ni), silver (Ag), Zinc (Zn), Iron (Fe), Manganese (Mn).
- o Total Organic Content
- o Chemical Oxygen Demand

Table 2: Laboratory analysis

The lowest concentration the laboratory is requested to analyze is called the detection limit (D.L.). The laboratory will report only the values that exceed the detection limits. The D.L.'s requested for the various compounds in the water samples were suggested by

Charbonneau, (pers. comm., Oct, 1987). His suggested D.L.'s were based on experience acquired in the EH&S study (1988). Table 3 lists the D.L.'s for the various compounds in question.

C.O.D.	1.0mg/L	T.O.C.	.001 mg/L
Cr Hex.	.01	As	.002
Cd	.0001	Cu	.001
Pb	.001	Hg	.0001
Ni	.05	Ag	.0001
Fe	.03	Mn	.01

Table 3: Detection Limits

Data

The data were collected over a 14-day period beginning 19 November 1987 and ending 3 December 1987. During this period there were six days of rain. Sites that were sampled in the rain included 2, 3 and 4 .

The data collected are shown in Table 4. The results of the EH&S study (1988) are listed alongside the present data for comparison. The two projects are listed by date.

COD and TOC were detected at all sites. For COD, Site 3 was the highest with 63mg/L. The lowest was at Site 6 where <1mg/L was found. TOC ranged from 26mg/L at Site 3 to 2.2mg/L at Site 1. Once again Site 3 reported the highest value.

Arsenic, nickel and silver were not detected at any of the Sites. Manganese was found only at Site 3, at a concentration of .02mg/L. Mercury was detected at Sites 1 and 2, at concentrations of .003mg/L and .002mg/L respectively. Cadmium was detected at Sites, 3, 4 and 6. Site 3 had the highest concentration at .008mg/L. Iron was found at Sites 1, 3, 6 and 7. Sites 6 and 7 had the highest concentrations with .23mg/L. Zinc was found at Sites 3, 4, 6 and 7. The highest level was detected at Site 3, 12mg/L.

Copper and lead were detected at all of the sites. For copper, the highest concentration was found at Site 3, .024mg/L; the lowest at Site 4, .0069mg/L. Lead concentrations ranged from .009mg/L at Site 3 to .002mg/L at Site 2.

Generally, Site 3 had the highest concentrations of the various compounds being tested.

Parameter	Site 1		Site 2		Site 3		Site 4		Site 6		Site 7	
COD	<DL[a]	15.[b]	<DL	29	<DL	63	<DL	31	11	<DL	<DL	10
TOC	1	2.2	1	4.3	4	2.6	6	3.8	3	3.8	4	3.8
Cr Hex.	NT[c]	<DL[d]	NT	<DL	NT	.03	NT	<DL	NT	<DL	NT	<DL
Arsenic	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL
Cadmium	<DL	<DL	<DL	<DL	<DL	.008	<DL	.001	<DL	.0002	<DL	<DL
Copper	<DL	.019	<DL	.014	<DL	.024	<DL	.0069	<DL	.02	<DL	.02
Iron	<DL	.09	<DL	<DL	.04	,13	<DL	,<DL	<DL	23	.05	.23
Lead	<DL	.003	<DL	.002	<DL	.009	<DL	.003	<DL	.003	<DL	.003
Manganese	<DL	<DL	<DL	<DL	.01	.02	<DL	<DL	<DL	<DL	<DL	<DL
Mercury	NT	.0003	NT	.0002	NT	<DL	NT	<DL	NT	<DL	NT	<DL
Nickel	<DL	<DL	<DL	<DL	<DL	.<DL	<DL	<DL	<DL	<DL	<DL	<DL
Silver	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL
Zinc	<DL	<DL	<DL	<DL	.03	.12	.04	.02	<DL	.11	<DL	.11

a, EH&S 1988;
b, present study;
c, not tested;
d, less than detection limit

Table 4: Metal concentrations in Strawberry Creek

When sampling at Site 3, a foul smell was encountered. Later soil tests revealed that a high concentration of organic matter was present in the soil below the drain. This may point to a possible sewage leak into the storm drain system. The high values of TOC and COD detected at Site 3 substantiate this assumption. Sewage, industrial or domestic, may contain compounds which are not found in ordinary storm drain effluent. This may be the reason that Site 3 had the highest concentration of the various compounds in question.

The water quality of the drains flowing into Strawberry Creek is not consistent. The rate of effluent discharge and concentrations of the various metals change with weather, day, semester and year. The concentrations of the metals from one site cannot be added to other sites to calculate a cumulative discharge concentration because all of the test locations were sampled on different days.

