Department of Environment
Environmental Protection Service
Pacific Region

SHELLFISH GROWING WATER SANITARY SURVEY OF THE VANCOUVER ISLAND COASTLINE FROM DUVAL POINT TO FALSE HEAD, INCLUDING HARDY BAY AND BEAVER HARBOUR, BRITISH COLUMBIA, 1978

Regional Program Report: 79-18

by

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ERRATA

Figure 2, page 5. The location of S10 sampling station is incorrect. The correct location is at the mouth of the Quatse River.

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ABSTRACT

A sanitary and bacteriological survey of the bivalve molluscan shellfish growing areas and foreshore from Duval Point to False Head, including Hardy Bay and Beaver Harbour, was conducted between November 20 and December 8, 1978 by personnel of the Environmental Protection Service, Pacific Region.

The bacteriological study was undertaken to evaluate shellfish growing water quality and to assess the adequacy of the two existing Schedule 1 shellfish closures. A sanitary survey was conducted concurrently to identify and evaluate sewage pollution sources to the study area.

During the survey 368 marine and 99 freshwater and effluent samples were collected. A total of 58 marine stations were sampled, and of these, 11 did not meet the shellfish growing water standards.

The survey results indicate that the present Schedule 1 closures 12-1 and 12-3 of Hardy Bay and Beaver Harbour should remain in effect.

RÉSUMÉ

Une étude bactériologique et de salubrité des aires de culture des mollusques bivalves et des crustacés ainsi que des rives s'étendant de Duval Point à False Head, en passant par Hardy Bay et Beaver Harbour, a été menée du 20 novembre au 8 décembre 1978 par le Service de la protection de l'environnement de la région du Pacificque.

L'étude bactériologique avait pour but d'évaluer la qualité des aires de culture des crustacés et de mettre à jour les données concernant les secteurs contaminés, actuellement fermés. Menée simultanément, l'étude de salubrité visait à déterminer et évaluer les sources de pollution que constituent les effluents de la région.

Aux fins de cette étude, on a recueilli 368 échantillons marins et 99 d'eau douce et d'effluents. On a fait ces prélèvements dans 58 stations marines au total. Parmi celles-ci, 11 n'ont pas satisfait aux normes de qualité exigée.

Les conclusions de l'étude démontrent que les secteurs 12-1 et 12-3 de Hardy Bay et Beaver Harbour devraient demeurer fermés.

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CONCLUSIONS

1. Portions of the intertidal areas of Hardy Bay were contaminated with fecal pollution to such an extent that consumption of bivalve molluscan shellfish may pose a health hazard. The contaminated areas included the Quatse River estuary, the public boat moorage area, the receiving waters immediately around the mouth of Stink Creek, and the receiving waters around the mouth of the Tsulquate River. The major identified sources of contamination to Hardy Bay included: discharges from moored boats at the public boat basin and floating homes located on the east side of Hardy Bay; domestic sewage originating from Seafood Products Ltd.; septic tank effluent discharged by Robert Scott Elementary School and teachers' houses; septic tank overflows and/or raw sewage discharges to the boat basin from surrounding homes; urban and uplands runoff in Stink Creek; and sewage effluent discharged by the Tsulquate sewage treatment plant.
2. The District of Port Hardy Tsulquate sewage treatment plant was unable to consistently produce a high quality effluent due to: raw sewage discharge resulting from high influent flows; the discharge of digested sludge through the outfall and, sludge carry-over from the clarifier. The carry-over of biological solids from the clarifier to the final effluent may be caused by the contact stabilization mode of operation, or by denitrification.
3. A dye study conducted on the Tsulquate sewage treatment plant discharge (Appendix VII) indicated that significant intrusion of effluent into the shellfish growing areas at the Tsulquate estuary can occur. The results of this study were supported by the marine bacteriological results.
4. Portions of Storey's Beach and the intertidal waters off the Fort Rupert Indian Reserve in Beaver Harbour were contaminated with fecal pollution to the extent that consumption of bivalve molluscan shellfish may pose a health hazard. The major identified sources of sewage contamination were septic tank seepage from a home on the Indian Reservation and from the Department of Highways workyard.

5. Subsurface septic tank seepage is a possible cause of contamination at Storey's Beach due to the proximity of unsewered homes to the foreshore and the coarse-grained nature of the soil in the area, although no evidence of malfunctioning sewage disposal systems was observed.
6. The discharge of sewage from the District of Port Hardy Airport sewage treatment plant did not impair water quality in the immediate foreshore areas of Beaver Harbour. This plant produced a high quality effluent during this study, although the maintenance of a low MLVSS concentrations in the aeration tank may eventually lead to system failure.
7. Drainage from the Port Hardy Airport (including Keogh River) was not contaminated with fecal material and did not impair receiving water quality.

SCHEDULE 1 CLOSURES

1. The present Schedule 1 Area 12-1 closure of Hardy Bay should remain in effect.

   Retention of this closure is predicated on the observed and/or potential contamination of the major bivalve molluscan shellfish resource areas in the bay.

2. The present Schedule 1 Area 12-3 closure of Beaver Harbour should remain in effect.

   Retention of the closure is predicated on the observed marine contamination presumably arising from unsewered areas in Beaver Harbour.

   Closures are shown in Figure 1.

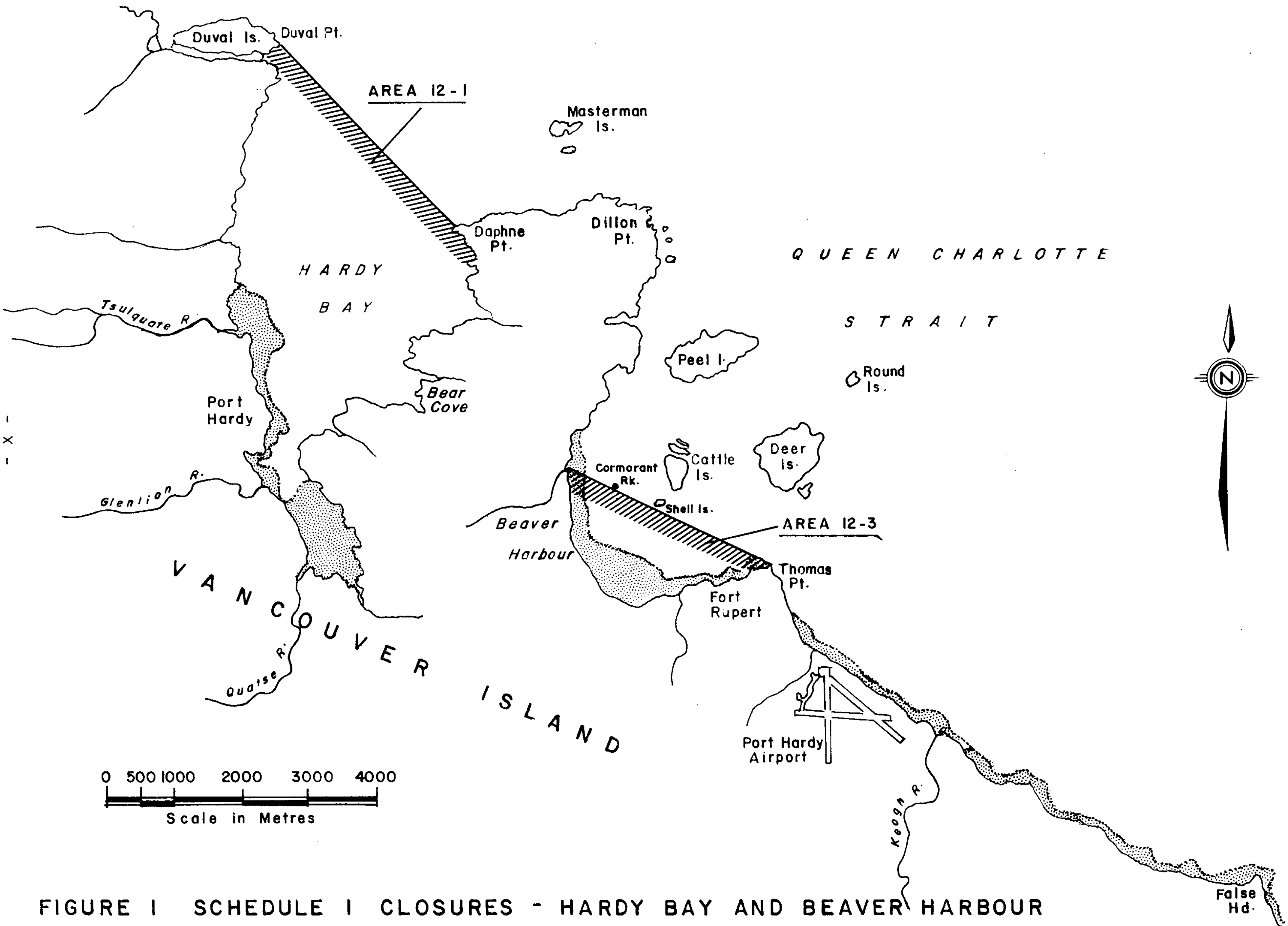

FIGURE I SCHEDULE I CLOSURES - HARDY BAY AND BEAVER HARBOUR

1 INTRODUCTION

Port Hardy, located on the northeast coast of Vancouver Island, is developing into the dominant regional centre for the Northern Vancouver Island and Mid-Coast regions. An excellent discussion of the present and future development plans of the area can be found in the publication Port Hardy Community Plan (1) from which much of the introductory information presented herein was taken.

The Port Hardy area was initially established as a population centre in 1856, when the Hudson's Bay Company situated a trading post at Fort Rupert. The present town centre has been re-located from the original location on the east side of Hardy Bay to the west side, and now serves a population of approximately 3800. Port Hardy experienced a dramatic increase in population in 1971 with the establishment of the Utah Mines Island Copper development beside Rupert Inlet. This mine accounts for 43% of the total employed population.

Forestry is another major activity in the area and the recent Mid-Coast report issued by the B.C. Department of Economic Development states that Port Hardy has the potential to become a main focal point for new economic development in Northern Vancouver Island based largely on forest-related manufacturing and port activities.

The fishing industry is also vital to the economy of Port Hardy, with the Mid-Coast region accounting for 51.4% of the total commercial fish landings (by value).

The shellfish industry has suffered as a consequence of sewage contamination of the major shellfish beds located in the Tsulquate estuary and in Beaver Harbour. Considerable shellfish harvesting was occurring prior to the establishment of Schedule J (now Schedule 1) closures 12-1 and 12-3 in 1971. A total of 28 700 kg of butter clams were harvested from the Tsulquate River estuary in 1969-70.

Shellfish growing water surveys conducted in 1971 and 1972 by the federal Departments of National Health and Welfare, and Environment, concluded that significant bacteriological contamination of shellfish areas was occurring in both Hardy Bay and Beaver Harbour (2, 3).

Sewage contamination in Hardy Bay was attributed to the discharges of raw sewage and septic tank effluent from at least nine outfalls. Other possible pollution sources cited included discharges from fishing and pleasure boats using moorage facilities and septic tank effluent and seepage from the dwellings at the head of Hardy Bay in the Quatse Estuary. Contamination in Beaver Harbour was primarily attributed to direct sewage discharges and sewage contamination of the unnamed creek which flows through the Fort Rupert Indian Reserve into Beaver Harbour. This contamination originated from septic tank seepage from dwellings in the watershed. The report also concluded that sewage discharged to Beaver Harbour via an outfall from the proposed G.M.G. Logging Trailer Park sewage treatment plant could conceivably contaminate the waters in the vicinity of Shell and Cattle islands and cause further deterioration of the foreshore water quality.

As a result of the surveys conducted in 1971 and 1972, it was recommended to retain the Schedule 1 closures 12-1 and 12-3 for Hardy Bay and Beaver Harbour.

Considerable improvement and expansion of the sewage collection and treatment systems serving Hardy Bay and Beaver Harbour has taken place since these surveys were conducted. The town of Port Hardy is served by a trunk sewer on the Hardy Bay Road - Rupert Street Axis and a feeder branch network. Sewage is transported to a secondary treatment plant located on the south side of the Tsulquate River, at its mouth. The treated sewage is discharged through a 30 cm diameter outfall terminating 500 m from shore in 6.1 m of water below zero tide. The plant became fully operational in 1972 and is designed to serve a population of 5000 with provision to expand the plant to serve a population of 10 000. Sewage in portions of the Beaver Harbour area is collected by gravity or is pumped via a force main to a secondary treatment plant on Airport Road. Sewage is discharged through an outfall located northwest of the airport. This system became operational in 1977 resulting in the cessation of the 69 m^3/day sewage discharge from the G.M.G. Logging Trailer Park to Beaver Harbour. Recognizing that these changes to the sewage collection and treatment systems could effect an improvement in shellfish growing water quality, the Environmental Protection Service conducted a bacteriological and sanitary survey of the shellfish growing waters of Hardy Bay and Beaver Harbour, from November 20 to December 8, 1978. The purposes of the survey were to:

1. re-assess the Schedule 1 closure areas following installation of new sewage treatment facilities.
2. evaluate the operational efficiency of the two sewage treatment systems.
3. conduct a comprehensive sanitary survey of Hardy Bay and Beaver Harbour.

2 SAMPLE STATION LOCATIONS

Marine sample stations were located in shellfish growing areas where identified or suspected bacterial pollution sources were observed. The major sampling areas were the Quatse River estuary, the Tsulquate River estuary and the tidal foreshore of Beaver Harbour.

Freshwater sample stations were established on the major rivers, streams and drainage culverts which would be anticipated to have a potential influence on the shellfish growing waters.

Influent and effluent samples were taken at the two sewage treatment plants to assess effluent quality and potential impact on shellfish growing waters.

Sediment and groundwater samples were collected for bacteriological analysis at selected foreshore locations in an attempt to determine the presence of septic tank seepage.

Sample station locations are shown in Figure 2 and a detailed description of both marine and freshwater sample station locations is presented in Appendices I and II respectively.

