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Shellfish Growing Water Sanitary Survey of The Vancouver Island Foreshore From Sherard Point to Bare Point Including The Shoal Islands and Outlying Areas, British Columbia, 1977

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SHELLFISH GROWING WATER SANITARY SURVEY OF THE VANCOUVER ISLAND FORESHORE FROM SHERARD POINT TO BARE POINT INCLUDING THE SHOAL ISLANDS AND OUTLYING AREAS. BRITISH COLUMBIA, 1977

by

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ABSTRACT

A sanitary and bacteriological survey of the waters contiguous to and entering into the Vancouver Island foreshore between Sherard Point and Bare Point, the foreshore waters of the Shoal Islands and selected foreshore areas of Saltspring Island was conducted between January 11 and February 4, 1977 by personnel of the Shellfish Water Quality Program, Pacific Region.

The bacteriological study was undertaken to evaluate molluscan shellfish growing water quality and permit a review of relevant portions of the existing British Columbia Fisheries Regulations Schedule J Contaminated Shellfish Closure 17-3. A sanitary survey was performed concurrently to identify and evaluate major sources of bacteriological contamination to the study area.

During the survey period, 368 marine, 42 freshwater and 42 effluent samples were collected and analyzed for coliform levels. A total of 45 marine stations were sampled and, of these, 8 did not meet the shellfish growing water standards.

RÉSUMÉ

Dans le cadre du programme de la qualité des eaux à crustacés, région du Pacifique, un personnel scientifique a entrepris, entre le 11 juin et le 4 février 1977, une étude sanitaire et bactériologique des eaux qui bordent l'île Vancouver entre Sherard Point et Bare Point ou quiyy pénètrent, ainsi que des eaux qui longent les îles Shoal et certaines zones sélectionnées de l'île Saltspring.

On anentrepris l'étude bactériologique afin d'évaluer l'état des eaux où vivent les mollusques et crustacés et de permettre de revoir les sections pertinentes des Règlements actuels des Pêches en Colombie-Britannique,(annexe J, 17-3) concernant la barrière pour les crustacés contaminés. L'étude sanitaire a été faite enmmême temps pour déterminer et évaluer les sources principales de contamination bactériologique dans la zone étudiée.

Pendant la durée de l'étude, on a prélevé et analysé 368 échantillons d'eau de mer, 42 échantillons d'eau douce et 42 échantillons d'effluents, pour dénombrer les coliformes. Les échantillons provenaient de 45 stations maritimes. Sur ces 45 stations, 8 n'atteignaient pas les normes fixées pour la qualité des eaux à crustacés.

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CONCLUSIONS

1. Osborn Bay waters off B.C. Forest Products and adjacent Stuart Channel Wharves proved to have high fecal counts due to the four direct discharges from the three septic tanks and the Bio Pure Sewage Treatment Plant to the receiving waters from the onshore facilities (Station 27-31).

2. The intertidal waters at the southwestern end of the Shoal Islands are contaminated with fecal pollution to the extent that consumption of molluscan shellfish can constitute a health hazard. The pollution is introduced into this area by Bonsall Creek, the main contributors of bacterial contamination observed being farm animals. The presence of human fecal pollution was suggested by the FC:FS ratio. However, the sanitary survey did not reveal any sewage disposal problems. There is a possibility that some of this contamination could have come from the south sewer outfall from the B.C. Forest Products mill which was occasionally running at an abnormally high pH during the survey period with a resultant lower dieoff of microrganisms.

3. The Georgia Generating Station at Bare Point has a direct piped sewage discharge to Stuart Channel. It is conceivable that this discharge could result in fecal coliform levels in excess of shellfish growing water standards in the foreshore waters.

4. Intertidal waters 2 km. south of Bare Point are contaminated with fecal pollution to the extent that consumption of molluscan shellfish may constitute a health hazard. The contamination could conceivably emanate from two residences which respectively display septic tank ground disposal seepage problems and an apparent direct sewage discharge to the receiving waters.

5. The intertidal and subtidal waters in the vicinity of the BCFP Crofton Mill (Stations 19-26) were of acceptable bacteriological water quality during the survey period. However, the presence of Kraft Mill Effluent in these waters, and the lack of information concerning the human health effects related to the consumption of oysters grown in the presence of KME have resulted in this area remaining under Schedule J closure.

6. The intertidal waters of Osborn Bay south of the ferry dock (Stations 35-38) were of acceptable water quality during the survey period. However, the discharge of raw or partly treated sewage into this bay from the Crofton Sewage treatment plant, and the reportedly poor dilution of sewage (5000:1, Dobrocky SeaTech), particularly in early summer, precludes this area from shellfish harvesting.

RECOMMENDATIONS

1. The present contaminated area 17-3 Schedule J closure should be amended to read: Area 17-3. "The waters and tidal foreshore of Area 17, lying inside a straight line drawn from the old wharf located about 2000 feet west of Sherard Point to the North Reef light, south of a straight line drawn from that light to the southern tip of Willy Island (National Topographic Map 92B/13, East Half), south of a straight line drawn from Willy Island to the northernmost tip of land on the southern bank at the mouth of the Chemainus River".

2. The Pollution Control Branch should be requested to investigate the Sewage discharge from the Georgia Generating Station with a view to attainment of shellfish growing water quality in the foreshore waters.

3. The Director of the Central Vancouver Island Health Unit should be requested to investigate:

   (a) The efficacy of the sewage disposal systems at the two residences suspected of causing fecal contamination in the foreshore waters at sample station 1.

   (b) The source of the high fecal coliform levels found in the two small streams (S4 and S5). Both streams are drainage ditches from the Crofton townsite.

   (c) The source of the high fecal coliform levels found in Bonsall Creek. It is suspected that run-off from grazing land may be a principal contributor

(d) The two small streams below the Twin Gables Motel (S4 and S5) exhibited high counts. Both are drainage ditches from the Crofton townsite.

(e) Bonsall Creek exhibited high counts which were partially attributable to runoff from grazing land; a potential contributor is the dairy farm of Mr. Joe Groenendyk. There is also human fecal contamination entering this creek although the source was undetermined.

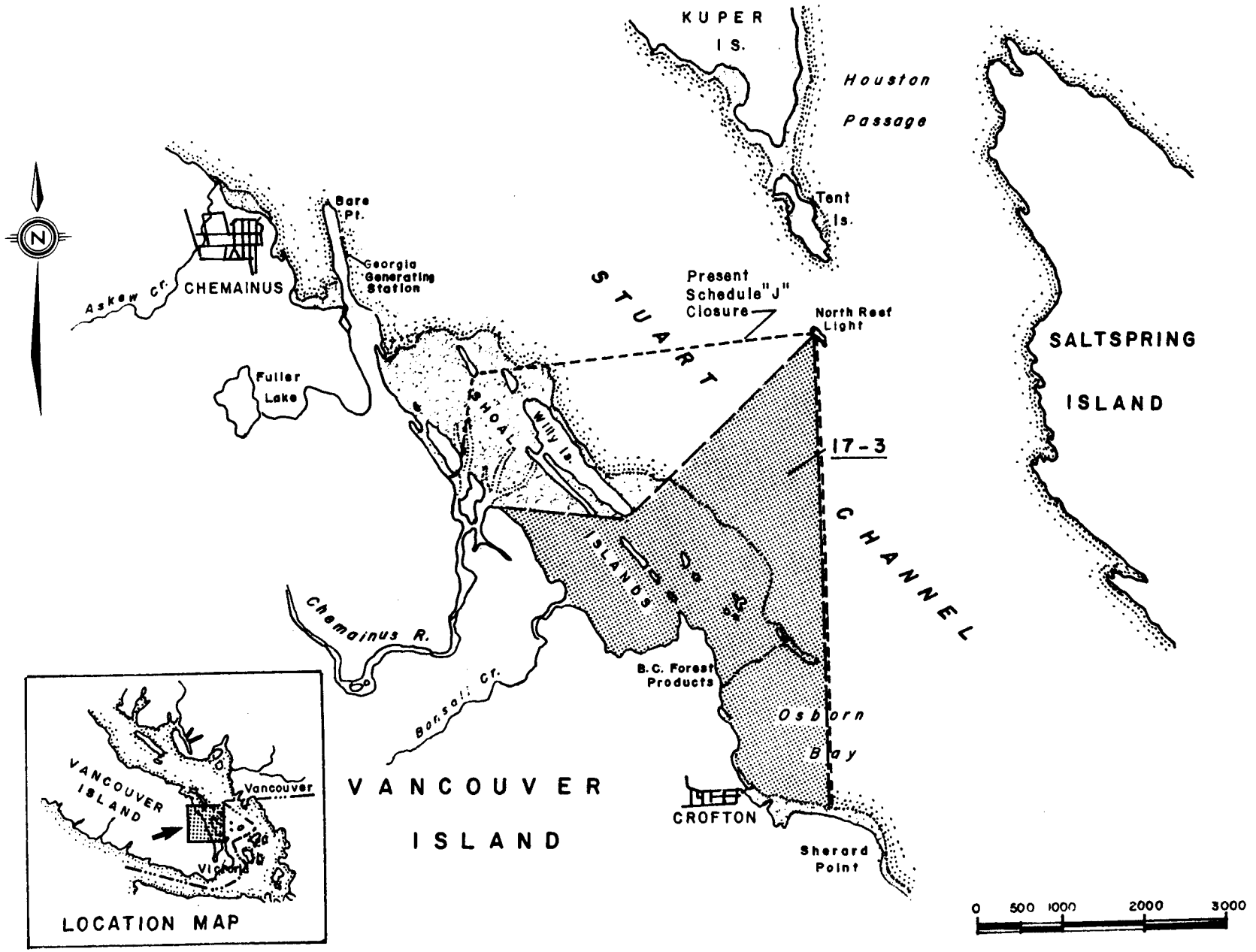

FIGURE 1 RECOMMENDED AREA 17-3 SCHEDULE "J" CLOSURE AMENDMENT

1 INTRODUCTION

Oyster growing leases in the Crofton area adjacent to the Shoal Islands were a significant source of commercial oyster production prior to their takeover by British Columbia Forest Products Ltd. in 1964-1965. The takeover action was initiated because of complaints from the oyster growers in the area that the mill effluent was having an adverse effect on the quality of the oysters that were being cultivated. The mill disposes of its wastes at the rate of 2.6m /sec through two submarine outfalls into the waters of Stuart Channel.

The influence of the pulp mill on the local oyster population has been previously reported (Dobrocky SeaTech, 1973, (1) Porter, 1969, (2). The last shellfish survey of the area (Fisheries Statistical Area # 17) in 1964 was reported by the Department of National Health and Welfare, Public Health Engineering Division. (3) The survey indicated unacceptable growing water quality at oyster leases oyster 337, 316, 81 and 118B. High bacteriological counts were also found in the Chemainus River. The high bacteriological counts in the area were attributed to the mill outfall. The survey report recommended that certain leases be closed to the taking of molluscan shellfish. In 1972, the contaminated area was geographically defined and included as a contaminated area in "Schedule J" of the British Columbia Fishery Regulations. The present contaminated area is defined as:

> Area 17-3. The waters and tidal foreshore of Area 17, lying inside a straight line drawn from the old wharf located about 2000 feet west of Sherard Point to the North Reef light, south of a straight line drawn from that light to the southern tip of Island 14 (National Topographic Map 92B/13, East Half), east of a straight line drawn from Island 14 to the southeast extremity of Mainguy Island to the shore of Vancouver Island.

A resurvey of the area was undertaken for the following reasons:

a) the oyster leases held by B.C. Forest Products had reverted to the crown (last lease reverted June 8, 1976).

b) condition factors in the oysters had significantly improved in the area under closure (personal communication from Dave Smith, Marine Resources Branch, Province of B.C., Appendix VI).

c) the Program Manual of Operations referred to in the 1948 Canada-U.S.A. Bilateral Shellfish Control Memorandum of Agreement recommends that surveys of commercial shellfish harvesting areas should be conducted once every ten years.

d) oyster leases outside of the closure area had not been surveyed since 1964.

3) shellfish growing waters outside of the closure area had not been previously surveyed.

Hence a bacteriological and sanitary survey of the waters contiguous to and entering into the Vancouver Island foreshore between Sherard Point and Bear Point as well as the foreshore waters of the Shoal Islands was conducted between January 11 - February 4, 1977 by personnel of the Shellfish Water Quality program, the Environmental Protection Service. The growing waters of Booth and Burgoyne Bays at Saltspring Island were also surveyed.

2 SAMPLE STATION LOCATIONS

Marine sample stations were chosen to assess the extent and degree of bacteriological contamination to the shellfish growing waters arising from the B.C. Forest Products mill outfall to Stuart Channel and the District of North Cowichan sewage outfall to Osborne Bay. Stations were also established in the dock loading area in Osborne Bay (to monitor the effects of direct inputs from septic tanks in the area), off the

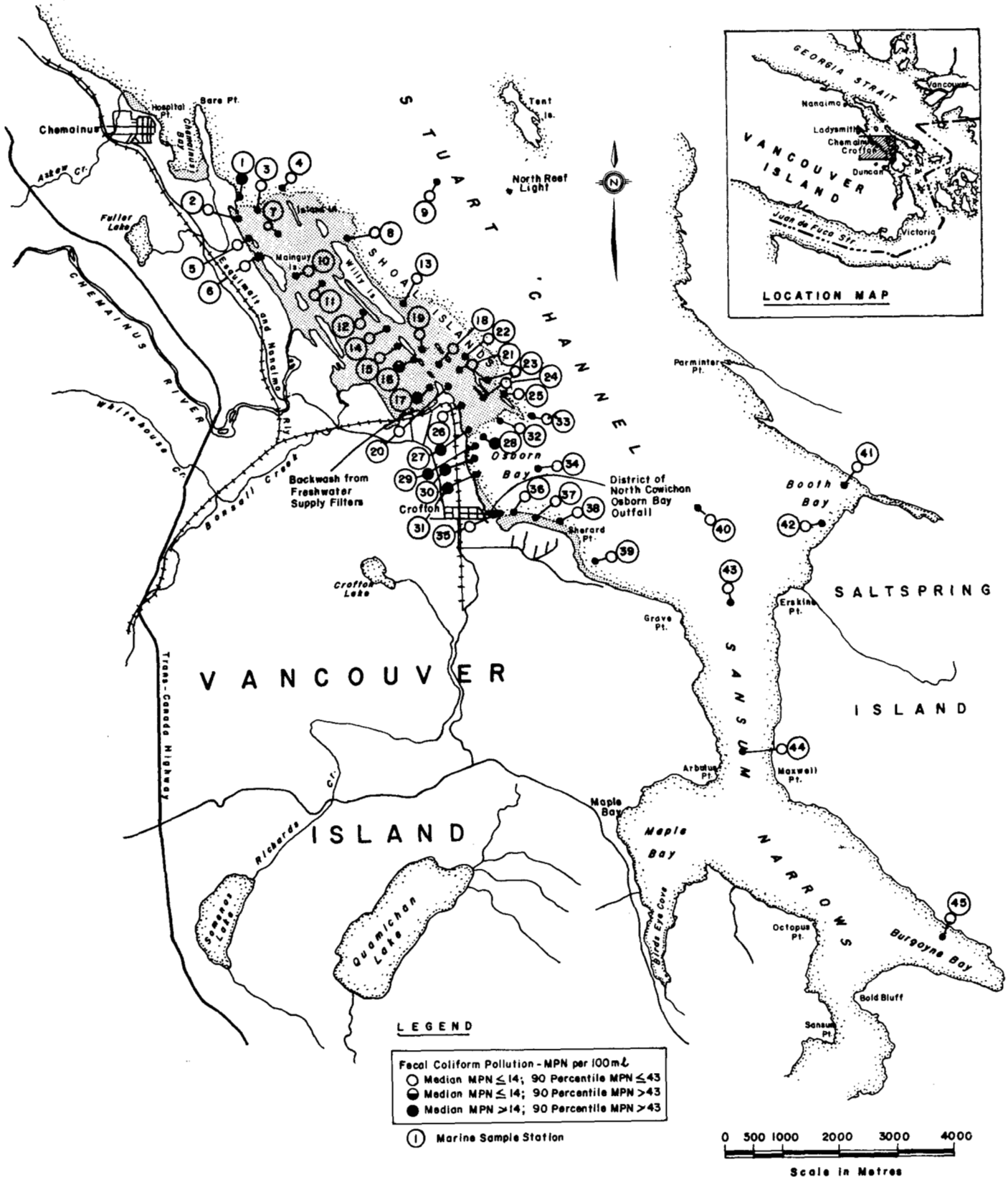

FIGURE 2 SHERRARD POINT TO BARE POINT AND OUTLYING AREAS SAMPLE STATIONS

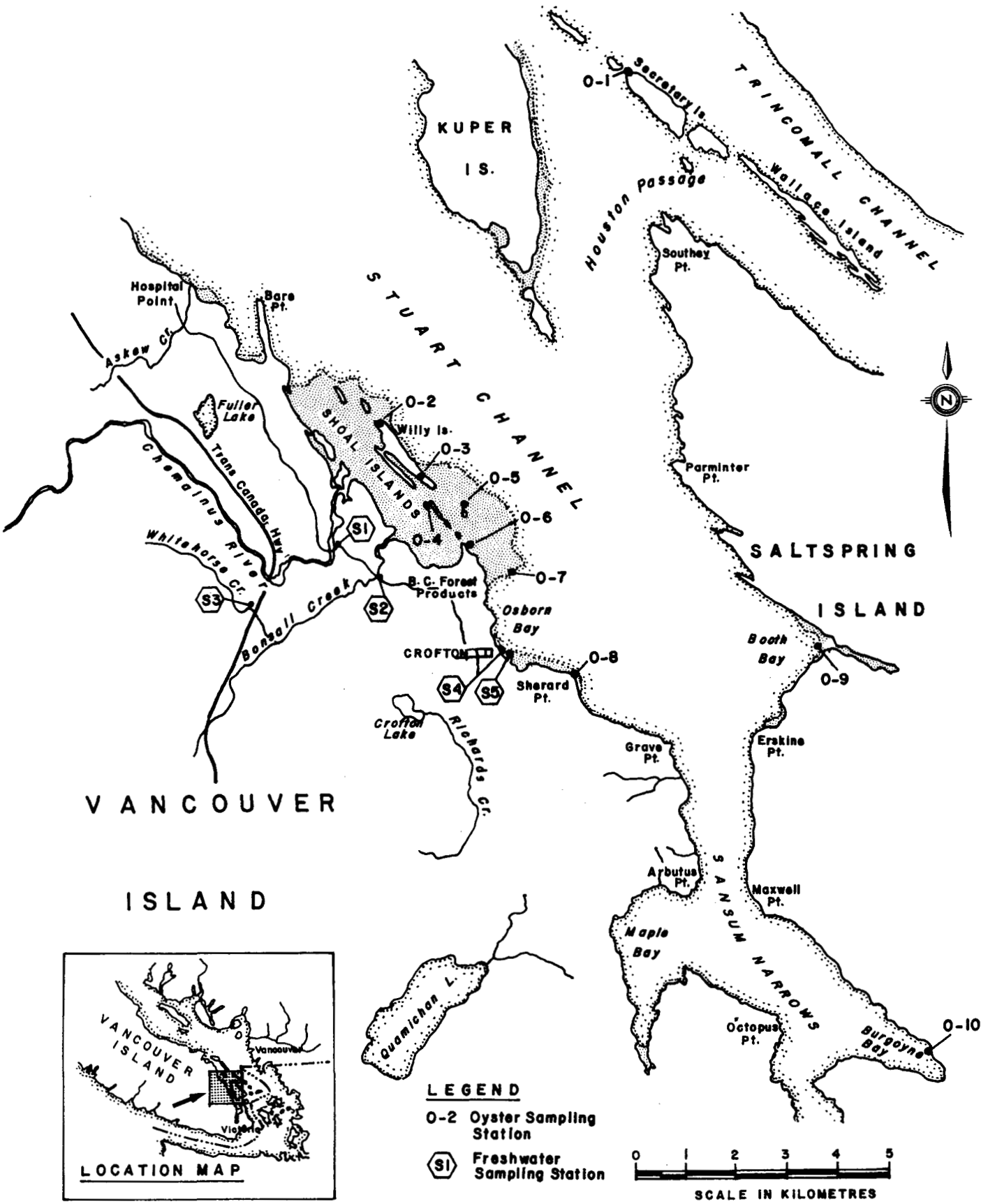

FIGURE 3 OYSTER AND STREAM SAMPLING STATIONS

mouths of creeks and the Chemainus River, and at random intervals along the foreshore (dependent on residential development in some cases). Samples were also taken at various locations for colour and odour measurements with the results presented in Appendix VI.

