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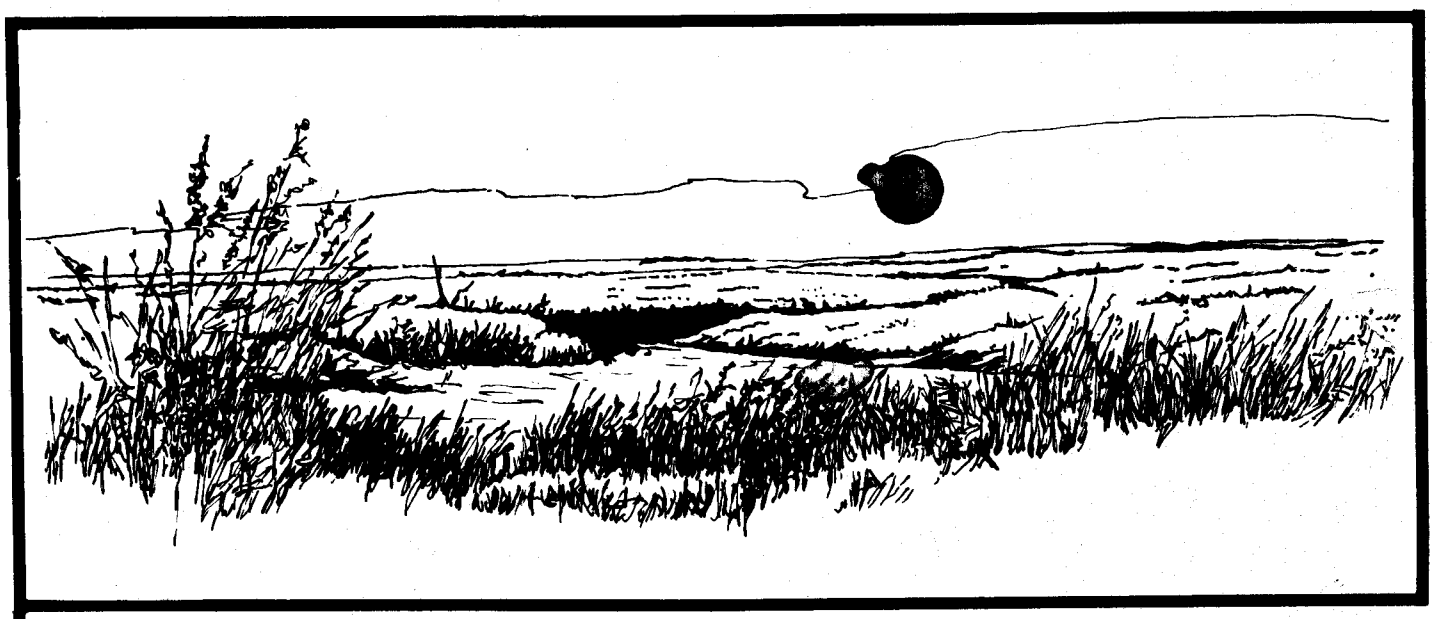

DABOB AND QUILCENE BAYS WATER QUALITY PROJECT

Welch and Banks 1987

I have known many
who could not
when they would,
for they had not done it
when they could.

Rabelais

FINAL REPORT

THE QUILCENE/DABOB BAYS WATER QUALITY PROJECT

Prepared by
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In cooperation with
Jefferson County Planning and Building Department
Port Townsend, Washington 98368

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For
Washington State Department of Ecology
Olympia, Washington 98504

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EXECUTIVE SUMMARY

In response to a report of high fecal coliform concentrations in Quilcene Bay, Jefferson County initiated a 13 month intensive analysis in the watersheds of Quilcene and Dabob Bays. In addition to identifying the major sources and extent of fecal coliform contamination, the study team developed and implemented a long term correction strategy. The sampling methodology used ambient and reconnaissance monitoring of source and recieving waters, sanitary survey, animal survey, and storm event sampling. A seal study was contracted with Cascadia Research Collective to analyze the potential for coliform contribution from the resident population of marine mammals. A Citizen's Advisory Committee was established to provide a format for public input into the planning, implementation, and correction stages of the project.

The findings of this work supported those of previous investigations in other areas of Puget Sound and Hood Canal, with identification of sources including failing septic systems, poor animal keeping practices, and possibly a large population of marine mammals. Excellent water quality existed in stream reaches with little or no human development upstream while poorer quality and water quality violations occurred in areas of animal keeping and/or residential use. Water quality was excellent in all parts of Dabob Bay, while occasional water quality violations occurred in the closure area of Quilcene Bay.

Correction of malfunctioning septic systems was undertaken as problem sites were discovered. The correction efforts were entirely voluntary with incentives offered to property owners in the form of no-cost technical assistance and septic system design, and a loan program for low to moderate income households. Response to the program was excellent. Owners of agricultural property in impacted areas were referred to the Conservation District for assistance in developing best management practices (BMP's). Response to this voluntary program was varied.

Recommendations for long term correction of water quality problems in the project area were provided both by the study team and the Citizen's Advisory Committee. Differences between the two were relatively minor. Some of the recommendations had been were included as elements of the Puget Sound Water Quality Management Plan. Research recommendations from the study team included the expansion of baseline monitoring countywide and further investigation of water quality impacts from marine mammals. Agricultural recommendations favored educational efforts and a voluntary program of watershed protection with the Conservation District providing technical assistance. Septic recommendations advocated changes in health department policies and procedures to ensure quality service and protection of the water resource, the expansion of the septic repair/loan program, and creation of a septic education program for property owners. Other recommendations included lobbying for site specific management of marine mammals, use of tax breaks to preserve wetlands, support of forest practices which fully address watershed runoff characteristics, and promotion of the voluntary use of private road standards.

INTRODUCTION

The Quilcene and Dabob watersheds are located in Jefferson County on the eastern shore of the Olympic Peninsula 30 miles south of Port Townsend, Washington. The only population center in the watersheds is the town of Quilcene, a town of about 600 residents, located at the head of Quilcene Bay.

This project was initiated after an initial examination of water quality in Quilcene Bay was conducted by the Department of Social and Health Services in 1983. The report of that examination, prepared by Kirk V. Cook, indicated that several of the marine sampling stations failed to meet U.S. Food and Drug Administration standards for water quality in areas used for commercial shellfish growing/harvest. Results of water samples taken from the Little Quilcene River and Donovan Creek seemed to point to these two tributaries as major contributors to bacterial contamination of Quilcene Bay. Based on this data the headwaters of the bay were closed to commercial shellfish growing/harvest. The closure area extends from the head of the bay to the mouth of the Big Quicene River on the western shore and the southern end of the log dump on the eastern shore. Because much of this area was not suitable for the commercial production of shellfish, the closure did not have major economic repercussions. Its importance, rather, has been to raise a red flag that a water quality problem existed and that the shellfish harvest outside the closure area could be threatened.

No sewage treatment plants or major industrial outfalls exist in Quilcene or Dabob Bays. With no point sources identified, non-point sources became the object of concern. Suspected fecal contributors in the watershed included failing septic systems, livestock, seals, and native fauna. Recognizing the importance of the shellfish industry and the potential for a worsening of the water quality situation, Jefferson County applied for and received grants from the Washington Department of Ecology to conduct an in-depth study of the problem and begin correction of identified sources.

The objectives of this project were as follows:

> To characterize baseline fecal coliform levels to define the magnitude and geographic extent of fecal contamination in the watersheds and to provide sufficient baseline data so that future monitoring would be able to detect changes in the water quality.
>
> To locate and evaluate actual and potential sources of bacterial contamination. This included reconaisance monitoring, a sanitary survey of septic systems, a survey of farms and animal keeping, and a study of the impact of harbor seals on water quality.
>
> To provide information on the benefits of clean water and to inform the residents of the importance of individual efforts in protecting water quality.

To develop and implement a correction strategy to remove as many identified sources as possible.

To recommend a plan of action for the future reduction and prevention of bacterial contamination.

To establish a Citizen's Advisory Committee which would provide a mechanism for direct public input into the process of reviewing data, formulating conclusions, and developing management recommendations.

PROJECT AREA DESCRIPTION

Geology

The geology of the project area consists of basalt ridges, low gradient valley bottoms, and river outwash. A major geologic factor in determining the susceptibility of the project area to bacterial contamination is the glaciation that occurred 12,000 to 15,000 years ago. These glaciers brought great quantities of medium and course textured gravelly and stony material from as far away as 500 miles. As the immense Vashon glacier merged with the Olympic Glacier along the flanks of the northern and eastern Olympic Mountains they built up to a thickness of as much as 3000 feet. This great weight of ice deposited and compressed thick layers of glacial material and formed the thick, very compact, weakly cemented layers of glacial till that are common in the project area today. Today this "hardpan" is widely found at a depth of 10" to 40" and acts as a barrier to water absorption. The high water tables which may result can create special problems for pasture management and can interfere with the proper functioning of septic systems.

The valley bottoms and the area stretching between the Big Quilcene and Little Quilcene Rivers consists of alluvial outwash of sand and gravel with localized silt, clay, or peat deposits. Due to their topographic position, nearly level slopes and fine textured soil, the seasonal high water perches at depths of 0-24 inches below the surface in much of this area.

Climate

The project area has a maritime climate characterized by short, dry summers and long, cool, wet winters. Rainfall data recorded at the Quilcene Ranger Station shows average annual rainfall from 1950 to 1986 to be about 49 inches, over 77% of which falls from October through March. Ambient temperatures are moderated by Puget Sound. Summertime highs are generally in the 70's and wintertime lows in the 30's.

Except for an unusually wet January, rainfall for the project period is fairly consistent with historical records (Table 1). To facilitate an analysis of water quality in various conditions, the project period was divided into wet (winter) and dry (summer) seasons. The first major rainfall of the winter months followed the sampling run on 10/27/86. Subsequent sampling was included in the the wet season analysis of data and statistical comparisons. Although stream flows remained moderately high, 3/9/87 was chosen as the end of the wet season with the llast major storm occurring 3/6/87.

Socio-Economic

The project area is sparsely populated with only about 1300 residents, 600 of

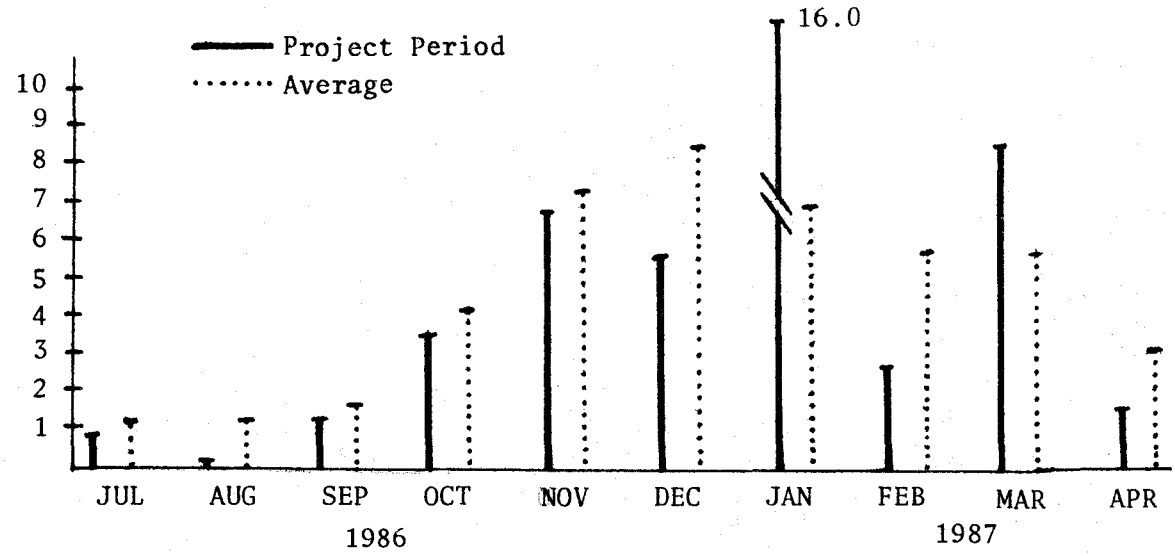


TABLE 1. MONTHLY RAINFALL TOTALS, INCHES

whom reside in the Town of Quilcene. The economy of the area is resource based, being primarily forest and water related. A multitude of industries based on these resources support schools and related commercial development.

The majority of the project area is forested and used for timber production with the timber industry, including the US Forest Service, being the largest employer in the area. Although the industry has experienced setbacks in the past few years, 1987 will be a boom year. Over 3000 acres of the Little Quilcene drainage will be logged in 1987 with the log rafting operation expected to handle up to 50 million board feet of logs as a result. While this is a boon for the local economy, it may have impact on water quality in the region. Other forest related industries include seasonal brush and bough picking, silvacultural activities, firewood cutting, and recreation.

Industries based upon water resources provide the next largest employment base. There are over 10 commercial shellfish growers in the area. In addition to being world famous for the quality of the oysters it produces, Quilcene Bay is one of the few areas where a consistent spawning of oysters occurs. Located on the west shore of Quilcene Bay is a shellfish hatchery which supplies a company that markets in excess of 350,000 gallons of oyster meat per year. Other water based industries include a federal hatchery on the Big Quilcene River, small scale salmon ranching operation, and commercial and recreational shellfish and fin fish production.

A considerable amount of small scale agriculture is occurring in the project area. Most agricultural employment is supplimental to the primary source of income. The remaining employment base in the area is provided by education, services, and small commercial establishments.