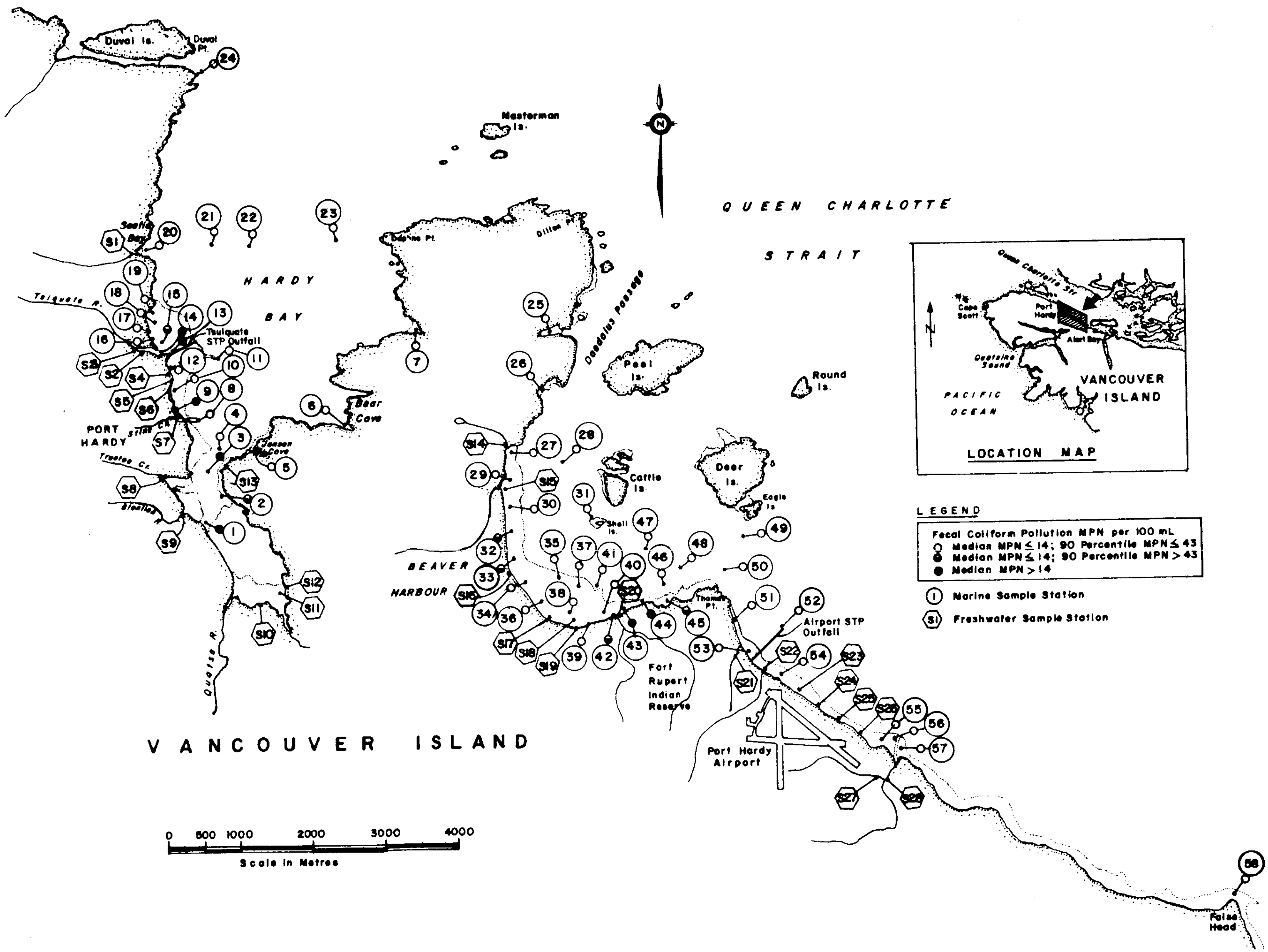

FIGURE 2 MARINE AND FRESHWATER SAMPLE STATION LOCATIONS

3 FIELD PROCEDURES AND METHODS

3.1 Bacteriological Sampling and Analyses

All marine water samples for bacteriological analyses were collected in sterile wide-mouth glass bottles, approximately 15 to 30 cm below the water surface. The water depth at collection points over shellfish beds did not exceed two meters. Samples were collected by boat or on foot. The samples were stored in coolers at temperatures not exceeding 10°C until processed. Analyses were carried out within three hours of collection in the mobile microbiology laboratory of the Environmental Protection Service, located in Port Hardy.

The fecal coliform most probable number (MPN) per 100 ml was determined using the multiple tube fermentation technique (at least three decimal dilutions of five tubes each) as described in Part 407C of the 14th edition of Standard Methods for the Examination of Water and Wastewater (4). The culture medium used was the A-1 medium, as described by Andrews and Presnell (5). This medium and the method described below were accepted by the Canadian government as the method of choice for the enumeration of fecal coliforms in shellfish growing waters, in April 1977. An evaluation of the A-1 medium in the Pacific Region has been done by Kay (6) and the reader is referred to this paper for further information.

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

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

3.2 Physical and Chemical Testing Equipment and Analyses

Temperature measurements on marine and freshwater samples were made using an immersible Celcius thermometer with an accuracy of $\pm$0.5°C. Salinity measurements were made on all marine samples using an American Optical refractometer (Catalogue No. 10413) which has a resolution to the nearest 0.5 part per thousand. Wind speeds and direction were determined with a Telcor series 210 electronic wind speed/direction indicator. Tide data used was that for Port Hardy (Figure 3) and rainfall data was obtained from the Port Hardy Airport (Figure 4). Wind direction data is shown in Figure 5.

All samples for chemical analysis were submitted to the Environmental Protection Service/Fisheries and Marine Service Chemistry Laboratory, Cypress Creek, West Vancouver, and analyzed according to the most recent edition of the EPS/FMS Laboratory Manual (7).

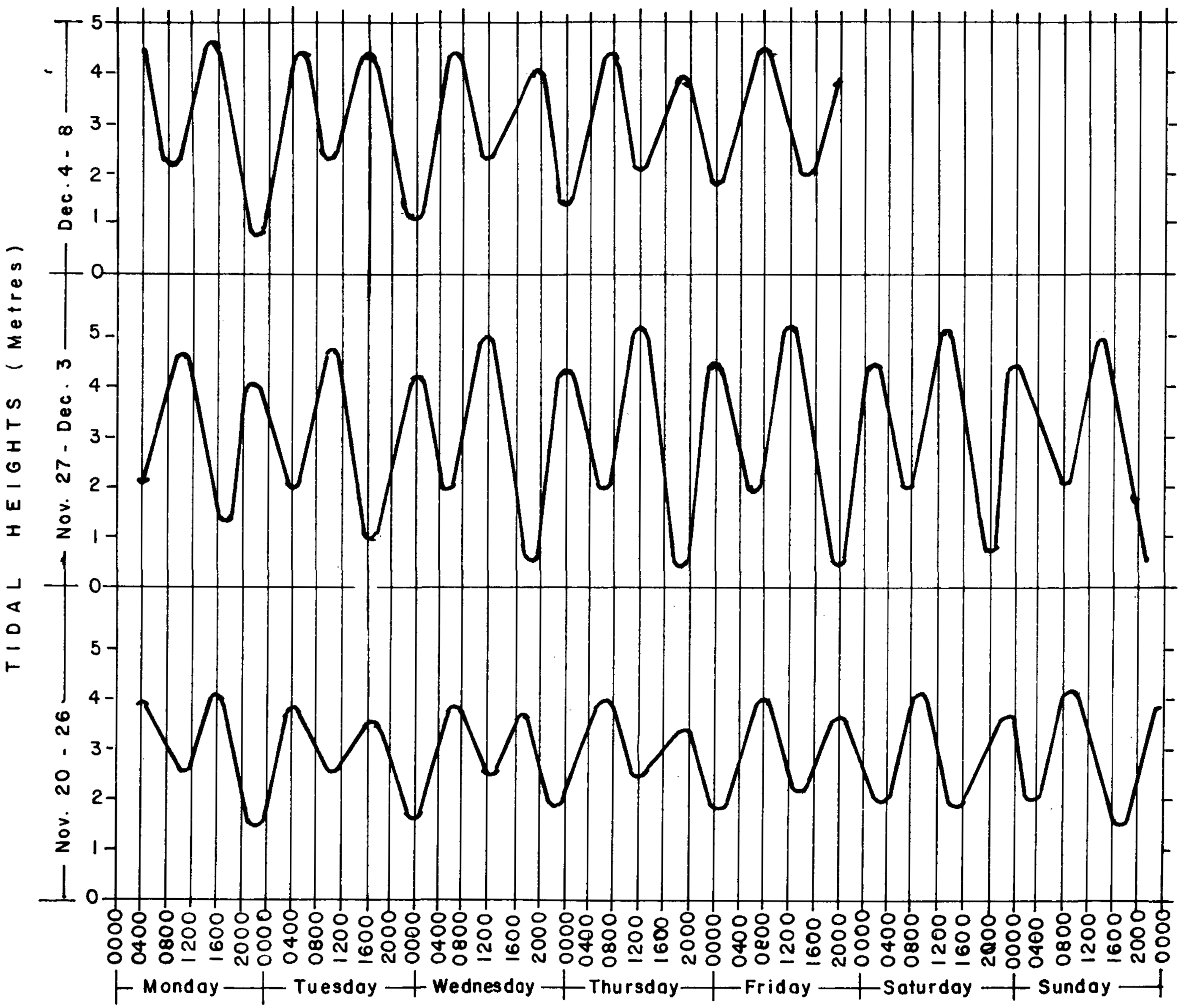

FIGURE 3 TIDAL CYCLE GRAPH, November 20 - December 8, 1978
ALERT BAY

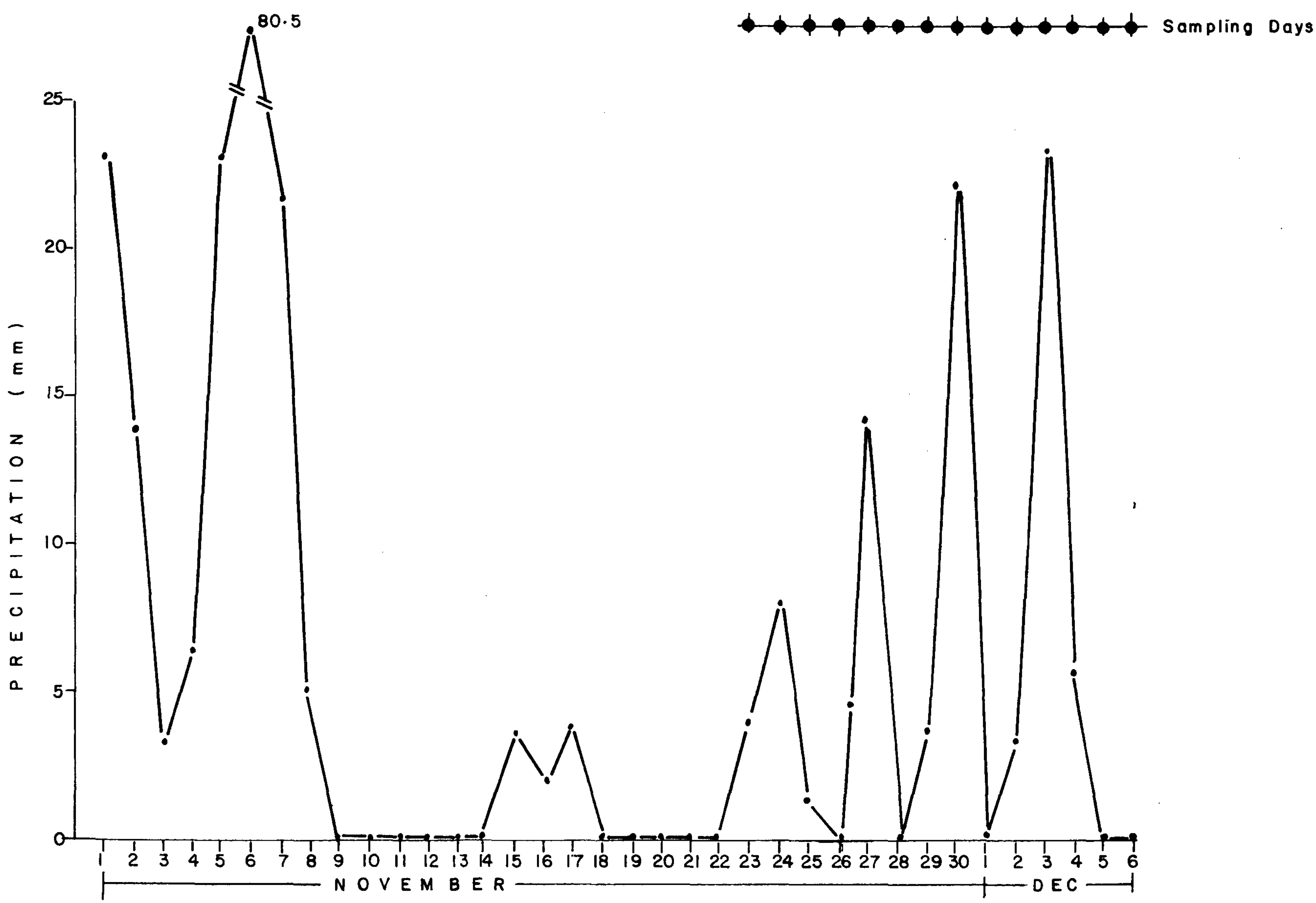

FIGURE 4 PRECIPITATION DURING SURVEY PERIOD - Nov. - Dec. 1978

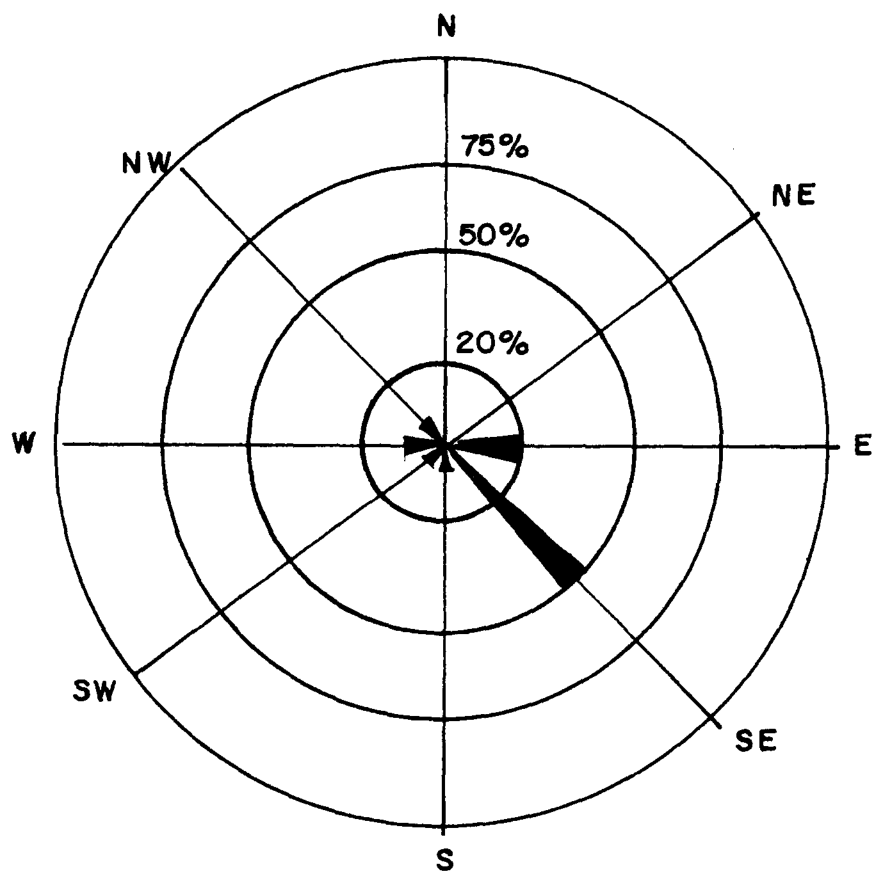

FIGURE 5 WIND DIRECTION ROSETTE - PORT HARDY AIRPORT - November 20 - December 6, 1978

4 RESULTS AND DISCUSSION

Canadian shellfish growing waters are classified according to the following criterion.