Freshwater samples were taken from the Chemainus River, Bonsall and Whitehorse Creeks and two small streams in Crofton to assess their influence on receiving water quality.

Oysters were sampled for determination of fecal coliform bacteria, polychlorinated biphenols (PCB's) and chlorinated insecticides in the meat.

Marine and freshwater sample station locations are illustrated in Figures 1 and 2. The oyster sample stations are illustrated in Figure 2.

3 FIELD PROCEDURES AND METHODS

Sampling stations were selected and a bacteriological and physical water testing program was developed to assess the shellfish growing water quality and the source and impact of bacteriological pollution.

3.1 Bacteriological Testing and Analyses

All water samples for bacteriological analyses were collected in sterile 170 or 340 cc wide-mouth bottles with the marine stations being sampled approximately 15 to 30 cm below the water surface. The water depth at collection points over shellfish beds did not exceed 1.2 metres. Samples were collected by boat or on foot and stored in coolers at temperatures not exceeding 10°C until processed. Analyses were carried out in the Environmental Protection Service mobile laboratory located at the sampling area and were performed within three hours of collection.

The fecal coliform MPN per 100 ml was determined using the multiple tube fermentation technique (at least 3 decimal dilutions of 5 tubes each) as described in Part 908C of the 14th edition of Standard Methods for the Examination of Water and Wastewater (4). Incubation was for 24± 2 hours in a bath equipped with a circulation device, and maintained at 44.5± 0.2°C. Presumptive culture medium used was Bacto-Lauryl Trptose Broth; fecal coliform determinations were made using Bacto-EC medium.

All freshwater samples were analysed for fecal coliforms and fecal streptococci using membrane filtration techniques (Part 909 of Standard Methods). The volume of sample filtered was not less than 100 ml and appropriate dilutions were made in order that the number of colonies per plate normally ranged between 20 and 80. Colonies were counted under 10 power magnification using a cool white fluorescent bulb as a light source. Bacto-mFC Agar was used for the fecal coliform determinations; fecal streptococci determinations were made using KF Streptococci Agar. Factory sterilized membrane filters (0.45 micron pore size) were obtained from Sartorius (West Germany). Fecal coliform plates were incubated at 44.5± 0.2°C for 24 hours in water-tight plastic bags submerged in a water bath. Colonies which were totally or partially blue in colour were counted as fecal coliforms.

IMViC analyses on bacterial isolates were performed as described in Part 911B of Standard Methods. Oxidase testing and the MOMoC biochemical test series was performed on suspected Klebsiella isolates. All test media used were Bacto brand.

3.2 Physical and Chemical Testing Equipment and Analyses

Temperature and salinity measurements at marine sample stations were made at a depth of 15 to 30 cm below the water surface using a YSI Model 33 Salinity-Conductivity-Temperature meter or a Beckman Model RB3-349 Solubridge Electrolytic Conductivity meter in conjunction with a

standard immersible thermometer. Wind data was determined with a Telcor series 210 electronic wind speed/direction indicator. pH determinations were made with a Sargent-Welch Model PBL pH meter. Samples were also taken for tristimulus analysis, colour (Hellige colour comparator) and odour determination. The results for the latter are presented in Appendix VI.

Tidal data presented is that for Fulford Harbour and the rainfall data was obtained from the Atmospheric Environment Data Centre in Victoria and was for the Cowichan Bay station.

DISCUSSION OF RESULTS

Daily bacteriological, physical and elemental data for each sample station is presented in Appendices IV and V. Fecal coliform results for marine and fresh water stations are summarized in Tables 1 and 2 respectively.

The results have been interpreted and the growing waters classified based on the following criteria.

> In order that an area can be considered bacteriologically safe for the harvesting of shellfish, the fecal coliform median MPN of the water must not exceed 14 per 100 ml, and not more than 10 percent of the samples ordinarily exceed an MPN of 43 per 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.*

During the survey, 368 marine, 42 freshwater and 42 effluent samples were collected and analyzed for fecal coliform levels. The bacteriological results presented in Table 1 show that 37 of the 45 marine stations met the shellfish growing water standard. Of the remaining 8 sample stations were classified as unacceptable, 7 exceeded the standard at the median level and one exceeded the standard at the 90 percentile level. Fecal coliforms were detected in all oyster meat samples (see Table 4), the highest counts being at stations 0-6 (220/100ml), 0-7 (130/100ml) and 0-9 (230/100ml).

Rainfall during the survey period totalled 75.2 mm which is less than one half of the mean total precipitation for the period 1941-1970. Precipitation data is presented graphically in Figure 3. There was no apparent relationship between rainfall and bacteriological results. Most of the sampling in the vicinity of the Shoal Islands could

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*This report expresses the 10 per cent limit in terms of a 90 percentile which must not exceed 43/100 ml.

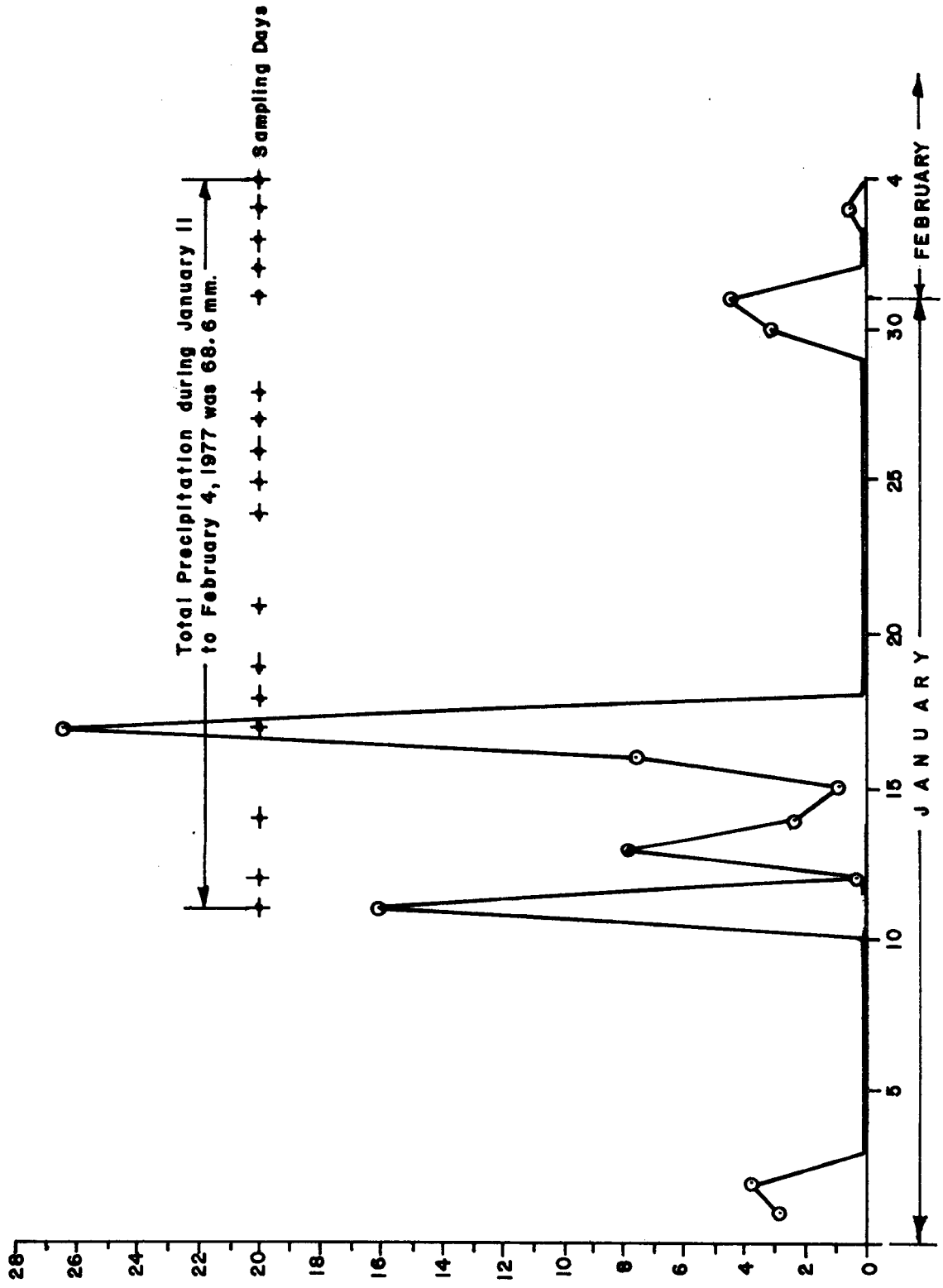

FIGURE 4 TOTAL PRECIPITATION DURING JANUARY 1 TO FEBRUARY 4, 1977
COWICHAN BAY, B. C.

TABLE 1

SUMMARY OF FECAL COLIFORM MPN DATA FOR MARINE STATIONS

SAMPLE STATION	NUMBER OF SAMPLES	MPN RANGE	MPN per 100 ml MEDIAN	90 PERCENTILE
1	6	2-240	28.0	143.4
2	11	2-63	5.0	10.7
3	11	2-33	5.0	30.5
4	6	2-5	3.5	5.0
5	6	2-22	6.0	13.6
6	7	2-23	8.0	16.0
7	11	2-46	5.0	31.0
8	6	2-8	5.0	8.0
9	6	2-11	3.5	11.0
10	10	2-49	7.0	13.0
11	10	4-79	8.0	17.0
12	8	2-13	4.5	8.2
13	7	2-17	2.0	9.3
14	13	2-130	8.0	33.0
15	13	2-33	13.0	33.0
16	12	2-240	9.5	92.6
17	8	2-130	34.5	114.0
18	12	2-49	3.0	12.0
19	14	2-33	6.0	17.6
20	13	2-33	7.0	20.3
21	8	2-13	3.5	13.0
22	14	2-23	5.0	19.4
23	7	4-13	8.0	11.6
24	6	2-11	6.0	9.8
25	6	2-5	3.0	4.4
26	7	5-70	7.0	30.8

TABLE 1 (Cont.)

SUMMARY OF FECAL COLIFORM MPN DATA FOR MARINE STATIONS

SAMPLE STATION	NUMBER OF SAMPLES	MPN RANGE	MPN per 100 ml MEDIAN	90 PERCENTILE
27	7	5.70	17.0	55.3
28	7	2-350	33.0	224.0
29	7	11-1600	140	1124.0
30	7	2-240	17	240.0
31	7	8-350	23	139.3
32	10	2-49	9.0	27.0
33	6	2-17	5.0	9.8
34	11	2-49	5.0	25.6
35	6	2-13	4.5	13.0
36	6	2-33	7.5	19.8
37	6	2-21	2.0	11.4
38	6	2-11	2.0	8.6
39	6	2-17	2.0	9.8
40	6	2-8	2.0	6.2
41	6	2-8	2.0	5.6
42	8	2-17	2.0	9.8
43	6	2-23	3.5	14.0
44	6	2-8	2.0	4.4
45	6	2-2	2.0	2.0

TABLE 2 SUMMARY OF FECAL COLIFORM AND FECAL STREPTOCOCCI MEMBRANE FILTRATION DATA FOR FRESHWATER STATIONS

SAMPLE STATIONS	MEAN FLOW M /SEC	MEAN FECAL COLIFORM (F.C) COUNT/100 ml	MEAN POPULATION EQUIVALENT (P.E)	MEAN FECAL STREPTOCCI (F.S.) COUNT/100 ml	FC:FS RATIO
S1	13.05**	11.4 (5)*4**	2.10	6.28 (7)	1.81
S2	2.7m^3/sec**	1046.5 (7)6**	59.94	222 (7)	4.7
S3	0.76m^3/sec**	1314.3 (7)7**	52.98	180.4 (7)	7.28
S4	0.055m^3/sec**	2131.4 (7)4**	3.28	451.6 (6)	4.72
S5	0.012m^3/sec**	184 (7)4**	0.035	122.2 (6)	1.51

** Number of samples

** Number of samples for which FC counts and flow information is available and therefore the number of samples which the mean flow rate and the mean P.E. is based upon.

TABLE 3

SUMMARY OF FECAL COLIFORM MPN DATA FOR EFFLUENT STATIONS

Effluent Station	No. of Samples	MPN Range	MPN/100ml Median	MPN/100ml Mean	Mean flow (m^3/sec)	Mean Population Equivalent
E01	3	$2x10^5$-$3.5x10^6$	$2.3x10^6$	$2.0x10^6$		
E02	4	$5x10^5$-$1.7x10^6$	$1.35x10^6$	$1.1x10^6$		
E03	5	2-540	4	109.8	-	
E04	5	80-920	170	400	0.11	1.19
E05	5	2- 1600	2	-	1.27	-
E06	5	2-1600	700	618	1.27	6.62
E07	2	2-4	-	-	-	
E08	2	$1.3x10^6$-$2.4x10^6$	$1.85x10^6$	$1.85x10^6$	$7.9x10^{-5}$	3.94
E09	2	$2.3x10^5$-$9.9x10^5$	$5.85x10^5$	$5.85x10^5$	$1.3x10^{-6}$	0.02
E10	2	$1.7x10^6$-$3.5x10^6$	$2.6x10^6$	$2.6x10^6$	$1.3x10^{-5}$	0.91
E11	2	$3.3x10^5$-$1.1x10^5$	$4.15x10^5$	$7.15x10^5$	$7.6x10^{-6}$	0.146
E12	4	33-350	89.5	140.5		

E01 - Crofton sewage (treated))
E02 - Crofton sewage (raw))
E03 - solid waste leachate)
E04 - woodroom effluent)
E05 - north sewer)
E06 - south sewer)
E07 - filter backwash) B.C.F.P. Crofton
E08 - woodroom septic tank)
E09 - #1 dock septic tank)
E10 - #2 dock septic tank)
E11 - #3 dock Bio pure STP)
E12 - Island Processing lagoon effluent

TABLE 4

FECAL AND TOTAL CONFIRMED MPN DATA FOR OYSTER MEATS

	January 25		February 1	
Station	Total Confirmed	Fecal	Total Confirmed	Fecal
0-2	1300	50	1100	70
0-4	230	50	3500	20
0-6	1300	70	330	220
0-7	-	-	790	130
0-8	230	20	2400	40
0-9	430	230	-	-
0-10	490	50	-	-

the area. Hydrographic conditions were considered to be at their worst as there was limited wind and wave action to assist in effluent dispersal.

4.1 British Columbia Forest Products Ltd. (Crofton Division)

This B.C. Forest Products mill which began operation in the spring of 1958 produces newsprint and bleached kraft pulp. The mean production of newsprint and kraft pulp during January 1977 was 765 and 560 metric tons per day respectively.

The mill has eight discrete discharges. There are two main sewers that discharge through two submarine outfalls (diffuser type) at the combined rate of 2.6 m^3/sec into 20 metres of water in Stuart Channel adjacent to the Shoal Islands. In addition to these outfalls, woodroom effluent is discharged at the rate of 0.1 m^3/ sec. into Osborn Bay after treatment in two settling ponds. During January 1977, the mean pH of this effluent was 6.5 and the mean temperature was 8°C.

Waldichuck (5) gave a comprehensive summary of the oceanographic features of Stuart Channel and factors affecting the dispersal of effluent. He described the area as being a "stratified, estuarine region typical of B.C. 'inside waters'."

Tidal currents in Stuart Channel move along the axis of the channel, setting NW on the flood and SE on the ebb with velocities generally less than one knot at all depths. During Waldichuck's study, effluent discharged from the diffusers mixed with seawater in a ratio of 1:22 and formed a boil above the diffusers. Due to entrainment of cold, highly saline water, this effluent in the boil usually sank and spread at a depth of 3 to 10 metres. Waldichuck concluded on the basis of current measurements; "Non-tidal currents at the surface and at 9 to 10 metres depth could be expected to give the effluent present in these layers a net displacement seaward through Sansum Narrows. Effluent at a depth of

4 to 5 metres would receive a net transport in the opposite direction (NW) and could be expected to be retained in the channel much longer." A shellfish heavy metal monitoring program (6) conducted in 1973 by the Environmental Protection Service confirms this observation.

Domestic mill sewage is processed by a system of septic tanks which overflow to the general sewer. As might be expected, there is a direct correlation between fecal coliform levels in the north and south sewers and pH as shown below.

