STAFF REPORT

regarding

RUSSIAN RIVER BACTERIAL WATER QUALITY MONITORING IN THE VICINITY OF FITCH MOUNTAIN SONOMA COUNTY, CALIFORNIA April through September, 1995

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INTRODUCTION

Background

For over twenty years the Regional Water Quality Control Board has conducted bacterial water quality monitoring at summer recreational areas on the Russian River. During many years, these were joint efforts with the Sonoma County Health Department.

The summer recreational season typically begins during the Memorial Day weekend in late May of each year and ends at the conclusion of the Labor Day weekend in early September of each year. Summer impoundments are created with the installation of temporary dams at several locations along the Russian River, including Healdsburg Memorial Beach, located immediately downstream of Fitch Mountain.

A review of monitoring data collected from 1986 to 1994 at Healdsburg Memorial Beach (Theresa Wistrom, December 6, 1994[1]) revealed that exceedances of the Regional Water Board's numerical objective of 50 MPN fecal coliform/100 ml occurred consistently during the summer recreation season (Memorial Day through Labor Day) at several sampling locations in the Healdsburg Memorial Beach area. Of 122 sampling sets, 88 (72%) exceeded the objective. Results of an intensive sampling of the "kids' area" in August and September 1994 indicated exceedance of the objective in 9 of 9 (100%) sampling sets. The December 6, 1994 memorandum from which this summary was taken is included as Appendix A.

A study of fecal coliform levels in the Russian River in the vicinity of Fitch Mountain was conducted by Sarah Underwood, a Piner High School senior, from October 1994 through early May 1995[2]. Her report titled "Water Quality Analysis of the Russian River in the Fitch Mountain Region" is included as Appendix B. Weekly samples were collected from four Russian River sites and a Fitch Mountain drainage tributary to the Russian River and analyzed using the millipore membrane filter technique. Results of this study indicated that fecal coliform levels fluctuated from low to high colony numbers at all sites. In the early part of the study, fecal coliform levels did not increase in response to rainfall until over five inches of rainfall had fallen during four back to back storms. In the later part of the study fecal coliform levels did not seem to rise and fall in response to the rainfall pattern. There was no apparent relationship between fecal coliform and site location. An upstream reference site did not show significantly lower or higher bacteria levels in comparison to the three sites located along Fitch Mountain. The drainage ditch did show consistently higher bacteria levels than the Russian River sites, and was identified for further investigation.

These data raised questions regarding the source of high bacterial levels at Healdsburg Memorial Beach during the dry-weather months. Potential sources of bacteria include failing septic systems immediately upstream along Fitch Mountain, the very presence of many people in an impounded swimming area where the water turnover rate is low, or suspension of sediments containing bacteria by waders and swimmers.

Basin Plan and Bacteriological Water Quality Standards

The ***Water Quality Control Plan for the North Coast Region*** (Basin Plan)[3] describes beneficial uses and water quality objectives for waters of the North Coast Region. Beneficial uses of the Russian River include, municipal and domestic water supply, agricultural and industrial water supply, recreation, commercial and sport fishing, warm and cold freshwater habitat, wildlife habitat, and fish migration and spawning.

The Basin Plan includes water quality objectives for bacteria as follows:

> "The bacteriological quality of waters of the North Coast Region shall not be degraded beyond natural background levels. In no case shall coliform concentrations be degraded beyond natural background levels. In no case shall coliform concentrations in waters of the North Coast Region exceed the following:
>
> In waters designated for contact recreation (Rec-1), the median fecal coliform concentration based on a minimum of not less than five samples for any 30-day period shall not exceed 50/100 ml, nor shall more than ten percent of total samples during any 30-day period exceed 400/100 ml."

The U. S. Environmental Protection Agency developed new criteria in 1986[4], which recommended measurements of *E. coli*[1] and enterococci[2] rather than fecal coliform bacteria. The EPA developed these criteria based on EPA studies which indicated that enterococci have a better correlation with swimming associated gastrointestinal illness in both marine and fresh waters than fecal coliform, and that *E. coli*, a specific bacterial species included in the fecal coliform group, has a correlation with gastrointestinal illness in fresh waters equal to the enterococci.

The EPA recommendations for freshwater are *E. coli* not to exceed 126/100 ml or enterococci not to exceed 33/100 ml. These criteria are calculated as the geometric mean of a statistically sufficient number of samples, generally not less than five samples equally spaced over a 30-day period. The State of California Department of Health Services (DOHS), however, has not adopted the criteria for *E. coli* and enterococcus. Rather, the DOHS developed its own recommended standards for freshwater recreation areas that called for a log mean of not less than five samples over a 30-day period not to exceed a fecal coliform concentration of 200 per 100 ml., and not more than 10% of the total samples over a 30-day period to exceed 400 per 100 ml.

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[1] *E. Coli* is the predominant member of the fecal coliform group and is a natural inhabitant of the intestines of warm-blooded animals only.

[2] Enterococcus is a subgroup of fecal streptococci.

Study Area

Fitch Mountain is located immediately adjacent to the Russian River near the City of Healdsburg in Sonoma County, California (Figures 1 and 2). Healdsburg Memorial Beach is located immediately downstream of Fitch Mountain. Topography is variable with predominantly steep hillsides and some flat lowlands within the floodplain of the Russian River. Both forms of topography are of concern with regard to the potential for contributions of bacterial contamination to the Russian River.

Land use in the Fitch Mountain area is principally residential with a few commercial establishments (restaurant, clubhouse). Small lots are served by individual wastewater treatment and disposal systems, most of which are old and antiquated. Cesspools and seepage pits are common in this area. The Sonoma County Health Department has a building moratorium on the Fitch Mountain area because the combination of small lots on steep slopes with shallow soils is conducive to failing septic systems. The City of Healdsburg is served by the City's wastewater treatment plant located downstream of Healdsburg Memorial Beach

Other land uses in the area include Rio Lindo Academy, a private residential school housing approximately 500 people with agricultural land (apple orchards) and its own wastewater treatment and disposal ponds located adjacent to the Russian River. Upstream of the Fitch Mountain area land uses are primarily agricultural with a few urban areas (Cloverdale, Hopland, Ukiah).

Body-contact and non-body contact recreation are common in the summer in this area. Fishing is common year-round. Two summer dams encourage summertime recreation at Del Rio Woods (located along Fitch Mountain) and Healdsburg Memorial Beach (located immediately down stream of Fitch Mountain). Camp Rose is a private beach located on Fitch Mountain.

The City of Healdsburg and Russian River Mutual Water Company both have well fields for domestic water supply located along this section of the river.

Past Studies

The Fitch Mountain area of the Russian River has been the subject of past bacteriological studies and sanitary surveys.

The oldest survey of record was summarized in the "Report on Sanitary Survey of Sonoma County, California with Recommendations for Control of Epidemics" prepared by Charles H. Lee, Consulting Sanitary Engineer for the Sonoma County Board of Supervisors and the Sonoma County Health Department on February 1, 1944.[5] This report describes sources of communicable disease that were present in the Russian River watershed at that time. Sanitary standards have improved significantly since the time of that report. However, this survey provides interesting historical background.

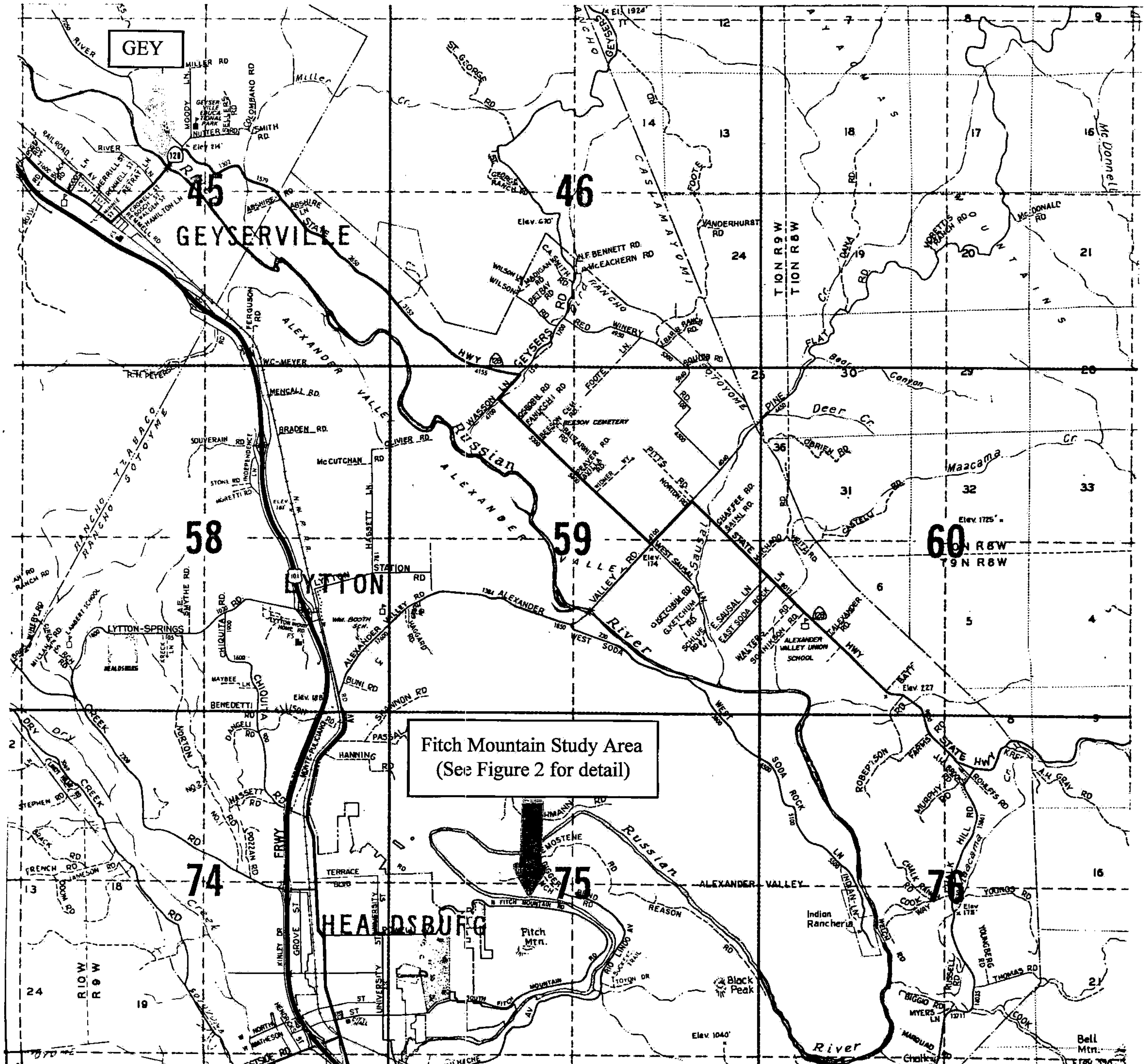

Figure 1. Study Area for Fitch Mountain Bacteriological Monitoring. Figure shows the location of Fitch Mountain in relation to the Geyserville (GEY) sampling site.

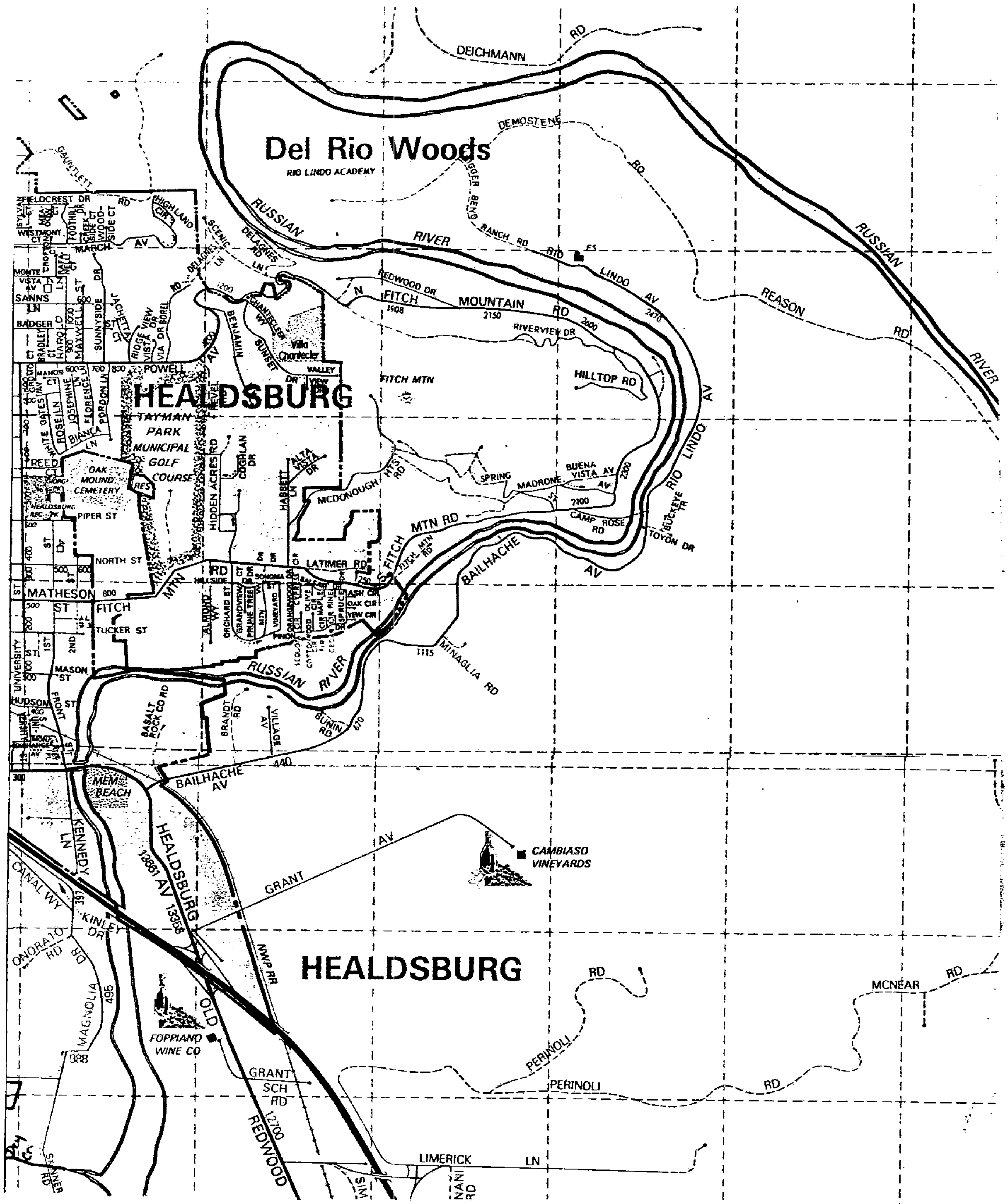

Figure 2. Russian River Bacteriological Sampling Sites for Fitch Mountain Study

The "Russian River Sanitary Survey, Fitch Mountain and Hacienda to Jenner" prepared by the State of California Department of Public Health Bureau of Sanitary Engineering on November 28, 1951[6] reports on a sanitary survey and bacteriological sampling conducted in July 1951. The study identified no conditions of "pollution" or "nuisance". The study indicated that "several individual sewage disposal units on the Russian River ... could at times impair the bacteriological quality of the [river] water". The report also noted that river bank erosion reduces the area available for treatment of wastewater from individual systems which are located close to the river.

An April 1973 *Memorandum Report on Fecal Coliform Standards for Freshwater Recreation* by the California State Department of Public Health[7] provides the rationale for the current Basin Plan fecal coliform standard. After surveying the literature and standards employed in other states, this author provided recommended and action levels for streams with different water quality levels. The current Basin Plan fecal coliform standard corresponds to this author's "coastal and mountain streams" standard which is stated to be applicable to freshwater recreation areas which are beyond the direct obvious influence of sewage discharges. The author further explains that "It is not indicative of safe water quality conditions where drainage or wastewater constitutes a significant portion of the freshwater resource. The standard constitutes an evaluative tool which must be used in conjunction with a knowledge of sanitary conditions in the area." and "...it appears that a fecal coliform standard of 50/100 ml represents an attainable limit for mountain and coastal streams. Heavy recreational usage of low flow streams will normally result in fecal coliform levels above 50/100 ml which may have little health significance, however, a higher level of recommended quality would allow significant degradation of most streams."

In April 1975, the California Regional Water Quality Control Board, North Coast Region prepared a report titled "Bacterial Quality of the Russian River, Sonoma and Mendocino Counties, California, Summer 1974"[8]. This report presents the results of fecal coliform sampling at seven sampling stations riverwide, including Healdsburg Memorial Beach. This report concluded that "In order to effectively control the bacterial quality of the Russian River, it will be necessary to know the specific identity and source of the fecal coliform bacteria observed." and recommends further study.

Bacteriological sampling continued in 1975 and 1976 and a sanitary survey was also conducted in 1976 in the Fitch Mountain area. These were summarized int the November 1976 Regional Water Board report titled "Bacterial Quality of the Russian River, Sonoma and Mendocino Counties, California, Summer 1976"[9]. The median fecal coliform concentration at Healdsburg Memorial Dam for the summer of 1976 was reported as <30 MPN/100 ml which was down from the 1975 median of 40 MPN/100 ml and the 1974 median of 43 MPN/100 ml. The sanitary survey focussed on riverside lots in the Fitch Mountain area, identified only one home with evidence of a dry weather source of contamination into the river, and concluded that it is reasonable to assume that this was not an isolated case.

In summary, these past reports lead this author to the following conclusions:

1. Sanitary standards have improved significantly since the 40's, 50's, and 60's, reducing the number and magnitude of potential bacterial sources and the associated threat of water-borne communicable diseases.

2. The potential for failure of older septic systems in the Fitch Mountain area is probably greater in the 90's due to further aging of the systems, year-round rather than seasonal use of many of the systems, and further erosion of the river bank in the vicinity of some systems.

3. The current Basin Plan fecal coliform standard is a conservative standard which is highly protective of water quality.

4. The presence of low fecal coliform levels in the water column does not mean that there are no bacterial discharges to the Russian River. Due to the statistical nature of the fecal coliform test and the likelihood of dilution, bacterial discharges may be difficult to identify.

METHODS

Study Design

The sampling strategy was designed to 1) determine if the Fitch Mountain area contributes bacteria to surface waters of the Russian River, 2) evaluate bacterial trends to determine the existence of other sources, and 3) compare bacteria levels in the Fitch Mountain/Healdsburg Memorial Beach area to levels at an upstream reference site which may provide the best indication of background bacteriological levels for the Russian River. Sampling was biased toward monitoring in and downstream of the Fitch Mountain area.

Samples were collected from April 25 through September 5, 1995. In the spring and early summer river flows and water level were dropping and soils were saturated providing a potential conduit for wastewater from failing septic systems to reach the river.

The Healdsburg Memorial Beach dam was not installed until late June 1995 due to high flows in the river. The 94/95 wet-weather season resulted in two major flood events along the Russian River - one in January 1995 and one in March 1995, and rains continued into mid-June, 1995.

Sampling during the summer months was directed toward determining the impacts of the summer impoundment at Healdsburg Memorial Beach and/or the presence of people in the river on bacteria levels.

Sampling Sites

The following sites were sampled for this study. Each site has an associated acronym which is identified in parentheses next to the site name. These acronyms are used to identify the sampling sites in the computer database and on Figures 1 and 2.