> 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*.

Based on this criterion, 11 of the 58 marine sample stations were classified as contaminated. The major sources of contamination encountered during the survey included: the discharge of sewage from the treatment plant located on the Tsulquate River; storm drainage in Stink Creek; boat discharges, septic tank seepage and direct sewage discharges from homes in the vicinity of the government marina (Hardy Bay); septic tank seepage from houses on the Fort Rupert Indian Reserve; and a direct discharge from the Highways Department workyard in Beaver Harbour. The discharge of sewage from the new airport sewage treatment plant did not appreciably impair water quality in the vicinity of the outfall. Marine and freshwater sample station bacteriological summaries are presented in Tables 1 and 2 respectively.

Rainfall during the survey period totalled 86.5 mm compared to 117.4 mm during the same period in the preceeding year; however much of the recorded precipitation in 1977 was in the form of snow (38.3 cm). The total rainfall during November 1978 was 271.4 mm compared with an average historical monthly rainfall of 234.4 mm (8). Thus the rainfall during November 1978 was higher than average. However, this was due

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

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

Station	No. of Samples	MPN Range	MPN per 100 ml	
			Median	90 Percentile
1	9	L2 - 33	17	31.2
2	9	2 - 350	13	64.7
3	9	L2 - 23	17	23
4	9	L2 - 180	7	27.9
5	7	2 - 33	13	21.8
6	6	L2 - 33	L2	16.2
7	6	L2 - 2	L2	L2
8	6	L2 - 8	3	8
9	7	11 - 79	31	72.7
10	8	L2 - 49	14	36.2
11	6	L2 - 8	L2	4.4
12	8	L2 - 33	10.5	33
13	8	L2 - 49	23	49
14	4	13 - 70	19.5	50.8
15	5	8 - 70	11	43.5
16	5	L2 - 33	11	28
17	5	2 - 33	2	20
18	4	2 - 17	3	11.8
19	4	L2 - 8	L2	5.6
20	6	L2 - 13	7	11.8
21	7	L2 - 31	2	12.8
22	7	L2 - 17	L2	6.5
23	6	L2 - 17	L2	8
24	5	L2 - 2	L2	2
25	4	L2 - 11	2.5	8.6
26	5	L2 - 8	L2	5
27	7	L2 - 46	L2	17.3
28	5	L2 - 2	L2	L2
29	8	L2 - 33	2	20.2
30	8	L2 - 33	9.5	17
31	5	L2 - 5	2	3.5
32	8	L2 - 49	6	49
33	8	L2 - 110	6.5	85.2
34	8	L2 - 33	2	17.8
35	5	L2 - 5	2	5
36	7	L2 - 33	5	19
37	6	L2 - 8	5	6.2
38	7	L2 - 13	2	11.6
39	6	L2 - 33	13	33
40	5	2 - 49	14	33

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

Station	No. of Samples	MPN Range	MPN per 100 ml	
			Median	90 Percentile
41	5	L2 - 4	L2	2
42	6	2 - 130	13.5	71.8
43	6	L2 - 350	17.5	153.8
44	5	L2 - 79	49	64
45	6	L2 - 110	3.5	48.2
46	5	L2 - 2	L2	L2
47	5	L2 - 8	L2	6
48	5	L2 - 2	L2	L2
49	4	L2 - 2	L2	2
50	5	L2 - 2	L2	L2
51	5	L2 - 8	L2	5
52	5	L2 - 2	L2	L2
53	5	L2 - 5	L2	3.5
54	4	L2 - 22	3.5	16
55	4	L2 - 4	L2	3.2
56	4	L2 - 11	2	7.4
57	4	L2 - 5	2	3.8
58	4	L2 - 23	L2	14.6

L = "less than"
G = "greater than"

TABLE 2 SUMMARY OF BACTERIOLOGICAL MEMBRANE FILTRATION DATA FOR FRESHWATER SAMPLES

Sample Station	No. of Samples	Total Coliform/100 ml		Fecal Coliform/100 ml		Fecal Streptococci/100 ml		FC:FS Ratio
		Range	Mean	Range	Mean	Range	Mean	
S1	2	3 - 115	59	0 - 4	2	0 - 8	4	0.5
S2	4	L10 - 45	L45	0 - 12	7.3	0 - 38	10	0.73
S3	3	330 - 770	580	33 - 96	68	4 - 59	39.3	1.73
S4	1	33	-	15	-	91	-	0.16
S5	2	7 - 100	53.5	4 - 50	27	30 - 109	69.5	0.38
S6	3	550 - 10 700	5083.3	150 - 1000	663.3	L10 - 1080	543	1.22
S7	3	230 - 7100	G2710	52 - 98	79	8 - 124	54.6	1.44
S8	3	38 - G80	G47.6	15 - 36	25	4 - G80	G34	L0.73
S9	3	1 - 31	18.3	0 - 3	1.3	0 - 0	0	-
S10	3	39 - 54	44.3	4 - 34	17.6	0 - 34	11.6	1.51
S11	3	360 - 900	550	29 - 46	36	L2 - 5	L3.3	G10.9
S12	1	30	-	L10	-	L10	-	-
S13	1	20	-	L10	-	L10	-	-
S14	1	22	-	0	-	0	-	-
S15	4	12 - 140	59	0 - 22	7.5	3 - 13	7.5	1.0
S16	2	11 - 64	37.5	1 - 7	4	2 - 4	3	1.3
S17	3	17 - 330	152.3	6 - 110	40.6	16 - 210	135.3	0.3
S18	3	10 400 - 67 000	31 766.6	1150 - 4100	2616.6	40 - 110	73.3	35.7
S19	3	240 - 730	476.6	0 - 110	52	2 - 40	L17.3	G3
S20	5	27 - G80	G56	10 - 18	13.8	12 - 113	52.2	0.26
S21	2	29 - 75	52	2 - 9	5.5	1 - 16	8.5	0.64
S22	2	23 - 40	31.5	3 - 4	3.5	0 - 11	5.5	0.63
S23	2	5 - G80	G42.5	1 - 1	1	0 - 0	0	-
S24	2	16 - 20	18	0 - 3	1.5	0 - 1	0.5	3
S25	2	30 - 45	37.5	5 - 13	9	0 - 6	3	3
S26	2	7 - 233	120	0 - 10	5	0 - 2	1	5
S27	2	14 - 64	39	5 - 9	7	1 - 5	3	2.3
S28	2	17 - 130	73.5	4 - 20	12	1 - 3	2	6

L = "less than" G = "greater than"

primarily to an extremely heavy rainfall of 80.5 mm which occurred on November 6, well before the start of this study. The precipitation encountered during our survey period could therefore be considered near normal.

Sewage contamination of the marine environment encountered in the study area could not be directly correlated with either precipitation or salinity changes from freshwater sources (using multiple linear regression analysis), one exception being the marine water quality in the vicinity of the Fort Rupert Indian Reserve. However, there was generally good correlation of marine water quality with the location of point and non-point sources of contamination identified during the sanitary survey.

Determination of the source and impact of fecal contamination in the freshwater sources was aided by the use of fecal coliform to fecal streptococci ratios and population equivalents. Membrane filtration fecal streptococci analyses were performed on all freshwater samples in an attempt to determine the origin of fecal contamination observed in the freshwater inputs. Geldreich and Kenner (9) have reported higher fecal streptococci (FS) than fecal coliform (FC) densities in all warm-blooded animal feces except for humans. The FC:FS ratio in humans was 4.4, whereas in other warm-blooded animals the ratio was less than 0.7. The FC:FS ratios were calculated using mean freshwater results and are shown in Table 2.

The concept of population equivalents was used to compare the theoretical relative receiving water impacts of the various freshwater inputs. The population equivalent of a source of fecal contamination was calculated using the average daily per capita value for the fecal coliform contribution to a sewer system. An average person discharges 1.6×10^{11} total coliforms/day and the fecal coliform concentration in domestic sewage has been estimated at 20% of the total concentration (10). This yields a value of 3.2×10^{10} fecal coliforms/person/day. The equation used for calculating population equivalents was:

$$\text{Population Equivalents} = \frac{\text{Fecal coliform discharged per day}}{\text{Fecal coliforms/person/day}} = \frac{\text{Flow} \times \text{fecal coliform concentration}}{3.2 \times 10^{10}}$$

The results of these calculations are shown in Table 3 and will be discussed in subsequent sections.

TABLE 3 MEAN POPULATION EQUIVALENTS FOR FRESHWATER SAMPLE STATIONS

Sample Station	Mean Fecal Coliform/100 ml	Mean Flow (m^3/sec)	Population Equivalents (P.E.)	Percent P.E. of Area
Hardy Bay				
S1	2	0.23	0.012	0.34
S2	7	3.2	0.60	17
S3	68	0.076	0.14	4.0
S4	15	0.0045	0.0018	0.056
S5	27	0.00085	0.00062	0.029
S6	663	0.0048	0.086	2.4
S7	79	0.051	0.11	3.1
S8	25	0.011	0.0074	0.21
S9	1	0.15	0.0074	0.21
S10	18	4.5	2.2	62
S11	36	0.045	0.044	1.2
S12	L10	-	-	-
S13	L10	0.0023	0.00062	0.02
STP (Tsulquate)	1670	0.0070	0.32	9.1
Beaver Harbour				
S14	0	-	-	-
S15	7	0.028	0.0053	0.14
S16	4	0.0037	0.00040	0.01
S17	41	0.048	0.053	1.4
S18	2620	0.011	0.78	21
S19	52	0.0065	0.0091	0.25
S20	14	0.15	0.057	1.5
S21	6	0.15	0.024	0.65
S22	4	0.015	0.0016	0.04
S23	1	0.017	0.00046	0.01
S24	2	0.015	0.00081	0.02
S25	9	0.023	0.0056	0.15
S26	5	0.0082	0.0011	0.03
S27	7	0.15	0.028	0.76
S28	12	1.9	0.62	17
STP (Airport)	12000	0.0065	2.1	57

L = Less than

4.1 Hardy Bay

Twenty-four marine and 13 freshwater sample stations were established in Hardy Bay to assess the shellfish growing water and source(s) of contamination. Seven marine sample stations did not meet acceptable shellfish growing water standards.

4.1.1 Quatse River Estuary. Marine sample stations 1, 2, and 3 located at the head of Hardy Bay near the Quatse River estuary, all exceeded the shellfish growing water standard.

Numerous freshwater inputs were sampled (S8 to S13) however none exhibited exceptionally high bacterial levels.

Of the freshwater inputs to the Quatse estuary area only S11 exhibited a FC:FS ratio of greater than 4.4. This may not be significant due to the low fecal coliform (36 counts/100 ml) and fecal streptococci (less than 3.3 counts/100 ml) levels noted at this station. However, there is a potential human source of fecal pollution in the drainage area. View Construction Company operates a temporary camp just north of Forestry Development Road. Reportedly (11, 12), the septic tank drainage field from this facility is flooded during high tides. In any case, the low levels of contamination noted at S11 indicate that little fecal pollution reaches this stream. The camp was to have been removed by May 1979.

Based upon the population equivalent calculations, the only significant source of fecal pollution to the foreshore waters in the vicinity of the Quatse estuary is the Quatse River (S10). This source contributed 62% of the freshwater stream contamination in Hardy Bay. The bacterial loading from this sample station, however, is influenced more by the high flow than by high bacterial concentrations. During this survey the Quatse River exhibited a mean fecal coliform level of 17.6/100 ml. Monitoring data obtained by the Pollution Control Branch over the last five years indicate that the level was somewhat higher, having a mean fecal coliform MPN of 102.4/100 ml over 14 samples.

Other identified sources of bacteriological contamination to this area included:

a) Float homes. A total of 12 occupied float homes were located on the east side of Hardy Bay from S11 to S13 (Figure 2). It is known that some of the residents utilize on-shore pit privies and other approved sewage disposal methods, but, some do not (11, 12, 13).

b) Anderson's marina: At the time of our study, there were three live-aboard vessels in the marina. In the summer, up to 200 live-aboards may be docked (13). A toilet on a float at the marina appears to discharge raw sewage directly.

c) Raw sewage or septic tank discharges: Seven pipes which extended from land to the foreshore were observed in the area of the boat basin. Of these, two were confirmed as raw sewage or septic tank discharge (greater than 80 000 FC/100 ml and septic waste accumulations), two were suspected discharges and three were indeterminate. Marine samples taken in the boat basin ranged from fecal coliform MPN's of 49/100 ml to 1600/100 ml, with a decreasing pollution gradient towards the boat basin entrance.

d) Seafood Products Ltd. Fish Processing Plant. According to the PCB permit issued for this facility there are two wastewater discharges. These include:

1) an average of 240 m^3/day (52 000 IGPD) of coarse and fine screened fish processing effluent, barometric leg and scrubber water, and refrigeration cooling water, discharged through a 8.6 meter deep (from zero tide) outfall; and,
2) an average of 4.5 m^3/day (1000 IGPD) of septic tank treated domestic sewage, discharged through a 5.6 meter deep outfall.