	North Sewer		South Sewer	
	MPN	pH	MPN	pH
Jan. 20	2	3	2	4.4
Jan. 26	2	3	1600	-
Jan. 27	1600	8.8	790	5
Jan. 28	2	-	2	3.2
Jan.31	2	3	700	9-11

Table 5. Correlation between fecal coliform levels and pH in B.C.F.P. (Crofton Division) north and south sewers.

Outfall data supplied by the mill showed the mean pH of the south sewer outfall to be 3.5 in November 1976 and 3.4 in December 1976. However, the main south sewer outfall pH during January 1977 was 5.2. The population equivalent for the south sewer outfall was calculated to be 21.7, based on a flow of 1.3 m^3/sec. The combined contribution of both sewers will be higher, however indeterminate MPN values for the north sewer did not allow a population equivalent calculation to be made. Suffice it to say that there is a considerable bacterial discharge from the mill when the effluent pH approaches 7. This discharge did not, however, adversely affect the bacteriological water quality in the immediate vicinity of the outfall. Process modifications being made at the mill during the survey resulted in this greater than normal variation in the pH of the south sewer as a result of black liquor spills.

Reference has already been made to the influence of pulp mill discharge on oyster populations (1)(2). There has been little research done to investigate the effects on human health due to the consumption of shellfish grown in waters subject to Kraft Mill Effluent (KME).

The standard for the purposes of this study is bacteriological only.

Other discrete discharges from the mill not already listed include; the backwash from the water supply filters which is discharged to the mudflats about one mile north of the mill site, and four direct discharges from septic tanks with one each at dock #'s 1, 2 and 3 and at the woodroom. Data from these sources is summarized in Table 3.

High fecal counts in the dock areas were attributed to three septic tank and one package treatment plant direct discharges to the receiving waters, the most significant being E08 and E10 with population equivalents of 3.94 and 0.91 respectively. Discharges from freighters undoubtedly contributed to the water quality deterioration. During the sampling period, up to three freighters were docked at Stuart Channel Wharves at any one time. There was no investigation into the quantity of sewage discharged from these ships during the period of the study.

Coliform bacteria isolates were taken from the woodroom effluent and from the north and south sewers and subjected to IMViC* and/or HOMoC** biochemical analysis series. The MOMoC series was performed to check for the presence of Klebsiella species, specifically in the woodroom effluent. The results are summarized in Table 6.

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* Indole, Methyl red, Voges-Proskauer and Citrate tests.

**H_2S, Ornithine decarboxylase, molitity and citrate tests.

TABLE 6

BIOCHEMICAL DATA - B.C.F.P. CROFTON COLIFORM ISOLATES

Sample Station	Number of Isolates	IMViC type ++--	-+--	--++	other	--++ HOMoC isolates
Woodroom effluent	25	7	2	11	5	1/11
North Sewer	28	9	0	12	7	4/12
South Sewer	43	31	2	7	3	5/7

All isolates have a --++ IMViC result were subjected to the HOMoC test series and oxidase analysis. Klebsiella species were not detected in significant numbers in the woodroom effluent, the major IMVic type most probably being an Enterobacter. Both E. coli and Klebsiella species were detected in the north and south sewer effluents.

4.2 The Shoal Islands north to Bare Point

Station #1 exceeded the growing water standard at the median level thus indicating that continuous pollution was occurring at this location. The contamination could conceivably emanate from two residences which respectively display septic tank ground disposal seepage problems and an apparent direct sewage discharge to the receiving waters.

The Georgia Generating Station is situated at Bare Point and operates intermittently during peak power periods. There is a minimum staff of 1 to 2 people at the plant at all times and more when the plant is operating. Waste disposal is by septic tank and a direct piped discharge to Stuart Channel.

The remainder of the waters from the southern tip of Willy Island and north proved to be of acceptable growing water quality. The main freshwater input in the area is the Chemainus River. Through the sampling period, no appreciable fecal coliform contamination in the river was observed with a mean fecal coliform count of 11.4 per 100 ml or a population equivalent of less than 4.

The major freshwater contaminating input to the shellfish growing waters in this area is Bonsall Creek (S2) which is fed, in part, by Whitehouse Creek (S3) near the Island Highway. This combined input had a mean population equivalent (PE) of 76.3 which was the highest of the non-effluent inputs monitored in the survey area. Both Bonsall and Whitehouse Creeks had high fecal coliform levels with mean fecal counts of 1046.5/100 ml and 1314.3/100ml respectively.

The waters at sample stations 16 and 17 mix with the outflow from Bonsall Creek as indicated by salinity data. Both stations exceeded the growing water standards; the former at the 90 percentile level and the latter at the median level (MPN's of 92.6/100 ml and 34.5/100 ml respectively). Waters to the north of these stations, although they did

meet the standard, were none the less affected (station 15 had a 90 percentile MPN of 33/100 ml). There is a possibility that some of this contamination could have come from the south sewer outfall from the mill which was running at an abnormally high pH during the survey period with the resultant lower dieoff of microrganisms. However, there did not appear to be any obvious correlation between high fecal counts at stations 16 and 17 and high pH (ie 7) in the mill effluents.

The fecal coliform: fecal streptococci (FC:FS) ratios for Bonsall and Whitehouse Creeks were 4.7 and 7.28 respectively indicating human fecal pollution to be the major contributing source although there was no evidence of sewage problems along the course of these creeks. Several animal sources were identified by a sanitary survey of this area which was carried out on February 3, 1977, at which time 20 head of cattle were observed grazing in proximity to Bonsall Creek and the animals had direct access at this point. Upstream investigation of Whitehouse Creek revealed considerable pastureland, some of which is fenced off, although most of the creek is open access. Eleven cattle with creek access were observed where the creek approaches the Island Highway.

The main potential source of contamination is a dairy which is farmed, owned and operated by Mr. Joe Groenendyk on Mt. Sicker Road. The dairy has 200 head at any one time. His feed lot wastes are hosed into a concrete-lined lagoon and the effluent is used to irrigate 57 hectares of grazing land. The lagoon has a capacity of approximately 3925 m^3. Although the farm is a considerable distance from the mouth of the creek, contamination can and does enter the creek from the irrigation system. However, Mr. Groenendyk is aware of the problem and does try to keep the sprinkler out of the range of the creek to prevent direct contamination. The creek is fenced off, so the cattle do not have direct access.

A potential source of contamination to Bonsall Creek is the Island Processing Plant. Cooling water condensate at the plant is pumped

to a lagoon which discharges to Whitehouse Creek. The mean MPN of this effluent was 140.5/100 ml and, considering the high fecal coliform levels already in the creek, did not appear to be a major contributor. There was definite seepage from their ground disposal system for floor and truck washings, but it is doubtful that this would reach the creek. There could be seepage from the plant washroom ground disposal system; in addition the tile field is covered under ashphalt which contravenes the sewage disposal regulations of the Provincial Health Act.

Oysters were collected for meat analysis at five areas in the Shoal Islands. The highest meat bacteriological MPN count in the survey area was at station 0-6. A sample taken at this location on February 1, 1977 had an MPN of 220/100 gm which was most likely due to the influence of Bonsall Creek. At the north end of Willy Island, station 0-2 had a fecal MPN of 70/100 gm. The most likely source of contamination at this station is the mill outfalls. As mentioned earlier with respect to Waldichuck's study (1964), effluent at a depth of 4 to 5 metres would receive a net transport in the northwesterly direction and could thus inundate the growing waters at this station.

Oysters were also sumbitted to the B.C. Ministry of the Environment Pesticide Analytical Laboratory for pesticide analysis (PCB's and chlorinated insecticides). Neither of the chemicals were detected in any of the samples taken which included stations 0-4, 0-5, 0-7, 0-8 and 0-9.

Samples were also taken for odour determinations to determine the extent of influence of the mill effluent and were positive at most stations. The stations in from the mill outfalls, as might be expected, were the most consistantly positive. Positive determinations were also made in Osborn Bay and at the centre of Stuart Channel. A tristimulus colour analysis was carried out as well in conjunction with the odour determination. A description of this test and tabulation of the results are presented in Appendix VI.

4.3 Osborn Bay

The District of North Cowichan (Crofton) Osborn Bay outfall currently discharges about 9.5 x 10^4 litres/day of settled septic tank chlorinated sewage into 8 metres of water 168 metres from shore. With an area of 3 km^2 and an average depth of 37 metres, Osborn Bay is relatively open to Stuart Channel. At the north end it is protected by the Shoal Islands. The bay is comparatively open to flushing by marine waters, however the ciruclation in the bay is sluggish in comparison to the tidal currents in Stuart Channel. The Dobrocky SeaTech report to the District of North Cowichan (1976)(7) states; "it appears that currents in Osborn Bay are opposite in direction to those in Stuart Channel. Circulation in the bay thus consists of eddies of the main system, and Osborn Bay must, in the absence of other information, be considered an embayed area." The report adds further; "During periods of weak density stratification, effluent will almost certainly surface at Crofton ... There are occasions, especially during the early summer, when people are exposed to direct contact with water contaminated with sweage effluent at dilutions as low as 5,000:1."

During the survey, samples were taken of both treated and raw Crofton sewage and the results of the tests indicate that very little, if any, chlorination is taking place (see Table 3). The mean fecal coliform MPN of the final effluent was 1.1 x 10^6/100 ml which is equivalent to a PE of 32.7. (Note that the PE in reality is probably much higher as the flow rate is reportedly above design capacity; however the design capacity flow was used in the PE calculation.) It would appear that there was excess flow for the design capacity of the septic tank. It is therefore doubtful that there is any significant hydraulic retention time of fluids in the plant; a fact inconsistent with Pollution Control Branch requirements for 48 hour retention before discharge. Nevertheless the growing waters that were sampled in the southeast end of Osborn Bay all proved to be within the shellfish growing water standard. The only area in the bay that prove unaccetable was the previously mentioned Stuart

Channel Wharves area. Data obtained from oyster meat analysis at station 0-8 did not indicate any unacceptable degree of contamination in the Sherard Point area. Two small streams, S4 and S5 were contaminated with mean fecal coliform counts of 2131.4/100 ml and 184/100 ml respectively; although counts were high, the corresponding PE's of 3.16 and 0.059 were not significant. These streams carry general drainage from the Crofton township, and no discrete contaminating sources could be determined.

The Government Wharf can accommodate up to 50 boats. Any sewage from these craft would be discharged infrequently as the wharfinger reports that there are no live-aboards.

The Saltspring Queen ferry was running temporarily during the survey period and has no holding tank for sewage. The Vesuvius Queen normally does the run and does have a holding tank. A self-contained outhouse serves the ticket office on the ferry dock and is pumped out regularly.

4.4 Saltspring Island

Three sample stations were located in foreshore waters of Saltspring Island; two in Booth Bay and one in Burgoyne Bay. In addition, oyster samples were also taken in both of these locations. The waters at all three sample stations met the shellfish growing water standard. However, the oysters collected at station 0-9 in Booth Bay had a meat bacteriological MPN count of 230/100 gm which is equal to the market level set by the Fish Inspection Branch of the Fisheries and Marine Service. A sanitary survey of the Booth Bay area carried out during the survey did not reveal the source of this contamination.

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APPENDIX I

MARINE SAMPLE STATIONS - LOCATIONS AND DESCRIPTIONS

SAMPLE STATION	LATITUDE (48° NORTH)	LONGITUDE (123° WEST)	LOCATION
1	48°54.90'	123°41.75'	Off Red House South of Chemainus inside Shoal Islands
2	54.65'	41.75'	100 m. south of Small point south of Bare Point (Tall Snag)
3	54.75'	41.45'	500 m. offshore of Station 2
4	54.95'	41.20'	At closure sign on Island #70 of Shoal Islands
5	54.40'	41.55'	Small island between north end of Mainguy Island and Vancouver Island
6	54.30'	41.40'	Between north end of Mainguy Island and Vancouver Is. (off old stump)
7	54.45'	41.00'	Halfway between southern tip of Island #135 and north tip of Mainguy Island
8	54.45'	40.20'	Beach at north end of Willy Island
9	55.05'	39.00'	Midchannel between north end of Willy Island and south end of Tent Island
10	54.15'	40.90'	Mouth of Chemainus River, N.E. of island in river mouth
11	54.00'	40.55'	Midchannel between north tip of small arm on Willy Island and south channel of Chemainus River
12	53.80'	39.95'	500 m. north of southern end of Willy Island
13	53.85'	39.35'	500 m. from southern tip of Willy Island (large dead tree)

APPENDIX I (Cont'd)

MARINE SAMPLE STATIONS - LOCATIONS AND DESCRIPTIONS

SAMPLE STATION	LATITUDE (48° NORTH)	LONGITUDE (123° WEST)	LOCATION
14	53.60'	39.60'	Midway between end of Willy Island peninsula and north end of Island 115
15	53.45'	39.40'	Off trespassing sign - 200 m. from north end of Island 115
16	53.35'	39.25'	Between Islands 115 and 100
17	53.00'	39.00'	100 m. offshore of green sheds (Island 90)
18	53.25'	38.75'	Midway between Island 90 and southern tip of Island 105
19	53.35'	38.70'	Offshore of Island 105
20	52.90'	38.80'	Off S.E. end of seawall, where road comes down hill
21	53.10'	38.55'	At northern tip of Island 60
22	53.20'	38.50'	Midway between Islands 105 and 115
23	53.10'	38.25'	Southeastern tip of 115 (off shucking plant)
24	53.00'	38.20'	Off shucking plant n.w. of Island 80 (opposite side of station 13)
25	52.95'	37.95'	Northern tip of Island 80
26	52.90'	38.60'	Off point of land south of south sewer from tank at BCFP mill
27	52.60'	38.50'	Off log dump north of BCFP woodmill
28	52.60'	38.30'	Outside logboom 500 m. offshore of BCFP woodmill
29	52.55'	38.40'	Middle of BCFP terminal area
30	52.45'	38.45'	Off "Limit of Dredging" sign at BCFP #2 dock

APPENDIX I (Cont'd)

MARINE SAMPLE STATIONS - LOCATIONS AND DESCRIPTIONS

SAMPLE STATION	LATITUDE (48° NORTH)	LONGITUDE (123° WEST)	LOCATION
31	52.30'	38.35'	BCFP #3 dock at end of walkway
32	52.65'	38.05'	Osborn Bay, midchannel between beacon and mill
33	52.70'	37.50'	S.E. of Beacon off Island 80, Osborn Bay
34	52.30'	37.70'	Middle of Osborn Bay
35	51.85'	38.10'	Old ferry slip south of government float
36	51.80'	37.90'	Off pair of dolphins S.E. of old ferry slip
37	51.80'	37.50'	Off green house with large lawn, Osborn Bay
38	51.75'	37.10'	Near Sherard Point, off brown house with big windows
39	51.45'	36.95'	South of Sherard Point
40	51.85'	35.25'	Midchannel between Sherard Point and Booth Bay in Stuart Channel.
41	52.05'	33.20'	Booth Bay at mouth of Booth Inlet
42	51.70'	33.40'	Booth Bay - 100 m. southwest of old float, off brown house on banks.
43	50.95'	34.80'	Midchannel between Erskine Point and Grave Point, Sansum Narrows N.
44	49.45'	34.70'	Midchannel between Maxwell and Arbutus Points, Sansum Narrows S.
45	47.90'	31.85'	Burgoyne Bay

APPENDIX II

FRESHWATER SAMPLE STATION LOCATION DESCRIPTIONS

APPENDIX II

FRESHWATER SAMPLE STATION LOCATION DESCRIPTIONS

SAMPLE STATION	LOCATION
S1	Chemainus River below bridge on old highway
S2	Bonsall Creek at road to Crofton
S3	Whitehouse Creek at Island Highway
S4	More northerly of 2 small streams on beach at Crofton (front of motel)
S5	More southerly of 2 small streams in Crofton
P1	BCFP sold waste leachate
P2	Woodroom effluent
P3N	North Sewer
P3S	South Sewer
P4	Filter backwash
P5	Woodroom washroom
P6	No. 1 dock lunchroom
P7	No. 2 dock lunchroom
P8	No. 3 dock lunchroom
IP1	Island Processing
IP2	Island Processing
Crofton (T)	Treated (not really) sewage
Crofton (R)	Raw Sewage
Crofton Outfall	

APPENDIX III

OYSTER SAMPLE STATION LOCATION DESCRIPTIONS

APPENDIX III

OYSTER SAMPLE STATION LOCATION DESCRIPTIONS

SAMPLE STATIONS	LATITUDE (N)	LONGITUDE (W)	LOCATION
0-1	48°58.15'	123°36.40'	N. end of Northern Secretary Island
0-2	48°54.45'	123°40.20'	Beach at north end of Willy Island (same as Marine Station 8)
0-3	48°53.85'	123°39.35'	500 m. north of southern tip of Willy Island (same as Marine Station 13)
0-4	48°53.45'	123°39.40'	Off trespassing sign 200 m. from north end of Island 115 (same as Marine Station 15)
0-5	48°53.35'	123°38.70'	Offshore of Island 105 (same as Marine Station 19)
0-6	48°53.30'	123°38.80'	South of Island 90
0-7	48°52.80'	123°37.85'	25 m. N.W. of unmanned Light
0-8	48°51.70'	123°36.90'	Off Sherard Point, almost midway between Marine Stations 38 & 39
0-9	48°52.00'	123°33.00'	Mouth of Booth Inlet
0-10	48°47.45'	123°31.10'	Head of Burgoyne Bay

APPENDIX IV

BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 1 Location Shoal Islands

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 12	0850	0225	1.8	6.5	.2	Nil	29.0	2
		0930	3.6					
14	0955	0405	2.6	6.5	2.3	180°@2	29.0	13
		1055	3.5					
17	1628	1320	3.4	-	26.4	130°@13	-	33
		2110	0.3					
18	1431	1415	3.3	6.0	Nil	260°@4	7.0	79
		2200	0.3					
19	1535	1525	3.2	5.5	Nil	300°@6	28.0	240
		2240	0.3					
21	0928	0700	3.5	6.0	Nil	340°@13	20.0	23
		1235	2.3					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 2 Location South of Bare Point