Beneficial Uses

Quilcene and Dabob bays support a number of beneficial uses. Together they support more than 10 commercial shellfish operations as well as the largest

shellfish hatchery in the world. Other marine resources include crab, shrimp, salmon, and searun cutthroat. As well, herring spawn on eelgrass in the shallower portions of the bays and large numbers of waterfowl reside in or migrate through the area. Because the waters of Quilcene Bay warm considerably during summer months, it is also a desirable recreational resource for boating, fishing, and swimming.

Timber resources are a predominant economic factor in the project area. Annual production averages 150 million board feet. In addition, there exists on the northeast shore of Quilcene Bay a log rafting area which handles 15-30 million board feet of logs per year. The log dump also provides a haulout area for a large resident seal population.

Because of its depth and relatively gentle currents, Dabob Bay is used extensively by the Navy for torpedo testing. At the north end of the bay and separated from it by two large sand spits is Tarboo Bay. The outer spit, Long Spit, as recently been acquired by the Nature Conservancy to preserve its highly valuable habitat. On the southwest shore of Dabob Bay is the Washington Department of Fisheries shellfish laboratory at Whitney Point.

Bay Characteristics

Quilcene Bay possesses a number of qualities which make it unique in the Puget Sound region. One of these features is the temperature of the water. The Bay's somewhat protected location limits water circulation during warm summer months and allows surface layers of water to stratify and warm dramatically. Temperatures of 70 degrees are not uncommon.

Unlike the nutrient rich tidelands of southern Puget Sound and Hood Canal, much of Quilcene Bay's economic value lies in its clean, nutrient deficient water quality. This purity, along with the warming of the waters in the summer months, makes it an ideal location for the natural spawning of oysters without the high mortality rates encountered in nutrient and micro-organism rich waters. For this reason, Quilcene Bay's value to the shellfish industry globally is not only for its highly praised shellfish, but for its commercial production of natural and hatchery raised oyster seed.

The northern half of Quilcene Bay is shallow and bares on an extremely low tide. As a result, the tidal flushing action in this area is quite pronounced. A large amount of freshwater enters the bay in this shallow area via the Big and Little Quilcene Rivers and a number of smaller surface and groundwater inputs. This freshwater remains, to varying degrees, unmixed on the surface of the bay and, during periods of heavy freshwater input, may extend to a depth of 1/2 meter or more. The predominant current in the shallower portion of the bay is just to the west of the log dump opposite the Big and Little Quilcene River deltas. Ambient station Q2 is located in that channel.

The characteristics of Dabob Bay are dissimilar to those of Quilcene Bay. Virtually all of Dabob Bay is extremely deep, extending to 600 feet or more in places. As a result, it tends to be less affected than Quilcene Bay by climatic factors. Similarly, one would expect it to be less affected by human impacts.

BO – BIG QUILCENE
LO – LITTLE QUILCENE
LL – LELAND
DV – DONOVAN
TB – TARBOO
CY – COYLE
CD – CEMETERY DRAIN

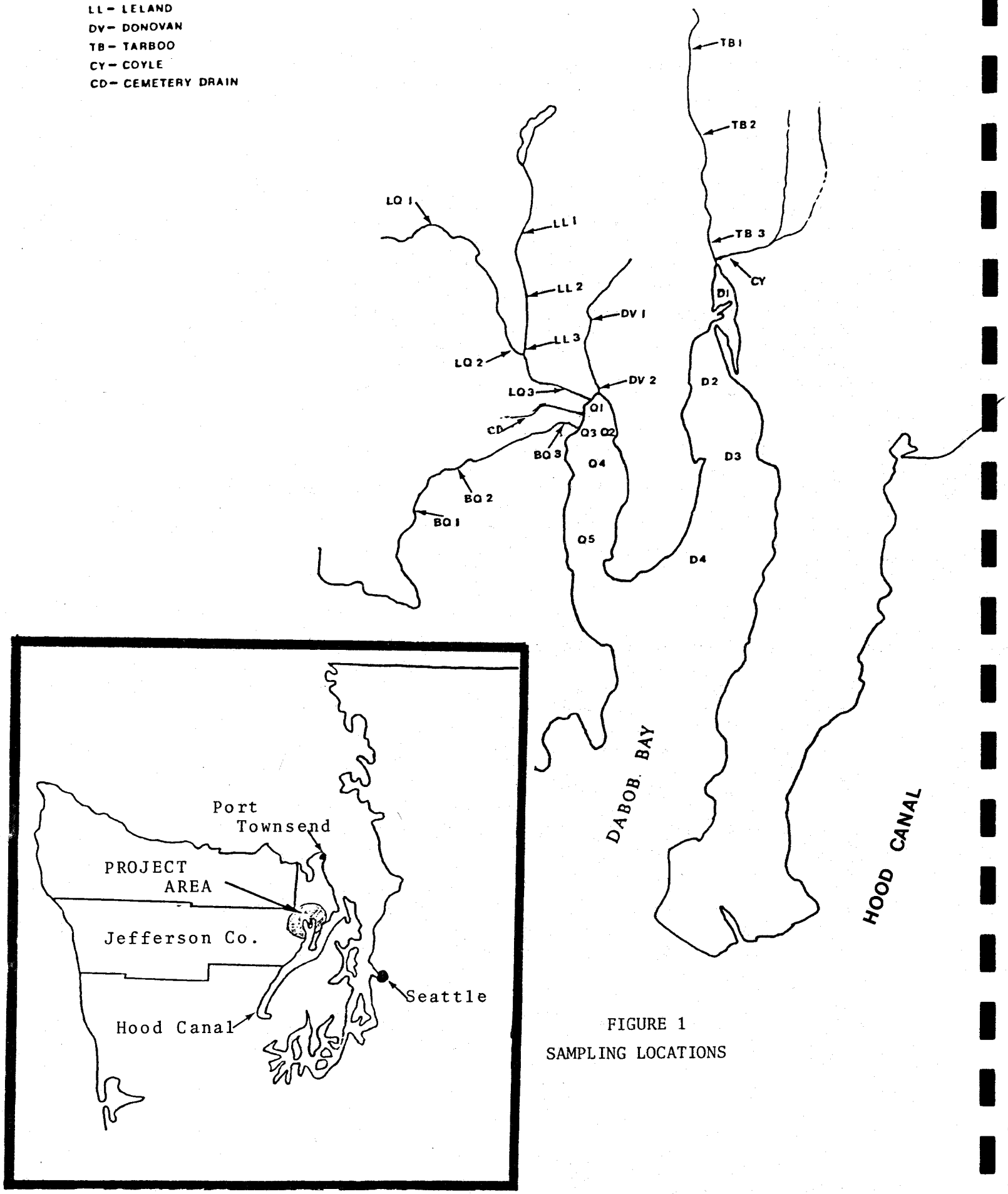


FIGURE 1
SAMPLING LOCATIONS

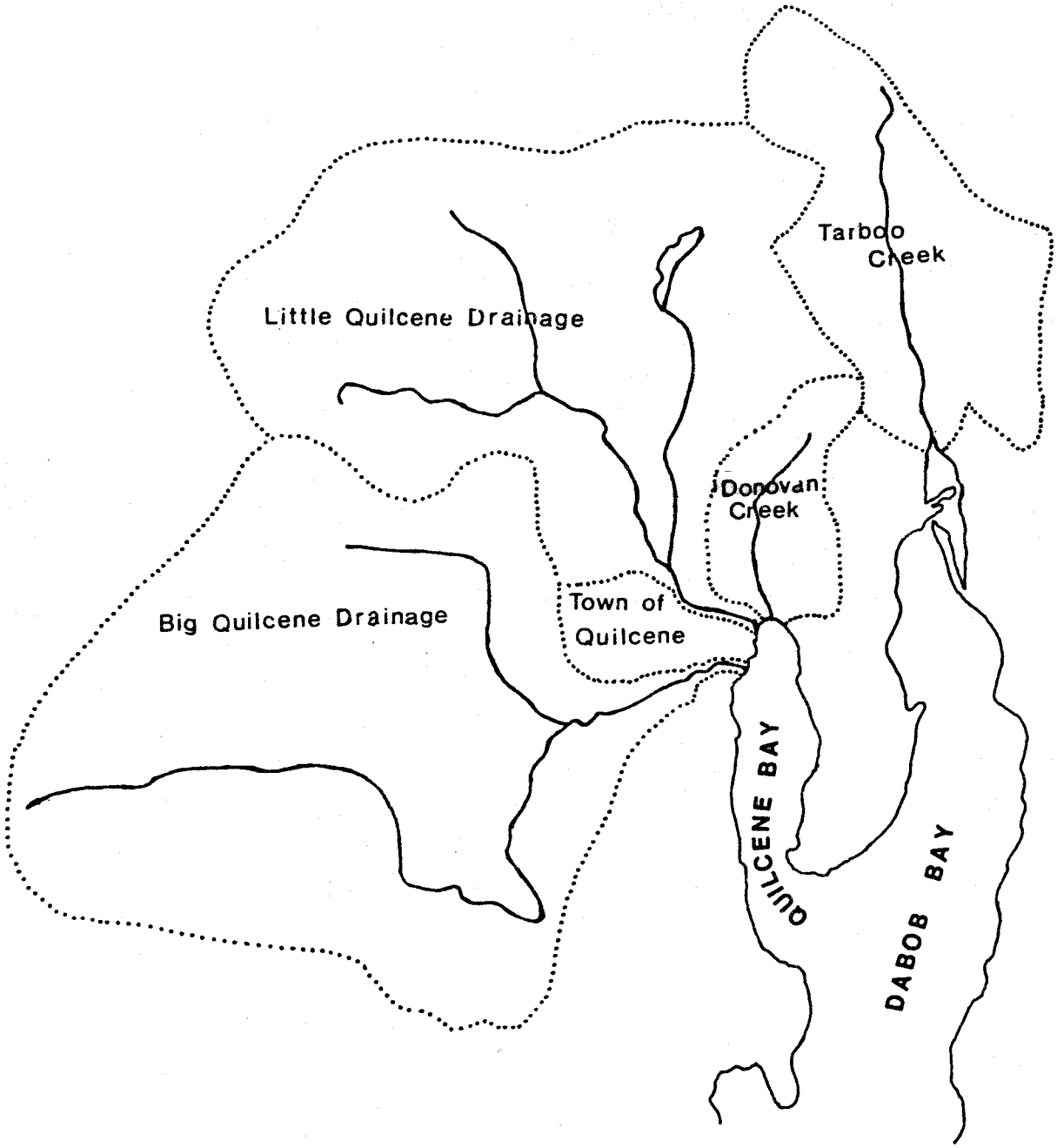


FIGURE 2

MAJOR DRAINAGE AREAS

Unlike Quilcene Bay, Dabob does not gradually become shallower as it nears its head. Instead, it remains deep in the northernmost portion of the bay where two large sands spits are located. Moving into the shallow water north of those spits, the nature of the bay changes enough that it is often referred to as Tarboo Bay. Tarboo is approximately 70 acres in size and, since it drains on a low tide, tends to reflect ambient temperatures and freshwater inputs more than does Dabob Bay.

Topography

The project area encompasses a wide range of topographic features. The Big and Little Quilcene Rivers drain the eastern portion of the Olympic Mountains and have their headwaters at elevations exceeding 4000 feet. The lower reaches of these two rivers flow through gently rolling terrain at or near sea level. The Town of Quilcene is situated in this alluvial plain and is where the majority of the human impact occurs. The short, low to moderate gradient streams of Leland, Donovan, and Cemetary Creeks flow through this area. The entire eastern shore of Quilcene Bay and the majority of the western shore is comprised of high bluff, steep, low to moderate stability slopes.

Like Quilcene Bay, the east and west shores of Dabob Bay are steep and unstable. Except for the portion on the southwest shore paralleled by Hwy 101, road access to the water is provided only at the head of the bay and four areas of light residential development.

METHODS

Monitoring

Like many water quality investigations in other areas of Puget Sound, the project in the Quilcene area was initiated in response to violations in water quality standards for shellfish growing areas. The parameter used in this study was the enumeration of fecal coliform. This indicator is nationally recognized as an indicator of fecal contamination in fresh and marine waters and shellfish growing areas.

Not typically pathogenic in itself, fecal coliform is a reliable indicator of contamination by fecal sources. It does not, however, lend itself to the differentiation of bacterial sources strictly through laboratory analysis. To mitigate this limitation, a variety of techniques were employed to attempt to quantify, isolate, and confirm the nature of the bacterial sources. In addition to the ambient sampling program, these included reconnaissance sampling, land use mapping, and sanitary and animal surveys.

The purpose of the ambient program was to provide baseline information on fecal coliform density over space and time. This set of data was analyzed statistically to draw general conclusions regarding the nature and extent of the contamination while providing the foundation for continued monitoring. If the program is continued or repeated in the future, statistical tests can then be applied to determine the amount of change that has occured over time. The program was established for both fresh and marine waters. The freshwater program was designed so that each station bracketed a predominant land use in the drainage. Eighteen freshwater stations were monitored for a 10 month period. The marine stations were located to emphasize the shellfish closure area in Quilcene Bay (Fig. 2). Nine marine stations were established.

The nature of non-point pollution problems requires that a search be made, not for "the source" of the pollution but for all of the nearly insignificant inputs into the watershed. Water quality impacts from tributaries, ditches, and overland flows can be determined by sampling above and below the inputs, as well as from the input itself. This is a highly effective means of identifying sources when stream flows are small enough to exhibit quantifiable changes in fecal coliform concentrations.

In addition to identifying pollutant sources in the watersheds, it is necessary to quantify those sources, to the extent possible, so that correction efforts can be directed first at the most significant issues. For this reason, effective water quality investigations must include more than bacterial concentrations. Because a concentration of 50 in a large river reflects a more significant pollution source than a similar count at a lower flow or in a smaller stream, an analysis of stream flow in conjunction with concentrations is necessary. The product of the concentration and the flow, the stream loading, provides the researcher with this ability.