An inspection of the plant revealed four process effluent discharges through separate outfalls, a septic tank treated domestic wastewater discharge, and two discharges of raw sewage.

e) Robert Scott Elementary School. At the time of this study, septic tank treated domestic wastewater from this school and about six homes in a teachers' residence was discharged at the mouth of Trustee Creek. At the completion of this survey, the septic tank had been removed and the facility connected to the District of Port Hardy's sewerage system.

4.1.2 Port Hardy Townsite - Tsulquate Estuary. Marine sample stations 8-20 and freshwater sample stations S1-S7 were established along the foreshore of the townsite. Marine sample stations 9, 13, 14 and 15 all exceeded the shellfish growing water standard and stations 10, 12 and 16 exhibited borderline bacteriological water quality.

The major freshwater input (in terms of population equivalents) was the Tsulquate River (S2) however once again this was due to its relatively large flow rather than to fecal coliform concentrations (mean FC level of 7.3/100 ml).

Localized contamination of the receiving waters occurred at marine sample stations 9 and 10 as a result of discharges from Stink Creek (S7) and a storm culvert at Central Street (S6). The FC:FS ratios at both stations were indeterminate. Station S6 was the most contaminated of the two with the highest fecal coliform level (1000/100 ml) being recorded on December 3 during 23.2 mm of rainfall. This suggests the contamination observed results from urban runoff.

4.1.2.1 District of Port Hardy Tsulquate sewage treatment plant. The townsite area extending as far south as Trustee Creek is serviced by the Tsulquate sewage treatment plant, which is located at the mouth of the Tsulquate River. This is a secondary type sewage treatment system which features comminution, aeration, clarification, and chlorination. Wasted sludge from the aeration tank is stabilized in an aerobic digestor. Treated effluent is discharged through an outfall terminating 500 meters from shore in 6.4 m of water (below average low water). A more detailed description of the sewage treatment plant and the results of an operational assessment are presented in Appendix VI.

The Tsulquate STP raw sewage influent fecal coliform count was 2.0×10^6 FC/100 ml. The treatment system, including chlorination, effected almost a four log reduction in the fecal coliform levels producing an average final effluent count of 1350 FC/100 ml. (Pollution Control Branch monitoring data collected since 1972, indicates the final effluent has a mean fecal coliform MPN of 1534.9/100 ml over seven samples.) However, the final effluent counts were slightly variable, ranging from less than 19 to 11 000 FC/100 ml. The higher bacterial concentrations were noted during the bypass of raw sewage and the carry-over of biological solids from the clarifier.

The bypass of raw sewage resulted from high influent flows to the STP. These high flows occurred when the Port Hardy swimming pool's filters were backwashed and when high precipitation caused excessive inflow/infiltration into the sewage collection system.

On several occasions bulking sludge was noted in the clarifier resulting in significant suspended solid concentrations in the final effluent (see Appendix VI for a more detailed discussion of this problem). Fecal bacteria associated with these solids are relatively resistant to disinfection.

Float studies conducted during the August 1971 shellfish survey of Hardy Bay, indicated that the sewage plume from the Tsulquate STP discharge would likely move towards shore during a rising tide (2). This information, the apparent inability of the present treatment system to consistently produce a high quality effluent and the absence of other identified pollution sources, suggests that the unacceptable shellfish growing water quality noted at marine sample stations 13, 14, and 15 probably is due to the sewage discharge from the Tsulquate STP.

A dye tracer study was conducted at this plant to better assess the dispersion and dilution characteristics of the effluent plume. The results of this study are presented in Appendix VII.

Based on the bacteriological data, water quality at marine sample stations 17, 18, and 19 was not affected by the discharge of sewage during the survey period.

4.1.2.2 Port Hardy sewage pump stations. There are six sewage pump stations in the District of Port Hardy's Tsulquate STP system. The characteristics of the stations are shown in Table 4. Of these, four have alarm systems to warn of pump failure. All are on line voltage and, therefore, would not be effective in the event of a power outage.

In the event of an overflow, sewage would reach the foreshore directly from the Central Street, Seagate, and Trustee Creek pump stations. No overflows occurred during this survey.

TABLE 4 DISTRICT OF PORT HARDY TSULQUATE STP PUMP STATIONS

Station	Location	Wet Well Capacity* (m^3)	Overflow to	Alarm System
Tsulquate STP - raw sewage	at Tsulquate Indian Reserve	2.7	over manhole	none
Central Street	corner of Central and Market Street	2.9	old outfall at Central Street	warning light
Seagate	at Government Wharf	4.2	overflow to foreshore	warning light
M and B	Glenlion Drive and Rupert Street	0.30	drainage ditch	none
Trailer Park	Cedar Heights Trailer Park	0.30	over manhole	bell
Trustee Creek	Trustee Creek and Hardy Bay Road		at mouth of Trustee Creek	warning light

*maximum capacity to overflow.

4.1.3 B.C. Ferry Corporation - Bear Cove. The new terminal for the B.C. Ferry Prince Rupert run will be moved from Kelsey Bay to Bear Cove. Sewage generated at the terminal will be treated in a septic tank and disposed in an underground tile field on site. This should not be a source of fecal pollution to shellfish growing waters. Marine sample station 6 located in Bear Cove did not exhibit significant fecal coliform levels. Marine sample stations 20-23 were established across the entrance of Hardy Bay to determine the influence of the sewage treatment plant discharge. Fecal coliform levels were generally very low at all stations although occasionally evidence of contamination was detected.

4.2 Beaver Harbour

Marine sample stations 25-50 and freshwater sample stations S14 to S20 were established in Beaver Harbour. Stations 32, 33, 42, 43, 44 and 45 all exceeded the shellfish growing water standards. All other stations were acceptable although there was evidence of fecal contamination at stations 27, 29 and 30. Stations 34, 37, 41 and 46 were positioned along the seaward boundary of the intertidal area and all were well within acceptable limits suggesting the observed contamination originated along the shoreline of the harbour was not introduced from the Airport sewage treatment plant.

With the exception of S18, samples collected from freshwater inputs to Beaver Harbour exhibited low fecal coliform counts. Station 18 was located in a drainage system adjacent to the Department of Highways yard at the corner of Beaver Harbour Road and the Fort Rupert Indian Reserve Road. The drainage at this station was contaminated by a septic tank discharge believed to originate from the house adjacent to the yard (greater than 80 000 FC/100 ml). The Department of Highways' trailers, houses, and yard were to be connected to the District of Port Hardy's sewerage system in early 1979 (15).

The homes adjacent to the foreshore along Beaver Harbour from Fort Rupert Park north (Storey's Beach) are unsewered. Sediment and groundwater samples (Sed #3 and #4, GW #3 and #4 - Appendix I) obtained from the beach in front of these homes did not reveal evidence of septic tank seepage. However, given the proximity of these homes to the foreshore, particularly in the northern section, and the coarse-grained soil in the area, there is a possibility that the contamination noted at marine sample stations 32 and 33 may have been due, at least in part, to subsurface septic seepage contaminating the groundwater.

The Fort Rupert Indian Reserve is unsewered. Septic tank seepage was noted at one home on the lower beach road and a groundwater sample (GW #1) taken on the beach exhibited a count of 460 MPN/100 ml. Given this identified contamination and the possibility of other sources in this area, subsurface septic seepage contaminated groundwater is believed to be responsible for the high fecal coliform levels noted at marine sample stations 42, 43, 44, and 45. Multiple linear regression analysis indicates the poor water quality at these stations is highly correlated with rainfall, suggesting that landwash and/or high water table are responsible, in part, for the high counts observed. A brief study conducted in 1974 by the Pollution Control Branch (16) indicated that the major sources of contamination at that time to Beaver Harbour were the stream draining the trailer park (S18) and the stream passing through the Indian Reserve (S20). The discharge of sewage from the G.M.G. Logging trailer park outfall was not implicated in causing water quality deterioration. Previous investigations (17) revealed the uplands area to be responsible for the contamination observed in the Indian Reserve Creek due to faulty septic tank facilities at homes along the airport road. Since that study the uplands area has been sewered and the bacteriological quality of the creek has improved significantly.

The nature of sewage dispersion and dilution in Beaver Harbour has not been studied. Therefore, it is difficult to predict the cause and effect relationships which may exist in the area. Preliminary float studies conducted by EPS in 1971 (3) suggested that, during the flood tide, a counter-clockwise motion occurred in Beaver Harbour which moved the floats shoreward. Since Beaver Harbour is relatively protected from the open sea, it would be expected that a slow exchange of water would occur resulting in poor dispersion of pollutants. During this survey, the water in the harbour was highly coloured as a result of freshwater discharges to the area, even at stations with high salinities.

4.3 Thomas Point to False Head

Marine sample stations 51-58 were established along this shoreline to assess the impact of the airport sewage treatment plant discharge and the various freshwater inputs (S21-S28). All marine stations were of acceptable quality for the purposes of shellfish harvesting and none of the freshwater inputs were significant sources of contamination. The most "significant" source of contamination to the foreshore was the Airport sewage treatment plant discharge, which accounted for 57% of the total measured fecal coliform input to the area. However, even this source had a population equivalent of only 2.1.

The District of Port Hardy's Airport STP was designed to service the residences along Beaver Harbour and Airport Roads, including the homes and facilities at the Port Hardy Airport. The treatment plant is an extended aeration type secondary system utilizing comminution, aeration, and clarification. The final effluent is discharged through a 650 meter outfall terminating 19 meters below average low water. Reportedly (18), the Port Hardy Airport sewer system is subject to severe inflow/infiltration such that the STP aeration tank and clarifier would be "washed-out" if this section of the system were connected to the influent of the sewage treatment plant. For this reason, the trunk sewer from the Airport system bypasses the STP, and is discharged with the treated final effluent via the outfall. A more detailed description of the airport STP and an operational assessment are included in Appendix VI.

The treatment plant effected a two log reduction in the fecal coliform concentration, producing a final effluent count of 12 000 FC/100 ml. Analysis using the Rawn Palmer model for sewage dispersion indicates that at average low water, the sewage would receive an initial dilution of 516 while rising to the surface. This would result in a 23 FC/100 ml count. Further dilution would occur as the sewage plume moved in response to wind, current, and tidal forces. It is highly unlikely, therefore, that this discharge was responsible for the fecal contamination noted at marine stations 42, 43, 44, and 45, some 2.5 km away from the outfall. Moreover, the water quality adjacent to the outfall at marine stations 51 to 54, was acceptable for shellfish harvesting.

No decision has been made as to the future of the homes on the Port Hardy Airport property. It is anticipated that a new sewage collection system will be constructed should these homes remain in use.

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APPENDIX I

MARINE SAMPLE STATION LOCATION DESCRIPTIONS

APPENDIX I MARINE SAMPLE STATION LOCATION DESCRIPTIONS

Sample Station	Latitude (North)	Longitude (West)	Description
1	50°42.6'	127°29.1'	Off small float at head of navigable portion of Hardy Bay inner harbour.
2	50°42.8'	127°28.8'	At floathouse opposite government docks at east shore of Hardy Bay inner harbour. Near 15 ft dr. rock.
3	50°42.95'	127°29.00'	Inner harbour mid-channel between Esso fuel float and point of land opposite.
4	50°43.1'	127°29.00'	Light at entrance to inner harbour.
5	50°43.25'	127°28.4'	Jensen Cove.
6	50°43.4'	127°27.3'	Southernmost covelet in Bear Cove.
7	50°44.00'	127°26.4'	head of unnamed cove north of Bear Cove on east side of Hardy Bay.
8	50°43.4'	127°29.1'	At seaward end of main government dock.
9	50°43.4'	127°20.4'	Off public library, Port Hardy.
10	50°43.6'	127°29.4'	Off municipal pump station, Port Hardy.
11	50°43.75'	127°28.85'	Off outer harbour light, Hardy Bay.
12	50°43.75'	127°29.45'	Off playground near STP, Hardy Bay.
13	50°43.85'	127°29.4'	Off Tsulquate STP.
14	50°43.85'	127°29.6'	Mouth of Tsulquate River.
15	50°43.9'	127°29.5'	Opposite large metal shed on Tsulquate I.R. on line between point at north end of I.R. bay and Tsulquate Point.
16	50°43.85'	127°26.65'	Off white house with blue trim on I.R.
17	50°44.00'	127°26.7'	North side of I.R. bay.
18	50°44.1'	127°29.6'	opposite car dump on line between Tsulquate Point and the point north of station 19.
19	50°44.15'	127°29.65'	Opposite stream north of I.R.
20	50°44.6'	127°29.8'	Scotia Bay off boat ways. Opposite Hardy Bay from Daphne Point.
21	50°44.6'	127°28.4'	On line between Scotia Bay and Daphne Point where inner and outer harbour markers line up.

APPENDIX I MARINE SAMPLE STATION LOCATION DESCRIPTIONS (Cont.)

Sample Station	Latitude (North)	Longitude (West)	Description
22	50°44.6'	127°28.45'	On line between Scotia Bay and Daphne Point where outer harbour light and government dock line up.
23	50°44.6'	127°27.3'	300 metres off Daphne Point.
24	50°46.00'	127°28.9'	Off fishing marker boundary on Point south of Duval Point.
25	50°44.9'	127°24.85'	Cove by Herald Rock, opposite Peel Island.
26	50°43.5'	127°24.95'	South portion of small bay at northern extremity of Beaver Harbour.
27	50°43.05'	127°25.35'	Off rocks at edge of kelp bed near stream.
28	50°42.95'	127°24.7'	On line between Cormorant Rock and western tip Peel Island opposite channel between the Cattle Islands.
29	50°42.85'	127°25.35'	Off point of land (rock).
30	50°42.65'	127°25.35'	Off new wood house.
31	50°42.55'	127°24.4'	Northwest corner of Shell Island.
32	50°42.45'	127°25.35'	Off house with sloping cedar shingle roof.
33	50°42.25'	127°25.35'	Off old yellow house with green roof behind trees.
34	50°42.05'	127°25.2'	On line with Cormorant Rock and Seven Hills Peninsula at shoreline.
35	50°42.05'	127°24.8'	500 metres off station 36 towards Shell Island.
36	50°41.95'	127°25.00'	Clump of trees off Arena.
37	50°42.00'	127°24.55'	Between station 38 and Shell Island 500 metres offshore.
38	50°41.8'	127°25.00'	Clump of trees off Department of Highways' truck lot.
39	50°41.75'	127°24.4'	Off brown house with yellow trim.
40	50°41.8'	127°24.3'	Off rock west of cemetery.
41	50°42.00'	127°24.4'	Opposite large water tower at edge of tidal flats.
42	50°41.8'	127°24.2'	Off green house, last on west.
43	50°41.85'	127°24.1'	Off dilapidated white house with twin gables.
44	50°41.9'	127°23.8'	Off white house in first small bay north of main settlement.
45	50°41.9'	127°23.5'	Off rocky projection in first bay north of station 44.