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 11	1111	0910	3.6	5.5	16	0	14.0	2
		1605	1.7					
12	0900	0225	1.8	6.5	.2	210°@2	29.0	2
		0930	3.6					
14	1010	0405	2.6	6.5	2.3	180°@2	28.5	8
		1055	3.5					
17	1615	1320	3.4	-	26.4	050°@15	-	8
		2110	0.3					
18	1434	1415	3.3	5.0	Nil	210°@11	5.0	63
		2200	0.3					
19	1538	1525	3.2	5.5	Nil	270°@4	16.0	71
		2240	0.3					
21	0924	0700	3.5	5.0	Nil	240°@4	13.0	2
		1235	2.3					
24	1112	0820	3.4	4.5	Nil	249°@6	25.0	5
		1505	1.8					
26	1105	0925	3.3	7.0	Nil	270°@4	28.0	11
		1655	1.5					
27	0951	0950	3.2	2.8	Nil	Nil	31.0	21
		1745	1.3					
28	1055	1005	3.1	6.8	Nil	270°@2	27.5	2
		1825	1.2					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 3 Location 500m off Bare Point

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 11	1110	0910	3.6	6.5	16	310°@4	24.0	2
		1605	1.7					
12	0920	0225	1.8	5.0	.2	210°@4	29.5	8
		0930	3.6					
14	1030	0405	2.6	6.5	2.3	315°@7	29.0	6
		1055	3.5					
17	1557	1320	3.4	-	26.4	100°@9	-	8
		2110	0.3					
18	1425	1415	3.3	6.0	Nil	270°@7	5.0	33
		2200	0.3					
19	1522	1050	2.7	6.0	Nil	210°@4	23.0	33
		1525	3.2					
21	0901	0700	3.5	5.5	NIl	189°@6	22.0	5
		1235	2.3					
24	1046	0820	3.4	5.0	Nil	240°@6	20.0	2
		1505	1.8					
26	1013	0925	3.3	6.0	Nil	240°@2	28.0	2
		1655	1.5					
27	0955	0950	3.2	6.5	NIl	Nil	27.0	4
		1745	1.3					
28	1050	1005	3.1	7.0	Nil	180°@4	27.5	2
		1825	1.2					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 4 Location At closure sign on island #70 of Shoal Islands

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 11	1120	0910	3.6	6.5	16	270°@9	24.0	5
		1605	1.7					
12	0920	0225	1.8	6.0	.2	150°@6	29.0	2
		0930	3.6					
14	1035	0405	2.6	6.5	2.3	120°@6	29.0	5
		1055	3.5					
17	1554	1320	3.4	8.0	26.4	090°@11	28.0	2
		2110	0.3					
18	1421	1415	3.3	7.5	Nil	270°@9	Nil	2
		2200	0.3					
19	1518	1050	2.7	7.5	Nil	300°@4	27.5	5
		1525	3.2					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 5 Location North of Mainguy Island

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 11	1125	0910	3.6	4.0	16	270°@4	11.5	2
		1605	1.7					
12	0905	0225	1.8	6.0	.2	120°@2	29.0	2
		0930	3.6					
14	1010	0405	2.6	6.5	2.3	100°@2	20.0	7
		1055	3.5					
17	1712	1320	3.4	-	26.4	090°@7	-	5
		2110	0.3					
18	1438	1415	3.3	5.0	Nil	110°@2	3.0	22
		2200	0.3					
19	1542	1525	3.2	5.1	NIl	150°@2	3.5	8
		2240	0.3					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 6 Location North end of Mainguy Island

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 11	1135	0910	3.6	4.0	16	220°@2	13.5	2
		1605	1.7					
12	0910	0225	1.8	6.0	.2	130°@2	29.5	8
		0930	3.6					
14	1015	0405	2.6	6.5	2.3	135°@2	28.5	13
		1055	3.5					
17	1607	1320	3.4	4.5	26.4	180°@4	-	23
		2110	0.3					
18	1441	1415	3.3	5.0	Nil	100°@2	1.0	13
		2200	0.3					
19	1545	1525	3.2	5.5	Nil	130°@2	6.0	8
		2240	0.3					
21	0918	0700	3.5	5.0	Nil	120°@2	8.0	5
		1235	2.3					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 7 Location East of Mainguy Island

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 11	1200	0910	3.6	7.0	16	330°@9	24.0	2
		1605	1.7					
12	0930	0225	1.8	6.0	.2	150°@4	28.0	5
		0930	3.6					
14	1040	0405	2.6	6.5	2.3	150°@4	28.0	4
		1055	3.5					
18	1450	1415	3.3	6.0	Nil	090°@4	1.0	46
		2200	0.3					
19	1528	1525	3.2	76.0	Nil	270°@6	10.0	13
		2240	0.3					
21	0907	0700	3.5	5.0	Nil	130°@7	18.5	8
		1235	2.3					
24	1057	0820	3.4	7.0	Nil	210°@9	26.0	2
		1505	1.8					
26	1021	0925	3.3	6.0	Nil	210°@2	24.0	5
		1655	1.5					
27	1003	0950	3.2		Nil	230°@2		5
		1745	1.3					
28	1055	1005	3.1	-	Nil	-	-	2
		1825	1.2					
Feb. 2	1030	1000	2.8	5.5	Nil	-	7.5	33
		1400	3.1					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 8 Location Beach at north end of Willy Island

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 11	1235	0910	3.6	6.5	16	300°@9	25.0	8
		1605	1.7					
12	1145	0930	3.6	6.5	.2	150°@2	28.5	2
		1710	1.4					
14	1105	1055	3.5	7.0	2.3	100°@7	-	2
		1855	0.8					
17	1634	1320	3.4	-	26.4	090°@26	-	2
		2110	0.3					
18	1501	1415	3.3	7.0	-	360°@4	7.0	8
		2200	0.3					
19	1219	1050	2.7	6.5	-	090°@2	18.5	8
		1525	3.2					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 9 Location Willy Island

Date	Sample Time	Tide Conditions Time Ht.	(Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 11	1225	0910	3.6	6.5	79 snow	330°@4	22.0	2
		1605	1.7		8 rain			
12	1150	0930	3.6	7.0	.2	290°@6	28.5	2
		1710	1.4					
14	1100	1055	3.5	7.0	2.3	090°@7	-	11
		1855	0.8					
17	1546	1320	3.4	7.5	26.4	090°@11	28.0	2
		2110	0.3					
18	1415	1415	3.3	8.0	Nil	290°@11	19.0	5
		2200	0.3					
19	1502	1050	2.7	sfc 7.0	Nil	240°@4	sfc 20.0	11
		1525	3.2					
19	1502			2m 7.5	Nil	-	2m 31.0	2
19	1502			3m 7.5	Nil	-	3m 31.5	4

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 10 Location Mouth of Chemainus River

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 12	0935	0930	3.6	5.5	.2	150°@4	32.0	2
		1710	1.4					
14	1055	1055	3.5	6.0	2.3	-	28.5	13
		1855	0.8					
26	1034	0925	3.3	4.0	Nil	Nil	23.5	7
		1655	1.5					
27	0935	0950	3.2	4.5	Nil	-	22.5	5
		1745	1.3					
28	1100	1005	3.1	-	Nil	-	-	2
		1825	1.2					
31	1330	1205	3.1	-	4.3	-	-	49
		2035	8					
Feb. 1				-	Nil	-		8
2	1010	1000	2.8	4.5	Nil	-	7.5	8
		1400	3.1					
3				-	.5	-		7
4	0900	0610	3.4	4.5	trace	-	10.0	5
		1115	2.5					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 11 Location West of Willy Island

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 12	0945	0930	3.6	5.5	.2	090°@2	29.0	5
		1710	1.4					
14	1115	1055	3.5	6.5	2.3	-	28.5	79
		1855	0.8					
17	10	1320	3.4		26.4	300°@6		
		2110	0.3					
26	1043	0925	3.3	5.0	Nil	300°@6	19.0	13
		1655	1.5					
27	0940	0950	3.2	5.0	Nil	-	9.5	8
		1745	1.3					
28	1100	1005	3.1	-	Nil	-	-	5
		1825	1.2					
31	1330	1205	3.1	-	4.3	-	-	4
		2038	.8					
Feb. 1				4.5	Nil	-	13.0	8
2	1000	1000	2.8	-	Nil	-		8
		1400	3.1					
3				-	.5	-		17
4	0910	0610	3.4	6.5	trace	-	26.0	13
		1115	2.5					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 12 Location South end of Willy Island

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 12	1000	0930	3.6	5.5	.2	270°@9	26.0	5
		1710	1.4					
14	1135	1055	3.5	6.5	2.3	130°@6	27.0	13
		1855	0.8					
17	1642	1320	3.4	-	26.4	300°@9	-	5
		2110	0.3					
18	1516	1415	3.3	5.5	Nil	300°@11	1.0	7
		2200	0.3					
19	1601	1525	3.2	5.5	Nil	270°@7	3.0	2
		2240	0.3					
21	0830	0700	3.5	4.5	Nil	210°@2	15.0	4
		1235	2.3					
31				-	4.3	-	-	2
Feb. 1				-	Nil	-	-	2

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 13 Location South of Willy Island

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 11	1240	0910	3.6	6.5	16	300°@6	25.5	2
		1605	1.7					
12	1140	0930	3.6	6.5	.2	140°@4	27.5	2
		1710	1.4					
14	1110	1055	3.5	6.5	2.3	090°@6	-	2
		1855	0.8					
17	1637	1320	3.4	-	26.4	130°@15	-	2
		2110	0.3					
18	1505	1415	3.3	7.5	Nil	240°@9	9.0	6
		2200	0.3					
19	1310	1050	2.7	6.5	Nil	090°@6	20.0	17
		1525	3.2					
28	1120	1005	3.1	6.5	Nil	330°@4	29.0	2
		1825	1.2					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 14 Location Island 115

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 12	1020	0930	3.6	5.5	.2	270°@4	26.5	2
		1710	1.4					
14	1140	1055	3.5	7.0	2.3	090°@9	29.5	130
		1855	0.8					
17	1644	1320	3.4	-	26.4	330°@6	-	11
		2110	0.3					
18	1510	1415	3.3	7.0	Nil	250°@9	8.0	33
		2200	0.3					
19	1557	1525	3.2	7.0	Nil	300°@6	18.0	33
		2240	0.3					
21	0835	0700	3.5	6.0	Nil	210°@7	26.0	2
		1235	2.3					
24	0947	0820	3.4	6.0	Nil	180°@6	23.0	2
		1505	1.8					
26	1122	0935	10.7 3.3 m.	6.5	Nil	270°@6	27.5	2
		1655	4.8 1.5 m.					
27	1020	0950	3.2	6.5	Nil	270°@7	27.0	2
		1745	1.3					
28	1110	1005	3.1	-	-	-	-	8
		1825	1.2					
31	1316	1205	3.1	6.0	4.3	300°@4	29.5	8
		2035	.8					
Feb. 2	1040	1000	2.8	6.0	3.8	-	26.0	2
		1400	3.1					
4	0915	0610	3.4	-	-		-	13
		1115	2.5					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 15 Location Island 115

Date	Sample Time	Tide Conditions Time Ht.	(Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 12	1030	0930	3.6	4.5	.2	210°@4	25.9	13
		1710	1.4					
14	1145	1055	3.5	7.0	2.3	090°@6	27.0	23
		1855	0.8					
18	1522	1415	3.3	6.0	Nil	120°@4	3.5	17
		2200	0.3					
19	1607	1525	3.2	6.0	Nil	300°@4	8.0	33
		2240	0.3					
21	0822	0700	3.5	4.0	Nil	250°@2	18.0	5
		1235	2.3					
24	0959	0820	3.4	4.0	NIl	Nil	17.5	2
		1505	1.8					
27	0950	0950	3.2	6.0	Nil	-	6.5	2
		1745	1.3					
28	1110	1005	3.1	-	Nil	-	-	17
		1835	1.2					
31	1321	1205	3.1	6.0	4.3	300°@2	30.0	2
		2035	.8					
Feb. 1				-	Nil	-	-	33
2	1040	1000	2.8	5.5	Nil	-	24.5	11
		1400	3.1					
3				-	.4	-	-	33
4	0920	0610	3.4	-	trace	-	-	8
		1115	2.5					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 16 Location Island 115

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 12	1040	0930	3.6	5.0	.2	240°@2	24.5	2
		1710	1.4					
14	1150	1055	3.5	6.5	2.3	090°@4	18.0	110
		1855	0.8					
18	1525	1415	3.3	6.0	Nil	100°@4	4.0	23
		2200	0.3					
19	1610	1525	3.2	7.0	NIl	090°@6	18.5	13
		2240	0.3					
21	0816	0700	3.5	5.0	Nil	300°@6	16.5	11
		1235	2.3					
24	1003	0820	3.4	6.5	NIl	090°@6	25.5	2
		1505	1.8					
27	0955	0950	3.2	6.0	N8l	-	7.5	8
		1745	1.3					
28	1110	1005	3.1	-	Nil	-	-	4
		1825	1.2					
31	1326	1205	3.1	6.5	4.3	270°@4	29.5	2
		2035	.8					
Feb. 1				-	NIl	-	-	7
2	1045	1000	2.8	5.5	Nil	-	15	240
		1400	3.1					
4	0920	1610	3.4	-	trace	-	-	17
		1115	2.5					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 17 Location Island 90

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 12	1050	0930	3.6	3.5	.2	180°@4	15.0	130
		1710	1.4					
14	1155	1055	3.5	6.5	2.3	150°@4	28.0	23
		1855	0.8					
18	1532	1415	3.3	6.5	Nil	030°@6	4.5	46
		2200	0.3					
19	1615	1525	3.2	7.0	Nil	270°@5	9.0	70
		2240	0.3					
21	0809	0700	3.5	4.0	Nil	210°@7	15.0	5
		1235	2.3					
24	1010	0820	3.4	5.0	Nil	130°@11	23.0	13
		1505	1.8					
27	1010	0950	3.2	6.0	Nil	-	25.5	2
		1745	1.3					
Feb. 2	1055	1000	2.8	6.0	Nil	-	18.0	110
		1400	3.1					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station : 18 Location Island 90

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 12	1100	0930	3.6	6.0	.2	250°@4	27.0	2
		1710	1.4					
14	1200	1055	3.5	7.0	2.3	090°@7	28.0	6
		1855	0.8					
18	1537	1415	3.3	7.0	Nil	330°@9	10.0	49
		2200	0.3					
19	1619	1525	3.2	6.0	Nil	300°@11	13.0	2
		2240	0.3					
21	0805	0700	3.5	5.5	Nil	270°@7	25.0	2
		1235	2.3					
24	1014	0820	3.4	6.5	Nil	090°@7	26.0	2
		1505	1.8					
27	1000	0950	3.2	7.0	Nil	-	29.0	2
		1745	1.3					
28	1135	1005	3.1	5.5	Nil	300°@4	28.0	8
		1825	1.2					
31	1423	1205	3.1	-	4.3	-	-	2
		2035	.8					
Feb. 1				-	Nil	-	-	4
2	1105	1000	2.8	6.5	Nil	-	27.0	5
		1400	3.1					
3				-	.4	-	-	13

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station : 19		Location Island 105						
Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 11	1255	0910	3.6	6.5	16	270°@7	25.5	2
		1605	1.7					
12	1130	0930	3.6	7.0	.2	210°@13	28.5	2
		1710	1.4					
14	1220	1055	3.5	7.0	2.3	270°@2	28.0	11
		1855	.8					
17	1652	1320	3.4	-	26.4	330°@7	-	33
		2110	0.3					
18	1610	1415	3.3	6.5	Nil	270°@4	7.0	7
		2200	0.3					
19	1646	1525	3.2	7.0	Nil	290°@6	22.0	22
		2240	0.3					
21	0846	0700	3.5	6.0	Nil	210°@11	25.0	7
		1235	2.3					
24	0937	0820	3.4	7.0	Nil	210°@7	27.5	2
		1505	1.8					
25	1119	0850	3.3	7.0	Nil	310°@2	28.0	2
		1610	1.6					
26	1142	0925	3.3	8.0	Nil	270°@6	26.5	2
		1655	1.5					
27	1028	0950	3.2	7.0	Nil	270°@2	28.0	5
		1745	1.3					
28	1125	1005	3.1	6.5	Nil	240°@2	27.0	7
		1925	1.2					
31	1407	1205	3.1	7.0	4.3	300°@2	29.0	2
		2035	.8					
Feb. 3	1013	0545	3.4	7.0	.4	270°@2	27.0	8
		1045	2.7					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station : 20		Location S. end of Seawall						
Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 12	1100	0930	3.6	5.0	.2	210°@9	26.0	13
		1710	1.4					
14	1203	1055	3.5	7.0	2.3	120°@7	28.0	5
		1855	.8					
18	1540	1415	3.3	8.0	Nil	150°@4	17.0	23
		2200	0.3					
19	1622	1525	3.2	7.5	Nil	210°@7	21.0	33
		2240	0.3					
21	0801	0700	3.5	6.0	Nil	240°@2	25.0	11
		1235	2.3					
24	1018	0820	3.4	6.5	Nil	150°@4	27.0	5
		1505	1.8					
25	1056	0850	3.3	4.0	Nil	220°@2	19.0	8
		1610	1.6					
27	1005	0950	3.2	4.5	Nil	-	25.5	14
		1745	1.3					
28	1130	1505	3.1	-	Nil	-	-	5
		1825	1.2					
31	1425	1205	3.1	-	4.3	-	-	2
		2035	.8					
Feb. 2	1110	1000	2.8	6.5	Nil	-	28.0	7
		1400	3.1					
3				-	.4	-	-	5
4	0925	0610	3.4	-	trace	-	-	5
		1115	2.5					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 21 Location Island 60

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 12	1100	0930	3.6	6.0	.2	210°@4	28.0	2
		1710	1.4					
14	1207	1055	3.5	7.0	2.3	090°@6	28.0	13
		1855	0.8					
18	1545	1415	3.3	7.0	Nil	120°@4	6.0	13
		2200	0.3					
19	1626	1525	3.2	7.0	Nil	300°@7	21.0	13
		2240	0.3					
21	0757	0700	3.5	6.0	Nil	210°@2	26.0	5
		1235	2.3					
24	1022	0820	3.4	6.5	Nil	360°@2	27.0	2
		1505	1.8					
25	1107	0850	3.3	6.0	Nil	210°@6	27.0	2
		1610	1.6					
Feb. 2				-	Nil	-	-	2

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station : 22 Location Island 105