Stream flows were measured and loading calculated at the lowest station on each of the watercourses and their major tributaries as a part of the ambient fresh water monitoring program. The cumulative effect of small tributaries and inputs into streams was much more difficult to quantify, however. For example, tributaries which provide no pollutant input would result in no change in total stream loading of the pollutant, although the concentration would decrease due to dilution. This effect of tributary input on concentrations can thus account for some of the statistical variation seen in the results and should not be mistaken for bacterial reduction through stream purification.

Reconnaissance monitoring involved taking up to 100 water samples in a particular drainage over a period of a day or two to further define the existence and location of sources. This sampling was conducted twice for most drainages to provide a wet-season, dry-season comparison. Reconnaissance monitoring is, however, limited in its use. Even though a large number of samples are taken, the sample data does not provide a useable statistical baseline because it reflects environmental conditions only on those dates. When this information is taken together with surveys of land use, soils, septic systems, and animals, however, it can provide an useful snapshot of the watershed. This information, compiled on drainage area maps, can be used to pinpoint source areas of bacterial contamination. In this way correction efforts can be targeted in locations that can provide the greatest benefits.

Sampling was conducted at each marine and freshwater ambient monitoring station at least once per month for 10 months with replicate samples taken at all stations. Attempts were made to sample fresh and marine stations with as little delay as possible given lab, weather, and time constraints. Samples were taken at 1 to 6 inches from the surface to maintain consistency with historical records and monitoring protocol. No sediment or water column sampling was conducted. Samples were stored at temperatures of 4 degrees C or less from time of collection and were analyzed within 6 hours. Marine samples were analyzed at a lab set up for the project using the modified MPN (Most Probable Number) procedure, five tube decimal dilution test. Freshwater samples were analyzed at this lab using the membrane filter technique with MFC dehydrated media. Analytic procedure was as described in Standard Methods for the Examination of Water and Wastewater, using the 2 hour resuscitation technique.

In addition to analysis of fecal coliform concentration in marine waters, salinity and temperature were recorded at each station to the bottom or until readings stabilized. This was done with a Beckman salinometer Model RS5-3. For freshwater stations, temperature and stream flow were also measured at the lowest station in each stream. Flows were measured with the Marsh-McBirney water current meter Model 201-D. The flow data were used in calculating bacterial loading to the receiving waters. The complete data set and a description of statistical methods is published under separate cover.

Citizen's Advisory Committee

A Citizen's Advisory Committee was formed in the early stages of the water quality project to provide a forum for public input into the project. Membership in the committee was open to residents of the project area, and attempts were made to obtain as much diversity as possible. The following

individuals met on a monthly or bi-monthly basis to discuss the methodology, findings, and future direction of the project: Herb Beck, Lavonne Dobeas, Judy Edwards, Barbara Fisk, Jerry Getz, George Hansberry, Tom Mahan, Harvey Olson, Andy Simonson, Juel Simonson, Chuck Smith, Dick Steele, and Don Ward. Jeannie Mahan took notes and provided minutes of the meetings. The Committee reviewed the findings of the staff and compiled a set of recommendations to be included in this report and presented to the County Commissioners and the Department of Ecology.

Soil Mapping

Soil types and their suitability for septic system drainfields were mapped for each drainage. The information was compiled from Soil Survey of Jefferson County Area, Washington (1975) prepared by the Soil Conservation Service, USDA. Field inspections of areas of concern were done to refine and confirm the information. This information is included under separate cover in the supporting document.

Land Use Mapping

Various types of land use were mapped and tabulated from aerial photographs (OLY-85) obtained from the Washington Department of Natural Resources. The photographs were taken during October 1985 and the land uses mapped were field checked in conjunction with the sanitary surveys.

Storm Event Sampling

In the Puget Sound Region elevated bacterial counts in marine waters have been correlated with periods of intense rainfall, with state mandated temporary closures of shellfish areas necessary in some areas. For this reason, storm event sampling was included as an element in the sampling methodology in the Quilcene watershed. Optimally, storm event monitoring includes sampling of both fresh and marine waters for the duration of the storm. In the Quilcene/Dabob area, however, storms were typically accompanied by strong winds during the project period which effectively prevented marine travel for sampling purposes. For this reason, only freshwater samples were collected during storm events.

Seal Study

The study of Harbor Seal Populations and their Contributions to Fecal Coliform Pollution of Quilcene Bay (1987) was conducted in conjunction with this project prepared by J. Calambokidis and B. McLaughlin of Cascadia Research Collective. The executive summary is included on page 36. The report is available through the Jefferson County Planning and Building Department at a cost of $2.00.

Sanitary Survey

The sanitary survey was conducted in cooperation with the Jefferson Conservation District in each of the major drainages and along the shores of Quilcene and Dabob Bays. A week in advance the survey team notified residents of each drainage of the date that the survey would occur. This gave residents the opportunity to ask questions and establish convenient times for the visits if necessary. The survey team went door-to-door and interviewed residents concerning the age, location, type, and maintenance history of septic systems and the seasonal changes, number, and type of livestock pastured on the property. During the survey, residents provided the team with valuable insights on the history, development, and special problems of each drainage. Visual inspections were made of the condition of the septic system, pasture, stream bank, and riparian vegetation. The team discussed with residents the value of clean water and the importance of septic system maintenance, pasture management, and stream protection. Residents were also informed of programs available to aid in septic system repair and the implementation of Best Management Practices (BMP's) for agricultural areas. Intensive reconnaissance sampling was conducted to provide a water quality log of the stream and to help pinpoint problem areas and sources. Public meetings were held shortly after each major survey to present survey results.

RESULTS

Common to all drainages and both bays is the State Water Quality Classifications of "AA" (Extraordinary). These waters are given the highest level of protection in the state. The criteria for fecal coliform organisms in these waters are as follows:

Freshwater----Fecal coliform organisms shall not exceed a geometric mean value (GMV) of 50 organisms/100 ml, with not more than 10% of samples exceeding 100 organisms/100 ml.
Marine water--Fecal coliform organisms shall not exceed a geometric mean value (GMV) of 14 organisms/100 mL, with not more than 10% of samples exceeding 43 organisms/100 ml.

To provide greater clarity in the text, all fecal coliform concentrations will be reported as the number of organisms/100 ml, with the unit excluded. Total bacterial loading is calculated as the product of the fecal coliform concentration multiplied by the stream flow. The complete data base and a full description of statistical methods used is published under separate cover.

Results will be given first for ambient and reconnaissance monitoring conducted in each of the watersheds and bays, followed by the results of the storm event monitoring, seal study, and sanitary survey.

Major Drainages

Tarboo Creek drains an area of about 7245 acres, of which about 321 acres (4.4%) is in residential use and about 575 acres (7.3%) is in agricultural use (Fig. 3). The bulk of the remainder is used for timber production. The residential areas tend to be on the uplands and on the valley sides while the agricultural areas tend to follow the stream bottom. The creek begins near SR104 at about 600 feet elevation and flows in a southerly direction about 6.5 miles to Tarboo Bay at the head of Dabob Bay. This is the only major freshwater input directly into Dabob Bay.

For the first two miles the stream emerges from many small springs and intermittent streams to form a perennial creek at about 300 feet elevation and 4.5 miles from the mouth (Mile 4.5). At this point it begins to flow through agricultural and residentially developed areas. Sampling station TB1 at Mile 4.0 recorded a geometric mean value (GMV) for the project period of 24.7, with 25.0% of the samples exceeding 100. This is the highest count recorded for all the headwater stations (Table 2). Residents of the upper watershed above sampling station TB1 reported a dramatic increase in sedimentation corresponding to increased logging in the upper watershed. This may have raised water tables and contributed to a failing septic system found in the area. A design for the repair of the septic system identified as a possible source has been submitted. In addition, a farm above this station has begun work with the Jefferson

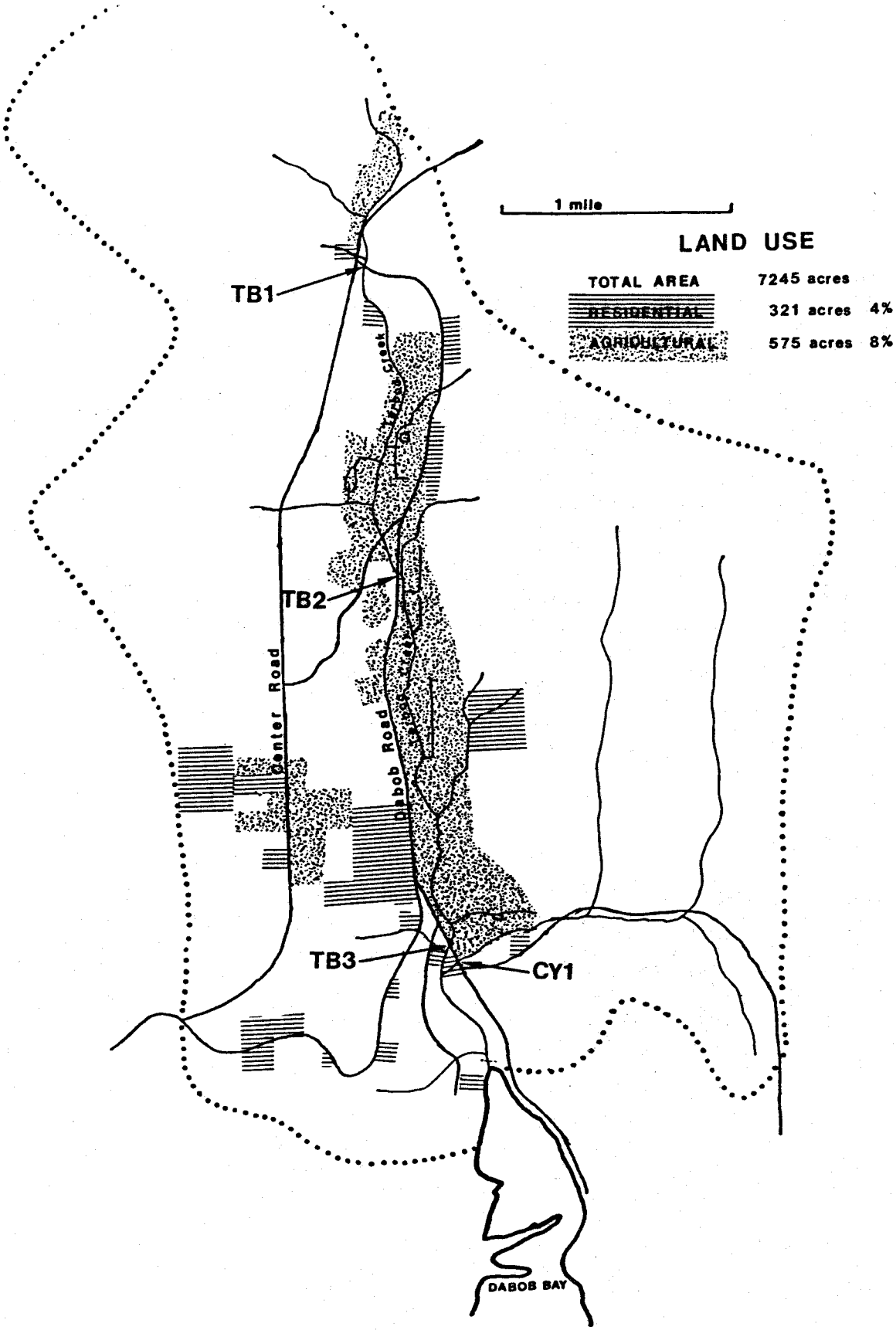


FIGURE 3

TARBOO CREEK DRAINAGE

Conservation District to develop a farm management plan. This station in particular should be monitored in the future to evaluate changes in the water quality associated with mitigation efforts.

From station TB1 the stream flows for the next 2.1 miles through a predominantly agricultural area. Eight or nine farms border the stream and many small tributaries and drainage ditches enter this reach. Sampling station TB2 at Mile 2.4 recorded a GMV for the project period of 126.9 with 25% of samples exceeding 100. This far exceeds state water quality standards. Animal access to the stream, tributaries, and drainage ditches compounded by tight soils subject to saturation are likely contributors to these high counts. Livestock on one farm can be seen with mud above their knees through the wet months. Efforts to implement management plans which address water quality in this stream reach have been largely unsuccessful.

Sedimentation may also be contributing to high counts in this segment by prolonging the life of bacteria and possibly allowing them to reproduce. The effects of sediments in this area could not be quantified statistically, but during the reconnaissance survey children playing in the stream and stirring up sediments elevated counts from a typical of 200-300 to over 2000. Further research concerning the association between logging and sedimentation and between sedimentation and bacterial survival rates is needed.

For the next 1.5 miles from station TB2 to TB3 the stream flows through a predominantly agricultural area similar to the previous segment but with widespread seasonal saturation and surface flooding. Station TB3 at Mile 0.85 recorded a GMV of 83.8 with 38.7% of the samples exceeding 100. This also exceeds state water quality standards. The lower GMV at TB3 than at TB2 can be partially explained by comparing the data variance of the two stations (Table 3). The high degree of variability of TB2 data resulting from a few extremely high counts could be related to livestock crossings not far above TB2. Direct animal inputs and/or animals stirring up sediments are the most likely factors contributing to the extremely high counts. Two large farms occupy the majority of this stream reach. The owner of the well managed property downstream has expressed interest in further excluding his animals from the stream. Implementation of a management plan on the upstream property is, however, still badly needed.

