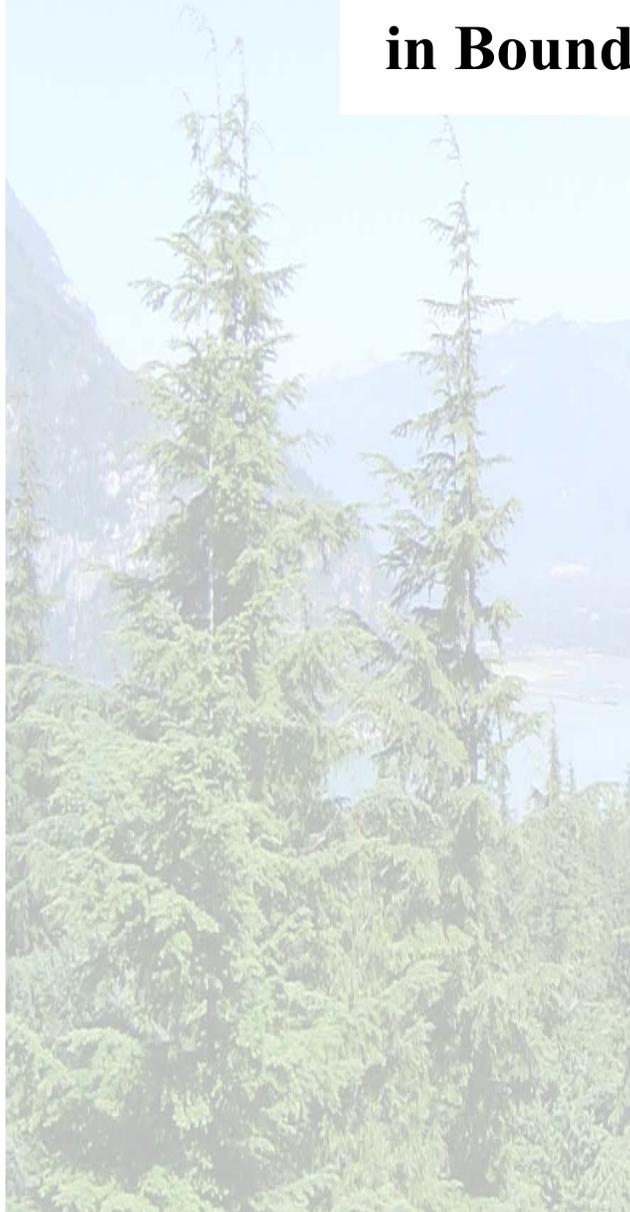




# Ministry of Water, Land & Air Protection

## LOWER MAINLAND REGION

### Water Quality Objectives Attainment Monitoring in Boundary Bay in 2002



Prepared by:

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November 2003

ENVIRONMENTAL QUALITY

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## **PREFACE**

### **Water Quality Objectives and Attainment Monitoring**

Water quality objectives are established in British Columbia for water bodies on a site-specific basis and are set to protect the most sensitive designated water uses at a specific location. Objectives are prepared for those water bodies and water quality measurements that may be affected by human activity currently, or in the future.

Attainment monitoring and reporting is conducted to check whether the objectives are being met, and is important for preparing waste management plans, issuing of permits, licenses and orders, as well as for regulating water uses. Monitoring usually takes place at a critical time, during a five-week period, when water quality objectives may not be met. This will generally represent the 'worst case scenario' for the water uses in question, which will ensure that they will be protected at other times when the threat to water quality is lower.

### **Water Quality Index**

A water quality index was developed by the Canadian Council of Ministers of the Environment (CCME) in 1999 to reflect the overall and ongoing condition of water bodies. The index is based on a formula developed by the BC Ministry of Environment, Lands and Parks (MOELP, 1995), with a few modifications. The index can be used to assess water quality relative to its desirable state (as defined by the water quality objectives) and to provide insight into the degree to which water quality is affected by human activity. The index is also useful for ranking the suitability of water for use by humans and aquatic life.

The index is founded on three factors involving the measurement of the attainment of water quality objectives. The factors measure the number of objectives not met (scope), the frequency with which objectives are not met (frequency), and the maximum amount by which objectives are not met (amplitude). The index then ranks water quality into one of five categories: excellent, good, fair, marginal, and poor.

