Chapter 4

WATER QUALITY OF CREEKS AND STORM DRAINS

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Introduction

The East Bay creeks have been described as "natural virtues . . . furrowing their way through the canyons and pressing on toward the bay . . . " (Shipounoff, 1979, p. 11). In the East Bay there are several creeks that run through the cities of Albany, Berkeley, Emeryville, and Oakland. A list of Berkeley's creeks includes Cerrito Creek, Marin Creek, Codornices Creek, Schoolhouse Creek, Lincoln Creek, Strawberry Creek, Potter Creek, and several others (FIGURE 1).

To some of the residents of the East Bay, these waterways have brought much delight with their peaceful, identifiable sounds of rushing waters and with the feeling of being close to nature. However, as the years passed with the development of land areas and population growth in the East Bay, odor and health hazards became a problem. Creeks also have the potential to be polluted so that their natural beauty and forms of life within are destroyed. These waterways have caused much public concern over their water quality and their safety.

The purpose of this report is to study the water quality of the creeks and storm drains that flow into the East Bay shoreline and to investigate the major pollutants and the possible sources of contaminants. Water quality is an important aspect that affects recreational activities along the shore and should be considered in the East Bay Shoreline Park proposal. The focus will be directed to Berkeley's creeks, mainly Strawberry Creek which begins in the Berkeley hills and drains out at the foot of University Avenue. The report includes an evaluation of results of past bacterial contamination tests performed by public agencies and also a more recent bacterial contamination test performed by a few of the Environmental Sciences Seminar students (Aaron Jeung, Arthur Molseed, and Bessie Lee).

Water Quality Problems

Berkeley's creeks are not only a part of the city's natural drainage system, but they are also important as pathways for the removal of storm and spring water