Although bacterial loading from Tarboo Creek has not, to date, adversely affected water quality in Tarboo and Dabob Bays, what the capacity of the system is to absorb additional impacts is not known. Elimination of the most significant sources will help to assure that, as the area becomes more developed, water quality in the creek will improve and the bays will remain unimpacted.

Throughout the Tarboo drainage livestock appears to be the major contributor to bacterial contamination to the stream. A majority of the stream banks and riparian vegetation have been heavily impacted by animal access. The willingness of some property owners to implement management plans to reduce these impacts should be commended. Other residents of this drainage should be encouraged to work with the Conservation District to develop similar strategies. The inclusion of water quality considerations in farm management decisions may be sufficient to correct bacterial problems in this drainage.

	LQ1	LQ2	LQ3	LL1	LL2	LL3	BQ1	BQ2	BQ3
7/7		●	●	✚	●	●		●	●
7/28	●	●	✚	✚	●	●	•	●	•
8/11	✚	●	●	●	●	✚	•	•	●
9/3	●	●	✚	●	●	●	•	●	●
10/13	●	•	●	●	•		●	•	•
10/27	●	●	✚	●	●	●	●	●	●
11/13	•	●	●	•	●	●	●	●	✚
11/25	●	●	●	●	●	●	●	●	●
12/16	●	●	●	●	•	●	•	●	●
1/6	●	•	●	●	●	●	•	•	•
1/30	●	●	●	●	●	●	•	•	•
2/2	●	●	●	●	●	●	•	•	•
3/11	●	●	●	●	●	●	•	●	•
4/2	•	•	•	●	•	•	•	•	•
4/28	•	●	●	•	●	•	•	•	●

• 0-1 FC/100 ml

• 2-4

• 5-10

● 11-22

● 23-50

✚ 51-110 (Exceeds Standards)

✚ 111-225

✚ 226-550

✚ >551

TABLE 2. FRESHWATER CONCENTRATIONS

	DV1	DV2	CD1	CD2	CD3	TB1	TB2	TB3	CY1
7/7									
7/28									
8/11									
9/3									
10/13									
10/27									
11/13									
11/25		2A							
12/16		2A							
1/6									
1/30		2A							
2/2									
3/11		2A							
4/2									
4/28									

- 0-1 FC/100 ml
- 2-4
- 5-10
- 11-22
- 23-50
- 51-110
- 111-225
- 226-550
- >551

TABLE 2. FRESHWATER CONCENTRATIONS

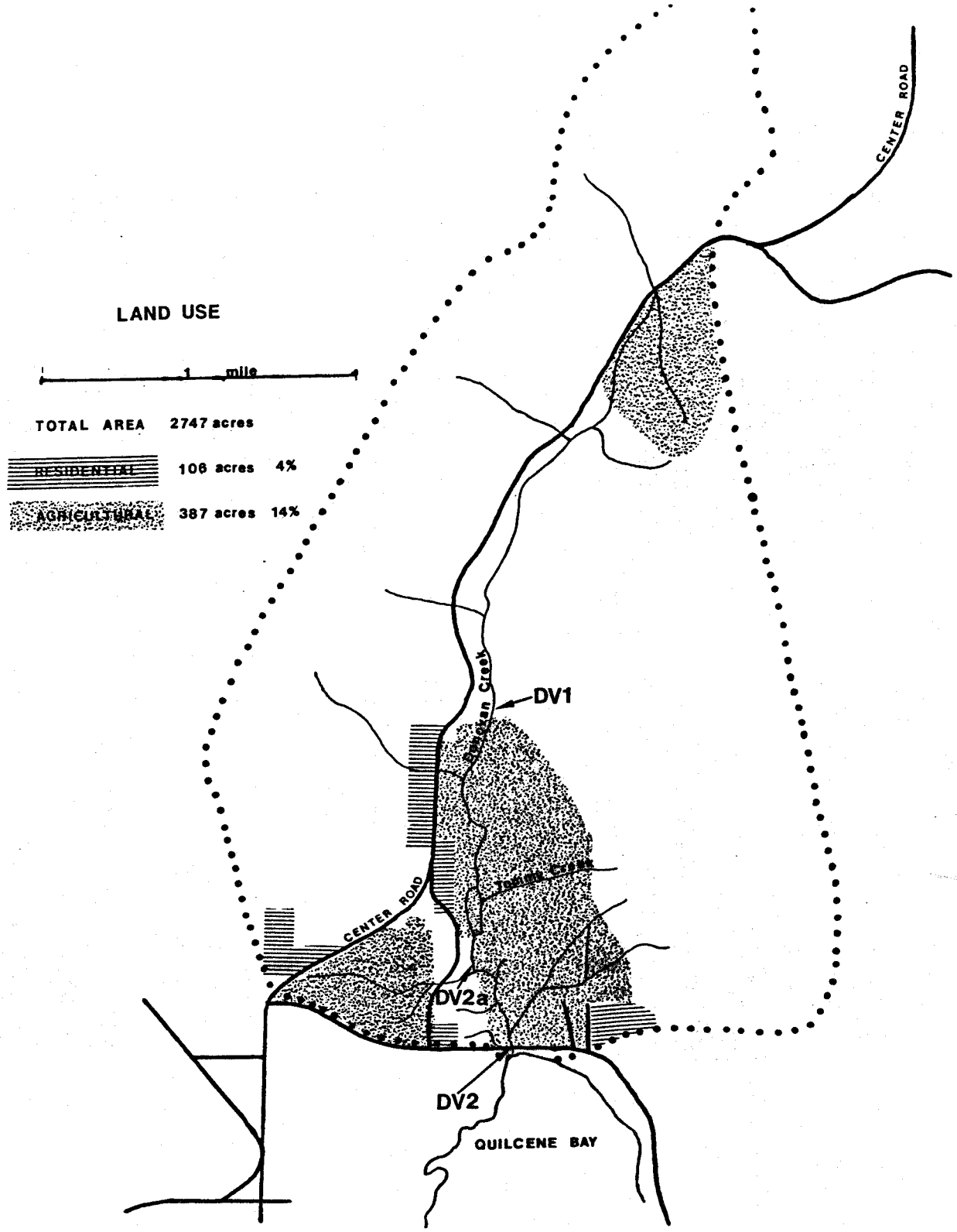


FIGURE 4

DONOVAN CREEK DRAINAGE

One area of future concern in this watershed is related to residential development. The trend is toward development of five acre tracts which avoids subdivision regulation. Development of this kind has the potential for resulting in major cumulative water quality impacts. At present, septic permitting requirements are likely to preclude residential development on saturated soils in the valley bottom. Similarly, care should be taken with residential development on the steep valley sides and near springs and intermittent streams to prevent contamination from septic systems and sedimentation from private road building and construction.

Donovan Creek drains an area of 2747 acres, of which 387 acres (14%) is in agricultural use and 106 (4%) is in residential use. Donovan Creek is a very short stream, flowing just 3.2 miles from its headwaters near the junction of Dabob-Coyle Road and Center Road to its mouth at the head of Quilcene Bay.

There are two farms at the headwaters of Donovan Creek. One farm has installed exclusion fencing along the creek and tributaries and the other was not pasturing livestock through much of the year. Bacterial counts at the sampling station DV1 at Mile 1.5 located below this area had been very low, with a GMV of 6.1 and no sample exceding 100. This pattern changed, however, in midwinter when the farm without exclusion fencing began pasturing horses. During these wet months the pastures were saturated and the counts recorded at DV1 increased. This property owner has applied for cost share funding for stream fencing and is working with the Conservation District to implement BMPs. Elimination of this source in the near future is likely.

Most of the development in the Donovan Drainage is located in the lower 1.7 miles. In this segment Donovan Creek and its side channels and tributaries are nearly completely accessible to various densities of livestock. Compounding the problem of livestock access, this segment of stream is very low gradient and is subject to annual flooding. As well, the last 1/3 mile of the stream bisects a 25 acre pasture which is periodically inundated by high tides and freshwater flooding. As a result, manure is washed off the fields and into the bay with every extreme high tide. The counts at the sampling station DV2 at the mouth of the river exceeded both parts of the State Water Quality Standards (GMV=64.0 with 29.2% >100). Counts at this station began declining in November, with a wet-season GMV of 30.6; 0 >100. Because of greatly increased flows, however, bacterial loading to the bay from the freshwater component of the flow increased during the winter months. Combined loading from the freshwater and tidal outflow following periods of inundation was not determined. Reduction of bacterial loading from this area has been targeted as a high priority in correction of the water quality problem. The Conservation District has been successful in gaining the cooperation of some of the property owners in this area in implementing BMPs, applying for funding for fencing, and working with the Department of Fisheries to develop stream enhancement projects.

The reduction of bacterial loading from the tidally inundated pasture will require the removal of livestock from a 25 acre parcel. The owner is interested in selling the property for conservation management but has, to date, been turned down by The Nature Conservancy. A proposal by the study team to request state funding for acquisition of the property was vigorously opposed by the

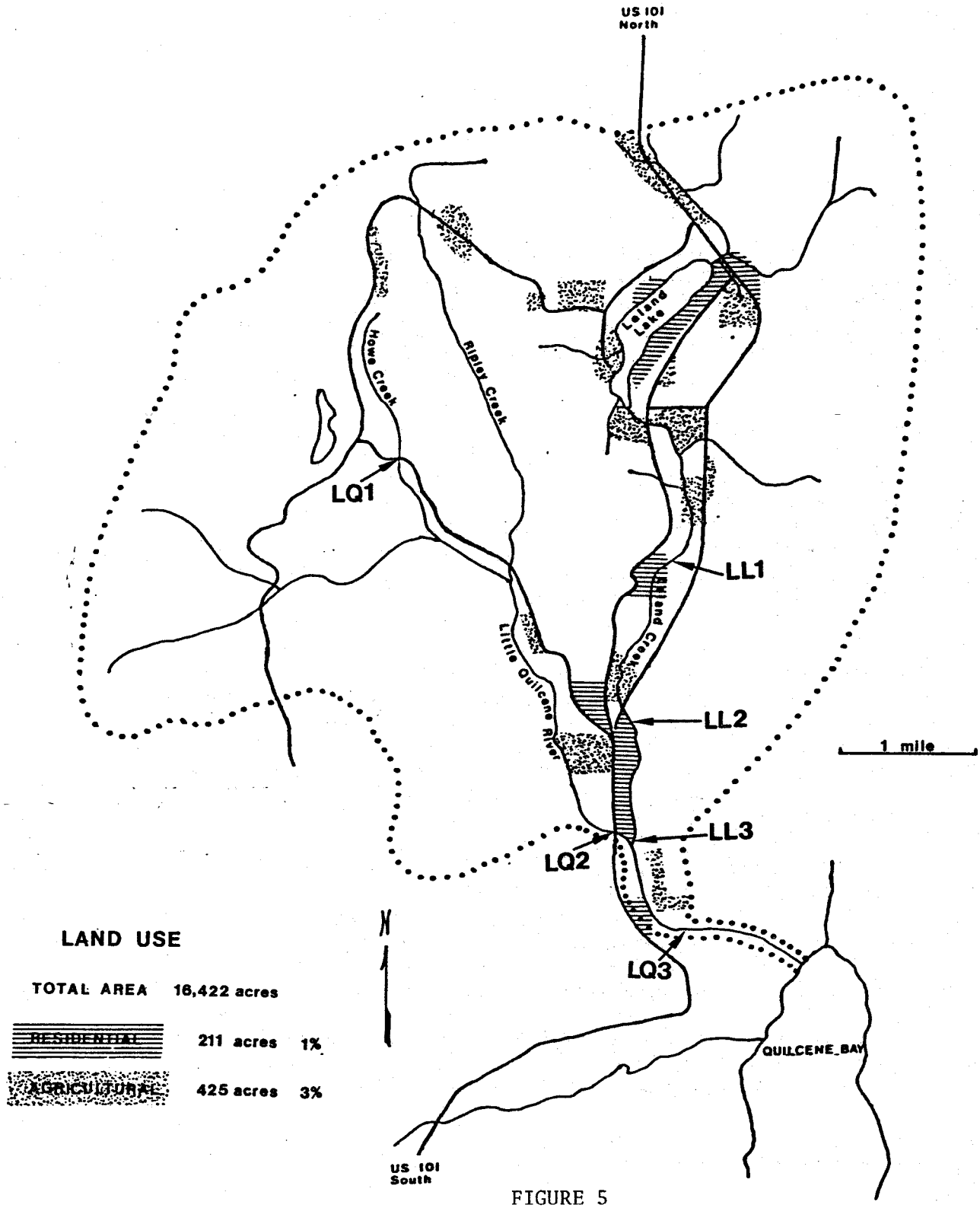


FIGURE 5

LITTLE QUILCENE DRAINAGE

Citizen's Advisory Committee. Efforts are still underway to find acceptable alternatives to the present situation.

A comparison of loading from the various freshwater inputs into the bay appears to indicate that the overall contribution by Donovan Creek, because of its low flows, is no greater than other freshwater inputs (Table 3). It is important to recognize, however, that these flows represent only the freshwater component of the total. Tidal inundation can result in brackish flows of as much as 10 times the normal freshwater input with a corresponding increase in loading.

While livestock appear to be the primary source of bacterial contamination in this drainage, one greywater drain and two malfunctioning septic systems were also located. The owners of all three of these systems are participating in the County's septic system repair program and these sources should be eliminated by fall of 1987. Elimination of contributions by livestock will, however, be more difficult. Erosion, siltation, flooding (caused by siltation, debris build-up, beaver dams, & low gradient), tidal inundation, and nearly complete livestock access to the stream have combined to create a complex problem. A comprehensive approach to management of this stream segment involving land owners, the Conservation District, Department of Fisheries, and other relevant agencies is needed.