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 11	1300	0910	3.6	6.5	16	300°@9	27.0	11
		1605	1.7					
12	1125	0930	3.6	7.0	.2	220°@15	28.5	5
		1710	1.4					
14	1223	1055	3.5	7.0	2.3	210°@2	28.0	23
		1855	0.8					
17	1649	1320	3.4	-	26.4	330°@6	-	13
		2110	0.3					
18	1605	1415	3.3	9.0	Nil	210°@11	14.0	2
		2200	0.3					
19	1744	1525	3.2	6.5	Nil	270°@11	13.5	23
		2240	0.3					
21	0843	0700	3.5	6.0	Nil	270°@9	24.5	14
		1235	2.3					
24	0933	0820	3.4	7.0	Nil	210°@4	27.0	5
		1505	1.8					
25	1124	0850	3.3	7.0	Nil	210°@2	27.0	2
		1610	1.6					
26	1252	0925	3.3	6.5	Nil	210°@2	26.5	2
		1655	1.5					
27	1030	0950	3.2	7.0	Nil	210°@2	28.0	2
		1745	1.3					
28	1135	1005	3.1	6.5	Nil	340°@4	27.0	8
		1825	1.2					
31	1415	1205	3.1	7.0	4.3	270°@4	29.0	2
		2035	.8					
Feb. 3	1018	0545	3.4	6.5	.4	270°@2	25.5	5
		1045	2.7					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 23 Location Island 115

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 11	1305	0910	3.6	6.5	16	030°@6	25.0	4
		1605	1.7					
12	1120	0930	3.6	7.0	.2	220°@9	28.5	13
		1710	1.4					
14	1214	1055	3.5	7.0	2.3	270°@4	28.0	8
		1855	0.8					
17	1658	1320	3.4	-	26.4	300°@9	-	11
		2110	0.3					
18	1600	1415	3.3	8.5	Nil	230°@2	14.0	4
		2200	0.3					
19	1639	1525	3.2	7.0	Nil	270°@11	18.0	8
		2240	0.3					
21	0743	0700	3.5	7.0	Nil	210°@2	27.5	4
		1235	2.3					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 24 Location Island 115

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 12	1115	0930	3.6	6.0	.2	270°@4	27.0	2
		1710	1.4					
14	1211	1055	3.5	7.0	2.3	180°@4	28.0	4
		1855	0.8					
18	1550	1415	3.3	8.5	Nil	100°@2	12.0	9
		2200	0.3					
19	1630	1525	3.2	7.5	Nil	270°@4	25.5	11
		2240	0.3					
21	0752	0700	3.5	6.5	Nil	Nil	33.0	8
		1235	2.3					
24	1026	0820	3.4	7.0	Nil	100°@4	27.0	2
		1505	1.8					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 25 Location Island 80

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 11	1315	0910	3.6	7.0	17	300°@7	32.0	2
		1605	1.7					
12	1210	0930	3.6	7.0	.2	150°@4	28.5	4
		1710	1.4					
14	1229	1055	3.5	7.0	2.3	150°@6	28.0	2
		1855	0.8					
17	1701	1320	3.4	-	26.4	300°@4	-	2
		2110	0.3					
18	1557	1415	3.3	8.5	-	090°@6	24.9	4
		2200	0.3					
19	1636	1525	3.2	7.5	-	240°@6	17.0	4
		2240	0.3					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 26 Location South of South Sewer, BCFP mill

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 27	1020	0950	3.2	6.0	Nil	-	25.0	7
		1745	1.3					
28	1155	1005	3.1	6.5	Nil	270°@9	27.5	14
		1825	1.2					
31	1446	1205	3.1	7.0	4.3	270°@9	28.5	5
		2035	.8					
Feb. 1				-	-	-	-	5
2	1105	1000	2.8	7.0	Nil	270°@9	27.0	8
		1400	3.1					
3	1030	0545	3.4	7.0	.4	330°@6	26.0	5
		1045	2.7					
4	0930	0610	2.5	6.5	trace	090°@4	24.0	70
		1115	3.0					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 27 Location Log dump, BCFP woodmill

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 27	1025	0950	3.2	6.0	Nil	-	27.5	17
		1745	1.3					
28	1200	1005	3.1	6.5	Nil	300°@2	27.0	5
		1825	1.2					
31	1450	1205	3.1	7.0	4.3	050°@2	28.0	33
		2035	.8					
Feb. 1				-	-	-	-	70
2	1125	1000	2.8	7.0	Nil	330°@6	26.5	13
		1400	3.1					
3	1034	0545	3.4	7.0	.4	120°@2	26.0	49
		1045	2.7					
4	0932	0610	2.5	1.0	trace	090°@4	26.5	17
		1115	3.0					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 28 Location Offshore of BCFP Woodmill

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 27	1030	0950	3.2	7.0	Nil	-	30.0	4
		1745	1.3					
28	1203	1005	3.1	7.0	Nil	300°@6	28.5	5
		1825	1.2					
31	1453	1205	3.2	7.0	4.3	210°@6	29.0	2
		2035	.8					
Feb. 1				-	-	-	-	33
2	1128	1000	2.8	7.5	Nil	330°@9	27.5	170
		1400	3.1					
3	1037	0545	3.4	7.0	.4	150°@9	25.5	350
		1045	2.7					
4	0934	0610	2.5	7.0	trace	060°@4	26.5	170
		1115	3.0					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 29 Location BCFP terminal area

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 27	1030	0950	3.2	7.0	Nil	-	29.5	11
		1745	1.3					
28	1205	1005	3.1	7.0	Nil	170°@4	28.5	23
		1825	1.2					
31	1456	1205	3.1	7.0	4.3	240°@2	29.5	920
		2035	.8					
Feb. 1				-	-	-	-	350
2	1130	1000	2.8	7.5	Nil	330°@4	27.5	1600
		1400	3.1					
3	1040	0545	3.4	7.0	.4	120°@7	27.0	140
		1045	2.7					
4	0937	0610	2.5	7.0	trace	090°@4	27.0	79
		1115	3.0					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 30 Location BCFP #2 dock

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 27	1035	0950	3.2	6.0	Nil	-	29.5	7
		1745	1.3					
28	1206	1005	3.1	7.0	Nil	360°@4	28.0	2
		1825	1.2					
31	1500	1205	3.1	7.0	4.3	120°@2	28.5	240
		2035	.8					
Feb. 1				-	-	-	-	17
2	1133	1000	2.8	7.5	Nil	300°@6	27.0	130
		1400	3.1					
3	1042	0545	3.4	7.0	.4	150°@4	26.5	240
		1045	2.7					
4	0939	0610	2.5	7.0	trace	Nil	27.0	17
		1115	3.0					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 31 Location BCFP #3 dock

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 27	1040	0950	3.2	6.0	Nil	-	30.0	23
		1745	1.3					
28	1210	1005	3.1	7.0	Nil	060°@4	28.0	8
		1825	1.2					
31	1505	1205	3.1	7.0	4.3	150°@9	29.5	350
		2035	.8					
Feb. 1				-	-	-	-	9
2	1137	1000	2.8	7 5	Nil	360°@9	27.0	49
		1400	3.1					
3	1046	1045	2.7	7.0	.4	Nil	26.0	27
		1500	3.0					
4	0941	0610	2.5	7.0	trace	300°@4	26.8	23
		1115	3.0					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station : 32 Location Osborn Bay

Date	Sample Time	Tide Conditions Time Ht.	(Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 11	1625	1605	1.7	6.5	16	300°@4	-	5
		2135	2.3					
12	1250	0930	3.6	-	.2	-	-	13
		1710	1.4					
14	1235	1055	3.5	6.5	2.3	220°@6	32.0	14
		1855	0.8					
17	1714	1320	3.4	-	26.4	090°@7	0	5
		2110	0.3					
18	1129	1000	2.9	8.5	Nil	030°@17	29.0	2
		1415	3.3					
19	1732	1525	3.2	7.0	Nil	310°@6	27.0	17
		2240	0.3					
21	0946	0700	3.5	7.0	Nil	300°@22	26.0	2
		1235	2.3					
31	1441	1205	3.1	7.0	4.3	270°@9	29.0	2
		2035	.8					
Feb. 1	1159	0915	2.8	7.5	Nil	300°@7	27.5	49
		1310	3.1					
2	1100	1000	2.8	7.0	Nil	-	27.5	27
		1400	3.1					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 33 Location Island 80

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 11	1330	0910	3.6	7.0	16	240°@4	25.0	2
		1605	1.7					
12	1220	0930	3.6	6.5	.2	205°@9	31.0	2
		1710	1.4					
14	1233	1055	3.5	7.0	2.3	190°@6	28.0	17
		1855	0.8					
17	1711	1320	3.4	-	26.4	090°@9	-	5
		2110	0.3					
18	1405	1000	2.9	8.5	Nil	330°@13	26.0	5
		1415	3.3					
19	1653	1525	3.2	8.0	Nil	210°@4	16.0	5
		2240	0.3					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station : 34 Location Osborn Bay

Date	Sample Time	Tide Conditions Time Ht. (Metres)		Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 11	1630	1605	1.7	-	16	250°@11	-	2
		2135	2.3					
12	1250	0930	3.6	-	.2	4	-	5
		1710	1.4					
14	1238	1055	3.5	6.5	2.3	135°@4	31.0	49
		1855	0.8					
17	1717	1320	3.4		26.4	090°@19	-	13
		2110	0.3					
18	1125	1000	2.9	8.0	Nil	090°@4	29.5	8
		1415	3.3					
19	1728	1525	3.2	7.0	Nil	210°@6	27.0	27
		2240	0.3					
21	0949	0700	3.5	7.0	Nil	190°@4	25.5	5
		1235	2.3					
24	1138	0820	3.4	6.5	Nil	210°@4	27.0	2
		1505	1.8					
25	1247	0850	3.3	6.0	Nil	310°@11	28.0	4
		1610	1.6					
26	1308	0925	3.3	5.5	Nil	180°@4	28.0	2
		1655	1.5					
27	1042	0950	3.2	6.0	Nil	270°@9	27.0	5
		1745	1.3					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 35 Location Old ferry slip

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 21	1156	0700	3.5	7.0	Nil	330°@19	28.5	13
		1235	2.3					
24	1642	1505	1.8	-	Nil	-	-	7
		2040	2.4					
25	1251	0850	3.3	6.0	Nil	330°@9	27.5	2
		1610	1.6					
26	1515	0925	3.3	6.0	Nil	040°@2	28.5	2
		1655	1.5					
27	1045	0950	3.2	6.0	Nil	280°@2	27.5	13
		1745	1.3					
28	0902	0600	2.7	6.0	Nil	180°@2	28.0	2
		1005	3.1					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 36 Location Old ferry slip

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 21	1202	0700	3.5	7.0	Nil	330°@17	30.0	4
		1235	2.3					
24	1642	1505	1.8	-	Nil	-	-	8
		2040	2.4					
25	1255	0850	3.3	6.0	Nil	360°@7	27.0	2
		1610	1.6					
26	1520	0925	3.3	6.0	Nil	060°@4	27.5	7
		1625	1.5					
27	1053	0950	3.2	5.0	Nil	240°@4	28.0	33
		1745	1.3					
28	0905	0600	2.7	6.5	Nil	180°@2	28.0	11
		1005	3.1					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 37 Location Osborn Bay

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 21	1207	0700	3.5	7.0	Nil	360°@11	25.5	2
		1235	2.3					
24	1642	1505	1.8	6.0	Nil	Nil	27.5	2
		2040	2.4					
25	1300	0850	3.3	6.0	Nil	330°@7	27.0	2
		1610	1.6					
26		0925	3.3	6.0	Nil	130°@2	28.0	2
		1625	1.5					
27	1055	0950	3.2	6.0	Nil	330°@2	27.0	21
		1745	1.3					
28	0911	0600	2.7	7.0	Nil	Nil	28.0	5
		1005	3.1					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 38 Location Sherard Point

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 21	1215	0700	3.5	7.0	Nil	330°@13	25.0	2
		1235	2.3					
24	1646	1505	1.8	6.0	Nil	Nil	27.5	2
		2040	2.4					
25	1306	0850	3.3	6.0	Nil	320°@4	27.0	2
		1610	1.6					
26	1530	0925	3.3	5.5	Nil	170°@2	28.0	7
		1625	1.5					
27	1102	0950	3.2	5.5	Nil	330°@2	28.0	11
		1745	1.3					
28	0920	0600	2.7	5.0	Nil	Nil	27.5	2
		1005	3.1					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 39 Location Sherard Point

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 21	1229	0700	3.5	6.5	Nil	330°@11	26.0	5
		1235	2.3					
24	1651	1505	1.8	6.0	Nil	240°@2	27.5	2
		2040	2.4					
25	1312	0850	3.3	5.5	Nil	330°@11	26.5	2
		1610	1.6					
26	1535	0925	3.3	5.5	Nil	230°@4	27.5	17
		1625	1.5					
27	1105	0950	3.2	6.0	Nil	020°@7	28.0	2
		1745	1.3					
28	0925	0600	2.7	5.5	Nil	Nil	27.5	2
		1005	3.1					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 40 Location Stuart Channel

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 11	1555	0910	3.6	6.5	16	Nil	-	2
		1605	1.7					
12	1240	0930	3.6	-	.2	-	-	5
		1710	1.4					
14	1243	1055	3.5	6.5	2.3	070°@6	31.0	2
		1855	0.8					
18	1119	1000	2.9	8.0	Nil	360°@6	30.0	2
		1415	3.3					
19	1658	1525	3.2	7.0	Nil	160°@7	25.0	8
		2240	0.3					
21	1309	0700	3.5	7.0	Nil	330°@20	27.5	2
		1235	2.3					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 41 Location Booth Bay

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 21	1257	0700	3.5	6.5	Nil	030°@7	25.0	8
		1235	2.3					
25	1334	0850	3.3	6.0	Nil	240°22	26.0	2
		1610	1.6					
26	1552	0925	3.3	6.0	Nil	240°@4	28,0	2
		1625	1.5					
27	1120	0950	3.2	6.0	Nil	330°@2	28.0	4
		1745	1.3					
28	0940	0600	2.7	6.0	Nil	310°@2	28.0	2
		1005	3.1					
31	1043	0845	2.9	6.0	4.3	Nil	29.0	2
		1205	3.1					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 42 Location Booth Bay

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 21	1251	0700	3.5	6.0	Nil	270°@7	23.5	17
		1235	2.3					
25	1359	0850	3.3	6.5	Nil	210°@7	27.0	2
		1610	1.6					
26	1548	0925	3.3	6.0	Nil	150°@4	28.0	8
		1625	1.5					
27	1116	0950	3.2	6.0	Nil	270°@7	27.5	2
		1745	1.3					
28	0935	0600	2.7	6.0	Nil	270°@4	27.5	2
		1005	3.1					
31	1037	0845	2.9	6.5	4.3	Nil	27.5	2
		1205	3.1					
Feb. 2	1151	1000	2.8	7.0	Nil	280°@11	27.0	2
		1400	3.1					
4	0917	0610	2.5	7.0	trace	Nil	27.0	2
		1115	3.0					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 43 Location Sansum Narrows, North

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 11	1600	0910	3.6	7.0	16	Nil	-	2
		1605	1.7					
12	1245	0930	3.6	-	.2	-	-	5
		1710	1.4					
14	1247	1055	3.5	6.5	2.3	120°@9	31.0	2
		1855	0.8					
18	1113	1000	2.9	8.0	Nil	120°@11	30.0	8
		1415	3.3					
19	1703	1525	3.2	8.0	Nil	060°@4	29.0	23
		2240	0.3					
21	1231	0700	3.5	6.0	Nil	340°@11	24.0	2
		1235	2.3					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 44 Location Sansum Narrows, South

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 11	1605	0910	3.6	6.5	16	300°@4		2
		1605	1.7					
14	1252	1055	3.5	7.0	2.3	190°@9	28.5	2
		1855	0.8					
18	1106	1000	2.9	7.5	Nil	150°@6	31.0	2
		1415	3.3					
19	1708	1525	3.2	7.5	Nil	360°@7	27.5	8
		2240	0.3					
				5m 7.5	Nil	-	5m 32.0	2
				10m 8.0	Nil	-	10m 32.0	2
21	1236	1700	3.5	6.0	Nil	330°@18	24.0	2
		1235	2.3					
27	1152	0950	10.5	6.0	Nil	240°@6	28.0	2
		1745	4.3					

APPENDIX IV BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR MARINE SAMPLES

Sample Station: 45 Location Burgoyne Bay

Date	Sample Time	Tide Conditions Time	Ht. (Metres)	Water Temp. (°C)	Total Precip. (mm)	Wind (Km/h)	Salinity (ppt)	Fecal coliform MPN/100ml.
Jan. 25	1548	0850	3.3	6.0	Nil	090°@2	28.0	2
		1610	1.6					
26	1611	0925	3.3	7.0	Nil	090°@6	28.5	2
		1625	1.5					
27	1139	0950	3.2	7.0	Nil	240°@6	28.0	2
		1745	1.3					
28	1005	0600	2.7	7.0	Nil	300°@6	28.0	2
		1005	3.1					
31	1105	0845	2.9	6.5	4.3	270°@4	27.5	2
		1205	3.1					
Feb. 1	1310	1310	3.1	7.5	Nil	-	28.0	2
		2110	.7					

APPENDIX V

BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR FRESHWATER SAMPLES

APPENDIX V BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR FRESHWATER SAMPLES

SAMPLE STATION: S1 LOCATION: Chemainus River - below bridge on Island Highway

Date	Sample Time	Water Temp.(C)	Total Precip. (inches)	MF Count per 100 ml Fecal Coliform	MF Count per 100 ml Fecal Streptococci	Flow (m^3/day)	Fecal Coliform/day	Population Equivalent
Jan 13	1340	2.0	.31 inches	11	2	$73.96 \times 10^4 m^3$	8.14×10^{10}	2.5
14	0850	3.0	.09	31	17	no flow info.	no flow info.	
17	1045	4.0	1.04	5	3	$227.04 \times 10^4 m^3$	1.14×10^{11}	3.56
18	1010	5.0	-	-	10	$504.8 \times 10^4 m^3$	-	
19	0945	5.0	-	-	0	$103.2 \times 10^4 m^3$	-	
20	0900	4.0	-	2	2	$73.96 \times 10^4 m^3$	1.48×10^{10}	0.46
21	1050	4.0	-	8	0	$73.96 \times 10^4 m^3$	5.91×10^{10}	1.85
Feb 4			trace	2	-	no flow info.	no flow info.	

Mean of samples = $13.05 m^3$/sec.