1. Geyserville (GEY). This station served as a reference or background site. All samples were collected upstream of the Highway 128 bridge. There are no locations along the river that are not impacted by human activity. However, this monitoring station was selected in an area upstream of Fitch Mountain that has as little human impact as possible (i.e., little recreation and no nearby bacteria sources such as poorly designed individual systems, confined animal facilities, etc.). The river has a gravel substrate at this site.

2. Fitch Mountain at Redwood Drive (RWDDR). This station is located at the upstream end of Fitch Mountain and functioned as a reference site to determine what the bacterial water quality is like as it flows into the Fitch Mountain area. A small stream enters the Russian River at Redwood Drive. The Russian River sampling site RWDDR was located upstream of the discharge from this stream. The stream was sampled at two locations (STREAM1a and STREAM1b) when it was flowing to determine if the stream was receiving inputs of fecal coliform.

3. Another small stream (STREAM2) which discharges to the river about one mile downstream of Redwood Drive was sampled at Hilltop Drive five times in the early part of the study.

4. Two additional Russian River sites were located at each of the two recreational beaches along Fitch Mountain - Del Rio Woods and Camp Rose (CR). Unfortunately, after the study began, samplers routinely found the gates at Del Rio Woods locked so the Del Rio Woods station was dropped from the study. The Camp Rose beach is at the upstream end of the influence of the Healdsburg Memorial Beach impoundment.

5. Almond Drive at the downstream end of Fitch Mountain (ALMDR). This site is located in a neighborhood that is served by the City of Healdsburg sewer system, therefore it is downstream of all homes served by septic systems. In addition, this site does not have high recreational use, although it is in the section of the river which is impounded when the Healdsburg Memorial Beach dam is up.

6. Healdsburg Memorial Beach (HMB). Three sites were selected within the impoundment at Healdsburg Memorial Beach in order to evaluate whether or not bacterial levels vary at different locations of this beach. HMBSWIM1 was located at the upstream end of the beach immediately downstream of the automobile bridge. HMBKIDS was located in the area designated for young children to swim (a shallow area marked off with rope). HMBSWIM2 was located at the downstream end of the swim area.

7. Healdsburg Memorial Beach - below dam (HMB-BD). These samples were collected from the gravel bar at the Fisherman's beach, immediately downstream of the dam.

Sampling Frequency

In order to compare the sample results to existing Basin Plan standards sampling occurred on a weekly basis so that five samples would be collected at each site within any 30-day period.

Samples were collected weekly from April 25, 1995 through September 6, 1995, with the following exceptions. The weekly sample was not collected at Camp Rose on July 11, 1995 due to safety concerns related to a dog roaming the beach unattended. Sample collections were discontinued at Redwood Drive after August 1, 1995 because the spring-fed stream stopped flowing. Prior to the installation of the Healdsburg Memorial Beach dam, the beach area was inaccessible because it was fenced off due to the winter flooding and high flows that continued into June 1995. Sample sites were added in the swim area at Healdsburg Memorial Beach after the summer dam was installed.

Sample Collection

Samples were collected by Regional Water Board staff in the morning of each sampling day. Samples were collected in 120 ml plastic bottles which had been autoclaved at the U. S. Environmental Protection Agency (EPA) Region IX Richmond laboratory. Samples were collected midstream when flow conditions allowed. When flow conditions prohibited this, samples were collected from shore in an area well mixed flowing water. Samples were collected approximately 12 inches below the water surface where the water was deep, and at mid depth where the water was less than two feet deep. The opening of the sample container was pointed into the flow. Unpreserved samples were stored on ice for transport and refrigerated upon arrival at the laboratory.

All sampling activities were recorded in a bound field notebook. Entries included the sampling date, personnel on the sampling team, calibration of field instruments, weather conditions, sampling location, time of sample collection, records of field measurements, and field observations (i.e., activities, sources, or conditions that may influence the bacteria results, physical observations about the river, etc).

Sample Delivery

The sample sets collected on April 25 and May 2 were shipped to the EPA Region IX laboratory in Richmond, California by overnight mail. On all subsequent sampling dates, samples were picked up at the Regional Water Board office by EPA personnel and delivered directly to the EPA laboratory within six hours of the time that the first sample was collected.

Sample Analysis

Samples were analyzed at the EPA Region IX laboratory in Richmond, California for total coliform, fecal coliform, *E. Coli,* and enterococcus.

Total and fecal coliform were analyzed through the entire study using the multiple-tube fermentation methods 9221B and 9221E. Early in the study the EPA laboratory also performed comparisons using the commercial Colilert[3] method (Standard Method 9223) for the analysis of total coliform and *E. coli*. Some samples were also analyzed for enterococcus using membrane filtration (Standard Method 9230C) and the commercial Enterolert method.

Samples collected on April 25, May 5, 9 and 15, June 26, July 18 and 24, August 1, 7 and 21, and September 6 included field monitoring for pH, specific conductance, dissolved oxygen, and temperature. Selected samples collected on May 2, 9, and 15, August 7, and September 6 were analyzed for turbidity at the Regional Water Board using a Hach Model 2100A Turbidimeter.

Quality Assurance/Quality Control

Chain-of-custody forms were completed on all sampling dates. Since the samples were delivered directly to EPA staff by Regional Water Board staff custody seals were not placed on the bottles or the coolers.

Replicate samples were submitted to the EPA laboratory on two sampling dates: May 30 and September 6, 1995. The replicate samples were collected by holding two sample bottles side by side to fill them simultaneously from the same location in the river. On three other dates, laboratory personnel selected a sample from which they ran the bacteriological analyses twice: May 9, August 1, and August 21, 1995. Results of QA/QC samples are summarized in Appendix C.

Data Analysis

All bacterial and physical data was entered into a Lotus© spreadsheet program and bacterial data was plotted in three ways: 1) by station, with median fecal coliform concentration (MPN/100ml) plotted against sampling date, 2) by date, with actual fecal coliform, *E. coli,* and enterococcus concentrations plotted against station, and 3) as a three dimensional bar graph displaying all of the mainstem fecal coliform data for the entire study period. The Lotus© worksheet and graphs are included in Appendix D.

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[3]Colilert and Enterolert are products of IDEXX Laboratories, Inc. Colilert is a chromogenic/fluorogenic substrate which allows the simultaneous identification and quantification of total coliform and *E. coli* in 18 to 24 hours, compared to two to four days for traditional methods. It is approved by EPA under the Safe Drinking Water Act for drinking waters and surface waters. Colilert detects total coliform through their production of the enzyme B-galactosidase. In this study, the total coliform counts obtained using Colilert were significantly higher than those obtained using the traditional multiple-tube method. Although it contains agents to inhibit non-coliform organisms, Colilert has been reported to give false positive reactions for total coliform in surface waters experiencing coliform bloom events, which typically happen in the spring and summer. During these bloom events, coliform levels in receiving water samples are too concentrated for this method to work well.

RESULTS

Analysis of Fecal Coliform Medians By Station
Fecal coliform medians are summarized on pages D-1 through D-4 and presented graphically by station on pages D-5 and D-6 of Appendix D.

The median fecal coliform levels during the dry-weather, summer recreation season were in compliance with the Basin Plan median water quality objective for fecal coliform at all sampling stations except the three stations in the Healdsburg Memorial Beach swim area (HMBSWIM1, HMBKIDS, HMBSWIM2).

Median fecal coliform levels generally decreased with time during the study period at Geyserville, Redwood Drive, Camp Rose, and Almond Drive. Median coliform levels exceeded the Basin Plan water quality objective for fecal coliform twice at Redwood Drive, and once at Almond Drive. All three of these exceedances occurred during wet-weather periods.

Median fecal coliform levels at all three stations in the Healdsburg Memorial Beach swim area fluctuated during the study period and slightly exceeded the Basin Plan water quality objective for fecal coliform five times from mid-July through mid-August at HMBSWIM1 and one out of two times in late August at HMBSWIM 2. Only five weekly samples were taken at HMBKIDS area providing only one median of 30 MPN, which is less than the Basin Plan water quality objective for fecal coliform.

Median coliform levels immediately downstream of the Healdsburg Memorial Beach dam (at the fisherman's beach) fluctuated slightly during the study period. Median fecal coliform exceeded the Basin Plan water quality objective one time at the beginning of the study corresponding to the wet-weather period. Thereafter, the median coliform values at this station were at or below the Basin Plan water quality objective.

Analysis of Fecal Coliform by Sampling Date
Fecal coliform data is summarized on pages D-1 through D-4 and presented graphically by sampling date on pages D-7 through D-13 of Appendix D.

In general, the upstream reference station at Geyserville had the lowest fecal coliform levels compared to downstream stations on most sampling dates. This did not hold true on three sampling dates: May 9 and 15, and June 6. Rainfall had occurred on or right before these three sampling dates.

The small stream at Redwood Drive (STREAM1b) was sampled twelve times and had high fecal coliform levels throughout the sampling period (with the exception of one sample on June 20), ranging from a low of 7 to a high of >1600 MPN/100 ml. Seven medians at STREAM1b ranged from 240 to 1600 MPN/100 ml. On five sampling dates an upstream site on this spring was sampled (STREAM1a), with results ranging from 13 to 240 MPN/100 ml giving one median of 80 MPN/100 ml. On four of those five sampling dates there was a significant increase in fecal coliform bacteria from upstream (STREAM1a) to downstream (STREAM1b).

Analysis of *E. Coli* Data
E. Coli results are summarized on pages D-1 through D-4 and presented graphically on pages D-7 through D-10 of Appendix D.

Although the State has not adopted an *E. Coli* standard, the *E. Coli* data was compared to the EPA recommended criteria. All Russian River mainstem sites had *E. Coli* median values that were less than the EPA five- sample median recommended criteria of 126 MPN/100 ml. The HMBSWIM1 site, which exceeded the Basin Plan criteria for fecal coliform, had the highest *E. Coli* results of all the Russian River mainstem sampling sites with median *E. Coli* values ranging from 15 to 73.8 MPN/100 ml values. These values are all less than the EPA recommended criteria.

The small stream at Redwood Drive (STREAM1b) exceeded the EPA recommended criteria for *E. Coli* in four of five median values.

In this study, the results for *E. Coli* enumerated by Colilert were generally less than or equal to the results for fecal coliform by multiple tube, as expected.

Analysis of Enterococcus Data
Enterococcus results summarize on pages D-1 through D-4 and presented graphically on pages D-8 through D-13 of Appendix D.

Although the State has not adopted an enterococcus standard, the enterococcus data was compared to the EPA recommended criteria. All Russian River mainstem sites had enterococcus median values that were less than the EPA five- sample median recommended criteria of 33 MPN/100 ml. The HMBSWIM1 site, which exceeded the Basin Plan criteria for fecal coliform, had the highest enterococcus results of all the Russian River mainstem sampling sites with median enterococcus values ranging from 19 to 28 MPN/100 ml. These values are all less than the EPA recommended criteria.

The small stream at Redwood Drive (STREAM1b) exceeded the EPA recommended criteria for enterococcus in all three median values.

In this study, the results for enterococcus indicated that the commercial Enterolert method and membrane filtration gave very similar results.

CONCLUSIONS

The following conclusions can be drawn from this study:

1. During the dry-weather, summer recreation season, fecal coliform levels were in compliance with the Basin Plan water quality objective for fecal coliform most of the time at most sampling sites.

2. Fecal coliform levels increased, and exceeded the Basin Plan water quality objective for fecal coliform, in the Healdsburg Memorial Beach swim area in mid- to late summer. There appears to be a relationship between the number of swimmers in the water and the level of fecal coliform. This may be a result of bacteria being stirred up from the sediment.

3. Total and fecal coliform levels increased in response to rainfall, and decreased during dry weather periods. There was an insufficient amount of wet-weather data collected during this study to determine if fecal coliform levels increase in the Fitch Mountain area compared to the upstream reference site.

4. There was a general trend of decreasing fecal coliform from upstream to downstream during dry weather periods. Since only one sample was collected at each site on each sampling date, it is difficult to assess whether this general trend has any significance.

5. All mainstem sites complied with the EPA recommended criteria for *E. Coli* and enterococcus.

6. The small stream at Redwood Drive (STREAM1a-b) was a conduit of bacterial discharge to the Russian River.

RECOMMENDATIONS

Further study of this area is warranted based on the results of the 1995 data. General conclusions drawn from the existing data should be used to design a future study for the purpose of better identifying trends in the data and to identify sources of bacteria.

Future bacteriological studies should include the following:

1. Further study of the small stream (STREAM1a-b) and other streams in the area sources of bacterial contamination to determine sources of bacterial contamination.

2. Further study of the Russian River during the wet-weather season to determine if fecal coliform levels increase in the vicinity of Fitch Mountain in comparison to the upstream reference station.

3. Additional sampling locations and multiple samples from selected sampling locations. Multiple samples in the location of potential sources may help to identify any existing sources. Also multiple samples per sampling date could help evaluate if any significant upstream to downstream trends exist.

4. Surveys of the Fitch Mountain shoreline by boat to determine if seepage is present that could be originating from individual systems.

5. Future bacteriological studies could be directed at determining the effect of the substrate in a swim area on bacteria levels when bathers are present. (i.e., test whether gravel substrate areas are less susceptible to increases in bacteria when swimmers are present compared to sediment substrate bottoms).

6. Collection of field data (air and water temperature, specific conductance, pH, and dissolved oxygen), careful weather records, including amount of rainfall, and turbidity on every sampling run. Field measurements are easy to collect and this type of data could be correlated with fecal coliform to see if any relationships exist between field measurement data and fecal coliform levels. Turbidity measurements would be useful in wet-weather periods to determine the relative amount of sediment load being carried by the river and in dry-weather periods to determine whether sediment has been kicked up by swimmers and whether or not this has a direct influence on the level of total and fecal coliform detected in samples.

7. Use of other study methods. A great deal of literature is available describing the use of sediment bags to determine sources of bacterial contamination. A list of those literature sources is included in Appendix E.

REFERENCES

1. North Coast Regional Water Quality Control Board, December 9, 1994 Interoffice Communication from Theresa Wistrom

2. Underwood, Sarah, Water Quality Analysis of the Russian River in the Fitch Mountain Region, California Regional Water Quality Control Board, North Coast Region, May 17, 1995

3. North Coast Regional Water Quality Control Board, *Water Quality Control Plan for the North Coast Region*, Adopted on December 9, 1993 and amended on March 24, 1994, June 22, 1995, and May 23, 1996.

4. U.S. Environmental Protection Agency, Federal Register, March 7, 1986

5. Charles H. Lee, Consulting Sanitary Engineer, *Report on Sanitary Survey of Sonoma County, California with Recommendations for Control of Epidemics*, prepared for the Sonoma County Board of Supervisors and the Sonoma County Health Department, February 1, 1944

6. Russian River Sanitary Survey, Fitch Mountain and Hacienda to Jenner" prepared by the State of California Department of Public Health Bureau of Sanitary Engineering on November 28, 1951

7. Stewart, Morgan E., *Memorandum Report on Fecal Coliform Standards for Freshwater Recreation*, California State Department of Public Health, Bureau of Sanitary Engineering, April 1973

8. North Coast Regional Water Quality Control Board, "Bacterial Water Quality of the Russian river, Sonoma and Mendocino Counties, California, Summer, 1974"

9. North Coast Regional Water Quality Control Board, "Bacterial Quality of the Russian River, Sonoma and Mendocino Counties, California, Summer 1976"

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
NORTH COAST REGION
Interoffice Communication

TO: File - Russian River Monitoring **DATE:** December 6, 1994

FROM: Theresa Wistrom

SUBJECT: Russian River Bacterial Levels

This memorandum serves to summarize the results of monitoring the Russian River for bacteria, from 1986 through 1994. It is an update to an Interoffice Communication of August 26, 1986 and to the discussion included in the "Interim Staff Report regarding Russian River Water Quality Monitoring" of January 27, 1993, pages 13 & 14, both of which are attached. In addition to summarizing the results of recent bacteriological monitoring on the Russian River, this memorandum will discuss two issues: 1) the determination of compliance to the Basin Plan bacterial objectives, and 2) impacts on the public health.

Monitoring

As in the past, Regional Board focus for monitoring has been during the summer months, the period of peak use for body contact recreation, and the period during which there is most interest regarding the impact of bacterial levels in the Russian River on the public health. Regional Board staff conducted limited monitoring to "spot-check" compliance to the numerical Basin Plan objective - the monitoring was not systematic, nor did it provide a thorough baseline for evaluation. The Sonoma County Health Department conducted more thorough monitoring of major bathing areas along the lower Russian River. The results of both Regional Board and Sonoma County Health Department bacteriological monitoring are included in files labelled "Bacteriological Data for Russian River, 1986- ," located in my cubicle.

Basin Plan Objective

The Basin Plan includes both narrative and numerical objectives for bacteria. The narrative objective is that the bacteriological quality of the Russian River not exceed natural background levels. The numerical objectives are: 1) that the median concentration of fecal coliform, based on a minimum of not less than five samples for any 30-day period, exceed 50/100 ml, and 2) that not more than ten percent of total samples taken during any 30-day period exceed 400/100 ml.

Implementation of the Narrative Objective - Natural Background Levels

The Basin Plan prohibits the discharge of waste, and thus the discharge of bacteria, to the Russian River and its tributaries during the period May 15 through September 30. The Regional Board and the health departments of Mendocino County and Sonoma County have enforced this prohibition the extent possible through waste discharge orders and septic tank ordinances. Regional Board waste discharge orders prohibit the municipalities and industries located on the Russian River watershed from discharging during the period May 15 through September 30, and require the dischargers to report on compliance to the prohibition. Between 1986 and 1994, no incidences of non-authorized discharges of waste by dischargers under Regional Board waste discharge orders to the seasonal waste discharge prohibition were reported or known to occur. However, malfunctioning septic systems, which may result in discharge to the Russian River, probably continue to occur. Whenever such discharges are identified, the health departments can and do initiate proceedings requiring repair, then if necessary, abatement. To attempt to identify and control malfunctioning septic systems affecting water quality and public health, the Mendocino County and Sonoma County health departments have in the past and continue to conduct areawide pollution prevention studies along the Russian River watershed. One such study currently underway is in the Forestville-Mirabel Heights area in Sonoma County. In addition, the Regional Board is attempting to develop a monitoring effort utilizing EPA Region IX laboratory services, to assess the impacts of Spring runoff and infiltration to the Russian River from the Fitch Mountain area upstream of Healdsburg Memorial Beach.

Nonpoint sources of pollution which may introduce bacteria to the river, which include urban and agricultrual runoff during storm events, are more difficult to assess and control. Regional Board efforts to minimize such impacts include: 1)

Compliance to the Numerical Objective - 10% of samples taken within a 30-day period not to exceed Fecal Coliform MPN of 400/100 ml

The monitoring did not specifically check for compliance to this objective. However, fecal coliform bacterial levels exceeding 400/100 ml. occurred at the following locations and frequencies.