The Little Quilcene River drains an area of over 16,407 acres, of which 425 acres (3%) is in agricultural use and 211 acres (1%) is in residential use. There is very little development in the upper watershed. There is a small farm at the head of Howe Creek, a major tributary to the upper reaches of the Little Quilcene. The sampling station LQ1 is located on Howe Creek where it crosses Lord's Lake Road (Mile 5.2) and is below the farm. During the dry season, when livestock were present, counts at LQ1 were elevated but well within standards (GMV=7.9; 0% >100). From LQ1 the stream flows through a sparcely developed area to Hwy 101 (Mile 1.5). Sampling station LQ2 is located at this bridge. Counts at this station have also been well within standards (GMV=4.7; 0% >100). The Little Quilcene drainage shows marked reductions in counts from dry season to wet season, resulting in relatively constant loading to the bay in spite of increased winter flows.

Leland Creek enters the Little Quilcene River just downstream of station LQ2. Most of the development in the Leland Creek portion of the drainage is in the upper watershed around Lake Leland. All three sampling stations on Leland Creek (LL1, LL2, LL3) are located below the lake at Miles 2.3, 0.9, and the mouth, respectively. All three stations are within water quality standards (GMV's= 9.0, 7.2, 9.4 with 4.2%, 4.2%; 0% >100). Over the study period, however, Leland Creek provided about 20% of the total bacterial loading in the lower Little Quilcene. The majority of the loading occurs during the winter months. Even though the counts on Leland Creek decrease somewhat from summer to winter, the much larger flows create significantly larger loading during the wet winter months. Similar counts in all three Leland stations indicates that this loading originates above Leland 1. It is recommended that future monitoring reestablish this station farther upstream at the outlet of the lake in order to more accurately determine whether the loading originates in the lake or from agricultural property downstream. Residents of the area have reported rising water levels of the lake and poor drainage in the low gradient segment of the

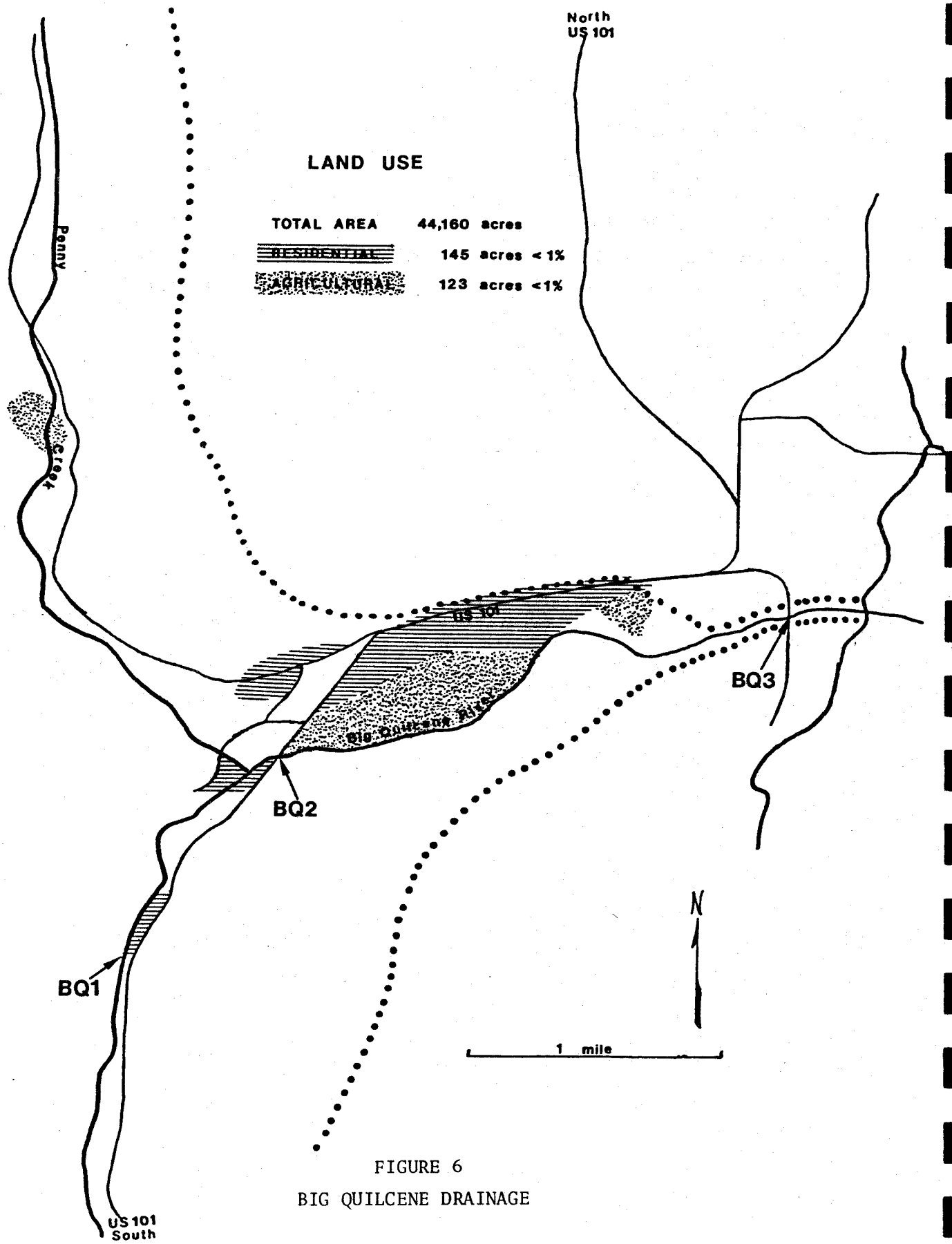


FIGURE 6

BIG QUILCENE DRAINAGE

creek below the lake. This type of problem is similar to that found on lower Donovan Creek and its solution will require a similar comprehensive approach.

The Big Quilcene River drains an area of over 44,000 acres with very little of the area developed (145 acres residential, 123 acres agricultural). The upper sampling station, BQ1, located above all development at Mile 3.5 recorded the lowest average count (GMV of 0.7) of all stations sampled during the project. The next lowest count with a GMV of 1.8 was recorded at BQ2 located at the U.S.101 bridge (Mile 2.7), below a small residential area, the U.S. Fish & Wildlife hatchery, and the confluence of Penny Creek. While virtually all of the developed portion of the drainage lies between the stations BQ2 and BQ3 (located at the Linger Longer Rd. bridge at Mile 0.2), average counts recorded at BQ3 were lower than stations on any other river with a GMV of 2.8. Even with flows exceeding 700 cfs, the counts were low enough that the total bacterial loading from the Big Quilcene River was at or below inputs from the smaller streams. The wet season loading was, however, significantly greater than that of the dry season.

There are several apparent reasons for these low counts, including the dilution factor, land use, and topography. Small bacterial inputs into large rivers may result in a minimal change in bacterial concentrations, while the same contribution in a smaller river would result in a more noticeable change. Although 40 head of livestock are pastured along this segment, they are fenced away from the stream. In addition, most of the residences in the upper area are relatively new with septic systems installed to modern standards.

The major problems in this drainage are located in the area of the river's alluvial fan, near the mouth of the river. This reach has been diked to halt the natural process of meandering. Sediments trapped by the dike have been raising the level of the stream bed in this reach for several years, resulting in flooding every two or three years and soil saturation to the surface every winter. The diking of the lower portion of the river has also effectively prevented surface water runoff into the river. As a result, bacterial loading from failing septic systems, livestock, or stormwater is seen, not in the river itself, but in ditches and drainageways outside the dike. This topic is covered more thoroughly under The Town of Quilcene and discussion of the impact of this saturation on septic function in the floodplain will be presented under Sanitary Survey.

A long term strategy to correct the sedimentation problem is not forthcoming. In 1972 the Corps of Engineers studied 13 alternative solutions to the problem and concluded that the only solution was "flood plain regulation by local interests". A flow of 2760 cfs is expected to occur on an average of every 3.3 years, and the Corps of Engineers estimated that a flow exceeding 3000 cfs would cause major damage. During the water quality project minor flooding occured when flows reached 1200 cfs on March 4, 1987.

Town of Quilcene

Two areas in the town of Quilcene drain neither into the Big or Little Quilcene Rivers, but rather into small ditches which enter the bay directly. Sampling

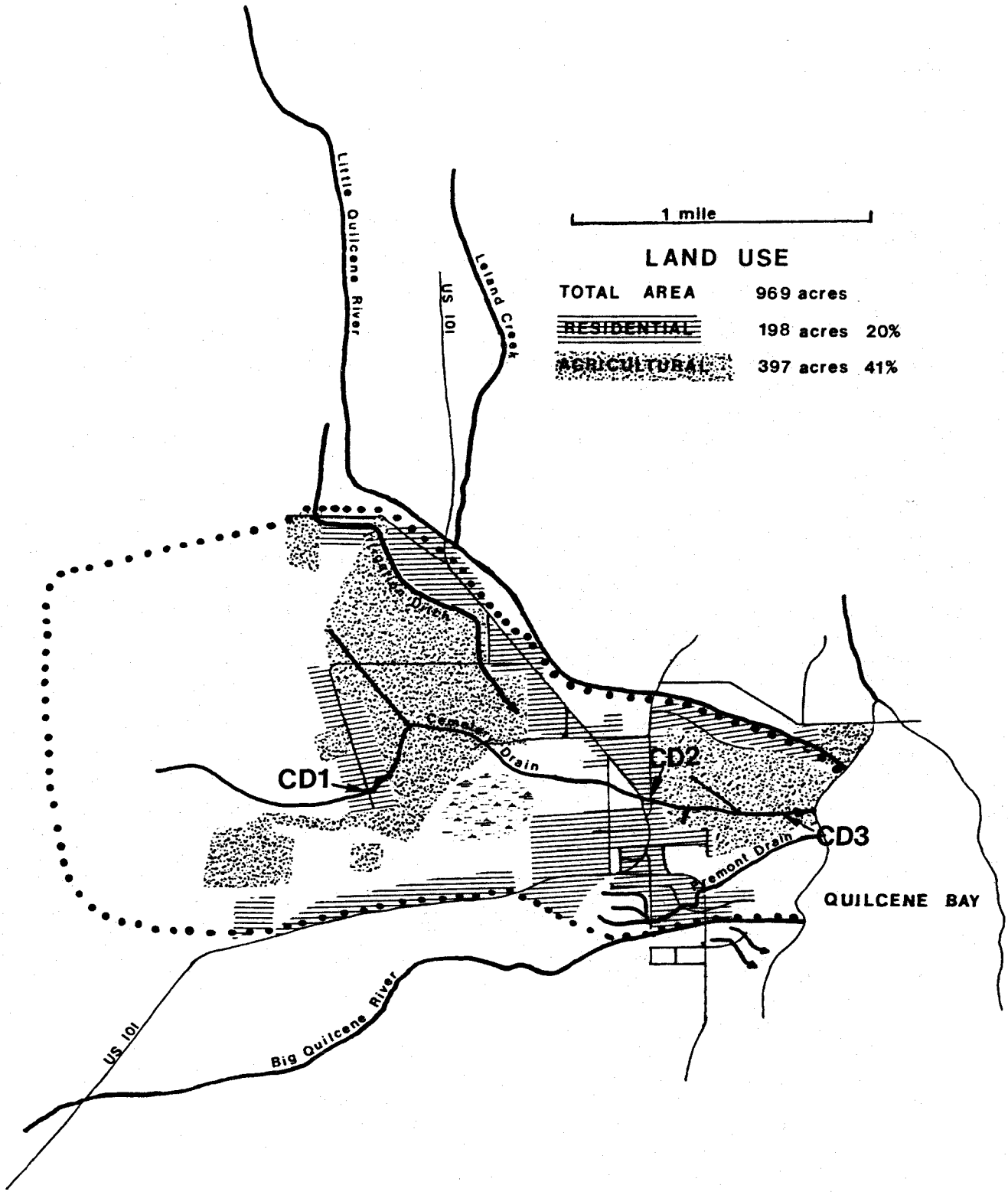


FIGURE 7

TOWN OF QUILCENE DRAINAGE AREA

conducted as part of the sanitary survey pointed to a multitude of water quality problems associated with these drainages. Malfunctioning septic systems, livestock access, stormwater, and small amounts of industrial waste were all identified as sources. The major drainage network in this area is a ditch built by the WPA to drain the swampy area southeast of the cemetary, referred to here as the Cemetary Drain. The drain flows only during the wet winter months except in the lowest section where it produces surface flow year around.

The drain begins in the wooded area above Shady Lane. Sampling station CD1 is located at the culvert under Shady Lane at Mile 1.6. Water quality at this station is within standards with a GMV of 7.9 and 6.7% >100. From this point the drain transects a low, swampy area where approximately 18 head of livestock are pastured. Animals have access to both the drain and the saturated fields. After joining with a smaller flow from the north, the drain flows through a sparcely developed residential area and crosses Columbia Street. Three more animals have access to it before it flows under Hwy 101 and the Center Road. Sampling station CD2 is located at this point (Mile 0.6). The variance in the GMV at this station is very high and both parts of the water quality standards are violated with a GMV of 86.6 and 61.1% >100. Animal keeping is the primary source of bacteria in this reach. Correction of the principal source in this reach will require a coordinated effort between the Conservation District, property owner, renter, and the Department of Fisheries.

Just below CD2 a set of storm drains enters the main flow. These drain a residential street, a pasture, a long stretch of the road, and the gas station. Reconnaissance sampling of the storm drains showed intermittently high counts. Dye testing was used to identify a graywater discharge into the drain entering from the north. The discharge has been corrected and the drainfield inspected and found to be functioning satisfactorily.

