WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

LAND USE AND WATER QUALITY

MISSION CREEK
LITTLE MISSION CREEK
SUB-BASINS

LOWER HOOD CANAL

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Washington State Department of Ecology
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EXECUTIVE SUMMARY

Since 1987 part of Lynch Cove (Lower Hood Canal) has been downgraded for shellfish harvest. The affected areas includes Belfair State Park (North Shore about two miles southwest of Belfair in Mason County). Belfair State Park has the second highest oyster production in Puget Sound, Washington. Washington State Parks and Recreation staff expressed concern about pollution presumed to be coming from Mission/Little Mission creek sub-basins. Mason County Department of Health Services has focused most grant-funded energy surveying on-site sewage treatment/disposal systems along the shoreline. The sub-basins were assigned lower priority. The Department of Ecology conducted a land use assessment and intensive storm-event sampling of the sub-basins to provide information to the County and others to aid in reviewing survey priorities.

Most development lies in the southern end of the sub-basins near Belfair State Park and in the nothernmost end of the watershed (Kitsap County). Light recreation-related commercial activity is located next to the park. There is intensive residential use along the lower end of each main stream and nearby on the eastern boundary of the Mission Creek sub-basin. Agricultural activity is minimal. Logging is occurring in the central part of the Mission Creek sub-basin.

Samples were collected from Mission and Little Mission creeks above and below developed segments and from several undeveloped tributaries. Three sampling runs were made in February and March 1994 during rain events. Two runs were made during a dry period.

Results suggest Mission and Little Mission creeks are not important sources of fecal coliforms to tideland at Belfair State Park. Fecal coliform levels from all stations were very low. All sites complied with Part 1 of the State Water Quality Standards for fecal coliforms. Compliance with Part 2 is likely. There was no significant difference between the creeks for either fecal coliform levels or loadings. Neither were rain-event results significantly different from dry results. Sites downstream of developed stretches of the creeks were not statistically different from either sites upstream of development or undeveloped tributaries.

Mission and Little Mission creeks were compared with seven streams of comparable size (but with various land uses) throughout Puget Sound. These streams were Bell Creek (Sequim Bay), Chimicum Creek (draining into Port Townsend), Donavan Creek (Quilcene Bay), Kennedy Creek (Totten Inlet), McLane Creek (Eld Inlet), Minter Creek (Case Inlet near Purdy), and Mayo Creek (Mayo Cove near Penrose Point State Park). Both Mission and Little Mission creeks ranked lowest in fecal coliform levels. Little Mission Creek was among the lowest fecal coliform loaders. Mission Creek ranked in the middle but was well below the four highest loading streams (Bell, Chimicum, McLane and Minter creeks).

Since completion of the sampling survey, the County undertook inspections in the sub-basins. Fifteen of 117 inspected on-site systems were found to be failures. Yet it seems that these failures did not affect stream quality appreciably. This outcome may be due to the unique nature of the hydrology in the stream corridors.

The strategy of rigorous inspection of on-site systems along the marine shoreline is likely to produce the greatest return for the effort. Continued inspections of on-site sewage treatment/disposal systems would probably be best done by working along the shoreline in both directions away from the Park.

The County should consider intensive sampling of Mission Creek during low summertime flow to test the hypothesis presented herein that fecal coliform loading may be higher at that time.

It is suggested that a routine weekly census of birds in Park tidelands be conducted for evidence of their role in marine water quality.

ACKNOWLEDGEMENTS

The authors thank Wayne Clifford and the Mason County Water Quality Office for their assistance in this project (particularly for loaning their Marsh McBirney current meter). Thanks also to Marilou Pivirotto, Mikel McCormick, and Bill Young of Ecology's Southwest Regional Office for their assistance in sampling. In particular, we thank the several citizens who allowed us across their land to reach our sampling sites. The report has benefited from comments of several reviewers, including Marilou Pivirotto and Bill Young (Ecology Southwest Regional Office), Brian Hovis (State Parks and Recreation Commission), and Bob Genoe (Belfair State Park). Grant Holdcroft (Mason County Water Quality Office) provided details on the on-site systems survey program in Lynch Cove, and Mark Thompkins clarified aspects of the on-site survey protocol. Finally, thanks to Laura Bachmann (Ecology Water Quality Program) for her assistance in formatting the final report.

INTRODUCTION

In 1987, the Washington State Department of Health (DOH) downgraded the eastern end of Lynch Cove (Hood Canal near Belfair) from "Approved" for direct harvest of shellfish to "Prohibited" due to unacceptable levels of fecal coliform bacteria. The closure halted commercial harvest from 630 acres of intertidal growing area. Recreational and tribal harvest was curtailed at Belfair State Park (about two miles west southwest of Belfair on the north shore), the second most productive public oyster site in Puget Sound. In 1993, DOH extended the boundaries of the closure zone.

Shellfish Resources. Over 11 million oysters were recently counted at Belfair State Park (1990 Hood Canal Oyster Harvest Plan). Nearly 1.8 million oysters were of harvestable size. Recent court action has affirmed treaty rights to half the shellfish resource at usual and accustomed sites. Thus half the harvestable resource at Belfair State Park is reserved as treaty share. The remaining oyster resource at Belfair State Park could support 50,000 recreational harvest trips per year, assuming that each recreational harvester collected his/her sport limit. A recent study (Washington State Parks and Recreation Commission, updated) used a figure of $21.50 per day per visitor to estimate the positive economic effect of public parks in the Columbia Gorge vicinity If this value is applied to Belfair State Park, the recreational shellfish resource could potentially generate 1.1 million dollars a year in nearby motels, restaurants, fuel stations, and stores. The closure of the Park to shellfish harvest represents a significant economic loss to the local economy.

Suspected Pollution Sources. DSHS (1988) strongly suggested that sewage from failed on-site sewage systems within the Belfair area was the cause of reduced water quality in Lynch Cove. The report also concluded that the soils around Belfair and Belfair State Park were generally poor for conventional on-site sewage treatment/disposal systems. DSHS (1988) recommended severe restrictions be placed on installation of new systems, and that planning be commenced to remedy existing failures and secure long-term solutions. Kitsap/Mason Counties (1990) confirmed that bacterial contamination from failing or improperly maintained on-site septic systems on or near Hood Canal was the single most significant water pollution problem in the watershed.

Mason County On-site System Surveys. The Mason County Water Quality Office has been inspecting on-site sewage systems along marine shorelines and stream corridors in response to shellfish concerns in several Mason County watersheds. Mason County's procedure includes initial interviews with residents, inspection of facilities, and dye-testing with activated charcoal packets if needed (Mark Thompkins, Mason County Water Quality Office, personal communication). Although inspections are best done in winter when soils are saturated, many vacation homes must be surveyed in the summer when occupied. This labor-intensive effort (supported by state and federal funds) has taken nearly all the resources of the Water Quality Office for several years.