Discussion

This study did not examine the background concentrations of the trace metals in Strawberry Creek: however, between 1980 and 1984 the RWQCB compiled data from 72 stations on 28 rivers (EH&S, 1988). These data were used to determine the mean background concentrations of trace metals in the rivers (Table 5). The present study will assume these background concentrations are valid for Strawberry Creek.

Parameter	Mean
Total Cadmium	.0009
Total Chromium	.001
Total Copper	.0014
Total Lead	.001
Total Nickel	.0011
Total Zinc	.0035

Table 5: Natural Background Levels of trace Metals in California Rivers (mg/L)
Source: After EH&s, 1988, from Harte, 1983.

Hexavalent chromium and cadmium were detected in higher concentrations than the background levels at Site 3. These metals are used as biocides, added to cooling waters to prevent bacterial growth on the pipe walls.

Copper concentrations were higher than the mean background levels at Sites 1, 3, 6 and 7. The proliferation of copper plumbing may be the cause for these elevated levels. Zinc was also detected above backgound at Sites 3, 4, 6, and 7.

The lead concentrations were higher than background at all sampling locations. Lead plumbing may be oxidizing and releasing elevated concentrations of lead compounds into the Creek. Also, the samples were taken during or immediately after rains. The road wash may have delivered lead compounds from motor vehicles into the storm drains.

Comparison between Fall and Summer Data

Table 4 lists data for both the EH&S (summer) and the present (fall) studies. The comparability between the two investigations is low because of the different detection limits used in the laboratory analysis. For some compounds the detection limits differ on the order of three magnitudes.

The TOC and the COD levels are generally higher in the fall study than in the summer. This may have been caused by the wet weather during the fall sampling period. Previous investigations have shown elevated concentrations of TOC and COD and lower levels of dissolved oxygen in samples taken during wet weather (Frazier, 1983).

At Site 3, iron and zinc are triple and manganese is double the concentrations detected in the summer study. At Site 7, iron is four times greater in the fall than the summer. In the fall study, zinc at Site 4 is half of the value detected in the summer study.

The point that must be stressed is the variability of test results with respect to time sampled. The results are not accurate representations of the quantity of each metal discharged into the Creek in one day from the campus. All the samples were gathered over a period of two weeks in the fall study.

Is UC Berkeley Polluting Strawberry Creek?

The Non-Degradation Policy Act passed in 1969 by the State of California provides that bodies of water shall not be degraded if they are potential drinking water sources. Most rivers and creeks are considered to be drinking water sources. The concentrations the RWQCB follow are prescribed by the EPA. There are seven lists of standards that are applicable, cadmium, at Sites 3 and 6, is the only compound to exceed the regulations.

In February 1988, the first list containing hazardous and toxic chemicals which fall under Proposition 65 was published. At present this is only a warning list; however, after 12 months it will be illegal to discharge any of these compounds. Currently, the law requires anyone releasing any amount of these compounds into the environment to issue warnings to those who may be affected by the discharge.

Compounds detected in this study which fall under this law include: Hexavalent chromium, and lead. Arsenic is also on the State's list; however, it was not detected at any of the sampled locations.

Recommendations

The sewage leak at Site 3 should be stopped as soon as possible because this site had elevated levels of chromium. After the leak has been corrected the issue of Non-Degradation may be addressed.

The Creek should be sampled above and below the campus to determine if, and to what extent, the water quality is degraded by the campus. If degradation is occurring, then a comprehensive monitoring program of the drains flowing into the Creek should be conducted.

The monitoring program should simultaneously test all of the drains over a period of at least 8-10 months. Trends in elevated concentrations of the various compounds which threaten the health of the Creek should be monitored. Sources of contamination need to be identified and stopped.

If, during the course of monitoring the Creek, compounds on the Governor's Warning list for Proposition 65 are found to be flowing into the Creek from campus sources, then warning signs should be posted alongside the Creek advising which compounds the Creek contains and their respective health risks. If the compounds detected are on the illegal discharge list, the origins of these compounds must be found and stopped. For example, on the basis of this study, warning signs stating that hexavalent chromium and lead are being discharged into the Creek would need to be posted. The warning should include that Cr. Hex. is a known carcinogen and lead is a reproductive toxin.

The State will update its list with new compounds every few months. It would be beneficial for U.C. Berkeley to begin this monitoring program before there is any violation of the law.

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