Cemetary drain then flows behind the high school and through a farm pasturing 25 head of cattle which have full access to the drainage before it enters Quilcene Bay. Sampling station CD3 at Mile 0.2 is located at this point. Ambient sampling at this station yielded the highest variation among all of the freshwater stations, and both parts of the standard were violated (GMV of 493.5 with 82.4% >100). The flow in Cemetary Drain is among the smallest of the streams in the project area but bacterial loading from this input is among the highest. Although the landowner in this reach has begun to feed his animals away from the waterway, areas of the streambank and bottom continue to be heavily impacted by animal access. Reduction of loading from this site should be considered to be a high priority for reducing overall bacterial loading to the bay.

In addition to livestock, two malfunctioning septic systems located at substantial distances from the drainage were also identified as potential sources of fecal coliform loading to the bay from this drainage. These sources have agreed to repair the systems and septic system designs have been submitted.

A second network of drainage ditches exists on either side of the lower Big Quilcene River. Because of the diking of the river, drainage from this area enters Quilcene Bay directly. High counts were found in a number of the ditches during both of the reconnaissance surveys of this area. The primary source is septic effluent from a number of substandard septic systems. Additional

	LL3	LQ2	LQ3	BQ3	DV2	CD3	TB3	CY1
7/28	•	●	●	●	●		●	
8/11	●	●	●	●	●		●	
9/3	•	●	●	●			●	
10/13		•	●	•	●		●	
10/27	●	●	●	●	●		●	●
11/13	•	●	●	●			●	●
11/25	●	●	●	●	● 2A		●	•
12/16	●	●	●	●	• 2A		●	•
1/6	●	●	●	●	●	●	●	•
1/30	●	●	●	●	● 2A	●	●	●
2/2	●	●	●	●	●	●		
3/9	●	●	●	●	● 2A	●	●	•
4/2	●	•	●	•	•	●	●	●
4/28	•	●	●	●	●	●	●	•

• <.12 x 10^9 FC/Day

● .12-.30

● .31-.76

● .77-1.9

● 1.9-4.8

● 4.8-12

● 12-30

● 30-75

● >75

TABLE 3. FRESHWATER LOADINGS

discussion of the impact on septic systems is included under Sanitary Survey.

Quilcene Bay

Five sampling locations were located in Quilcene Bay. Three of the stations were located within the closure area: Q1 at the head of the bay, Q2 west of the log dump/seal haulout, and Q3 off the mouth of the Big Quilcene River. Stations Q4 and Q5 were located in the center of the bay east of the marina and just inside the mouth of the bay where it joins Dabob Bay, respectively. Stations Q1, Q2, and Q3 were chosen to give an indication of the extent of the bacterial contamination in the closure area and possibly assist in the determination of the sources of the pollution. Stations Q4 and Q5 were located where they could give general information on the quality of the bay under conditions of dilution and flushing.

The pattern of fecal coliform concentration in Quilcene Bay was of improvement from Q1 to Q5 (GMV of 9.1, 5.8, 4.8, 3.5, and 0.7 respectively). All stations met the first part of the standards and only Q1 and Q2 exceeded the second (23% and 15%). Bacterial counts in stations Q1 through Q4 were highly variable between sampling occassions but showed similarities between stations. For example, during a period that extremely high loading was observed on the Big Quilcene River, very high counts were seen at Q2, Q3, and Q4. When animal activity was observed in the tidally inundated pasture above Q1, counts were elevated at Q1, Q2, and Q4. Bacterial concentrations in excess of water quality standards occurred only on four sampling occassions. Reliable correlations between freshwater loading into the bay and marine counts did not emerge from this data base and the exact causes for these deviations are not known. General and site specific understanding of the effects of tides, wind, current, and other factors on water movement and sediment transport is limited. Continued monitoring may, however, establish correlations between bay counts and high freshwater flow and/or bacterial concentrations, tidal patterns, seal behavior, or animal access to tideland and streams.

That water quality violations observed in both this study and the one conducted by DSHS in 1984 were a result of occasional high counts is evidence that the bacterial problem in Quilcene bay is an intermittent one, with excellent water quality being the norm. It is safe to assume that, while numerical correlations have not been made between stream impacts and marine water quality problems in the project area, a relationship does exist. Until such time that the specific causes of the erratic marine samples can be narrowed, the reduction of bacterial loading from the streams is the appropriate place to begin correction efforts. The normally high water quality in the bay indicates that correction of the occasional problems is not likely to require radical changes in the administration of the resources of the area.

The results of the ambient sampling were also analyzed to determine if a correlation could be made between bacterial counts in the bay and the resident seal population concentrated near Q2. With between 100 and 230 seals residing in the vicinity of the log dump, the bacterial contribution from the seals would be expected to be somewhat stable over time, excluding effects of wind and tides. Higher bacterial counts in the vicinity of Q2 which would have pointed

	Q1	Q2	Q3	Q4	Q5	D1	D2	D3	D4
7/2	●	•	•	•		✚	•	•	•
7/11	✚	●	✚	•	●				
8/13	●	•	●	●	•	•	•	•	•
10/7	✚	✚	•	✚	•	•	•	●	•
10/23	●	•	●	•	•	•	•	•	•
11/6	●	✚	✚	✚	●	•	•	•	•
11/24	✚	✚	●	●	●	•	•	•	•
12/18	•	•	•	●	•	•	•	•	•
1/8	•	●	•	•	•				
2/3	•	•	•	●	•	●	•		
4/1	•	●	•	●	•	•	•	•	•
4/23	•	•	●	•	•	•	•	•	•

• <1.8 FC/100 ml

● 1.9-3.7

● 3.8-7.3

● 7.4-14.0

✚ 15-29 (Exceeds Standards)

✚ 30-59

✚ 60-120

✚ 121-240

✚ >240

TABLE 4. MARINE CONCENTRATIONS

to such a contribution by the seals were not found. While low bay counts were found on the sampliing run of 4/27/87 when heavy use of the log dump had scared the seals off the log booms, sampling at times when seals were present also yielded low counts. Continued marine monitoring through the summer while the log dump is heavily used would be useful to compare counts with 1986 dry season findings when seals were present. Although the seal study documented a high potential for fecal coliform contribution by the seals, the findings of this study cannot quantify their impact. It it, nevertheless, safe to assume that, like upstream activity in the watershed, seals also contribute to some extent to elevated bacterial counts in the bay.

To identify sources and quantify their proportional bacterial contributions to marine waters, it may be necessary to develop alternative study methodologies. The use of the fecal coliform indicator is an effective tool in source identification in freshwater where sampling can be accompanied by reconnaissance monitoring, surveys, and interviews with property owners. Its use for source identification in marine waters which experience tidal action, contributions from fresh and marine (e.g. seals) inputs, and considerable dilution is, however, extremely limited. Development of a more species specific indicator as an adjunct to fecal coliform could provide a valuable tool to identify sources in marine waters. In addition, sampling of more than surface waters may be useful. A carefully designed sediment sampling strategy could, for example, provide information on bacterial loading of sediments by marine mammals. Such a strategy did not exist for use in this project.

Dabob Bay

Four ambient sampling stations were located in Dabob Bay. Stations D1 and D2 were located inside and outside long spit at the head of the bay, respectively, and were chosen to determine water quality in the most sensitive area of the bay. Stations D3 and D4 were placed in the middle of the bay off Broad Spit and Lindsay Beach to give an indication of general water quality. All of the Dabob Bay stations were well within state standards with a GMV of less than 1.

While the dilution factor could easily explain the high water quality in stations D3 and D4, the high quality of D1 came as a pleasant surprise to study personnel in light of the high fecal coliform counts in Tarboo Creek. A number of explanations have been considered for these findings. These include the following:

low total daily loading into Tarboo Bay
stream purification taking place in the unimpacted reach between TB3 and the bay
extensive flushing and dilution of bacteria entering the bay

From a management perspective it would be helpful to know the extent to which a system such as Tarboo/Dabob can absorb water quality impacts. Because land use in the upper reaches of the stream are not, at present, degrading the water quality in the bay, it is clear than some impact can indeed be absorbed by the system. It is unknown, however, at what point upstream activity in Tarboo Creek will begin to translate into water quality degredation downstream. For that

Dry Season

	Q1	Q2	Q3	Q4	Q5
07/02/86	11.0	0.0	2.0	2.0	
07/11/86	79.0	13.0	22.0	0.0	8.0
08/13/86	4.5	0.0	5.5	1.9	0.0
10/07/86	318.0	27.6	1.3	22.0	0.0
10/23/86	17.2	3.1	6.9	0.0	0.0
04/01/87	1.1	11.4	1.5	4.2	0.0
04/23/87	0.0	0.0	3.3	0.0	0.0
GMV/STA	12.0	3.1	4.1	1.7	0.4
COEF/VAR	72.6	94.3	45.8	107.6	223.6
N /STA	15	14	16	10	7
% > 43	26.7	0.0	0.0	0.0	0.0

COEF OF VARIANCE OF REPLICATES = 11.5788

Wet Season

	Q1	Q2	Q3	Q4	Q5
11/06/86	9.4	79.0	148.7	130.0	4.5
11/24/86	67.4	74.4	8.3	18.8	6.0
12/18/86	1.5	1.3	2.9	4.5	0.0
01/08/87	2.0	6.2	0.0	0.0	0.0
02/03/87	2.1	3.4	2.1	4.1	0.0
GMV/STA	6.0	12.5	6.0	8.4	1.1
COEF/VAR	64.0	56.7	86.8	72.4	122.9
N /STA	15	12	13	9	9
% > 43	20.0	33.3	15.4	11.1	0.0

COEF OF VARIANCE OF REPLICATES = 21.4945

Yearly

	Q1	Q2	Q3	Q4	Q5
07/02/86	11.0	0.0	2.0	2.0	
07/11/86	79.0	13.0	22.0	0.0	8.0
08/13/86	4.5	0.0	5.5	1.9	0.0
10/07/86	318.0	27.6	1.3	22.0	0.0
10/23/86	17.2	3.1	6.9	0.0	0.0
11/06/86	9.4	79.0	148.7	130.0	4.5
11/24/86	67.4	74.4	8.3	18.8	6.0
12/18/86	1.5	1.3	2.9	4.5	0.0
01/08/87	2.0	6.2	0.0	0.0	0.0
02/03/87	2.1	3.4	2.1	4.1	0.0
04/01/87	1.1	11.4	1.5	4.2	0.0
04/23/87	0.0	0.0	3.3	0.0	0.0
GMV/STA	9.1	5.8	4.8	3.5	0.7
COEF/VAR	72.1	79.2	70.4	96.7	164.5
N /STA	30	26	29	19	16
% > 43	23.3	15.4	6.9	5.3	0.0

COEF OF VARIANCE OF REPLICATES = 15.7804

TABLE 5

QUILCENE BAY SUMMARY STATISTICS

Dry Season

	D1	D2	D3	D4
07/02/86	23.0	0.0	0.0	
08/13/86	0.7	0.0	0.0	0.0
10/07/86	0.0	0.0	2.0	0.0
10/23/86	0.0	0.0	0.0	0.0
04/01/87	0.7	0.0	0.0	0.0
04/23/87	0.0	0.0	0.0	0.0
GMV/STA	1.0	0.0	0.2	0.0
COEF/VAR	159.9	0.0	223.6	0.0
N /STA	12	6	6	5
% > 43	0.0	0.0	0.0	0.0

COEF OF VARIANCE OF REPLICATES = 8.69565

Wet Season

	D1	D2	D3	D4
11/06/86	0.0	0.0	0.0	0.0
11/24/86	0.0	0.0	0.0	4.5
12/18/86	0.0	2.0	0.0	0.0
02/03/87	1.3	0.0		
GMV/STA	0.2	0.3	0.0	0.8
COEF/VAR	173.2	173.2	0.0	141.4
N /STA	9	6	3	3
% > 43	0.0	0.0	0.0	0.0

COEF OF VARIANCE OF REPLICATES = 7.14286

Yearly

	D1	D2	D3	D4
07/02/86	23.0	0.0	0.0	
08/13/86	0.7	0.0	0.0	0.0
10/07/86	0.0	0.0	2.0	0.0
10/23/86	0.0	0.0	0.0	0.0
11/06/86	0.0	0.0	0.0	0.0
11/24/86	0.0	0.0	0.0	4.5
12/18/86	0.0	2.0	0.0	0.0
02/03/87	1.3	0.0		
04/01/87	0.7	0.0	0.0	0.0
04/23/87	0.0	0.0	0.0	0.0
GMV/STA	0.7	0.1	0.1	0.2
COEF/VAR	184.1	300.0	282.8	264.6
N /STA	21	12	9	8
% > 43	0.0	0.0	0.0	0.0

COEF OF VARIANCE OF REPLICATES = 8.10811

TABLE 6

DABOB BAY SUMMARY STATISTICS

reason, adoption of practices targeted at water quality improvement in problem areas of the Tarboo watershed should not be overlooked.

Wet Season/Dry Season Comparisons

A comparison of wet season and dry season mean values reveals consistently lower wet season counts at all stations. At some stations such as those on the Big Quilcene River, the change is not significant; however, in others the change can be dramatic. The greatest changes occurred in Donovan, Cemetary, and Tarboo Creeks where livestock were identified as a primary source.