Mason County prioritized on-site surveys in Lynch Cove as follows (Grant Holdcroft, Mason County Water Quality Office): 1. North Shore from Belfair to Elfendahl Pass Road (five miles west northwest of Belfair, 189 on-site systems); 2. South Shore to a point two miles southwest of Belfair; 3. Mission Creek drainage (more than 117 systems); 4. Belfair area.

State Parks Concerns. In April 1994, the Washington State Parks and Recreation Commission directed their staff to explore, with the State Attorney General, legal options available to the Commission to speed reopening of shellfish harvest at Belfair State Park. Concern was expressed in some quarters that the Mission/Little Mission creeks should receive higher survey priority. In light of these concerns Ecology staff selected Mission Creek/Little Mission sub basins from among a number of candidate watersheds for an assessment of nonpoint sources.

OVERALL ASSESSMENT STRATEGY

The Mission Creek watershed assessment was done in early spring, 1994. There were two elements:

> **Land Use Assessment**. Field inspections and literature review was done to characterize land use. Major drainages were identified. Sites were selected for water sampling and stream flow measurements.
>
> **Water Quality Assessment**. Intensive rain-event sampling was done at representative sites to measure nonpoint pollutant levels and loads and to rank their contribution. One goal of the ranking was to provide a tool with which the County could evaluate their priorities for remedial action. Another goal was to provide baseline information to gauge effectiveness of future remedial action.

LAND USE ASSESSMENT

Physical Description. Table 1 gives dimensions of stream corridors within the Mission/Little Mission sub-basins. The narrow axis of the Mission Creek watershed stretches 15.3 miles north-northeast of Belfair State Park (Figure 1). The headwaters of Mission Creek are wetlands associated with Mission Lake in Kitsap County.

Six tributaries join Mission Creek along its length. The main stem from the mouth to West Fork No. 1 (3.7 miles upstream) is classified as Water Type 1 ("Shorelines of the State" under the State Shoreline Management Act). Above this point, main stem and tributaries are classified as Water Type 3 (moderate to slight use and importance to water quality). Annual precipitation averages around 60 inches. The entire watershed is heavily forested with low, rolling hills. The slopes in the upper watershed are moderate to steep.

Both Mission and Little Mission creeks are good producers of coho and chum salmon. Despite its small size, Little Mission Creek outproduces both Mission Creek and Union River (near Belfair) in fish production due to its high flow during low-flow periods (PSCRBT 1991).

Soils. Soils in the Mission Creek/Little Mission Creek watershed consist of glacial outwash terraces (25%), glacial moraines and till plains (74%), and bottomlands (1%).

Glacial moraines and till plains are interspersed between glacial outwash terraces in the upper reaches of Mission and Little Mission creeks. Glacial outwash soils generally follow the path of Big Mission Creek. They occur as gravel ridges on glacial moraines or as fairly continuous outwash channels in the Mission Creek drainage. About 40% of the soils are Everett soils, 40% other. These soils are very deep and somewhat excessively drained. In other words, water movement through Everett soils is rapid because they lack fine soil particles and organic matter. Excessive drainage can limit effectiveness of on-site sewage treatment. Current Washington State Department of Health requirements allow a maximum density of one unit per acre on this type of soil using conventional septic systems.

Table 1. Major hydrological features of Mission and Little Mission basins		
SUB-BASINS	STREAM LENGTH (MILES)	BASIN AREA (SQUARE MILES)
MISSION CREEK		
Main stem to headwaters	7.0	
West Tributary No. 1	0.7	
West Tributary No. 2 (main stem to headwaters)	2.7	
West Tributary No. 3 (southern trib. of West Tributary No. 2)	0.5	
East Tributary No. 1 (main stem + east fork)	2.1	
East Tributary No. 2 (west fork of Tributary No. 1)	1.3	
Upper drainage tributary	0.7	
TOTALS FOR MISSION CREEK SYSTEM	15.0	13.2
LITTLE MISSION CREEK		
Main stem + east fork	1.9	
West fork	1.4	
TOTALS FOR LITTLE MISSION CREEK SYSTEM	3.3	1.9
GRAND TOTALS FOR BOTH STREAM SYSTEMS	18.6	15.1

Most slopes along stream corridors are fairly steep. The creeks and their tributaries have little or no floodplains. Seventy-four percent of the soils in stream corridors are Shelton soils and 26% are other types. The soils are moderately deep, well drained, and highly erodible. The depth to hardpan ranges from 30 to 36 inches. During the rainy season, Shelton soils usually develop a high water table which limits effective treatment of effluent.

Soils on bottomlands cover a relatively insignificant portion of this watershed. These soils are located around Belfair State Park and State Route 300.

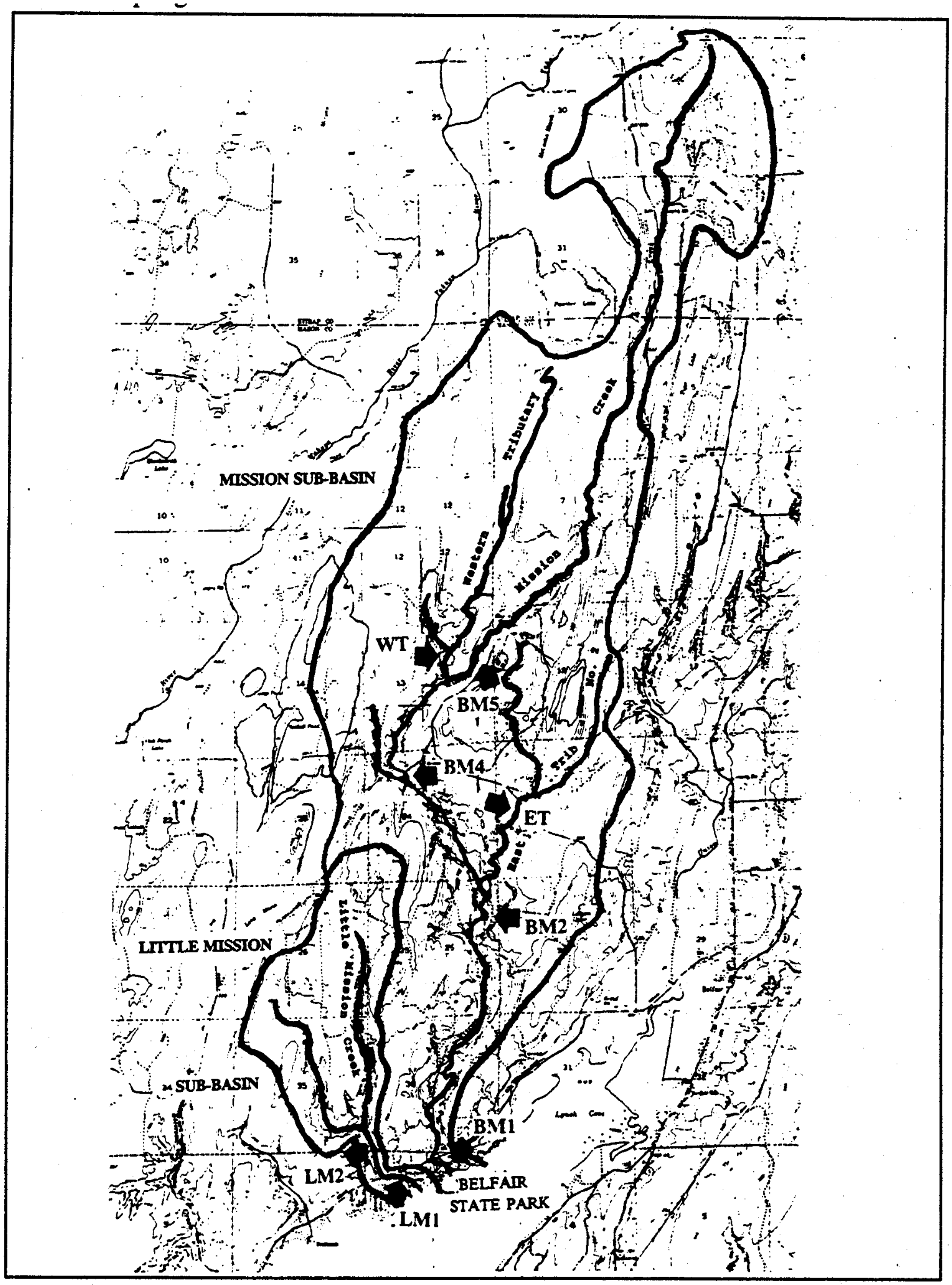
Belfair State Park. Belfair State Park is about thirty years old and covers about 60 acres. There are 184 camp sites, 23 of which are next to Little Mission Creek (Bob Genoe, Belfair State Park, personal communication). About 25% of all campsites have sewage hook-ups for recreational vehicles. All but two RV sites are away from the creek. One drain for disposal of cooking and dish wash water into the ground is provided for every five or six campsites.

