Environmental Protection Service
Environmental Protection Branch
Pacific Region

SHELLFISH GROWING WATER SANITARY SURVEY OF THE VANCOUVER ISLAND COASTLINE, FROM QUALICUM BAY TO NORTHWEST BAY, BRITISH COLUMBIA, 1980

79-22

by

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ABSTRACT

A bacteriological survey of molluscan shellfish growing waters along the eastern Vancouver Island shoreline from Qualicum Bay to Northwest Bay was conducted from May 29 to June 19, 1979, by personnel of the Environmental Protection Service, Pacific Region.

A sanitary survey was conducted concurrently with the bacteriological survey to identify and evaluate sources of fecal pollution to the study area. Chemical and bacteriological analyses were performed on various treatment stages at the French Creek Water Pollution Control Centre, Nanaimo Regional District, to evaluate the operation of the plant.

During the study, 93 marine stations, 23 freshwater stations and 40 miscellaneous stations were sampled, representing 706, 88 and 43 samples respectively.

Ten of the marine stations did not meet the shellfish growing water standards.

Changes to the two Schedule I shellfish closures in the survey area are proposed.

RESUME

Le Service de la protection de l'environnement Région du Pacifique, a effectué, du 29 mai au 19 juin 1979, une étude bactériologique des deaux où croissent des mollusques et des crustacés, entre Qualicum Bay et Northwest Bay, sur le littoral est de l'île de Vancouver.

Une étude hygiénique a été effectuée en même temps que l'étude bactériologique pour évaluer les sources de pollution par les égouts dans le secteur étudie. On a procédé à des analyses chimiques et bactériologiques à diverses étapes du traitment des eaux, au Centre de contrôle de la pollution de French Creek, dans le district régional de Nanaimo, afin d'évaluer le fonctionnement de l'usine de traitement du Centre.

Au cours de l'étude, on a prélevé respectivement 706, 88 et 43 échantillons dans 93 stations marines, 23 stations d'eau douce et 40 stations diverses.
Dix des stations marines ne répondaient pas aux normes établies pour les eaux où croissent des crustacés.

L'on propose des modifications aux deux calendriers nº 1 pour la fermeture des stations dans le secteur étudié.

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LIST OF ABBREVIATIONS

EPS	Environmental Protection Service
FC	fecal coliform
G	"greater than"
L	"less than"
FS	fecal streptococci
MF	membrane filtration
MPE	mean population equivalent
MPN	most probable number
NRD	Nanaimo Regional District
PCB	Pollution Control Branch
TC	total coliform
WPCC	Water Pollution Control Centre

CONCLUSIONS

1. The waters and tidal foreshore of Qualicum Bay were of acceptable bacteriological quality for the purpose of shellfish harvesting. Nile Creek and an unnamed creek were considered insignificant sources of fecal pollution to Qualicum Bay.

2. Portions of the tidal foreshore of Qualicum Beach were contaminated with fecal pollution to the extent that consumption of bivalve molluscan shellfish may pose a health hazard. Offshore sampling transects of Qualicum Beach indicated that the contamination was not the result of sewage discharged from the French Creek Water Pollution Control Centre. Fecal contamination in Grandon Creek was responsible for localized pollution in the foreshore waters; however, the source(s) to other areas of Qualicum Beach was not ascertained.

   Improved water quality was noted in the eastern section of the Qualicum Beach foreshore as compared with the western end.

3. The waters and tidal foreshore adjacent to the Eagle Crest development were of acceptable water quality for the purpose of shellfish harvesting. Sampling of freshwater stations showed no significant input of fecal pollution. Results obtained by the Environmental Protection Service in September 1978 indicated that two marine stations in this area did not meet the shellfish growing water standard. The poorer water quality noted during the latter sampling occurred as a result of increased precipitation with an associated increase in the amount of contaminated drainage reaching the foreshore.

4. The waters and tidal foreshore of the French Creek area were of acceptable water quality for the purpose of shellfish harvesting. The present four hundred foot Schedule I closure around the French Creek boat basin is considered adequate.

5. The waters and tidal foreshore of the Parksville Bay area were of acceptable water quality for the purpose of shellfish harvesting. Freshwater stations showed insignificant fecal pollution. Offshore transects indicated that the discharge from the French Creek WPCC had no effect on water quality in Parksville Bay.

6. The waters and tidal foreshore of Craig Bay were of acceptable water quality for the purpose of shellfish harvesting. The single freshwater input sampled showed insignificant fecal pollution.

7. The waters and tidal foreshore of Northwest Bay were of acceptable water quality for the purpose of shellfish harvesting.

SCHEDULE I CLOSURES

The following amendments to Schedule I are proposed:

1. Revoke the present Closure Area 14-7 (Parksville Bay) in its entirety and replace with the following new closure: "Area 14-7. The waters and tidal foreshore extending from the foot of Yambury Road, Eagle Crest, westward to the western end of Seacrest Place, Eagle Crest."

2. Re-word Closure 14-8 as follows: "Area 14-8. The tidal foreshore of Qualicum Beach lying between the foot of Surfside Drive at the western headland and Hall Road at the eastern headland of Qualicum Beach."

Schedule I closure amendments are shown in Figure 1.

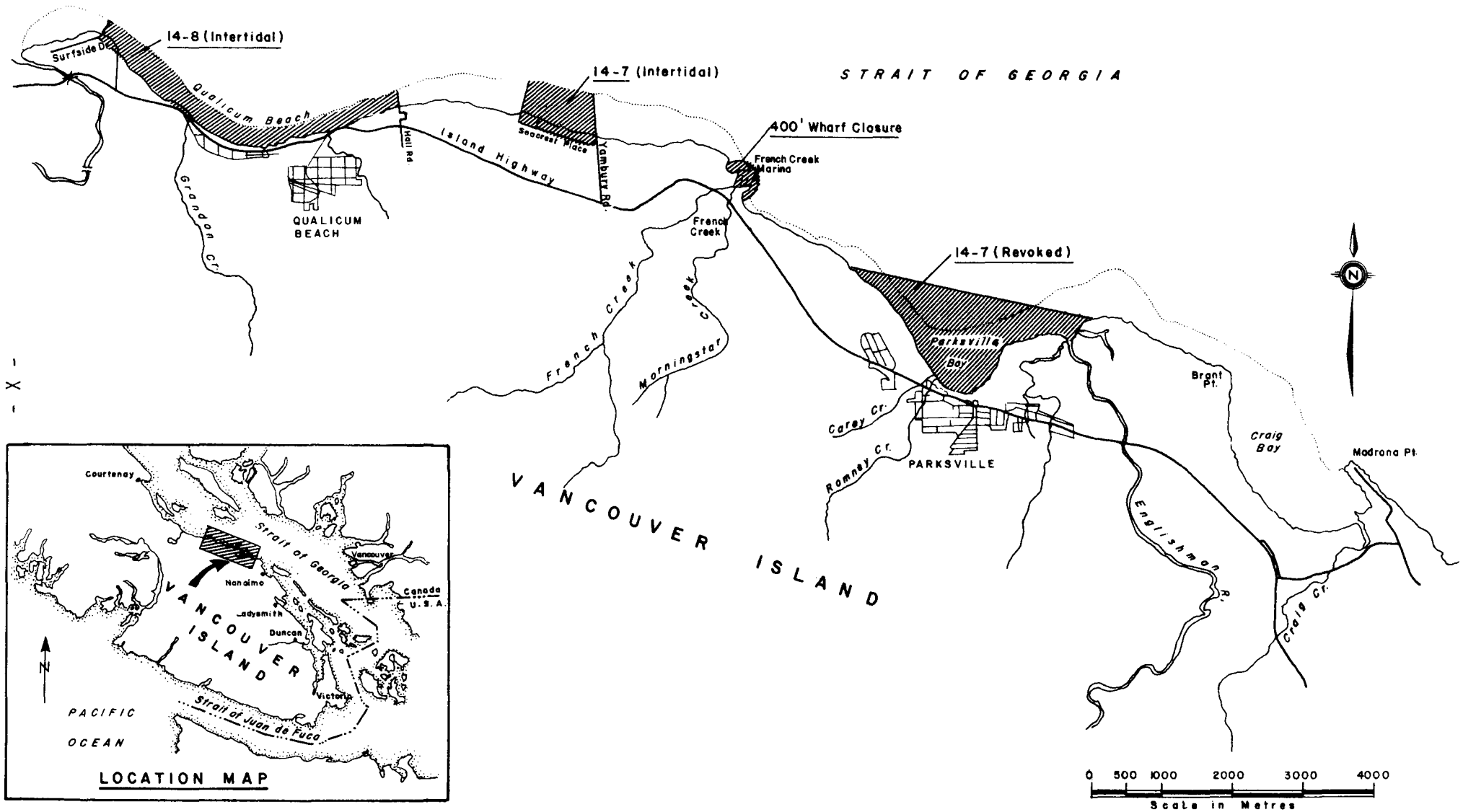

FIGURE I PROPOSED SCHEDULE I CLOSURES

1 INTRODUCTION

The Parksville-Qualicum area is located on the eastern side of Vancouver Island and is a popular tourist area during the summer months. The approximate population of the area is 4,900 (1) with the major population centres being the Village of Qualicum Beach and the Town of Parksville.

Due to the large number of tourists during the summer months, there is considerable recreational harvesting of bivalve molluscs, particularly oysters and clams. Recreational harvesting was curtailed, however, with the imposition of three Schedule I shellfish closures resulting from a survey conducted by the Environmental Protection Service in 1975. At that time fecal contamination was observed in Parksville Bay, in the French Creek Boat Basin and in Qualicum Beach.

The identified sources of fecal contamination in Parksville Bay included the Parksville sewer system outfall and contamination from faulty septic tank disposal fields. This resulted in contaminated storm drainage reaching the eastern foreshore of Parksville Bay during heavy rainfall, an occurrence which was subsequently verified by the Central Vancouver Island Health Unit.

The water at the entrance of the French Creek Boat Basin was subject to intermittent fecal contamination from boat discharges. The 1975 report also concluded that the shellfish growing water quality in the area could possibly be intermittently contaminated during the discharge of raw sewage from the new French Creek WPCC outfall. This raw discharge was to continue until completion of the sewage treatment plant.

The 1975 data indicated that the foreshore of Qualicum Beach was exposed to fecal contamination from a creek at the east end of the beach (Beach Creek), and from several culverts that drain storm water from residential areas. The contamination was due to sewage wastes from faulty septic tank disposal systems reaching the storm drainage system. As a result of the 1975 survey, the following Schedule I closures were imposed:

Area 14-7 - "The waters and tidal foreshore lying within a line drawn from the west side of Parksville Bay at Longitude 124° 20' 00 W. to the most northerly point of land immediately east of the mouth of the Englishman River."

Area 14-8 - "The waters and tidal foreshore lying within a 3,500 foot (1.07 kilometre) radius drawn from the mouth of French Creek."

Area 14-9 - "The waters and tidal foreshore lying within a line drawn from the most northerly point of land at the west end of Qualicum Beach to the most northerly point of land at the east end of Qualicum Beach.

Since 1975, considerable changes have occurred in the sewerage systems of the Parksville-Qualicum area. In March 1977, the Nanaimo Regional District began construction of a secondary sewage treatment plant at French Creek to service the town of Parksville and the Village of Qualicum Beach. The treatment plant was completed in February 1978 and was receiving sewage from Parksville and portions of the previously unsewered Village of Qualicum Beach.

The Environmental Protection Service undertook a limited bacteriological and sanitary survey of the foreshore in the vicinity of French Creek during September 1978. The purpose of the survey was to evaluate Schedule I Closure Area 14-8 and the impact of the sewage effluent discharge on the near foreshore areas.

As a result of this 1978 survey; Schedule I closure 14-8 was revoked: However, Closure 14-9 was increased to include the foreshore fronting the Eagle Crest sub-division, west of French Creek. The closure is worded as follows: "The waters and tidal foreshore extending from the most northerly point of land at the west end of Qualicum Beach, eastward to the foot of Yambury Road, Eagle Crest."

By February 1979, the majority of the Parksville, French Creek, Columbia Estates and Qualicum Beach areas were connected to the sewerage system.

As a result of the major changes effected in sewage collection and treatment in the Parksville-Qualicum area, the Environmental Protection Service conducted a shellfish growing water sanitary survey of Qualicum Bay to Northwest Bay between May 28 and June 19, 1979.

The purpose of the survey was to:

1. Reassess Schedule I closures 14-7 and 14-9 in light of the new sewage collection and treatment system.
2. Identify and evaluate all major potential sources of fecal contamination to the study area, by conducting a sanitary survey of the foreshore and upland areas.
3. Evaluate the operation of the French Creek WPCC.
4. Evaluate the effect of the French Creek WPCC final effluent discharge on foreshore water quality, specifically during non-chlorination, and determine the necessity for chlorination with respect to the maintenance of acceptable shellfish growing water quality.

In order to facilitate this last condition, it was agreed by all pollution control and health agencies that chlorination would be suspended at the French Creek plant during the survey.

2 SAMPLE STATION LOCATIONS

Marine sample stations were located in the inter-tidal and sub-tidal areas to assess the degree of fecal pollution from known or suspected sources. The location of sample stations was also dependent, in part, on the shellfish resource. Resource information was obtained from the Marine Resources Branch, Ministry of Environment, Province of B.C., and the federal Department of Fisheries and Oceans.

All major freshwater and effluent inputs to the study area were sampled to determine the significance of their bacterial contributions to the receiving waters. The inputs were selected for sampling if they met one of the following criteria:

(1) major flow
(2) proximity to known, suspected or potential pollution sources
(3) proximity to contaminated marine sampling stations.

Additional samples of tidepools, groundwater, shellfish and sediments were also analysed for fecal contamination, to assist in source determination.

Marine sample stations are shown in Figures 1, 2 and 3, (Appendix I) and freshwater sample stations are shown in Figures 4, 5 and 6, (Appendix I).

3 FIELD PROCEDURES AND METHODS

3.1 Bacteriological Sampling and Analyses

All bacteriological analyses were begun within three hours of collection in the mobile microbiology laboratory of the Environmental Protection Service, located at the French Creek WPCC. All marine samples for bacteriological analyses were collected in sterile wide-mouth glass bottles, approximately 15 to 30 cm below the water surface. The water depth at collection points for the intertidal foreshore did not exceed two metres. The depths at the transect collection points varied. Samples were collected on foot or by boat. The samples were stored in coolers at temperatures not exceeding 10°C until processed.

The fecal coliform most probable number (MPN) per 100 ml was determined using the multiple tube fermentation technique (at least three decimal dilutions of five tubes each) as described in Part 908C of the 14th edition of Standard Methods for the Examination of Water and Wastewater (2). The culture medium used was the A-1 medium as described by Andrews and Presnell (3). This medium and the method described below were accepted by the Canadian Government in April, 1977 as the method of choice for the enumeration of fecal coliforms in shellfish growing waters. An evaluation of the A-1 medium in the Pacific Region has been done by Kay (4) and the reader is referred to this paper for further information.

The "modified A-1" technique involves the innoculation of a series of dilutions in accordance with the multiple tube fermentation technique. Ten milliliter volumes of sample water were innoculated into five double strength tubes of A-1 medium, and 1.0 ml and 0.1 ml volumes were innoculated into five tubes each of single strength medium. The tubes were incubated at 35 ± 0.5°C in air incubators for three hours and then transferred to a water bath at 44.5 ± 0.2°C and incubated for a further 21 hours for a total of 24 ± 2 hours. All gassing tubes with growth were considered to be fecal coliform positive. The most probable number for each sample was then determined according to the manner described in Standard Methods.

All freshwater samples were collected in sterile wide-mouth glass bottles and were tested for total coliform, fecal coliform and fecal streptococci using the membrane filtration (MF) method described in Part 909 of the 14th edition of Standard Methods. Media used were m-Endo LES, m-FC, and KF streptococcous agars obtained from Difco Laboratories, Detroit, Michigan, U.S.A., for total coliforms, fecal coliform and fecal streptococcus tests respectively. The membrane filters used were Millipore HC, obtained from Millipore Limited, Mississauga, Ontario.

Sediment samples were collected aseptically and placed in sterile Whirl Pak bags. Ten grams of sediment were suspended in 90 ml of phosphate buffered dilution water and mixed thoroughly. This suspension was used for fecal coliform determinations using the MPN method previously described.

Shellfish tissue samples were analyzed according to accepted procedures (5). Sufficient animals were obtained to provide 250 grams for analysis.

3.2 Physical and Chemical Testing Equipment and Analyses

The salinity of all marine samples was determined using an American Optical Refractometer (Catalogue No. 10413) which has a resolution to the nearest 0.5 parts per thousand. Wind speeds and direction were determined using a Dwyer Wind Meter (Patent No. 299374) and an Airguide 919 Deluxe Windial with compass.

Rainfall data was obtained from the MacMillan-Bloedel log sort in Northwest Bay and the Ranger Station in Parksville (Figure 2). The tide data used was that for Point Atkinson (Figure 3).

Physical and chemical testing procedures and methods employed in the sampling of the French Creek WPCC are discussed in Appendix X.

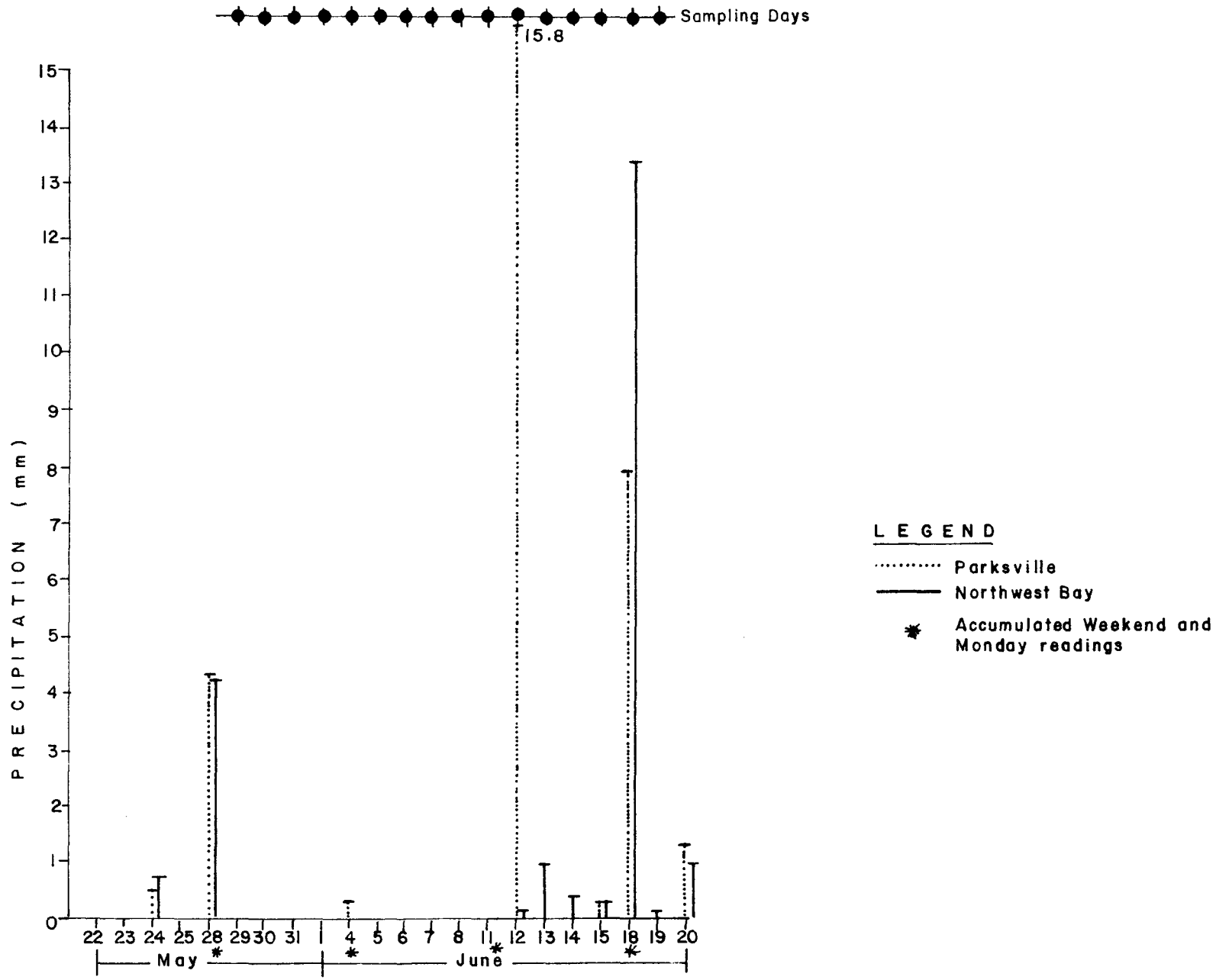

FIGURE 2 DAILY PRECIPITATION - May 22 to June 20, 1979

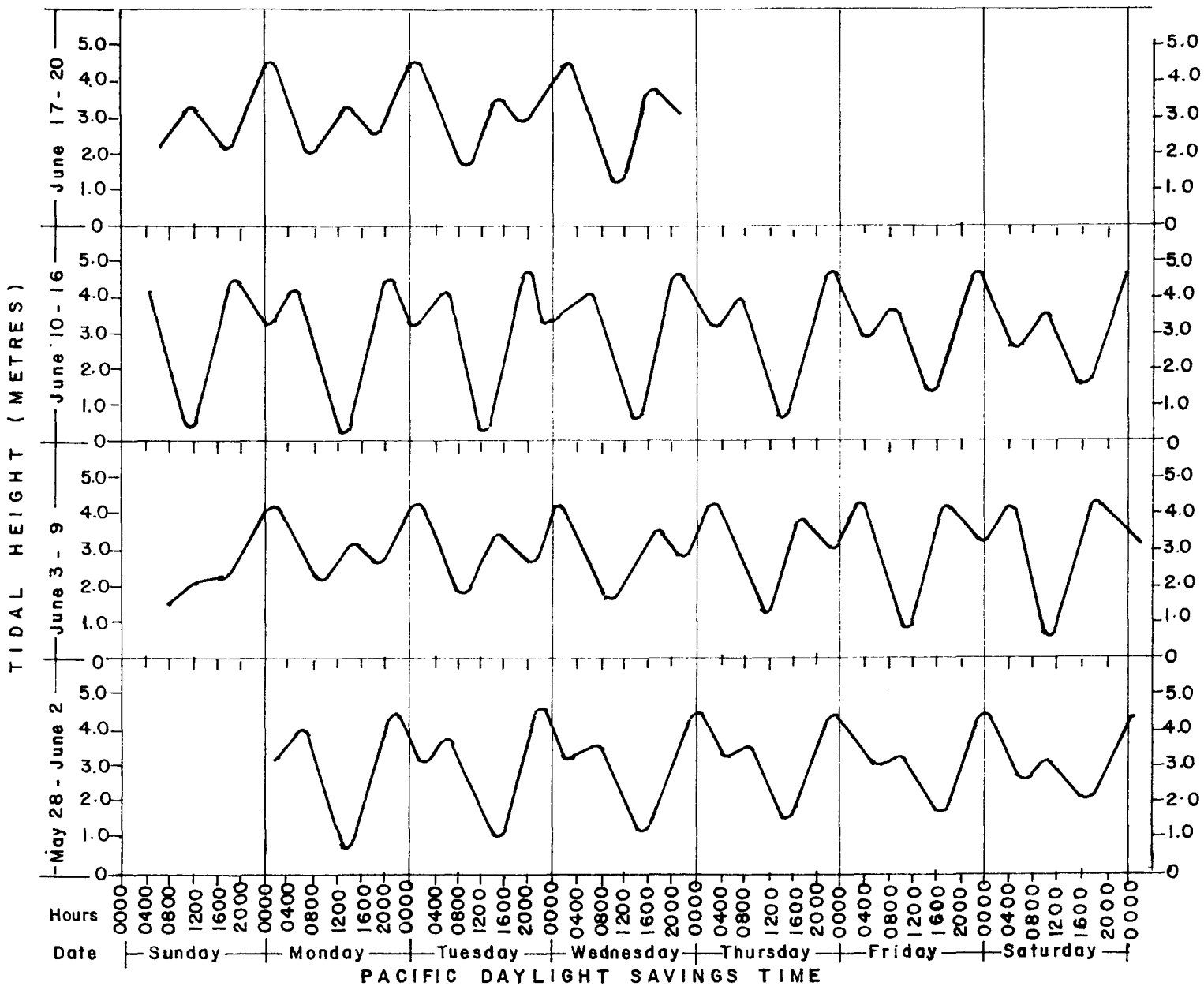

FIGURE 3 TIDAL HEIGHT GRAPH - POINT ATKINSON - May 28 to June 20, 1979

4 RESULTS

The bacteriological results for marine and freshwater sample stations are summarized in Tables 1 and 2, while daily bacteriological results are presented in Appendices V, VI and VII, respectively. Descriptions of marine and freshwater sample stations are listed in Appendices II, III and IV, and salinity data from marine sample stations are summarized in Appendix VIII.