APPENDIX I MARINE SAMPLE STATION LOCATION DESCRIPTIONS (Cont.)

Sample Station	Latitude (North)	Longitude (West)	Description
46	50°42.00'	127°23.6'	200 metres off schoolhouse.
47	50°42.3'	127°23.8'	On line and midway between Thomas Point and Shell Island.
48	50°42.2'	127°23.4'	On line between Thomas Point and Shell Island opposite twin houses.
49	50°42.4'	127°22.55'	On line between Thomas Point and Eagle Island two-thirds of the way to Eagle Island.
50	50°42.1'	127°22.8'	On line between Thomas Point and Eagle Island one-third of way to Eagle Island.
51	50°41.75'	127°22.8'	Off small twin spruces south of Thomas Point.
52	50°41.7'	127°22.15'	End of STP outfall where Thomas Point lines up with the gap between Shell and Cattle islands.
53	50°41.5'	127°22.5'	Near roadway to beach, at angled red post. Steel grate at H.W.M.
54	50°41.3'	127°22.1'	Off red and white checkerboard airport shed.
55	50°40.8'	127°20.9'	Off grey house 100 metres northwest of Keogh River mouth.
56	50°40.8'	127°20.75'	At Keogh River mouth.
57	50°40.75'	127°20.65'	Off clump of alder 100 meters southeast of Keogh River mouth.
58	50°39.6'	127°16.8'	Off fishing boundary marker at False Head.

APPENDIX II

FRESHWATER, EFFLUENT AND SEDIMENT SAMPLE STATION LOCATION DESCRIPTIONS

APPENDIX II FRESHWATER EFFLUENT AND SEDIMENT SAMPLE STATION LOCATION DESCRIPTIONS

Station	Description
S1	Scotia Bay Marina stream.
S2	Tsulquate River.
S3	stream tributary to Tsulquate River.
S4	culvert at Seaview Drive.
S5	culvert about 75 m south of H-1.
S6	culvert at Central Street.
S7	Stink Creek.
S8	Trustee Creek.
S9	Glenlion River.
S10	Quatse River.
S11	unnamed stream about 1 km east of S10.
S12	unnamed stream about one-half km north of S11.
S13	unnamed stream on east side of Hardy Bay in line with channel marker and government wharf.
S14	unnamed stream at marine station 42.
S15	unnamed stream at end of Beaver Harbour Road.
S16	stream about 1 km south of S15.
S17	stream about 200 metres north of S18.
S18	stream opposite Dept. of Highways yard.
S19	stream about 100 metres south of S18.
S20	stream through Fort Rupert Indian Reserve.
S21	stream at north end of beach road.
S22	stream at road to weather station.
S23	culvert opposite glide slope.
S24	culvert opposite Ceilometer.
S25	culvert opposite aircraft mock-up.
S26	culvert opposite aircraft hanger.
S27	stream
S28	Keogh River.
STPT	Tsulquate sewage treatment plant final effluent.
STPA	Airport sewage treatment plant final effluent.
SED #1	at marine station 42.
SED #2	at marine station 39.
SED #3	at marine station 33.
SED #4	at marine station 32.
GW #1	at SED #1.
GW #2	at SED #2.
GW #3	at SED #3.
GW #4	at SED #4.

APPENDIX III

DAILY BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS

APPENDIX III DAILY BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS

Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100 ml
1	Nov 23	1600	11
	24	1105	23
	26	1112	2
	27	1515	33
	28	1325	17
	29	1115	31
	30	1200	2
	Dec 1	1620	23
	2	1515	L2
2	Nov 23	1555	13
	24	1110	2
	26	1105	13
	27	1510	350
	28	1320	23
	29	1110	6
	30	1155	33
	Dec 1	1610	31
	2	1510	11
3	Nov 23	1545	13
	24	1115	L2
	26	1100	23
	27	1505	23
	28	1315	17
	29	1105	14
	30	1155	11
	Dec 1	1606	22
	2	1505	23
4	Nov 23	1540	L2
	24	1115	L2
	26	1055	5
	27	1450	180
	28	1310	5
	29	1100	11
	30	1150	11
	Dec 1	1605	7
	2	1500	8

L = "less than"

APPENDIX III DAILY BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS (Continued)

Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100 ml
5	Nov 23	1540	7
	24	1125	2
	26	1050	2
	27	1300	33
	28	1300	13
	29	1023	14
	30	1150	17
6	Nov 23	1525	L2
	24	1135	L2
	26	1045	L2
	27	1425	2
	28	1240	33
	29	1005	5
7	Nov 23	1515	L2
	24	1145	L2
	26	1038	L2
	27	1415	L2
	28	1230	2
	29	0955	L2
8	Nov 23	1615	L2
	24	1120	4
	26	1120	L2
	27	1445	2
	28	1250	8
	29	1020	8
9	Nov 24	0840	31
	25	0945	11
	26	1010	17
	27	1330	79
	29	1205	13
	Dec 1	1520	33
	3	1630	70

APPENDIX III DAILY BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS (Continued)

Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100 ml
10	Nov 24	0845	33
	25	0940	11
	26	1010	11
	27	1345	17
	29	1210	4
	Dec 1	1525	49
	3	1645	17
	6	1035	L2
11	Nov 23	1620	L2
	24	1130	L2
	26	1135	L2
	27	1435	8
	28	1245	2
	29	1010	2
12	Nov 24	0850	33
	25	0935	L2
	26	1015	2
	27	1345	17
	29	1215	13
	Dec 1	1530	33
	3	1635	8
	6	1045	5
13	Nov 24	0855	49
	25	0930	9
	26	1020	49
	27	1355	46
	29	1220	21
	Dec 1	-	23
	3	1640	23
	6	1100	L2
14	Nov 24	1010	22
	25	0920	13
	26	1035	70
	29	1140	17

APPENDIX III DAILY BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS (Continued)

Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100 ml
15	Nov 24	0955	70
	25	0905	9
	26	1025	17
	29	1430	11
	Dec 3	1650	8
16	Nov 24	1000	33
	25	0915	L2
	26	1025	11
	29	1135	23
	Dec 3	1700	2
17	Nov 24	1005	33
	25	0915	2
	26	1030	2
	29	1130	2
	Dec 3	1705	7
18	Nov 25	0925	2
	26	1035	4
	29	1125	17
	Dec 3	1715	2
19	Nov 25	0925	2
	26	1030	L2
	29	1125	8
	Dec 3	1710	L2
20	Nov 23	1435	4
	24	1205	5
	26	1020	9
	27	1355	13
	28	1215	L2
	29	0930	11
21	Nov 23	1440	2
	24	1200	L2
	26	1025	5
	27	1400	3
	28	1220	L2
	29	0935	5
	30	1140	L2

APPENDIX III DAILY BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS (Continued)

Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100 ml
22	Nov 23	1445	L2
	24	1200	L2
	26	1030	17
	27	1405	L2
	28	1225	2
	29	0940	L2
	30	1135	2
23	Nov 23	1455	L2
	24	1150	L2
	26	1032	2
	27	1410	L2
	28	1230	17
	29	0950	L2
24	Nov 23	1420	2
	25	1345	L2
	26	1015	L2
	27	1345	2
	29	1125	L2
25	Nov 28	1155	L2
	30	0940	5
	Dec 1	1545	L2
	2	1150	11
26	Nov 25	1305	2
	28	1150	L2
	30	0950	8
	Dec 1	1540	L2
	2	1145	L2
27	Nov 28	0950	5
	30	1220	46
	Dec 1	1350	L2
	3	1330	5
	4	1340	L2
	5	1555	L2
	6	1620	L2

APPENDIX III DAILY BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS (Continued)

Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100 ml
28	Nov 25	1255	L2
	28	1145	L2
	30	0955	L2
	Dec 1	1540	2
	2	1145	L2
29	Nov 28	1000	2
	30	1215	5
	Dec 1	1355	2
	2	1410	33
	3	1335	2
	4	1405	17
	5	1605	2
	6	1620	L2
30	Nov 28	1005	33
	30	1230	13
	Dec 1	1355	4
	2	1415	8
	3	1345	13
	4	1410	11
	5	1615	L2
	6	1615	2
31	Nov 25	1240	2
	28	1135	2
	30	1000	2
	Dec 1	1535	L2
	2	1140	5
32	Nov 28	1010	8
	30	1235	49
	Dec 1	1400	5
	2	1420	5
	3	1350	2
	4	1420	7
	5	1620	49
	6	1615	L2

APPENDIX III DAILY BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS (Continued)

Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100 ml
33	Nov 28	1020	5
	30	1240	8
	Dec 1	1400	79
	2	1300	23
	3	1400	L2
	4	1430	L2
	5	1625	110
	6	1610	4
34	Nov 28	1030	2
	30	1245	14
	Dec 1	1400	5
	2	1305	33
	3	1405	L2
	4	1455	L2
	5	1630	L2
	6	1610	2
35	Nov 30	1255	5
	Dec 1	1415	5
	2	1355	L2
	3	1500	L2
	6	1605	2
36	Nov 28	1035	5
	30	1250	5
	Dec 1	1410	8
	2	1310	13
	3	1405	2
	4	1510	L2
	6	1606	33
37	Nov 28	1140	5
	30	1257	5
	Dec 1	1415	5
	2	1355	L2
	3	1500	L2
	6	1603	8

APPENDIX III DAILY BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS (Continued)

Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100 ml
38	Nov 28	1135	2
	30	1300	2
	Dec 1	1420	7
	2	1325	2
	3	1410	11
	4	1520	L2
	6	1600	13
39	Nov 28	1130	33
	30	1305	33
	Dec 1	1425	13
	2	1330	L2
	3	1415	8
	6	1558	13
40	Nov 30	1310	14
	Dec 1	1425	17
	2	1430	2
	3	1420	49
	6	1557	5
41	Nov 25	1225	L2
	28	1130	4
	30	1005	L2
	Dec 1	1530	L2
	2	1135	L2
42	Nov 28	1120	5
	30	1315	46
	Dec 1	1430	L2
	2	1335	5
	3	1445	130
	6	1555	22
43	Nov 28	1105	13
	30	1317	350
	Dec 1	1430	22
	2	1340	L2
	3	1440	23
	6	1552	8

APPENDIX III DAILY BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS (Continued)

Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100 ml
44	Nov 30	1320	49
	Dec 1	1435	49
	2	1345	2
	3	1435	79
	6	1548	L2
45	Nov 28	1110	2
	30	1325	L2
	Dec 1	1440	5
	2	1345	110
	3	1430	7
	6	1545	2
46	Nov 25	1220	L2
	28	1125	L2
	30	1010	L2
	Dec 1	1520	L2
	2	1130	2
47	Nov 25	1230	8
	28	1115	L2
	30	1015	L2
	Dec 1	1525	4
	2	1125	L2
48	Nov 25	1215	2
	28	1110	L2
	30	1020	L2
	Dec 1	1515	L2
	2	1125	L2
49	Nov 28	1105	L2
	30	1035	2
	Dec 1	1510	L2
	2	1120	2

APPENDIX III DAILY BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS (Continued)

Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100 ml
50	Nov 25	1203	L2
	28	1100	L2
	30	1030	2
	Dec 1	1510	L2
	2	1120	L2
51	Nov 25	1145	2
	28	1055	L2
	30	-	8
	Dec 1	1505	L2
	2	1115	L2
52	Nov 25	1200	L2
	28	1045	L2
	30	1045	2
	Dec 1	1455	L2
	2	1110	L2
53	Nov 25	1150	L2
	28	1050	L2
	30	-	L2
	Dec 1	1500	5
	2	1115	2
54	Nov 25	1140	L2
	28	1040	L2
	Dec 1	1450	22
	2	1105	7
55	Nov 25	1050	L2
	28	1030	L2
	Dec 1	1445	4
	2	1055	2
56	Nov 25	1040	2
	28	1015	L2
	Dec 1	1435	11
	2	1050	2

APPENDIX III DAILY BACTERIOLOGICAL RESULTS FOR MARINE SAMPLE STATIONS (Continued)

Sample Station	Collection Date	Collection Time	Fecal Coliform MPN/100 ml
57	Nov 25	1100	2
	28	1020	5
	Dec 1	1430	2
	2	1050	L2
58	Nov 25	1115	2
	28	0950	L2
	Dec 1	1410	23
	2	1035	L2

APPENDIX IV

DAILY BACTERIOLOGICAL RESULTS FOR FRESHWATER SAMPLE STATIONS

APPENDIX IV DAILY BACTERIOLOGICAL RESULTS FOR FRESHWATER SAMPLE STATIONS

Sample Station	Date of Collection	Total Coliform/100 ml	Fecal Coliform/100 ml	Fecal Streptococci/100 ml
S1	Nov 28	115	4	8
	Nov 29	3	0/50	0/50
S2	Nov 22	L10	0	0
	Nov 24	13	9	1
	Nov 25	45	8	1
	Dec 3	-	12	38
S3	Nov 22	770	96	4
	Nov 24	640	75	55
	Nov 25	330	33	59
S4	Dec 2	33	15	91
S5	Dec 2	100	50	30
	Dec 3	7	4	109
S6	Dec 2	550	150	550
	Dec 3	4000	1000	1080
	Dec 6	10 700	840	L10
S7	Dec 3	230	98	124
	Dec 4	G800	87	32
	Dec 6	7100	52	8
S8	Nov 22	38	24	4
	Nov 24	25	15	18
	Nov 25	G80	36	G80
S9	Nov 22	31	0	0
	Nov 24	1	1	0
	Nov 25	23	3	0

L = "less than"
G = "greater than"

APPENDIX IV DAILY BACTERIOLOGICAL RESULTS FOR FRESHWATER SAMPLE STATIONS (Continued)