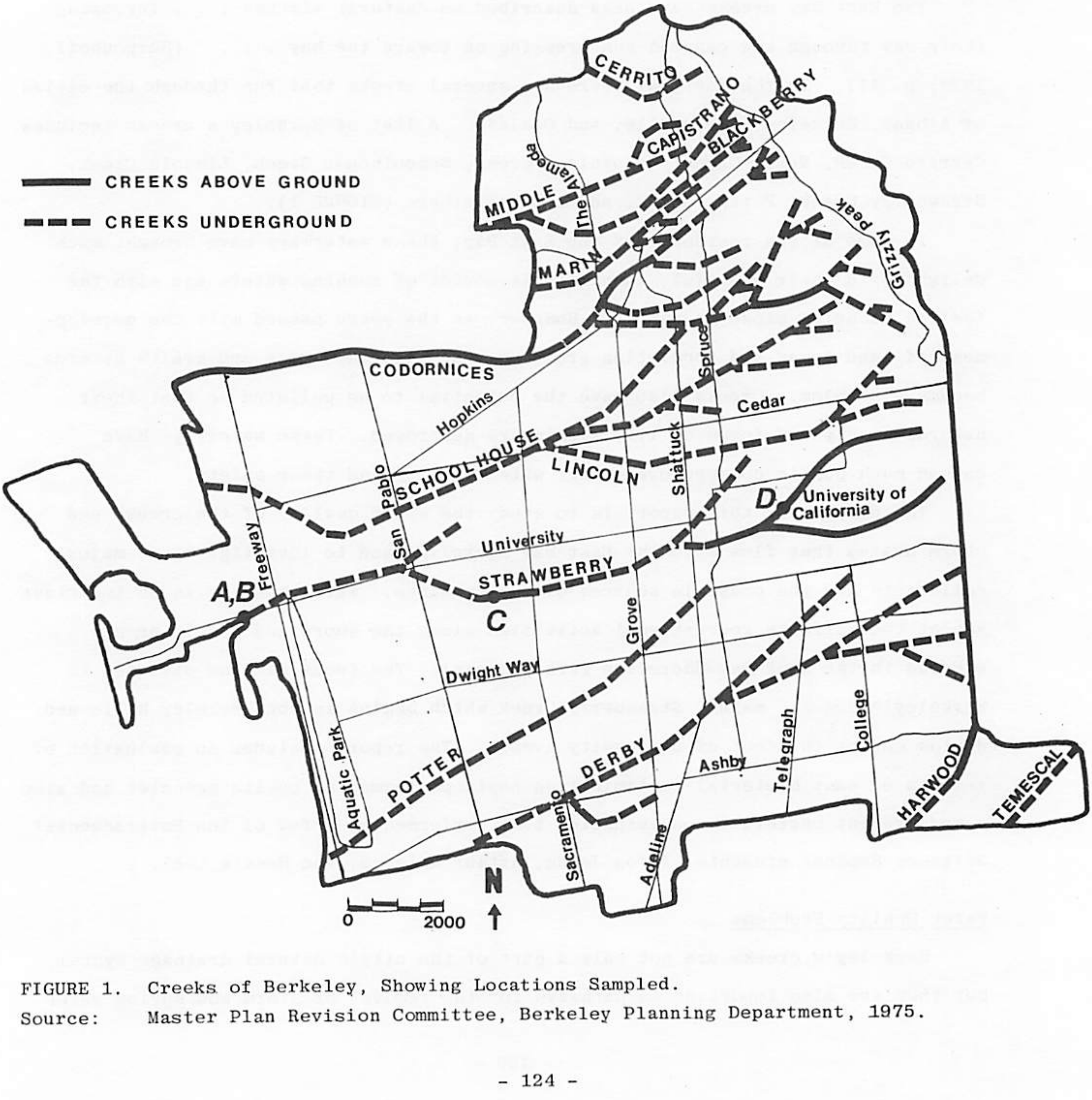

FIGURE 1. Creeks of Berkeley, Showing Locations Sampled.
Source: Master Plan Revision Committee, Berkeley Planning Department, 1975.

originating in the Berkeley hills area. Many of the city's storm water catch basins run into the creeks, which in turn run directly into the bay.

There is no doubt that the water in the creeks is contaminated to some degree. Contaminants first enter the picture as they are picked up by rain water as it passes through the atmosphere. These pollutants include oxides of sulfur and nitrogen and particulate matter. The precipitation then picks up additional material as it falls on streets, homes, industries, fields, lawns, and flows to a storm drain or nearby creek. These sources of pollution are called "non-point sources."

The main contaminants from non-point sources originate from surface runoff. The San Francisco Bay Area Environmental Management Plan (ABAG, 1978) identifies the surface runoff problems as:

1. Sedimentation and erosion
2. Bacterial contamination
3. Heavy metals, pesticides, and other toxic chemicals
4. Oil and grease
5. Litter and debris
6. Nutrients and algae growth
7. Organic wastes and low dissolved oxygen

After the identification of these major problems, it is then possible to recommend control measures to prevent these pollutants from occurring, as will be discussed later in this report.

Those sources of pollution which originate at specific locations are called "point sources." Examples of these include municipal wastes from sanitary sewers or inadequately treated sewage and industrial outfall. Point sources are easily recognizable sources of water pollution that pose a great threat to water quality. Through public willingness to allocate funds to protect water quality from point source pollution, this form of pollution has been greatly eliminated.

Pollutants that affect the East Bay shoreline include sediments, heavy metals, organic matter, algal nutrients, and bacteria. Sediments from erosion are a problem in that they tend to interfere with the drainage system and flood control systems. Heavy metals that originate from motor vehicles include lead, zinc, and copper. The source of organic matter and algal nutrients are believed to be from litter and vegetation. Because bacteria originating from animal feces and sanitary sewers are associated with health hazards and contamination of shellfish (see Mirtha Ninayahuar's paper), they are an important concern.

Bacterial examinations are performed to detect contamination of water by sewage and thus eliminate the possibility that disease may be transmitted by its use. Contamination is determined by the total number of bacteria present and the presence or absence of common organisms of intestinal or feces origin. Among the most common organisms of the intestine or feces are the bacteria of the coliform group. Coliforms are constantly present in both healthy and diseased human intestines in large numbers. Thus, it is an advantage to use them as indicator organisms in testing for contamination. Another index organism for human and animal feces is fecal streptococcus. These bacteria are easily isolated from water and are frequently used as indices of fecal pollution.

Past Studies of Water Quality

In 1976, 1977, and 1978 sampling surveys of the Berkeley Marina and Strawberry Creek were conducted by the City of Berkeley Environmental Health Section (Gerber, 1978). The samples in the 1978 survey were collected after a rainy period occurring the previous day and weekend. The other surveys in 1976 and 1977 were conducted during periods of little or no surface runoff under dry or normal conditions.

Among the locations sampled were Potter Creek storm sewer outlet, the Strawberry Creek storm sewer outlet, and a few points on Strawberry Creek. Results showed high counts of coliform near these localities. The data indicated that the counts were high near the storm sewer outlets and that the counts decreased for the samples the farther away they were taken from the outlets. In all the years tested, Strawberry Creek samples showed extremely high coliform counts. The creek samples, #25 and #26, had Most Probable Numbers (MPN - an estimate of the number of index organisms per 100 ml) or at least 2,300. Such a high count is unsuitable for recreational activities.