The fecal coliform results obtained from the marine stations are used in classifying the shellfish growing waters according to the following criteria:

In order that an area be considered bacteriologically safe for the harvesting of bivalve molluscan shellfish, the fecal coliform median MPN of the water must not exceed 14/100 ml. In addition, not more than 10% of the samples may exceed an MPN of 43/100 ml for a 5-tube decimal dilution test, in those portions of the area most probably exposed to fecal contamination during the most unfavourable hydrographic and pollution conditions. (This report expresses the 10% limit in terms of a 90 percentile which cannot exceed 43/100 ml).

Based on these criteria, the approved growing water standard was exceeded at 10 sample stations.

Determination of the source and impact of fecal contamination in the freshwater sources was aided by the use of FC:FS ratios and population equivalents. Membrane filtration fecal streptococci analyses were performed on all freshwater samples in an attempt to determine the origin of fecal contamination observed in the freshwater inputs. Geldreich and Kenner (6) have reported higher FS than FC densities in all warm-blooded animal feces except for humans. The FC:FS ratio in humans was 4.4, whereas in other warm-blooded animals the ratio was less than 0.7. FC:FS ratios were calculated for all freshwater samples and a summary of these results is presented in Table 2.

TABLE 1 SUMMARY OF FECAL COLIFORM MPN DATA FOR MARINE SAMPLE STATIONS

Sample Station	No. of Samples	MPN Range	MPN per 100 ml Median	MPN per 100 ml 90 pct.	Sample Station	No. of Samples	MPN Range	MPN per 100 ml Median	MPN per 100 ml 90 pct.
1	6	L2 - 5	L2	2	30	3	L2 - 23	L2	16.1
2	6	L2 - 2	L2	2	31	3	L2 - 2	2	2
3	6	L2 - 70	2	40.4	32	7	5 - 240	17	127.3
4	6	L2 - 11	2	5.6	33	7	L2 - 49	7	26.6
5	6	L2 - 5	L2	2	34	7	L2 - 22	L2	8
6	6	L2 - 13	2.5	13	35	7	L2 - 49	2	18.2
7	6	L2 - 6	L2	3.6	36	7	L2 - 17	2	14.2
8	6	L2 - 33	2.5	16.2	37	7	L2 - 23	7	16
9	8	L2 - 350	L2	71.6	38	7	L2 - 33	8	21.8
10	8	L2 - 5	L2	2.6	39	7	L2 - 11	2	8.2
11	6	L2 - 2	L2	2	40	6	L2 - 2	L2	2
12	8	L2 - 1600	L2	321.6	41	6	L2 - 2	L2	L2
13	6	L2 - 13	L2	7.6	42	6	L2 - 2	L2	L2
14	8	L2 - 33	5	25	43	6	L2 - 2	L2	L2
15	10	L2 - 49	8	31	44	6	L2 - 2	L2	2
16	10	2 - 130	6	34	45	6	L2 - 11	2	9.2
17	8	L2 - 46	9.5	27.6	46	6	L2	L2	L2
18	8	5 - 33	8	15.4	47	6	L2	L2	L2
19	10	2 - 70	10.5	23	48	6	L2 - 2	L2	L2
20	8	8 - 23	15.5	22.2	49	6	L2 - 8	L2	6.2
21	10	L2 - 79	17	79	50	8	L2 - 79	2	36.4
22	3	L2	L2	2	51	6	L2 - 8	L2	4.4
23	3	L2 - 13	2	9.7	52	6	L2 - 7	L2	5.8
24	10	L2 - 70	15.5	49	53	6	L2 - 2	L2	2
25	10	2 - 79	17.5	79	54	6	L2 - 5	L2	5
26	3	L2 - 33	L2	23.1	55	6	L2	2	L2
27	3	L2 - 2	L2	2	56	6	L2 - 33	17	33
28	8	L2 - 49	12	49	57	6	L2	L2	L2
29	9	L2 - 33	5	24	58	6	L2 - 2	L2	L2

TABLE 1 SUMMARY OF FECAL COLIFORM MPN DATA FOR MARINE SAMPLE STATIONS (Cont.)

Sample Station	No. of Samples	MPN Range	MPN per 100 ml Median	MPN per 100 ml 90 pct.	Sample Station	No. of Samples	MPN Range	MPN per 100 ml Median	MPN per 100 ml 90 pct.
59	6	L2 - 2	L2	2	88	5	L2 - 83	L2	6.2
60	6	L2 - 2	L2	L2	89	5	L2 - 49	5.5	33.8
61	6	L2	L2	L2	90	5	L2 - 2	L2	2
62	6	L2 - 5	L2	2	91	5	L2 - 6	2	5.5
63	6	L2 - 5	L2	2	92	5	L2 - 8	L2	5
64	6	L2 - 11	L2	5.6	93	5	L2-13	L2	6.5
65	6	L2 - 5	L2	3.2					
66	6	L2 - 5	L2	2					
67	6	L2 - 5	L2	3.2					
68	6	L2 - 7	2	4					
69	6	L2 - 8	L2	4.4					
70	6	L2 - 49	6.5	26.2					
71	6	L2 - 17	L2	8					
72	6	2 - 17	7	12.2					
73	6	2 - 33	6	27					
74	6	L2 - 8	2	6.2					
75	6	5 - 46	6.5	23.2					
76	6	2 - 17	5.5	11.6					
77	5	L2 - 17	5	12.5					
78	5	L2 - 8	2	6.5					
79	5	L2 - 5	5	5					
80	5	L2 - 8	2	6					
81	5	L2 - 2	L2	L2					
82	5	L2 - 23	L2	12.5					
83	5	L2 - 2	L2	L2					
84	5	L2 - 8	2	6.5					
85	5	5 - 130	8	89.5					
86	5	L2 - 8	7	8					
87	5	L2 - 11	2	11					

TABLE 2 SUMMARY OF FRESHWATER MEMBRANE FILTRATION DATA

Sample Station	No. of Samples	Fecal Coliforms/100 ml Range	Fecal Coliforms/100 ml Mean	Fecal Streptococci/100 ml Mean	FC:FS
S1	3	96 - 250	172	115	1.50
S2	3	9 - 12	11	27	0.41
S3	3	170 - 830	537	230	2.33
S4	3	5 - 8	6	26	0.23
S5	5	70 - 2700	746	566	1.32
S6	4	6100 - 28400	18250	10825	1.69
S7	3	22 - 42	34	48	0.71
S8	4	54 - 410	206	394	0.52
S9	3	93 - 210	154	71	2.17
S10	4	400 - 1400	733	500	1.47
S11	3	5 - 19	13	38	0.34
S12	3	4 - 20	11	93	0.12
S13	3	9 - 80	40	191	0.21
S14	4	0 - 10	4	42	0.10
S15	4	410 - 1120	828	17975	0.05
S16	5	10 - 170	85	188	0.45
S17	3	13 - 24	17	7	2.43
S18	2	70 - 240	155	120	1.29
S19	3	120 - 260	173	43	4.02
S20	3	120 - 780	360	158	2.28
S21	3	23 - 170	78	570	0.14
S22	3	22 - 119	62	56	1.11
S23	3	3 - 25	13	29	0.45
Upstream Samples					
S10A	3	350 - 870	580	560	1.04
S15A	2	86 - 320	203	191	1.06
S16B	2	90 - 130	110	5005	0.02
S18A	4	40 - 610	220	161	1.37

The mean FC:FS ratio was not greater than 4.4 for any freshwater station; however 11 stations showed a ratio less than 0.7, suggesting contamination of animal origin in these instances.

In addition to FC:FS ratio determinations population equivalents were also calculated for all freshwater inputs. The concept of "population equivalents" takes into account both the fecal coliform concentration and the flow of contaminated water and is useful in comparing relative impacts of freshwater inputs. The population equivalent of a source of fecal contamination may be calculated using an average value for the fecal coliform contribution per capita to a sewage system. The average per capita daily discharge of coliforms has been estimated at 1.6×10^{11} total coliforms. The fecal coliform concentration in domestic sewage has been estimated at 20% of the total concentation (7). This yields a value of 3.2×10^{10} fecal coliforms/person/day. The equation for population equivalent becomes:

$$\text{Population Equivalents} = \frac{\text{Fecal Coliform Discharged per day}}{\text{Fecal Coliforms/Person/Day}}$$

$$= \frac{\text{Flow} \times \text{Fecal Coliform Counts}}{3.2 \times 10^{10}}$$

The mean population equivalents for all freshwater inputs sampled are presented in Table 3 and will be discussed in subsequent sections.

During the survey, precipitation totalled 24.3mm, (Parksville Ranger Station), which was representative of the average rainfall expected for the month of June in this area (8). However most of the rain fell on June 12, and over the period June 16-18. The effect of rainfall on marine water quality is discussed in subsequent sections.

The winds during the survey were predominantly from the northwest and southwest and did not appear to influence bacterial levels in the study area.

TABLE 3 MEAN POPULATION EQUIVALENTS FOR FRESHWATER SAMPLE STATIONS

Sample Station	No. of Samples	Mean Fecal Coliforms/100 ml	Average Estimated Flow (m^3/sec)	Mean Population Equivalent
Parksville Bay - Craig Bay				
S1	3	172	0.03	L1
S2	3	11	9.8	3
S3	3	537	0.002	L1
S4	3	6	--	--
S5	5	746	0.015	L1
French Creek - Eagle Crest				
S6	4	18,250	7.95×10^{-5}	L1
S7	3	34	0.36*	L1
S8	4	206	0.002	L1
S9	3	154	0.001	L1
S10	4	733	4.3×10^{-4}	L1
Qualicum Beach				
S11	3	13	0.001	L1
S12	3	11	--	--
S13	3	40	0.002	L1
S14	4	4	0.0001	L1
S15	4	829	0.003	L1
S16	5	85	0.002	L1
S17	3	17	9.5*	4
Qualicum Bay				
S18	2	155	0.018	L1
S19	3	173	0.0002	L1
S20	3	360	0.005	L1
S21	3	78	3.8*	L1
S22	3	62	0.009	L1
S23	3	13	0.4*	L1

* Mean flows from "Historical Streamflow Summary, B.C. to 1976" Inland Water Directorate

S2 - (1913-1917, 1970-1971))
S7 - (1969-1971)) all data for the
S17 - (1960-1976)) month of June
S21 - (1913-1922, 1956-1974))
S23 - (1959-1976))

4.1 Qualicum Bay (Marine Stations 1-13)

Marine stations 1-13 were selected to assess shellfish growing water quality in Qualicum Bay. All stations met the approved shellfish growing water standard with the exception of Stations 9 and 12, with single highs MPN's of 350/100ml and 1600/100ml respectively. On all other sampling days, fecal coliform levels were less than or equal to 2/100ml. The sanitary survey did not reveal any significant sources of contamination, with freshwater sample stations S22 and S23 having mean fecal coliform levels of 62/100ml and 13/100ml respectively. Earlier data by Cooper (9) indicated water quality in this area was acceptable and no pollution sources were evident.

No marine sampling was undertaken between Qualicum Bay and Qualicum Beach due to limited analytical capability. However, four freshwater stations (S18 to S21) were sampled. Only station S21 (Big Qualicum River), with an MPE of 8, would be considered to be of any influence on the receiving water. This high MPE was due more to the high flow than the fecal coliform level (mean of 78/100ml). Previous data (9) indicated acceptable water quality conditions existed for shellfish harvesting.

4.2 Qualicum Beach (Marine Stations 14-44)

Marine stations 14-44 were selected to assess water quality in Qualicum Beach. Foreshore stations 20, 21, 24, 25, 28 and 32 exceeded the shellfish growing water standard.

Sampling transects were instituted from headland to headland, in an attempt to determine the impact of the French Creek WPCC discharge on foreshore water quality. Sampling stations were also located 150m and 300m seaward of stations 21, 25 and 29. The headland transects showed acceptable water quality with an MPN median of less than 2/100ml, and seaward samples indicated reduced fecal coliform levels with increasing distance from shore. The data would indicate that the source of pollution is land-based and water quality is not affected by the discharge of sewage from the French Creek WPCC.

During the 1975 study, Cooper (9) found unacceptable shellfish growing water quality at two sample stations near the western end of Qualicum Beach which was attributed to Beach Creek. The remainder of the foreshore was subject to pollution from several culverts draining storm water from the residential areas. Faulty sewage disposal systems were implicated as the source of fecal contamination to the storm drains.

The construction of the French Creek WPCC was completed in February 1978, and most of the dwellings in Qualicum Beach were connected by February 1979. The beach front area is completely serviced (10), however, a few homes in the uplands area remain unconnected. Thus the major sources of fecal contamination encountered during the 1975 survey should have been eliminated. However, as evidenced by the marine water quality results, unacceptable fecal contamination still occurred in portions of Qualicum Beach. Freshwater sample stations S11-S16 and S17 were not considered major sources of fecal contamination, primarily due to their low flows and low fecal levels. Station S17 (Little Qualicum River) had an MPE of 4 due to its flow, but did not result in significant fecal contamination at marine stations 14, 15 and 16.

Sample station S15 (Grandon Creek) had a mean fecal coliform level of 828/100ml and was implicated as the major source of localized contamination reflected in marine stations 21, 24 and 25. Clam samples (*P.staminea*) taken in the vicinity of marine stations 21 and 24 also showed elevated fecal levels of 170/100g and 2400/100g respectively.

Grandon Creek demonstrated a very low FC:FS ratio (0.05) indicating the observed contamination was primarily of animal origin. Upstream examination of the watershed revealed a cattle ranch and some smaller farms with a few animals, although samples taken upstream (S15A) on two occasions yielded lower FC and FS levels than did S15.

The fecal contamination observed at stations 20, 28 and 32 may have been caused by Grandon Creek. However, the low MPE of 0.05 and the distance of these two stations from the creek argue against this source. It is also unlikely that Grandon Creek was responsible for the low level contamination observed at other marine stations in Qualicum Beach. There was no definite correlation between salinity and fecal coliform levels at any of the contaminated stations.

In an attempt to identify other possible sources of contamination, sub-surface drainage, tidepool, groundwater, ditch and sediment samples were taken at various locations along the foreshore. These results are presented in Appendix VII.

Sediment samples showed low fecal coliform (MPN) levels (generally less than 20/100g) with sediment sample station 16 having the highest count of 80/100g. This sediment sample was taken near the mouth of Grandon Creek and would be expected to show some fecal contamination based upon the contamination found in the creek.

Five tidepool samples were taken in the vicinity of marine stations 24 and 25, and had fecal coliform values ranging from 17 to 350/100ml. Since the salinities of these tidepool samples were not recorded, it is unknown to what extent Grandon Creek contributed to the fecal coliform levels. No other sources of contamination were identified.

Ditch and groundwater samples (Figure 5, Appendix XI) did not exhibit significant fecal coliform levels with the exception of GW8 which had a fecal coliform MPN of 330/100ml. This sample was taken near Beach Creek, a considerable distance from the contaminated marine stations and, although the source was not ascertained, it is unlikely this groundwater would affect the marine water quality near Grandon Creek.

The possibility of contaminated subsurface drainage being the cause of poor water quality in Qualicum Beach cannot be excluded, although it seems remote based on the following considerations. Firstly, as previously mentioned, all foreshore dwellings and most upland dwellings are connected to the regional sewerage system. At the time of connection, all septic tanks were cleaned out and then either filled in or removed (10) by

February, 1979, thereby effectively removing the source of fecal contamination. Secondly, any remaining coliform organisms present in the in sufficient numbers, to cause significant marine water quality deterioration. Schmidt et al (11) have shown that fecal coliforms were reduced from approximately 10^6/100ml to generally less than 200/100ml after 9 metres of percolation through soil. Additional lateral movement of 30 m reduced coliform densities to less than 10/100ml and to 0/100ml after 90 metres. It is therefore unlikely that groundwater emanating from the uplands portion of Qualicum Beach and/or disused tile fields would contain significant fecal coliform numbers.

It was difficult to assess the effects of rainfall on marine water quality since significant precipitation occurred only on June 12 and the weekend preceding June 18. Fecal coliform levels in marine stations (34, 35 and 36 located near the mouth of Beach Creek (S11) did increase on June 13 although it was not ascertained whether the creek was the source of contamination. The effect of the rainfall which preceded June 18 was not determined as neither the creek nor the marine stations were sampled.

Beach Creek has historically been contaminated and swimming closures were often invoked in its vicinity. The results of this survey indicated a significant improvement in Beach Creek water quality although contaminated run-off may still impair water quality in the area during high rainfall periods.

Pollution Control Branch and Nanaimo Regional District data collected for the mouth of Beach Creek indicate the marine waters do not meet approved shellfish growing water standards (Table 5). However, much of this data was collected prior to the complete sewering of Qualicum Beach and additional wet weather data is required to assess any changes in water quality resulting from the sewering program in this area.

TABLE 4 SUMMARY OF EPS, PCB AND NRD FECAL COLIFORM MPN DATA FOR SELECTED SAMPLE STATIONS (PARKSVILLE - QUALICUM)

Sample Station (EPS)	Sample Station (PCB)	Fecal Coliform MPN per 100 ml							
		EPS (1979)		EPS (1978)		NRD(Dec'77- Aug'78)*		PCB((Aug'76-Mar'79)	
		Median	90 pct.	Median	90 pct.	Median	90 pct.	Median	90 pct.
35	S1	2	18.2	not sampled		22	48.5	21	1314
51	S2	L2	2	11	27	1	4.5	2	33
56	S3	17	33	6.5	8	5	19	3	316 [1]
60	S5	L2	L2	L2	8.2	1	17.6	2	370 [2]
70	S6	L2	5.6	not sampled		3	9	5	88 [1]
74	S7	2	6.2	not sampled		3	49.5	10.5	322.9[1]

[1] skewed by a high pre-discharge count

[2] skewed by a single high count of 2400/100ml

* All NRD data was obtained using the membrane filtration technique.

4.3 Eagle Crest (Marine Stations 45-51)

Marine stations 45-51 were selected to assess water quality along the Eagle Crest development foreshore. All stations met the shellfish growing water quality standard. Station 50 did have a high count of 79/100ml on June 11. The source of contamination was not determined. Station 51 was also sampled by the NRD and PCB (Table 5). The NRD showed low level contamination with a 90 percentile of 4.5/100ml (Dec. 1977 to Aug. 1978) while the PCB showed higher fecal levels with a 90 percentile of 33/100ml.

Freshwater stations S9 and S10 were established in Eagle Crest and exhibited fecal coliform means of 154 and 733/100ml respectively. The source of contamination was not determined however septic tank seepage is suspected.

Subsurface water samples (Appendix IV & VIII) were also taken (GW2-GW7) and these demonstrated fecal counts which ranged from 4 to 44/100ml and did not indicate a pollution problem.

The Eagle Crest foreshore was also sampled in September 1978 and the results and discussion are presented in Appendix IX. During this study, unacceptable fecal coliform pollution was detected at marine stations 49 and 50. The contamination was associated with onshore sources of pollution, as samples taken offshore did not exhibit high counts. The fecal coliform levels were highest during rough seas, presumably due to the disturbance of inshore bottom sediments and consequent resuspension of bacteria. The 1978 study resulted in the extension of Schedule I Closure Area 14-8 to include the Eagle Crest foreshore to the foot of Yambury Road.

The discrepancy between the 1978 results and the results from this survey are likely due to differences in precipitation. Since the Eagle Crest subdivision is not sewered, contamination reaching the foreshore would arise primarily from faulty septic tank disposal systems. Such systems are more prone to malfunction during high rainfall/high water table periods. During the September 1978 sampling, rainfall was 10.8mm over 7 days, while during this survey only 0.3mm of rain fell during the sampling period. This difference in rainfall could account, at least in part, for the marine station results.

4.4 Columbia Estates (Marine Stations 52-55)

Marine stations 52-55 were selected to assess water quality in the Columbia Estates area. All stations met the shellfish growing water standard. The MPN range was L2 to 7/100ml for all stations.

Only one freshwater station, S8, was sampled as a possible contamination source. The station had a mean fecal coliform count of 206/100ml but an insignificant MPE. The FC:FS ratio of 0.52 suggests contamination from a source other than human. Further investigation revealed that this culvert partially drained a pond containing a few ducks and geese.

Prior to 1978, a sewage treatment plant on Columbia Drive near Admiral Tyson Blvd., serviced this subdivision. Following completion of the French Creek WPCC, sewage was diverted to the NRD system and the treatment plant was abandoned.

Marine water quality was also investigated in 1978 (Appendix IX) and was shown to be acceptable for shellfish harvesting.

4.5 French Creek Area (Marine Stations 56 and 57)

Marine stations 56 and 57 were selected to assess water quality in the French Creek boat basin area. Station 56 showed unacceptable water quality for the harvesting of shellfish. The source of contamination was not positively identified, but is probably a combination of low level fecal pollution contributed by French Creek and pollution generated by the boat basin. This sample station is included in the general 400 foot wharf closure around the French Creek boat basin. Sample station 57 was of acceptable shellfish growing water quality.

Marine samples BB1, BB2, BB3 and BB4 were taken inside the boat basin, with MPN results of 7, 49, 23 and 170/100ml respectively. The source of contamination possibly originates from live-aboards at the basin (approximately 10 per day (13)).

One other possible source of contamination in the vicinity is a fish unloading and grading facility on the south end of the boat basin. The facility consists of an unloading dock and ice plant (which was under construction during this survey). Located nearby is a trailer which serves as the office and residence of the owner. A sloped concrete surface, with drains, on the dock has been designed to catch drippings and washwater from the unloading and storage operations. Under the dock is a drainpipe which will carry the effluent to a 3800 litre concrete cylindrical tank buried at ground level next to the trailer. An identical tank alongside holds domestic sewage from the trailer. Both tanks are or will be pumped out as needed by a septic tank cleaning service. No outfall or overflow pipes were noted near the dock or the tanks and the plant was not in operation during the survey. It is unlikely that fecal contamination will result from sewage collection system at this facility however, some fecal contamination may originate from vessels discharging their sewage in the basin rather than out at sea.

One freshwater station, S7, was established on French Creek. It had a mean fecal coliform count of 34/100ml and a low MPE of 0.33 which indicated little impact on the receiving waters.

Sampling results have also been obtained by the Nanaimo Regional District and the Pollution Control Branch for this area and are shown in Table 5. PCB data indicates unacceptable contamination at station 56 does occur, which corroborated our results.

In the study by Cooper (9), a marine station located at the mouth of the boat basin exceeded the shellfish growing water standard. Vessel discharges were implicated as the source of contamination. Similar results were obtained during the 1978 survey (Appendix IX).

4.6 French Creek Water Pollution Control Centre

Bacteriological results for samples taken at the WPCC are presented in Appendix XII.