Mean of samples =<2.10

APPENDIX V BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR FRESHWATER SAMPLES

SAMPLE STATION: S2 LOCATION: Bonsall Creek at road to Crofton

Date	Sample Time	Water Temp.(C)	Total Precip. (inches)	MF Count per 100 ml Fecal Coliform	MF Count per 100 ml Fecal Streptococci	Flow (m^3/day)	Fecal Coliform/day	Population Equivalent
Jan 13	1455	4.0	.31	190	24	$28.38 \times 10^4 m^3$	5.39×10^{11}	13.72
14	0905	4.0	.09	320	100*	-	no flow info.	
17	1145	6.0	1.04	930*	180*	$15.48 \times 10^4 m^3$	1.44×10^{12}	45.0
18	1045	6.5	-	5500	940	$15.48 \times 10^4 m^3$	8.51×10^{11}	265.94
19	1010	6.0	-	230	20*	$36.12 \times 10^4 m^3$	8.31×10^{11}	25.97
20	0930	5.0	-	120	100*	$15.48 \times 10^4 m^3$	1.86×10^{11}	5.81
21	1110	4.7	-	36	190*	$28.38 \times 10^4 m^3$	1.02×10^{11}	3.19
Feb 3	1200	-	.02	130/130	-	-	no flow info.	
						Mean of flow of 6 samples = $2.7 m^3$/sec.		Mean of P.E. of 6 samples = 59.94

*estimates, i.e. colonies on plate < 20 or >80 (for dilutions)

APPENDIX V BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR FRESHWATER SAMPLES

SAMPLE STATION: S3 LOCATION: Whitehouse Creek at Island Highway

Date	Sample Time	Water Temp.(C)	Total Precip. (inches)	MF Count per 10 ml		Flow (m^3/day)	Fecal Coliform/day	Population Equivalent
				Fecal Coliform	Fecal Streptoccocci			
Jan 13	1435	2.5	.31	50	14	3.87×10^4	1.94×10^{10}	0.61
14	0840	3.5	.09	160*	44	-	no flow info.	
17	1120	5.5	1.04	260	260	4.3×10^4	1.12×10^{11}	3.50
18	1030	6.5	-	7700	855	13.76×10^4	1.06×10^{13}	331.25
19	0930	5.5	-	670	50*	13.76×10^4	9.22×10^{11}	28.81
20	0920	4.2	0	270	10*	4.3×10^4	1.16×10^{11}	3.63
21	1100	4.0	-	90*	30*	3.096×10^4	2.79×10^{10}	0.87
Feb 3	1350	-	.02	920		-	no flow info.	
				540				
4			trace	270		2.58×10^4	6.97×10^{10}	2.18

Mean flow on 7 samples = $0.76 m^3$/sec

Mean P.E. on 7 samples = 52.98

*estimates, i.e. <20 or >80 colonies on plate (for dilutions)

APPENDIX V BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR FRESHWATER SAMPLES

SAMPLE STATION: S4 LOCATION: More northerly of 2 small streams on beach at at Crofton (front of Motel)

Date	Sample Time	Water Temp.(C)	Total Precip. (inches)	MF Count per 10 ml Fecal Coliform	MF Count per 10 ml Fecal Streptoccocci	Flow (m^3/day)	Fecal Coliform/day	Population Equivalent
Jan 13	1520	4.6	.31	2060*	270	0.172×10^4	3.54×10^{10}	1.11
14	0915	5.5	.09	880*	770*	-	no flow info.	
17	1440	8°C	1.04	1780*	530	-	no flow info.	
18			-	1800*	700*	1.204×10^4	2.17×10^{10}	6.78
19	1030	8°C	-	1900*	-	-	no flow info.	
20			-	1300*	180*	0.258×10^4	3.35×10^{11}	1.05
21	1125	6.1	-	5200	260	0.258×10^4	1.34×10^{11}	4.19

Mean flow of 4 samples = $0.055 m^3$/sec.

Mean P.E. of 4 samples = 3.28

*estimates, i.e. < 20 or > 80 colonies on plate (for dilutions)

APPENDIX V BACTERIOLOGICAL ANALYSES RESULTS AND SAMPLING CONDITIONS FOR FRESHWATER SAMPLES

SAMPLE STATION: S5 LOCATION: More southerly of 2 small streams in Crofton

Date	Sample Time	Water Temp.(C)	Total Precip. (inches)	MF Count per 10 ml		Flow (m^3/day)	Fecal Coliform/day	Population Equivalent
				Fecal Coliform	Fecal Streptoccocci			
Jan 13	1525	4.0	.31	400*	-	0.086×10^4	3.44×10	0.11
14	0930	4.5	.09	120*	70*	-	no flow info.	
17	1440	8°C	1.04	230	120*	-	no flow info.	
18			-	430	510	0.258×10^4	1.11×10	0.03
19	1030	7.5°C	-	90*	10*	-	no flow info.	
20			-	8*	13*	0.034×10^4	2.72×10	0.85×10
21	1125	5.8	-	10	10	0.034×10^4	3.4×10	0.11×10

Mean flow of 7 samples = .012m^3/sec

Mean P.E. = 0.035

*estimates, i.e. <20 or >80 colonies on plate (for dilutions)

APPENDIX VI

THE CROFTON PULP MILL OUTFALL ZONE OF INFLUENCE, JANUARY 1977

by

V. Bradshaw

LIST OF FIGURES

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THE CROFTON PULP MILL OUTFALL ZONE OF INFLUENCE

1 GENERAL OCEANOGRAPHY

In several surveys carried out by Dr. M. Waldichuk during the 1960's for the Fisheries Research Board of Canada, the physical oceanography of Stuart Channel near the Crofton mill was studied.

Tidal currents were found to move along the axis of the channel, setting northwest on the flood and southeast on the ebb, with velocities generally less than 1 knot at all depths. With respect to the Crofton outfal, Waldichuk (1964) pointed out that discharged effluent forms boil when it mixes with seawater at the outfall. Generally, it then sinks in the vicinity of the boil and spreads at a depth of 3-10 meters.

"As effluent leaves the 'boil' in a thin layer at either some subsurface level or on the surface, depending on the density of the surface seawater, it first forms a plume, almost as a smoke plume leaving a stack, and then gradually forms a widening ribbon of effluent. This behavior can be seen in aerial photos of Stuart Channel. With the changing tide, the ribbon of dilute effluent is twisted back into the channel, and depending on the currents at the depth of effluent, it may diffuse throughout the channel on subsequent tides or form only a meandering stream with cells of high concentration of effluent separated by areas of relatively unpolluted seawater."

This pattern of diffusion means that unpolluted seawater and effluent-contaminated seawater are both likely to be found at a given location from time to time, although certainly within close range of the outfall the presence of effluent-contaminated seawater occurs with a higer frequency. In addition, Waldichuk (1964) detected the presence of Kraft Mill Effluent (KME) at a station 550m south east of the

outfall regardless of the state of the tide. Two of the three highest KME levels registered at this station were associated with flooding tides.

Since these early surveys were conducted, other studies have been carried out in an effort to assess the environmental impact of the effluent discharged into Stuart Channel. Numerous parameters have been measured but those we are concerned with here are those which show direct influence of the effluent. We will attempt to define the zone of influence by the effluent.

2 HISTORICAL SIGNIFICANCE

2.1 Zinc

During the period from the first mill start-up in 1958 to some time in 1973, zinc dithionate ZnS_2O_4 was used for brightening groundwood pulp (i.e. mechanically ground). It was discovered in a 1971 study, initiated by the mill after oyster growers in the area expressed their concern, that zinc was accumulating in the shellfish, even in those taken from stations quite remote from the mill. The health or fatness of the oysters, as measured by the Condition Factor (CF)*, was also found to have deteriorated in a strong inverse relationship with the increase of zinc in their tissues. Zinc is numbered amongst those heavy metals that are accumulated by oysters. This has been well demonstrated by Chipman et al (1958) and others.

As reported by Drinnan (1966), there is no accepted injurious or minimum lethal dose of zinc in man or laboratory mammals. He cites Vallee's (1959), figure of 2 mg Zn/Kg body weight, which is approximately 150 mg Zn for man, which would result in a depression of blood count. However, this data is based on the intake of zinc salts. Much of the zinc in oyster meat is probably part of an organic complex. By feeding oysters containing zinc to cats (McFarren 1961), it was found that at least 100 mg Zn/Kg body weight, or approximately 7500mg for man, were required to induce vomiting.

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*CF or Condition Factors is an expression of relative fatness which indicates the volume of meat to the volume of the shell cavity and is calculated according to the method by Quayle (1964):
$CF = \frac{\text{weight of dry meat}}{\text{volume of shell cavity}} \times 1000$; where the volume of the shell cavity is determined from the difference in volume of a whole, closed intact oyster and the volume of the shells after the oyster is shucked.

Although a baseline toxic level has yet to be accepted, it is known that zinc in high concentrations in oysters can be clinically manifested as nausea and vomiting in mammals, and cuases deterioration in oysters. Therefore, there is cause for concern about anthropogenic inputs of zinc into the environment.

Once the Zn-CF relationship was realized, the zinc concentration in oyster meat was used as a reliable indicator of the range of effluent dispersion in Stuart Channel. The net southeasterly movement of water through Sansum Narrows, as predicted by Waldichuk, was confirmed. Oyster meat from stations northwest of the outfall and northeast beyond Houston Passage were of normal ambient or slightly elevated zinc levels while meat from stations in Stuart Channel south and southeast of the outfall had highly elevated zinc concentrations although the oysters were quite distant (3.2 km) from the mill. Table 1 lists the zinc levels obtained in surveys by Dobrocky Seatech (1973-75) and by the Environmental Protection Service (1973 and 1977). These are discussed later in the text.

In 1973, the BCFP Crofton mill switched to a whitening process that releases boron into the environment as sodium metaborate, ($NaBO_2$) from sodium borohydride ($NaBH_4$), rather than zinc.

2.2 Boron

Boron is a major constituent of seawater, present at approximately 3.5 ppm in coastal surface waters. However, it is conceivable that it could have an adverse effect on phytoplankton above this concentration. Boron has been known to have an inhibiting effect on photosynthesis in terrestrial plants at concentrations of 1-4 ppm. Laboratory studies of born uptake in Pacific oysters, reported by Thompson & Davis (J. Water Research Vol. 10), have shown that tissue boron levels approximated the levels found in the water within 36 days of exposure. Following cessation of dosage, tissue boron levels

TABLE 1 A COMPARISON OF ZINC CONCENTRATIONS IN OYSTER MEATS (ppm. dry weight)

Sampling Location	1972	1973	1973	1973	1973	1974	1975	1977
	*	*	May**	Aug**	Nov**	*	*	***
Cardale Pt.	1400	2700	----	----	----	1900	1900	----
North Cove	2100	3300	----	----	----	6100	2900	----
Evening Cove	1800	2900	----	----	----	----	2000	----
Saltair	1600	2700	----	----	----	3200	2400	----
Fernwood Point	----	3500	----	----	----	----	2400	----
Secretary Island	5200	2100	4760	3000	----	4500	2400	3100
Burgoyne	----	6000	6360	4300	4500	10700	5200	----
Tent Island	7900	6100	4600	4100	3800	4100	2500	----
Osborn Bay	8000	8600	----	----	----	11100	5800	----
Booth Bay	9600	9100	10020	8000	11300	11800	8400	----
Mill Beach	19800	1400	8060	16900	12700	0000	9500	4825
North Point of Shoal Island	----	----	6960	5000	6200	----	----	5200
Sherard Point	----	----	7840	9300	6400	----	----	6000
Poirlier Pass	----	----	2080	2300	----	----	----	----
Roxton & Danger Reef	----	----	2920	----	2100	----	----	----
North end of Willy Island	----	----	----	----	----	----	----	4650

* Dobrocky Seatech

** Environmental Protection Service, marine Biological Studies Group

*** E.P.S. Microbiology

returned to background levels by the 71st day of the study thus illustrating both a fairly rapid clearance and no evidence of long term retention. This seemed to indicate that there is no accumulation of boron by the Pacific oyster (Crassostrea gigas) as there is with zinc. Boron emissions from the groundwood pulping process in B.C. coastal mills according to Thompson and Davis are reported to be less than 1 µg/mℓ (ppm). Their results indicated no obvious hazard at this level to oysters.

2.3 Condition Factors

As previously explained, the CF is an expression of the relative fatness of an oyster. The approximate range is from 40 (poor) to 150 (very good). It appears to show annual variation, peaking in the May-July period. In a study reported by Dr. Quayle (1969), it was noted that in water containing a KME concentration of 48-103 ppm, oysters were grown with CF's in the 50-120 range and those grown with no KME present in their environment had CF's in the 120-153 range.

Quayle's data for the 1952-56 period for Ladysmith Harbour showed CF's during the May-July period averaging 117. CF's obtained north and northwest of the Crofton outfall in separate studies reported by Dobrocky Seatech and the Environmental Protection Service during the period from 1970-1973 showed that the condition of the oysters there were comparable to those surveyed by Quayle, i.e., they had CF's generally greater than 120.

Table 2 lists CF's obtained in the area during three different survey program during 1970-1977. The programmes were carried out by Dobrocky Seatech, by the Environmental Proctection Service, and by the Marine Resources Branch, Province of B.C. In general, stations in the north and northwest sections of the sampled area showed no significant changes in CF values, remaining close to 120, which compares favorably with Quayle's data for Ladysmith Harbour during 1952-56 (before mill start-up) of, roughly, 117.

TABLE 2 A COMPARISON OF CROFTON OYSTER CONDITION FACTORS

Direction	Station	1970		1973	1974	1975	1976	1977
from outfall	#'s = Dobrocky STN's	N/A	May*	Aug**	May*	May*	Nov.***	Jan.***
North	25	----	----	----	71	80	----	----
	Poirlier Pass	----	----	183	----	----	----	----
	(23) Secretary Island	----	----	129	132	128	----	----
	(24) Tent Island	143	108	161	121	146	----	----
	16	140	169	----	119	153	----	----
East & South	15	99	171	----	40	99	----	----
	14	93	115	----	54	98	----	----
	12	107	109	----	108	72	----	----
	(11) Booth Bay	69	98	61	----	60	132.68	----
	(7) Burgoyne Bay	106	----	145	50	71	104.80	----
	10	----	----	----	54	103	----	----
	(17) Sherard Point	77	----	93	89	121	----	----
Northwest	22	138	140	----	104	146	----	----
	Boulder Point	----	----	----	----	----	144.34	----
	18	90	82	----	40	60	----	N. end of L337 at 4' level 153.6
	19	65	66	----	42	40	----	S. end of L337 at 8' level 115.4
	BCFP-outfall Beach	50	71	73	----	----	----	S. end of L345 at 4' level 115.4
	20	117	95	----	26	95	----	N. end of L277 at 4' level 89.0
	21	125	159	----	44	57	----	L81 at 4' level 65.4
	North Shoal Island	----	----	133	----	----	----	----
	Shoal Island	----	----	----	----	----	84.86	----

* Dobrocky Seatech 1975
** Marine Resources Branch, Province of B.C., Victoria, B.C.
*** Environmental Protection Service, Marine Biological Studies Group

Stations east and south of the outfall gave oysters with depressed CF's of approximately 80, until 1976 when the CF's from Burgoyne and Booth Bays were 105 and 133 respectively. Stations near the outfall gave oysters with very low CF's of approximately 65, until 1976 when the CF for the Shoal Islands was reported as 85, and when individual leases were surveyed in 1977, most of the CF's obtained were greater than 100. Figure 1 shows the leases that were surveyed at that time by the Maine Resources Branch. The leases with the lowest CF's, and hence the least healthy oysters, were those two closest to the outfall. The others, which in previous years had been approximately 80, gave CF's of approximately 130.

It appears that the condition of oysters in the zone of influence of effluent from the Crofton mill is improving, excepting those extremely close to the outfall, in so far as Condition Factors are concerned.

2.4 Chlorophyll-a

Chlorophyll-a is a standard index for phytoplankton crops. It is a measure of biomass and since it is also an important component of oyster food, any influence mill effluent may have on it would affect oyster growth. Dobrocky Seatech (1973), reported that chlorophyll-a levels at stations ranging in distance from close proximity to the mill outfall, east to Booth Bay, northeast to Houston Passage, and northwest as far as Ladysmith Harbour and Yellow Point, show no significant differences between stations when subjected to statistical Analysis of Variance. This led the authors of that mauscript to conclude that even directly in the outfall boils where high KME values were obtained consistently, there was no affect on chlorophyll-a levels, and that oyster growth via the pathway of the lower levels of the food chain, was not being affected by the effluent from the mill.