LOCATION	OCCURRENCE OF SAMPLES WITH FECAL COLIFORM LEVELS GREATER THAN 400/100 ml.
Healdsburg Memorial Beach	6.6%
Hilton Park	One
Odd Fellows	One
Midway Beach	One
Johnson's Beach	1.8%
Casini Ranch	31% between July 1992 and July 1993 None from August 1993 to August 1994

Public Health

The Statewide Conference of Directors of Environmental Health developed fecal coliform standards for freshwater recreation in 1973. The standards describe "recommended" and "action" levels of 50/100 ml and 200/100 ml respectively. The recommendations call for "investigations to commence into the causes" when the recommended level is exceeded, and the application of public warning or restrictions when the action level is exceeded. Federal criteria for full body contact are different than the statewide standards. Prior to 1986, they called for a log mean of not less than five samples over a 30-day period not to exceed a fecal coliform concentration of 200 per 100 ml, and not more than 10% of total samples over a 30-day period to exceed 400/100 ml. The EPA developed new criteria in 1986, which called for measurements of E. coli and enterococci rather than fecal coliform bacteria, based on findings nationwide of better correlation to swimming-associated gasteroenteritis at both marine and freshwater bathing beaches. The State, however, has not adopted the new criteria for E. coli and enterococcus.

Based on recommendations from the State Department of Health Services, the Sonoma County Department of Public Health has chosen to continue sample bathing areas along the Russian River for fecal coliform bacteria and not for E. coli or enterococci. Results in the area of most concern, Healdsburg Memorial Beach, indicated the need for increased sampling, which was subsequently implemented by the Sonoma County Health Department, and no further action.

Conclusions

Spot checks for background levels of fecal coliform bacteria indicated compliance with Basin Plan objectives in areas along the Russian River which are not heavily used or influenced by summer dams. However, the numerical objective of 50/100 ml fecal coliform bacteria was exceeded at times (ranging from 44% to 75% of sampling sets) in high-use bathing areas, and in areas with summer dams along the Russian River (Healdsburg Memorial Beach, Johnson's Beach, and Monte Rio Beach. These bathing areas received increased monitoring for public health purposes. Assessment of the results by Sonoma County Health Department, based on guidance provided by the State Department of Health Services, indicated that no action with respect to public warning or restriction was warranted.

Figure 3. Median Fecal Coliform MPN/100 ml at Monte Rio Beach

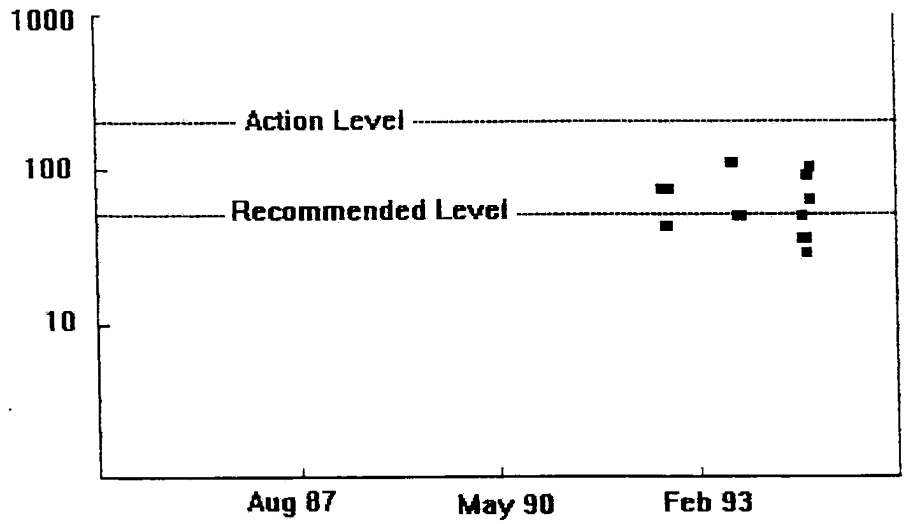

Table 6. Healdsburg Memorial Beach

Date	Median Fecal Coliform MPN/100 ml.				
	Upstream Railroad Bridge	Upstream Car Bridge	Swim Area	Kids' Area	Downstream
28-Oct-86		13	17		17
19-May-87		130	220		240
27-May-87		130	70		170
02-Jun-87		140	79		110
09-Jun-87		140	70		110
17-Jun-87		130	70		79
22-Jun-87		8	70		33
30-Jun-87		8	49		33
11-Aug-87		70	79		110
12-Aug-87		49	22		23
19-Aug-87		17	7		5
26-Aug-87		11	79		11
01-Sep-87		22	23		33
23-Jun-88		70	69		33
30-Jun-88		70	69		33
12-Jun-89		49	120		
07-Aug-89		23	43		
18-Sep-89		240	93		
30-Jun-92			33		17
20-Jul-92			93		
27-Jul-92		75	93		43
27-Jul-92			43		
03-Aug-92		43	93		23
10-Aug-92		75			23
17-Aug-92		75			
24-Aug-92		75			43
13-Oct-92			49		
13-Jul-93			110		
20-Jul-93			110		
27-Jul-93			<110		
03-Aug-93			92		
10-Aug-93			92		
17-Aug-92			92		
24-Aug-93			92		
31-Aug-93			92		
30-Jun-94		49	120		
05-Jul-94			71		
12-Jul-94			71		
19-Jul-94			92		
20-Jul-94			106		
26-Jul-94			120		
27-Jul-94			140		
29-Jul-94		230	120		
01-Aug-94		170	120		161
03-Aug-94		110	120		140
05-Aug-94		<110	120		161
08-Aug-94		110	140	>230	140
15-Aug-94	110	110	140	>225	161
17-Aug-94	170	110	120	>230	161
22-Aug-94	230	<110	190	>225	161
24-Aug-94		<110		>230	161
26-Aug-94		110		>225	<140
29-Aug-94			190	>220	<165
31-Aug-94		110		165	220
02-Sep-94		110		110	220

Table 9. Odd Fellows

Date	Median Fecal Coliform MPN/100 ml.
30-Jun-92	13
13-Oct-92	23
30-Jun-94	33

Table 10. Midway Beach

Date	Median Fecal Coliform MPN/100 ml.
27-Jul-92	93
03-Aug-92	93
17-Aug-92	93
24-Aug-92	43
31-Aug-92	23
08-Sep-92	23
14-Sep-92	23
13-Jul-93	110
20-Jul-93	<110
27-Jul-93	<110
03-Aug-93	92
10-Aug-93	92
17-Aug-93	22
24-Aug-93	22
31-Aug-93	22
05-Jul-94	51
12-Jul-94	36
19-Jul-94	36
20-Jul-94	29
26-Jul-94	29
01-Aug-94	29
08-Aug-94	29
15-Aug-94	29

Table 12. Monte Rio Beach

Date	Median Fecal Coliform MPN/100 ml.
27-Jul-92	75
03-Aug-92	75
10-Aug-92	75
17-Aug-92	43
24-Aug-92	75
31-Aug-92	43
08-Sep-92	75
14-Sep-92	75
13-Jul-93	110
20-Jul-93	110
27-Jul-93	110
03-Aug-93	<110
10-Aug-93	51
17-Aug-93	51
24-Aug-93	51
31-Aug-93	51
30-Jun-94	51
05-Jul-94	36
12-Jul-94	36
19-Jul-94	36
20-Jul-94	29
26-Jul-94	92
01-Aug-94	92
08-Aug-94	106
15-Aug-94	64

INTERIM STAFF REPORT

regarding

RUSSIAN RIVER WATER QUALITY MONITORING

by

North Coast Regional Water Quality Control Board
5550 Skylane Boulevard
Santa Rosa, California 95403

January 27, 1993

Pages 13 & 14:

B. BACTERIOLOGICAL
Prior to and including 1976, fecal coliform levels in the Russian River, from Alexander Valley to Duncans Mills, consistently exceeded the Basin Plan's water quality objective for body contact recreation (fecal coliform MPN/100 ml of 50 or less for a median of five samples taken within a 30-day period). From 1985 to 1991, the objective was met in the Russian River with few exceptions. However, the results of more intensive monitoring of popular swimming areas in the lower Russian River by the Sonoma County Health Department during the peak of the recreational season in 1992 revealed exceedances of the Basin Plan objective for bacteria. The data suggests that the higher bacterial levels were localized to the most popular swimming areas, and are the result of high public use. These results raise concerns from both a water quality and public health perspective. This area of concern needs to be monitored closely early on in the next recreational season.

Increased levels of fecal coliform bacteria in surface waters can and do result from malfunctioning individual wastewater disposal systems.

Malfunctioning individual wastewater disposal systems are abated through the Sonoma County and Mendocino County Health Departments. In addition, the discharge of wastewater from existing or new individual systems utilizing subsurface disposal have been prohibited in areas of Sonoma and Mendocino Counties which have known problems with on-site wastewater disposal. Waiver prohibition areas have also been established by the local health departments in areas where geographical conditions may threaten or result in health hazards or water quality impairment.

The numerical fecal coliform objective is relatively stringent and specific as far as water contact recreation indicator levels are concerned. It probably can be attained in the Russian River (main stem) through continued good water quality control and waste management.

Between 1973 and 1978, the Regional Board either independently conducted or cooperated with other agencies in water quality studies[3] to support its regulatory functions in the Russian River system. Based on those studies, it appears that the fecal coliform objective was generally met beginning in the spring of 1975 and continued during successive low-flow seasons[4] through the summer of 1978. These observations have since been repeated at some sampling stations in 1985. Table 1 illustrates this rather wide-spread attainment of the 50 MPN/100 ml objective in the watershed; approximately 88 river-miles are involved, ranging from Lake Mendocino near Ukiah to Duncan Mills near the Pacific Ocean. Figure 1 shows the sampling station network and some general geographic features of the Russian River basin.

Fecal coliform conditions in Mark West Creek near Mirable Heights (Xs all the way across in Table 1) warrant special notice; the objective was not met there. The Mark West Creek site is very near the creek's confluence with the Russian River. Mark West Creek carries the entire flow of Laguna de Santa Rosa, which meanders through a peneplain with many potential sources of fecal coliforms from urban and rural runoff. (Laguna de Santa Rosa is also the immediate receiving water for a regional wastewater treatment plant when surface water discharges are permitted.) Mark West Creek and Laguna de Santa Rosa are protected by the bacterial objectives, at least the narrative one about not exceeding natural background levels. However, lower Mark West Creek and Laguna de Santa Rosa waters may never meet either coliform objective in the summertime[5] (or anytime) unless land use practices change significantly — and perhaps not even then. Nevertheless, the Russian River downstream of its confluence with Mark West Creek evidently can meet the fecal coliform objective (probably mainly by dilution). (See Figure 2)

These standards were developed by the Bureau for the Statewide Conference of Directors of Environmental Health; they were recommended by the Bureau for trial application. The numerical fecal coliform "recommended" and "action" levels of 50/100 ml and 200/100 ml, respectively, are not presently officially adopted criteria of the Bureau of the Department of Health [Services]. Nevertheless, the standards are considered valid and applicable to the Russian River because they were formulated by experts using the best available information.

2 The concentrations are in terms of MPN/100 ml of water.

3 That work is reported in Sylvester, M.A., and R. L. Church. 1984. A water quality study of the Russian River basin during the low-flow seasons, 1973-78, Sonoma and Mendocino Counties, California. U.S. Geological Survey, Water-Resources Investigations Report 83-4174. VIII + 106 pp.

4 Low-flow seasons here mean May 15-September 30, which are in the Russian River area generally recognized as the main water contact recreation season.

APPENDIX B

Report titled

"Water Quality Analysis of the Russian River in the Fitch Mountain Region"

Water Quality Analysis

of the

Russian River

in the

Fitch Mountain Region

Sarah Underwood

Volunteer Student Intern

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North Coast Region
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May 17, 1995

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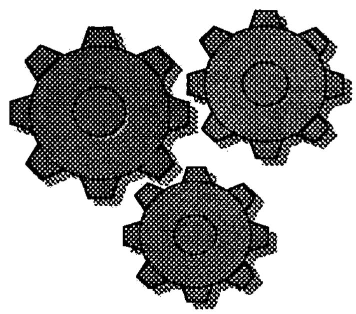


Abstract

Fecal coliform bacteria, an indicator of human or animal waste, were consistently being found in amounts exceeding Regional Water Quality Control Board limits during the summer months at Healdsburg Memorial Beach on the Russian River. Fitch Mountain, upgradient from Memorial Beach, was suspected of contributing fecal coliforms to the river in the form of septic tank effluent. Four sites on the river at Fitch Mountain were sampled weekly over a seven month period, using the membrane filter technique to screen for fecal coliform (FC). Significant differences between the FC levels would be indicative of septic waste contaminating the river. Results showed that there was no apparent relationship between site location and FC level. There was however, a drainage ditch found on Fitch Mountain halfway through the study which contained higher levels of FC than found at any of the river sites. Continued sampling should be done through the summer at Healdsburg Memorial Beach and Fitch Mountain in order to see if they have correlating FC levels. The drainage ditch on Fitch Mountain should also continued to be sampled.

Introduction

The North Coast Regional Water Quality Control Board and Sonoma County Public Health department are currently planning a study which will determine bacteria levels along the northern length of the Russian River between Geyserville and Healdsburg. They are particularly concerned with high fecal coliform levels at Healdsburg Memorial Beach, which were successively found during the summer months of 1986 through 1994 (North Coast RWQCB 1994). However, they need preliminary information on bacteria levels upstream of this beach in order to focus a further investigation and devise any necessary pollution control efforts.

Fitch Mountain, located three to four miles north of Memorial Beach, is a residentially populated area that supports 200 to 300 houses. Most of the houses are located within 2 miles from the river and are known to be built on septic tanks, some of which are 50 or more years of age. The mountain itself is made of fractured bedrock covered with a thin layer of soil. Both of these facts put together call for concern. Aging septic systems on Fitch Mountain may be infiltrating raw sewage into the ground, which in turn contaminates the top soil or the groundwater supply. (Mallard et al. 1978) As the winter rain begins, the saturation point rises and the contaminated water is either forced into the river as moving groundwater or subsurface storm runoff.

The study I developed is an offshoot of the RWQCB's proposed study, which will hopefully provide them with the screening information they need.

Fecal coliform, a type of symbiont bacteria, are found in the intestinal tract of warm blooded animals (Geldreich et al. 1968). Therefore, I used the membrane filter technique to screen the Russian River at various points on Fitch Mountain for fecal coliforms, an indicator of human or animal waste. If the levels were distinguishably different between the chosen sites on the river, then deductions could be made about possible septic pollution sources. This in turn would call for further investigation.

Methods

Study design and site selection

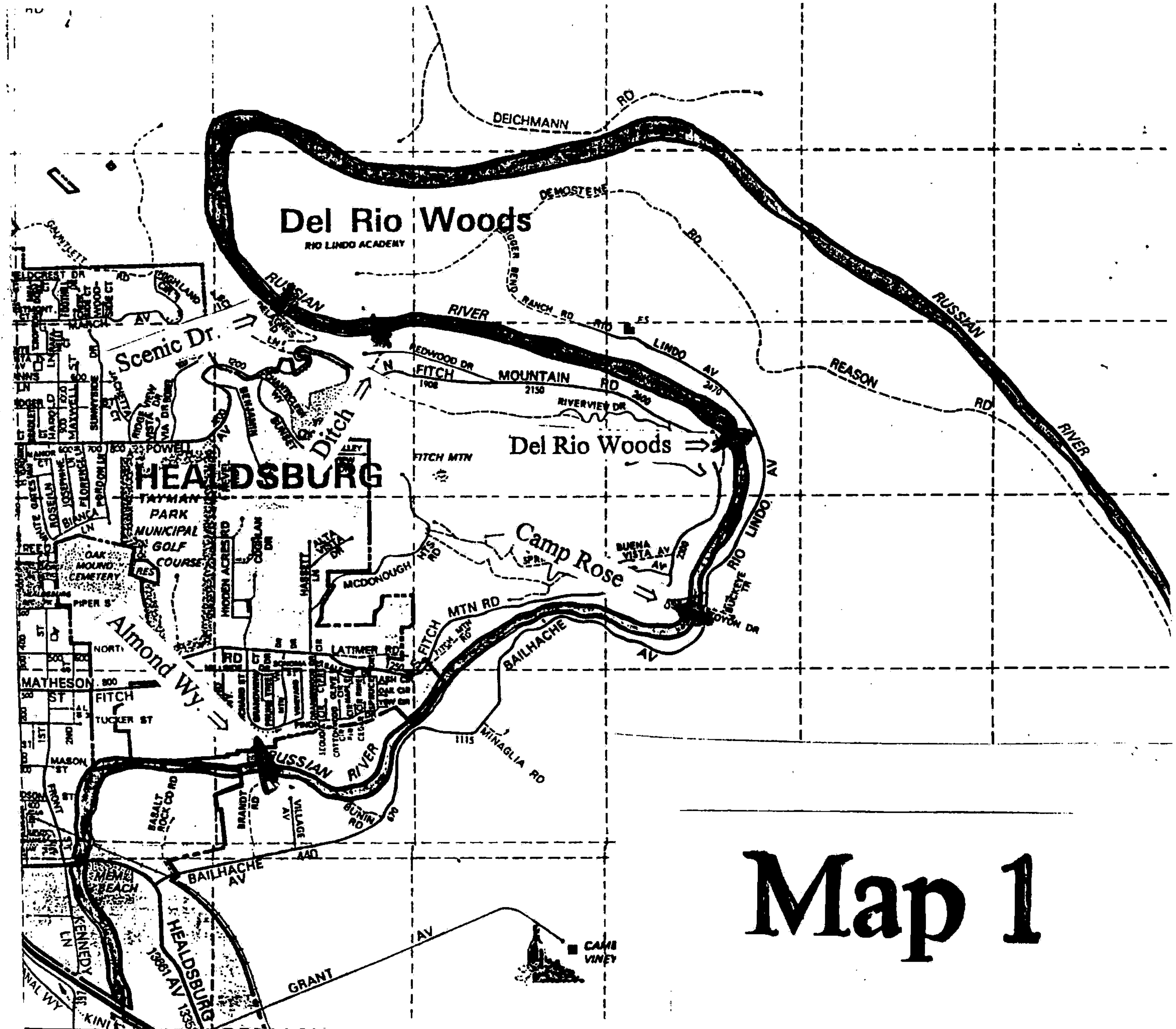
In order to detect areas on the river contaminated by septic effluent, four sampling stations were chosen. The sites were each a mile or more apart from each other. This was done so the fecal coliform levels of each site could be compared to each other. If a site was consistently higher at a particular site, then the source could invariably be identified between two sites.

All sampling stations were on the Russian river at Fitch Mountain, which is in Healdsburg, California. (Figure 1) The reference site, Scenic Dr., is on the north end of Fitch Mountain and is privately owned. Del Rio Woods, a neighborhood owned beach, is two miles down gradient from the reference site. The next site, Camp Rose, is another 2 miles down gradient, and is also under private ownership. All three sites contain homes using septic systems along the banks of the river. Almond Wy., the fourth site, is located on the south end of the mountain. The homes along this site are under the city of Healdsburg's sewer system. All together there are 200 to 300 homes depending on septic systems between the reference site, (Scenic Dr.) and Almond Wy., which could contribute to fecal contamination of the Russian River.

The sites were visited once a week, at which time samples were collected. However, large rainstorms were a contributing factor in determining the specific day to obtain samples. Sampling during active periods of surface runoff could contain FC in higher proportion than the septic effluent; therefore, I didn't sample during these periods.

Field Procedures

For safety reasons and precautions, I always had another person go sampling in the field with me. Using the RWQCB's car, we made the 10 minute drive to Fitch Mountain in Healdsburg.