There are four large bathrooms and changing facilities and a sewage dump station for recreational vehicles. Wastewater is treated by a conventional on-site system with a large drainfield in a broad meadow near the entrance to the park. The system is about two hundred yards from Mission Creek. A level 1 inspection (i.e, search for signs of failure and appropriateness for dye testing, Mark Thompkins, Mason County Water Quality Office, person communication) showed the system to be functioning properly (Sargeant and Seyferlich, 1994).

Belfair State Park occupies over 3,500 feet of Hood Canal shoreline (Scott, et al, 1986). Sixty two acres of tidelands support abundant shellfish. There are four species of clams (littleneck, native littleneck, manila, and eastern softshell) along with oysters. The upper intertidal zone at Belfair State Park is made up of gravels, sands and muds covered with eelgrasses and riddled with small inlets and tide pools. Both streams flow into Hood Canal across these tidal flats. Mission Creek flows along the eastern boundary of the park and Little Mission Creek flows through the center. At the time of inspection, the muddy substrate had a noticeable sulfuric smell from decaying organic matter.

Numerous water birds were also observed in the tide flats. These birds have been cited as an important potential source of fecal coliform contamination (Rick McNicholas, Kitsap County Department of Community Development, formerly Mason County WQ Office, personal communication.)

Figure 1. Mission and Little Mission sub-basins showing major drainage systems and sampling sites.



One issue is whether the number of birds has increased over the years to match the increase in fecal coliform levels in the shellfish growing area. However, the dynamics of waterfowl populations and their effect on water quality have not been evaluated.

Mission Creek Sub-Basin The most intensive development occurs in the southern end of the sub-basins. Homes line the marine shoreline in both directions from the park. Across State Route 300 is a gas station, grocery store, and laundromat. These businesses lie within one hundred yards of Mission Creek. Park Place Mobile Home Park is directly behind the store. At the time of the land use survey, 48 travel trailers and mobile homes were present. The community on-site sewage system serving Park Place was deemed a maintenance failure by the Mason County Environmental Health Dept. The case was turned over to the State Department of Health for enforcement (DOH has authority for community-sized systems with daily flow of less than 14,500 gallons per day). The case is still pending (Grant Holdcroft, Mason County Water Quality Office, personal communication).

Mission Creed Rd. N.E. runs north from State Road (SR 300) parallel to Mission Creek for a half mile. Dense residential development exists in pockets along this stretch and beyond to River Mile 2.1 (Site BM2, Figure 1). The total number of lots and their estimated distance from Mission Creek are as follows:

Lots under 25 feet from the creek:	29
Lots between 25 and 50 feet from the creek:	14
Lots between 50 and 100 feet from the creek:	19
Lots over 100 feet from the creek:	93
Total Lots	**155**

These creekside residences are mainly older houses and mobile homes. According to Mason County (1990), 47% of respondents listed their water supply as a community system, 38% listed private wells. A sampling site (BM 2, Figure 1) is located 2.1 miles from the creek mouth immediately upstream from residential development.

Considerable residential development is occurring on the ridge east of Mission Creek. These relatively new homes were not counted due to their distance from the creek.

About 4 miles north of its Highway 300 junction, Sand Hill Road crosses East Tributary No. 1 about 0.4 miles above its Mission Creek confluence (Site ET, Figure 1). The tributaries upstream from this point drain a large revegetating clearcut. This site was chosen as an undeveloped control. PSCRBT (1991) reports two locations along Eastern Tributary No. 1 with 1-3 animal units. These animals were not observed in the clearcut and were presumed to be located downstream from Site ET.

About a mile further along Sand Hill Road, a left turn onto a gravel road ("Goat Ranch Road") leads to Mission Creek at River Mile 3.7 (Site BM 4, Figure 1). PSCRBT (1991) identified an off-road vehicle (ORV) park at this spot as a major source of eroded soils into Mission Creek.

Two undeveloped tributaries flow from the west into Mission Creek between River Mile 3.7 and River Mile 4.9 (Site BM5, Figure 1). These tributaries drain an area that has recently been logged. No other activity was observed. Sampling Site WT is located on one of these tributaries (Figure 1).

Sand Hill Road continues north from Goat Ranch Road to a baseball field across from Mission Creek Youth Rehabilitation Center. A walk westward from the road to the sample site takes five minutes across moderately sloped, heavily forested terrain. This site was determined to be suitable for an upstream control (Site BM5, Figure 1).

There was little nonpoint impact observed between BM5 to the upper boundary of the watershed. Most land is uninhabited and development is as yet minimal. Commercial and private forest land comprise 84% of the watershed (PSCRBT 1991). Most development in the upper watershed surrounds two lakes. They are Mission Lake and Tiger Lake (88 and 110 acres respectively). Mission Lake is 50% developed and Tiger Lake is 100% developed.

Agricultural activity in Mission Creek watershed is minimal. Only four locations were found to have agricultural activity. Three locations had three or less animals and one had three or more animals (PSCRBT 1991).