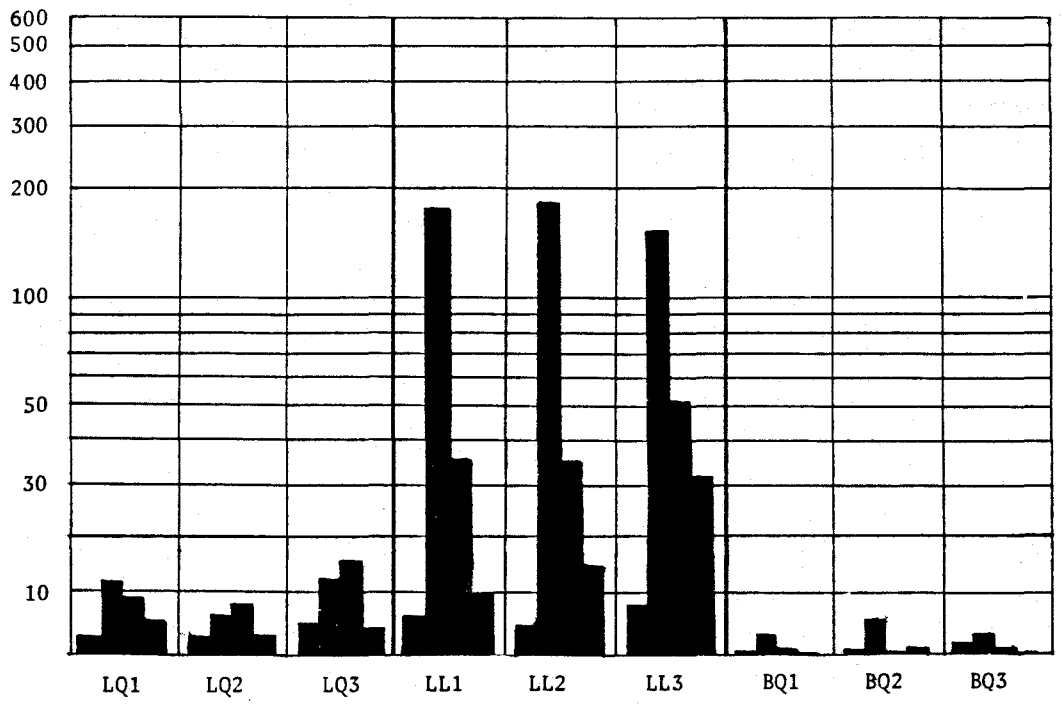
Because of the increased stream flow during the wet season, however, wet season loadings do not reflect the reduction in bacterial concentration. Loadings from different streams were similar, with the smaller, lower quality streams each contributing as much bacteria as the Big Quilcene River with its high flow and low counts. Total contribution by streams in the Quilcene and Dabob watersheds were comparable to those of similar streams investigated in other water quality projects in Puget Sound. Like the findings elsewhere, differences in loading between sampling occassions were dramatic, with tenfold changes occurring frequently. While sediment release of bacteria may account for some of this variance, changing patterns of bacterial loading into the streams are the more likely cause.

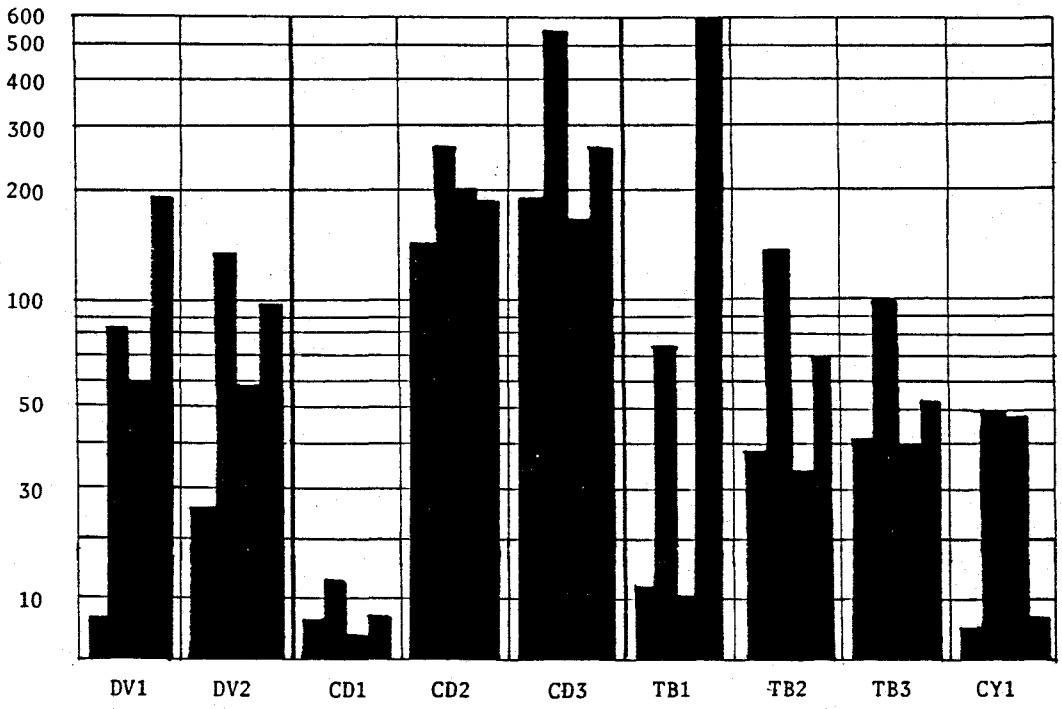
The primary cause for increased pollutant contribution to the streams during the wet season is the saturation of the soils. Soil is capable of adsorbing bacteria and purifying water moving through it only when it is unsaturated. Thus, septic system malfunctions, animal waste runoff, and pollutants carried by stormwater are more likely to cause water quality problems during the wet season. In addition, surface flow and flooding during the wet season transports animal waste directly into streams and waterways.

Storm Event Monitoring

To obtain data for bacterial loading into streams from fully saturated soils, a late winter storm event was chosen for analysis. Heavy precipitation began on March 2, 1987 and continued until March 5 with a total of 4.98 inches. Sampling took place on March 3, 4, and 5. The results of that sampling along with the wet season mean for each station are summarized in Table 7. This table contains the bacterial concentrations for three days of the storm event as well as the wet season GMV for comparison.

As illustrated in the table, sampling on March 3 yielded extremely high counts which were in most stations well above state standards. The counts dropped at most stations to near normal levels by March 5. Routine sampling the following week yielded typical results. The dramatic increase in bacterial concentration immediately following periods of rainfall is known as the "first flush". This phenomena has been documented elsewhere in the case of the first storm of the winter season when soils are unsaturated. Results of this storm event sampling showed that increased counts can also occur following heavy precipitation well into the wet season after seasonal soil saturation has occurred.





Bar 1: Wet Season GMV

Bar 2: Sampling 3/3/87

Bar 3: Sampling 3/4/87

Bar 4: Sampling 3/5/87

TABLE 7. STORM EVENT CONCENTRATIONS

It is clear that some drainages respond more dramatically to storm events than do others in the same vicinity. The greatest change from the wet season GMV occurred on Leland (LL), Donovan (DV), and Tarboo (TB) Creeks. The loading on Leland was above LL1 and so could have originated at the lake or in the agricultural area just downstream. Relocation of this station to the lake outlet will make future differentiation of the source possible. The increased concentration in Tarboo also originates above TB1. Sewage effluent carried ;by surface runoff is suspected to be the primary cause.

Seal Study Results

The following is the Executive Summary from the report Harbor Seal Populations and their Contributions to Fecal Coliform Pollution in Quilcene Bay, Washington:

"High fecal coliform concentrations in the northern part of Quilcene Bay have recently been reported and have resulted in the decertification of this area for commercial shellfish growing. The bay also supports a growing population of harbor seals. This study was undertaken to evaluate the potential contribution of harbor seals to the fecal coliform pollution and make recommendations on how to more precisely determine the portion of fecal coliforms contributed by seals. A maximum of 230 harbor seals were counted in Quilcene Bay, primarily concentrated at a log dump on the eastern side of the bay. Seals were present year around, with no dramatic season patterns in the number of animals. Seal defecation rates were estimated as between 250 to 500 grams per day for a 50 kg seal, with 375 grams the best estimate of average daily fecal production. A variety of bacterial species were identified in 10 fresh seal feces collected from the Dosewallips River Delta (adjacent to Quilcene Bay). Bacillus sp. and E. coli were the most often found predominant bacterial populations. No Salmonella or Yersinia were found in enrichment procedures conducted for these two pathogenic bacteria. Fecal coliform concentrations in the 10 harbor seal feces analyzed by Biochem Environmental Services ranged from 4.0×10^{6} to 9.2×10^{8} coliforms per gram with a geometric mean of 3.1×10^{7}. These concentrations are similar to those reported for humans but are higher than for most domestic animals. Ratios of fecal coliforms to fecal streptococcus were much higher than reported for humans or domestic animals. This ratio and some other unique bacterial indicators may be of value in tracing the source of bacteria found in Quilcene Bay. This study indicated that fecal coliform densities in harbor seals are fairly high and given the population size of seals and their defecation rates, seals have the potential to be significant contributors to the high fecal coliform levels in Quilcene Bay."

"Recommendations to more accurately determine the proportion of fecal coliform contributed by seals include: 1) increase the sample size of seal feces tested, 2) determine portion that dissolves in marine water, 3) determine the portion of seal feces excreted in different parts of Quilcene Bay, 4) use specific bacterial indicators to trace the source of fecal coliforms found in Quilcene Bay waters, 5) test fecal coliform levels at other sites where seals are the only potential source, 6) examine fecal coliform concentrations produced by captive seals."

Sanitary Survey

Door to door septic system surveys were conducted in conjunction with intensive sampling of individual drainages and shoreline surveys. Of the 224 properties surveyed that lie adjacent to or near freshwater sources, 24 or approximately 10% received follow-up visits. Sites were chosen for follow-up visits based on the following criteria:

Report of malfunction by property owner or neighbor
Surfacing sewage
Surface discharge
Evidence of localized saturation
Collapsing septic tank or cover

Some of these systems were subsequently found to be operating satisfactorily, and the remainder were addressed in correction efforts.

The majority of the malfunctioning systems were installed prior to statewide adoption of health regulations in 1974 and would be considered substandard under present regulations. The causes of the identified failures were generally a combination of poorly drained soils, age, and size. This situation exists throughout the project area, illustrating an ongoing need for systematic replacement of the systems.

A unique situation exists in the Big Quilcene River floodplain with respect to septic disposal. While soils in this area are permeable enough to permit effluent disposal, during the wet winter months an extreme high groundwater situation exists. The groundwater, which rises to distances of 0-18" from the surface, effectively prevents adequate soil treatment of sewage effluent. This, in combination with localized high density housing results in a greatly accelerated risk of disease transmission via shallow drinking water wells in the area. Substantive disease incidence has not occurred to date in families residing in this area, but no assurances can be given that disease transmission could be avoided if pathogens were to be introduced into the area. Intensive sampling conducted in this area during both wet and dry conditions substantiated the concern that inadequate effluent treatment and disposal might be occurring. Bacterial counts in road ditches and drainageways which violated water quality standards were typical and exceeded 2000 in places. Reconnaissance sampling in the tidal zone of the Big Quilcene floodplain also yielded counts in violations of standards. Systematic well sampling and groundwater quality testing to determine the full extent of this contamination were, however, beyond the scope of this study. Further investigation and implementation of correction measures, if necessary, are recommended.

Reduction in disease transmission risk and water quality impact could be achieved directly by replacing the septic drainfields or indirectly by replacing the shallow wells in the immediate area with a community water system. Septic upgrading could be achieved at the individual level with installations of a number of above ground systems or at the community level with installation of two or more drainfields placed in a more suitable location to serve the four block area.

There are a number of on-site issues that are being addressed at the state level. The statewide adoption of increasingly stringent on-site standards has resulted in the installation of septic systems which address not only effluent disposal--the primary issue in the past--but also effluent treatment. Larger sizing, shallower systems, and strict adherance to soil capabilities have made newer systems less likely to result in surfacing sewage. There are questions, however, as to the adequacy of these regulations in assuring thorough effluent treatment prior to encountering subsurface water when the soil depth is at or near the legal minimum. The resulting pollution may not be detected in a septic survey such as the one conducted in this project, but could still result in water quality impact. The highest risk sites are those systems installed into coarse material and near ground or surface water. Examples of such conditions include installations behind bulkheads, fill, or gravel outwash. Identification of such a problem is well beyond the scope of this type of study. Attention has been focused on these and other issues by the Puget Sound Water Quality Authority.

One longstanding problem with repair of malfunctioning septic systems in the project area has been a widespread lack of public trust and confidence in the health department. Many residents feel there is a lack of willingness on the part of the health department to assist property owners in solving their problems. There has been a fear that if property owners contact the department for assistance with a septic repair, they would be forced into an expensive repair or eviction. As a result, unnecessary water quality degredation has continued while people who do recognize the inadequacy of their septic system do nothing or install inadequate systems without health department review.

Personnel changes in the health department are occuring, however, and efforts are being made to improve public relations. Nonetheless, these attempts to provide consistent, thorough, and helpful service may continue to be stifled by minimal departmental staffing, low wages, and lack of personnel support. Final inspections of installations, public education, response to complaints and issues of public concern, short turnaround time, and other tangible needs may not be possible under existing staffing and case loads.

Recognizing these problems, the decision was made to have grant funded personnel handle septic corrections in the Quilcene/Dabob watersheds as they were identified instead of referring them to the health department. Septic repair assistance in the form of site inspections, septic system design, public education, and financial assistance have been provided as a part of the water quality project. Integral in the repair process has been the establishment of a low-interest loan program for low and moderate income households. Approaching these repairs from this non-regulatory perspective has yielded favorable results and a high level of cooperation from property owners.