The mean fecal coliform count from the pre-chlorination stage to final effluent (unchlorinated) was reduced from 4.7×10^6/100ml to 1.9×10^4/100ml while the mean fecal streptococcus count was reduced from 2.7×10^5/100ml to 7950/100 ml. This degree of reduction is similar to that observed at other plants of this type in North America (12). A more detailed description of the plant operation can be found in Appendix X. Results of an operational assessment conducted by EPS in 1978 are also presented in the appendix.

Although no marine sample stations were placed over the diffuser during this study, four stations in the vicinity of the outfall were sampled in 1978 (Appendix IX). There was no evidence of the sewage plume reaching the surface during this sampling. Appendix IX also presents a summary of outfall sampling conducted by the Nanaimo Regional District. This data also indicates the plume does not reach the surface.

4.7 Parksville Bay Area (Marine Stations 58-78)

Marine stations 58-78 were selected for the assessment of water quality from French Creek to the mouth of the Englishman River. All stations met the shellfish growing water standard.

There was low level contamination from stations 58 to 65 located west of Parksville Bay, with a MPN range of less than 2/100ml to 11/100ml for all stations.

The sanitary survey did not reveal any sources of contamination to this area with the exception of S6, which exhibited a mean fecal coliform density of 18,250/100ml. The low MPE would indicate little environmental impact. The source of contamination to S6 was identified as animal fecal matter in the ditch.

Fecal coliform levels ranged from less than 2/100ml to 49/100ml in the Parksville Bay foreshore stations (70-73). There is considerable residential and commercial development along the foreshore however sewage contamination from these sources is unlikely as the entire area is sewered.

Marine station 70, located near the pump station on Bay Avenue, showed a count of 49/100ml on June 4. The nearest freshwater station is S5, which exhibited a mean fecal coliform count of 2700/100ml on that day, and may be responsible for the observed contamination.

Freshwater station S3, located at the foot of McMillan Street, had a mean fecal coliform count of 537/100ml but a low MPE which would indicate very little environmental impact on receiving water.

Three sediment samples were analysed from Parksville Bay (Appendix VIII) with two showing less than 20/100g. The third sample, located at the foot of McMillan Road, had a mean fecal coliform count of 330/100g. The contamination of the sediment is likely the result of the localized influence of S3.

Marine stations 66 to 69 were sampled offshore at Parksville Bay, in a line from headland to headland. The low levels of fecal contamination observed would indicate that the French Creek WPCC discharge has no influence on Parksville Bay and that the limited contamination observed is shore-based.

Stations 74-78 were located in the Englishman River area. Station 75 had one high count of 46/100ml on June 1st. At all other times the MPN range was less than 2 to 17/100 ml for all stations. The single high count

could be attributed to the influence of the Englishman River (S2) since fecal coliform levels at stations 75 and 76 were inversely related to salinity values. The Englishman River exhibited a low mean fecal coliform count of 11/100ml and a MPE of L1. Thus, the influence on the marine environment would be minimal.

The Parksville Bay area has also been sampled by the Nanaimo Regional District and the Pollution Control Branch at sample stations approximating EPS stations 60, 70 and 74 (Table 5). Results obtained by the PCB are consistently higher than those observed during this survey. However the results are either skewed by high counts obtained prior to the cessation of the old Parksville Bay discharge, or by a single aberrant high count. NRD data is similar to our results, although station 74 would exceed the standard at the 90 percentile level based on this data.

In the 1975 EPS survey, Parksville Bay was sampled as was the Englishman River. Unacceptable water quality was found near the old Parksville sewage treatment plant outfall. It was concluded that the high counts on a flood tide were the result of the sewage plume surfacing shoreward of the outfall (9).

4.8 Craig Bay to Northwest Bay (Marine Stations 79-93)

Marine stations 79-93 were selected to assess water quality in Craig Bay and Northwest Bay. All stations met the shellfish harvesting standard with the exception of station 85 in Craig Bay. The 90 percentile was skewed by a high count of 130/100ml on May 30. The cause was not determined and appears to be localized.

One freshwater station was established in Craig Creek (S1) and showed a mean fecal coliform count of only 172/100ml and an MPE of L1.

This coastline was also surveyed in 1975 and little change or development has occurred since that time. The reader is referred to the shellfish report by Cooper (9) for further information on the area.

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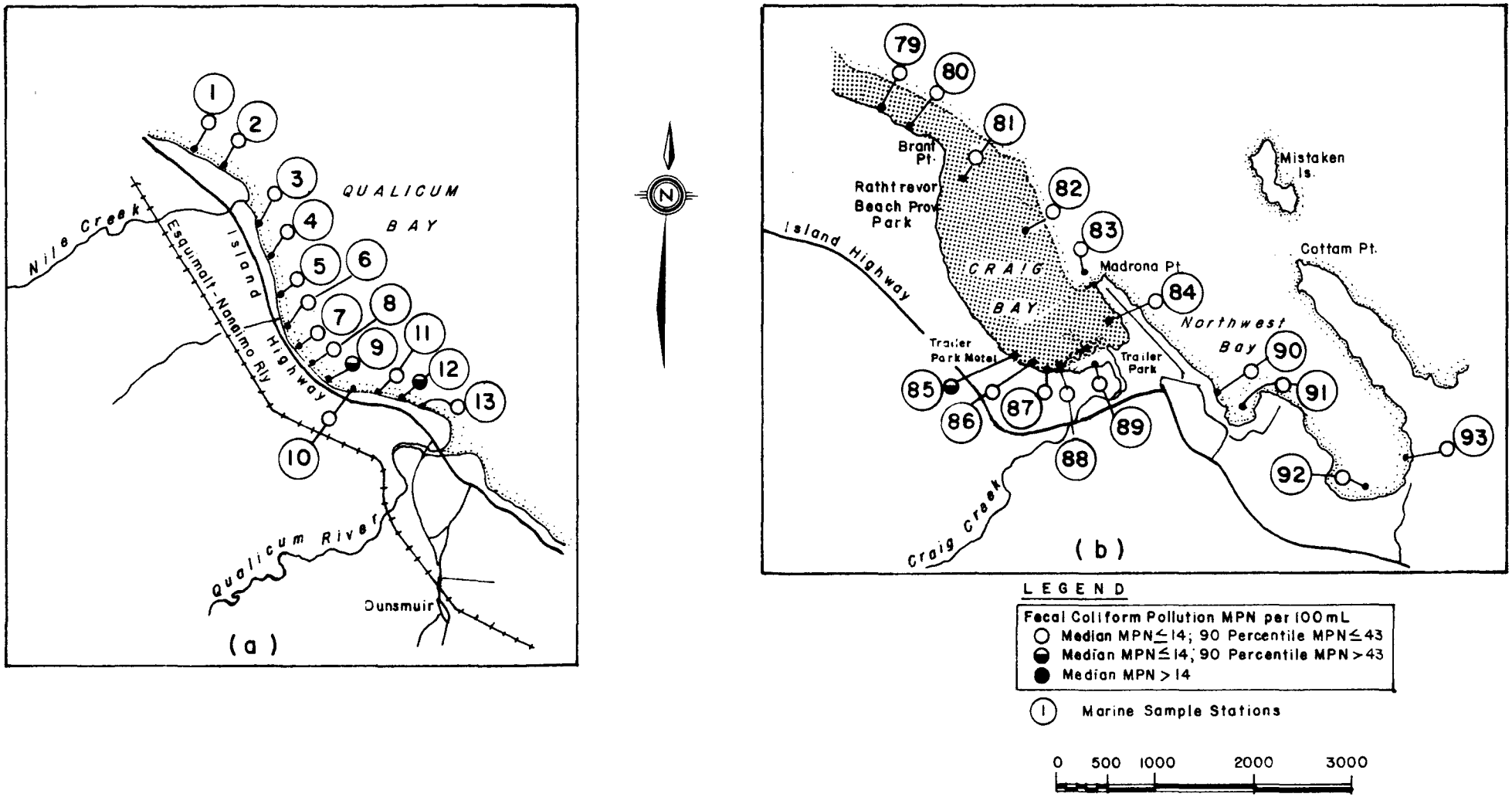
APPENDIX I

MARINE AND FRESHWATER SAMPLE STATION LOCATIONS

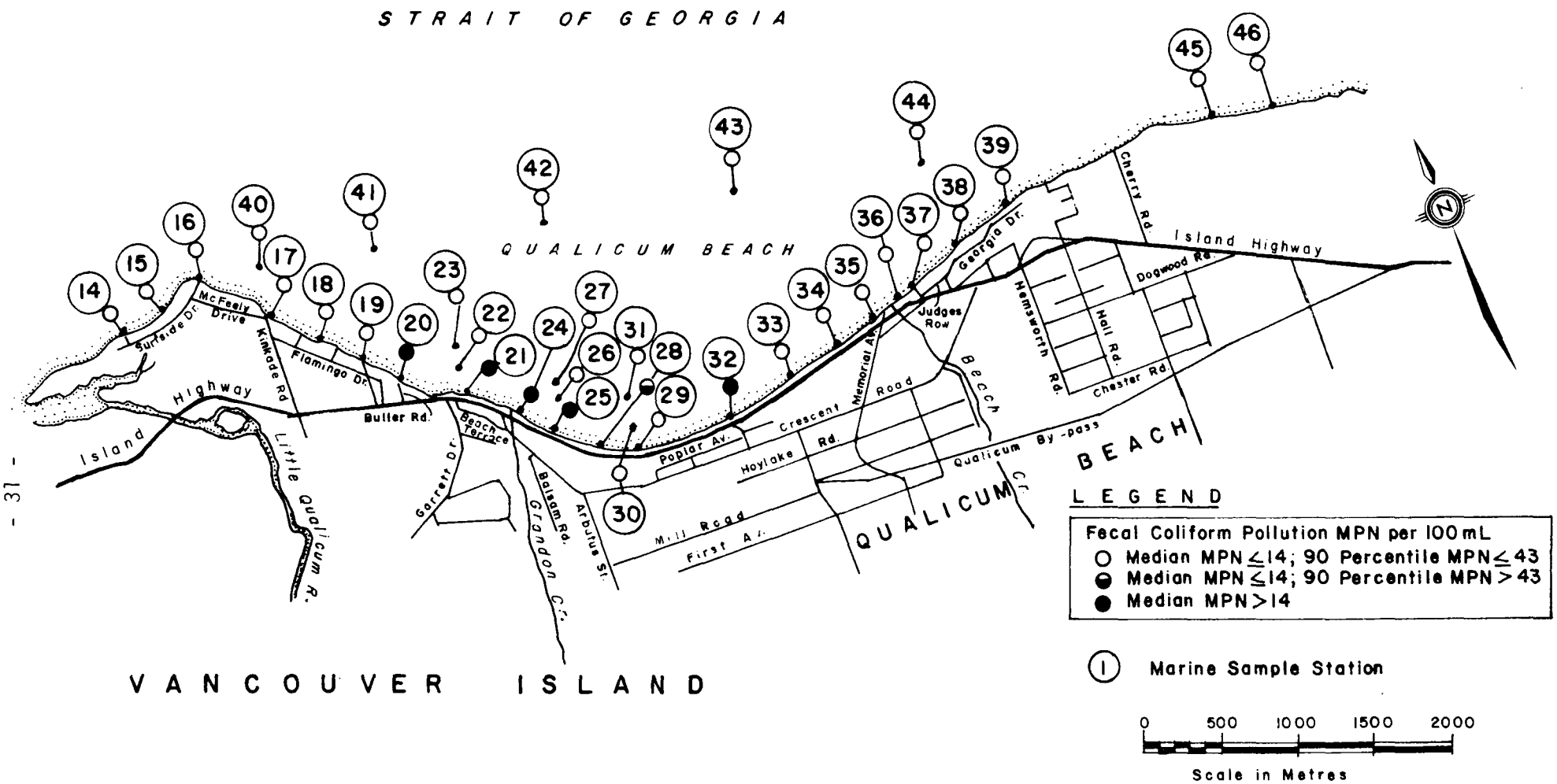


APPENDIX I

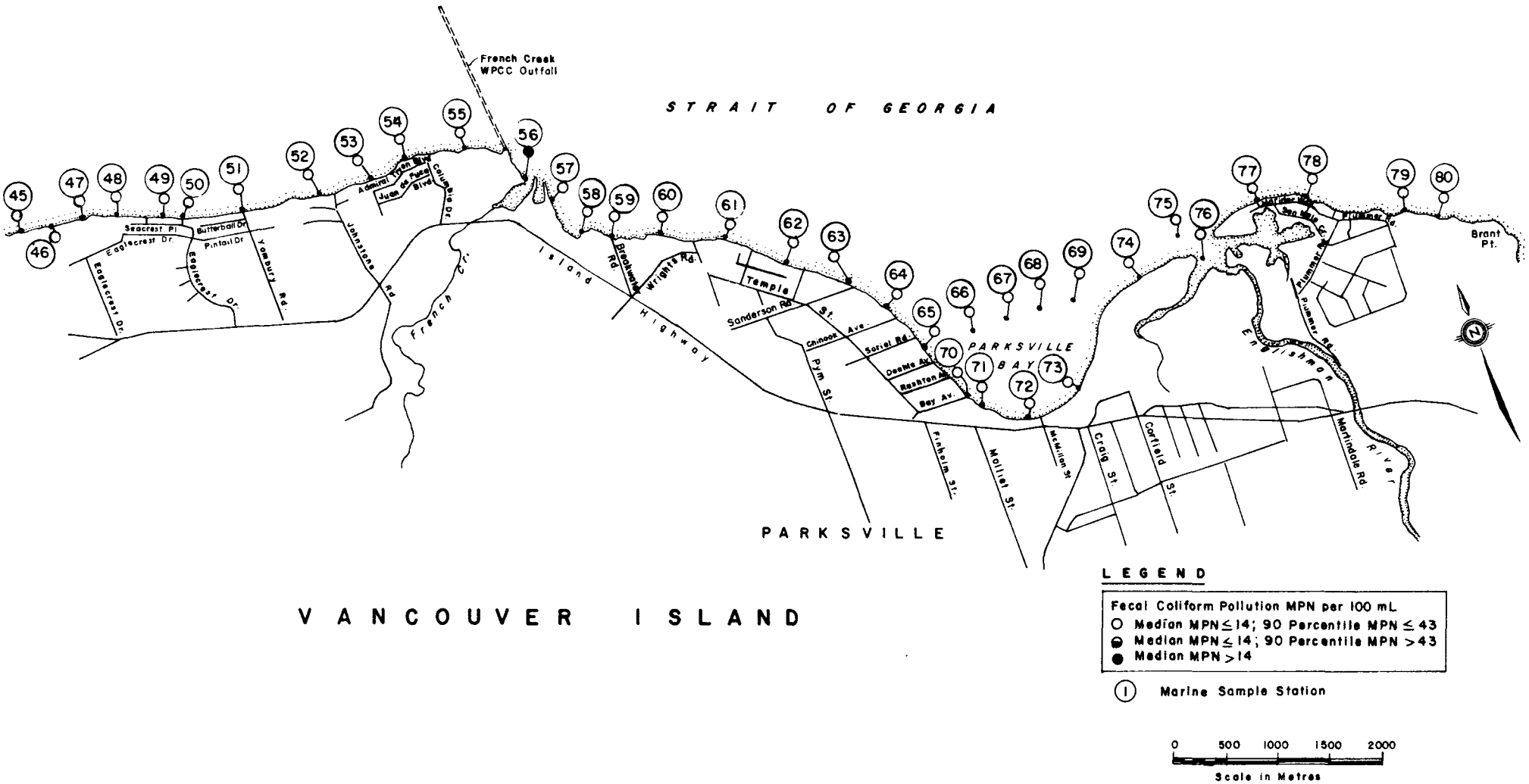
FIGURE I MARINE SAMPLE STATION LOCATIONS -