Del Rio Woods
RIO LINDO ACADEMY
Del Rio Woods ⇒
Scenic Dr. ⇒
Ditch ⇒
Camp Rose ⇒
Almond Wy. ⇒
HEALDSBURG
RUSSIAN RIVER
DEICHMANN RD
DEMOSTENE RD
REASON RD
RIO LINDO AV
FITCH MOUNTAIN RD
RIVERVIEW DR
FITCH MTN
TAYMAN PARK MUNICIPAL GOLF COURSE
OAK MOUND CEMETERY
BUENA VISTA AV
MCDONOUGH HTS RD
HIDDEN ACRES RD
LATIMER RD
BAILHACHE AV
MINAGLIA RD
BASALT ROCK CO RD
BRANDT RD
VILLAGE AV
BUNIN RD
GRANT AV
HEALDSBURG AV
KENNEDY LN
MATHESON ST
FITCH ST
TUCKER ST
MASON ST
FRONT ST
POWELL
PIPER ST
MEM'L BEACH

Map 1

An important part of sampling is where to take the sample. Most often we brought knee or hip boots, so as to get as far out into the flow of the river as possible. During the autumn months of October and November, 3 sterilized whirl packs were taken to each site to collect the samples. Only 1 whirlpack became necessary after the rains began. I took notes on the estimated width, depth, flow and clarity of the river at each site, as well as other important factors which may have influenced the bacteria level of the river. The whirlpacks were stored in a cool ice chest and transported directly back to the RWQCB.

Laboratory Procedures

Once in the RWQCB laboratory, the Millipore membrane filter technique was prepared (see Appendix 1 for complete process). Three different volumes of sample water from each site were poured through a filter cup. Using a vacuum pump, the water was sucked through a gridded pad which retained the FC. The pad was then transferred to a petri dish containing a agar nutrient rich media, which was then incubated at 44.5° C. After 24 hours, the blue FC colonies were counted (Standard Methods 1981).

During the course of the study, heterotrophic bacterial growth became a problem in distinguishing FC colonies. Colonies were appearing to be gray, green and sometimes yellow, rather than the ordinary dark blue color of FC. I used the EC confirmation method to verify all FC colonies (see Appendix 2).

Data Analysis Techniques

All FC data was counted in terms of colonies/100ml of sample water. The raw data was logged into a Lotus1-2-3 spreadsheet which calculated the average colonies/100ml for each sampling date (see Appendix 3). Over the course of the sampling period the data was plotted in chart form and analyzed to see if there was relationship of FC numbers to sampling site or rainfall data. Rainfall data was collected from Cimis (California Irrigation Management Information System) which is run by the California Department of Water Resources.

Results

Fecal coliform colonies ranged in value from 0 colonies/100ml to the highest count of 500 colonies/100ml (Figure 2) over the eight month sampling period.

The early months of October and November saw very low colony numbers at all sites. Seven consecutive sampling days produced data at very low ranges of 5 colonies/100ml or below.

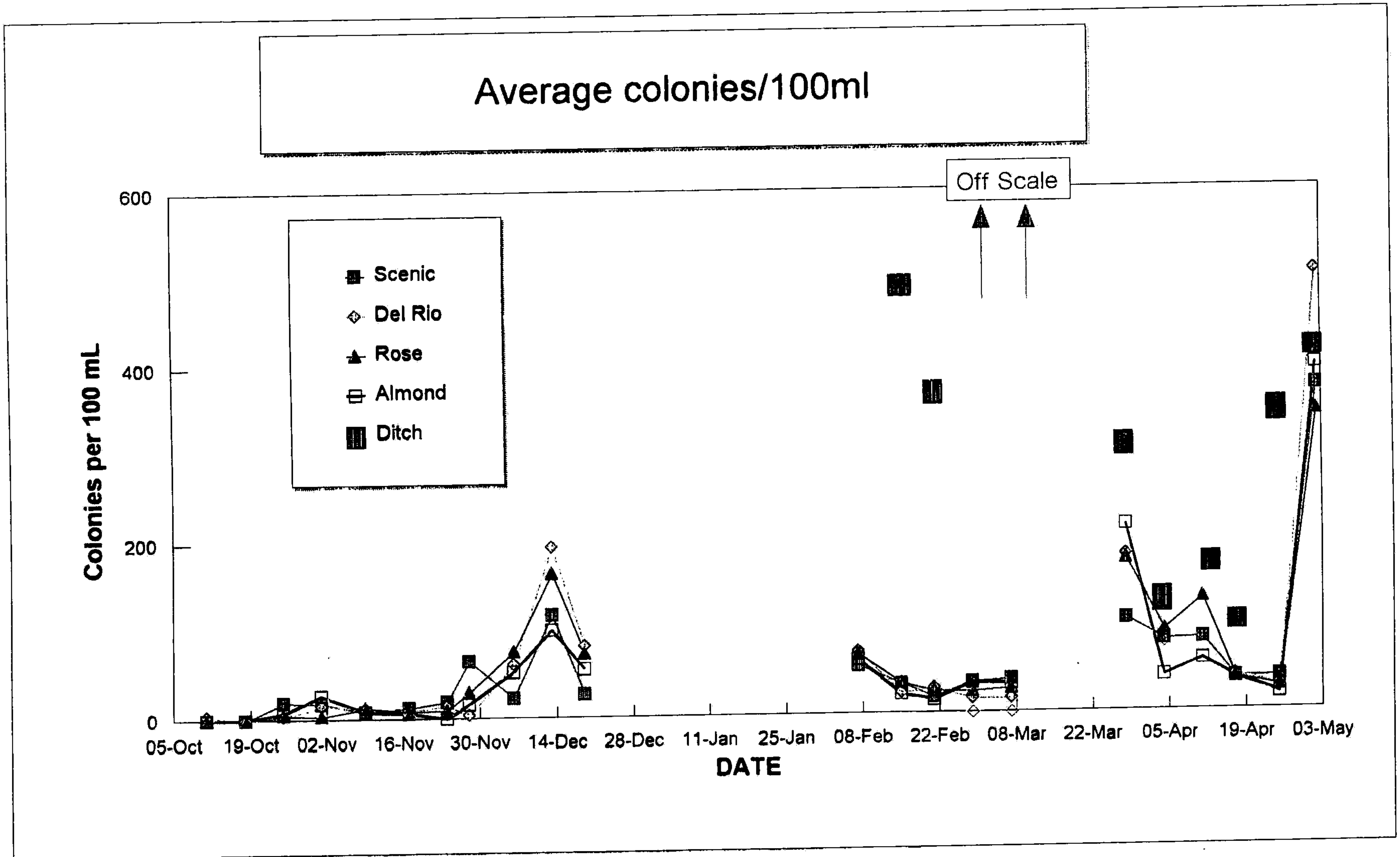


Figure 2 Fecal coliform data was collected at Fitch Mountain on the Russian River for a seven month period. Also included is fecal coliform levels at a drainage ditch.

The month of December resulted in higher colony numbers at all sites, the highest of which was 200 colonies/100ml. At this point in the year, Healdsburg had received almost 10 inches of cumulative precipitation (Figure 3).

January of 1995 produced a major flood, during which data was not collected. Fecal coliform colonies from the successive months of February and March were lower at all the sites, the highest being near 100 colonies/100ml. This was a significant drop from the previous data gathered in December.

Flooding occurred once more during March. Results after this period of rain showed fecal coliform levels near 200 colonies/100ml at all sites once again. The levels began to slowly drop back down to very low values over the month of April.

Data from early May was taken within 24 hours of a rainstorm which resulted in almost 2.5 inches of rain. Fecal coliform levels for this particular day of sampling were unusually high at all the sites. The highest value was at Del Rio Woods, which showed more than 500 colonies/100ml.

Throughout the seven month period of sampling, there was no apparent relationship between fecal coliform levels and site location (Figure 2). On all sampling days, the reference site, Scenic Dr., did not show significantly lower or higher bacteria levels in comparison to the other three down gradient sites. Likewise, the three down gradient sites were not appreciably different. The maximum range of data for any particular sampling day was 160 colonies/100ml.

An ditch draining the hillside was found in the process of winter sampling near Scenic Dr. Subsequent testing of the ditch water showed high fecal coliform levels for four consecutive weeks (Figure 2). Two of those weeks had coliform levels which were too numerous to count, or above 600 colonies/100ml. The levels dropped down to as low as 100 colonies/100ml during the months of March and early April, although they began to rise in response to a rainfall event in May.

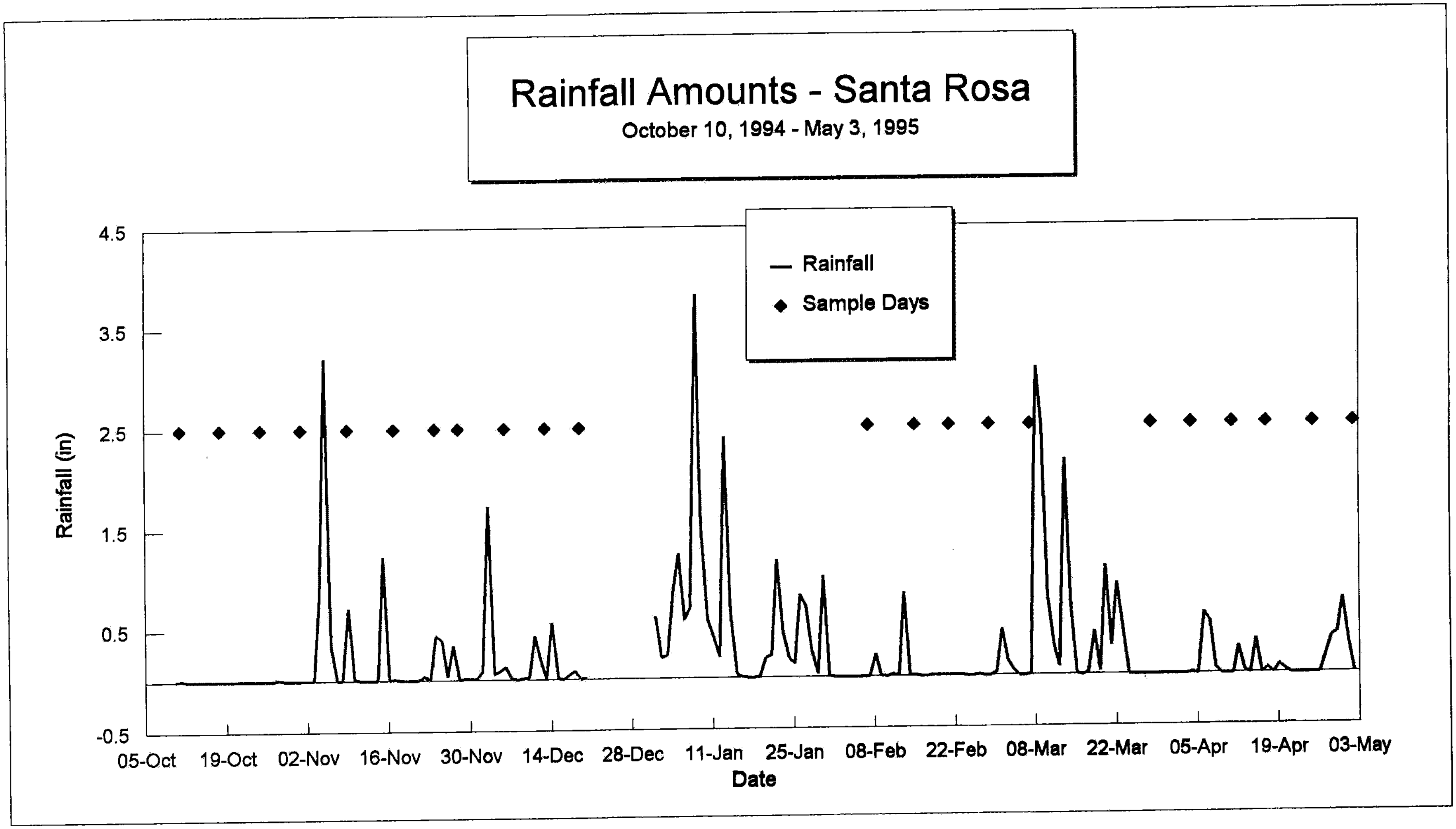


Figure 3 Rainfall data in the Santa Rosa plain was collected over the seven month sampling period.

Discussion

Fecal coliform (FC) densities between the four sites on any given sampling day were very consistent. All sites rose and fell in the same general pattern, with no particular site always having the highest or lowest FC level. Since there was no apparent relationship between the bacteria levels and the site, it was impossible to determine specific areas on Fitch Mountain where septic effluent was entering the river.

A holistic approach to the FC levels shows that the elevated levels cannot be attributed directly to septic sewage as well. The first sign of rising bacteria levels in November were initially thought to have been in response to saturated soil conditions. Small amounts of rain shot the FC levels up past the 100 colonies/100ml mark. This caused reason to believe that either active storm runoff or moving groundwater tainted with septic effluent was a source of contamination to the river, henceforth driving the bacteria levels up.

This first theory, however, was countered later in the sampling period, when the FC levels dropped back down to under 75 colonies/100ml. January flooding finalized all possibilities of the soil being completely saturated. Sampling began again, but small amounts of rain had no significant effect on the bacteria levels as they had done in November and December. This meant that any rise in the FC levels could not be pointed directly to septic effluent.

The only way to explain the event of the elevated FC levels at all sites is the occurrence of a factor which is not apparent. One possible factor is excessive surface storm runoff. When soils are saturated and a rainstorm occurs, the rain becomes runoff. The water picks up everything in its path, including soil and domestic or wild animal wastes, all contributors to fecal pollution. In fact, fecal bacteria may remain in soil from 2 weeks to 2 months (Geldrich 1968) The more runoff that is emptying into the river, the more likelihood of FC levels being high. Also, if a sample is taken too close to a storm, more bacteria will be present in the water, therefore giving high results. Sampling done on March 28th and May 3rd can be attributed to this problem. Water was taken from the sites within 24 hours of a rainstorm. This produced excessively high FC levels. Sequential sampling before, during, and after rainstorms of varying intensities would confirm this hypothesis.

Results from the ditch data show that it had no effect on the FC levels of the Russian River. On two sampling days in December, the FC levels were below 50 colonies/100ml, yet the ditch data was too numerous to count, over 500 colonies/100ml. This means that the dilution rate of a small amount of creek water into the river is very great. If the ditch were to carry an estimated

40 cubic inches of water a second, into a river supporting 5,000 cubic feet of water a second, the ditch water would be diluted by the gigantic body of river water within a matter of seconds. Therefore, the possibility of detecting septic pollution from ditches like this one are very slim. One must either take a sample within a close range to where the ditch collides with the river, or have several FC contaminated large or middle sized ditches in a condensed area.

Though the cause of the high FC numbers in the ditch are unknown, it is speculated that septic tank effluent may have played a role in the contamination. The ditch is located within close proximity to many homes and had counts over 300 colonies/100ml six times out of the nine, or two thirds of the entire sampling period. Even though FC levels in the Russian River were low following the January flooding, the ditch had excessively high numbers during this time. This may have been from storm runoff causing a leach field to empty into the ditch. However, the possibility of confined animals near the ditch should be investigated as well.

The FC levels that were collected over the 7 month sampling period are relatively low in comparison to objective bacterial levels. The chosen levels of comparison are based on microbiological criterion for recreational waters. These standards are based on numerous studies done in the 1960's and 1970's, looking at gastrointestinal illness rates, along with the mean coliform densities. The studies concluded that 2300 total coliform colonies/100ml was an unsafe amount of bacteria for recreational use. This data resulted in the criterion for FC levels, which is that no more than 10% of total samples during any 30 day period should exceed 400 colonies /100ml (RWQCB 1993).

This study is not directly comparable to criterion because sampling was only done once a week, or four times in a 30 day period. This standard of 400 colonies/100ml was only exceeded once at one of the four sampling stations, which was in May at Del Rio Woods. This number can be explained by rainfall amounts and excessive storm runoff. The ditch, however, was very often much closer to the 400 colonies/100ml FC level. Ditch water exceeded the 400 colonies/100 ml criterion for both the month of February and March.

However, when comparing the results of this study to the criterion, one must take several things into consideration. The data obtained for the FC criterion levels were based on summer sampling, when people are in contact with the water. This study was conducted during the winter, for which there is no previous background data. Since very few people use the river as a recreational source in the winter, there wasn't a need to establish a health objective or bacteria standard. Therefore, one would assume that a slight discrepancy would be seen between the summer recreational objective and the winter data. The likelihood of having counts over 400 colonies/100ml are much greater in the winter, due to storm runoff and other related factors. The data, however, was shockingly lower than the criterion for the majority of the study, with exception of the ditch. This was exciting and uplifting news about the overall water quality of the Russian River in terms of FC bacteria levels.

High summer FC levels at Healdsburg Memorial Beach are unlikely to be coming from Fitch Mountain. The data collected in this study was the most representative of the highest likelihood of finding septic effluent. Results showed exceptionally low numbers in the Russian River, which means that the chances of septic contamination reaching the river in the summer are even smaller. The only possibility of pollution coming from this area is if the usage of the homes in the summer differs from the winter, causing septic tank overload. The high FC levels at the Memorial Beach may also just be from the heavy public usage it gets in the summer; the result of many bodies adding bacteria to the water.

Continuation of sampling the drainage ditch on Fitch Mountain is suggested. Although there was no significant effect on the Russian River, the levels of this ditch were excessively high numerous times and posed a health threat to anybody coming into direct contact with it. Care should be taken to identify the source of the FC contamination of the ditch and look for others of a similar nature on Fitch Mountain. Also, summer time sampling should continue at Healdsburg Memorial Beach and Fitch Mountain in order to see if they have correlating FC levels.

Acknowledgments

I would like to thank the following organizations and individuals for making this study a worthwhile endeavor and complete success: The North Coast Regional Water Quality Control Board for helping me to undertake this extensive study by funding all my laboratory equipment, transportation costs, and providing office space. Piner High School for the opportunity to be working with a community agency. Bob Klamt, my mentor and teacher, for his expertise and personal support throughout the duration of the study, as well as showing me the meaning and joy in the field of science. Neil Glasgow and Dan Gonzalez for allowing me this incredible opportunity in science education. Cathy Goodwin, Theresa Wistrom, Bruce Gwynne, and Dave Evans for their guidance and giving me that extra shove to make this project stand above the rest. I'd also like to thank my parents, for their never ending support and encouragement to always do my best and never give up.

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Critique

Science is unpredictable; this is probably the biggest conclusion I have made throughout my high school career. Learning the names and functions of something from a text book is one thing, but going out into the field and actually seeing, hearing, and touching it is something completely different. In my experiences last year and this year, I went out into the field with a concocted vision of the way everything was "supposed" to turn out. These assumptions were not only refuted by mother nature, they were laughed at. "Why isn't this turning out the way I want?", I would ask in frustration. Well, finally I have come to terms with the fact that science is a mysterious, unpredictable way of looking at life. If the river is flowing south, then watch it with awe. If a plant climbs up to the sun, then don't stand in its path. Never mind trying to control science, because it controls us. This realization was the best park of my study with the RWQCB.

As far as improvement areas, a few minor changes could have been made. The first is in regards to the weekly sampling technique. The C-TEC '94-'95 schedule gave me three project periods, for a total of five hours a week. However, the membrane filter method of counting fecal coliform is tedious and requires a 24 hour incubation period. In the beginning of the year I used Tuesday for collecting the samples, Wednesday for running the samples and Thursday for reading samples. Later in the year I discovered that collecting and running the samples on one day and reading them on the next saved much time. On the third day I could do computer work, background research or any other necessary work relating to the study. However, I didn't use this time management technique until halfway through the school year. Had I thought of this earlier, I may have progressed into my background research sooner and moved the report along faster.