Little Mission Creek Sub-Basin. Little Mission Creek passes through the center of Belfair State Park along the western edge of the campground. The area of the compact Little Mission Creek sub-basin is about 2 square miles and lies close to Hood Canal. The length of all streams is about 3.3 miles (Table 1). The lower segment of Little Mission Creek to the confluence of its two tributaries is classified Stream Type 2 (high use and importance to water quality). The upper tributaries are Water Type 3 (PSCRBT 1991).

Housing in Little Mission Creek consists of older houses and mobile homes along the main stem from SR 300 to a point 0.8 miles upstream from the mouth (Site LM2, Figure 1). Access above this point is limited and the land is heavily forested. The number of lots and their estimated distance from Little Mission Creek are as follows:

Lots under 25 feet from the creek: 37
Lots between 25 and 50 feet from the creek: 6
Lots between 50 and 100 feet from the creek.. 5
Lots over 100 feet from the creek: 15
Total Lots:... 63

No agricultural activity was observed in Little Mission Basin.

WATER QUALITY ASSESSMENT

Materials and Methods

Sampling Sites. Sampling sites were placed at the following locations (Figure 1):

a. Mouths of major streams and tributaries

b. Above/below land uses presumed to be sources of fecal coliforms.

Undeveloped tributaries were sampled to provide "spatial" controls (i.e. comparison of "development" versus "undevelopment").

Sites were located in public right-of-way where possible. Two sites were located on private land and permission to sample was obtained from the landowners. Table 2 summaries locations and descriptions of each sampling site.

The tide backs up into Mission Creek about one hundred to 150 yards from its mouth. A sampling station is located within this stretch of stream. Tidal effects were minimized by sampling at times when tide height was well below the river bed at the site. The tide does not affect Little Mission Creek because the stream bed is perched above the limit of tide by accumulated beach sediments.

Sampling Frequency. Each site was sampled and flow measured once during on day during each of three rain events (February 28, March 2, March 22) and two consecutive days following a lengthy dry period (March 15, 16). Rain-event sampling was to be done when total rainfall on the previous day exceeded 0.5 inches. Dry-period sampling provided a "temporal" control (i.e., comparison of "runoff" periods versus "dry").

Table 2. Sampling sites on Mission and Little Mission creeks.		
STATION	DESCRIPTION	COMMENT/ACTIVITY
(MISSION CREEK SUB-BASIN)		
BM5	Northernmost sampling site 4.9 miles upstream from Mission Creek mouth.	Sparse housing/ag upstream; residential area (limited drainage into Mission Creek) 4 miles further north.
WT	Undeveloped western basin; site above confluence with Mission Creek.	No residential or agricultural use observed; active logging area.
BM4	Mission Creek below confluence with western tributary and 3.7 miles upstream of Mission Creek mouth.	No residential or agricultural use observed; ORV park located here.
ET	Undeveloped eastern basin; site 0.4 miles upstream of confluence with Mission Creek.	No residential or agricultural use observed; logged area.
BM2	Mission Creek 2.1 miles upstream of mouth.	Minimal activity upstream; intensive residential use between here and stream mouth.
BM1	Mission Creek at mouth (east boundary Belfair State Park).	Downstream limit of residential development.
(LITTLE MISSION CREEK SUB-BASIN)		
LM2	Little Mission Creek upstream of residential development and 0.8 miles upstream of mouth.	Minimal use upstream; intensive residential use between here and stream mouth.
LM1	Little Mission Creek (within Belfair State Park.	Downstream limit of residential development.

Parameters. Table 3 describes parameters measured and methods employed. Data (concentrations and loads) were converted to base-10 logarithms prior to applying statistical tests. This "transformation" converts log-normally distributed data into approximate normal

Table 3. Sampling and analytical methods for parameters sampled or measured during the intensive survey of Mission and Little Mission creeks.			
PARAMETER	FIELD SAMPLING/MEASUREMENT METHOD, STORAGE	ANALYTICAL METHOD	PRECISION
Fecal Coliform	SAMPLE: grab midstream, 15-30 cm depth. CONTAINER: sterilized glass: supplied by Ecology Manchester Laboratory. STORAGE: 1-4oC (ice chest); to lab within 6-12 hours of sampling.	Membrane filter (SM-18 9222 D)	Precision Criterion as per SM-18 9020 B (4.)
Stream flow	MEASURE: in situ using a Marsh McBirney Model 201 flowmeter.	as per manufacturer's instructions; current meter method described in Buchanan and Somers (1969)	RSD=3.7% (30 x-sectional points); 6.3% (10 x-sectional points); (from Carter and Anderson 1963).
Rainfall	MEASURE: NOAA rain gauge at Bremerton National Airport.	daily measurement by NOAA cooperator	na

distributions. An arithmetic mean was calculated for each group of log-transformed data. This mean was then "retransformed" by taking the antilog. This value is mathematically identical to the geometric mean. Geometric means were compared to the State Surface Water Quality Standards (Chapter 173-201 WAC).

STATGRAPHICS statistical software (Statistical Graphics Corporation) was used for statistical analysis and graphics. Despite the log-transformation, the data still did not fit a normalized model due to numerous low values. The data were pooled into groups of various kinds (sites, dates, wet/dry weather, etc.) and comparisons were made using nonparametric statistical methods. Nonparametric methods (based on ranks rather than absolute values) are appropriate for data with non-normal or "skewed" distributions.

Fecal coliform loads were calculated from the following equation:

FC load (CFU/sec) = [FC] Q (284.7)

where [FC] = concentration of FC as "Colony-Forming Units"/100mL

Q = stream flow (cu. ft. per sec.)

and 284.7 = correction factor

Results and Discussion

Rainfall. Figure 2 shows cumulative rainfall during three rain events (February 28, March 2, and March 22), and two dry-period days (March 16-17). "Significant" storm events occurred on February 28 (0.78 inches) and March 2, 1994 (1.05 inches). Rainfall on March 22 (0.24 inches) was less than the set criterion (0.5 inches). However, the data were used because of the relatively high three-day rainfall total (1.72 inches), and the rapidly waning probability of additional significant rain events due to the lateness in the wet season. Only trace rainfall occurred on or previous to dry-period sampling.

Stream Flow. Stream flow at all sites (Figure 3) was significantly correlated to one-day rainfall (Spearman's rho = 0.5544, p = 0.001). Two and three-day rainfall were also significantly correlated, but tto a lesser degree (Spearman's rho = 0.46 and p = 0.0015 for both 2-day and 3-day rainfall). Flow increased in Mission Creek by over a third between BM5 and BM4 (Table 4). Another 50 to over 80 percent was added between BM4 and BM2. These additions were likely due to runoff and/or groundwater contributions. A fraction of flow (3 to 14%) appears to have been lost downstream of BM2. However, this "loss"between BM2 and BM1 on March 2 may be an artifact of erroneously high velocity readings at BM2 caused by deviations from ideal conditions for accurate flow measurement.