(a) QUALICUM BAY

(b) BRANT POINT TO COTTAM POINT

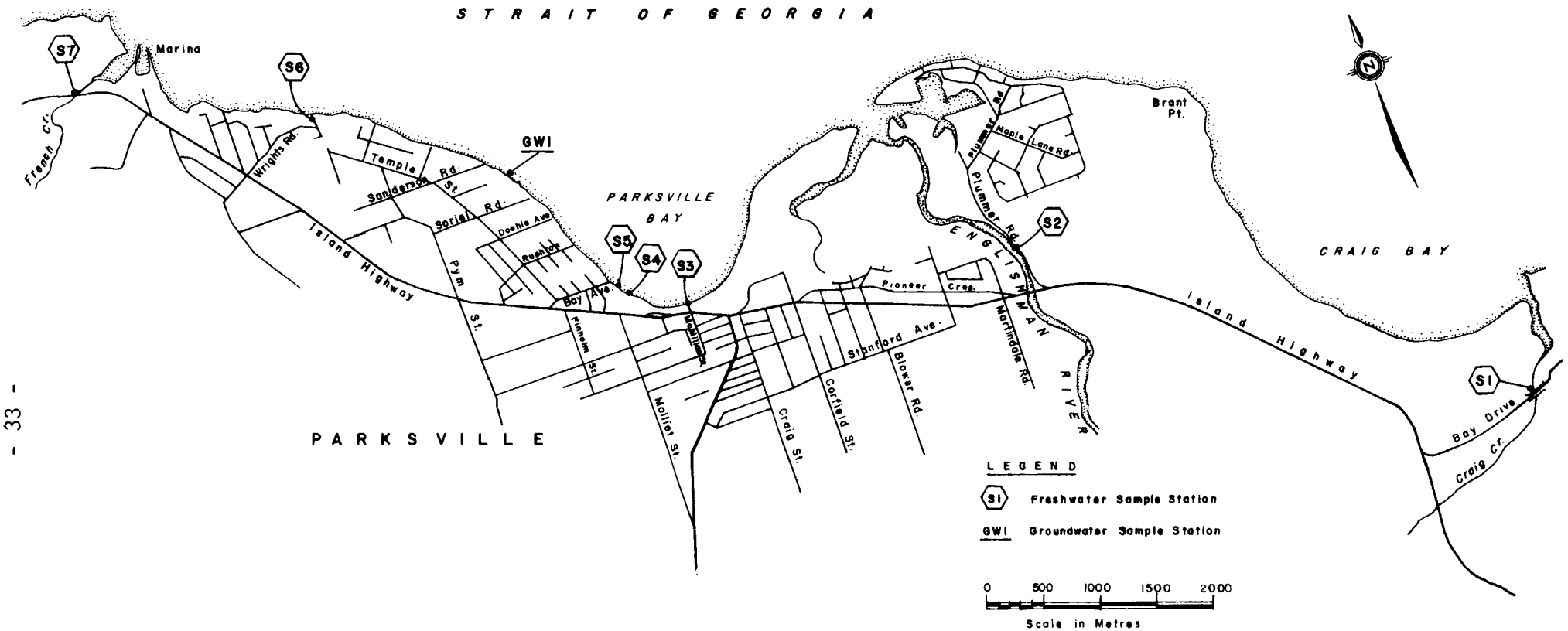


APPENDIX I
FIGURE 2 MARINE SAMPLE STATION LOCATIONS - QUALICUM BEACH

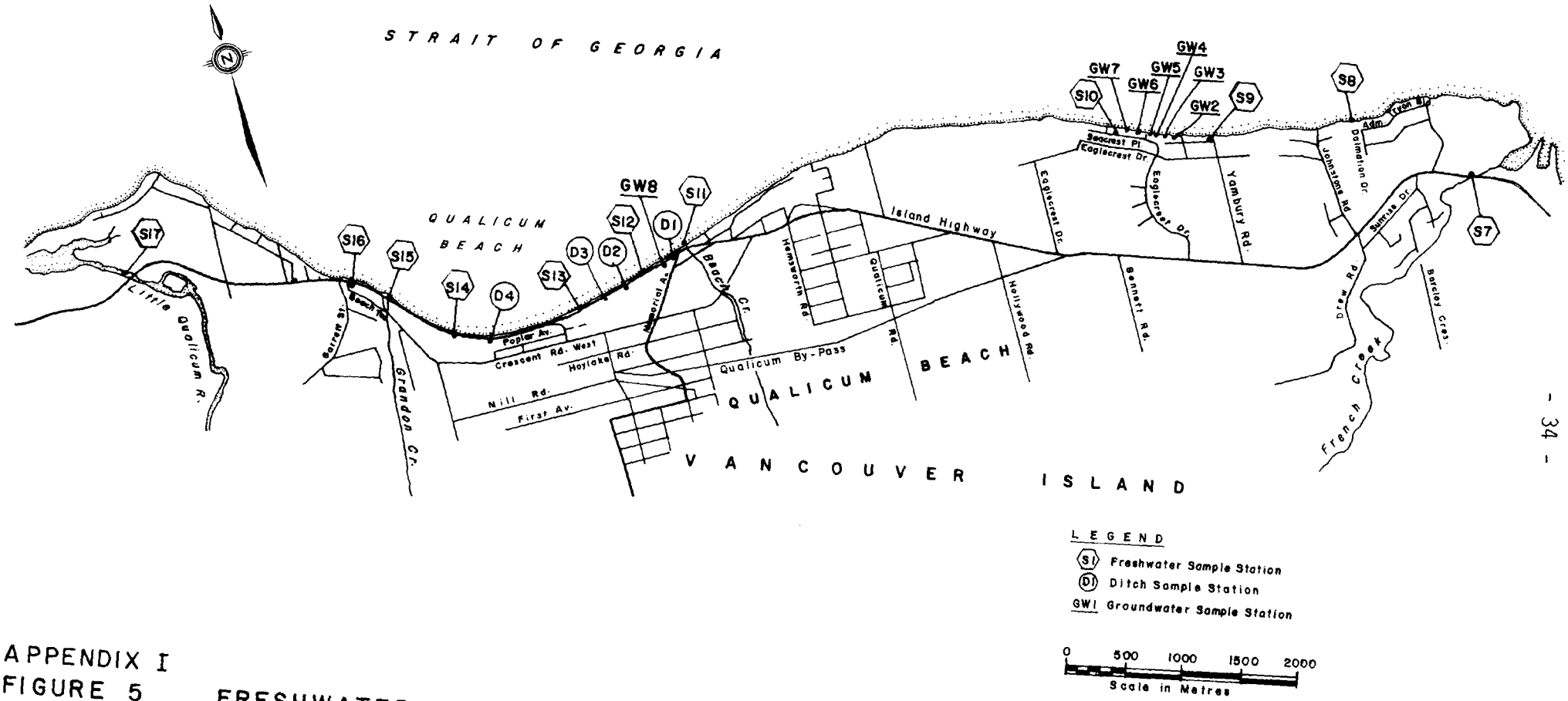


APPENDIX I

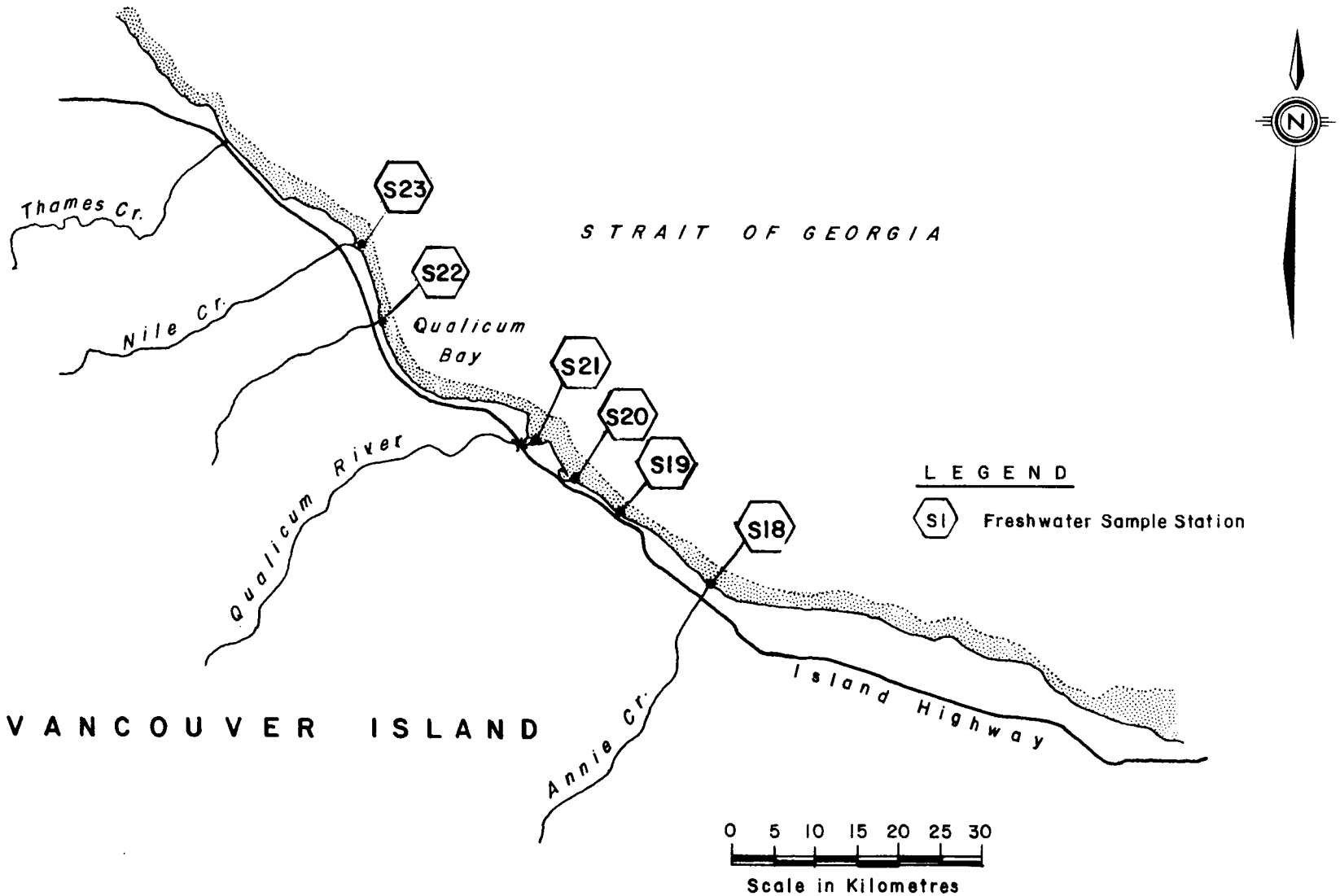
FIGURE 3 MARINE SAMPLE STATION LOCATIONS - EAGLE CREST TO PARKSVILLE BAY



APPENDIX I
FIGURE 4 FRESHWATER SAMPLE STATION LOCATIONS - FRENCH CREEK TO CRAIG BAY



APPENDIX I
FIGURE 5 FRESHWATER SAMPLE STATION LOCATIONS - QUALICUM BEACH TO FRENCH CREEK



APPENDIX I
FIGURE 6 FRESHWATER SAMPLE STATION LOCATIONS - QUALICUM BAY

APPENDIX II

MARINE SAMPLE STATION LOCATIONS

APPENDIX II MARINE SAMPLE STATION LOCATIONS

Sample Station	Longitude (West)	Latitude (North)	Location
1	124°38.60'	49°25.40'	Qualicum Bay
2	124°38.20'	49°25.28'	Qualicum Bay
3	124°38.10'	49°25.00'	Qualicum Bay
4	124°38.07'	49°24.90'	Qualicum Bay
5	124°38.00'	49°24.78'	Qualicum Bay
6	124°37.90'	49°24.63'	Qualicum Bay
7	124°37.80'	49°24.50'	Qualicum Bay
8	124°37.60'	49°24.40'	Qualicum Bay
9	124°37.45'	49°24.30'	Qualicum Bay
10	124°37.30'	49°24.23'	Qualicum Bay
11	124°37.12'	49°24.18'	Qualicum Bay
12	124°37.05'	49°24.18'	Qualicum Bay
13	124°36.90'	49°24.13'	Qualicum Bay
14	124°29.35'	49°22.18'	Qualicum Beach
15	124°29.10'	49°22.25'	Qualicum Beach
16	124°28.90'	49°22.26'	Qualicum Beach
17	124°28.72'	49°22.18'	Qualicum Beach
18	124°28.50'	49°22.04'	Qualicum Beach
19	124°28.30'	49°21.90'	Qualicum Beach
20	124°28.22'	49°21.84'	Qualicum Beach
21	124°28.15'	49°21.78'	Qualicum Beach
22	124°28.15'	49°21.63'	Qualicum Beach
23	124°28.15'	49°21.66'	Qualicum Beach
24	124°28.00'	49°21.70'	Qualicum Beach
25	124°27.80'	49°21.60'	Qualicum Beach
26	124°27.75'	49°21.63'	Qualicum Beach
27	124°27.77'	49°21.66'	Qualicum Beach
28	124°27.62'	49°21.50'	Qualicum Beach
29	124°27.41'	49°21.40'	Qualicum Beach
30	124°27.41'	49°21.46'	Qualicum Beach
31	124°27.41'	49°21.43'	Qualicum Beach
32	124°27.12'	49°21.40'	Qualicum Beach
33	124°26.70'	49°21.42'	Qualicum Beach
34	124°26.50'	49°21.45'	Qualicum Beach
35	124°26.30'	49°21.50'	Qualicum Beach
36	124°26.15'	49°21.55'	Qualicum Beach
37	124°25.89'	49°21.60'	Qualicum Beach
38	124°25.60'	49°21.69'	Qualicum Beach
39	124°25.38'	49°21.72'	Qualicum Beach
40	124°28.92'	49°22.47'	Qualicum Beach

APPENDIX II MARINE SAMPLE STATION LOCATIONS (Cont.)

Sample Station	Longitude (West)	Latitude (North)	Location
41	124°28.10'	49°22.20'	Qualicum Beach
42	124°27.58'	49°22.10'	Qualicum Beach
43	124°26.70'	49°21.98'	Qualicum Beach
44	124°25.60'	49°21.80'	Qualicum Beach
45	124°24.70'	49°21.80'	Eagle Crest
46	124°24.52'	49°21.72'	Eagle Crest
47	124°24.35'	49°21.70'	Eagle Crest
48	124°24.15'	49°21.67'	Eagle Crest
49	124°23.98'	49°21.65'	Eagle Crest
50	124°23.72'	49°21.52'	Eagle Crest
51	124°23.50'	49°21.50'	Eagle Crest
52	124°23.00'	49°21.41'	Eagle Crest
53	124°22.60'	49°21.37'	Eagle Crest
54	124°22.40'	49°21.30'	Eagle Crest
55	124°21.95'	49°21.25'	Eagle Crest
56	124°21.60'	49°21.08'	Eagle Crest
57	124°21.70'	49°20.93'	Eagle Crest
58	124°21.25'	49°20.86'	Eagle Crest
59	124°21.00'	49°20.75'	Eagle Crest
60	124°20.73'	49°20.70'	Eagle Crest
61	124°20.40'	49° . '	Eagle Crest
62	124°20.10'	49°20.56'	Eagle Crest
63	124°19.97'	49°20.35'	Parksville Bay
64	124°19.72'	49°20.22'	Parksville Bay
65	124°19.40'	49°19.87'	Parksville Bay
66	124°19.10'	49°19.84'	Parksville Bay
67	124°18.85'	49°19.83'	Parksville Bay
68	124°18.62'	49°19.80'	Parksville Bay
69	124°18.40'	49°19.78'	Parksville Bay
70	124°19.35'	49°19.70'	Parksville Bay
71	124°19.15'	49°19.65'	Parksville Bay
72	124°18.90'	49°19.62'	Parksville Bay
73	124°18.68'	49°19.90	Parksville Bay
74	124°17.95'	49°19.00	Parksville Bay
75	124°17.70'	49°19.90	Parksville Bay
76	124°17.60'	49°19.00	Parksville Bay
77	124°17.40'	49°19.95	Parksville Bay
78	124°16.97'	49°19.77	Parksville Bay
79	124°16.30'	49°19.68	Parksville Bay
80	124°16.00'	49°19.28	Parksville Bay

APPENDIX II MARINE SAMPLE STATION LOCATIONS (Cont.)

Sample Station	Longitude (West)	Latitude (North)	Location
81	124°15.50'	49°19.28'	Parksville Bay
82	124°15.00'	49°19.09'	Parksville Bay
83	124°14.52'	49°18.82'	Parksville Bay
84	124°14.32'	49°18.57'	Parksville Bay
85	124°15.30'	49°18.50'	Parksville Bay
86	124°15.10'	49°18.47'	Parksville Bay
87	124°14.73'	49°18.40'	Craig Bay
88	124°14.50'	49°18.45'	Craig Bay
89	124°14.50'	49°18.25'	Northwest Bay
90	124°14.15'	49°18.05'	Northwest Bay
91	124°14.00'	49°17.75'	Northwest Bay
92	124°14.80'	49°17.90'	Northwest Bay

APPENDIX III

FRESHWATER SAMPLE STATION LOCATIONS AND DESCRIPTIONS

APPENDIX III FRESHWATER SAMPLE STATION LOCATIONS AND DESCRIPTIONS
PARKSVILLE - QUALICUM

Sample Station	Descriptions
	Craig Bay
S1	Craig Creek by Terrien Road and Bay Drive at the bridge.
	Parksville Bay - Eagle Crest
S2	Englishman River approximately 100m below the bridge. Culvert at foot of McMillan Street draining to Parksville Bay.
S4	Romney Creek at beach emergence to Parksville Bay.
S5	Carey Creek at beach emergence to Parksville Bay.
S6	Drainage ditch at foot of Sunray Road, about 10m. below Wright Road intersection.
S7	French Creek at the bridge.
S8	Culvert about 100m. east of the foot of Johnstone Road, Columbia Estates.
S9	Stream at foot of Yambury Road below Butterball Drive, Eagle Crest.
S10	Culvert between the white tudor-style cottage and the brown angle-roofed cottage near the west end of Sea Crest Place.
	Qualicum Beach - Qualicum Bay
S11	Beach Creek below the intersection of Memorial Avenue and Island Highway.
S12	Storm drain under the parking lot area about 100m. east of Mayfair Motel.

APPENDIX III FRESHWATER SAMPLE STATION LOCATIONS AND DESCRIPTIONS
PARKSVILLE - QUALICUM

Sample Station	Descriptions
S13	Storm drain under 325 Island Highway.
S14	Culvert about 75m. S.E. of Shady Rest Hotel on Island Highway.
S15	Grandon Creek by W. Crescent Road and Island Highway.
S16	Culvert at the foot of Beach Terrace Road.
S17	Little Qualicum River at the bridge on Island Highway.
S18	Annie Creek at the beach access about 75m. east of the foot of Van Isle Road.
S19	Culvert by the Walsh's residence on Island Highway.
S20	Culvert about 10m. below the high water mark, below the Hawkin's residence on Island Highway.
S21	Qualicum River at the bridge on Island Highway
S22	Unnamed creek by the "Pic-a-Nic" store.
S23	Nile Creek at the foot of the beach access road by Island Highway.
Upstream Samples	
S6A	150 m. upstream of S6, at the corner of Temple Road and Sunray Road.
S10A	Drainage ditch opposite wood-panelled house with "Nahanni Clipper" boat in front yard on Sea Crest Place.
S15A	Located about 100 m. upstream of S15, at the bottom of a ravine below sideroad near railroad tracks on Arbutus Street.
S16A	Drainage ditch at corner of Beach Terrace Road and 664 Island Highway.
S16B	Located about 15 m. upstream of S16A, in roadside ditch.
S18A	Annie Creek at the foot of Van Isle Road.

APPENDIX III MISCELLANEOUS SAMPLE STATION LOCATIONS AND DESCRIPTIONS - SEDIMENT SAMPLES

Sample Station	Descriptions
Sed S1	Located about 10m. below high tide mark below beige/ orange building on east side of Parksville Bay.
Sed S2	Located about 10m. below the foot of McMillan Street.
Sed S3	Located about 15m. west of S5.
Sed S4	Located below the beach access road on Judges Row, near the B.C. Tel Cable sign.
Sed S5	Located below the Shoreline Motor Inn, about 15m. west of 213 Island Highway.
Sed S6	Located below the Sand Pebbles Inn.
Sed S7	Located below the peach house next to the Sand Pebbles Inn.
Sed S8	Located below the Mayfair Motel.
Sed S9	Located below the Qualicum Beach Marina.
Sed S10	Located about 15m. east of S11 by Manhole 37.
Sed S11	Located below 325 Island Highway.
Sed S12	Located below the pink house on Island Highway.
Sed S13	Located below the Captain's Quarters Motel.
Sed S14	Located below the Shady Rest Hotel.
Sed S15	Located below the Snow White Motel.
Sed S16	Located at S15.
Sed S17	Located at the foot of Sea Croft Road.
Sed S18	Located at Marine Station 59.
Sed S19	Located at Marine Station 58.

APPENDIX IV

MISCELLANEOUS SAMPLE STATION LOCATIONS AND DESCRIPTIONS

APPENDIX IV MISCELLANEOUS SAMPLE STATION LOCATIONS AND DESCRIPTIONS - SEEPAGE/SURFACEWATER SAMPLES

Sample Station	Descriptions
GW1	Located about 15m. below the shake shack and outhouse below the Koer's residence at the foot of Chinook Avenue.
GW2	Located at the beach about 25m. below a panelled barn-shaped cottage on Sea Crest Place.
GW3	Located about 15m. below and between a green cottage and a beige cottage with dark brown trim on Sea Crest Place.
GW4	Located about 25m. below a green cottage next to the beach access road on Sea Crest Place.
GW5	Located about 25m. below the beach access road next to the green cottage on Sea Crest Place.
GW6	Located at the beach about 25m. below a greenish panelled cottage with green door trim on Sea Crest Place.
GW7	Located at the beach about 25m. below a grey-green cottage with white trim on Sea Crest Place.
GW8	Located below the Tourist Information Bureau on Island Highway at Qualicum Beach.

APPENDIX IV MISCELLANEOUS SAMPLE STATION LOCATIONS AND DESCRIPTIONS - DITCH/TIDAL POOL SAMPLES

Sample Station	Descriptions
D1	Located on roadside opposite the Qualicum Beach Tourist Information.
D2	Located on roadside opposite the Mayfair Motel.
D3	Located on roadside under the triangle-shaped Qualicum Beach Marina sign.
D4	Located on roadside opposite 381 Island Highway.
<u>East side of Grandon Creek</u>	
TP1	Located about 25m. east of 569 Island Highway.
TP2	Located about 30m. below 569 Island Highway.
TP3	Located about 30m. below 575 Island Highway.
<u>West side of Grandon Creek</u>	
TP4	Located about 5m. below the high tide mark below the tan/white trim and brick-base house.
TP5	Located about 10m. below the high tide mark below the beach access near W. Crescent Road.

APPENDIX V

DAILY BACTERIOLOGICAL RESULTS FOR MARINE STATIONS

APPENDIX V DAILY BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS

Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100ml
1	June 06/79	1205	L2
	June 07	1720	L2
	June 08	0540	L2
	June 11	0555	5
	June 12	0630	L2
	June 13	0735	L2
2	June 06/79	1210	L2
	June 07	1725	L2
	June 08	0545	L2
	June 11	0600	2
	June 12	0631	L2
	June 13	0736	L2
3	June 06/79	1255	L2
	June 07	1735	70
	June 08	0605	8
	June 11	0700	33
	June 12	0635	2
	June 13	0740	L2
	June 14	0725	2
	June 15	0840	L2
4	June 06/79	1305	2
	June 07	1740	2
	June 08	0610	2
	June 11	0700	11
	June 12	0640	L2
	June 13	0740	L2
5	June 06/79	1310	L2
	June 07	1740	L2
	June 08	0615	L2
	June 11	0705	5
	June 12	0640	L2
	June 13	0745	L2
6	June 06/79	1315	5
	June 07	1745	L2
	June 08	0620	L2
	June 11	0705	13
	June 12	0645	13
	June 13	0745	L2
7	June 06/79	1320	L2
	June 07	1750	L2
	June 08	0625	L2
	June 11	0715	6
	June 12	0650	L2
	June 13	0750	2
8	June 06/79	1325	5
	June 07	1735	L2
	June 08	0625	L2
	June 11	0630	33
	June 12	0650	L2
	June 13	0750	5

L=less than

APPENDIX V DAILY BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS (Cont.)

Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100ml
9	June 06/79	1320	2
	June 07	1740	L2
	June 08	0635	2
	June 11	0635	350
	June 12	0655	L2
	June 13	0750	L2
	June 14	0725	L2
	June 15	0840	L2
10	June 06/79	1315	L2
	June 07	1740	L2
	June 08	0635	L2
	June 11	0625	5
	June 12	0655	L2
	June 13	0755	2
	June 14	--	L2
	June 15	0845	L2
11	June 06/79	1310	L2
	June 07	1745	L2
	June 08	0645	2
	June 11	0620	L2
	June 12	0700	L2
	June 13	0755	2
12	June 06/79	1305	L2
	June 07	1750	2
	June 08	0650	1600
	June 11	0615	2
	June 12	0700	L2
	June 13	0800	2
	June 14	0735	L2
	June 15	0850	L2
13	June 06/79	1255	L2
	June 07	1800	L2
	June 08	0655	L2
	June 11	0615	4
	June 12	0705	L2
	June 13	0800	13
14	June 06/79	1440	5
	June 07	1755	L2
	June 08	0600	5
	June 11	0625	23
	June 12	0620	33
	June 13	--	22
	June 14	0700	2
	June 15	0825	L2

L=less than

APPENDIX V DAILY BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS (Cont.)

Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100ml
15	June 06/79	1450	L2
	June 07	1800	5
	June 08	0605	31
	June 11	0625	23
	June 12	0630	7
	June 13	--	49
	June 14	0705	9
	June 15	0830	2
	June 18	1440	L2
	June 19	1540	23
16	June 06/79	1450	2
	June 07	1800	8
	June 08	0610	5
	June 11	0630	130
	June 12	0630	34
	June 13	--	33
	June 14	0705	2
	June 15	0835	5
	June 18	1445	5
	June 19	1550	7
17	June 06/79	1500	L2
	June 07	1805	L2
	June 08	0615	11
	June 11	0635	23
	June 12	0635	46
	June 13	--	2
	June 14	0710	8
	June 15	0840	13
18	June 06/79	1515	11
	June 07	1810	8
	June 08	0625	8
	June 11	0640	7
	June 12	0640	8
	June 13	--	5
	June 14	0715	5
	June 15	0840	38
19	June 06/79	1505	5
	June 07	1815	5
	June 08	0620	23
	June 11	0645	70
	June 12	0645	23
	June 13	--	5
	June 14	0720	13
	June 15	0845	8
	June 18	1450	23
	June 19	1600	2
20	June 06/79	1520	13
	June 07	1820	13
	June 08	0630	22
	June 11	0650	23
	June 12	0650	22
	June 13	--	17
	June 14	0720	8
	June 15	0850	14

L=less than

APPENDIX V DAILY BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS (Cont.)

Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100ml	Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100ml
21	June 06/79	1525	13	25	June 06/79	1540	79
	June 07	1845	22		June 07	1840	13
	June 08	0725	49		June 08	0645	33
	June 11	--	79		June 11	0655	46
	June 12	0655	17		June 12	0710	22
	June 13	--	17		June 13	--	11
	June 14	0725	79		June 14	0730	2
	June 15	0855	13		June 15	0905	7
	June 18	1455	L2		June 18	1500	79
	June 19	1610	8		June 19	1620	2
22	June 15/79	0855	L2	26	June 15/79	0910	33
	June 18	1455	L2		June 18	1505	L2
	June 19	1610	L2		June 19	1625	2
23	June 15/79	0855	13	27	June 15/79	0910	2
	June 18	1455	22		June 18	1505	L2
	June 19	1615	L2		June 19	1625	L2
24	June 06/79	1535	49	28	June 06/79	1545	49
	June 07	1835	23		June 07	1845	L2
	June 08	0640	5		June 08	0645	49
	June 11	0655	46		June 11	0700	11
	June 12	0703	8		June 12	0710	2
	June 13	--	7		June 13	--	17
	June 14	0730	5		June 14	0735	13
	June 15	0900	49		June 15	0910	2
	June 18	1500	L2				
	June 19	1620	70				

L=less than

APPENDIX V DAILY BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS (Cont.)

Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100ml
29	June 07/79	1845	L2
	June 08	0650	13
	June 11	0705	33
	June 12	0715	8
	June 13	--	5
	June 14	0740	2
	June 15	0915	23
	June 18	1510	L2
	June 19	1635	L2
30	June 15/79	0920	23
	June 18	1510	L2
	June 19	1630	L2
31	June 15/79	0920	2
	June 18	1510	2
	June 19	1630	L2
32	June 07/79	1850	240
	June 08	0655	17
	June 11	0710	79
	June 12	0715	8
	June 13	--	11
	June 14	0745	17
	June 15	0925	5
33	June 07/79	1855	7
	June 08	0700	5
	June 11	0740	49
	June 12	0720	L2
	June 13	--	11
	June 14	0745	17
	June 15	0925	5
34	June 07/79	1855	L2
	June 08	0700	L2
	June 11	0735	2
	June 12	0720	2
	June 13	--	22
	June 14	0750	L2
	June 15	0930	L2
35	June 07/79	1900	L2
	June 08	0705	L2
	June 11	0735	5
	June 12	0725	2
	June 13	--	49
	June 14	0750	2
	June 15	0930	5

L=less than

APPENDIX V DAILY BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS (Cont.)

Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100ml
36	June 07/79	1905	L2
	June 08	0710	L2
	June 11	0730	2
	June 12	0730	7
	June 13	--	17
	June 14	0755	L2
	June 15	0935	13
37	June 07/79	1850	L2
	June 08	0715	L2
	June 11	0730	13
	June 12	0730	23
	June 13	--	7
	June 14	0755	4
	June 15	0935	12
38	June 07/79	1855	2
	June 08	0715	L2
	June 11	0725	8
	June 12	0740	8
	June 13	--	17
	June 14	0755	2
	June 15	0940	33
39	June 07/79	1900	2
	June 08	0720	L2
	June 11	0720	11
	June 12	0745	2
	June 13	--	7
	June 14	0800	L2
	June 15	0940	2
40	June 12/79	0725	L2
	June 13	0815	2
	June 14	0700	2
	June 15	0905	L2
	June 18	1435	L2
	June 19	1635	L2
41	June 12/79	0730	L2
	June 13	0820	2
	June 14	0700	L2
	June 15	0910	L2
	June 18	1435	L2
	June 19	1630	L2
42	June 12/79	0730	L2
	June 13	0820	2
	June 14	0655	L2
	June 15	0910	L2
	June 18	1430	L2
	June 19	1630	L2
43	June 12/79	0740	L2
	June 13	0820	2
	June 14	0655	L2
	June 15	0915	2
	June 18	1430	L2
	June 19	1625	L2

L=less than

APPENDIX V DAILY BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS (Cont.)

Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100ml	Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100ml
44	June 12/79	0740	L2	48	June 12/79	0800	L2
	June 13	0825	2		June 13	0700	2
	June 14	0650	L2		June 14	0815	L2
	June 15	0915	L2		June 15	0935	L2
	June 18	1425	2		June 18	1415	L2
	June 19	1610	L2		June 19	1550	2
45	June 12/79	0810	L2	49	June 06/79	1615	5
	June 13	0710	4		June 07	1905	5
	June 14	0800	8		June 08	0755	L2
	June 15	0925	L2		June 11	0745	8
	June 18	1410	11		June 12	0755	L2
	June 19	1605	L2		June 13	--	L2
46	June 12/79	0810	L2	50	June 06/79	1630	L2
	June 13	0705	L2		June 07	1910	L2
	June 14	0800	L2		June 08	0805	8
	June 15	0925	L2		June 11	0750	79
	June 18	1405	L2		June 12	0750	4
	June 19	1600	L2		June 13	--	L2
47	June 12/79	0804	L2	51	May 29/79	0755	L2
	June 13	0700	L2		May 30	0825	8
	June 14	0810	L2		May 31	0820	L2
	June 15	0930	L2		June 01	0955	L2
	June 18	1415	L2		June 04	1405	2
	June 19	1535	L2		June 05	1455	L2

L=less than

APPENDIX V DAILY BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS (Cont.)

Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100ml	Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100ml
52	May 29/79	0755	2	56	May 29/79	0810	L2
	May 30	0820	L2		May 30	0845	33
	May 31	0825	L2		May 31	0840	23
	June 01	0955	L2		June 01	1000	33
	June 04	1355	7		June 04	1415	11
	June 05	1505	5		June 05	1510	L2
53	May 29/79	0800	L2	57	May 29/79	0815	L2
	May 30	0830	2		May 30	0850	L2
	May 31	0825	L2		May 31	0920	L2
	June 01	1000	2		June 01	1015	L2
	June 04	1415	2		June 04	1420	L2
	June 05	1510	L2		June 05	1515	L2
54	May 29/79	0805	2	58	May 29/79	0820	2
	May 30	0835	L2		May 30	0850	L2
	May 31	0830	L2		May 31	0920	L2
	June 01	1000	L2		June 01	1015	L2
	June 04	1420	5		June 04	1425	L2
	June 05	1515	5		June 05	1515	L2
55	May 29/79	0810	L2	59	May 29/79	0825	2
	May 30	0840	L2		May 30	0855	L2
	May 31	0835	L2		May 31	0925	L2
	June 01	1005	L2		June 01	1020	L2
	June 04	1410	L2		June 04	1425	2
	June 05	1500	L2		June 05	1515	L2

L=less than

APPENDIX V DAILY BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS (Cont.)

Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100ml	Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100ml
60	May 29/79	0830	L2	64	May 29/79	0845	11
	May 30	0855	L2		May 30	0915	2
	May 31	0925	L2		May 31	0940	L2
	June 01	1020	2		June 01	1035	L2
	June 04	1430	L2		June 04	1445	L2
	June 05	1520	L2		June 05	1535	L2
61	May 29/79	0830	L2	65	May 29/79	0850	2
	May 30	0900	L2		May 30	0920	L2
	May 31	0930	L2		May 31	0945	2
	June 01	1025	L2		June 01	1040	L2
	June 04	1435	L2		June 04	1450	5
	June 05	1525	L2		June 05	1540	L2
62	May 29/79	0835	L2	66	May 29/79	0855	L2
	May 30	0905	5		May 30	0925	L2
	May 31	0935	L2		May 31	0950	L2
	June 01	1030	L2		June 01	1045	L2
	June 04	1435	L2		June 04	1455	5
	June 05	1525	L2		June 05	1540	L2
63	May 29/79	0845	L2	67	May 29/79	0855	L2
	May 30	0915	L2		May 30	0925	L2
	May 31	0940	5		May 31	0950	5
	June 01	1035	L2		June 01	1045	L2
	June 04	1440	L2		June 04	1455	2
	June 05	1530	L2		June 05	1545	L2

L=less than

APPENDIX V DAILY BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS (Cont.)

Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100ml	Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100ml
68	May 29/79	0900	2	72	May 29/79	0910	7
	May 30	0930	L2		May 30	0830	9
	May 31	0955	2		June 01	1045	4
	June 01	1050	7		June 04	1500	17
	June 04	1500	2		June 05	1605	7
	June 05	1545	L2		June 19	1720	2
69	May 29/79	0900	2	73	May 29/79	0905	33
	May 30	0930	L2		May 30	0845	2
	May 31	0955	L2		June 01	1505	5
	June 01	1050	8		June 04	1600	23
	June 04	1500	L2		June 05	1600	5
	June 05	1545	L2		June 19	1725	7
70	May 30/79	--	11	74	May 29/79	0925	L2
	June 01	1035	5		May 30	0935	2
	June 04	1440	49		May 31	1000	2
	June 05	1535	5		June 01	1055	5
	June 18	1345	L2		June 04	1505	8
	June 19	1700	8		June 05	1555	L2
71	May 29/79	0910	17	75	May 29/79	0930	5
	May 30	0825	2		May 30	0940	8
	June 01	1045	2		May 31	1005	8
	June 04	1455	L2		June 01	1100	46
	June 05	1610	L2		June 04	1510	5
	June 19	1715	L2		June 05	1600	5

L=less than

APPENDIX V DAILY BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS (Cont.)

Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100ml
76	May 29/79	0930	4
	May 30	0945	7
	May 31	1010	8
	June 01	1105	17
	June 04	1515	2
	June 05	1600	2
77	May 29/79	0935	L2
	May 30	0950	5
	May 31	1015	17
	June 01	1110	8
	June 04	1515	L2
78	May 29/79	0940	L2
	May 30	0955	L2
	May 31	1015	8
	June 01	1110	5
	June 04	1520	2
79	May 29/79	0945	L2
	May 30	1000	5
	May 31	1020	5
	June 01	1115	L2
	June 04	1525	5
80	May 29/79	0950	L2
	May 30	1000	2
	May 31	1025	8
	June 01	1120	2
	June 04	1530	4
81	May 29/79	0955	L2
	May 30	1005	L2
	May 31	1030	L2
	June 01	1125	2
	June 04	1535	L2
82	May 29/79	1000	L2
	May 30	1010	23
	May 31	1035	L2
	June 01	1130	L2
	June 04	1540	L2
83	May 29/79	1005	L2
	May 30	1015	2
	May 31	1045	L2
	June 01	1130	L2
	June 04	1545	L2
84	May 29/79	1010	2
	May 30	1020	L2
	May 31	1045	8
	June 01	1135	5
	June 04	1545	L2
85	May 30/79	--	130
	June 01	1120	8
	June 04	1525	5
	June 05	1640	49
	June 18	1400	5

L=less than

APPENDIX V DAILY BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS (Cont.)

Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100ml	Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100ml
86	May 30/79	--	7	90	May 29/79	1030	L2
	June 01	1125	8		May 30	1035	L2
	June 04	1530	L2		May 31	1050	L2
	June 05	1645	8		June 01	1145	2
	June 18	1405	7		June 04	1550	2
87	May 30/79	--	11	91	May 29/79	1030	L2
	June 01	1130	2		May 30	1040	L2
	June 04	1535	L2		May 31	1050	5
	June 05	1650	L2		June 01	1145	6
	June 18	1410	11		June 04	1555	2
88	May 30/79	--	L2	92	May 29/79	1035	L2
	June 01	1145	8		May 30	1045	2
	June 04	1550	L2		May 31	1055	L2
	June 05	1715	5		June 01	1150	8
	June 18	1430	L2		June 04	1600	L2
89	May 30/79	--	L2	93	May 29/79	1040	L2
	June 01	--	--		May 30	1045	L2
	June 04	1555	11		May 31	--	L2
	June 05	1720	49		June 01	1155	13
	June 18	1435	2		June 04	1600	L2

L=less than

APPENDIX VI

DAILY BACTERIOLOGICAL RESULTS FOR FRESHWATER SAMPLE STATIONS

APPENDIX VI DAILY BACTERIOLOGICAL RESULTS FOR FRESHWATER SAMPLE STATIONS PARKSVILLE - QUALICUM

Sample Station	Date '79	Total Coliform/100ml	Fecal Coliform/100ml	Fecal Streptococci/100ml
S1	June 04	310	250	150
	June 05	330	170	140
	June 13	450	96	55
S2	May 30	220	11	35
	June 04	38	9	18
	June 05	37	12	29
S3	June 06	1150	170	270
	June 07	2300	830	140
	June 08	7000	610	280
S4	May 31	1780	6	3
	June 04	2700	5	14
	June 05	370	8	61
S5	May 31	360	128	74
	June 01	780	250	126
	June 04	3400	2700	250
	June 05	(avge) 1040	70	170
	June 18	6900	580	2210
S6	May 30	23 000	26 000	13000
	May 31	25 800	28 400	17700
	June 01	6900	6100	11100
	June 04	25 000	12 500	1500
S7	May 30	48	42	36
	June 04	108	22	46
	June 05	52	38	62
S8	June 01	8800	54	95
	June 06	200	L100	300
	June 07	360	410	770
	June 18	600	260	410

APPENDIX VI (Cont'd) DAILY BACTERIOLOGICAL RESULTS FOR FRESHWATER SAMPLE STATIONS PARKSVILLE - QUALICUM

Sample Station	Date '79	Total Coliform/100ml	Fecal Coliform/100ml	Fecal Streptococci/100ml
S9	May 30	420	93	37
	May 31	540	210	85
	June 01	610	160	90
S10	June 01	1100	1400	80
	June 06	1700	400	1200
	June 07	690	730	320
	June 08	650	400	400
S11	May 30	60	19	35
	May 31	102	14	47
	June 01	310	5	33
S12	May 31	410	20	27
	June 04	210	4	12
	June 06	350	L10	240
S13	May 31	60	9	46
	June 06	79	80	410
	June 08	48	30	118
S14	May 31	50	2	17
	June 01	120	3	13
	June 06	50	L10	80
	June 08	121	0	56
S15	June 11	2700	790	6500
	June 12	4700	1120	61000
	June 13	750	410	1300
	June 19	2100	990	3100
S16	May 31	110	L10	30
	June 01	200	170	130
	June 08	550	170	160
	June 18	1010	43	330
	June 19	330	30	290

APPENDIX VI (Cont'd) DAILY BACTERIOLOGICAL RESULTS FOR FRESHWATER SAMPLE STATIONS PARKSVILLE - QUALICUM

Sample Station	Date '79	Total Coliform/100ml	Fecal Coliform/100ml	Fecal Streptococci/100ml
S17	May 30	670	13	4
	June 08	80	24	12
	June 11	62	13	6
S18	June 11	1230	240	110
	June 12	G800	70	130
S19	June 11	900	140	48
	June 12	1290	260	43
	June 13	870	120	39
S20	June 14	13700	780	64
	June 15	1260	120	140
	June 18	3900	180	270
S21	May 30	250	23	180
	June 11	310	170	200
	June 12	2190	42	1330
S22	June 11	82	44	42
	June 12	1500	119	71
	June 13	90	22	54
S23	May 30	240	10	14
	June 11	70	25	25
	June 12	370	3	48
Upstream Samples				
S6A	June 01	35	0	29
S10A	June 07	720	520	670
	June 08	--	870	690
	June 13	530	350	320

APPENDIX VI (Cont'd) DAILY BACTERIOLOGICAL RESULTS FOR FRESHWATER SAMPLE STATIONS PARKSVILLE - QUALICUM

Sample Station	Date '79	Total Coliform/100ml	Fecal Coliform/100ml	Fecal Streptococci/100ml
S15A	June 15	1280	86	21
	June 19	G800	320	360
S16A	June 15	1000	230	700
S16B	June 15	2400	130	10000
	June 18	900	90	L10
S18A	May 30	1200	40	42
	June 11	1110	140	200
	June 12	910	610	230
	June 18	420	90	170

APPENDIX VII

DAILY BACTERIOLOGICAL RESULTS FOR MISCELLANEOUS SAMPLE STATIONS

APPENDIX VII DAILY BACTERIOLOGICAL RESULTS FOR MISCELLANEOUS SAMPLE STATIONS

Sample Station	Sal. %	Date '79	Total Coliform/100ml	Fecal Coliform/100ml	Fecal Streptococci/ 100 ml
Groundwater Samples					
GW1	-	June 06	100	500	130
GW2	7	June 07	9	14	6
GW3	1	June 07	L10	L10	L10
GW4	2	June 07	9	8	19
GW5	2	June 07	30	44	173
		June 13	150	4	19
GW6	17	June 07	30	10	6
GW7	16	June 07	0	4	0
GW8	2	June 19	4800	330	220
Ditch Samples					
D1		June 15	900	260	800
D2		June 15	230	30	200
D3		June 15	90	3	58
D4		June 15	6000	L100	700
Sediment Samples					
Sed1		June 18		L20	
Sed2		June 18		330	
Sed3		June 18		L20	
Sed4		June 15		20	
Sed5		June 15		L20	
Sed6		June 15		20	
Sed7		June 15		50	
Sed8		June 15		L20	
Sed9		June 14		40	
Sed10		June 14		L20	
Sed11		June 14		20	

APPENDIX VII DAILY BACTERIOLOGICAL RESULTS FOR MISCELLANEOUS SAMPLE STATIONS (Cont'd)

Sample Station	Sal. %	Date '79	Fecal Coliform/100ml
Sed12		June 14	L20
Sed13		June 14	L20
Sed14		June 14	L20
Sed15		June 14	L20
Sed16		June 14	80
Sed17		June 14	L20
Sed18		June 18	20
Sed19		June 18	L20
Sed20		June 14	L20
Tidal Pool Samples			
TP1		June 19	130
TP2		June 18	23
		June 19	79
TP3		June 18	17
		June 19	350
TP4		June 18	23
		June 19	79
TP5		June 18	23

APPENDIX VIII

SUMMARY OF SALINITY DATA FOR MARINE SAMPLE STATIONS

APPENDIX VIII SUMMARY OF SALINITY DATA FOR MARINE SAMPLE STATIONS

Sample Station	No. of Samples	Salinity Range 0/00	Mean Salinity	Sample Station	No. of Samples	Salinity Range 0/00	Mean Salinity
1	6	27.5 - 29.5	28.5	20	8	26.0 - 29.0	27.9
2	6	28.0 - 29.5	28.5	21	10	25.0 - 29.0	27.9
3	8	22.0 - 30.0	28.1	22	3	25.0 - 29.0	27.3
4	6	21.0 - 29.5	27.5	23	3	25.0 - 29.0	27.3
5	6	22.0 - 30.0	27.8	24	10	25.0 - 29.0	27.9
6	6	22.0 - 30.0	27.8	25	10	25.0 - 30.0	28.2
7	6	26.0 - 30.0	28.5	26	3	25.0 - 28.5	27.3
8	6	25.0 - 30.0	28.3	27	3	25.0 - 30.0	27.7
9	7	26.5 - 30.0	29.1	28	8	27.5 - 30.0	28.8
10	8	28.0 - 30.5	29.3	29	9	25.0 - 29.0	28.0
11	6	28.0 - 30.0	29.2	30	3	25.0 - 28.0	27.0
12	8	28.0 - 30.0	29.4	31	3	25.0 - 29.0	27.3
13	6	28.0 - 30.0	28.8	32	7	28.0 - 29.0	28.3
14	7	24.0 - 28.0	26.1	33	7	28.0 - 29.0	28.4
15	10	15.5 - 29.0	25.3	34	7	28.0 - 29.0	28.4
16	10	24.0 - 29.0	26.7	35	7	28.0 - 29.0	28.6
17	8	26.5 - 28.5	27.9	36	7	28.0 - 29.0	28.3
18	8	27.0 - 29.0	28.0	37	7	26.5 - 29.0	28.3
19	10	25.0 - 29.0	27.4	38	7	27.0 - 29.0	28.1

APPENDIX VIII SUMMARY OF SALINITY DATA FOR MARINE SAMPLE STATIONS (Cont'd)

Sample Station	No. of Samples	Salinity Range 0/00	Mean Salinity	Sample Station	No. of Samples	Salinity Range 0/00	Mean Salinity
39	7	26.0 - 29.0	28.1	58	6	27.0 - 28.5	27.8
40	6	26.0 - 30.0	28.7	59	6	27.0 - 29.0	28.0
41	6	26.0 - 30.0	28.5	60	6	27.0 - 28.5	27.6
42	6	26.0 - 29.5	28.5	61	6	27.0 - 29.0	28.1
43	6	24.5 - 30.0	28.5	62	6	27.0 - 29.0	28.0
44	6	25.0 - 29.5	27.7	63	6	26.0 - 29.0	27.8
45	6	25.0 - 29.0	27.5	64	6	26.0 - 30.0	27.8
46	6	25.0 - 29.0	27.3	65	6	26.5 - 30.0	27.8
47	6	24.5 - 29.0	27.3	66	6	26.0 - 29.0	27.8
48	6	24.5 - 29.0	27.0	67	6	26.0 - 29.0	27.7
49	6	24.0 - 29.0	27.8	68	6	26.0 - 30.0	28.0
50	6	24.0 - 29.0	27.7	69	6	26.0 - 30.0	27.7
51	6	27.0 - 29.0	28.0	70	5	22.0 - 28.0	26.0
52	6	27.5 - 30.0	28.1	71	6	22.0 - 29.0	26.7
53	6	26.0 - 28.0	27.6	72	6	22.0 - 29.0	26.8
54	6	27.0 - 28.5	27.8	73	6	23.0 - 29.0	27.3
55	6	27.0 - 28.0	27.8	74	6	25.5 - 29.0	27.0
56	6	26.5 - 29.0	27.8	75	6	12.0 - 26.0	21.2
57	6	28.0 - 28.5	28.1	76	6	4.0 - 20.0	8.8

APPENDIX VIII SUMMARY OF SALINITY DATA FOR MARINE SAMPLE STATIONS (Cont'd)

Sample Station	No. of Samples	Salinity Range 0/00	Mean Salinity	Sample Station	No. of Samples	Salinity Range 0/00	Mean Salinity
77	5	10.0 - 28.0	20.6	86	5	26.0 - 28.0	27.2
78	5	14.0 - 28.0	20.4	87	5	26.0 - 28.0	27.2
79	5	22.0 - 28.0	25.0	88	5	26.0 - 28.0	27.2
80	5	24.0 - 28.0	25.8	89	4	26.2 - 28.0	27.4
81	5	25.0 - 28.0	26.4	90	5	26.0 - 28.0	26.6
82	5	26.0 - 28.0	26.6	91	5	26.0 - 28.0	26.6
83	5	25.5 - 28.0	26.4	92	5	26.0 - 29.0	26.8
84	5	26.0 - 28.0	26.8	93	5	25.0 - 28.0	26.6
85	5	26.0 - 28.0	27.4				

APPENDIX IX

SHELLFISH GROWING WATER SANITARY SURVEY OF THE FORESHORE ADJACENT TO THE FRENCH CREEK WPCC

By

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K. WILE
B. KAY
J. WILLIAMS

September 18-24, 1978

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1.0 INTRODUCTION

From September 18-24, 1978, staff of the Environmental Protection Service conducted a shellfish growing water quality survey of the foreshore adjacent to the Nanaimo Regional District's sewage treatment plant outfall at French Creek. The purpose of this sampling program was to:

1. re-assess the Schedule I closure 14-8. "The waters and tidal foreshore lying within a 3500 foot radius of French Creek," which was originally established to prohibit harvesting of shellfish which may be contaminated by raw sewage discharged during the construction of the French Creek WPCC.
2. evaluate the effects of non-chlorination at the French Creek WPCC on the foreshore water quality and thereby determine the need for chlorination at the WPCC.
3. evaluate the operation of the French Creek WPCC (results are presented in Appendix XI of EPS Regional Report 79-22).
4. conduct a sanitary survey of the foreshore and upland areas.

Prior to our study, the French Creek WPCC final effluent was chlorinated. In order to facilitate our survey, it was agreed by all pollution control agencies that there would be no chlorination during the time of our study.

2.0 RESULTS

2.1 Marine Sampling Results

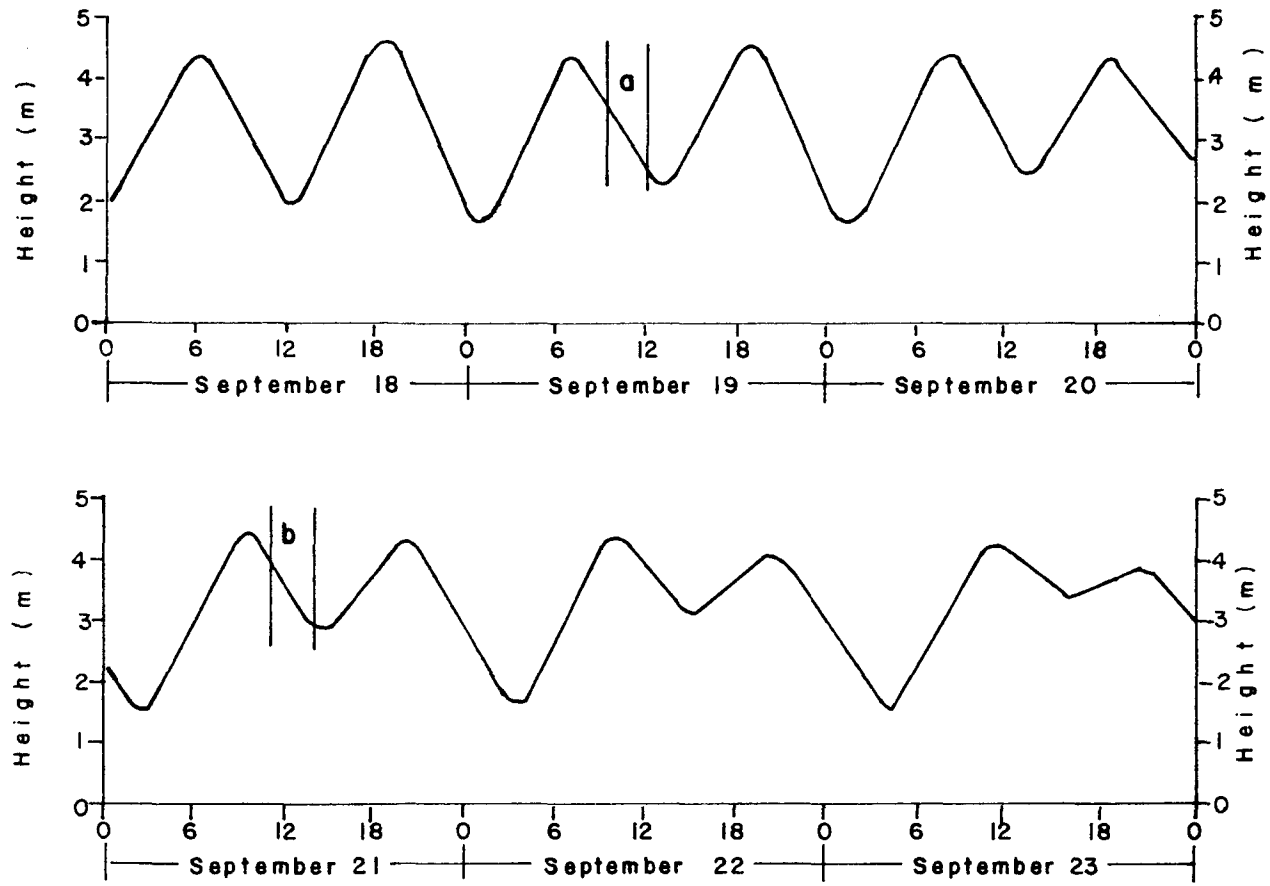
There was a moderate amount of precipitation encountered during this survey as shown in Table 1 and the winds were generally variable. Tidal conditions noted during the study are shown in Figure 1.

Float studies conducted by Dayton and Knight (1) as part of their oceanographic investigation of the Nanaimo Regional District's Northern Coastline indicate that the usual water movement is westerly on an ebbing tide and easterly on a rising tide, although winds strongly affected the float movement.

On September 19 and 21 sampling at stations 1 and 2 were conducted on falling tides ("a" and "b" Figure 3) while the prevailing wind was easterly.