### **Acknowledgements**

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## SUMMARY

This report presents the results of monitoring undertaken in 2002 to check for attainment of water quality objectives set for Boundary Bay in 1988. Fecal coliforms, enterococci, dissolved oxygen, and polychlorinated biphenyls (PCBs) were monitored over a five-week period at selected locations in Boundary Bay. Objectives for fecal coliform levels, dissolved oxygen, and PCBs have not been formally monitored since 1993, 1992, and 1990 respectively. The CCME Water Quality Index was also determined for Boundary Bay using 2002 results. Additional one-time sampling was carried out in 2001, as part of a separate study, to monitor fecal coliforms and polycyclic aromatic hydrocarbons (PAHs) in the water column and sediments in several locations in Boundary Bay.

Objectives were met in 2002 for fecal coliforms and enterococci at all locations in Boundary Bay. Objectives for fecal coliform levels, monitored weekly in the summer by the Fraser Health Authority, were also met at all beach locations tested around Boundary Bay. Bacteriological results from one-time sampling conducted in 2001 revealed low fecal coliform counts (<1–2 colonies/100 mL) at several offshore locations in Boundary Bay.

Objectives were also met for one-time sampling of PCBs in sediments at all locations in 2002. Dissolved oxygen objectives were met at all locations, except at bottom depths in the Boundary Bay-Centre location on three occasions (August 28, September 4, and September 11). While there appears to be a general improvement in dissolved oxygen results compared to previous years, it is recognized that the number of measurements taken are somewhat limited. The Water Quality Index rating for Boundary Bay was Excellent in 2002, with the provision that the available data for calculating the index was also limited.

While objectives were not set for PAHs in 1988, sampling in 2001 revealed that while PAH criteria were not exceeded in the water column, the provincial criterion for naphthalene was exceeded in sediment sampled from the Boundary Bay-White Rock location.

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## 1.0 Introduction

In the Boundary Bay marine system, objectives have been set to protect primary-contact recreation and aquatic life. Thus, important water quality indicators are fecal coliforms, enterococci, and dissolved oxygen in the water column, as well as polychlorinated biphenyls (PCBs) in sediments. Important bacteriological indicators include fecal coliforms, enterococci, and *Escherichia coli* (*E. coli*). While fecal coliforms have historically been used as the primary indicators, *E. coli* and enterococci are considered to be better indicators of gastrointestinal disease (MEP, 1988c). Additionally, enterococci are used as indicators in marine environments where *E. coli* do not survive well (MEP, 1988a). Dissolved oxygen is essential for respiration by most aquatic organisms and thus is important to monitor. Finally, polychlorinated biphenyls (PCBs) are of concern in this system because they can enter Boundary Bay through the Serpentine River from Mahood (Bear) Creek (MEP, 1988b).

Objectives for fecal coliforms, dissolved oxygen, and PCBs were first set and checked in Boundary Bay in 1988. Objectives monitoring was last conducted in 1992, although fecal coliform levels at bathing beach were monitored by the Fraser Health Authority in 1993. Fecal coliform objectives were exceeded in 1993 at times in White Rock and at Centennial Beach on the west side. Similar results were obtained in each year from 1988 to 1992. Dissolved oxygen levels were last monitored in 1992, where the lowest depth (9m) at the Boundary Bay-Centre location failed to meet the objective. Similar results were also found in previous years, except 1988. PCBs were monitored in sediments from 1988 to 1990, with objectives being met in all three years.

Since objectives for fecal coliforms, dissolved oxygen, and PCBs have not been checked since 1993, 1992, and 1990 respectively, it was a priority to monitor these environmental indicators, along with enterococci, in 2002. Additional results from one-time sampling in 2001 are also presented, where fecal coliforms and polycyclic aromatic hydrocarbons (PAHs) were sampled in the water column and sediments in several locations in Boundary Bay. The CCME Water Quality Index was also determined for Boundary Bay in 2002, which rates water quality based on objective attainment results.

## 2.0 Overview of the Study Area

### 2.1 Location

Boundary Bay, including its north-easterly extension of Mud Bay and the southeast section of Semiahmoo Bay, is located on the south side of the Fraser-Delta area approximately 19 km south of Vancouver (MEP, 1988b). It is 15 km long and 4 km wide, covering an area of 6087 hectares (Figure 1). Tides enter from the south and are more concentrated on the eastern side during flood tide, and more concentrated on the western side during ebb tide (MEP, 1988b). Boundary Bay can be influenced by water flow from the Blaine area in Washington State, as well as by outflows from the Serpentine, Nicomekl, and Little Campbell Rivers (MEP, 1988b).

## **2.2 Water Uses**

The Boundary Bay area sustains a crab fishery, although the herring fishery, which was last reported in 1993, no longer exists. The oyster fishery has been closed to commercial and recreational harvesting since 1963 due to pollution from fecal coliform and other contaminants (MEP, 1988b; GBEI, 2002b).