Most of the samples taken on the date April 18, 1978 following a rainy period had higher counts of coliforms than samples collected in previous years at the same location. A comparison of these surveys under the different weather conditions shows that most coliform densities were greater during the increased surface runoff conditions. In 1978, seven of the twenty-five locations tested had fecal coliforms above the criterion of 200 fecal coliforms per 100 ml recommended for recreational waters (EPA, 1976). The previous sampling dates in 1977, December 1976, and July 1976 had five, three, and two locations, respectively, exceeding the criterion. The recreational water standard was always exceeded at the two sampling locations on Strawberry Creek.

From the results of this survey, we can see that water quality should be of concern in considering the use of the shoreline areas near storm sewer outlets and the use of creeks. The possibility of health hazards occurring can be eliminated or minimized with proper attention towards water quality and safety.

Other studies of Strawberry Creek were conducted by the University of California in 1970, 1971, and 1972 (Herrera, 1970-1972). In these studies, samples were taken from both the north and south forks of the creek that runs through the campus. At various times the results showed coliform and fecal streptococci counts above 1,000. A 1977 study of the coliform count in Strawberry Creek under various weather conditions yielded the results given in TABLE 2. These samples were also taken at the University campus.

Methodology

The methods for routine detection and enumeration of coliforms and other indicator organisms are described by the American Public Health Association and affiliated societies (American Public Health Association, 1980). The technique used for our enumeration test is called the Most Probable Number (MPN) Method.

To test for coliforms, special media which enrich and select for certain bacteria are used. There are three parts to the standard coliform test, the presumptive test, the confirmed test and the completed test. The presumptive test consists of adding a known volume of the water sample into lauryl tryptose broth tubes and incubating for 24 ± 2 hours at $35^{o}C \pm 0.5^{o}C$. Presence of gas confirms the presumptive tests. If there is any doubt that the organisms present are coliforms, a completed test may be performed, and the organism examined microscopically to confirm. This test involves the use of eosin methylene blue agar. The normal extent of the coliform test consists of just the presumptive and confirmatory tests.

In order to estimate the number of coliforms in a sample, dilutions are made and inoculated into a series of tubes of media. The Most Probable Number can be determined by the distribution of positive tubes and determined by the use of tables in Standard Methods for the Examination of Water and Wastewater (American Public Health Association, 1980).

To determine fecal coliforms, a sample of all presumptive lactose tubes that showed a positive reaction are inoculated into *Escherichia coli* broth and placed in a waterbath for 24 ± 2 hours at $44.5^{o}C \pm 0.2^{o}C$. Production of gas in this medium

	Location	Total Colif. 4/18/78	Fecal Colif. 4/18/78	Total Colif. 8/25/77	Fecal Colif. 8/25/78	Total Colif. 12/14/76	Fecal Colif. 12/14/76	Total Colif. 7/1/76	Fecal Colif. 7/1/76
1	300 feet west from Potter St. storm sewer	24,000	500	<4.5	<4.5	230	<4.5	230	<4.5
2	400 feet west from Potter St.	6,200	620	<4.5	<4.5	230	<4.5	230	23
3	1500 feet north of Potter St. sewer	950	45	130	23	-	-	-	-
4	Opposite Aquatic Park near tidegate	60	<45	230	13	<4.5	<4.5	<4.5	<4.5
5	In a small bay, 100 of point 1,000 feet south of University Avenue storm sewer	60	<45	23	6	620	620	6	<4.5
6	600 feet west of University Ave. storm sewer outlet in small bay	6,200	1,300	1,300	500	500	60	62	6
7	800 feet west of University Ave. storm sewer outlet in small bay	620	<45	620	62	<4.5	<4.5	62	<4.5
8	1500 feet west of University Ave. storm sewer outlet in small bay	60	<45	230	230	230	<4.5	6	6
9	1800 feet west of University Ave. storm sewer outlet in small bay	<45	<45	23	23	60	<4.5	<4.5	<4.5
10	2400 feet west of University Ave. storm sewer outlet, 200 feet from proposed beach area	60	<45	<4.5	<4.5	<4.5	<4.5	<4.5	<4.5
11	100 feet out from small point 2500 feet west of University Ave. storm sewer outlet	620	60	<4.5	<4.5	230	<4.5	<4.5	<4.5
12	400 feet out from small point 2600 feet west of University Ave. storm sewer outlet	230	<45	6	6	230	<4.5	6	<4.5
13	500 feet out from small point 2700 feet west of University Ave. storm sewer outlet	230	60	23	23	60	<4.5	6	<4.5
14	100 feet east of small point (H's Lordships)	60	60	13	6	<4.5	<4.5	<4.5	<4.5
15	100 feet south of pier	620	<45	230	230	<4.5	<4.5	6	<4.5
16	South edge of breakwater	620	620	23	23	60	<4.5	6	<4.5