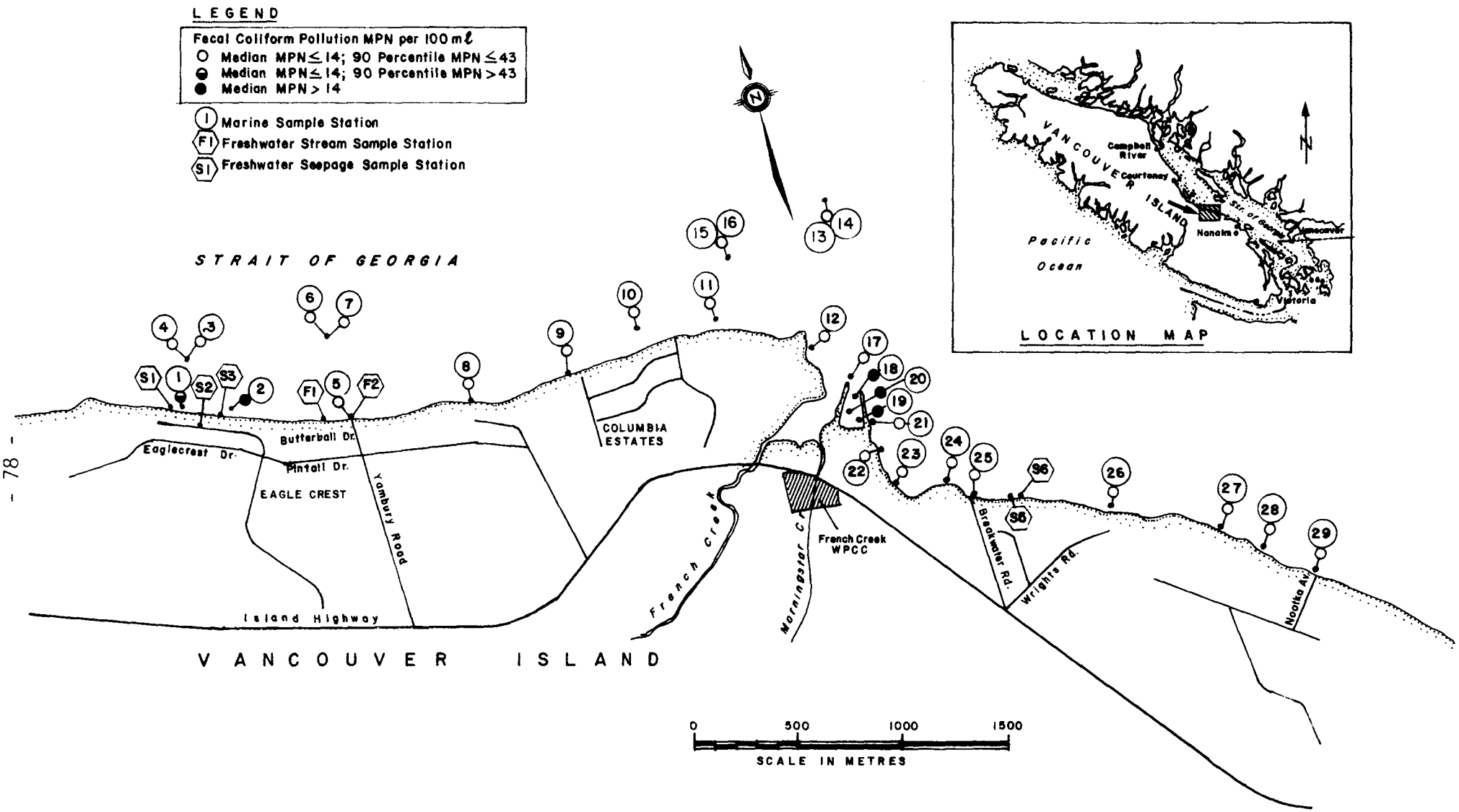
It is rather difficult to predict the movement of the French Creek WPCC effluent plume on September 19 and 21 based on the results of the Dayton and Knight float studies, since few of the studies were conducted during easterly winds and ebbing tides. Floats dropped on July 31, 1973 (Figure 3) under an ebbing tide and somewhat easterly wind conditions indicate that the effluent plume moved to the east or away from Eagle Crest subdivision. Floats dropped on July 23, 1973 (Figure 4) under a rising then ebbing tide and easterly wind conditions indicate that the effluent plume moved to the west towards Eagle Crest subdivision. In neither study did floats come ashore. Bacteriological sampling of the foreshore is also conducted monthly by the Nanaimo Regional District as a requirement of their PCB permit (Figure 5). A summary of these results is found in Table 4 and indicates that, even prior to the discharge of treated sewage, the shellfish water quality was acceptable in those foreshore areas tested. Even sampling directly over the outfall yielded negative results on most occasions. The Regional District results were obtained using the membrane filtration technique rather than the MPN technique, thus the interpretation of the data using medians and 90 percentiles is not statistically valid. Nevertheless, the fecal coliform levels at all stations were low enough to meet the shellfish growing water standard.

(1) Nanaimo Regional District Sewer Authority Oceanographic Investigation Nanaimo Regional District - Northern Coastline by Dayton & Knight November 2, 1973



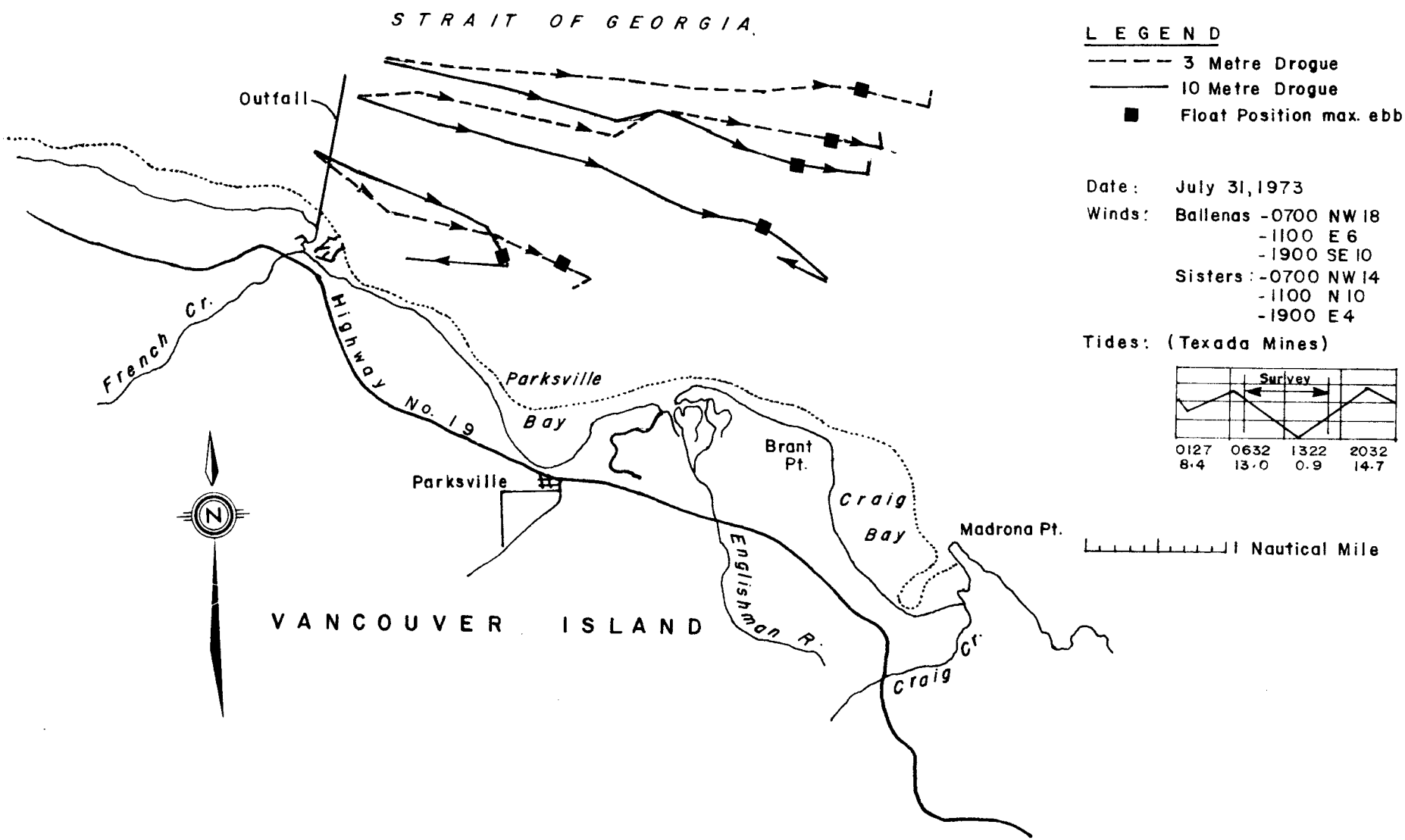
APPENDIX IX

FIGURE 1 TIDES DURING SAMPLING PERIOD September 18 - 23, 1978 AT NORTHWEST BAY.



APPENDIX IX

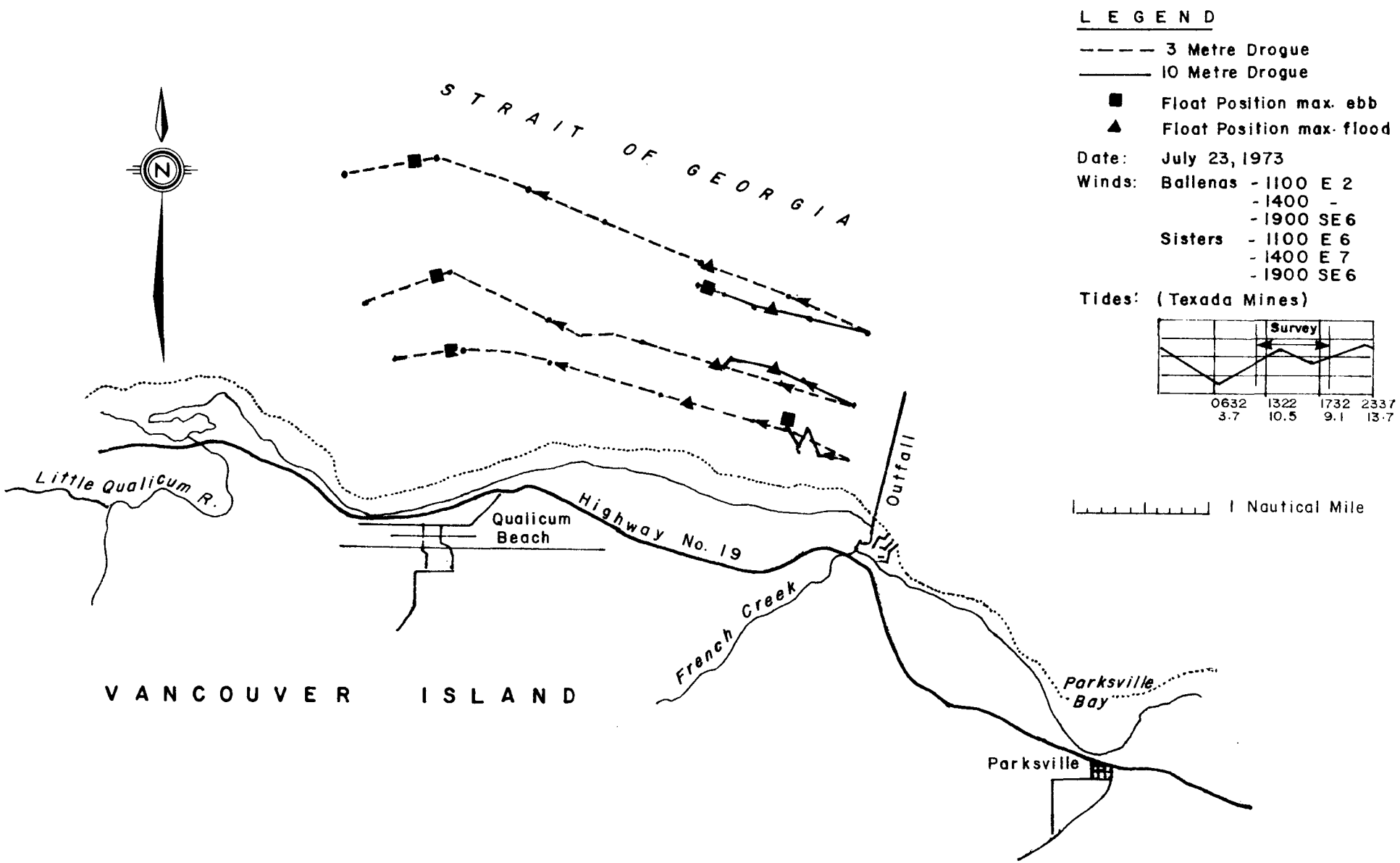
FIGURE 2 FRENCH CREEK MARINE AND FRESHWATER SAMPLE STATION LOCATIONS - September, 1978



APPENDIX IX

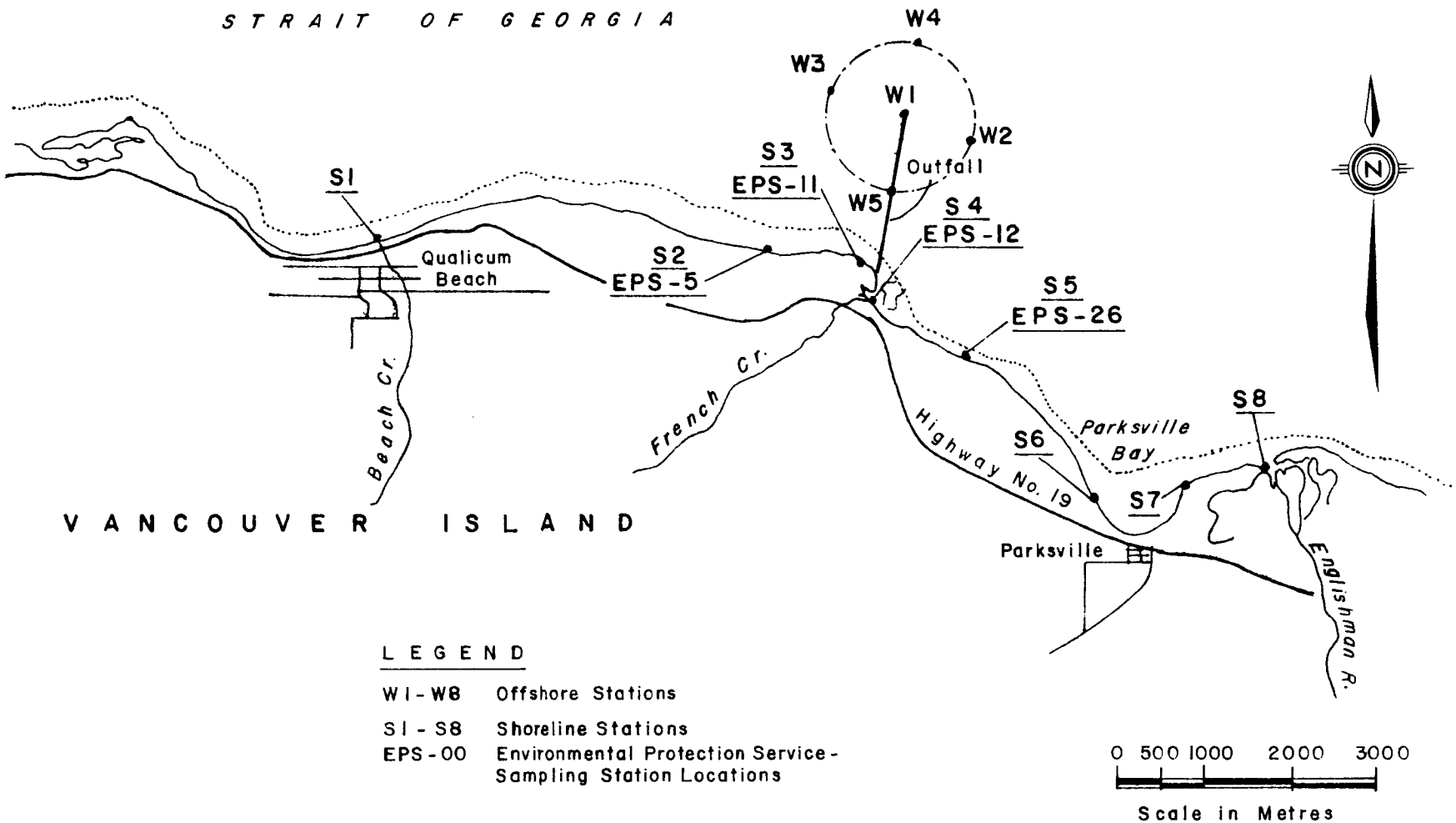
FIGURE 3 FLOAT STUDIES CONDUCTED BY Dayton and Knight, July 31, 1973

(By Permission of the Regional District of Nanaimo)



APPENDIX IX

FIGURE 4 FLOAT STUDIES CONDUCTED BY Dayton and Knight, July 23, 1973
(By Permission of the Regional District of Nanaimo)



APPENDIX IX

FIGURE 5 REGIONAL DISTRICT OF NANAIMO RECEIVING WATER MONITORING PROGRAM - SAMPLE STATION LOCATIONS (Pollution Control Branch Permit PE-4200)

It should be noted that the foreshore samples were not normally collected by the Regional District during the worst hydrographic and pollution conditions, i.e. strong shoreward winds. However, the quiescent conditions were perhaps the worst hydrographic conditions in terms of evaluating the effect of the outfall since there was limited disturbance of the surface waters.

At the time of this sampling, the breakwater around the French Creek boat basin was being extended, resulting in the disturbance of bottom sediments. The contamination noted at sample stations in the boat basin may be due in part to this bottom disruption. Station 18 was located closest to the construction area and samples from this station exhibited the greatest contamination. Samples collected at Station 17, which was outside the boat basin near the breakwater, exhibited some contamination, but results met the growing water standard.

2.2 Freshwater Sampling Results

A total of 14 freshwater sample stations for bacteriological analysis were established. Five of the stations (F1, F2, F3, F4 and STP) had measureable flows. The remaining stations (S1 to S6) were classified as seepage inputs. A detailed description of the freshwater sample stations is presented in Table 5. In addition to the water samples, two sediment samples were collected in the vicinity of stations S1 and S3.

A summary of results from bacteriological sampling at the fourteen freshwater stations is presented in Table 6. Daily data is presented in Table 8. The data indicates that the most significant contribution of fecal contamination was the French Creek Water Pollution Control Centre (STP). This source accounted for 99 percent of the total fecal contamination from identified sources entering the study area. The remaining one percent was primarily from French Creek (F3) (due to its large flow rather than high fecal coliform levels.)

Membrane filtration fecal streptococci analyses were performed on all freshwater samples in an attempt to determine the origin of fecal contamination observed in the freshwater inputs.

Samples collected from F1, F3, S3, S3A, S3C, S4 and S5 exhibited FC:FS ratios ranging from 0.22 to 0.66. However, the bacterial levels are low in all cases, except S4, consequently little interpretive value can be placed on the FC:FS ratio.

In regard to S4, the FC:FS ratio was determined from only one fecal streptococci value and two fecal coliform results, thus the value of the ratio is questionable. Since S4 is in a suburb residential area and the volume of the seepage was low, it is likely that the high fecal levels (7,800/100ml) are due to seepage from a nearby septic tank. In any case, the seepage did not reach the foreshore and marine water quality in the vicinity was acceptable.

Station S1, S2 and S3 exhibited fecal levels of 800, 310 and 205/100ml respectively. However, due to limited sampling the FC:FS ratios are inconclusive. Both S1 and S3 are streams which flow between homes located on Sea Crest Place. An inspection of the area revealed that the homes in the vicinity utilized septic tanks. A sample of the sediment at Station S3A exhibited a fecal level of 2400/100gm suggesting the presence of sub-surface septic tank seepage. Station S2 is a ditch which runs along Sea Crest Place and collects both surface run-off and groundwater from the Eagle Crest housing development.

The population equivalents of the freshwater inputs were calculated for stations F1, F2, F3, F4 and the STP, and the results are shown in Table 6.

Station F2, which was drainage from the basement of a home located on lot #2 just east of Yambury Road exhibited an average fecal coliform level of 70/100ml. A neighbour reported that there is a problem with groundwater seeping into the basement. Consequently, the owner had installed a sump with an automatic pump. Based on the population equivalent, this is not a significant source of fecal contamination.

In addition, a sample of well water from an adjacent house revealed no fecal contamination.

In an attempt to determine the source of fecal contamination in the Eagle Crest area, a dye test was conducted on three septic tank systems on Sea Crest Place. No discharge of dye was observed, and these tanks at least, appeared to be operating properly.

3.0 CONCLUSIONS AND OBSERVATIONS

1. The tidal foreshore adjacent to Eagle Crest subdivision to Yambury Road is contaminated to the extent that consumption of shellfish from this area may constitute a health hazard to the consumer.

2. The waters within the French Creek boat basin are contaminated, however, the pollution does not seem to extend beyond the basin waters.

3. The contamination noted in the foreshore adjacent to Eagle Crest subdivision would not appear to be due to the effluent discharged from the French Creek WPCC but rather to onshore faulty septic tank operation an seepage. This conclusion is based on:

   (a) the presence of fecal coliform-contaminated sediment along the foreshore suggesting the present subsurface septic seepage

   (b) improving marine quality with increasing distance from shore

   (c) the oceanographic data obtained by Dayton and Knight in 1973

   (d) the low fecal coliform levels obtained at the Regional District outfall sampling stations both during the discharge of raw sewage and treated sewage

APPENDIX IX TABLE 1
WEATHER CONDITIONS ENCOUNTERED DURING STUDY

DATE	PRECIPITATION (mm)	CALM	WIND DIRECTION* (% STATIONS RECORDED AT DIRECTION) NORTH	WEST	SOUTH	EAST
Sept. 18	-					
19	tr.	5		5%(7)**	5 (6)	85 (10)
20	-					100 (15)
21	0.1					100 (12)
22	8.7	33	25 (3)	17 (2)		25 (2)
23	2.0	12	4 (1)	84 (2)		
24	tr.			100 (1)		

* as measured at Northwest Bay - Nanoose (courtesy of MacMillan Bloedel)

** mean velocity mi/hr.

APPENDIX IX TABLE 2
MARINE SAMPLE STATION LOCATIONS

SAMPLE STATION	DESCRIPTION
1	Sea Crest Place - down access to right off white house with brown trim being built (yellow & white trailer beside it).
2	Sea Crest Place - off access to right of brown barn-like house with white balcony and t.v. aerial.
3	Heading of 245° from point of land west of Station #1.
4	Same as #3 except sampled at 2.5 cm depth.
	Off foot of Yambury Avenue - Nanaimo Regional District Marine Sample Station #S2.
6	Off Station #5 at heading of 245° from point of land west of Station #1 (2.5 cm depth sample).
7	Same as #6 at normal sampling depth.
8	Off beach access at eastern entrance to Longacres Farm (Mallard Road).
9	Foot of Dalmation Drive.
10	Off lot #12 (East of round house) - Columbia Beach Estates.
11	Nanaimo Regional District Marine Sampling Station S3.
12	Off beach just west of French Creek Boat Basin.
13	Outfall Point #1 - East of Station #12 in line with west point of breakwater.
14	Same as #13 - 2.5 cm sampling depth.
15	Outfall Point #2 - 40° leading from beach just off west of breakwater.
16	Same as #15 - 2.5 cm sampling depth.
17	Off west point of French Creek Boat Basin breakwater.
18	Off Float #5 at boat basin.

APPENDIX IX TABLE 2
MARINE SAMPLE STATION LOCATIONS (Cont'd)

SAMPLE STATION	DESCRIPTION
19	Mid-way between Float #1 and tide-marker at boat basin.
20	Off east side of mouth of boat basin.
21	Off east of breakwater - where breakwater joins land.
22	Off yellow house at head of bay east of boat basin.
23	Off small shed in front of Camelot Motel.
24	Bearing 157° off east head of French Creek Marina.
25	Off foot of Breakwater Road.
26	Off house with flagpole on beach east of stairs.
27	Off new house on cliff with big rock below (just outside closure).
28	Off large rock cliff east of Station #27.