Little Mission Creek consistently lost flow between LM2 and LM1 during both wet and dry periods. Presumably, some flow moved laterally out of the stream due to factors which will be discussed later in this report.

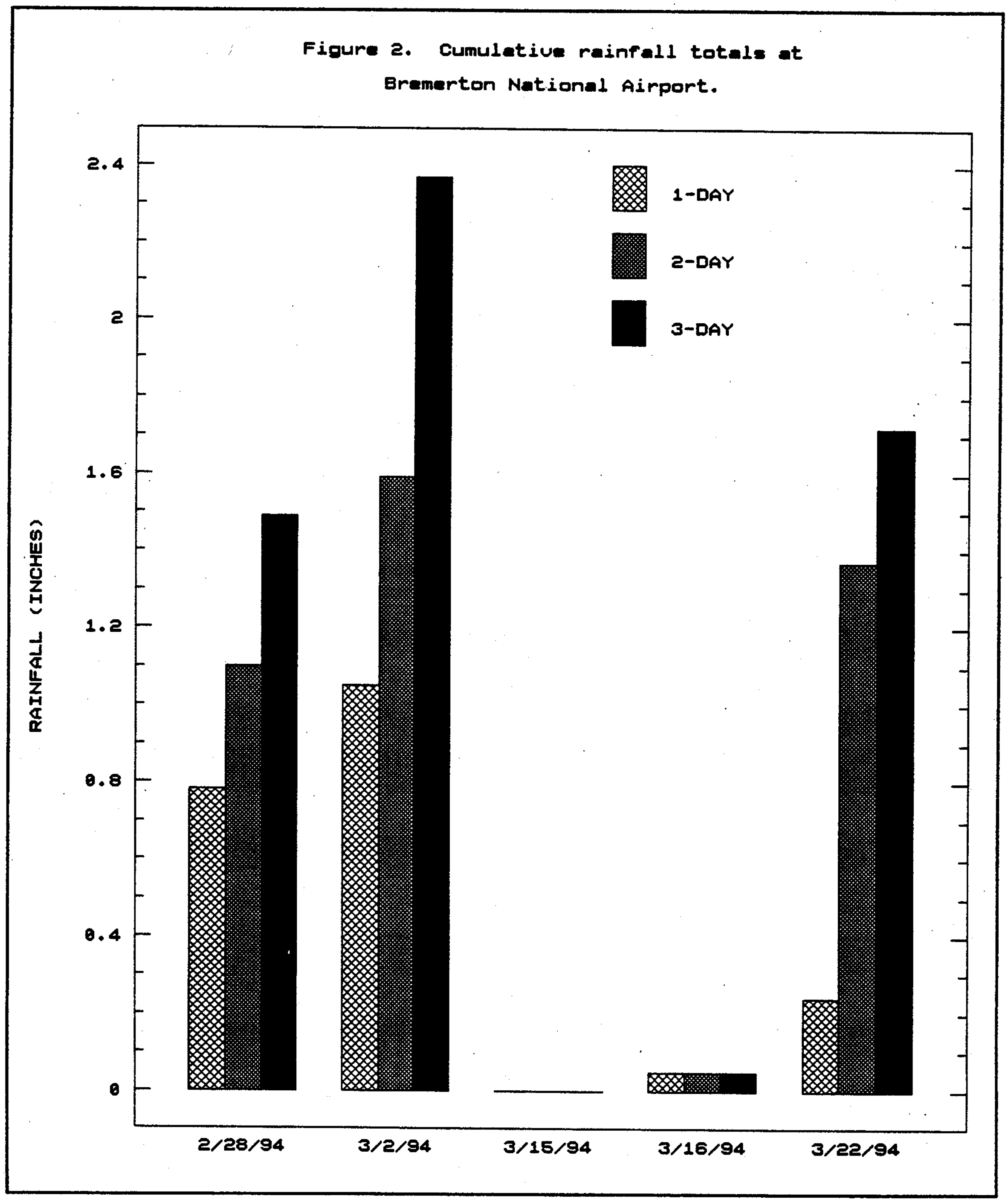


Figure 2. Cumulative rainfall totals at
Bremerton National Airport.
RAINFALL (INCHES)
2.4
2
1.6
1.2
0.8
0.4
0
1-DAY
2-DAY
3-DAY
2/28/94
3/2/94
3/15/94
3/16/94
3/22/94