Under Environment Canada's Georgia Basin Ecosystem Initiative (GBEI), the Semiahmoo Bay-Drayton Harbor Shared Waters Project was initiated to assess the potential for lifting the shellfish closure in portions of Semiahmoo Bay (GBEI, 2002a). Phase 1 of a three-year action plan to identify major sources of contamination, and to identify possible ways to improve shellfish conditions in the Bay, has recently been completed (GBEI, 2002b).

The area is also important for recreation such as boating, fishing, and swimming, which occurs at Boundary Bay Beach and Centennial Beach in Delta, and at Crescent Beach, East Beach, and West Beach in the White Rock area (T. Leathem, personal communication). The Little Campbell River, Serpentine River, and the Nicomekl River are tributaries to Boundary Bay, which provide important habitat for trout and salmon, and are used for irrigation.

## **3.0 Potential Sources of Contamination**

The main influences on water quality on the Canadian side of Boundary Bay are from agriculture and urban land uses along the tributaries flowing into Boundary Bay. There are land-drainage pumping stations on the tributaries that move water towards Boundary Bay, as well as stormwater outfalls into the Bay from the city of White Rock. Specifically, there are 23 stormwater outfalls between Nichol Rd. to the west and Habgood St. to the east in White Rock (G. Scott, personal communication). A recent study strongly suggested that stormwater outfalls had an impact on water quality with respect to fecal coliforms in Semiahmoo Bay (GBEI, 2002a). In addition to discharging stormwater, these outfalls also continually discharge groundwater into Boundary Bay. There are no permits to discharge wastes into Boundary Bay from White Rock or Delta.

## **4.0 Methodology**

In 2002, sites included Boundary Bay-Centre (EMS 0300070; 49° 00.204' N, 122° 50.138' W), Boundary Bay-White Rock (EMS 0300071; 49° 00.202' N, 122° 57.665' W), Boat Channel North (49° 02.159' N, 122° 54.898' W), Boat Channel South (49° 01.484' N, 122° 55.712' W), Mud Bay South (49° 03.156' N, 122° 53.873' W), and Mud Bay North (sediment only; 49° 04.497' N, 122° 52.125' W). Figure 1 shows these sampling locations.

Bacteriological and water quality measures, including temperature, conductivity, salinity, and dissolved oxygen, were monitored in 2002 on August 28, and September 4, 11, 18, and 25. Sampling was done on all sampling dates during ebb tide. This allows tidal waters to have contact with contaminants that may be present along the shoreline, which would represent the “worst case scenario” in tidal flow (GBEI, 2002a). Sediment samples were collected at each location on August 28.

Field water quality measurements were taken at the surface and at 1m above the bottom at each location, with a calibrated WTW Model 340i multimeter. Fecal coliforms and enterococci were monitored as bacteriological indicators using a 3 L Van Dorn sampler at the surface. Bacteriological sampling quality control was addressed by including field blanks and collecting triplicate samples at the Mud Bay South location on each sampling date (see Table 4, Appendix). The Fraser Health Authority sampled fecal coliform levels weekly from June 3 to August 19 at several beaches, including Crescent Beach, Centennial Beach, Tsawwassen Beach, and East and West Beaches in White Rock. The results from this weekly sampling were summarized and are useful in making inferences about possible fecal coliform levels at beaches extending into September. Sediment samples were collected using a stainless steel ponar grab and were composited using a Pyrex glass tray. Triplicate sediment samples were collected from Mud Bay North by compositing three ponar samples, which were then split into three ‘replicate’ samples. Triplicate PCB results are shown in Table 5 (Appendix).

On August 1, 2001, sampling of fecal coliforms and polycyclic aromatic hydrocarbons (PAHs) was conducted in Boundary Bay as part of a separate study conducted by the Ministry of Water, Land and Air Protection (MWLAP, 2001). Grab samples were collected from the water column and analyzed for PAHs and fecal coliforms. Composite sediment samples were also collected from several locations in Semiahmoo Bay, near White Rock, and analyzed for PAHs.

## **5.0 Results and Data Analysis**

Water chemistry and bacteriological data have been summarized in appended tables. The geometric mean and 90<sup>th</sup> percentiles were obtained for bacteriological results, with the requirement that at least five samples be collected within 30 days. Raw water chemistry, sediment, and weekly fecal coliform data for 2002 are shown in Tables 4 to 6 of the Appendix respectively. Raw water quality and sediment data for 2001 are shown in Table 7.