APPENDIX IX TABLE 3
SUMMARY OF BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS

SAMPLE STATION	NO. OF SAMPLES	MPN RANGE	FECAL MPN/100ml MEDIAN	90TH PERCENTILE
1	6	2 - 110	11	86
2	6	5 - 70	35.5	57.4
3	2	2 - 5	3.5	-
4	2	L2 - 6	3	-
5	6	2 - 33	11	27.0
6	2	L2 - 2	L2	-
7	2	L2	L2	-
8	6	2 - 33	8	18.8
9	6	L2 - 13	5	7.6
10	6	L2 - 5	5	7.6
11	6	L2 - 8	6.5	8
12	6	2 - 8	2	8
13	3	L2 - 2	L2	-
14	2	L2 - 2	L2	-
15	3	L2 - 5	L2	-
16	2	L2 - 7	3.5	-
17	6	L2 - 33	5	31.4
18	4	33 - 350	104.5	328.0
19	4	5 - 110	28.0	79.2
20	4	11 - 79	35.5	67.0
21	5	L2 - 2	L2	2
22	6	L2 - 13	2	8.2
23	6	L2 - 5	L2	5
24	6	L2 - 2	2	2
25	6	L2 - 5	2.5	5
26	6	L2 - 13	L2	8.2
27	6	L2 - 13	L2	6.4
28	6	L2 - 5	2	3.2

APPENDIX IX

TABLE 4
SUMMARY OF NANAIMO REGIONAL DISTRICT BACTERIOLOGICAL DATA (FECAL)

DATE	Foreshore Numbers (EPS Numbers) 5	11	12	26	Outfall Stations W1(5)	W1(10)	W2(5)	W2(10)	W3(5)	W3(10)	W4(5)	W4(10)	W5(5)	W5(10)
Oct. 08/76					0	0	1	0	0	0	0	0	0	1
Nov. 02/76					2	0	0	0	0	3	0	0	0	0
Jan. 06/77					0	0	0	0	0	0	0	0	0	0
Feb. 17/77					2	0	0	0	3	1	6	3	6	3
Mar. 25/77					0*	0*	0*	0*	0*	0*	0*	0*	0*	1*
Apr. 07/77					0*	0*	0*	0*	0*	0*	0*	0*	0*	0*
June 02/77					0*	0*	1*	0*	0*	0*	0*	0*	0*	0*
July 22/77	0	17	0	10	0*	0*	0*	0*	0*	0*	0*	0*	1*	-
Aug. 17/77	14	13	11	0	0*	0*	0*	1*	1*	0*	0*	0*	0*	1*
Sep. 09/77	0	0	2	0	0*	0*	0*	0*	0*	0*	0*	0*	0*	1*
Oct. 31/77	0	0	25	0	5*	0*	1*	0*	0*	0*	0*	0*	0*	0*
PRE-DISCHARGE														
Median	0	6.5	4.5	0	0	0	0	0	0	0	0	0	0	0
90 pct	8.4	15.4	19.4	6	2	0	1	L1	2.7	2.7	0	0	5.4	1
POST-DISCHARGE (RAW)														
Dec. 21/77	3	9	0	1	0	5	1	0	1	18	3	9	7	3
Jan. 28/78	1	1	42	0	0*	0*	0*	1*	1*	0*	0*	1*	0*	0*
Mar. 02/78	0	0	7	0	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+

* Collected at 5 & 30 metres
\+ Collected at 5 & 20 metres
L= less than

APPENDIX IX TABLE 4 (Cont'd)
SUMMARY OF NANAIMO REGIONAL DISTRICT BACTERIOLOGICAL DATA (FECAL)

DATE	Foreshore Numbers (EPS Numbers) 5	11	12	26	Outfall Stations W1(5)	W1(10)	W2(5)	W2(10)	W3(5)	W3(10)	W4(5)	W4(10)	W5(5)	W5(10)
Mar. 31/78	19	59	14	17	7*	4*	4*	1*	8*	3*	1*	0*	4*	1*
Apr. 29/78	0	(TNTC)												
		(80)	19	2	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*
June 03/78	0	1	8	0	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*
June 25/78	0	0	5	3	0*	0*	0*	0*	0*	0*	1*	0*	0*	0*
					(PARKSVILLE HOOKED IN, PLANT OPERATING)									
July 14/78					0*	0*	0*	0*	0*	0*	0*	0*	0*	0*
Aug. 10/78					0*	0*	0*	0*	0*	0*	0*	0*	0*	0*
Health Unit (MPN)														
July 19/78	4	9	15	23										
Aug. 30/78	4	9	15	3										
Median	1	5	14	1	0	0	0	0	0	0	0	0	0	0
90 Pct	4.5	19	21.3	17.6	.7	4.1	1.3	1	1.7	L4	1.2	1.8	4.3	1.2

APPENDIX IX TABLE 5
FRESHWATER SAMPLE STATION LOCATION DESCRIPTIONS

Sample Station	Description
	Major Freshwater Inputs
F1	Stormwater stream at Yambury Road.
F2	Drainage pipe (2") near Yambury Road.
F3	French Creek, 500 feet upstream from Island Highway.
F4	Storm run-off discharge from French Creek WPCC.
STP	Final effluent from French Creek WPCC.
	Seepage Inputs
S1	Seepage stream between lots #4 and #5 on Sea Crest Place
S2	Drainage ditch on Sea Crest Place.
S3	Seepage stream between lots #12 and #13 on Sea Crest Place.
S3A	Foreshore pool (freshwater) adjacent to S1.
S3B	Foreshore pool (freshwater) adjacent to lot #8.
S3C	Foreshore pool (freshwater) adjacent to S3.
S4	Seepage stream at the foot of Breakwater Road.
S5	Groundwater seepage at the beach at the foot of Glendale Crescent.
S6	Seepage stream on the shore rocks just east of the foot of Glendale Crescent.

APPENDIX IX TABLE 6

SUMMARY OF BACTERIOLOGICAL RESULTS FOR FRESHWATER SAMPLE STATIONS

SAMPLE STATION	NO. OF SAMPLES	TOTAL COLIFORMS (COUNTS/100ml)		FECAL COLIFORMS (COUNTS/100ml)		STREPTOCOCCI (COUNTS/100ml)	FECAL FC:FS	FLOW (m^3/day)	POPULATION EQUIVALENT
		RANGE	MEAN	RANGE	MEAN				
F1	3	400-4700	2700	6-470	180	595(2)	0.30	6.8	3.8×10^{-4}
F2	3	330-980	550	10-130	70(2)	2(2)	35	17	3.7×10^{-4}
F3	3	50-1330	480	6-14	10	38(2)	0.26	2.5×10^4	0.078
F4	3	45-240	140	0	0	1(2)	0	15	0
STP	3	1.8×10^5-1.6×10^6	6.9×10^5	4.0×10^4-5.4×10^5	2.2×10^5	3.2×10^4(2)	6.9	1.5×10^3	100
S1	1	7600	7600	800	-	300(1)	2.7	-	-
S2	1	7000	7000	310		200(1)	1.6	-	-
S3	2	6800-18,000	12,400(2)	200-210	205(2)	455(2)	0.45	-	-
S3A	1	-	-	20	20	40(11)	0.50	-	-
Sediment	1			2400					
S3B	1	220	220	0	0	0	0	-	-
Sediment	1			50	50				
S3C	1	480	480	60	60	200(1)	0.30	-	-
S4	2	51,400-90000	70,700(2)	660-15,100	7880(2)	12,000(1)	0.66	-	-
S5	2	500-3000	1750(2)	0-30	15(2)	67(2)	0.22	-	-
S6	1	4	4	0	0	0	-	-	-

Numbers in brackets denote number of samples analysed for fecal streptococci.

APPENDIX IX

TABLE 7
DAILY BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS

Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100ml
1	Sept. 19/79	0900	70
	Sept. 20	0930	5
	Sept. 21	0940	110
	Sept. 22	0915	2
	Sept. 23	1010	17
	Sept. 24	1005	2
2	Sept. 19/79	0905	70
	Sept. 20	0935	17
	Sept. 21	0955	49
	Sept. 22	0915	5
	Sept. 23	1020	49
	Sept. 24	1010	22
3	Sept. 23/79	1015	2
	Sept. 24	1010	5
4	Sept. 23/79	1015	6
	Sept. 24	1010	L2
5	Sept. 19/79	0920	33
	Sept. 20	0940	8
	Sept. 21	1000	2
	Sept. 22	0920	14
	Sept. 23	1025	23
	Sept. 24	1015	8
6	Sept. 23/79	1025	L2
	Sept. 24	1015	2
7	Sept. 23/79	1025	L2
	Sept. 24	1015	L2
8	Sept. 19/79	0940	33
	Sept. 20	0945	7
	Sept. 21	1005	8
	Sept. 22	0940	8
	Sept. 23	1040	2
	Sept. 24	1020	8
9	Sept. 19/79	1000	7
	Sept. 20	0945	5
	Sept. 21	1015	13
	Sept. 22	0945	2
	Sept. 23	1045	L2
	Sept. 24	1030	5
10	Sept. 19/79	1010	2
	Sept. 20	0950	5
	Sept. 21	1020	2
	Sept. 22	0945	2
	Sept. 23	1045	2
	Sept. 24	1030	5

L=less than

APPENDIX IX

TABLE 7
DAILY BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS (Cont'd)

Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100ml
11	Sept. 19/79	1020	8
	Sept. 20	0955	4
	Sept. 21	1025	8
	Sept. 22	0945	8
	Sept. 23	1045	L2
	Sept. 24	1030	5
12	Sept. 19/79	1400	8
	Sept. 20	1000	2
	Sept. 21	1035	2
	Sept. 22	0950	8
	Sept. 23	1050	2
	Sept. 24	1035	2
13	Sept. 22/79	0930	2
	Sept. 23	1030	L2
	Sept. 24	1025	2
14	Sept. 23/79	1030	L2
	Sept. 24	1025	2
15	Sept. 22/79	0935	L2
	Sept. 23	1035	L2
	Sept. 24	1040	5
16	Sept. 23/79	1035	L2
	Sept. 24	1040	7
17	Sept. 19/79	1410	L2
	Sept. 20	1005	5
	Sept. 21	1300	31
	Sept. 22	1000	L2
	Sept. 23	1050	33
	Sept. 24	1040	5
18	Sept. 19/79	1500	130
	Sept. 20	1047	33
	Sept. 21	1305	350
	Sept. 22	1025	79
19	Sept. 19/79	1505	33
	Sept. 20	1050	23
	Sept. 21	1305	110
	Sept. 22	1025	5
20	Sept. 19/79	1455	49
	Sept. 20	1045	22
	Sept. 21	1300	79
	Sept. 22	1020	11
21	Sept. 19/79	1420	2
	Sept. 20	1007	L2
	Sept. 22	1005	L2
	Sept. 23	1050	L2
	Sept. 24	1045	2

L=less than

APPENDIX IX TABLE 7

DAILY BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS (Cont'd)

Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100ml	Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100ml
22	Sept. 19/79	1040	13	26	Sept. 19/79	1430	L2
	Sept. 20	1010	2		Sept. 20	1020	L2
	Sept. 21	1050	2		Sept. 21	1135	5
	Sept. 22	1040	2		Sept. 22	1010	2
	Sept. 23	1055	L2		Sept. 23	1105	L2
	Sept. 24	1045	5		Sept. 24	1055	13
23	Sept. 19/79	1045	5	27	Sept. 19/79	1440	L2
	Sept. 20	1015	2		Sept. 20	1025	L2
	Sept. 21	1055	L 2		Sept. 21	1150	L2
	Sept. 22	1040	5		Sept. 22	1015	2
	Sept. 23	1055	L 2		Sept. 23	1105	L2
	Sept. 24	1050	L 2		Sept. 24	1055	13
24	Sept. 19/79	1055	2	28	Sept. 19/79	1450	2
	Sept. 20	1015	2		Sept. 20	1035	2
	Sept. 21	1115	2		Sept. 21	1200	2
	Sept. 22	1000	2		Sept. 22	1015	L2
	Sept. 23	1100	L2		Sept. 23	1110	L2
	Sept. 24	1050	L2		Sept. 24	1100	5
25	Sept. 19/79	1135	5		L=less than		
	Sept. 20	1035	2				
	Sept. 21	1125	5				
	Sept. 22	1000	2				
	Sept. 23	1100	L2				
	Sept. 24	1055	3				

APPENDIX IX TABLE 8

BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITONS FOR FRESHWATER SAMPLE STATIONS

STATION	SAMPLE DATE	MF COUNTS/100 ml TOTAL COLIFORM	FECAL COLIFORM	FECAL STREPTOCOCCI	PRECIPITATION DAILY (m.m.)
F1	Sept. 19	400	6	480	Trace
	21	3000	64	-	0.1
	23	4700	470	710	2.0
F2	Sept. 19	340	10	1	Trace
	21	980	-	-	0.1
	23	330	130	4	2.0
F3	Sept. 19	50	11	29	Trace
	20	60	6	48	-
	21	1330	14	-	0.1
F4	Sept. 19	240	0	1	Trace
	20	45	0	0	-
	21	140	0	-	-
S1	Sept. 23	7600	800	300	2.0
S2	Sept. 23	7000	310	200	2.0
S3	Sept. 20	18000	210	520	-
	23	6800	200	390	2.0
S3A	Sept. 23		20	40	2.0
S3B	Sept. 23	220	0	0	2.0
S3C	Sept. 23	480	60	200	2.0
S4	Sept. 21	51400	15100	-	0.1
	23	90000	660	1200	2.0
S5	Sept. 20	500	0	2.7	-

APPENDIX IX TABLE 8 (Cont'd)

BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITONS FOR FRESHWATER SAMPLE STATIONS

STATION	SAMPLE DATE	MF COUNTS/100 ml TOTAL COLIFORM	FECAL COLIFORM	FECAL STREPTOCOCCI	PRECIPITATION DAILY (m.m.)
S5	Sept. 23	3000	30	132	2.0
S6	Sept. 19	4	0	3	Trace
STP	Sept. 19	280000	40000	50000	Trace
	20	180000	70000	13000	-
	21	1.6×10^6	540000	-	0.1

APPENDIX X

OPERATIONAL REPORT ON THE FRENCH CREEK WPCC

By

K.D. Ferguson

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LIST OF TABLES

LIST OF ABBREVIATIONS

ADWF	average dry weather flow
BOD_5	5 day biochemical oxygen demand
COD	chemical oxygen demand
DO	dissolved oxygen
DFO	Department of Fisheries and Oceans
EPS	Environmental Protection Service
FR	filterable residue
kg	kilograms
LAS	linear alkylate sulfonates (anionic surfactants)
m^3/day	cubic meters per day
ml	millilitres
mg/l	milligrams per litre
NFR	non-filterable residue
PCB	Pollution Control Branch
TAlk	total alkalinity
TFR	total fixed residue
TOC	total organic carbon
TPO_4	total phosphate
TR	total residue
TRC	total residual chlorine
TVR	total volatile residue
WPCC	Water Pollution Control Centre

1.0 INTRODUCTION

The French Creek WPCC is a secondary type sewage treatment plant serving the Town of Parksville, The Village of Qualicum Beach and other selected areas. The raw sewage passes through a coarse screen, curved bar screen, aerated grit chamber, two primary clarifiers, two activated sludge basins, two secondary clarifiers, and finally a chlorine mix tank before discharge (Figure 1). Waste activated sludge is returned to the primary clarifiers where it settles with the primary sludge. The mixed sludge is pumped to an aerobic digestor for digestion, thickened, and finally transferred to sludge drying beds. The design characteristics of the treatment system are summarized in Table 1 and shown in Figure 1.

Two sets of 24 hour composite samples of the French Creek WPCC unchlorinated final effluent were obtained by EPS personnel during the September 1978 shellfish growing water sanitary survey of the foreshore adjacent to the treatment system outfall. Chemical and toxicity analyses conducted on these samples revealed that the treatment system produced a high quality non-toxic effluent during the study (Table 2).

Additional samples were obtained during the shellfish growing water sanitary survey conducted in May and June of 1979 in support of the bacteriological assessment of the receiving waters and possible fecal pollution sources. Samples were also obtained as part of an ongoing EPS program to determine the acute fish toxicity of various effluents discharged to British Columbia receiving waters.

2.0 PROCEDURES AND METHODS

2.1 Chemical Sampling

Two 24 hour composite samples were obtained of the raw sewage and final effluent from 0900 June 11 to 12, and from 0900 June 18 to 19. Raw sewage composites were obtained from about 250 ml samples taken every 2.5 minutes using a Markland Model 2101-Spec. Duckbill Sampler. Final effluent samples were collected using an "Eagle" signal timer and "Little Giant" submersible pump which provided approximate 400 ml samples every 5 minutes.

Grab samples were collected of the primary effluent, primary sludge, secondary sludge and digested sludge on June 12 and June 19. A grab sample of the digestor supernatant was collected on June 12 only.

All samples were split into sample bottles and preserved as outlined in the Environment Canada Pollution Sampling Handbook (2). Samples were delivered to the DFO-EPS Laboratory in West Vancouver for chemical analyses within four hours of the completion of the 24 hour sampling period.

2.2 Bioassay Sampling

Four 5-gallon capacity plastic jerry cans were filled with the June 11-12 and June 18-19 raw sewage and final effluent composite samples. Samples were transferred to the EPS Aquatic Toxicity Laboratory in North Vancouver within four hours of the completion of the sampling period. A bioassay determination was performed on each sample and a 96 hour LC_{50} value obtained.

The 96 hour LC_{50} is defined as the concentration of measurable lethal agent (in this case wastewater) required to kill the 50th percentile in a group of test organisms over a 96 hour period. In the test, a series of 30 l glass vessels containing different sample dilutions with five rainbow trout (*Salmo gairdneri*) per vessel were placed in a controlled environment room with a maintained temperature of 15.0 $\pm$ 1°C. Samples with a pH value below 6.0 or above 8.0 are neutralized to a pH of 7; however, pH adjustment was not required for any of the samples collected.

For this study, a bioassay procedure was used whereby the sample was pre-aerated at 150 to 200 ml/minute with air for two hours if the initial dissolved oxygen level (D.O) was found to be below 5 ppm; and pre-aerated for 30 minutes if the D.O. was greater than 5 ppm. This procedure was followed so that D.O. would not be a factor in sample toxicity while air stripping of the sample's chemical constituents would be minimized. All samples, except the June 11-12 raw sewage sample, had an initial D.O. concentration above 7.0 and were aerated for only 30 minutes. The June 11-12 raw sewage sample was aerated for 2 hours.

3.0 RESULTS

3.1 Chemical Analyses Results

Results of chemical analyses of raw sewage samples (Table 3) indicated that the French Creek WPCC influent may be characterized as weak to medium strength. Constituents which were present at "strong" levels included FR and TALK. Oil and Grease levels were particularly high on the June 18-19 sampling, possibly as a result of septic tank truck discharge to the system although no other parameters showed elevated concentrations. Both BOD_5 and NFR concentrations were typical of weak strength raw sewage.

Efficiently designed and operated primary sedimentation tanks should remove 50 to 65% of the NFR and 25 to 40% of the BOD_5 (3). The French Creek WPCC tanks achieved 59% NFR and 26% BOD_5 removal and, therefore, met this criteria. Relatively high removal efficiencies were also achieved for COD (43%), TVR (36%) and LAS (36%) (Table 4).

The entire treatment system achieved high pollutant removal for virtually all parameters except TR, TFR and TPO_4. BOD_5 and NFR removals were 81 and 90% respectively. The final effluent BOD_5 and NFR concentrations were an average of 20 and 13 mg/l respectively. These results met the PCB permit requirements of 45 mg/l BOD_5 and 60 mg/l NFR.

Results of the September 1978 sampling (Table 2) were comparable to results obtained during this survey. Somewhat greater nitrification was noted in the September study (1.98 mg/l NH_3 and 17.0 mg/l NO_3) compared to this most recent sampling (9.54 mg/l NH_3 and 10.0 mg/l NO_3).

The control of a biological waste stabilization system is usually based upon unit process parameters. Although recommended values are given in the literature, operators may adjust the system outside these ranges if treatment performance is increased.

Six important unit process parameters include:

θ_c - mean cell residence time

U - food/micro-organisms ratio

VL - volumetric loading

t - hydraulic retention time

R - recirculation ratio

MLVSS - aeration tank mixed liquor volatile suspended solids concentration

The equations used in the calculation of these parameters, the recommended values for a conventional activated sludge system and extended aeration system, and the values calculated for the French Creek WPCC are shown in Table 5. The values presented for the French Creek WPCC are based on data provided by the treatment plant operator (6) and analytical results of samples obtained during this study. Since only two samples each were obtained of the crude sludge, waste activated sludge and influent, the calculations (θ_c and U) involving these data are only approximate. Generally, a detailed sampling program is required to determine the θ_c and U values accurately.

Both θ_c and U values for the French Creek WPCC are somewhat lower than those recommended, but given the high effluent quality noted during this survey, the system appears to work well at these levels. The hydraulic detention time of 22 hours is well above the recommended level of 4-8 hours and the design value of 6 hours due to the low average dry weather flow. The volumetric loading rate is below the recommended values due to the low flow and low influent BOD_5 concentration.

Nitrification. Nitrification is achieved by a special group of aerobic organisms or "nitrifiers". The nitrifiers include *Nitrosomonas* which convert NH_3 to NO_2 while *Nitrobacter* convert NO_2 to NO_3. The nitrifiers are temperature and pH sensitive and have a lower growth rate than the heterotrophic aerobes which oxidize carbonaceous material (7). The minimum mean cell residence time required for nitrification is related to the reciprocal of the *Nitrosomonas* growth rate by the following equations (8).

$$\theta_c = 1/\dot{\mu}_N$$

and,

$$\dot{\mu}_N = \hat{\mu}_N \left(\frac{DO}{(KO_2 + DO)}\right) (1-0.833(7.2-pH))^*$$

and,

$$\hat{\mu}_N = 0.47\, e^{0.098\,(T-15)}$$

where: $\dot{\mu}_N$ = maximum possible nitrifier growth rate under given conditions.

$\hat{\mu}_N$ = maximum nitrifier growth rate

KO_2 = half saturation constant for oxygen approx. 1.3

DO, pH and T = aeration section dissolved oxygen concentration pH, and temperature respectively

Data collected by the operator of the French Creek WPCC during June 1979 indicate that the aeration tank DO and temperature was 1.3 mg/l and 16°C respectively, while the primary effluent had a pH of 7.4 as determined by grab sampling. Using this data and the equations given above. The minimum mean cell residence time required for nitrification was 3.9 days. Under these conditions the final effluent NH_3 concentration may be determined by:

$$N_1 = \frac{\mu_N \times K_N}{\dot{\mu} - \mu_N}$$

$$K_N = 10^{0.051T - 1.158}$$

where: N_1 = final effluent NH_3 concentration

K_N = half-saturation constant for NH_3-N

* the term (1-0.833(7.2-pH)) is 1.0 for pH greater than 7.2

In the case of the French Creek WPCC with a θ_c of 4.2 days the final effluent NH_3 concentration should be about 5.2 mg/l. This agrees fairly well with the actual value of 9.5 mg/l determined in this study, particularly in light of the possible inaccuracy as noted previously, in the observed θ_c value. The final effluent NH_3 concentration may be calculated for other θ_c values and these are shown in Table 6. These results show that a relatively small increase in θ_c would likely result in a large decrease in the final effluent NH_3 concentration. A decrease in temperature, DO or pH from those observed during this June sampling would result in a larger θ_c required for nitrification.

Metals. Composite samples of the raw sewage, primary effluent and secondary effluent and grab samples of the crude sludge (primary and secondary), secondary sludge, digested sludge, and digestor supernatant were analysed for total metals (Table 7). Relatively low total metal levels were found in the raw sewage and primary effluent compared to other effluents in the U.S. (Table 8). All final effluent total metal concentrations were relatively low. Percent metal removals were high for Al (78%), Ba (97%), Cu (84%), Fe (81%), and Mn (89%) (Table 9). All detectable total metals were concentrated in the sludges compared to the raw sewage concentrations. Parameters with comparably high concentration factors included Al, Cu and Fe.

3.2 Bioassay Results

A study of municipal wastewater toxicity of eight sewage treatment plants was conducted by personnel of the Environmental Protection Service during 1976 and the results appear in EPS published reports by T.W. Higgs (10). In that study, three chemical parameters were regularly noted to be responsible for acute toxicity to the test fish. These were anionic surfactants, un-ionized NH_3 and TRC.