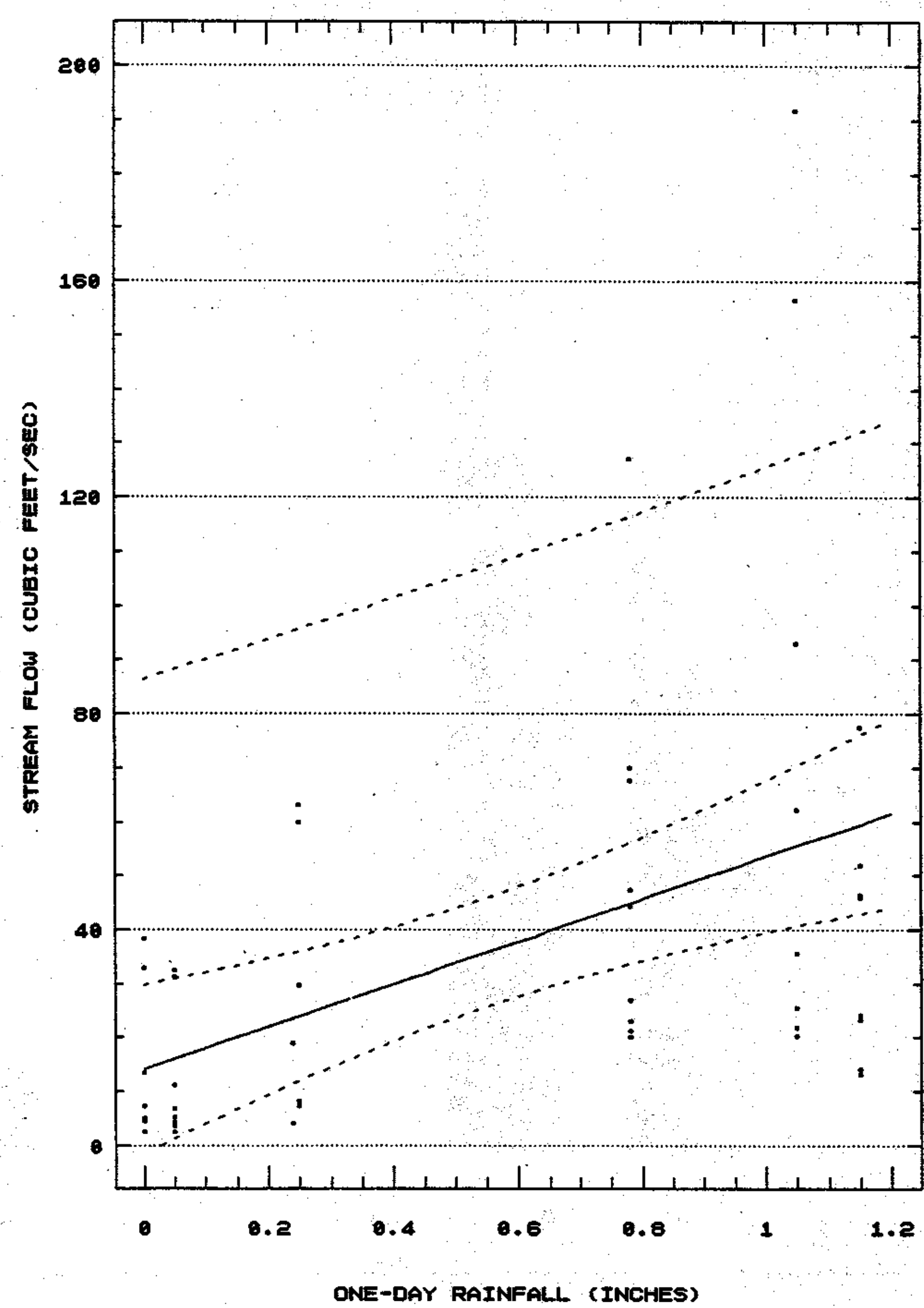


Figure 3. Stream flows at all sites versus one-day rainfall.

Table 4. Flow (cubic feet per second) measured at sampling sites on Mission and Little Mission creeks during dry and wet sampling days.

	DRY DAYS		WET DAYS			
SITE	3/15	3/16	2/28	2/28	3/2	3/22
(MISSION CREEK BASIN)						
BM5	7.3	6.8	44.4	47.4	62.2	18.9
WT	2.6	2.6	nv	nv	35.7	4.1
BM4	13.5	11.3	67.6	69.9	93.1	29.8
Flow added between BM4 and BM5; [% of BM4)	6.2; [46%]	4.5; [40%]	23.2; [34%]	22.5; [32%]	30.9; [31%]	10.9; [36%]
ET	4.6	3.7	21.2	20.2	22	7.3
BM2	33.0	31.4	sfty	sfty	191.9	60
Flow added between BM2 and BM4; [% of BM2)	19.5; [59%]	20.1; [64%]	nc	nc	161.0; [84%]	30.2; [50%]
BM1	38.3	32.5	127.0	instr	156.5	63.0
Flow added between BM1 and BM2; [% of BM1)	5.3; [14%]	1.1; [3%]	nc	nc	-35.4; [-23%]	3; [5%]
(LITTLE MISSION CREEK BASIN)						
LM2	5.0	5.3	instr	instr	25.6	8.2
LM1	4.5	4.3	23.0	2.07	20.4	7.5
Flow taken out between LM2 and LM1; [% of LM2)	-0.5; [-11%]	-1.0; [-23%]	nc	nc	-5.2; [-20%]	-0.7; [-8%]

nv: not visited due to remoteness of site and limited time.
sfty: not sampled due to safety issue.
nc: not calculated due to missing data.
instr: no data due to flow meter failure.

Fecal Coliform Levels. Hood Canal is classified as Class AA Marine Waters in the Water Quality Standards for Surface Waters of the State of Washington (Chapter 173-201A WAC). Lynch Cove is classified the same since it is part of Hood Canal. Mission and Little Mission creeks are "tributaries" to Lynch Cove and are therefore classified as Class AA Freshwaters (WAC 173-201A-120 General Classifications). Fecal coliform standards for Class AA Freshwaters are in two parts, both of which must be met for compliance.

a. Fecal coliform organisms shall not exceed a geometric value of 50 organisms/100mL;

b. Not more than 10 percent of samples shall exceed 100 organisms/100 mL.

Figure 4 summaries geometric mean fecal coliform levels for each sampling site sorted into wet (W) and dry (D) periods. Water quality in both streams was excellent. All stations complied fully with the first part of the fecal coliform standard. Geometric means ranged from 1 CPU per 100 ml (Sites WT, BM4, BM2, and LM2; dry days) to 8 CFU per 100 ml (BM1; wet days). The data at any single site were too few to evaluate the second part of the Standard. However, since the highest fecal coliform concentration detected at any site (wet or dry) was 22 CFU (Site LM2 on March 2), it is safe to conclude compliance with the second part of the fecal coliform standard.

Fecal Coliform Loads. Fecal coliform loads for each sampling site are summarized in Figure 5. Geometric mean loads are shown for dry and wet sampling periods at each site. Pairs of sites were compared using the Least Significant Difference (LSD) multiple comparisons procedure. Loads at the mouths of Mission and Little Mission creeks (BM1 and LM1) were not significantly different from sites immediately upstream of development (BM2 and LM2) during either wet periods (BM1W vs. BM2W; LM1W vs. LM2W, respectively) or dry periods (BM1D vs. BM2D; LM1D vs. LM2D, respectively). Thus developed stretches contributed insignificant contamination to either Mission or Little Mission creeks. Also, overall loading from Mission Creek and Little Mission sub-basins (BM1W vs. LM1W; BM1D vs. LM1D, respectively) was not significantly different. Indeed, fecal coliform loading was so low that pooled wet-weather results from the river-mouth sites were not significantly different from undeveloped sites WT and ET.

The low loading in Little Mission Creek during rain events may be partially explained by the porous soils along the stream in its lower stretch. Little Mission Creek showed a consistent net loss of flow between Site LM2 and LM1 (Table 4). The stream level may have been higher than the water table in the adjoining soils, and presumably, the lost flow moved laterally out of the stream bed and into permeable soils next the stream. The lower hydrostatic pressure in the soils may have kept on-site sewage from moving into Little Mission Creek during high flow. This hypothesis might be test by repeating the sampling during summertime low flow, when there is the greatest likelihood of a reversal in the hydrology (suggestion by Wayne Clifford, Mason County Health Services Department). A similar mechanism in Mission Creek may reduce seasonal loading. On the other hand, soils may effectively absorb effluent from failed systems before it reaches the stream. In this case, also, resampling during summertime low flow might be appropriate.

In summary, watershed loads do not account for elevated fecal coliforms in park shellfish. This outcome does not mean failures have not occurred in the sub-basins. Recent inspections of 117 systems in the basins revealed 15 failures (about 13 percent). However, the nature of the geology and hydrology of the sub-basins seem to diminish the effect of on-site failures at least during high flow periods. In general, the excellent water quality coming from Mission and Little Mission creeks support the County strategy of placing highest priority for on-site surveys on marine shorelines between Belfair and the state park.

Table 5 compares fecal coliform concentrations and loads from Mission/Little Mission creeks with other small Puget Sound streams draining rural basins. Data sources vary widely in terms of scope of study and sampling intensity. Also intensity of land use in the basin varies roughly in proportion to the fecal coliform loading. Thus any comparisons with Mission and Little Mission creeks are qualitative only.