Another change I would make if I were to start this study over, is regarding the drainage ditch. The ditch itself was sampled until February, which means that only half the amount of data was collected. If there had been data from the beginning of the year, then maybe the results would have been more conclusive. I should have scoured Fitch Mountain at the beginning of the year for any natural runoff creeks and sampled them right away.

Self-Evaluation

Working with a professional organization proved to be both an interesting and extremely valuable experience. I was treated as an intern, with respect for my capability to work and collect serious research which would be kept on file. Most of the employees were both friendly and helpful, which gave me the confidence and motivation to produce top-notch work that would be looked at as professional and worthwhile. I feel that I fully succeeded in accomplishing this goal. My work can be read as an authentic research paper, complete with repeatability and exactness of details. I am very satisfied with the amount of time and effort that I put into this goal, especially in light of the heavy work load I had in other classes at school. I proved to both my mentor and myself that I have the ability and talent to develop, organize, and synthesize a scientific study. I take pride in my work and feel that it deserves respect and applause. If it were to be given a grade, I would rate it as outstanding work, deserving of an A.

Peer Advice

The first and foremost advantage I had in making this project a success was an interest in science. Anyone who is curious and genuinely wants to know about something, will do it; this applies to any project in C-TEC. However, I suggest that if you wish to venture into the field of science, you have both motivation and creativity. The motivation will get you up off of your butt and the creativity will get your mind ticking; two essential beginnings of any big project.

Bob Klamt, an amazing and wonderful mentor, is a very busy man (to say the least). He was out of the office for the majority of my study, which forced me to become independent and rely solely on myself. If in fact, you have the opportunity to work with Bob, be ready for two things: setting up meetings and organization. If you need to talk or discuss something with Bob, he will always make time to do so, as long as you remember to jot down the day and time of the meeting. Also, since Bob is such a busy guy, it is best to be organized and have your project well structured, so he can evaluate it without having to hoard through mounds and stacks of scattered papers. Organization means having your raw data in a bound notebook and using your own directory on his computer to store all your files. By the way, you will have pretty-much unlimited use of Bob's PC whenever he isn't using it, but be warned that he uses WordPerfect and Lotus 1-2-3 for Windows. These programs are very similar to C-TEC software, and Bob or anyone in the office can usually answer any questions. Quick tip: make sure to start spreadsheets and charts at the **beginning** of the year, so you can update them as your study progresses. It will save loads of time and stress at the end of the year.

Working in a professional company is a topic of discussion as well. The RWQCB was extremely generous in providing me with laboratory equipment funding, office space, and transportation to the sites. This calls for much gratitude and appreciation, as well as respect for their policies and regulations in the office. Everyone I encountered here there was exceptionally friendly and helpful in answering my questions, which was quite often. You should know that you may have a lot of contact with Bob's unit while he is away, a definite advantage. Cathy, Theresa, Bruce, and Cecile are great people who were always willing to help when they had the time. Also, know that if you need to collect samples, it won't be done by yourself, due to safety precautions. A person from Bob's unit will usually accompany you to the sites in the company car. This is a great time to ask questions about what you are doing, what they do, and even about colleges.

Another piece of advice I'd like to give to you is about dedication and quality of work. The combination of working with a professional organization and with people who care about what you are doing, means that you better do a darn good job. There is no room for people who are lazy, flaky, negative, unmotivated, or not willing to follow through with what they start. Realize that Bob is doing this voluntarily as a way to further science education and that if you decide to commit to this project, you must be willing to be dedicated for a full year. The expectations are what you make of them, but I found that the only way to be successful in this endeavor was to work to the best of my ability and earnestly reach for the top.

Appendix 1

Millipore Membrane Filter methodology

Start by turning on the incubator and setting the temperature to 44.5° C. Next warm up the hot plate and place a flask of Alhambra water on it to be boiled. This will be used as sterile dilution water.

Sterilization is the next essential step in microbiological testing. The work bench near the vaccuum must be wiped down with a germicidal or bleach solution. Hands must be thoroughly washed with soap and water; forceps will be dipped in alcohol and flamed.

After sterilization, the samples will be run:

1) Insert the sterile filter cup into the filtering flask.
2) Place petri dishes, media ampoules, and gridded filters close at hand.
3) Transfer media to each petri dish by carefully breaking the ampoule and pouring the media onto the absorbent pad. Exercise care-don't touch any sterile surfaces in handling the petri dish and media ampoule.
4) Remove the top unit of the filter cup without touching the sides. Place on sterile surface so that the top and bottom openings are not contaminated.
5) Open a package containing a gridded filter pad. Carefully remove it using the forceps and discard the packaging.
6) Place the gridded pad on the silver disk located on the bottom of the filter cup unit. Make sure it covers all of the disk and the grid side is facing up. Carefully place the matched to p unit of the filter cup on the filter/disk.
7) Mix the water sample by shaking it vigorously 25 times in the whirl pack; carefully tear off the perforated tab. Place the whilrl pack in a stable upright position, such as a beaker.
8) Tear open the large end of the package containing a transfer pipet. Holding it by the larger end, attach pipettor.
9) Bring the boiled and cooled sterile water to work bench and pipet 20ml into a filter cup if sample volume is going to be less than 20ml. (Samples over 20ml can be poured or pipetted directly into the filter cup.)
10) Pour sample into filter cup and apply suction. Rinse filter cup with 30ml of sterile water.
11) After filtering a sample, close vaccuum valve, remove top unit of filter cup, and pick cup gridded pad with forceps.
12) Carefully place gridded pad evenly in petri dish, careful to trapping air bubbles.
13) Place petri dish in incubator for approximately 24 hours.

Appendix 2

Fecal Coliform Bacteria Confirmation Tests

Problem Statement:
Incubation of fecal coliform (FC) membrane filters from Russian River samples for 24 hours produce typical blue FC colonies, green colonies, and pink colonies. It has been observed that at 24 hours some of the green colonies were initially blue at 18-20 hours. Also, we have observed that at higher volumes (300 ml vs. 150 ml) the pink colonies dominate and a proportionate increase in blue colonies does not occur. That is, we expect to have twice as many blue colonies with twice as much water filtered, but the pink colonies often dominate and may be interfering with the growth of and the identification of FC.

Questions:
1) Are colonies that were blue after 18-20 hrs., but turn green by 24 hrs. actually FC?
2) Are blue colonies at 24 hours FC?
3) Are colonies that were green at 18-20 hrs., and still green at 24 hrs. FC?
4) Are green colonies at 24 hrs. FC?
5) Are pink colonies at 24 hrs. FC?

Design:
Perform confirmatory tests in individual colonies incubating in lauryl-tryptose broth, followed by inoculation of gas-positives and incubation in EC broth. Use two separate colonies for L-T inoculation, inoculate EC broth from any single positive L-T tube. Use the following plates and colonies from Dec. 6, 1994 sampling in reference to questions posed above:

1) Scenic Dr, 50ml - blue colonies at 18 hours, green at 24 hours
2) Camp Rose, 50ml - blue colonies at 18 and 24 hours
3) Camp Rose, 50ml - green colonies at 18 and 24 hours
4) Camp Rose, 150ml - green colonies at 24 hours (lots of pink colonies)
5) Scenic Dr, 50ml - pink colonies at 24 hours

Results:
1) Blue colonies turned green - FC positive (+,+)
2) Blue colonies stayed blue - FC positive (+,+)
3) Green colonies stayed green - FC positive (+,+)
4) Green colonies at 24 hrs., lots of pinks - FC positive (+,+)
5) Pink colonies at 24 hrs. - inconclusive (+,-)

Conclusions:
Blue and green colonies are FC.
Pink may be FC, or colony transfer loop hit a FC colony - retest

Average colonies/100mL

Date	Scenic	Del Rio	Camp Rose	Almond	Ditch
11-Oct-94	0	5	0	0	
18-Oct-94	0	0	0	0	
25-Oct-94	19	4	6	8	
01-Nov-94	18	15	4	27	
09-Nov-94	8	12	13	9	
17-Nov-94	13	10	9	6	
24-Nov-94	19	15	10	0	
28-Nov-94	65	4	30	16	
06-Dec-94	23	62	76	52	
13-Dec-94	118	195	165	100	
19-Dec-94	27	82	73	55	
07-Feb-95	55	72	68	62	
15-Feb-95	33	23	35	22	490
21-Feb-95	18	28	25	15	367.5
28-Feb-95	34	16	24	34	>500
07-Mar-95	38	16	28	32	>500
28-Mar-95	106	179	174	213	302
04-Apr-95	82		93	40	78
11-Apr-95	82		129	58	145
17-Apr-95	37	40	37	37	63
25-Apr-95	38	29	27	19	236
02-May-95	372	503	343	396	366

Appendix C

Quality Assurance/Quality Control Results

Station	**Type of QA/QC**	**Date Time**	**Total Coliform MPN/100ml**	**Fecal Coliform MPN/100ml**	**Entero-coccus cfu**
Stream @ Hilltop	2 samples same bottle	5/9/95 11:00	110 (30)	-------	-------
HMB - BD	2 samples same bottle	5/9/95 12:00	1600 (300)	-------	-------
HMB - BD	Replicate	5/30/95 11:25	900 (900)	30 (30)	5.3 (3.1)
HMBKIDS	2 samples same bottle	8/1/95 11:00	-------	-------	16 (16)
HMBSWIM2	2 samples same bottle	8/21/95 12:15	900 (300)	500 (300)	22 (29)
HMBSWIM1	Replicate	9/6/95 11:30	220 (170)	22 (23)	-------

APPENDIX D

LOTUS WORKSHEETS AND GRAPHS

FITCH MOUNTAIN BACTERIOLOGICAL DATA
RUSSIAN RIVER

Station	Date	Time	Total Coli	Fecal Coli	E. Coli	Entero-coccus	Median Fecal Coli	Median E. Coli	Median Enterococcus	DO	pH	Temperature	COND
			MPN/100 ml	MPN/100 ml	MPN/100 ml	MPN/100 ml	MPN/100 ml	MPN/100 ml	MPN/100 ml	mg/l		degrees C	umhos/cm
(Blanks indicate no data)													
GEY	950503	1345	1600	540						10	7.9	15.7	177
GEY	950509	930	500	50	324					10.4	7.9	14.4	253
GEY	950515	1000	1601	240	200.5					10.4	8.1	14.5	242
GEY	950522	1050	1600	11	13.7								
GEY	950530	1000	1600	14	11.1	8	50						
GEY	950606	955	500	220	101.3	1	50	101.3					
GEY	950613	930	220	30	5.3	1	30	13.7					
GEY	950620	1120	50	17	5.3	3	17	11.1					
GEY	950628	1200	70	50	1	0	30	5.3	1	9	8.2	22	274
GEY	950705	1035	130	11	2	3	30	5.3	1				
GEY	950711	930	130	13		13	17		3				
GEY	950718	1015	1600	8		5	13		3	9.6	8.4	22.5	247
GEY	950724	945	50	21		12	13		5	9.5	8.3	20.8	252
GEY	950801	925	240	7		15	11		12	9	8	21.5	241
GEY	950807	1030	240	8			8			9.7	8.3	21.9	236
GEY	950814	1140	1600	8		15	8						
GEY	950821	1030	130	11		6	8			9.5	8	20.6	249
GEY	950829	935	280	30		22	8						
GEY	950906	945	130	13		10	11			9.3	8.1	19.5	229
RDWDDR	950425	1245	280	280									
RDWDDR	950503	1235	2401	540						10	7.8	15.2	170
RDWDDR	950509	1015	500	80	23.8					10	7.7	14.5	261
RDWDDR	950515	1040	1600	140	56					10.2	7.8	15	252
RDWDDR	950522	1140	300	50	13.7		140						
RDWDDR	950530	1055	500	50	17.8	3	80						
RDWDDR	950606	1030	50	30	9.9	1	50	17.8					
RDWDDR	950613	1005	70	23	13.7	2	50	13.7					
RDWDDR	950620	1150	50	50	9.9	2	50	13.7					
RDWDDR	950628	1235	50	30	8.7	3	30	9.9	2				
RDWDDR	950705	1110	130	80	4.2	6	30	9.9	2				
RDWDDR	950711	1025	500	23		4	30		3				
RDWDDR	950718	1050	170	80		5	50		4	9	8.1	22.7	295
RDWDDR	950724	1015	170	23		6	30		5	8.5	8.1	22.3	295
RDWDDR	950801	1000	240	4		7	4		6	8	8	23.7	277
STREAM1a	950425												
STREAM1a	950502												
STREAM1a	950509	1045	900	80						10.8	7.5	12.6	204
STREAM1a	950515	1025	23	13	11.1					10.6	7.5	13.6	205
STREAM1a	950522	1130	110	22	6.4								
STREAM1a	950530	1045	900	240	78.2	200.5							
STREAM1a	950606	1020	240	130	62.4	7.5	80						
STREAM1b	950425	1240	2401	1600						10.8	7.6	13.9	213
STREAM1b	950502	1225	2401	240						10.4	7.6	14.7	210
STREAM1b	950509	1030	1600	170	59.1					10.9	7.5	12.5	219
STREAM1b	950515	1050	500	130	56					10.6	7.5	13.2	220

FITCH MOUNTAIN BACTERIOLOGICAL DATA
RUSSIAN RIVER

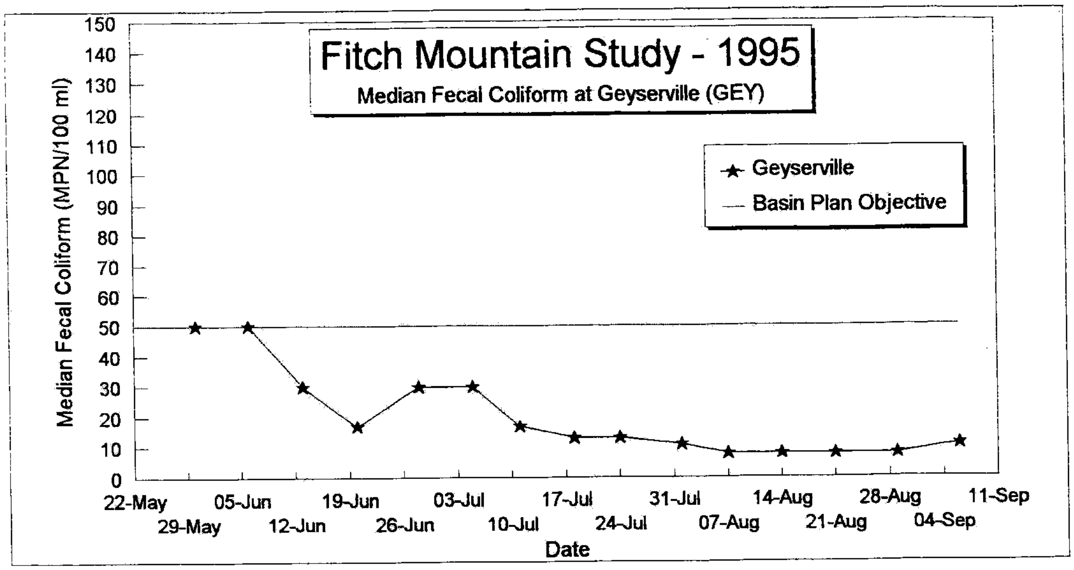
Station	Date	Time	Total Coli	Fecal Coli	E. Coli	Entero-coccus	Median Fecal Coli	Median E. Coli	Median Enterococcus	DO	pH	Temperature	COND
			MPN/100 ml	MPN/100 ml	MPN/100 ml	MPN/100 ml	MPN/100 ml	MPN/100 ml	MPN/100 ml	mg/l		degrees C	umhos/cm
(Blanks indicate no data)													
STREAM1b	950522	1135	1601	1600	201		240						
STREAM1b	950530	1045	900	240	78.2	200.5	240						
STREAM1b	950606	1035	1601	1601	200.5	201	1600	78.2					
STREAM1b	950613	1000	1601	1601	652	201	1600	200.5					
STREAM1b	950620	1150	130	7	9	9	240	200.5					
STREAM1b	950623	1230	500	240	238	200	280	200.5	200.5				
STREAM1b	950705	1105	1600	280	560	68	240	238	200				
STREAM1b	950711	1020	900	240		45			68				
STREAM2	950425	1300	140	140						9.3	7.6	13	301
STREAM2	950502	1310	350	5						10.2	7.6	13.7	241
STREAM2	950509	1100	110	1						10.2	7.5	12.4	273
STREAM2	950515	1100	300	8	2					10	7.6	13	296
STREAM2	950522	1150	110	28.8	1		8						
CR	950425	1200	240	240						10.2	8.1	17.7	275
CR	950503	1150	1600	920						10	7.8	15.3	158
CR	950509	1115	500	22	34.4					10.1	7.8	14.5	252
CR	950515	1115	1601	50	59.1					10.5	7.9	15.9	253
CR	950522	1210	240	23	22.2		50						
CR	950530	1100	900	30	17.8	3	30						
CR	950606	1050	130	50	12.4	0	30	22.2					
CR	950613	1020	70	21	13.7	2	30	17.8					
CR	950620	1215	50	30	8.7	4	30	13.7					
CR	950628	1245	50	23	12.4	6	30	12.4	3				
CR	950705	1125	30	23	7.5	5	23	12.4	4				
CR	950711						23						
CR	950718	1120	110	11		4	23			9.3	8.1	23.3	315
CR	950724	1030	170	11		5	23			8.6	8.1	22.7	294
CR	950801	1015	220	30		11	23			8.3	7.9	23.8	276
CR	950807	1110	130	11			11			8.8	7.9	22.9	273
CR	950814	1140	1600	8		15	11						
CR	950821	1115	240	13		24	11			9.4	8	22.9	274
CR	950829	1020	300	8		19	11						
CR	950906	1030	350	13		6	11			8.5	7.8	22.3	250
ALMDR	950425	1140	2401	2401						10.3	8.1	17.3	278
ALMDR	950503	1130	2401	920						10	7.8	15.3	159
ALMDR	950509	930	1600	30	32.4					10.2	7.8	14.8	252
ALMDR	950515	1130	900	80	73.8					10.3	7.9	15.4	252
ALMDR	950522	1220	300	30	27.1		80						
ALMDR	950530	1115	80	30	17.8	4.2	30						
ALMDR	950606	1105	30	13	7.5	2	30	27.1					
ALMDR	950613	1030	130	13	13.7	1	30	17.8					
ALMDR	950620	1225	30	23	6.4	13	23	13.7					
ALMDR	950628	1300	50	22	5.3	4	22	7.5	4				
ALMDR	950705	1135	80	50	2	0	22	6.4	2				
ALMDR	950711	1115	240	23		9	23		4				