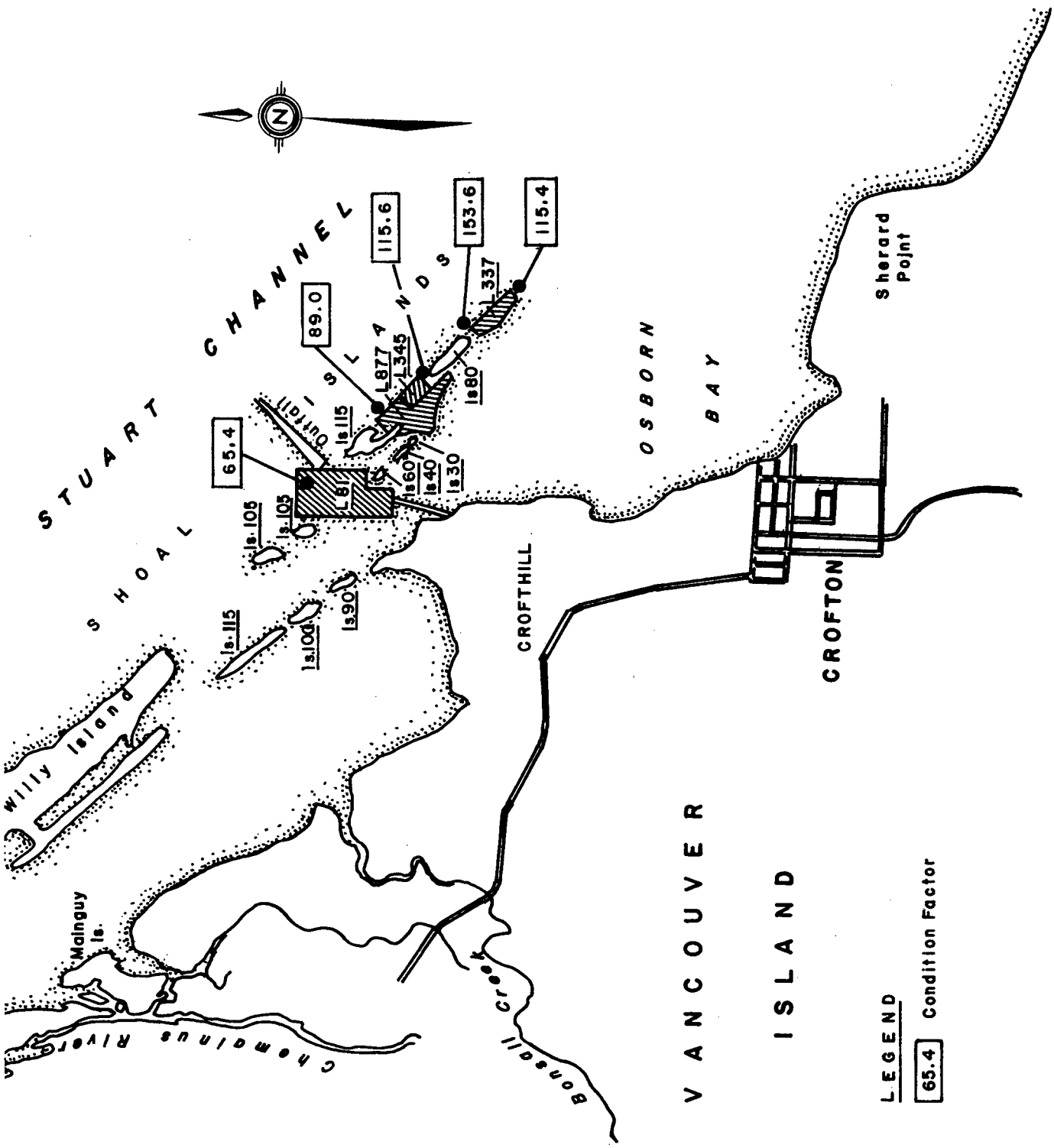

FIGURE 1 CONDITION FACTORS AT CROFTON OYSTER LEASES- January 1977

2.5 Fibre Deposition

Dr. Ellis (1970), as reported by Dobrocky (1974), surveyed the Crofton outfall by using a submersible and utilizing surface-sampling methods. Based on his findings, he reported that a fibre bed extended 1.6-3.2 km to the northwest and southeast of the outfall with the coarse fraction extending to approximately 300 metres offshore (to 45 metres depth). He reported that a coarse fibre bed ranged to 400 metres on each side of the outfall and was 10-15 cm thick. Normal marine life was observed within 1.6 km and also at 90 metres depth off the outfall.

In a subsequent study, reported by Dobrocky (1974), it was found that the fibre bed has laterally extended with the result that the area in which the normal benthic community had depauperized (including a surrounding transition zone), now extended from .8 km to 2 km to either side of the outfall in shallow (22 metres) water and for 300 metres directly offshore in deeper water (93 metres) on a fibre blanket greater than 25 mm thick. The effects include changes in the biomass, density, and diversity of the infauna. However, no tests were done on how this affects the intertidal and shallow subtidal organisms such as oysters. The EPS 1977 Crofton survey observed no noticeable fibre deposition at this level.

Dobrocky (1975), reported that although the fibre depth of the bed is increasing, the horizontal distribution appears stable. Figure 2 is from their report and illustrates the extent on the fibre bed.

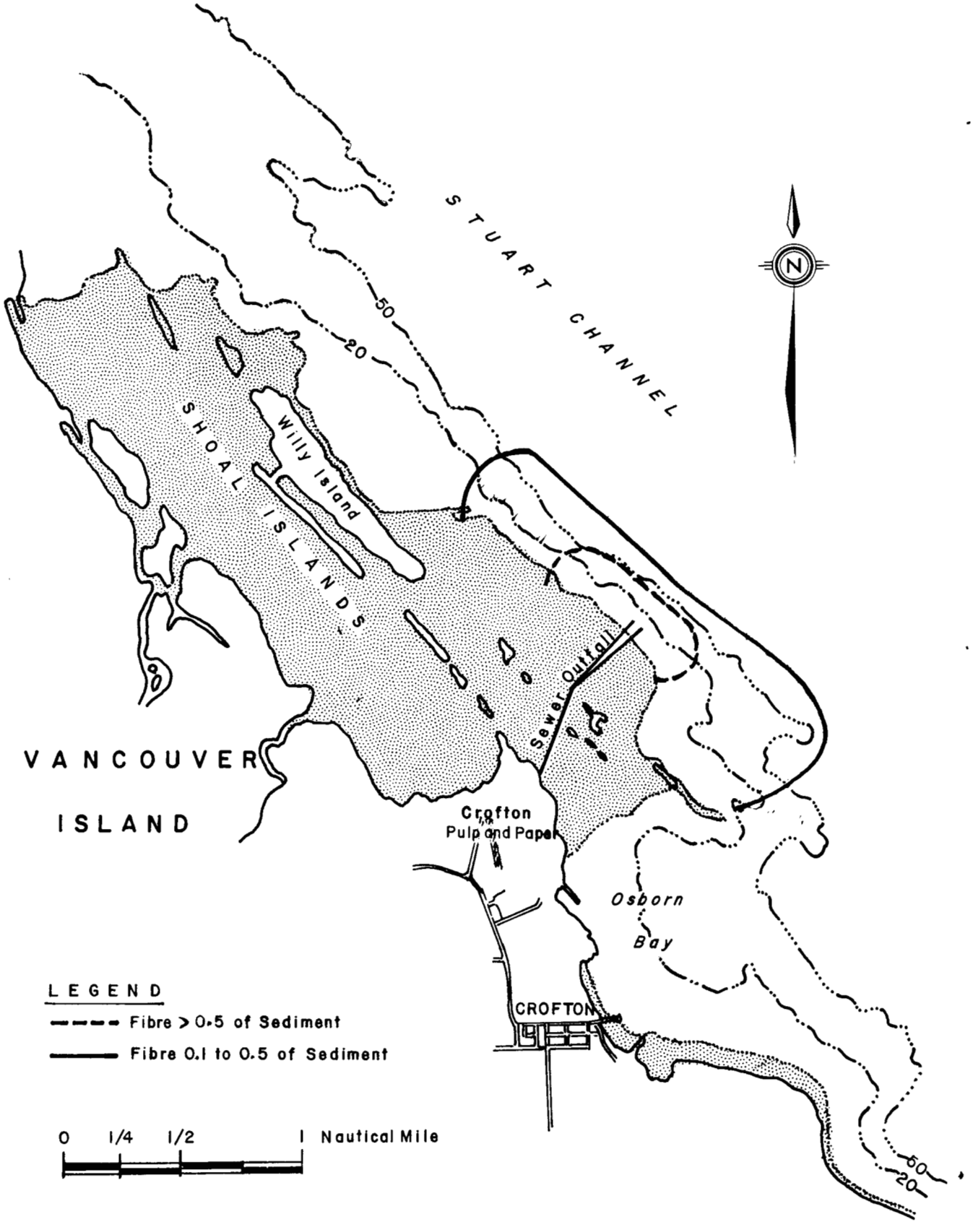

FIGURE 2 DISTRIBUTION OF FIBRE

3 1977 EPS CROFTON SURVEY OYSTER SAMPLING

Oysters were sampled on 3 occasions at the stations shown in Figure 3. Meats were analyzed for concentration of the heavy metals mercury, zinc, and cadmium; and for boron, polychlorinated biphenyls (PCB's), resin acids, and bacteriological (Coliform spp) content. However, not all of the samples were analyzed for all of the above mentioned parameters. Table 3 summarized the analyzes performed and lists the results obtained as of this writing.

3.1 Metals

3.1.1 Mercury. There was no significant difference in the mercury levels obtained from oysters at Station 2 at the north end of Willy Island (where other parameters indicated a lessening of the effects of the mill contamination) compared to the levels found at Station 5 or at Station 8. Station 5 is at the centre of the area known to receive high concentrations of KME whereas Station 8 is far to the south at Sherard Point. There is presently an allowable level of mercury content in oyster meats and fish flesh of 0.5 ppm wet weight. All of the levels found in Crofton area oysters in this survey were well below this level.

3.1.2 Zinc. The 1977 zinc data, when compared with earlier results for stations in the same areas, show that at Station 0-2, zinc concentrations recorded in 1977 of 3100 ppm compare favourably with the zinc levels recorded in oysters taken from what were considered to be uncontaminated areas in Saltair during 1973 and 1975 of 2700 and 2400 ppm respectively.

At Station 0-8 at Sherard Point, the 1977 values for both samplings were 6000 ppm which can be compared with the 1973 values for Sherard Point of 7840, 9300 and 6400 ppm. Osborn Bay values for 1973, 1974, and 1975 were 8600, 11,100 and 5,800 ppm respectively. The Sherard Point values for 1977 may be indicative of some flushing of the zinc from oysters in that area.

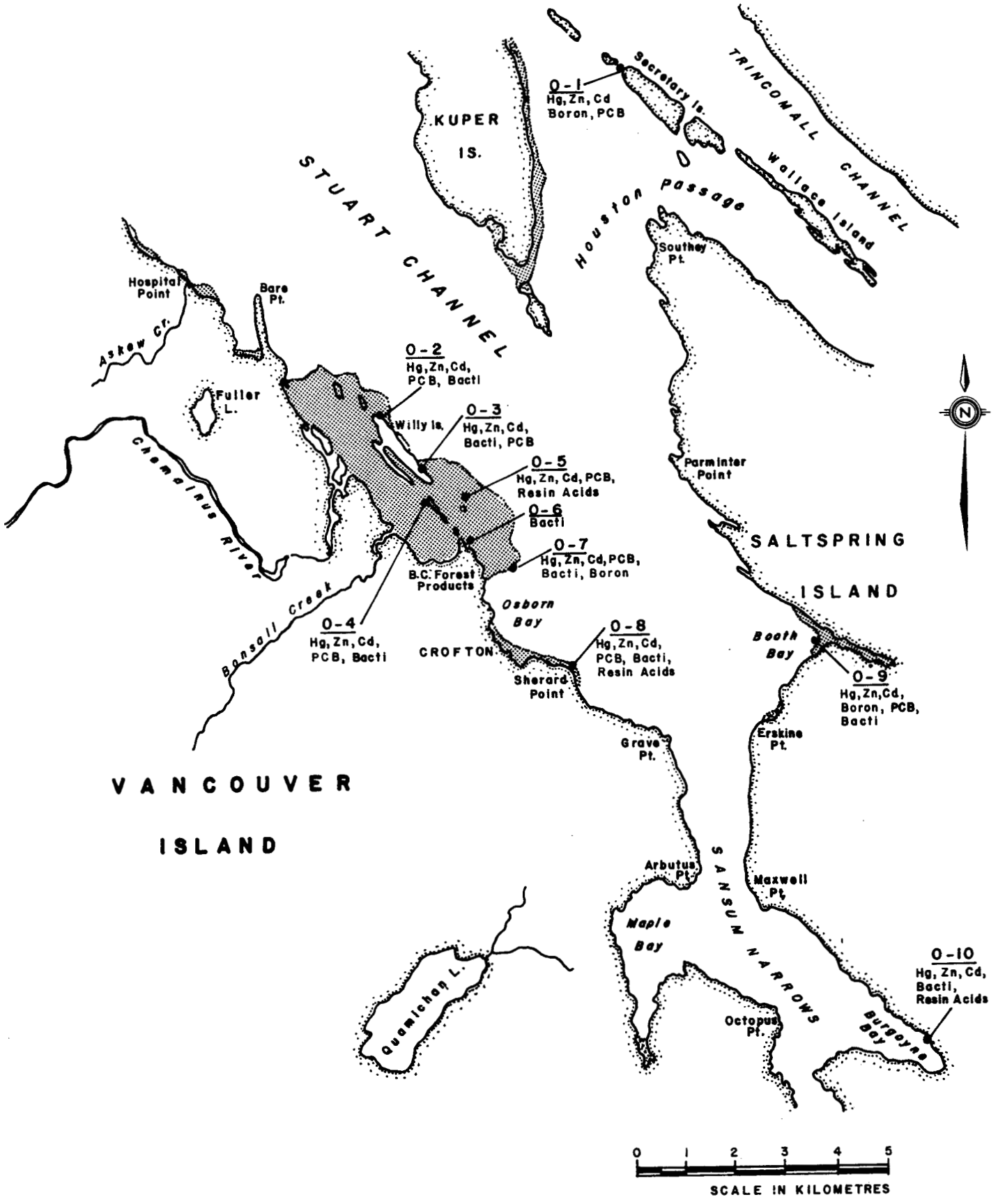

FIGURE 3 CROFTON OYSTER SAMPLE STATIONS AND ANALYSES
January 1977

TABLE 3 CROFTON OYSTER MEAT ANALYSIS JANUARY 1977

Sample Station	1977 Date of Sampling	Rep-li-cate	Mercury Hg (ug/g) wet	Mercury Hg (ug/g) dry	Zinc Zn (ug/g) wet	Zinc Zn (ug/g) dry	Cadmium Cd (ug/g) wet	Cadmium Cd (ug/g) dry	Boron' B(ug/g wet wt.) oyster	Boron' B(ug/g wet wt.) mussel	Polychlor-inated Biphenyls PCB	Bacteriological Analysis S.P.C./ml	Bacteriological Analysis Confirmed coli./100ml	Bacteriological Analysis Fecal Coli. per 100 ml.	Resin Acids
0-1	Jan. 19	A	0.10	0.59	520	3100	1.6	9.4	4.1	2.4	below detection	------	----------	----------	------
		B	0.09	0.54	520	3100	1.4	8.5							
0-2	Jan. 19	A	0.05	0.58	580	6200	1.1	11.0	----------		below detection	------	----------	----------	------
		B	0.06	0.60	620	6300	1.1	11.0							
0-3	Jan.19	A	0.05	0.53	460	5200	0.8	9.1	----------		below detection	------	----------	----------	------
		B	0.05	0.55	467	5200	0.8	9.2							
0-2	Jan. 25		----------		--------		--------		----------		----------	390	1300	50	------
0-4	Jan. 25	A	0.05	0.36	520	4100	0.8	6.0	----------		below detection	350	230	50	------
		B	0.04	0.33	540	4200	0.8	6.0							
0-5	Jan. 25	A	0.05	0.39	570	4300	0.7	5.0	----------		below detection	------	----------	----------	------
		B	0.06	0.40	600	4300	0.7	5.0							
0-6	Jan. 25		----------		--------		----------		----------		--------	850	1300	70	
0-7	Jan. 25	A	0.09	0.39	980	4150	1.0	6.0	4.0	4.0	below detection	------	----------	----------	-----
		B	0.09	0.43	940	4300	1.0	6.0							
0-8	Jan. 25	A	0.08	0.29	880	3200	2.0	6.0	----------		below detection	220	230	20	------
		B	0.10	0.38	860	3200	2.0	7.0							
0-9	Jan. 25	A	0.08	0.34	770	3500	2.0	7.0	4.0		below detection	310	230	230	------
		B	0.07	0.33	730	3300	2.0	7.0							
0-10	Jan. 25	A	0.08	0.40	720	3600	1.0	7.0	----------		----------	260	490	50	------
		B	0.04	0.26	550	3700	1.0	7.0							
0-2	Feb. 1	A	0.05	0.34	450	3100	1.2	8.4	----------		----------	120	1100	70	------
		B	0.06	0.39	460	3100	1.3	8.9							
0-4	Feb. 1		----------		--------		--------		----------		--------	930	3500	20	------
0-5	Feb. 1	A	0.04	0.39	490	5400	0.58	6.4	----------		--------	-------	----------	----------	------
		B	0.03	0.37	480	5300	0.52	6.0							
0-6	Feb. 1		----------		--------		----------		----------		--------	770	330	20	------
0-7	Feb. 1		----------		--------		----------		----------		-------	360	790	130	------
0-8	Feb. 1	A	0.05	0.37	700	6000	1.1	8.4	----------		--------	110	2400	40	------
		B	0.04	0.31	680	5900	1.0	8.6							
0-10	Feb. 1		----------		--------		----------		----------		--------	------	----------	----------	------

' Replicate samples not taken

3.1.3 Cadmium. Cadmium levels in the oyster meats sampled in this survey displayed no obvious overall differences. The levels ranged from 0.52 to 2.0 ppm wet weight, with the higher levels being found far to the northeast of the outfall at Station O-1 as well as far south and southeast at Stations O-8, O-9 and O-10.

3.1.4 PCB's. All PCB levels in the oyster meats were below the detection limit. These analyses were carried out by the British Columbia Ministry of the Environment, Pesticide Analytical Laboratory.

3.1.4 Boron and Resin Acids. Boron levels proved to be of normal ambient levels irregardless of the distance of the sampling site from the outfalls. No resin acids were detected at any of the sample stations.

3.1.6 Bacteriological Criteria. Bacteriological criteria for shucked oysters at the wholesale marketing level are set out in the National Shellfish Sanitation Program Manual of Operations, 1965 Edition. They state as acceptable without question; oyster meats with a fecal coliform density of not more than 230 MPN per 100 grams (ml) and a 35°C standard Plate Count of not more than 500,000 per gram (ml). All of the samples taken from the Crofton area in this survey met these standards and, with the exception of one taken at Booth Bay on January 25, were well below these limits. The Booth Bay area has been sampled more extensively in a Shellfish Growing Water Quality survey of Saltspring Island carried out in the summer of 1977.

4 COLOUR

In the January 1977 EPS survey for bacteriological contamination, samples were also taken for colour analysis. Samples were analyzed in the field using the Helige Aqua Tester, a colour comparator. The same samples were then sent to the EPS laboratory in West Vancouver to be analyzed using the Tristimulus method so that the two systems could be compared.

In the field, the samples were allowed to settle but were not centrifuged because there was no unit available for this. The sample was then compared with standards on the platinum cobalt scale using the Aqua Tester equipped with colour discs in the yellow-brown range. The remainder of the sample was then tested for the presence of KME odour and sent to the laboratory. In the laboratory, the same samples were centrifuged and pH adjustments to 7.6 were made when necessary (most samples had pH's approximating 7.5). A transmission curve from 400 to 700 mu was obtained using a UV-Vis spectrophotometer.

A computer programme then used the trichromatic co-efficients and the % transmission values to calculate the dominant wave-length, % purity, % luminance and the colour. These colour units can be compared to the colour units given by the Aqua Tester; however, the Aqua Tester detection lower limit is 5 units and increases in 5-units increments, whereas in the Tristimulus method, the lower detection unit is 1 and increases in single-unit increments.

Colour was detected as a tristimulus colour value between 1 and 5 at almost all remote stations. Assuming this was the background colour range, then, any colour values greater than 5 could be due to the presence of KME.