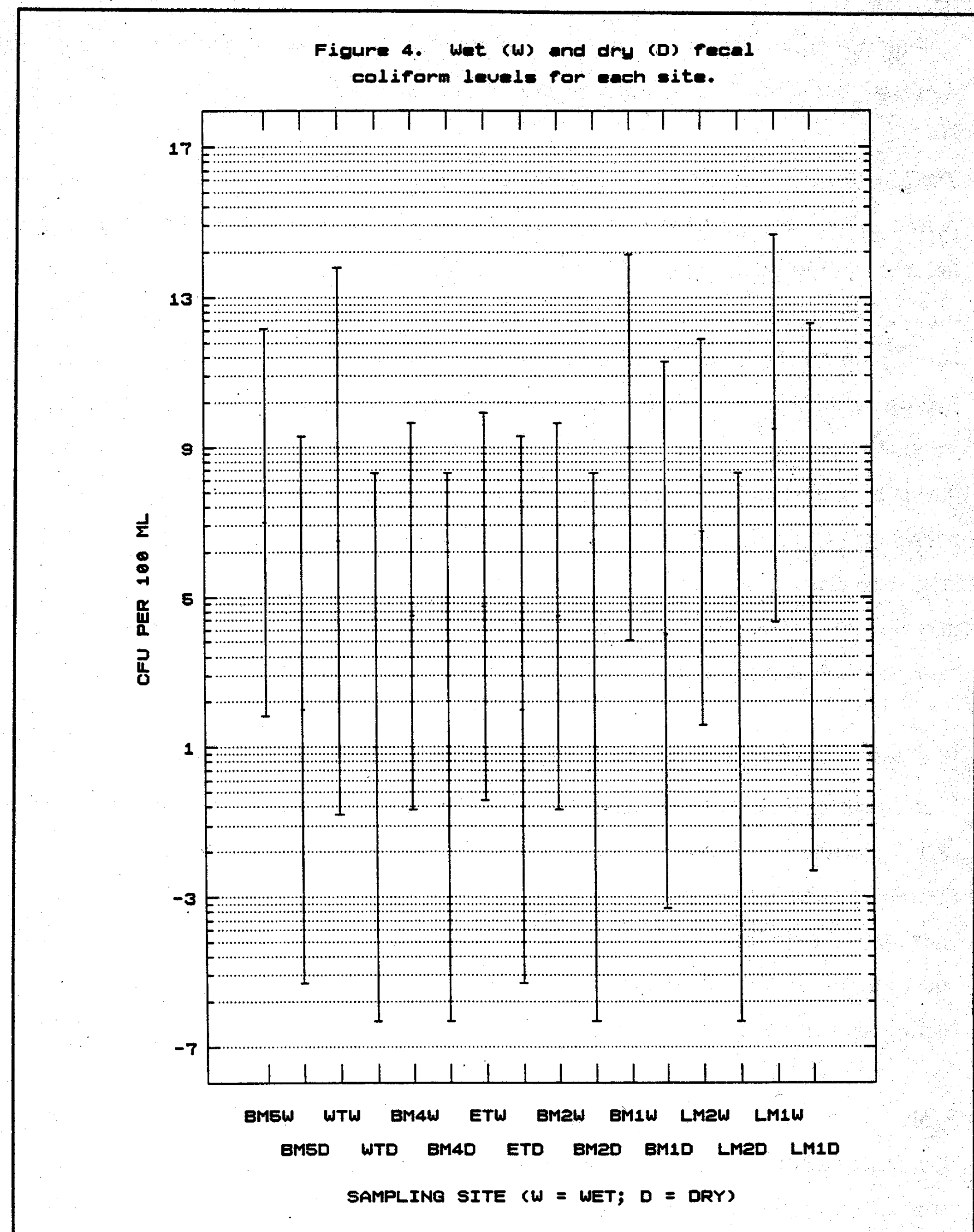


Figure 4. Wet (W) and dry (D) fecal coliform levels for each site.
CFU PER 100 ML
17
13
9
5
1
-3
-7
BM5W
BM5D
WTW
WTD
BM4W
BM4D
ETW
ETD
BM2W
BM2D
BM1W
BM1D
LM2W
LM2D
LM1W
LM1D
SAMPLING SITE (W = WET; D = DRY)