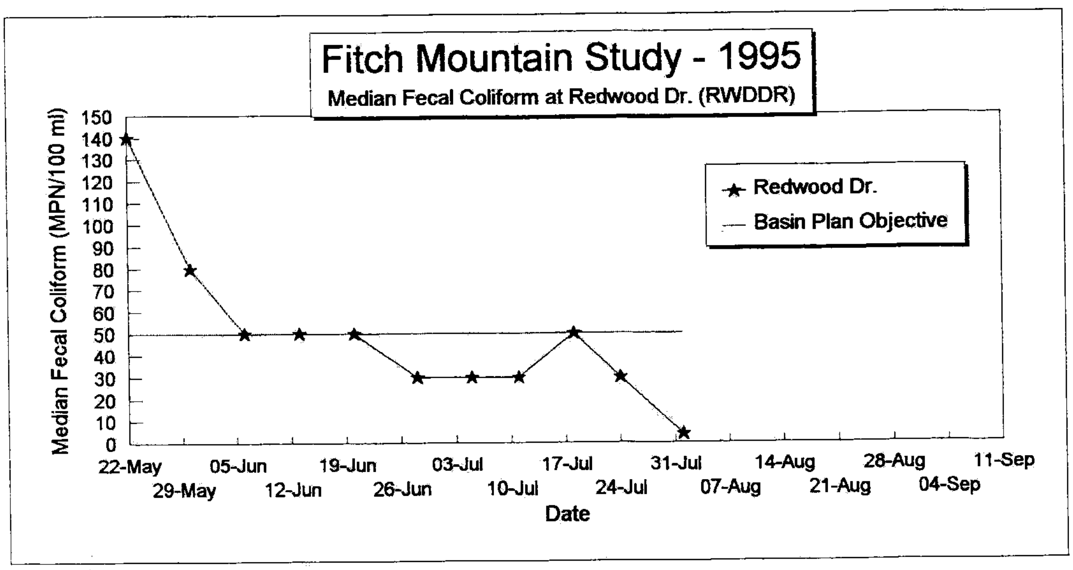
FITCH MOUNTAIN BACTERIOLOGICAL DATA
RUSSIAN RIVER

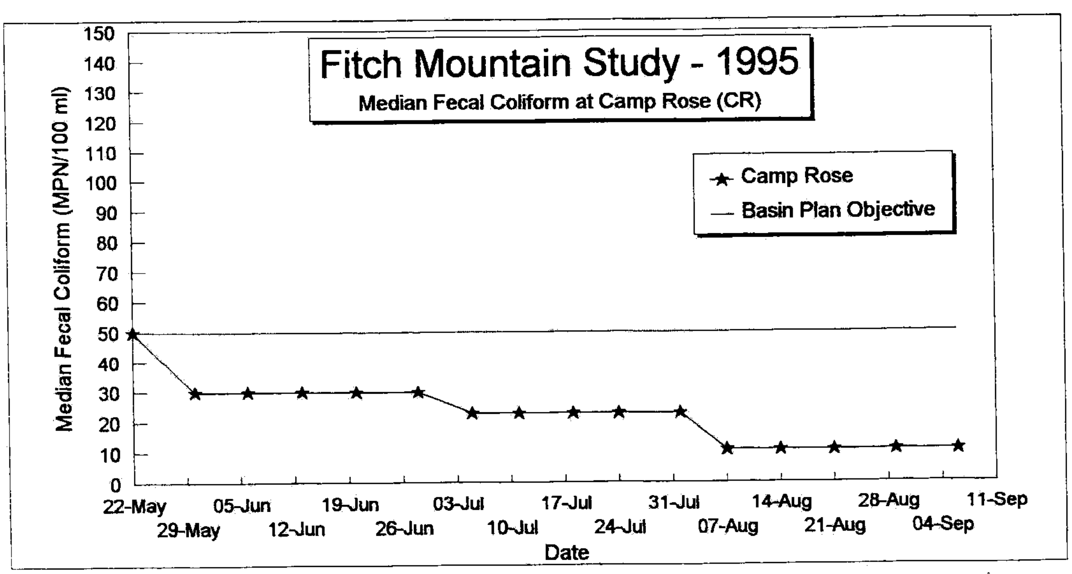
Station	Date	Time	Total Coli	Fecal Coli	E. Coli	Entero-coccus	Median Fecal Coli	Median E. Coli	Median Enterococcus	DO	pH	Temperature	COND
			MPN/100 ml	MPN/100 ml	MPN/100 ml	MPN/100 ml	MPN/100 ml	MPN/100 ml	MPN/100 ml	mg/l		degrees C	umhos/cm
(Blanks indicate no data)													
ALMDR	950718	1130	50	13		7	23		7	8.8	8.4	24.4	308
ALMDR	950724	1050	50	4		24	22		7	8.6	8.3	23.7	293
ALMDR	950801	1030	80	17		9	17		9	7.9	8	25.4	278
ALMDR	950807	1030	240	8			13			8.4	8	23.9	273
ALMDR	950814	1100	500	14		13	13						
ALMDR	950821	1140	500	22		36	14			7.8	8	23.2	280
ALMDR	950829	1010	300	30		36	17			8.5	7.9	22.7	273
ALMDR	950906	1050	500	50		12	22						
HMBSWM1	950522												
HMBSWM1	950530												
HMBSWM1	950606	1125	240	130	53.1	25							
HMBSWM1	950613	1050	80	50	73.8	28							
HMBSWM1	950620	1240	130	30	15	13							
HMBSWM1	950628	1050	140	90	42.9	27			25				
HMBSWM1	950705	1200	130	50	56	33	50	53.1	27				
HMBSWM1	950711	1140	900	23		32	50		28				
HMBSWM1	950718	1200	300	300		19	50		27				
HMBSWM1	950724	1110	500	500		15	90		27				
HMBSWM1	950801	1055	300	80		12	80		19				
HMBSWM1	950807	1155	50	50			80						
HMBSWM1	950814	1040	130	30		8	80						
HMBSWM1	950821	1210	170	80		19	80						
HMBSWM1	950829	1035	170	13		5	50						
HMBSWM1	950906	1130	220	22		10	30						
HMBKIDS	950522												
HMBKIDS	950530												
HMBKIDS	950606												
HMBKIDS	950613												
HMBKIDS	950620												
HMBKIDS	950628												
HMBKIDS	950705												
HMBKIDS	950711												
HMBKIDS	950718												
HMBKIDS	950724												
HMBKIDS	950801	1100	80	50		16							
HMBKIDS	950807	1150	130	17									
HMBKIDS	950814	1040	1600	23		10							
HMBKIDS	950821	1212	220	70		7							
HMBKIDS	950829	1040	500	30		48	30						
HMBSWM2	950522												
HMBSWM2	950530												
HMBSWM2	950606												
HMBSWM2	950613												
HMBSWM2	950620												
HMBSWM2	950628												

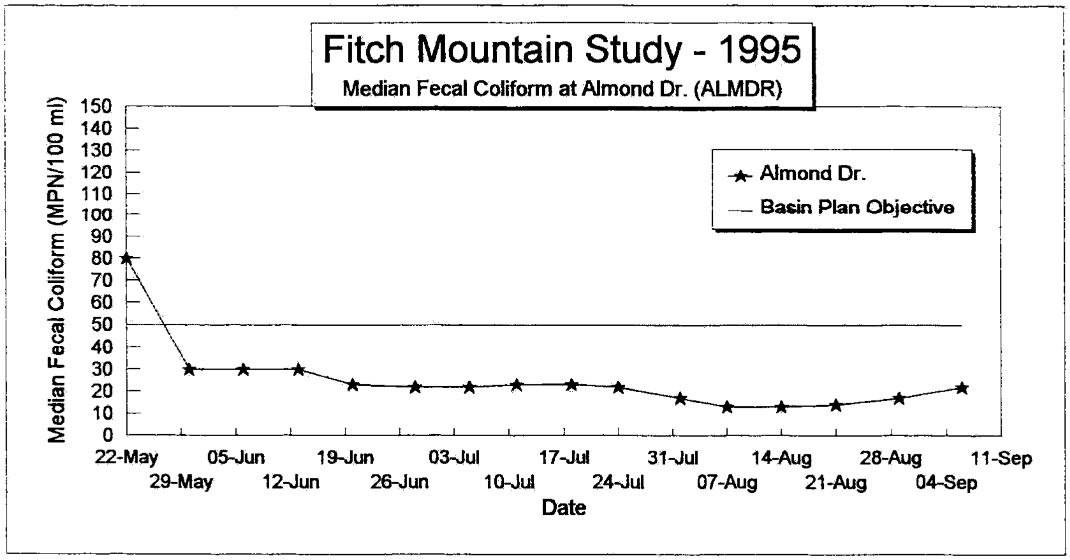
FITCH MOUNTAIN BACTERIOLOGICAL DATA
RUSSIAN RIVER

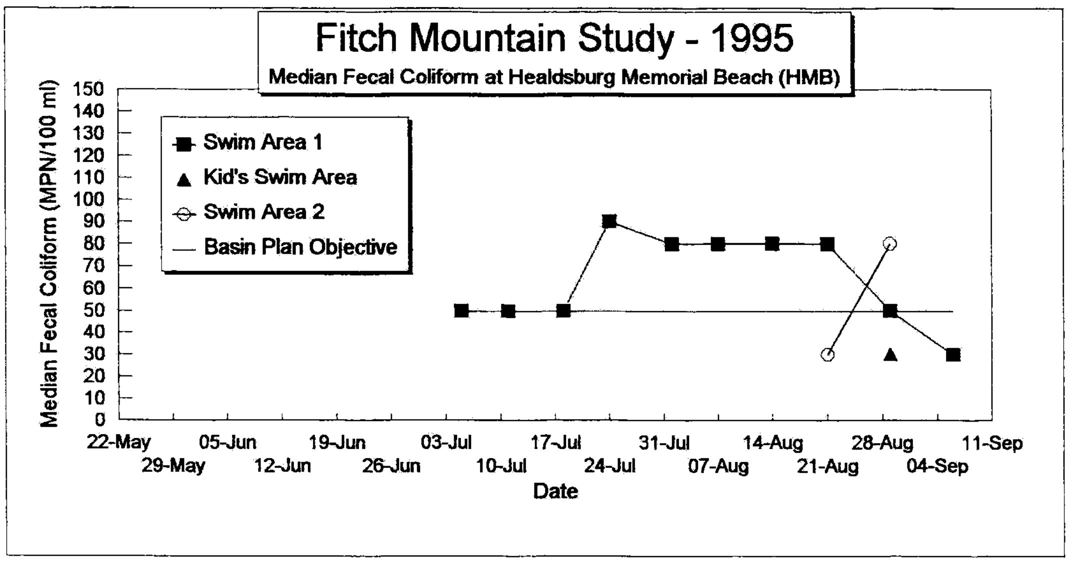
Station	Date	Time	Total Coli	Fecal Coli	E. Coli	Entero-coccus	Median Fecal Coli	Median E. Coli	Median Enterococcus	DO	pH	Temperature	COND
			MPN/100 ml	MPN/100 ml	MPN/100 ml	MPN/100 ml	MPN/100 ml	MPN/100 ml	MPN/100 ml	mg/l		degrees C	umhos/cm
(Blanks indicate no data)													
HMBSWM2	950705												
HMBSWM2	950711												
HMBSWM2	950718												
HMBSWM2	950724	1115	30	13		4							
HMBSWM2	950801	1110	170	70		10							
HMBSWM2	950807	1150	50	23									
HMBSWM2	950814	1035	500	30		16							
HMBSWM2	950821	1215	900	500		22	30						
HMBSWM2	950829	1045	900	80		5	80						
HMB-BD	950425	1340	1600	1600						10.7	8.3	19.5	277
HMB-BD	950503	1415	2401	540						10	7.9	17	171
HMB-BD	950509	1200	1600	30	40.6					10.4	7.8	15	252
HMB-BD	950515	1145	900	30	62.4					7			
HMB-BD	950522	1230	240	130	22.2		130						
HMB-BD	950530	1125	900	30	25.4	7	30						
HMB-BD	950606	1115	240	27	36.4	7	30	36.4					
HMB-BD	950613	1045	500	300	40.6	14	30	36.4					
HMB-BD	950620	1235	170	50	53.1	4	50	36.4					
HMB-BD	950628	1100	140	80	15	15	50	36.4	7	8.2	8.1	23	307
HMB-BD	950705	1210	50	50	27.1	4	50	36.4	7				
HMB-BD	950711	1140	110	50		5	50		5				
HMB-BD	950718	1210	170	70		11	50		5				
HMB-BD	950724	1130	80	13		4	50		5				
HMB-BD	950801	1115	220	17		8	50		5				
HMB-BD	950807	1205	130	30			30						
HMB-BD	950814	1030	500	13	8		17						
HMB-BD	950821	1155	130	17		12	17						
HMB-BD	950829	1050	80	23		6	17						
HMB-BD	950906	1115	1600	80		32	23						

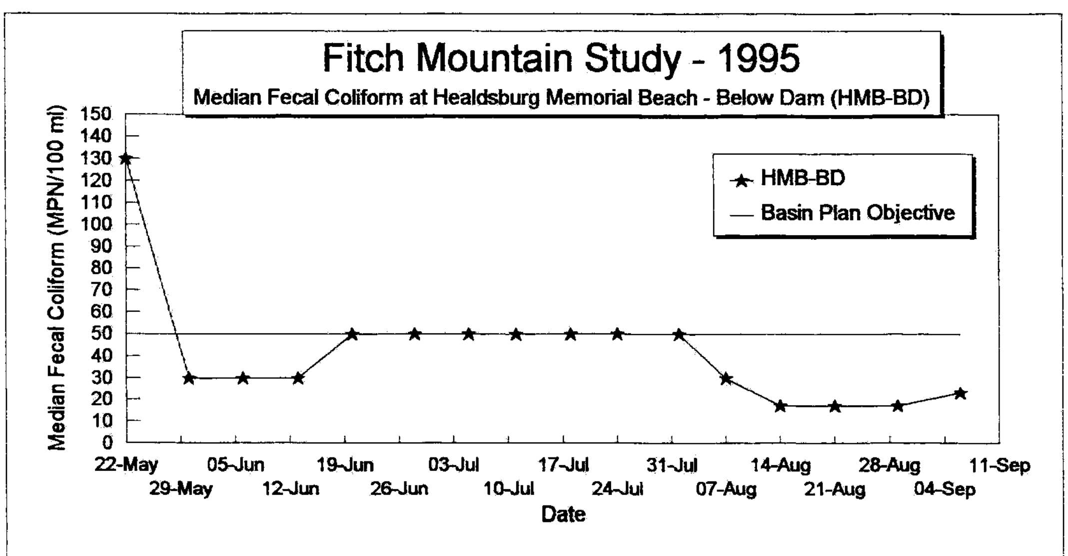

Fitch Mountain Study - 1995
Median Fecal Coliform at Geyserville (GEY)
Geyserville
Basin Plan Objective
Median Fecal Coliform (MPN/100 ml)
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
22-May
29-May
05-Jun
12-Jun
19-Jun
26-Jun
03-Jul
10-Jul
17-Jul
24-Jul
31-Jul
07-Aug
14-Aug
21-Aug
28-Aug
04-Sep
11-Sep
Date


Fitch Mountain Study - 1995
Median Fecal Coliform at Redwood Dr. (RWDDR)
Redwood Dr.
Basin Plan Objective
Median Fecal Coliform (MPN/100 ml)
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
22-May
29-May
05-Jun
12-Jun
19-Jun
26-Jun
03-Jul
10-Jul
17-Jul
24-Jul
31-Jul
07-Aug
14-Aug
21-Aug
28-Aug
04-Sep
11-Sep
Date

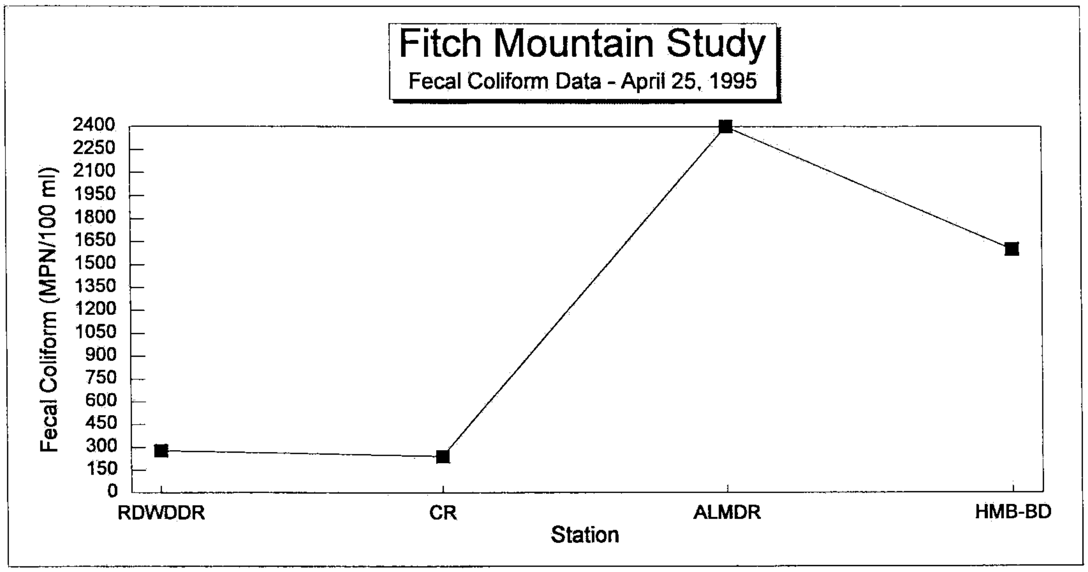

Fitch Mountain Study - 1995
Median Fecal Coliform at Camp Rose (CR)
Camp Rose
Basin Plan Objective
Median Fecal Coliform (MPN/100 ml)
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
22-May
29-May
05-Jun
12-Jun
19-Jun
26-Jun
03-Jul
10-Jul
17-Jul
24-Jul
31-Jul
07-Aug
14-Aug
21-Aug
28-Aug
04-Sep
11-Sep
Date

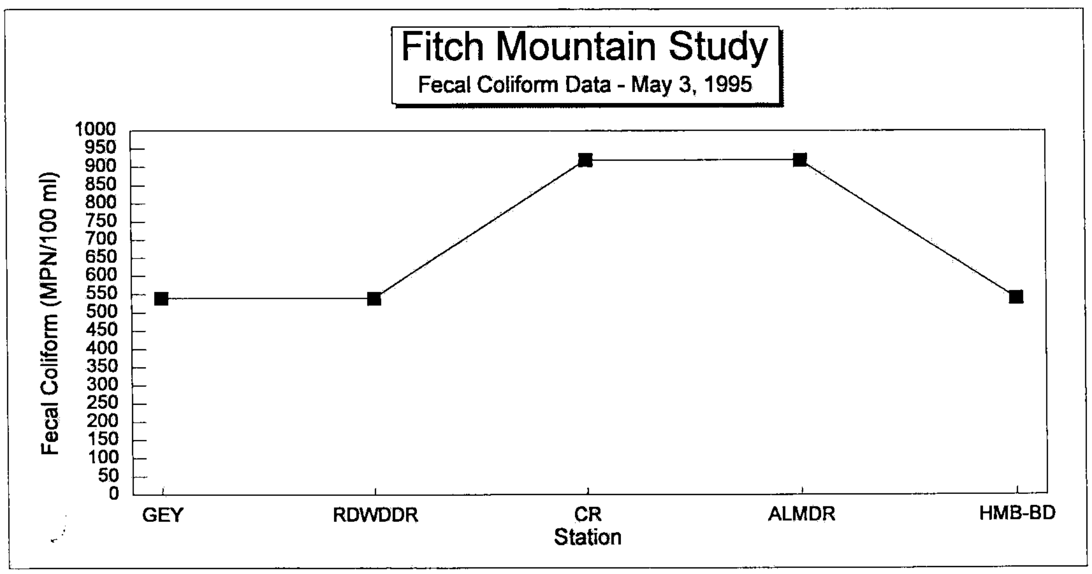

Fitch Mountain Study - 1995
Median Fecal Coliform at Almond Dr. (ALMDR)
Median Fecal Coliform (MPN/100 ml)
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Almond Dr.
Basin Plan Objective
22-May
05-Jun
19-Jun
03-Jul
17-Jul
31-Jul
14-Aug
28-Aug
11-Sep
29-May
12-Jun
26-Jun
10-Jul
24-Jul
07-Aug
21-Aug
04-Sep
Date