(continued)

	Location	Total Colif. 4/18/78	Fecal Colif. 4/18/78	Total Colif. 8/25/77	Fecal Colif. 8/25/77	Total Colif. 12/14/76	Fecal Colif. 12/14/76	Total Colif. 7/1/76	Fecal Colif. 7/1/76
17	200 feet north of Dike Point	620	620	<4.5	<4.5	<4.5	<4.5	12	<4.5
18	East of dump area (lagoon)	620	60	6	<4.5	-	-	-	-
19	South end of lagoon	620	60	-	-	-	-	-	-
20	East side of lagoon	230	<45	-	-	-	-	-	-
21	Center of lagoon	230	<45	-	-	-	-	-	-
22	Middle of Marina	230	<45	23	<4.5	230	<4.5	230	23
23	South edge of Marina	230	<45	620	6	60	<4.5	23	6
24	Opposite of dump entrance	-	-	50	12	230	60	62	23
25	Strawberry Creek near Strawberry Creek Lodge	23,000	6,200	≥24,000	7,000	23,000	500	70,000	6,200
26	Strawberry Creek near Oxford Street	62,000	2,300	≥24,000	7,000	23,000	6,200	13,000	2,300

TABLE 1. Marina and Strawberry Creek Water Quality Survey.
Source: Gerber, 1978.

indicates the presence of coliforms of fecal origin. An MPN based upon positive <u>Escherichia coli</u> broth tubes represents the fecal coliform number.

The enumeration of fecal streptococci in a sample involves inoculating dilutions of test samples into azide dextrose broth. These tubes are incubated for 24 ± hours at 35°C ± 0.5°C. Tubes that show no definite turbidity are reincubated and read again at the end of 48 ± 3 hours. Growth in the tube as indicated by turbidity, is considered a positive presumptive test. The next step calls for streaking a portion of growth from each positive azide dextrose broth tube onto a petri dish containing Pfizer selective enterococcus agar. The inverted dish is then incubated at 24 ± 2 hours at 35°C ± 0.5°C. Brownish-black colonies with brown halos will indicate the presence of fecal streptococci. An MPN based upon positive plates represents the fecal streptococci number.

<u>Sampling Survey of Strawberry Creek</u>

The water samples for the bacteriological tests were taken on the morning of April 19, 1982, a warm and sunny day. The last rainfall occurred two days prior to the sampling date.

MPN/100 ml			
	TOTAL COLIFORMS		
LOCATION	8/24/77 warm and sunny	9/12/77 warm and overcast	9/19/77 two days after rainfall
South fork of Strawberry Creek	540	920	540
Near the bridge in front of Giannini Hall	130	920	350

TABLE 2. 1977 Study of Strawberry Creek.

Source: University of California, Berkeley, Office of Environmental Health and Safety.

Many thanks are given to David Gan of the California Department of Health Services for his guidance through the performance of the test and to the Department for allowing us to use the laboratory facilities and supplying the necessary equipment and materials.

The locations selected for our sampling survey were as follows (FIGURE 1):

SAMPLE A	Strawberry Creek storm sewer outlet
SAMPLE B	Strawberry Creek storm sewer outlet
SAMPLE C	Residential/Industrial Near Allston Way and West Street
SAMPLE D	University of California, Berkeley campus Near bridge by Giannini Hall

The results of this survey are shown on TABLE 3. The last column of the table indicates the Fecal Coliform/Fecal Streptococci ratio calculated from the results. This ratio gives an indication of the origin of the fecal material. When the ratio is greater than or equal to 4, it may be taken as evidence that pollution originated from human fecal contamination (American Public Health Association, 1980). Since our ratios were less than 1, the water samples probably contained bacteria from the wastes of animals.

Discussion of Water Quality Studies

The U.S. Environmental Protection Agency's criterion for water quality for recreational waters is as follows:

Based on a minimum of five samples taken over a 30-day period, the fecal coliform bacteria should not exceed a log mean of 200 per 100 ml, nor should more than 10 percent of the total samples taken during any 30-day period exceed 400 per 100 ml. (EPA, 1976)

The amount of surface runoff affects the bacterial density in the water. The surface runoff from precipitation that occurs after a long dry period would tend to contain more contaminants than the surface runoff that follows several days of rainfall.