Both sets of colour values were plotted on a chart of the study area to determine the pattern of effluent dispersion in Stuart

Channel and Sansum Narrows (Figures 4 and 5). The Hellige results were similar to the tristimulus results but gave a coarser definition of the zone of influence. The pattern indicates that the zone of influence of the effluent is very similar to the pattern demonstrated by the inflated zinc concentrations in oyster meats and depressed CF's. To the north and northwest of the outfall, most colour values were less than 5, with the occasional intrusion of some colour into the seawater at Station 9 and at Station 8. This could perhaps be illustrative of the "ribboning" effect reported by Waldichuk (1964).

West of the effluent outfall amongst the smaller islands of the Shoal Islands group (Island 90, 100, 105, 115; Figure 1), colour values were generally greater than 5, and sometimes greater than 10.

South of the outfall, colour values were almost always greater than 5, and frequently greater than 15. The highest values obtained were 76 and 52, both from directly over the south boil.

The colour value of the North Sewer effluent before dispersion into the sea was 645; that of the South Sewer effluent was 2300.

Further south in Osborn Bay and Sansum Narrows, colour was detected regularly in the 6-10 range.

East of the outfall, in Booth Bay, on Saltspring Island, colour in the 6-10 range was detected.

Tidal influences were not readily apparent in this study. This finding corroborates those of Dobrocky Seatech (1975), and those of Ellis (1972), which stated that colour was detectable in seawater further south of the outfall than to the north of it. Figure 6 is taken from the report prepared by Dr. D.V. Ellis for the Crofton mill and illustrates the position of the effluent field during May 26, 1972.

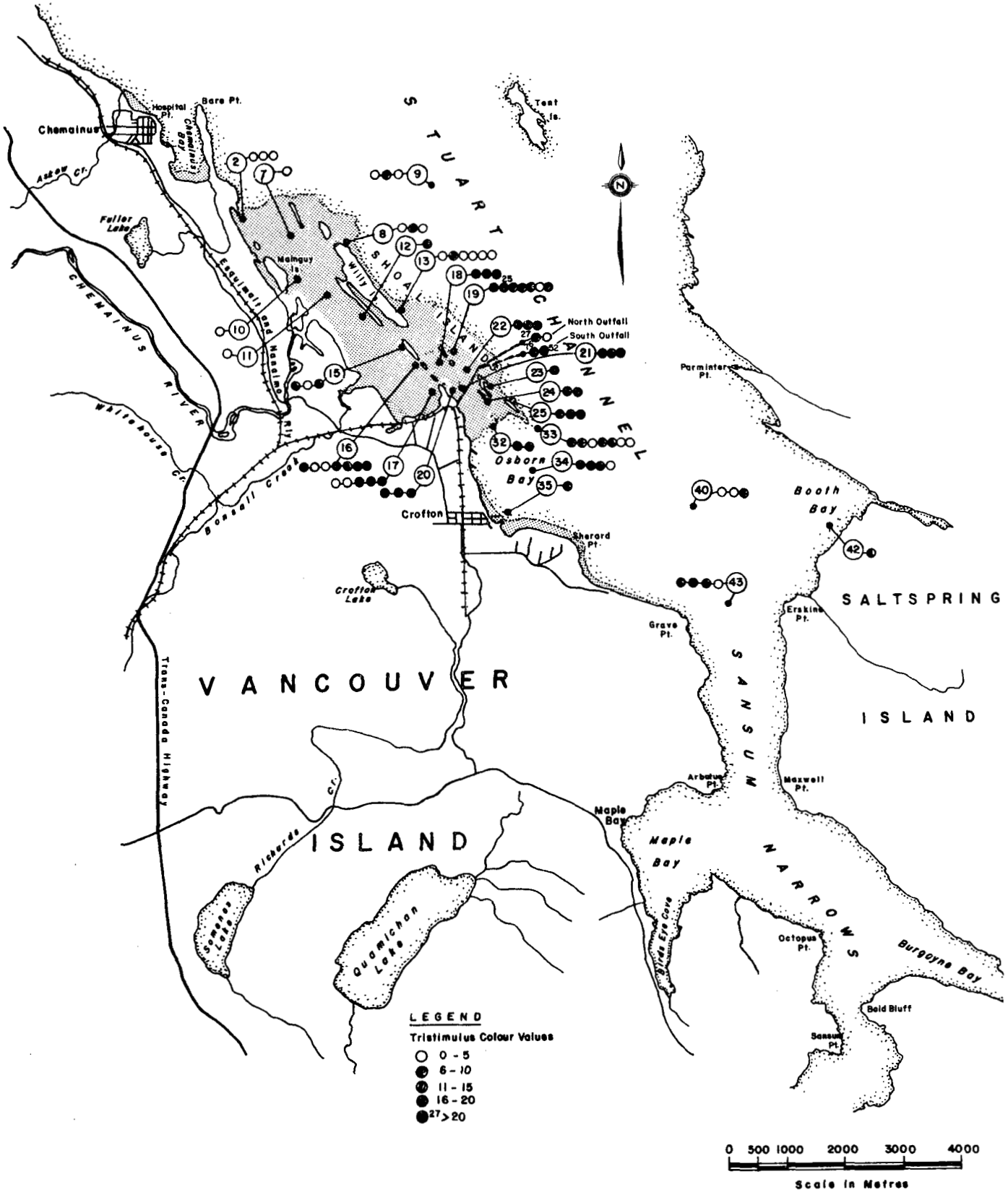

FIGURE 4 TRISTIMULUS COLOUR VALUES

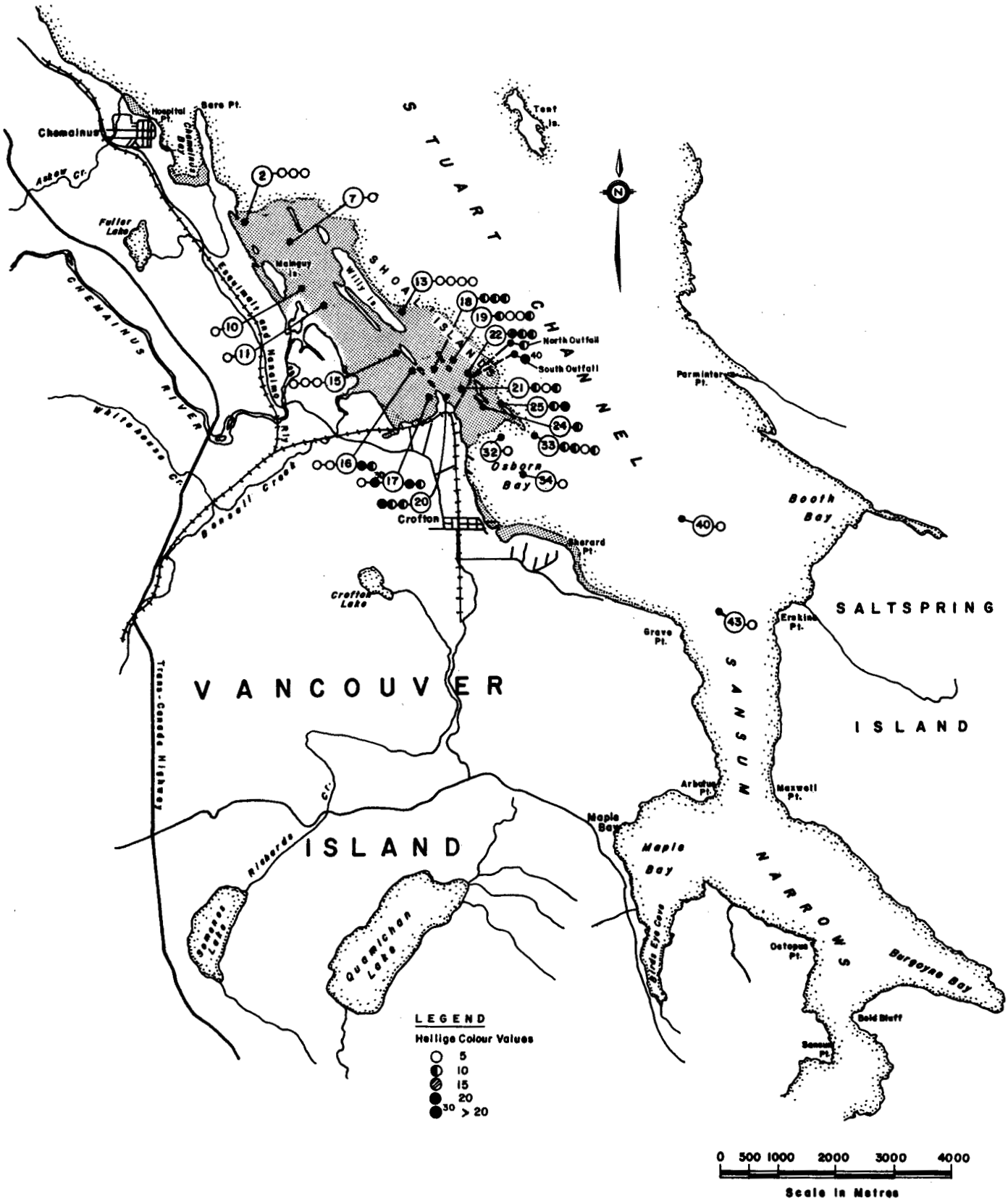

FIGURE 5 HELLIGE COLOUR VALUES

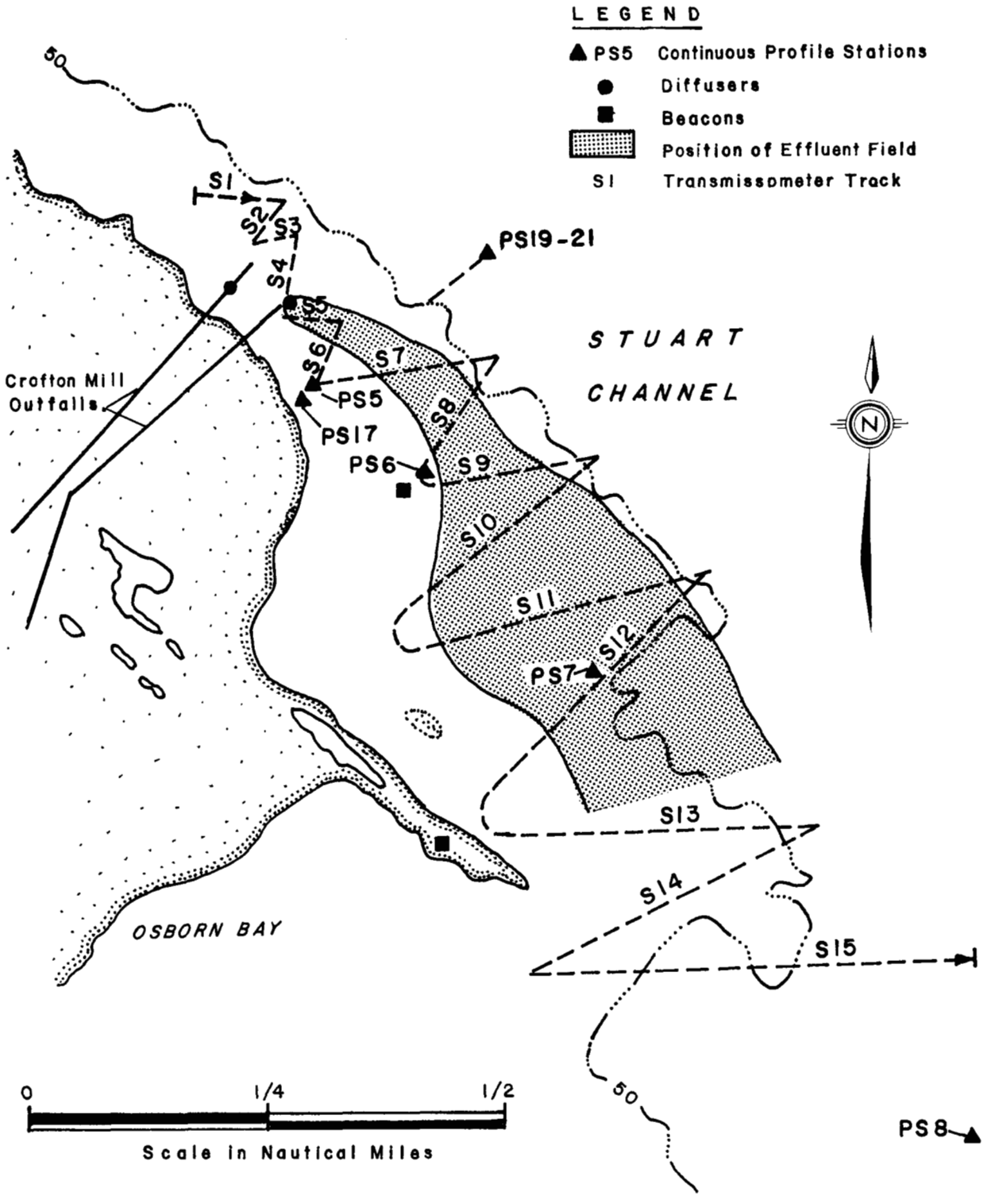

FIGURE 6 POSITION OF EFFLUENT FIELD DURING SURVEY - May 26, 1972

5 ODOUR

Coincidental with the colour evaluations of the Crofton marine samples was an odour evaluation of the identical samples used for colour testing. This was an experiment to determine whether the odour of effluent contaminated seawater would be a reliable indicator of pollution. "Sniff" tests were carried out by first shaking the samples and then trying to determine whether there was any effluent odour. The results were necessarily technician dependent and there could not be a range of odour intensity. A sample was either listed as "odour detectable" or "no odour detectable."

The results (Figure 7) were plotted in a similar manner to those for colour. The pattern that emerges is the same which indicates a net southeasterly movement of water through Sansum Narrows. In general, but not always, the sample with colour values greater than 5 had a detectable odour of KME. A sniff test is not an accurate indicator of colour; where there was colour there was not always odour, but wherever odour was detectable, a tristimulus colour value greater than 5 was obtained.

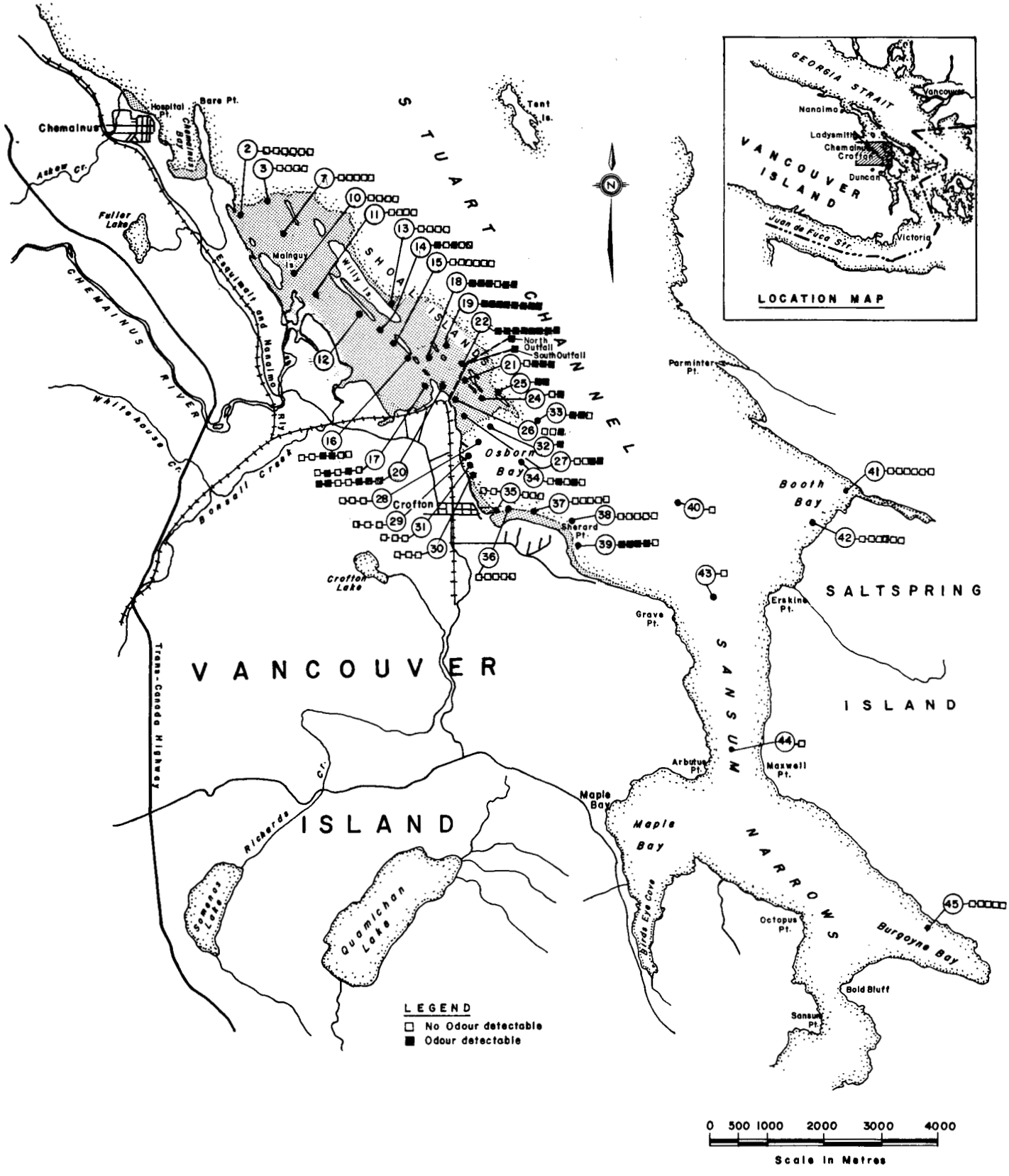

FIGURE 7 KME ODOUR STATIONS

6 SUMMARY

Based on chemical and bacteriological analyses of oyster meats, and on colour and odour testing of the marine receiving waters in the area of the B.C.F.P. Crofton Pulp and Paper Mill outfall, it appears that although the diffusion zone of the mill effluent can be detected as far away as the southerly end of the Sansum Narrows and as far east as Booth Bay, the concentrations of KME at these distant points cannot be said to be hazardous to the health of the shellfish or to man. The deleterious effect that high zinc emissions had previously had on oysters in the area has lessened since the mill switched over to the boron whitening process. Contamination from other heavy metals is also not evident. Coliform contamination of the water and oysters in the area has decreased since the previous survey conducted in 1964.

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