Sample Station	Date of Collection	Total Coliform/100 ml	Fecal Coliform/100 ml	Fecal Streptococci/100 ml
S10	Nov 22	39	4	0
	Nov 24	40	15	1
	Nov 25	54	34	34
S11	Nov 22	390	33	L2
	Nov 24	900	46	3
	Nov 25	360	29	5
S12	Dec 6	30	L10	L10
S13	Dec 6	20	L10	L10
S14	Dec 5	22	0	0/70
S15	Nov 22	140	0	13
	Nov 24	12	3	5
	Nov 25	58	22	9
	Nov 26	26	5	3
S16	Nov 26	11	7	4
	Nov 28	64	1	2
S17	Nov 26	17	6	210
	Nov 28	110	6	16
	Nov 30	330	110	180
S18	Nov 26	17 900	2600	70
	Nov 28	67 000	4100	40
	Nov 30	10 400	1150	110
S19	Nov 28	240	0	2
	Nov 30	730	110	40
	Dec 2	460	46	L10

APPENDIX IV DAILY BACTERIOLOGICAL RESULTS FOR FRESHWATER SAMPLE STATIONS (Continued)

Sample Station	Date of Collection	Total Coliform/100 ml	Fecal Coliform/100 ml	Fecal Streptococci/100 ml
S20	Nov 26	27	16	71
	Nov 28	G80	14	19
	Nov 29	54	10	12
	Nov 30	51	18	113
	Dec 4	68	11	46
S21	Nov 29	29	2	1
	Nov 30	75	9	16
S22	Nov 29	23	3	0
	Nov 30	40	4	11
S23	Nov 29	5	1	0
	Nov 30	G80	1	0/50
S24	Nov 29	16	0	0/50
	Nov 30	20	3	1
S25	Nov 29	45	5	0/50
	Nov 30	30	13	6
S26	Nov 29	7	0	0/85
	Nov 30	233	10	2
S27	Nov 29	14	5	1
	Nov 30	64	9	5
S28	Nov 29	130	20	1
	Nov 30	17	4	3

APPENDIX V

SUMMARY OF TEMPERATURE AND SALINITY DATA FOR MARINE SAMPLE STATIONS

APPENDIX V SUMMARY OF TEMPERATURE AND SALINITY DATA FOR MARINE SAMPLE STATIONS

Sample Station	No. of Samples	Temperature Range (°C)	Mean Temperature (°C)	No. of Samples	Salinity Range (°/oo)	Mean Salinity
1	7	6.0-8.0	7.4	9	11 - 31	22.1
2	7	6.5-8.0	7.5	9	21 - 31	27.9
3	7	6.5-8.0	7.4	9	14 - 30	27.1
4	7	7.0-8.5	7.9	9	23 - 31	29.1
5	7	7.5-8.5	8.0	7	26 - 31	30.0
6	7	7.0-8.5	6.7	7	30 - 33	27.3
7	6	7.0-8.5	7.9	7	31 - 33	31.8
8	6	6.0-8.5	7.6	6	31 - 33	31.8
9	5	7.0-7.5	7.1	7	26 - 31	28.0
10	5	7.0-8.0	7.3	8	18 - 32	28.8
11	6	7.0-8.5	7.8	6	30 - 32	31.3
12	5	7.0-7.5	7.1	8	23 - 32	29.5
13	5	4.5-7.5	6.6	8	11 - 31	24.8
14	2	4.0-6.5	5.3	4	8 - 25	19.0
15	4	5.0-7.5	6.5	5	12 - 30	24.6
16	4	6.5-7.0	6.9	5	27 - 31	29.0
17	4	6.5-7.0	6.9	5	25 - 31	27.4
18	3	6.0-7.0	6.7	4	21 - 31	26.8
19	3	6.5-8.0	7.5	4	24.5-31	28.4
20	6	7.0-8.0	7.5	6	24 - 29	28.5
21	7	7.0-8.5	8.0	7	30 - 32	31.3
22	7	7.5-8.5	8.1	7	29 - 32	31.0
23	6	7.5-8.5	8.1	6	30 - 33	31.8
24	4	7.5-8.5	7.9	5	31 - 32	31.8
25	2	7.0-7.5	7.3	4	30 - 32	31.0

APPENDIX V SUMMARY OF TEMPERATURE AND SALINITY DATA FOR MARINE SAMPLE STATIONS (Continued)

Sample Station	No. of Samples	Temperature Range (°C)	Mean Temperature (°C)	No. of Samples	Salinity Range (⁰/oo)	Mean Salinity
26	2	7.0-8.0	7.5	5	30-32	31.2
27	4	7.0-7.5	7.1	7	30-32	31.1
28	2	7.0-8.0	7.5	5	31-32	31.8
29	5	7.0-7.5	7.1	8	30-32	31.0
30	5	-7.0-	7.0	8	12-33	28.4
31	2	-8.0-	8.0	5	31-32	31.8
32	5	6.5-7.5	7.0	8	30-32	30.9
33	4	6.5-7.5	7.0	8	30-32	30.9
34	4	7.0-7.5	7.1	8	29-32	31.0
35	4	-7.0-	7.0	5	31-32	31.8
36	4	6.5-7.0	6.9	7	27-32	30.7
37	5	-7.0-	7.0	6	31-32	31.5
38	5	7.0-7.5	7.1	7	29-32	30.9
39	5	6.5-7.0	6.9	6	30-32	31.0
40	4	-7.0-	7.0	5	28-32	30.6
41	2	-8.0-	8.0	5	31-32	31.4
42	5	-7.0-	7.0	6	26-32	30.0
43	5	-7.0-	7.0	6	25-32	30.5
44	4	-7.0-	7.0	5	28-32	31.0
45	5	-7.0-	7.0	5	31-32	31.7
46	2	-8.0-	8.0	5	31-32	31.8
47	2	-8.0-	8.0	5	31-32	31.6
48	3	7.0-8.5	7.8	5	31-32	31.6
49	3	7.0-8.0	7.5	5	-32-	32
50	3	7.0-7.5	7.3	5	31-32	31.8

APPENDIX V SUMMARY OF TEMPERATURE AND SALINITY DATA FOR MARINE SAMPLE STATIONS (Continued)

Sample Station	No. of Samples	Temperature Range (°C)	Mean Temperature (°C)	No. of Samples	Salinity Range ($^{0}/oo$)	Mean Salinity
51	2	7.0-8.0	7.5	4	31-32	31.5
52	3	7.5-8.0	7.7	5	31-32	31.6
53	3	7.0-8.0	7.5	4	30-32	31.0
54	2	7.0-8.0	7.5	4	30-32	31.3
55	3	5.5-8.0	6.8	4	28-30	29.3
56	3	6.0-8.5	7.2	4	-31-	31
57	3	7.0-8.0	7.5	4	30-32	31.5
58	3	7.5-8.0	7.8	4	31-32	31.3

APPENDIX VI

OPERATIONAL ASSESSMENT OF THE DISTRICT OF PORT HARDY TSULQUATE AND AIRPORT SEWAGE TREATMENT PLANTS

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LIST OF ABBREVIATIONS

BOD_5	5 day biochemical oxygen demand
COD	chemical oxygen demand
DFO	Department of Fisheries and Oceans
DO	dissolved oxygen
DOE	Department of Environment
EPS	Environmental Protection Service
FR	filterable residues
l	liter
LAS	anionic surfactants
MLVSS	mixed liquor volatile suspended solids
m^3	cubic meters per day
ml	milliliters
mg/l	milligrams per day
NFR	non-filterable residue
PCB	Pollution Control Branch
ppb	parts per billion
ppm	parts per million
STP	sewage treatment plant
TAlk	total alkalinity
TFR	total fixed residue
TN	total nitrogen
TOC	total organic carbon
TPO_4	total phosphate
TR	total residue
TRC	total residual chlorine
TVR	total volatile residue
VNFR	volatile non-filterable residue

1 INTRODUCTION

An operational evaluation of the District of Port Hardy's Tsulquate and Airport sewage treatment plants was conducted in support of the shellfish growing water quality survey of Hardy Bay and Beaver Harbour. The evaluation was based upon bacteriological and chemical analyses conducted on samples obtained from each of the treatment systems. The bacteriological results were discussed in Sections 4.1.2.1 and 4.3 of this report.

Both of the treatment plants are classed as secondary facilities.

Airport STP

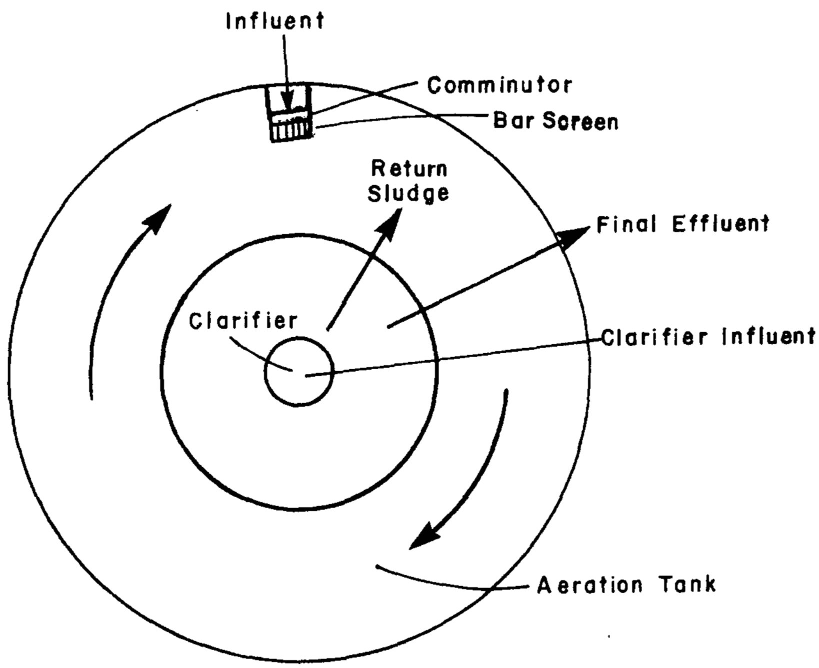
The Airport STP is operated in the extended aeration mode. The sewage is coarse-screened, comminuted, aerated, and clarified before discharge (Figure 1). Sludge collected in the clarifier is returned to the aeration section. According to the PCB permit, sludge may be wasted through the outfall on an ebbing spring tide.

Tsulquate STP

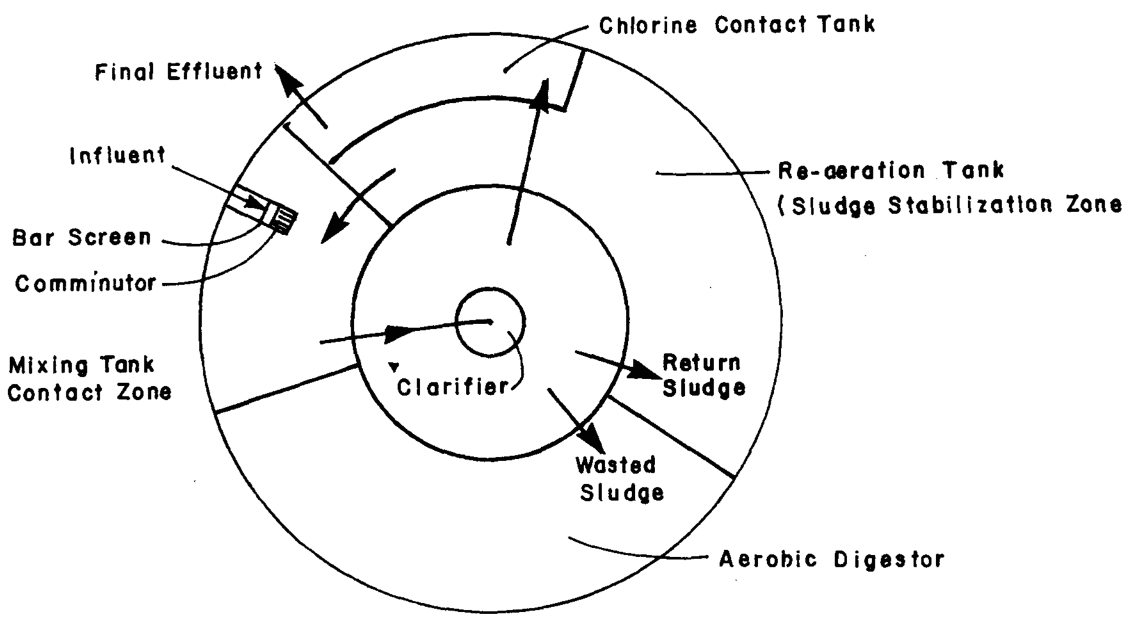
The Tsulquate STP has been designed to treat up to 1890 m^3/day (500 000 USGPD) of sewage from a population of 5000 (1). When the plant was designed in 1971, the projected serviced population in 1980 was 3000. It was intended that the plant be operated in an extended aeration mode until the average daily flow exceeded 1260 m^3/day (333 800 USGPD) at which time it would be converted to contact stabilization. The wasted sludge was to be discharged through the outfall thereby eliminating the need for sludge drying beds.

The Tsulquate STP was modified from extended aeration to contact stabilization just prior to this study (2). The plant has been subject to variable influent flows due to stormwater inflow and/or groundwater infiltration, which may result in aeration tank and clarifier "wash-outs". Contact stabilization aeration volume requirements are about 50% of those required for a conventional activated sludge plant and about 10% of those for extended aeration (3). Conceivably, the new design would be more amenable to the actual wastewater influent characteristics.

The influent sewage is coarse-screened, comminuted, aerated, clarified, and chlorinated before discharge (Figure 2). Sludge may be returned to the aeration section or wasted to the aerobic digestor.



APPENDIX VI
FIGURE I AIRPORT STP FLOW DIAGRAM



APPENDIX VI
FIGURE 2 TSULQUATE STP FLOW DIAGRAM

2 SAMPLING PROCEDURES AND METHODS

2.1 Airport STP

Two 24 hour composite samples were obtained from each of the raw sewage and final effluent lines at the Airport sewage treatment plant. Final effluent samples were collected using a signal timer and a submersible pump. By this method, approximate 1 litre aliquots were transferred every 15 minutes to a plastic collection bag. Raw sewage samples were obtained using a duckbill sampler whereby approximate 250 ml samples were taken every 2.5 minutes. Samples of the raw sewage and final effluent for oil and grease analysis were collected as grab samples in glass containers. Grab samples were also obtained of the aeration tank contents and return sludge.