MPN/100 ml				
SAMPLE	TOTAL COLIFORM	FECAL COLIFORM	FECAL STREPTOCOCCI	FECAL COLIFORM/ FECAL STREPTOCOCCI RATIO
A	16,000	1,300	5,400	1
B	9,200	1,100	3,500	1
C	3,500	1,100	3,500	1
D	3,500	1,300	5,400	1

TABLE 3. 1982 Study of Strawberry Creek.

The results of our sampling survey of Strawberry Creek indicate that fecal coliform bacteria counts greatly exceed the limit of 200 per 100 ml. The source of the bacterial pollution is probably due to warm-blooded animals other than man.

The analysis of the past water quality studies and our own bacteriological study indicates that the water in the creeks and storm drains has been contaminated with fecal pollution. The studies also show that the different coliform counts were not attributable to the weather conditions or increased surface runoff. These conclusions indicate strongly the need to consider water quality safety factors in the proposal of recreational uses of the creeks and the East Bay shoreline.

Pollution Prevention Recommendations

Because of the high costs of treatment and the lack of facilities to handle the additional load during runoff surges, water from the creeks and storm drains go untreated directly into the bay.

A method to reduce bacterial contamination of the creeks and the shoreline involves the proper disposal of domestic animal wastes. Another possibility is to construct a sand filter at the storm sewer outfall. The sand filter would be similar to the filter at sewage treatment plants with a top layer of activated carbon. The layers absorb bacteria and also absorb pesticides and other contaminants. The difficulties involved with the sand filter are its cost and the frequent need of backwashing (Singh, personal communication, 1982).

In addition to bacterial contamination as a pollutant, there are other pollutants not discussed in this paper that may also be a major concern. An effective solution to reduce the amount of pollutants going out to the bay is through public awareness. Controlling litter through anti-litter programs and educating the public on the water quality impacts of litter would reduce the amount of debris and oil, thereby reducing BOD, phosphates, suspended solids, and heavy metals introduced through the stormwater system.

An example of a much-needed awareness program is one to educate the public about the benefits of oil recycling, the ease of recycling, and the consequences of dumping oil into the sewers or storm drains. Among the benefits of oil recycling are reducing the incidence of odors associated with decomposing debris, enhancing water-oriented recreational potential where dumping of debris and oil impairs the use, and improving visual characteristics (ABAG, 1978).

In the past, Berkeley's Department of Public Works handled the issue of public awareness by distributing through the mail a notice to residents concerning the water quality and safety of the water which flows in the creeks (Jackson, pers. comm., 1982). It stressed the possibility of harmful organisms and toxic chemicals in the water and explained how everyone can help keep the creeks clean by not disposing of any waste directly into the creeks or through the storm drain system.

Another measure is to enforce the prohibition against dumping or discharging pollutants into the storm drains and creeks. The Berkeley Municipal Code states that it is unlawful for "any person to place, throw or deposit or cause or permit to be placed, thrown or deposited in any public sewer, drain, catch basin, privy, vault or cesspool or in any vessel or receptacle connected to any public sewer, any dead animal, fish, offal or garbage, hair, ashes, cinders, wastes, gasoline, distillate, lubricating oil, grease, . . . " (Berkeley Municipal Code, 1976, pp. 398-397).

Another measure to reduce the surface runoff pollutants includes the increased use and improvement of existing street sweeping. In the City of Berkeley, streets are usually cleaned daily in commercial areas and only by priority or request in residential areas due to the lack of manpower (Jackson, pers. comm., 1982). Exceptions are those areas which are highly populated with parked cars (e.g., streets near the University of California campus). Concentrating street sweeping prior to the rainy season, revising the street sweeping schedule to emphasize leaf pickups during fall and winter, and imposing parking restrictions to allow sweeper access to curb areas are approaches to reducing surface runoff.

Reducing pollution by cleaning the stormwater collection system is another measure. This involves a more frequent cleaning of the catch-basins, storm drains and open channels to remove all the material collected from contaminating runoff which should improve water quality and flood control. In the City of Berkeley, catch-basins are cleaned but once a year (Jackson, pers. comm., 1982).

By the education of the general public on the proper use and disposal of hazardous chemicals and regulating the use of certain chemicals (e.g., vector control chemicals and pesticides), health and safety risks should be reduce.

With the establishment of a water quality monitoring program, causes of specific problems can be identified and lead to reduction or elimination. This measure would insure proper operation of septic tanks and sewage pipes by identifying leaks and overflows.

These pollution prevention measures all involve some public participation and awareness and with these, the creeks and the bay would provide a safe and pleasing environment for us all.

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