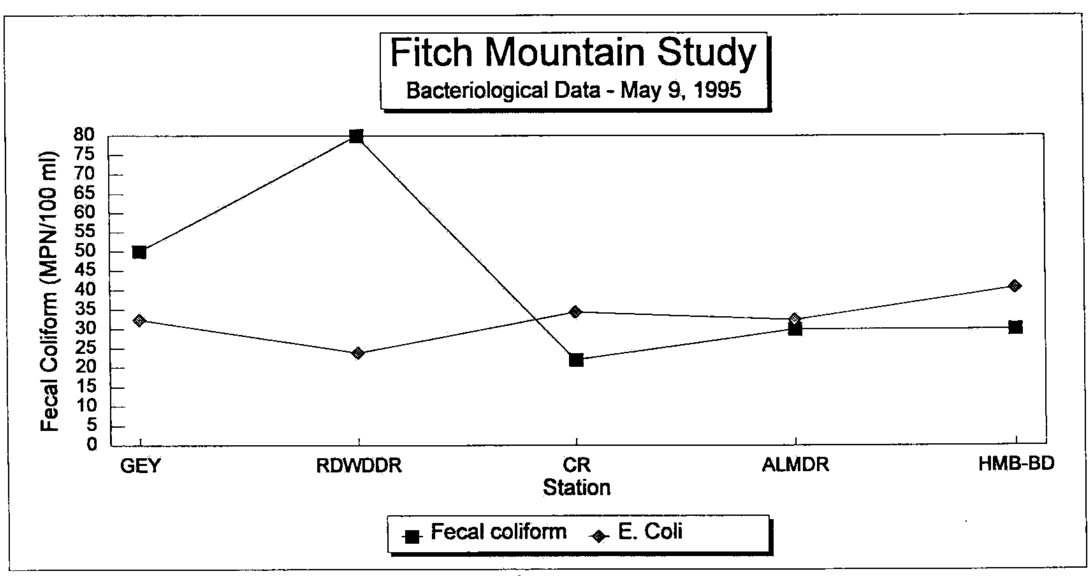

Fitch Mountain Study - 1995
Median Fecal Coliform at Healdsburg Memorial Beach (HMB)
Median Fecal Coliform (MPN/100 ml)
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Swim Area 1
Kid's Swim Area
Swim Area 2
Basin Plan Objective
22-May
05-Jun
19-Jun
03-Jul
17-Jul
31-Jul
14-Aug
28-Aug
11-Sep
29-May
12-Jun
26-Jun
10-Jul
24-Jul
07-Aug
21-Aug
04-Sep
Date


Fitch Mountain Study - 1995
Median Fecal Coliform at Healdsburg Memorial Beach - Below Dam (HMB-BD)
Median Fecal Coliform (MPN/100 ml)
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
HMB-BD
Basin Plan Objective
22-May
05-Jun
19-Jun
03-Jul
17-Jul
31-Jul
14-Aug
28-Aug
11-Sep
29-May
12-Jun
26-Jun
10-Jul
24-Jul
07-Aug
21-Aug
04-Sep
Date

NOTE: EACH GRAPH MAY HAVE A DIFFERENT SCALE







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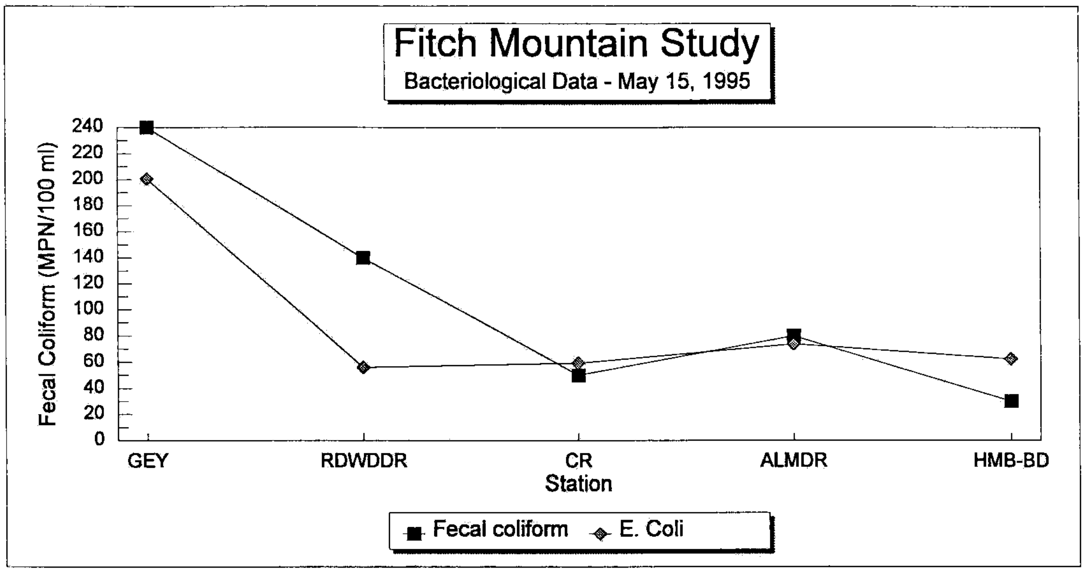

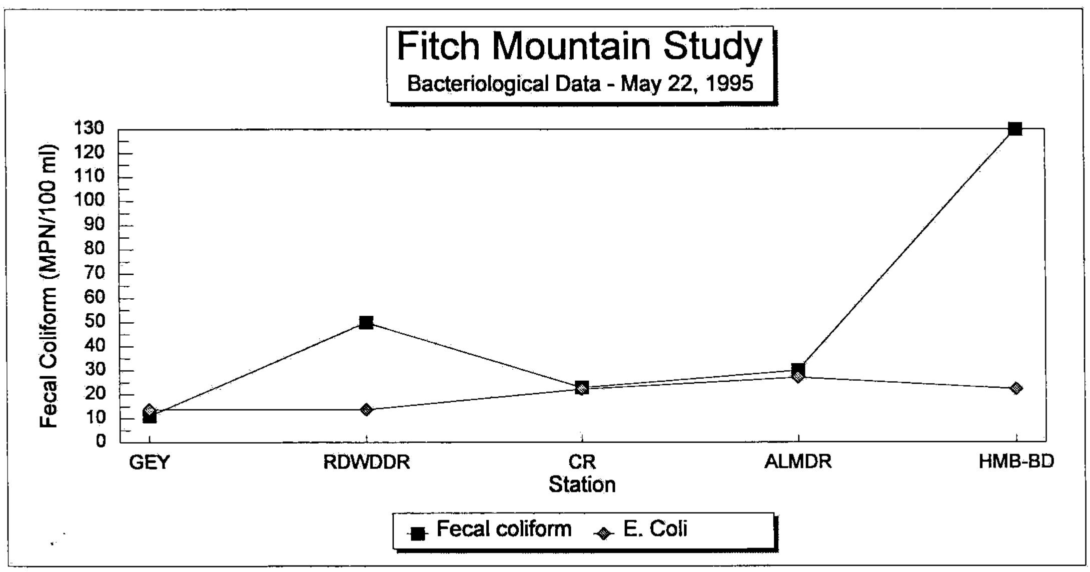

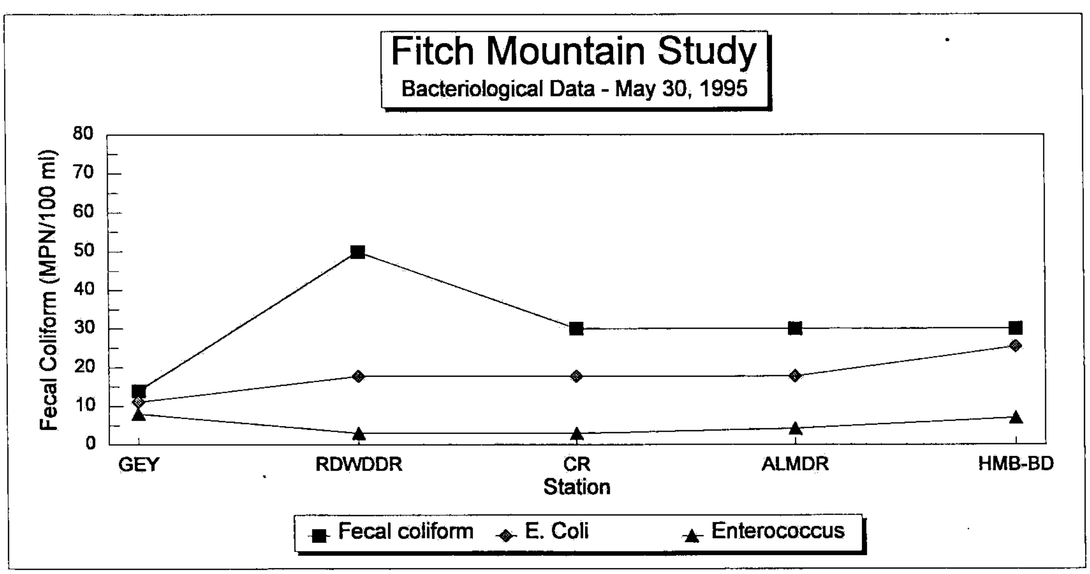

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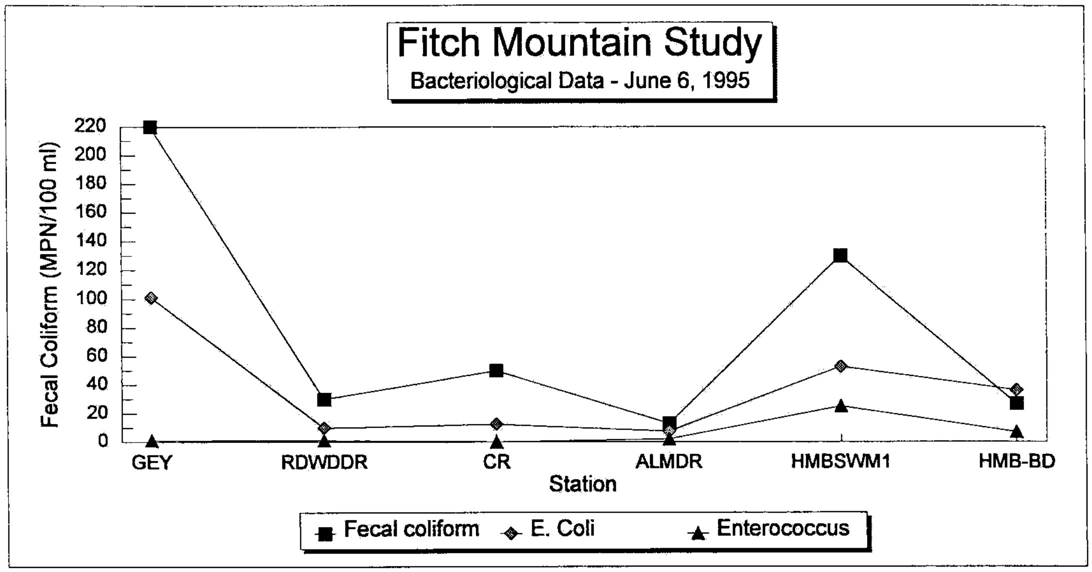

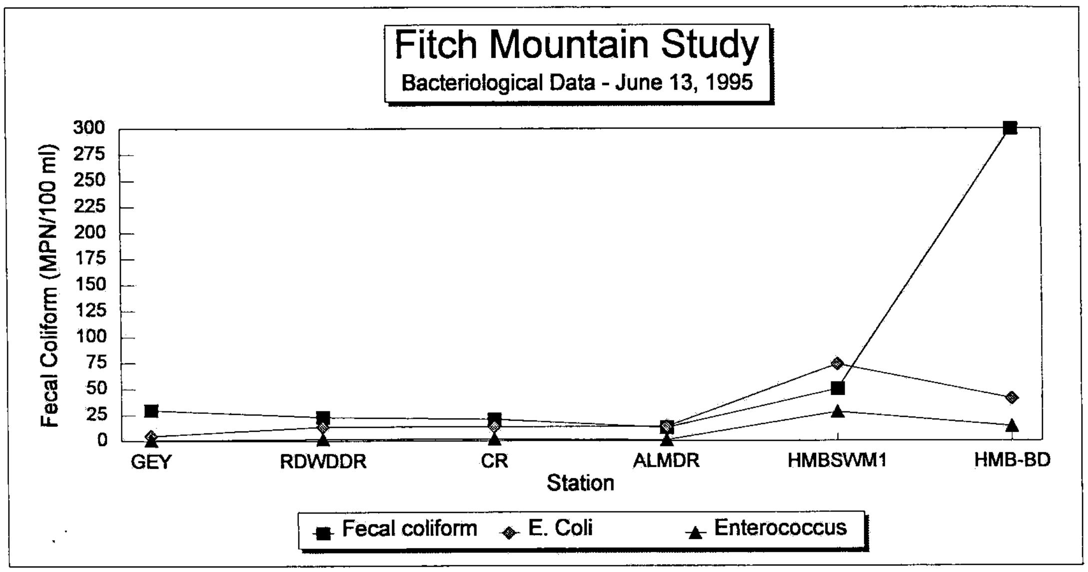

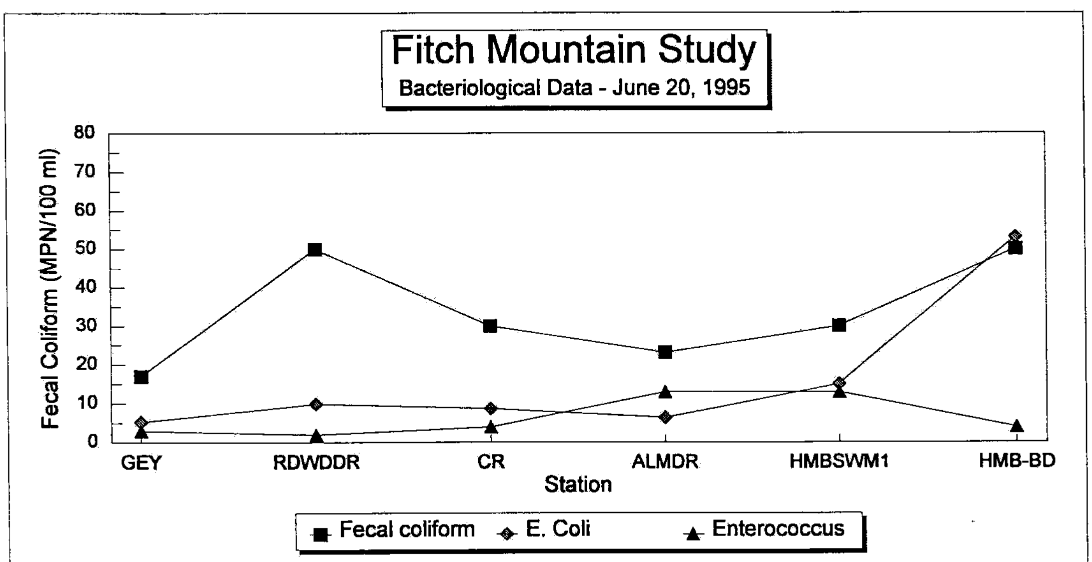

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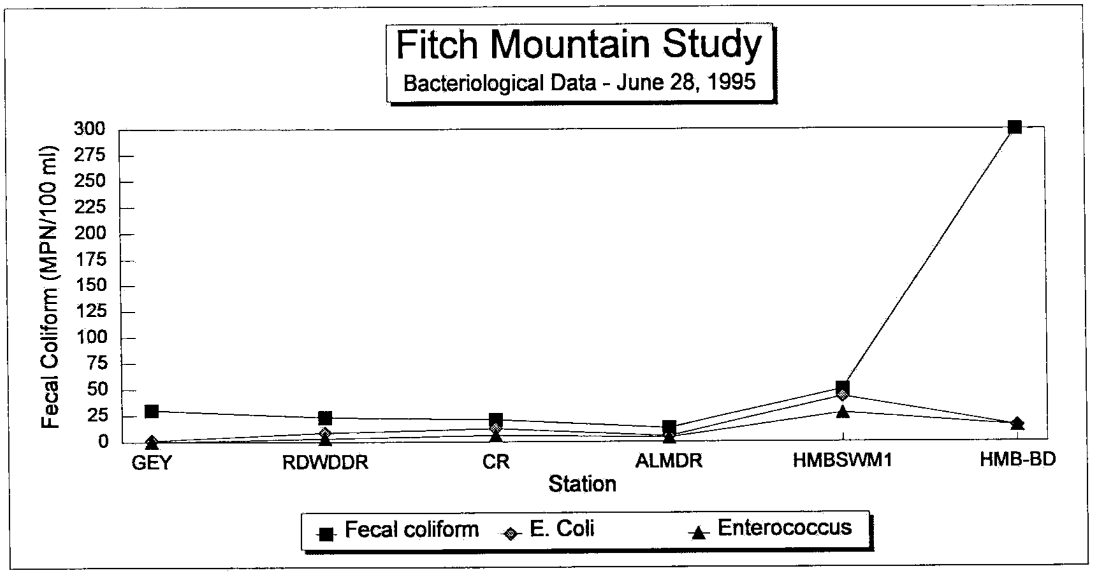