FINDINGS

Water quality problems in the project area are neither severe nor insurmountable. Isolated problems do exist, however, and their correction will require the cooperation of property owners, local and state agencies, project area residents, and industry.

Headwaters and stream reaches with little or no development activity upstream were generally found to be of high quality and well within state standards. Lower water quality existed in those reaches which flow through areas with agricultural use, with violations occurring at stations on Donovan, Cemetary, and Tarboo Creeks. Stations which violated standards exhibited the highest variance between sample runs, reflecting a varying human and animal activity in the watershed.

In marine waters, violations of water quality standards occurred at stations Q1 and Q2 at the headwaters of Quilcene Bay. High counts at Q2 near the seal haulout area occurred only in conjunction with high counts in adjacent stations.

Marine water quality violations occurred infrequently, and exact causes have not been determined.

Consistent correlations between sample results in the bay and freshwater inputs did not emerge from this data base.

Freshwater quality dropped during a period of heavy rainfall, most significantly at the beginning of the storm event. Typical bacterial levels resumed in the week following the storm event.

While freshwater counts dropped during the wet season, the total loading from the streams exhibited no pattern of increase or decrease for that period.

The majority of the soils in the project area have moderate to severe limitations for septic installation and intensive livestock management.

Septic system malfunctions were observed in approximately 5% of the systems surveyed. Additional systems could, however, be contaminating subsurface waters with no visible indication to either the property owner or observer. Correction of the majority of these identified malfunctioning systems is taking place.

Septic surveys on shoreline areas did not reveal significant direct loading from septic failures to marine waters. Subsurface contamination from septic systems could, be occurring, however. These findings may be in part due to low levels of development and the small number of residences built prior to septic system regulations.

Extremely high groundwater conditions exist on the Big Quilcene floodplain which, in combination with septic installations, may result in health threats to individual water systems in that area.

The Health Department has not taken consistent action in site evaluations, correction of septic malfunction, or resolution of matters of public inquiry.

The study conducted by Cascadia Research Collective concluded that the population of approximately 230 seals in Quilcene Bay is capable of producing a very high output of fecal bacteria. The actual impact of the seals cannot be known at this time without further research to determine bacterial die off and adsorption to bottom sediments.

Upstream activity and seal populations in the bay both contribute to bacterial loading into marine waters.

STAFF RECOMMENDATIONS

Some of these recommendations are addressed in the action plan of the Puget Sount Water Quality Authority, with implementation occurring at the state or regional level. Where such overlaps exist, close coordination between the count and regional and state agencies will be necessary. Follow-through at the local level will be needed if state efforts are to fully address the local issues and problems.

Future Research

1. Continue monitoring of the 18 established freshwater stations, the 5 marine stations in Quilcene Bay, and 2 of the 4 Dabob Bay stations (D1 and D2).

2. The County and the Department of Ecology should initiate baseline sampling for other watersheds in the county to provide historical perspective on water quality in the county.

3. The monitoring programs should be expanded to include the monitoring of turbidity to assist in evaluations for sediment loading.

4. The Department of Ecology should conduct further research to more precisely define the contribution of harbor seals to bacterial contamination.

5. Investigate ways to determine subsurface flow of untreated effluent into adjacent waterbodies.

6. Determine if alternative sampling methodologies exist which would provide more source identification in marine waters. Expand the sampling program to include the applicable techniques.

Agriculture

1. Neither the County nor the Department of Ecology should consider ordinances requiring the implementation of best management practices, but should encourge their voluntary implementation by initiating an educational program. This program should inform land owners of the importance of farm management to water quality and of the services available through the Jefferson Conservation District. At the end of two years the County should assess the success of such a voluntary program.

2. Conservation District efforts to implement best management practices should be given high priority in areas where natural purification of the water cannot or does not occur, including Cemetary, Tarboo, and lower Donovan Creeks.

3. Removal of livestock from the tidally inundated pasture at the mouth of Donovan Creek should be considered to be a high priority in efforts by the County and Conservation District to reduce bacterial loading to Quilcene Bay.

4. The County and the Department of Ecology should provide technical, physical, and financial support for the Conservation District's efforts to develop and implement management plans.

5. The County should coordinate with the Conservation District on an educational program addressing agricultural impact on water quality.

6. The County should develop criteria for the granting of "open space" tax status to land for which management plans have been developed and implemented.

7. The County should support the Conservation District in its efforts to coordinate the work of the Department of Fisheries, Soil Conservation Service, and local landowners to correct problems in areas subject to periodic flooding.

8. The County should request that the Conservation District conduct a workshop on agricultural management practices for the Planning and Building Department, Public Works, County Commissioners, Planning Commission, and Shorelines Commission.

On-site Septic Disposal

1. Staffing and funding levels for the Health Department should be adjusted to provide consistent, prompt, and personal service to the public.

2. The Health Department should formulate policies to assure quality control in the following areas:

Consistency in and among the field staff
Certification and continuing education for installers, designers, and field staff
Adequate supervision at all levels of staffing

3. The Health Department should respond promptly and thoroughly to public concerns where water quality may be in jeopardy.

4. The Health Department should develop procedural guidelines for major remodels, expansions, loan certification, variances, sub-acute septic malfunctions, etc. Procedures for major variances should include public notification and opportunity for input.

5. The Health Department should implement more detailed standards for vertical and horizontal separation in the project area.

6. The Board of Health should revoke the license of septic installers in serious violation of the sanitary code.

7. The Health Department should implement a designer program that will allow adequate oversight so that site evaluations will still be made, soil logs verified, installations inspected, etc.

8. The Health Department should clarify its present and past policy on the installation of septic systems into fill.

9. The Health Department should conduct educational workshops for septic pumpers on the evaluation of septic system function.

10.The Health Department should encourage regular septic tank pumping by sending out reminders every five years from the date of installation and retain on file the pumper reports.

11.The County should address potential health and water quality concerns in the lower Big Quilcene floodplain by investigating the technical, financial, and political feasibility of installing a community drainfield serving those 40 residences.

12.The Planning and Building Department should continue and expand the septic repair and loan program.

Marine Mammals

1. The County and the Department of Ecology should lobby the congressional delegation involved in the re-authorization of the Marine Mammals Act in calling for site-specific management of seal populations.

2. The Department of Ecology should fund continued research on the impact of seals on water quality in the State of Washington.

Wetlands Protection

1. The County should encourage preservation and conservation of wetlands through the use of favorable tax breaks.

2. Public works projects such as culverting over the mouth of Donovan Creek should address impacts on sedimentation, water flow, groundwater saturation, etc.

3. The County should promote programs which result in domestic animal exclusion from wetlands and tidally inundated pastures.

Sediment Control and Land Use

1. The County should advocate adoption of forest practices which maintain the natural runoff characteristics in logged watersheds.

2. The County should detail a set of private road standards and promote their use through education and assistance, relying on local ordinance only as a last resort.

3. Where existing lot standards are not in effect, shoreline development should be managed through the adoption of minimum lot width standards.

CITIZEN'S ADVISORY COMMITTEE RECOMMENDATIONS

General

1. County Commissioners will strive to keep future water quality study costs to a minimum. One way this can be achieved is that future water quality studies will be coordinated with other local, state, and federal agencies to keep costs and duplication of efforts to a minimum.

2. Public education could be enhanced by utilizing environmental education classes in local schools.

3. The Port and County Commissioners should assess the validity and the feasibility of providing a pumping station and/or informational material at the Quilcene Boat Haven about the importance of not dumping sewage from boats into Quilcene Bay.

4. Continue monitoring of stations set up by the study, with the permission of property owners, to determine if water quality in Dabob/Quilcene Bays is improving or degrading.

5. When the county upgrades roads it should address issues of upstream flooding caused by inadequate culvert sizing.

Seals

1. Recommend that the County do all it can to encourage the Congressional delegation to make changes to the Marine Mammal Act that allows the National Marine Fisheries Service to manage harbor seal populations. The Act is up for re-authorization next January and hearings begin this summer.

2. Recommend that the Department of Ecology conduct research on harbor seal populations to further define the level of fecal coliform bacterial contamination that can be attributed to seals.

3. Recommend that the Department of Ecology conduct bacterial speciation tests on a larger number of seal scats to determine the number and types of pathogens present and the degree to whuch harbor seals present a public health hazard.

4. Recommend that the Department of Social and Health Services and the US Food anbd Drug Administration begin using an indicator organism (perhaps E. coli) more closely correlated to the presence of a public health hazard. Sanitary surveys should also be conducted and used in conjunction with sampling for indicator bacteria when shellfish growing areas are certified or de-certified. It is felt that the use of an indicator alone, without a sanitary survey, and the use of fecal coliform bacteria as that indicator,

discriminates against rural areas because domestic animals, wood wastes, and perhaps seals contribute to high concentrations of fecal coliform yet may not contribute to a correspondingly high health hazard.

Agriculture

1. A high priority should be the provision of education to landowners and the general public about the issues of small farm management and water quality. Landowners should be made aware of the availability of technical assistenace, financial incentives and exiting educational materials provided by the County Extension Service, Soil Conservation Service, and the County Conservation District.

2. Since flood-prone areas can contribute to bacterial pollution even though the stream itself may be protected, a more comprehensive approach is needed. It is recommended that the Conservation District sponsor meetings with landowners and appropriate agencies, at the request of landowners, to work out the solutions to flooding and water quality problems.

3. The County and the Conservation District should cooperate in developing criteria and methods for providing tax incentives to landowners who voluntarily restrict animal access to streams through exclusion fencing. Compensation should be based on the amount of land lost to agricultural use.

4. It is strongly recommended that no new ordinances or regulations should be instituted regarding the keeping of livestock or other agricultural enterprises. The effectiveness of this program will be evaluated in 2 years by the Conservation District and a Citizen's Advisory Committee.

Septic Systems

1. Continue public education and voluntary compliance. This should include education about the importance of septic tank pumping, especially in geologically sensitive areas in the county.

2. County Commissioners should have a written policy of how they will handle citizen's voluntarily asking for assistance for failed septic systems. There should be firm written direction by the County Commissioners to the Health Department that they will cooperate with citizens, and that no cease and desist orders will be issued by the Health Department when property owners voluntarily request assistance.

3. Continue with low cost/interest loan program for upgrading failing septic systems in the county. Top priority should be septic systems in sensitive areas.

4. The Health Department must identify what is necessary to insure that septic systems are being designed and installed to state law. More funding may be necessary to make sure septic systems are being designed and installed so that public health, shellfish production, and water quality are protected and that degredation of water quality does not continue to occur in the county.

5. Major geographical areas in the county near bodies of water that affect public health, water quality, and shellfish production should be designated as "sensitive areas". The Health Department should prioritize work load in these areas to assure full compliance to state law in these sensitive areas. It should be mandatory that the Health Department inspect each septic system design and installation in these sensitive areas before systems are covered by the installer. There should be no major variance from state law in sensitive areas. If the Health Department allows any variance in state law in these sensitive areas they will document their reasons in writing.

6. Continue to encourage voluntary septic tank pumping in sensitive areas.

BIBLIOGRAPHY

Calambokidis, John and McLaughlin, Brian. Harbor Seal Populations and their Contributions to Fecal Coliform Pollution in Quilcene Bay, Washington. Cascadia Research Collective, 1987.

Citizens Review Committee, A Report for Pierce and Kitsap Counties Regarding Water Pollution in the Burley Lagoon and Mintercreek Watersheds, Pierce County Department of Planning and Development, 1986.

Cook, Kirk V. Sanitary Survey of Quilcene Bay, Jefferson County Washington, November 1984-December 1985. Department of Social and Health Services, 1985.

Determan, Timothy et al. Sources Affecting the Sanitary Conditions of Water and Shellfish in Minter Bay and Burley Lagoon, Washington State Department of Ecology, 1985.

Geldreich, Edwin. "Water-Borne Pathogens." In Water Pollution Microbiology. Edited by Ralph Mitchell. New York: Wiley-Interscience, 1978.

Gerba, Charles and McLeod, John. "Effect of Sediments on the Survival of Escherichia coli in Marine Waters." Applied and Environmental Microbiology, July 1976.

Hood Canal Coordinating Council, Hood Canal Regional Planning Policy, 1986.

Kittrell, F. W. A Practical Guide to Water Quality Studies of Streams. Federal Water Pollution Control Administration, Government Printing Office, Washington, D. C., 1969.

McNicholas, Richard P. Totten and Little Skookum Inlets Water Quality Investigation and Improvement. Mason County Department of General Services, 1986.

Mitchell, Ralph and Morris, J. Carrell. "The Fate of Intestinal Bacteria in the Sea." In Advances in Water Pollution Research. Proceedings of the Fourth International Conference held in Prague. Edited by S. H. Jenkins, 1969.

Oliveiri, Vincent. Chapter 2, Bacterial Indicators of Pollution. Edited by Wesley O. Pipes. CRC Press, Inc, 1982.

Puget Sound Water Quality Authority, 1987 Puget Sound Water Quality Management Plan. State of Washington, 1987.

Purser, Michael. Animal Survey and Bacterial Water Sampling Results in the Dabob/Quilcene Water Quality Study Area, 1987.

Saunders, Robert S. Shellfish Protection Strategy. Shorelands Division, Washington Department of Ecology, 1984.

Struck, Philip. An Evaluation of Non-point Bacterial Contamination in Hood Canal, Bremerton-Kitsap County Health Department, 1987.

Taylor, Marilou. The Henderson and Eld Inlet Water Quality Study. Thurston County Human Services Department, 1984.

U.S Department of Agriculture, Soil Survey of the Jefferson County Area, Washington, 1975.