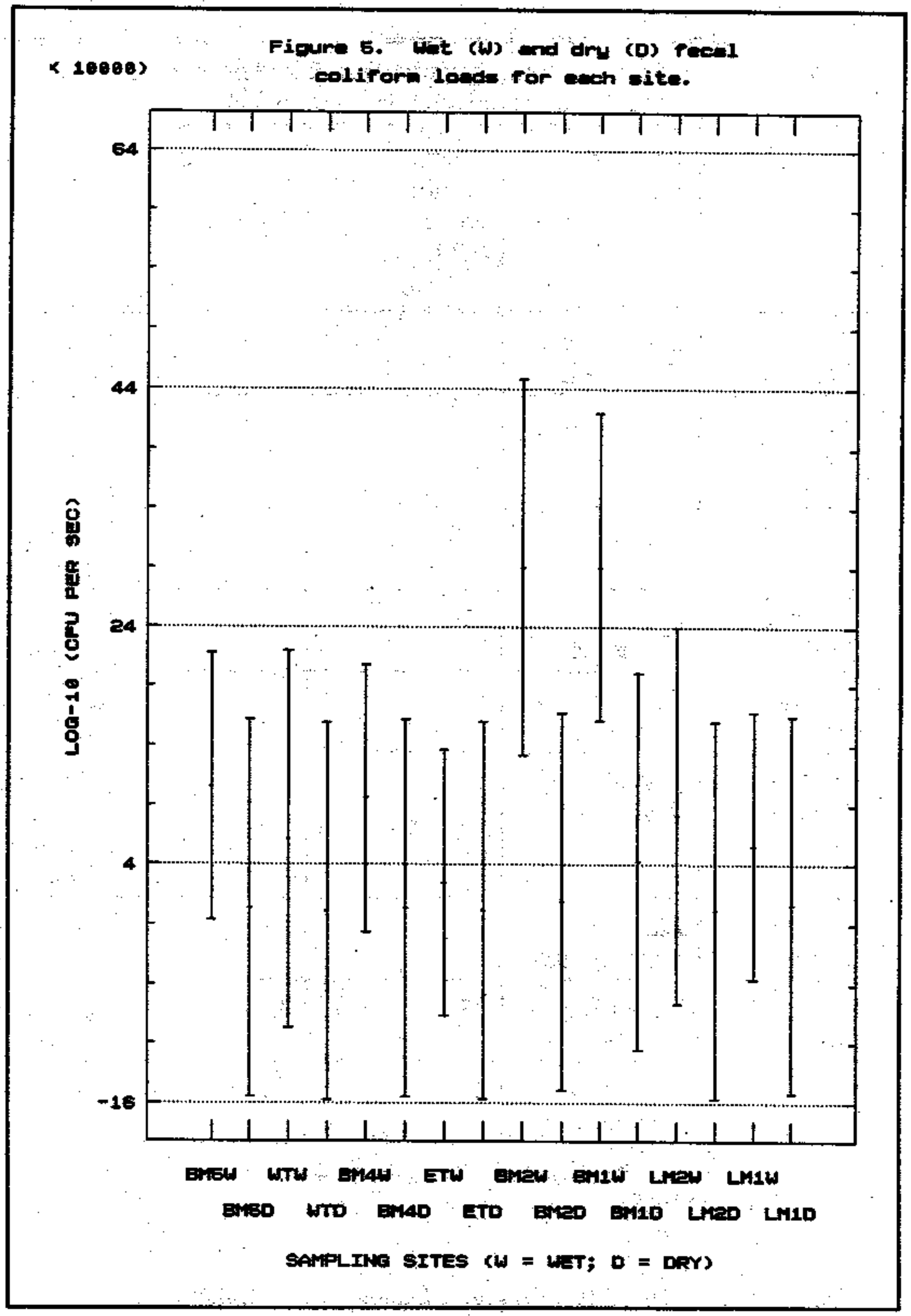


Figure 5. Wet (W) and dry (D) fecal coliform loads for each site.
(X 10000)
64
44
24
4
-16
LOG-10 (CFU PER SEC)
BM5W
WTW
BM4W
ETW
BM2W
BM1W
LM2W
LM1W
BM5D
WTD
BM4D
ETD
BM2D
BM1D
LM2D
LM1D
SAMPLING SITES (W = WET; D = DRY)

Table 5. Fecal coliform data from Mission and Little Mission creeks and other small streams draining rural watersheds in Puget Sound.

Stream	Receiving Waters	Geom. mean FC levels (CFU per 100 ml)	Geom. mean FC Loads (CFU x 10^9 per day)	Comments
Mission Creek	Lynch Cove, Hood Canal	6	8.2	combined wet, dry (5) samplings.
Little Mission Creek	Lynch Cove, Hood Canal	7	1.9	combined wet, dry (6) samplings.
Bell Creek[1]	Sequim Bay	359	310	10 samplings; 4/1991-3/1992.
Chimacum Creek[2]	Port Townsend	120	29	10 samplings; 2/1988-2/1989.
Donavan Creek[3]	Quilcene Bay, Hood Canal	41	5.6	six samplings; 12/1992-3/1993.
Kennedy Creek[4]	Totten Inlet, South Sound	7	1.4	[FC]: 20 samplings; Loads: 16 samplings; wet seasons 1987-1992.
McLane Creek[5]	Eld Inlet, South Sound	27	26	28 samplings; 11/1993-4/1994.
Minter Creek[6]	Minter Bay, Carr Inlet	38	31	24 samplings; 12/1983-12/1984.
Mayo Creek[7]	Mayo Cove, Carr Inlet	14	0.3	26 samplings; 2/1989-9/1990.

[1] from Joel Freudenthal, Clallam Co. (unpubl. data)
[2] from Rubida (1989)
[3] from Gately (1993)
[4] from Hofstad (1993)
[5] from Keith Seiders, EILS Program, Ecology (unpubl. data)
[6] from Determan, et al (1985)
[7] from Determan, et al (1992)

Loading from Little Mission Creek basin falls near the lower end of the range within the same order of magnitude as Kennedy and May creeks (Table 5.). Kennedy Creek basin is very sparsely developed. Mayo Creek basin is more intensively developed, perhaps to a greater degree than suggested by the low loading. On the other hand, Mayo Creek basin is considerably smaller and background sources (i.e. wildlife) may not be as significant a factor as in Kennedy Creek basin.

Mission Creek load lies at a median point between low and high loaders. Yet when the data are ranked quantitatively, Mission Creek lies within a "low-load" group composed of Little Mission, Kennedy, Donavan, and Mayo creeks. The next group (McLane, Chimacum, and Minter creeks) are higher by half an order of magnitude. Bell Creek stands alone at nearly two orders of magnitude higher loading than Mission Creek.

Bell Creek basin is agricultural at the headwaters and near the mouth. There is an intensifying urban use (City of Sequim) near the center of the basin. Chimacum Creek passes through large farms before flowing past residential/commercial areas near the mouth. Both Minter and McLane creek basins have mixed residential and small-scale agriculture.

General Water Quality. In the interest of economy, the only water quality parameters measured were those directly addressing the issue of shellfish contamination. There are no other data available. However, the general appearance of the streams was excellent. Water clarity was generally high during intense rainfall and high stream flow. This fact indicates minimal soils were washed into streams and tributaries. This is due in part to land use characteristics. Part of the explanation may also rest with the geology and hydrology of the sub-basins (both factors were discussed earlier). Site BM4 was an exception. Runoff-related turbidity here was high from soils carried off the ORV park (PSCRBT 1991).

CONCLUSIONS

1. In general water quality appeared to be excellent. Mission and Little Mission creeks met the first part of the State surface water fecal coliform standard. Evidence strongly suggests that the second part would have been met if enough data from individual sites were available.

2. Storm-generated fecal coliform loads from Mission and Little Mission creeks were low compared to streams elsewhere in Puget Sound. Fecal coliform loads from the watershed were not likely an important source of contamination for shellfish at Belfair State Park.

3. County water quality office staff have discovered 15 failures among 117 inspected on-site systems in the sub-basins to date. Despite the relatively high failure rate in the area, the effect on the creeks was undetectable.

4. Low fecal coliform levels in the lower stretches of Little Mission Creek may be partially explained by damming of on-site effluent in groundwater by stream flow moving laterally into streamside soils during high flow. In Mission Creek, soils and high flow in Mission Creek may combine to provide detention in groundwater and/or high dilution of sewage.

5. Conditions that minimize fecal coliform loading during heavy rain may be absent during low flow. The loading potential of the streams under summer low flow is presently unknown.

6. The most important human source of fecal coliform contamination is likely sewage from failed on-site systems along the marine shoreline.

7. Waterfowl that forage on the mudflats seaward of Belfair State Park have been suggested as a possible source of fecal coliform. This issue was not evaluated and is still unresolved.

8. The original strategy set by Mason County Health Department for carrying out on-site surveys (North Shore from Belfair to State Park: South Shore to Belfair State Park, then Mission/Little Mission creeks) appears to have been sound.

RECOMMENDATIONS

1. The present County strategy of rigorous inspection of on-site systems along the marine shoreline is likely to produce the greatest return for the effort.

2. Inspections of on-site sewage treatment/disposal systems would probably be best done by working along the shoreline in both directions away from the Park.

3. The County should consider intensive sampling of Mission Creek during low summertime flow to test the hypothesis presented here that fecal coliform loading may be more important during low stream flow.

4. The effect of bird populations on fecal coliforms in the shellfish growing area might be partially addressed by beginning a routine weekly census of numbers and kinds of birds observed in Park tidelands. Waterfowl census data may later be tested for evidence of correlation with marine water quality.

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