At the time of this study, the flow monitoring equipment at the treatment plant was not functioning. In order to obtain this data, a flow meter and chart recorder (Manning Dipper) was positioned at the final effluent weir from 1530 on December 3 to 1500 on December 7.

2.2 Tsulquate STP

Two 24 hour composite samples of the final chlorinated effluent were obtained from the Tsulquate sewage treatment plant using the signal timer and submersible pump system. No suitable site was available for use of the duckbill sampler, therefore, composite raw sewage samples were obtained from 3-10 litre grab samples collected about eight hours apart. Grab samples for oil and grease analysis as well as the aeration tank contents and return sludge were collected as previously discussed.

Flow data was obtained from the treatment plant float and weir system.

All samples were split into sample bottles, preserved as outlined in the DOE Pollution Sampling Handbook (4), and transferred by air-freight from Port Hardy to Vancouver. Samples were delivered to the DFO-DOE chemistry laboratory in West Vancouver on the same day as the completion of the composite sampling period.

3 RESULTS AND DISCUSSION

Flows through the Tsulquate plant were influenced by precipitation as shown in Figure 3. For example, flows recorded between 0300 and 1500 on December 3 following heavy rainfall were about 40% greater than those recorded during dry periods such as November 20 and 21. Sharp peaks on the flow diagrams are generally the result of digester supernatant discharge. Following supernatant discharge, return sludge is wasted back into the digestor.

Flows recorded at the Airport STP by the Manning Dipper averaged about 570 m^3/day.

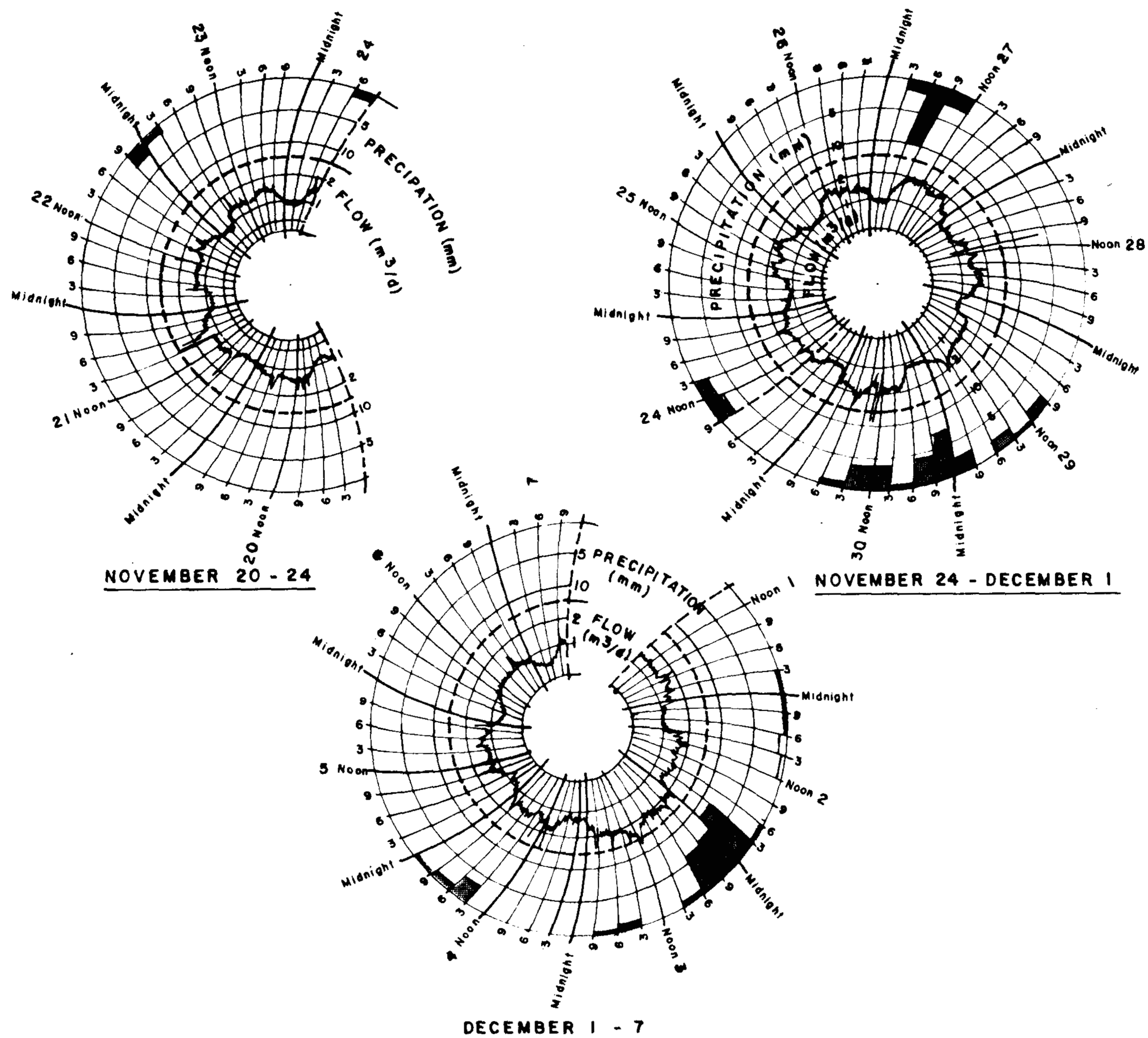
The raw sewage influent to both the Tsulquate and Airport STP's may generally be described as weak (Table 1). Only NH_3, FR, and TAlk concentrations were significantly above typical weak sewage levels.

3.1 Treatment Plant Performance

3.1.1 Airport STP. The results of chemical analyses of samples collected from the Airport STP are shown in Table 2. Generally, the treatment plant produced a high quality final effluent with a BOD_5 and NFR of 6 and less than 5 mg/l respectively. Significant nitrification was achieved as shown by the dramatic decrease in NH_3 levels from a raw sewage mean value of 24.9 mg/l to a final effluent value of 0.164 mg/l. Pollutant removal efficiencies were generally high with mean BOD_5, NFR, COD, and TOC reductions of 93, greater than 95, 82 and 83 percent respectively.

The PCB permit for this plant requires that the final effluent be equivalent to or better than 60 mg/l NFR and 45 mg/l BOD_5. Based on the data gathered during this study, the final effluent met this criteria.

A comparison of design data and observed results of this study is shown in Table 3. Actual flow and flow-related data such as aeration section detention times and settling tank overflow rates agreed with design values. The actual influent BOD_5 level of 90 mg/l was far below the design value of 204 mg/l. As a result, the actual BOD_5 loading was below the design value. Both BOD_5 and NFR reductions exceeded design estimates.



APPENDIX VI

FIGURE 3 FLOW THROUGH TSULQUATE RIVER SEWAGE TREATMENT PLANT AND PRECIPITATION

TABLE 1 RAW SEWAGE STRENGTH

Parameter	Typical Composition (5)			Tsulquate	Airport
	Strong	Medium	Weak		
	mg/l				
TR	1200	700	350	341	438
NFR	350	200	100	104	99
FR	600	350	175	237	339
TVR	600	350	175	190	185
TFR	850	500	250	151	253
BOD_5	300	200	100	118	90
TOC	300	200	100	-	68
COD	1000	500	250	310	290
Organic N	35	15	8	10.4	7.4
NH_3	50	25	12	36.7	24.9
NO_3	0	0	0	0.14	L0.010
NO_2	0	0	0	0.063	0.0074
TPO_4	20	10	6	5.86	5.73
TAlk	200	100	50	154	180
Grease	150	100	50	28	38

L = "less than"

TABLE 2 RESULTS OF AIRPORT STP CHEMICAL ANALYSES

Parameter	Influent			Final Effluent			Percent Reduction
	Nov. 21-22	Nov. 23-24	Mean	Nov. 21-22	Nov. 23-24	Mean	
pH	7.4	7.2	7.3	6.7	6.5	6.6	-
BOD_5	111	68	90	7	6	6	93
COD	360	220	290	L50	55	52	82
NFR	130	67	99	L5	L5	L5	G95
VNFR	130	66	98	L20	L20	L20	G80
TR	477	398	438	358	361	360	18
TVR	210	160	185	90	90	90	51
TPO_4	6.35	5.11	5.73	3.20	3.92	3.56	38
NH_3	24.5	25.3	24.9	0.265	0.0640	0.164	99
NO_2	0.0085	0.0064	0.0074	0.0125	0.0066	0.0096	-
NO_3	L0.010	L0.010	L0.010	21.6	26.5	24.0	-
Organic N	3.2	11.7	7.4	2.89	3.98	3.43	54
LAS	3.2	3.1	3.1	0.13	0.12	0.12	96
Oil and Grease	39	38	38	L5	L5	L5	G87
TAlk	184	177	180	17.9	13.8	15.8	91
TOC	91.0	45.0	68.0	12.0	11.0	11.5	83
Aeration Tank							
VNFR	1100	940	1020				
Return Sludge							
VNFR	690	1560	1125				

All values are mg/l except pH - pH units.
L = "less than"
G = "greater than"

TABLE 3 COMPARISON OF AIRPORT STP DESIGN DATA AND STUDY RESULTS

	Initial Design	Ultimate Design	Actual
Population Served	975	2300	-
Year	1975	1990	1978
Average Flow (m^3/day)	370	870	570
Peak Flow (m^3/min)	1.0	2.1	-
Influent BOD_5 (mg/l)	204	204	90
(kg/day)	75	177	51
NFR (mg/l)	240	240	99
(kg/day)	88	207	56
BOD_5 reduction (%)	80-85	75-80	93
NFR reduction (%)	80-85	75-80	G95
Effluent BOD_5 (mg/l)	35-45	35-45	6
Effluent NFR (mg/l)	40-50	40-50	L5
Aeration Section			
Volume (m^3)	926	926	-
Depth (m)	4.4	4.4	-
Detention Time - avg (hr)	60	25	39
Detention Time - peak (hr)	15	7	-
BOD_5 Loading (kg/day/1000 m^3)	81	191	55
Settling Tank			
Volume (m^3)	334	334	-
Depth (m)	3.7	3.7	-
Detention Time - avg (hr)	21.7	9.2	14.1
Overflow - avg (m^3/day/m^3)	4.3	9.8	6.4
Overflow - peak (m^3/day/m^3)	16.5	34.0	-
Rise Rate - peak (m/hr)	0.70	1.4	-
Weir Overflow - avg (m^3/day/m)	11.7	27.6	17.9
Return Sludge			
No. pumps	1	1	-
Capacity Min/Max (m^3/min)	0.091/0.91	0.091/0.91	-

L = "less than" G = "greater than"

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

Six important unit process parameters include:

- Θ_c - mean cell residence ratio
- U - food/microorganism ratio
- V_L - volumetric loading
- t - hydraulic retention time
- R - recirculation ratio
- MLVSS - aeration tank mixed liquor volatile suspended solids concentration.

The definitions of these parameters are shown in Table 4. Parameters were calculated for both the Airport and Tsulquate plants using the results of this study (Tables 5 and 6) and data supplied by the District of Port Hardy (2).

The mean cell residence time for the airport treatment plant was extremely long, much greater than recommended. This was due in part to the low effluent NFR concentration. Mean cell residence times of 10 to 20 days are normally required for nitrification (9). Based on the airport STP mean cell residence time of 332 days, significant nitrification, would be expected and was observed in this study.

The calculated food/microorganism ratio for the Airport STP was 0.050, just within the recommended range of 0.05 to 0.15. Therefore, it is suggested that the aeration tank MLVSS of 1020 mg/l is too low and, if maintained, may lead to system failure due to insufficient biomass for influent BOD_5 reduction.

3.1.2 <u>Tsulquate STP</u>. The results of chemical analyses of samples collected from the Tsulquate STP are shown in Table 7. This treatment plant has been subject to periodic bulking sludge conditions. Floating sludge was frequently observed in the clarifier and chlorine contact tank. Concurrently, high NFR concentrations have been noted in the final effluent. The results from the December 3-4 sampling indicate such a

TABLE 4 UNIT PROCESS PARAMETER DEFINITIONS (6)

$$\theta_c = \frac{\text{total active microbial mass in treatment system}}{\text{microbial mass removed daily (wasted and effluent)}}$$

$$= \frac{XV}{Q_w X_w + (Q-Q_w)\, X_e}$$

$$V = \frac{\text{mass of BOD}_5\text{ removed per day}}{\text{total active microbial mass}}$$

$$= \frac{QS_o - S_e}{VX}$$

$$VL = \frac{\text{mass of BOD}_5\text{ removed per day}}{\text{1000 units (ft}^3\text{ or m}^3\text{) of reactor volume}}$$

$$= \frac{QS_o - S_e}{V}$$

$$R = \frac{\text{recycle flow}}{\text{influent flow}}$$

$$= \frac{Q_r}{Q}$$

$$t = \frac{\text{volume of reactor}}{\text{influent flow}}$$

$$= \frac{V}{Q}$$

where: X = aeration tank MLVSS concentration
V = aeration tank volume
Q_w = wastage flow
X_w = waste MLVSS concentration
Q = influent flow
X_e = effluent MLVSS concentration
S_o = influent BOD_5
S_e = effluent BOD_5
Q_r = recycle flow

TABLE 5 CHARACTERISTICS OF AIRPORT AND TSULQUATE STP USED IN THE CALCULATION OF UNIT PROCESS PARAMETERS

	X (mg/l)	V (m^3)	Q_w (m^3/day)	X_w (mg/l)	Q (m^3/day)	X_e (mg/l)	S_o (mg/l)	S_e (mg/l)	Q_r
Airport STP	1020	926	-	-	570	L5	90	6	-
Tsulquate STP	1900	235* 604**	24^+	3100^{++}	645	90	118	50	1.5Q

* contact zone
** re-aeration zone
\+ wastage observed seven times in 17 days @ 58 m^3/wastage.
++ return sludge MLVSS
L = "less than"

TABLE 6 RECOMMENDED AND ACTUAL UNIT PROCESS PARAMETERS

	Θ_c (days)	V $\left[\frac{\text{kg } BOD_5}{\text{kg MLVSS - day}}\right]$	Volumetric Loading $\left[\frac{\text{kg } BOD_5}{1000 \text{ m}^3\text{-day}}\right]$	MLVSS (mg/l)	V/Q (hr)	Q_r/Q
Recommended (8) Process Values						
Contact Stabilization	5-15	0.2-0.6	960-1200	1000-3000** 4000-10 000+	0.5-1.0 3-6	0.25-1.0
Extended Aeration	20-30	0.05-0.15	160-400	3000-6000	18-36	0.75-1.50
Actual Process Values						
Airport STP	332	0.050	52	1020	39	
Tsulquate STP	12	0.028	52	1900** 3100+	8.7 15*	1.5-2.0

* based on a recyle ratio of 1.5 Q
** contact zone
\+ reaction zone

TABLE 7 RESULTS OF TSULQUATE STP CHEMICAL ANALYSES

Parameter	Influent			Final Effluent			Percent Reduction
	Dec. 3-4	Dec. 6-7	Mean	Dec. 3-4	Dec. 6-7	Mean	
pH	7.8	7.9	7.8	7.0	7.4	7.2	
BOD_5	102	135	118	95	4	50	58
COD	290	330	310	310	54	182	41
NFR	96	113	104	195	L5	100	4
VNFR	90	110	100	160	L20	90	10
TR	313	370	341	395	203	299	12
TVR	170	210	190	230	60	145	24
TPO_4	5.50	6.23	5.86	7.49	2.00	4.74	19
NH_3	21.4	52.0	36.7	7.26	15.0	11.1	70
NO_2	0.0090	0.117	0.063	0.0625	0.0125	0.0375	-
NO_3	0.242	0.038	0.14	1.15	0.038	0.59	-
Organic N	12.2	8.7	10.4	7.1	3.3	5.2	50
LAS	2.70	3.30	3.0	0.096	0.24	0.17	94
Oil and Grease	22	34	28	L5	L5	L5	G82
TAlk	151	158	154	80.9	164	122	21
Aeration Tank							
VNFR	1730	2070	1900				
Return Sludge							
VNFR	2700	3530	3100				

All values are mg/l except pH - pH units.
L = "less than" G = "greater than"

condition. In that period, the final effluent BOD_5 and NFR concentrations were 95 and 195 mg/l respectively. In fact, final effluent COD, NFR, VNFR, TR, TVR, and TPO_4 concentrations were higher than raw sewage values.