Critical concentrations of these parameters reported in the literature are shown in Table 10. A detailed discussion of the subject is beyond the scope of this report and the reader is referred to the appropriate references listed.

There was no chlorination of the French Creek WPCC final effluent during this study and therefore no toxicity due to TRC.

The results of the 96 hour LC_{50} bioassay test and selected chemical analyses for both September and June sampling are shown in Table 11. Both raw sewage samples were toxic to the test fish due to high un-ionized NH_3 and anionic surfactant levels.

All final effluent samples were non-acutely toxic. However, the June un-ionized NH_3 concentrations were above critical levels.

The synergistic effects of many substances may reduce the toxic effects that could be predicted from the chemical analyses results. Modifying conditions for bio-assays include effects of temperature, water hardness, alkalinity, pH, dissolved oxygen, among others (17). Moreover, air stripping during the bioassay set-up and chemical reaction during sample transport and storage may occur. Any one of these factors may be responsible for the apparent poor correlation between the June un-ionized NH_3 concentration and bioassay results.

APPENDIX X TABLE 1
DESIGN CHARACTERISTICS OF THE FRENCH CREEK WPCC (STAGE 1) (1)

POPULATION SERVED	12 000	
AVERAGE DRY WEATHER FLOW (ADWF)		5500 m^3/day
PEAK FLOW		12500 m^3/day
INFLUENT RAW SEWAGE	BOD_5	150 mg/l
	NFR	180 mg/l
	VNFR	135 mg/l
CAPACITIES		
Grit Tanks		45 m^3
Primary Clarifiers (each)		361 m^3
Activated Sludge Basins (each)		675 m^3
Secondary Clarifiers (each)		309 m^3
Aerobic Digester		991 m^3
Sludge Thickeners (each)		61 m^3
HYDRAULIC DETENTION TIME @ ADWF		
Grit Tanks		0.2 hrs.
Primary Clarifiers		3.2 hrs.
Activated Sludge Basins		6.0 hrs.
Secondary Clarifiers		2.7 hrs.
TOTAL		12.1 hrs.
SURFACE LOADING RATE @ ADWF		
Primary Clarifiers		32 m^3/day/m^2
Secondary Clarifiers		32 m^3/day/m^2
NFR LOADING RATE (MAX.)		
Aerobic Digester		958 kg/day
Sludge Thickeners		26 kg/day/m^2
SLUDGE PRODUCTION (MAX.)		
Digested @ 50% VNFR Reduction and 98% W.C.		10200 m^3/yr.
Dried @ 1200 kg/m^3 and 50% W.C.		360 m^3/yr.

APPENDIX X RESULTS OF SEPTEMBER 1978 FRENCH CREEK WPCC FINAL
TABLE 2 EFFLUENT SAMPLING

PARAMETER	SEPT. 19 - 20	SEPT. 12 - 22	MEAN
pH	7.4	7.2	7.3
TOC	15.0	14.0	14.5
NFR	17	11	14
TR	618	603	610
COD	L50	65	45
Anionic Surfactants	0.133	0.135	0.134
TPO4		7.77	7.77
NO2		1.18	1.18
NO3	16.6	17.3	17.0
NH3	3.50	0.450	1.98
LC50	NT*	NT*	NT*

* NT non-toxic

L = less than

APPENDIX X RAW SEWAGE STRENGTH
TABLE 3

Parameter	Typical Composition (4) Strong	Medium	Weak	French Creek WPCC
	mg/l			
TR	1200	700	350	772
NFR	350	200	100	131
FR	600	350	175	641
TVR	600	350	175	212
TFR	850	500	250	560
BOD5	300	200	100	105
TOC	300	200	100	86.5
COD	1000	500	250	288
Organic N	35	15	8	--
NH3	50	25	12	19.1
NO3	0	0	0	L0.010
NO2	0	0	0	0.0059
TPO4	20	10	6	5.43
TAlk	200	100	50	176
Grease	150	100	50	124

L = less than

APPENDIX X CHEMICAL ANALYSES RESULTS
TABLE 4

Parameter	Raw Sewage June 11-12	Raw Sewage June 18-19	Raw Sewage Mean	Primary Effluent June 11-12	Primary Effluent June 18-19	Primary Effluent Mean	% Red	Final Effluent June 11-12	Final Effluent June 18-19	Final Effluent Mean	% Red
pH	7.5	7.4	7.4	7.5	7.2	7.4	-	7.5	7.4	7.4	-
BOD_5	90	120	105	70	85	78	26	30	10	20	81
COD	300	275	288	180	150	165	43	65	30	48	83
TOC	96.0	77.0	86.5	-	-	-	-	12.0	11.0	11.5	87
NFR	142	120	131	61	47	54	59	17	9	13	90
TR	785	760	772	785	670	728	6	600	610	605	22
TVR	225	200	212	150	120	135	36	100	120	110	48
TFR	560	560	560	630	550	590	+6	500	490	495	11
NH_3	20.9	17.3	19.1	18.0	18.0	18.0	6	11.8	7.28	9.54	50
NO_3	L0.010	L0.010	L0.010	-	-	-	-	8.85	11.1	10.0	-
NO_2	0.0050	0.0668	0.0059	-	-	-	-	0.800	0.755	0.778	-
TPO_4	5.31	5.55	5.43	-	-	-	-	5.90	4.91	5.40	0.5
T.Alk	173	178	176	-	-	-	-	112	104	108	39
LAS	3.7	4.30	4.00	2.3	2.80	2.55	36	0.23	0.19	0.21	95
SO_4	55.0	54.6	54.8	60.2	49.2	54.7	0.2	48.0	51.4	49.7	9
S	0.22	L0.050	0.135	0.14	L0.050	0.082	39	0.086	L0.050	0.055	59
Oil-Grease	37	210	124	-	-	-	-	L2	90	46	63
T Cu	0.135	0.124	0.130	0.051	0.056	0.054	58	0.021	0.021	0.021	84
T Fe	0.838	0.771	0.804	1.02	0.986	1.00	+24	0.178	0.136	0.157	80
T Pb	L0.08	L0.08	L0.08	L0.08	L0.08	L0.08	-	L0.08	L0.08	L0.08	-
T Zn	0.137	0.145	0.141	0.087	0.097	0.092	36	0.025	0.097	0.061	57
T Cd	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	-	L0.01	L0.01	L0.01	-

All values in mg/l except pH-pH units
L = less than

APPENDIX X UNIT PROCESS PARAMETERS
TABLE 5

Parameter	Equation	Recommended Range (5) Activated Sludge	Recommended Range (5) Extended Aeration	French Creek WPCC
θ_c (days)	$\theta_c = \frac{XV}{QwXw+(Q-Qw)Xc}$	5-15	20-30	4.2
U $\left(\frac{kg\ BOD_5}{kg\ MLVSS\text{-}day}\right)$	$U = \frac{Q(So-Se)}{VX}$	0.2-0.4	0.05-0.15	0.062
VL $\left(\frac{kg\ BOD_5}{1000\ m^3}\right)$	$VL = \frac{Q(So-Se)}{V}$	310-610	150-380	110
R	$R = \frac{Qr}{Q}$	0.25-0.5	0.75-1.50	0.40
t (hr)	$T = \frac{V}{Q}$	4-8	18-36	22
MLVSS (mg/l)	MLVSS	1500-3000	3000-6000	1000

where:
X = aeration tank MLVSS concentration (1030 mg/l)
V = aeration tank volume (1350 m^3)
Qw = wastage flow (324 m^3/day)
Xw = waste MLVSS concentration (1030 mg/l)
Q = influent flow (1490 m^3/day)
Xe = effluent MLVSS concentration (13 mg/l)
So = influent BOD_5 (178 mg/l) - Primary Effluent
Se = effluent BOD_5 (20 mg/l)
Qr = recycle flow (505 m^3/day)

APPENDIX X FINAL EFFLUENT NH_3 - NH_4 CONCENTRATIONS FOR
TABLE 6 VARIOUS θ_c

Minimum θ_c for Nitrification		3.9 days
Aeration	D.O.	1.3 mg/l
Aeration	pH	7.4
Aeration	temperature	16°C

θ_c	NH_3-NH_4 (mg/l)
3.9	41.9
4.0	12.4
4.1	7.3
4.2	5.1
4.3	4.0
4.4	3.2
4.5	2.7
4.6	2.4
4.7	2.1
4.8	1.9
4.9	1.7
5.0	1.5
5.5	1.1
6.0	0.8
8.0	0.4
10.0	0.3

APPENDIX X TOTAL METALS IN EFFLUENTS AND SLUDGES
TABLE 7

Parameter	Raw Sewage June 11-12	Raw Sewage June 18-19	Raw Sewage Mean	Primary Effluent June 11-12	Primary Effluent June 18-19	Primary Effluent Mean	Final Effluent June 11-12	Final Effluent June 18-19	Final Effluent Mean	Crude Sludge June 12	Crude Sludge June 19	Crude Sludge Mean	Secondary Sludge June 12	Secondary Sludge June 19	Secondary Sludge Mean	Digested Sludge June 12	Digested Sludge June 19	Digested Sludge Mean	Digestor Supernatant June 12
	mg/l																		
Al	0.45	0.35	0.40	0.09	0.11	0.10	L0.09	L0.09	L0.09	235.0	158.0	196.5	23.1	20.9	22.0	393.0	267.0	330.0	3.5
As	L0.15	L0.15	L0.15	L0.15	L0.15	L0.15	L0.15	L0.15	L0.15	0.99	L1.5	0.90	L0.15	L1.5	L0.15	1.13	1.5	0.60	L0.15
Ba	0.243	0.0346	0.139	0.0114	0.0147	0.013	0.0042	0.0042	0.0042	11.3	7.47	9.38	1.98	1.53	1.76	4.77	9.12	6.94	0.217
Ca	32.5	34.5	33.5	35.7	33.8	34.8	30.4	33.5	32.0	647.0	484.0	566.0	157.0	130.0	144.0	916.0	664.0	790.0	98.3
Cd	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	0.201	0.215	0.208	0.056	L0.1	0.053	0.221	0.289	0.255	L0.01
Co	L0.015	L0.015	L0.015	L0.015	L0.015	L0.015	L0.015	L0.015	L0.015	0.72	0.51	0.62	0.301	0.208	0.254	0.868	0.794	0.831	0.029
Cr	L0.015	L0.015	L0.015	0.015	L0.015	L0.015	L0.015	L0.015	L0.015	0.822	0.544	0.683	0.146	L0.15	0.113	0.942	0.971	0.956	L0.015
Cu	0.135	0.124	0.130	0.051	0.056	0.054	0.021	0.021	0.021	30.6	22.9	26.8	6.45	5.98	6.22	47.9	33.3	40.6	0.452
Fe	0.838	0.774	0.806	1.02	0.986	1.00	0.178	0.136	0.157	351.0	249.0	300.0	107.0	89.5	98.2	552.0	391.0	472.0	12.4
Hg	L0.1	L0.1	L0.1	L0.1	L0.1	L0.1	L0.1	L0.1	L0.1	L0.1	L1.0	L0.1	L0.1	L1.0	L0.1	L0.1	L1.0	L0.1	L0.1
Mg	20.3	19.7	20.0	24.2	20.4	22.3	17.6	18.9	18.2	139.0	107.0	123.0	48.2	43.0	45.6	221.0	154.0	188.0	28.3
Mn	0.12	0.17	0.14	0.437	0.455	0.446	0.0174	0.013	0.015	26.2	23.9	25.0	35.7	35.2	35.5	26.2	31.2	28.7	2.01
Mo	L0.15	L0.15	L0.15	L0.15	L0.15	L0.15	L0.15	L0.15	L0.15	L0.15	L1.5	L0.15	L0.15	L1.5	L0.15	0.15	L1.5	L0.15	L0.15
Na	146.0	143.0	144.0	167.0	138.0	152.0	136.0	130.0	133.0	136.0	179.0	157.5	140.0	153.0	146.5	142.0	182.0	162.0	136.0
Ni	L0.08	0.09	0.06	0.08	0.09	0.08	L0.08	0.09	0.06	0.49	0.93	0.71	0.08	0.93	0.50	0.55	0.93	0.74	0.08
Pb	L0.08	L0.08	L0.08	L0.08	L0.08	L0.08	L0.08	L0.08	L0.08	4.04	2.95	3.50	0.61	L0.8	0.50	3.16	4.38	3.77	L0.08
Sb	L0.08	L0.08	L0.08	L0.08	L0.08	L0.08	L0.08	L0.08	L0.08	0.12	L0.8	0.26	L0.08	L0.8	L0.08	0.1	L0.8	0.25	L0.08
Se	L0.15	L0.15	L0.15	L0.15	L0.15	L0.15	L0.15	L0.15	L0.15	L0.15	L0.15	0.15	L0.15	L1.5	L0.15	L0.15	L1.5	L0.15	L0.15
Sn	L0.2	L0.2	L0.2	L0.2	L0.2	L0.2	L0.2	L0.2	L0.2	5.13	4.6	4.9	0.87	L2.0	0.94	5.26	7.08	6.17	L0.2
Sr	0.146	0.146	0.146	0.177	0.152	0.164	0.129	0.139	0.134	2.17	1.77	1.97	0.887	0.789	0.838	2.34	2.55	2.44	0.345
Ti	0.035	0.012	0.023	0.021	L0.009	0.012	0.017	L0.009	0.010	1.16	1.03	1.10	0.384	0.362	0.373	0.907	1.28	1.09	0.193
V	L0.05	L0.05	L0.05	L0.05	L0.05	L0.05	L0.05	L0.05	L0.05	0.917	0.69	0.80	0.14	L0.5	0.20	1.03	1.13	1.08	L0.05
Zn	0.137	0.145	0.141	0.087	0.097	0.092	0.025	0.097	0.061	29.4	24.7	27.0	6.28	4.12	5.20	44.5	31.8	38.2	0.412
P	6.5	6.65	6.58	7.19	7.58	7.38	6.04	5.72	5.88	367.0	321.0	344.0	178.0	154.0	166.0	430.0	472.0	451.0	35.7
S	10.7	17.0	11.3	10.8	10.8	10.8	9.96	11.6	10.8	12.2	40.7	26.4	13.2	24.8	19.0	6.73	13.0	9.8	19.6

APPENDIX X CONCENTRATION OF TRACE ELEMENTS IN VARIOUS U.S.(9)
TABLE 8 AND FRENCH CREEK WPCC WASTEWATERS

Element	Untreated Wastewater		Primary Effluents		Secondary Effluents	
	U.S.	French Creek WPCC	U.S.	French Creek WPCC	U.S.	French Creek WPCC
	mg/l					
As	0.003	L0.15	0.002	L0.15	L0.005-0.01	L0.15
Cd	0.004-0.14	L0.01	0.004-0.028	L0.01	0.0002-0.02	L0.01
Cr	0.02-0.700	L0.015	L0.001-0.30	L0.015	L0.010-0.17	L0.015
Cu	0.02-3.36	0.130	0.024-0.13	0.054	0.05-0.22	0.021
Fe	0.9-3.54	0.806	0.41-0.83	1.00	0.04-3.89	0.157
Pb	0.05-1.27	L0.08	0.016-0.11	L0.08	0.0005- 0.20	L0.08
Mn	0.11-0.14	0.14	0.032-0.16	0.446	0.021-0.38	0.015
Hg	0.002-0.044	L0.1	0.009-0.035	L0.1	0.0005-0.0015	L0.1
Ni	0.002-0.105	0.06	0.063-0.20	0.08	0.10-0.149	0.06
Zn	0.030-8.31	0.141	0.015-0.75	0.092	0.047-0.35	0.061

APPENDIX X REDUCTION OF TOTAL METALS IN EFFLUENTS AND
TABLE 9 CONCENTRATION IN SLUDGE

	% Reduction*		Concentration Factor*	
Parameter	Primary Effluent	Secondary Effluent	Crude** Sludge	Secondary Sludge
Al	75	G78	491	55
As	-	-	G6	-
Ba	91	97	67	13
Ca	+4	4	17	4
Cd	-	-	G21	G5
Co	-	-	G41	G7
Cr	-	-	G46	G8
Cu	58	84	206	48
Fe	+24	81	372	122
Hg	-	-	-	-
Mg	+12	9	6	2
Mn	+220	89	179	254
Mo	-	-	-	-
Na	+6	8	1.09	1.02
Ni	+33	0	12	8
Pb	-	-	G44	G6
Sb	-	-	G 3	-
Se	-	-	-	-
Sn	-	-	24	G5
Sr	+12	8	13	6
Ti	48	56	48	16
V	-	-	G16	G4
Zn	35	57	191	37
P	+12	11	52	25
Si	4	4	2	2

* from raw sewage

** crude sludge is a mixture of primary and secondary sludges

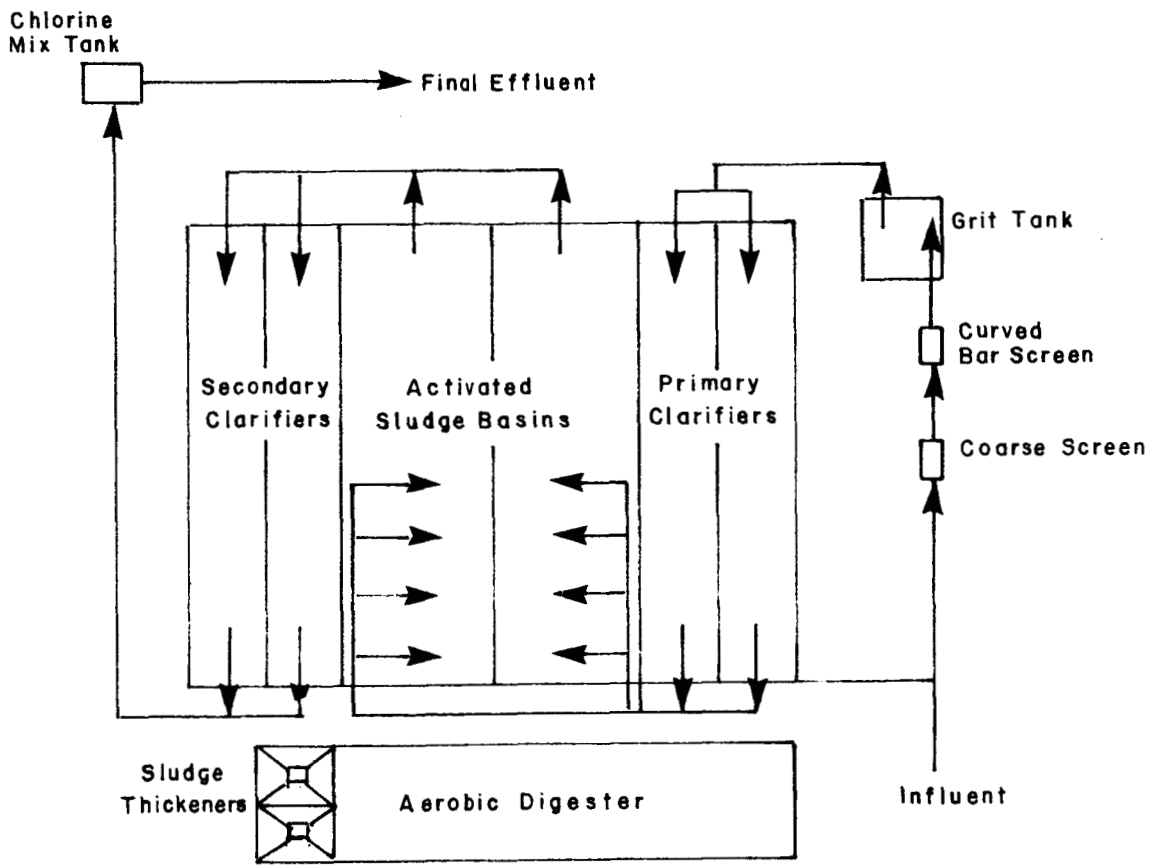
APPENDIX X CRITICAL CONCENTRATIONS OF ANIONIC SURFACTANTS,
TABLE 10 UN-IONIZED NH_3, AND TRC REPORTED TO BE TOXIC TO FISH

Parameter	Concentration (mg/l)	Significance	Reference
un-ionized NH_3	0.006	desirable upper limit	(11)
	0.025	maximum tolerated	(12)
	0.44	100% mortality after 96 hours	(13)
Anionic surfactants	3.3-6.4	96 hour LC_{50}	(14)
	5.9	96 hour LC_{50}	(15)
TRC	detectable (0.02)	likely toxic	(16)

APPENDIX X BIOASSAY AND SELECTED CHEMICAL ANALYSES RESULTS
TABLE 11 (SEPTEMBER 1978 AND JUNE 1979)

Date Sampled	96 Hour LC_{50}	Un-ionized NH_3	Anionic Surfactants
		Raw Sewage	
June 11-12	30%	0.18 mg/l	3.7 mg/l
June 18-19	44%	0.12 mg/l	4.3 mg/l
		Final Effluent	
Sept. 19-20	NT*	0.026 mg/l	0.13 mg/l
Sept. 21-22	NT	0.002 mg/l	0.13 mg/l
June 11-12	NT	0.10 mg/l	0.23 mg/l
June 18-19	NT	0.054 mg/l	0.19 mg/l

* NT - non-toxic



APPENDIX X
FIGURE I FRENCH CREEK WPCC FLOW DIAGRAM

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APPENDIX XI

CHARACTERISTICS OF PARKSVILLE AND QUALICUM SEWAGE PUMP STATIONS

APPENDIX XI CHARACTERISTICS OF PARKSVILLE AND QUALICUM SEWAGE PUMP STATIONS

Location	Pump Name	Warning System	Overflow Location	Homes/People Served	Wet Well Capacity
Parksville					
Bay Avenue	Flygt Submersible	telephone alarm system connected to answering service which contacts plant personnel via beeper.	6 m. from lift station on beach side.	3700 people	104,600 l
Butler Road	same	alarm	behind Butler Road in drainage area N.E. of lift station.	19 homes (not all inhabited)	5,300 l (to overflow) 11,800 l (to top)
Qualicum					
Higson Crescent	same	flashing light (checked daily)	ditch on Seacroft Rd. by Higson Crescent.	14 homes	39,100 l
Hall Road (pumped down to Lee Rd.)	same	same as Bay Avenue	4 m. from lift station on beach (30.5 cm steel pipe)	1900 people (May 1979 estimate)	22,700 l
French Creek					
Lee Road (connected to Hall Road station)	same	same as Bay Avenue	9 m. from lift station on beach side, beside Morningstar Creek	same group as Hall Road station plus a a few extra	22,700 l

APPENDIX XII

SUMMARY OF BACTERIOLOGICAL RESULTS FOR THE FRENCH CREEK WPCC

APPENDIX XII SUMMARY OF BACTERIOLOGICAL RESULTS FOR THE FRENCH CREEK WPCC

Date '79	Pre-Chlorination			Post Pre-Chlorination*			Final Effluent		
	TC/100ml	FC/100ml	FS/100ml	TC/100ml	FC/100ml	FS/100ml	TC/100ml	FC/100ml	FS/100ml
May 30							6 000	1 800	L1 000
May 31							26 000	25 000	7 100
June 1							88 000	6 600	400
June 4				2.1×10^7	7.3×10^6	3.8×10^5	34 000	12 000	700
June 5				8.0×10^6	2.2×10^6	1.5×10^5	10 250	200	300
June 6	8.1×10^5	7.9×10^5	1.4×10^5	L100 000	L100 000	L100 000	2 700	1 500	200
June 8	1.4×10^7	2.2×10^6	4.4×10^5	G3.0×10^6	1.3×10^6	3.9×10^5	59 000	8 800	900
June 14	>800 000	1.1×10^7	2.4×10^6	2.4×10^7	8.8×10^6	2.0×10^6	G8 000	104 000	53 000
Mean	5.2×10^6	4.7×10^6	2.7×10^5	7.4×10^6	3.9×10^6	2.1×10^5	29 240	19 890	7 950

* pretreated sample bottles on June 8 and June 14 only