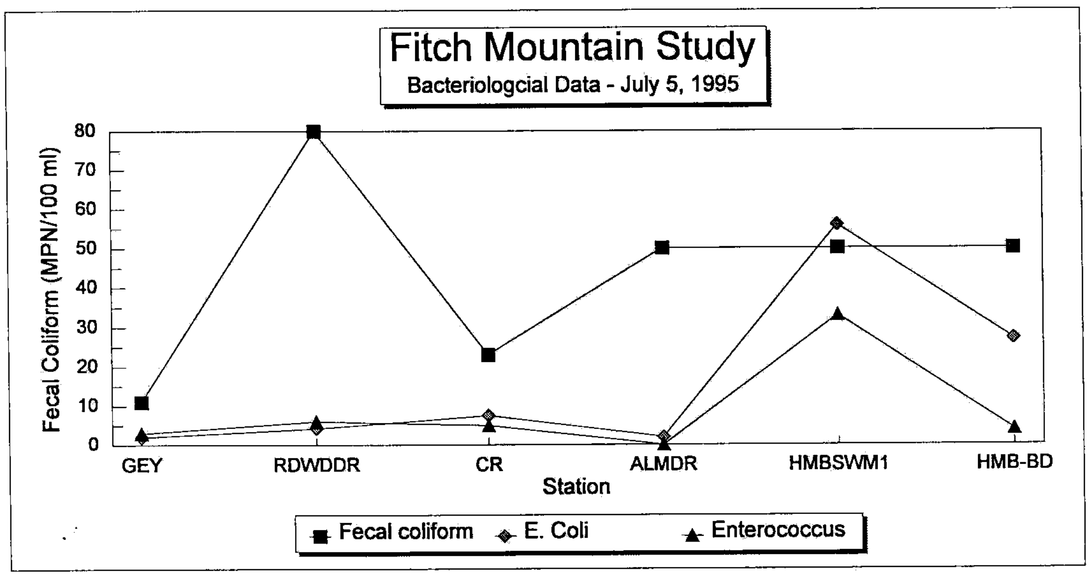

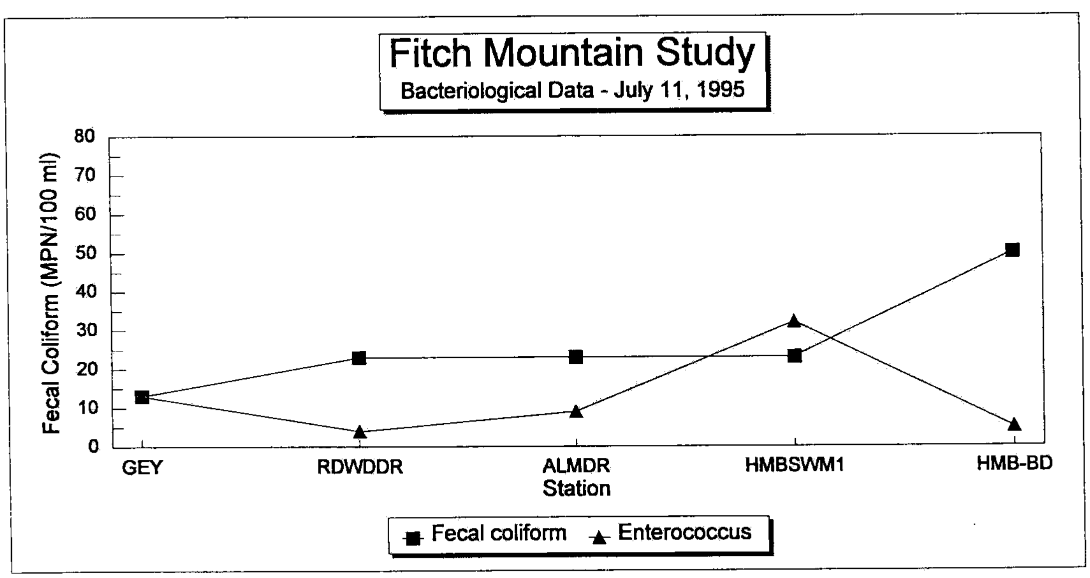

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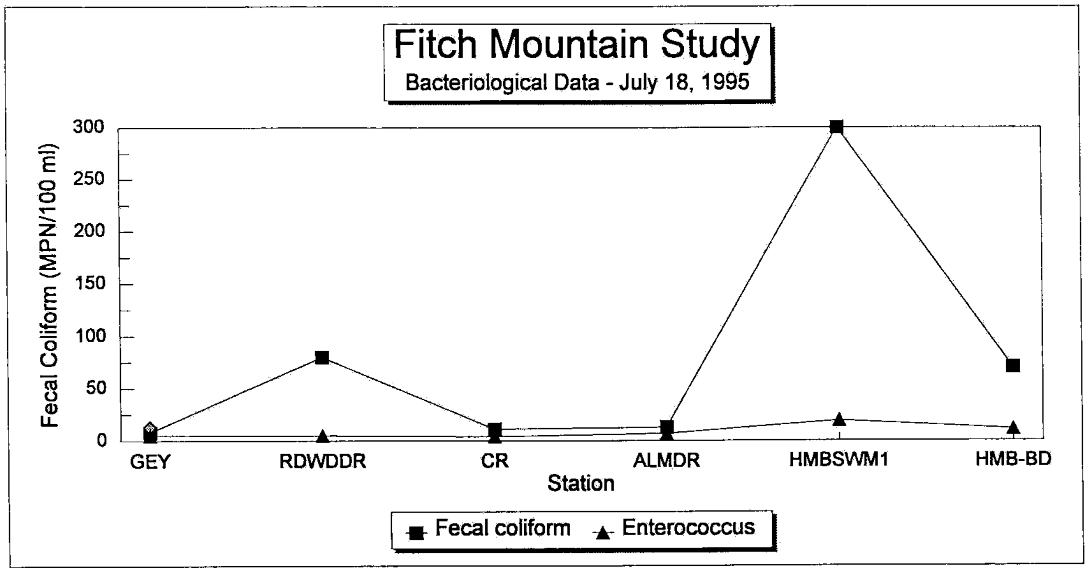
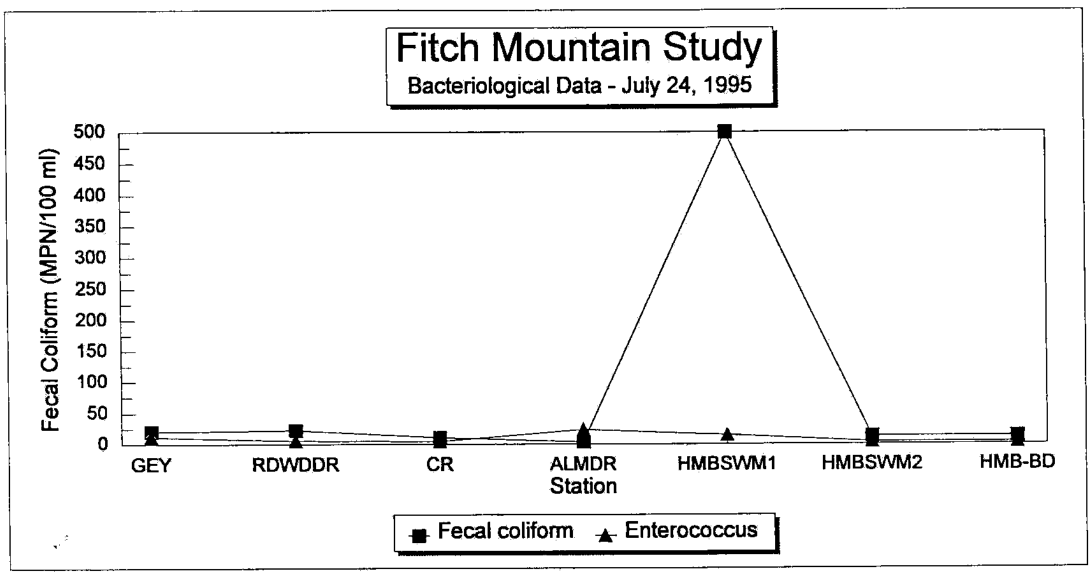
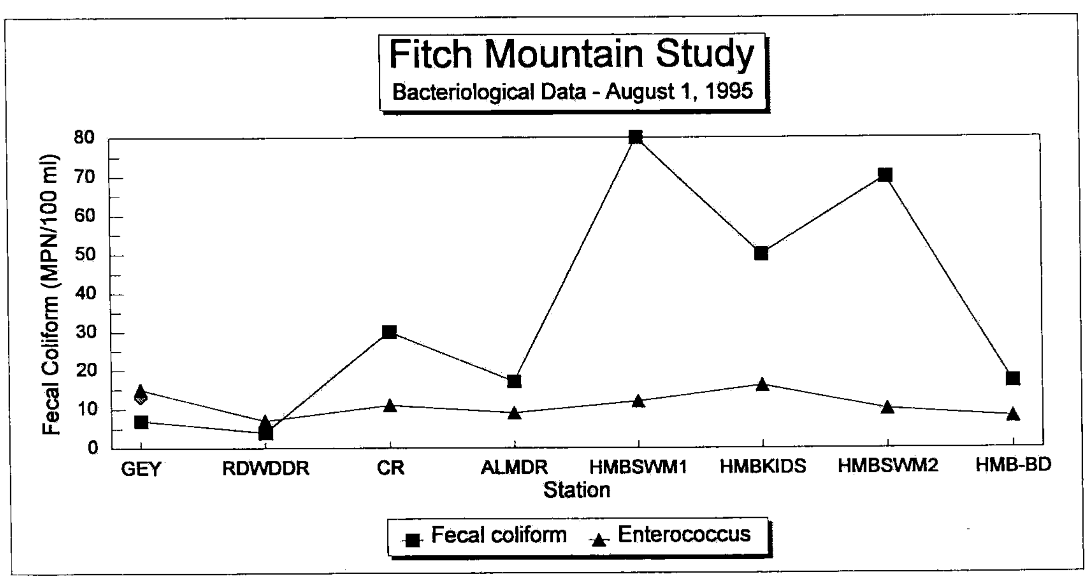
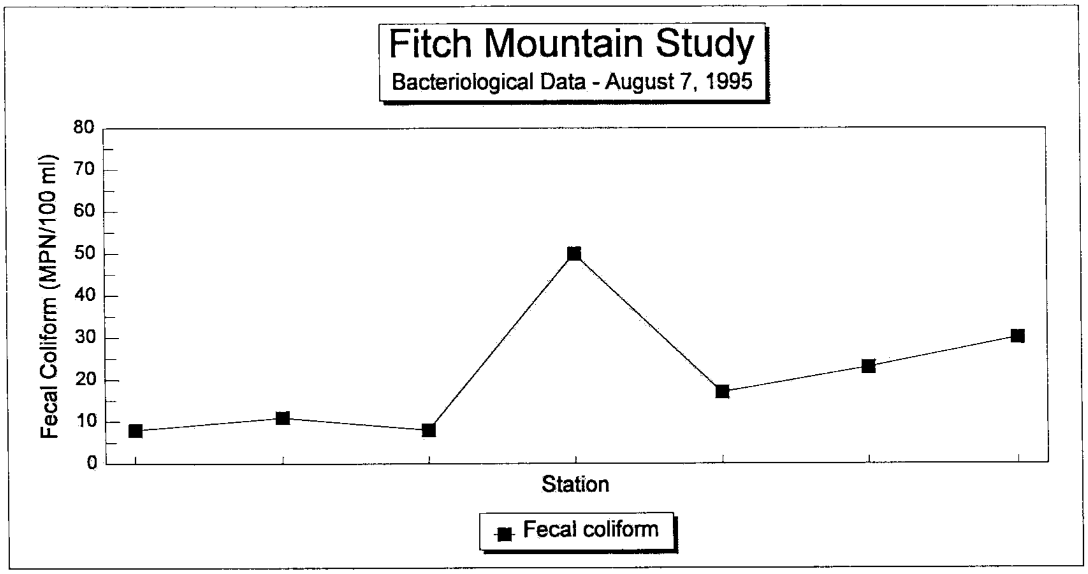
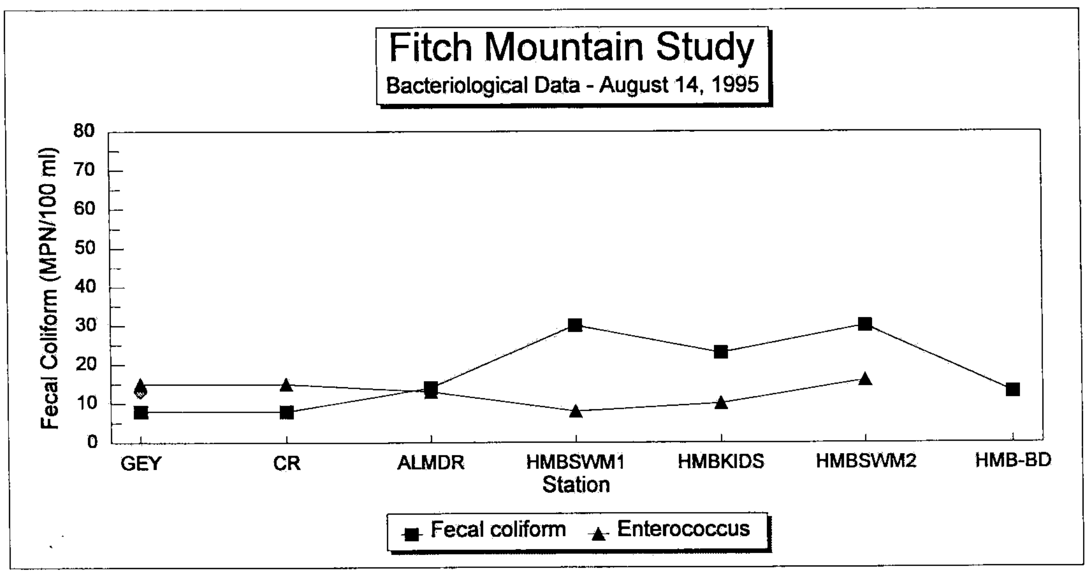


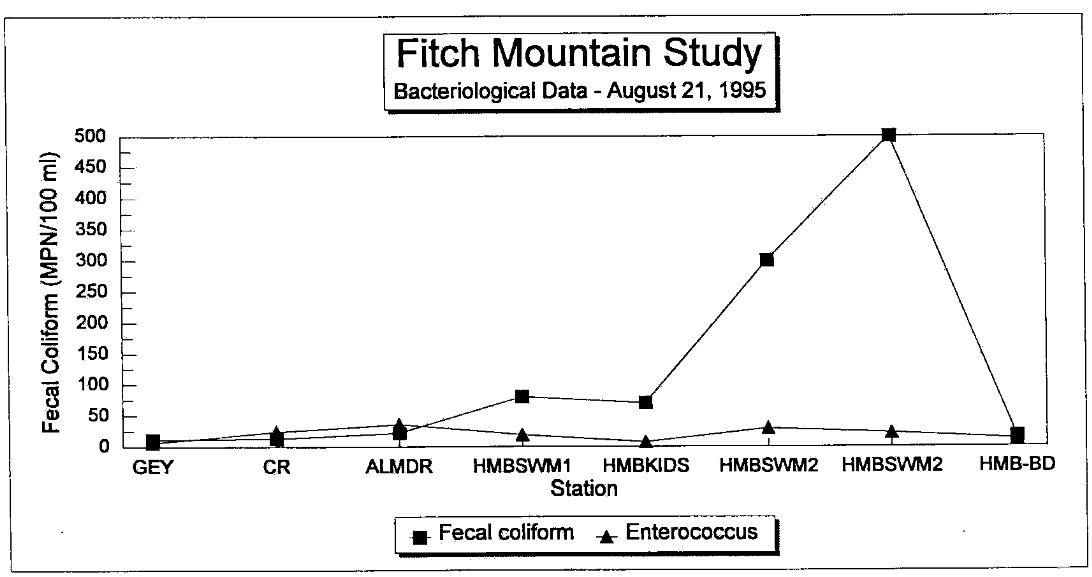




NOTE: EACH GRAPH MAY HAVE A DIFFERENT SCALE







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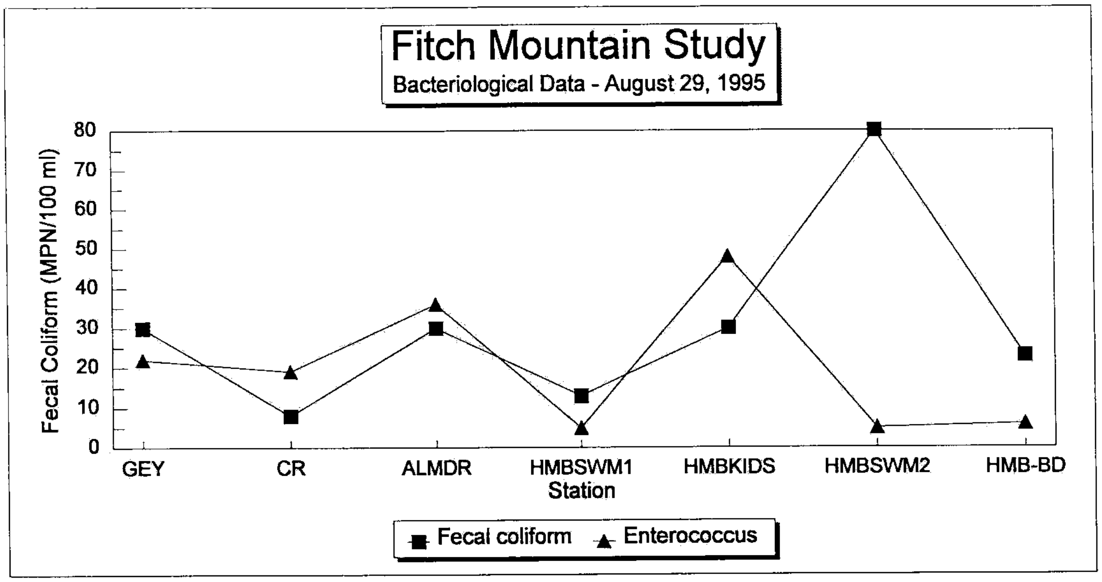

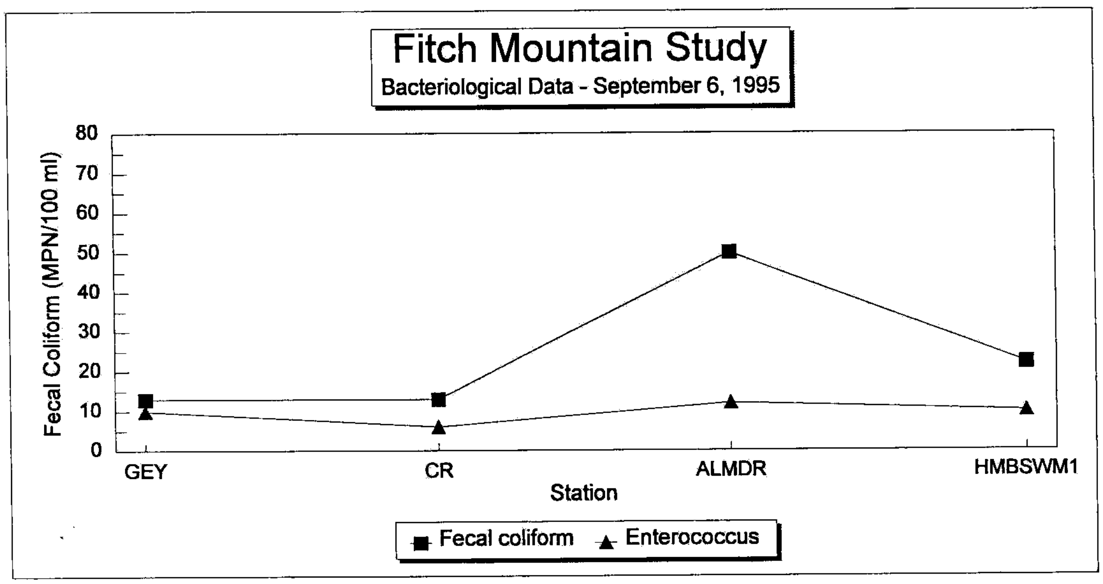

APPENDIX E

Literature describing the use of sediment bags for the determination of bacteria sources

Nix, P.G., Daykin, M.M., and Vilkas, K.L., (1994) Fecal pollution events reconstructed and sources identified using a sediment bag grid. Water Environment Research, Volume 66, Number 6, pp. 814-818.

Nix, P.G., Daykin, M.M., and Vilkas, K.L., (1990) Use of Sediment Bags as a Monitor of Fecal Pollution in Streams. Bulletin of Environmental Contamination and Toxicology, Volume 45, Number 6, pp. 864-869.

Nix, P.G., Daykin, M.M., and Vilkas, K.L., (1991) Sediment Bags as an Integrator of Fecal Contamination in Aquatic Systems. Water Research. Volume 27, Number 10, pp. 1569-1576