Results of the December 6-7 sampling show that the sewage treatment plant produced a high quality effluent during that period. Final effluent BOD_5 and NFR concentrations were 4 and less than 5 mg/l respectively. The PCB permit for this plant requires that the final effluent have BOD_5 and NFR concentrations equivalent to or better than 50 mg/l. This latter sampling met the permit criteria while the former did not.

The calculated unit process parameters for the plant, as operated during this study, were outside the normally recommended range for contact stabilization-type plants (Table 5). The food/micro-organisms ratio is about an order of magnitude below suggested limits. The low ratio is due to the low organic and hydraulic loadings of the treatment plant at the time of this sampling.

The Ten States Standards for sewage treatment plant design recommend that the contact tank hydraulic retention time for small treatment plants under 1870 m^3/day be about 3.0 hours (10) compared to a normally recommended value of 0.5 to 1.0 hour. A study of these plants in the United States indicated that in typical conservatively designed contact stabilization plants, all of the stabilization of raw wastewater organic matter occurs in the contact zone and only endogenous respiration occurs in the re-aeration zone. This often results in a sludge of poor settling characteristics.

A contact stabilization plant in Coralville, Iowa, provided a retention time of 2.6 and 6.5 hours in the contact and stabilization zones, respectively, and produced a sludge of poor settling characteristics. The treatment plant was upgraded to a modified complete mix flow pattern (11).

As mentioned previously, the Tsulquate STP contact zone retention time is 20 hours. As illustrated by the Coralville, Iowa case history, this represents one possible reason for the bulking sludge problem noted at the plant.

Analysis of nitrogen data shows that there was a 64% reduction in TN from raw sewage to final effluent. It is possible, therefore, that the floating sludge in the clarifier noted previously occurred from denitrification. Unfortunately no microscope was available during this study to examine the sludge for attached nitrogen bubbles. If denitrification is found to occur, then accumulated sludge in the clarifier could be removed by increasing the recycle rate, or wastage, or both.

Other possible reasons for bulking sludge conditions include both nutrient and oxygen deficiencies. Limited dissolved oxygen has been noted most often as a cause of bulking sludge.

The carry-over of biological solids to the final effluent also periodically occurred when the STP was operated as extended aeration. The flows noted in this study during rainy periods, such as December 3, were only about twice the average dry weather flows and would not be expected to cause washout problems. Reportedly, recommended MLVSS concentrations of 3000 to 6000 were maintained in the extended aeration system. As previously discussed and shown by the Airport STP performance, the low organic content of the influent to these plants allows a relatively low MLVSS concentration to be used. Moreover, the maintenance of an artificially high MLVSS level may result in a floc of poor settling characteristics due to the disintegration of bacterial cells and formation of pin-point flocs. Monitoring by the PCB of the STP final effluent during extended aeration operation revealed that the BOD_5 concentrations were consistently low while NFR levels were as high as 234 mg/l (Table 8).

TABLE 8 SUMMARY OF TSULQUATE STP FINAL EFFLUENT SAMPLING RESULTS FROM THE PCB

Parameter	No. of Samples	Range	Mean Concentration
pH	19	5.9 - 7.0	6.5
TR	3	238 - 258	251
NFR	18	2 - 234	30
TRC	6	0 - 0.29	0.33
TN	1	10.6	10.6
BOD_5	17	L10 - 20	11.9
TPO_4	1	4.47	4.47

Data stored on EQUIS.
All values are mg/l except pH - pH units.
L = "less than"

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8. <u>Ibid.</u>, p. 498.
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11. <u>Ibid.</u>, p. 5-43.

APPENDIX VII

FLUOROMETRIC DYE STUDY OF THE TSULQUATE SEWAGE TREATMENT PLANT EFFLUENT DISPERSION PATTERN

1 INTRODUCTION

In conjuction with the shellfish growing water quality survey of Hardy Bay, a dye study was conducted on December 5, 1978, to examine the dilution and dispersion patterns of effluent discharged by the Tsulquate sewage treatment plant.

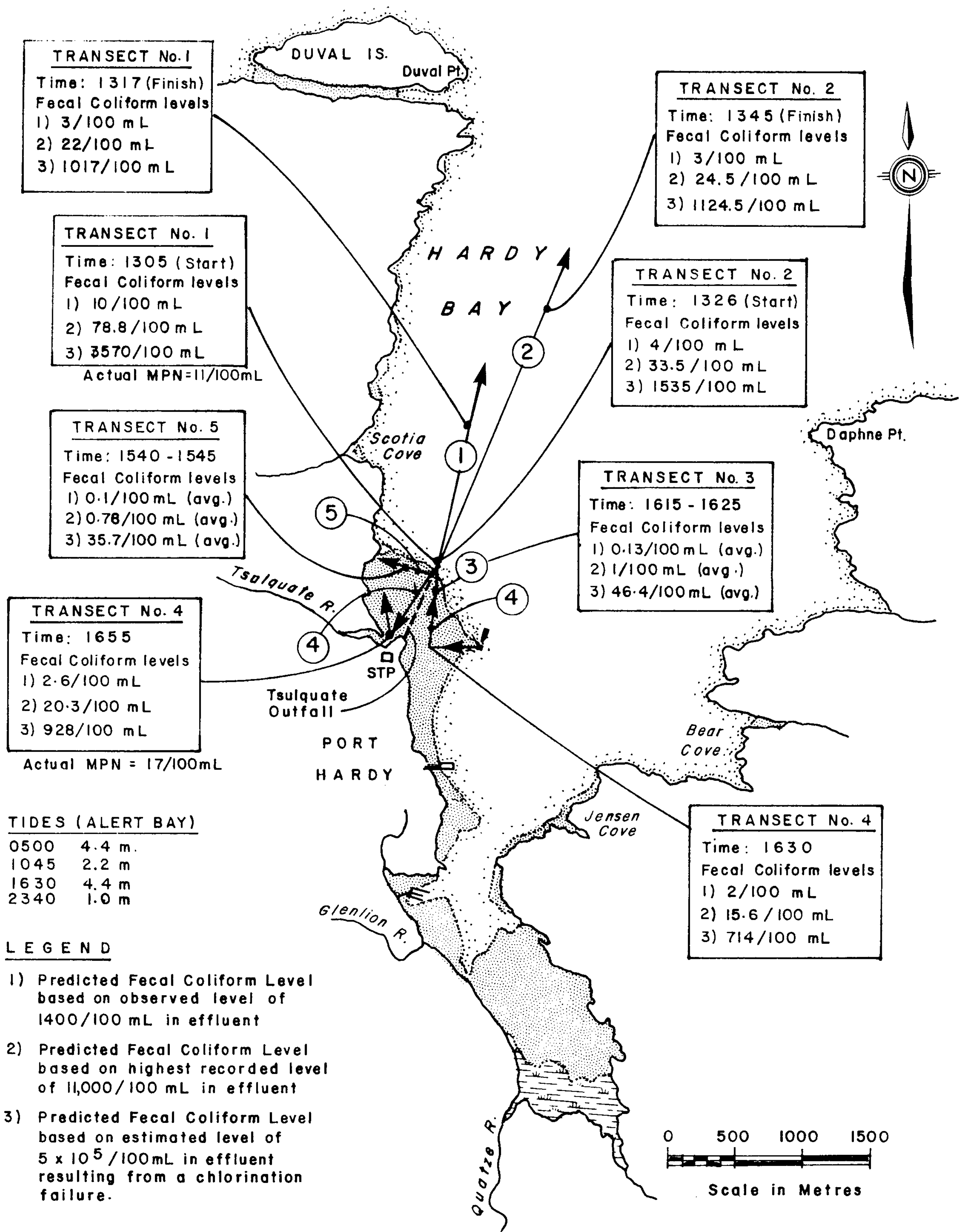
2 METHODS AND MATERIALS

Rhodamine WT dye (20%) obtained from Dupont, was added to the final effluent to produce a calculated dye concentration of 1.4 ppm. Dye addition took place over approximately a two-hour period (1045h-1257h) on an incoming tide (Figure 1).

Dye concentrations in the surface receiving waters were determined using a Turner Designs Model 10-005R fluorometer equipped with a flow through cuvette system. Fluorometer readings were recorded using a Hewlett-Packard Model 755B Recorder on board the survey boat "Klebsiella". The fluorometer was standardized using laboratory prepared Rhodamine dye standards diluted with seawater from the study area and tested using the flow-through cuvette system. Transects of either radiating lines from the outfall or circles of increasing distance around the outfall were used to follow the dispersion patterns over a five-hour period (1150h-1700h). During the study the sea was calm and there was no measurable wind.

3 RESULTS AND DISCUSSION

Selected transects and theoretical fecal coliform concentrations are shown in Figure 1. Generally speaking, dye concentrations were low in the transects at points moving away from the outfall (detection limit was 0.05 ppb dye). The exceptions to this were transects 1 and 2, where dye was detectable for up to 2000 metres seaward



APPENDIX VII
FIGURE 1 SELECTED TRANSECTS FROM DYE TRACER STUDY HARDY BAY - December 5, 1978

of the outfall. The results of these transects, combined with the low levels observed during the shoreward transects indicated that the main sewage plume moved away from shore under the conditions of this study. This was unexpected since transects 1 and 2 were conducted on a flood tide and the "expected" movement of sewage would be towards the shore. However, dye addition began on the low tide (1045h) and there would be a lag time before the water movement in the bay reversed its direction. Also, the freshwater outflow from the Tsulquate River would tend to carry the effluent plume seaward, regardless of the tidal conditions.

Dye was detected near shore (transect 4) during high tide, suggesting that although the initial movement of the plume was seaward, some of the plume moved towards shore under the influence of the flood tide.

Theoretical fecal coliform levels based on observed dye concentrations are shown in Figure 1 for each transect for three conditions. Firstly, the calculated bacteria levels were based on the observed effluent quality during the dye study (1350 fecal coliforms/100 ml). Secondly, receiving water bacteria levels were calculated on the basis of the highest recorded fecal coliform levels for the Tsulquate STP (11 000 fecal coliforms/100 ml). Thirdly, the possible effects of a total chlorination failure were examined using an effluent fecal coliform level of 5×10^5/100 ml (average raw sewage influent value).

The theoretical fecal coliform levels calculated for the first situation (i.e., the actual conditions encountered) are supportive of the bacteriological data obtained for marine sample stations. Fecal contamination was observed at stations 21, 22 and 23 (Figure 2, main text) indicating the effluent plume was detectable at this distance from the outfall. Low bacterial levels were observed at stations 16, 17, 18 and 19, directly offshore of the Tsulquate reservation, while unacceptable fecal coliform contamination was present at station 13 and 15. These data concur with the results of transects 4 and 5.

The observed bacteriological data also correlated well with predicted dilution values for the sewage plume as calculated by the Rawn

Palmer formula. This formula estimated the initial dilution at the surface of the plume to be 79:1 or 17.1 fecal coliforms/100 ml based on the effluent value of 1350/100 ml. The observed value of a sample taken at the plume was 11/100 ml.

It should be noted that the results obtained during this brief study are specific to the oceanographic and atmospheric conditions encountered at the time and it is not possible to extrapolate these results to the other situations. Also, fecal coliform die-off was not included as a factor in calculating the theoretical coliform levels. Actual levels may therefore be lower than calculated levels.

Additional data regarding the expected movement of sewage from this outfall comes from float studies conducted by Tevendale in 1971 (1). These studies indicate the movement of the sewage can be significantly affected by wind in addition to tidal conditions. Where wind is not a factor, floats moved either directly on shore or towards the harbour area on a flood tide.

4 CONCLUSIONS

1. The predicted fecal coliform levels correlated well with the observed data obtained during the marine sampling program.
2. Effluent discharged from the outfall initially moved seaward as a result of tidal and freshwater influences (Tsulquate River outflow), although it was apparent that portions of the effluent moved shoreward during the latter stages of the flood tide.
3. The predicted fecal coliform levels based on the highest recorded fecal coliform value in the final effluent indicate that growing waters at the mouth of Tsulquate River and off Tsulquate Point can become contaminated to unacceptable levels. This correlates completely with marine bacteriological data obtained.
4. Previous float studies conducted indicate that wind has a considerable effect on the movement of the sewage plume, probably due to the minimal depth of the outfall. Therefore the zone of influence of the sewage discharge on the intertidal area can be significantly altered by weather conditions.