The Water Quality Index was calculated as described in CCME (2001), with the recommendation that a minimum of four variables sampled at least four times be used for the calculation of the index. In this case, however, the index was calculated with only two variables, fecal coliforms and dissolved oxygen, which may affect the index accuracy. The factors used in the index are based on results of water quality objectives attainment and include;  $F_1$  (Scope), the number of objectives not met;  $F_2$  (Frequency), the frequency with which objectives are not met; and  $F_3$  (Amplitude), the amount by which objectives are not met. Table 8 in the Appendix gives numerical

ranges for the rankings and descriptions of the rankings. Since the CCME index was adapted from the BC Ministry of Environment, Lands and Parks index, the same conditions regarding data use were applied (MOELP, 1995). Some of these conditions include omitting incomplete monitoring results and using results from short-term objectives only (MOELP, 1995).

## **6.0 Discussion**

### **6.1 Bacteriological Indicators**

The objectives for fecal coliforms are a geometric mean of  $\leq 200/100$  mL and a 90<sup>th</sup> percentile of  $\leq 400/100$  mL from April to October. The objective for enterococci levels is a geometric mean of  $\leq 20/100$  mL, to protect primary recreation uses. These objectives were met at all sampling locations in Boundary Bay in 2002 (Table 1). Beach areas were not monitored in this sampling effort, although the Fraser Health Authority monitored fecal coliform levels weekly at beaches in the Boundary Bay area in the summer of 2002. Geometric means generated from twelve weeks of monitoring indicated that objectives for fecal coliform levels were also met at beaches in the White Rock area from June 3 to August 19 (Fraser Health Authority, 2002). Geometric means ranged from 5 to 147 per 100 mL and were generally the highest at East Beach locations in White Rock (Table 3). It should be noted that lower bacteriological levels were expected, as the Lower Mainland experienced a drier than normal summer. Since dry conditions persisted into September, relatively low bacterial levels at beaches would also have been expected to persist. Total monthly precipitation for August and September was 23 mm and 33 mm respectively.

One-time sampling of the water column in 2001, on July 26 or August 1, showed fecal coliform results ranging from  $<1 - 2$  colonies/100 mL (Table 7).

### **6.2 Dissolved Oxygen**

The objective for dissolved oxygen is a minimum of 6.5 mg/L. This objective was met in all areas, at both surface and depth, except in the bottom water of Boundary Bay-Centre (15.3 – 17.0 m, Table 2). This was also found in objectives attainment monitoring in 1992, where it was noted that low dissolved oxygen had been a chronic problem in the water body (MOELP, 1993).

### **6.3 PCBs**

The objective for PCBs is an average of  $<0.03$   $\mu\text{g/g}$  in sediment. This objective for Boundary Bay sediment was met at all locations in 2002 (Table 2). Objectives were also met in the past, from 1988 to 1990, when they were last checked.

## 6.4 PAHs

The 2001 results for one-time sampling of PAH concentrations in the water and sediment of Semiahmoo Bay are shown in Table 7. While objectives were not set for PAHs in 1988, they are of general concern in the environment due to their persistence and toxicity to aquatic life. Using provincially approved and interim criteria, it was determined that PAH criteria were not exceeded in the water column, when detection limits were lower than criteria, at the two sites sampled in 2001 (Table 7). The criterion for naphthalene (0.01 µg/g) was exceeded in sediment sampled from the Boundary Bay-White Rock location (0300071) in 2001, with a concentration of 0.03 µg/g (Table 6).

## 6.5 Water Quality Index rating

The calculated CCME Water Quality Index (WQI) rating for Boundary Bay was Excellent (index=95) in 2002, with the provision that limited data were available for use. With the available information, however, water uses in the Bay can be considered to be adequately protected and suitable for primary contact recreation and aquatic life at this time.

## 7.0 Conclusions and Recommendations

As water quality objectives had not been monitored since 1993 (earlier for dissolved oxygen and PCBs), the Ministry prioritized attainment monitoring in Boundary Bay in 2002. The objectives were met for all parameters tested in Boundary Bay, except dissolved oxygen at one site's bottom depth. There has been an overall improvement in dissolved oxygen levels in Boundary Bay compared to earlier years where objectives were not met at several locations. The Water Quality Index rating for Boundary Bay was Excellent in 2002, indicating adequate protection for primary contact recreation and aquatic life uses.

Given the consistency in results compared to earlier years, further monitoring may be a low priority in Boundary Bay at this time. It is anticipated, however, that the Fraser Health Authority will continue their bacteriological monitoring program at the bathing beaches.

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## Appendix

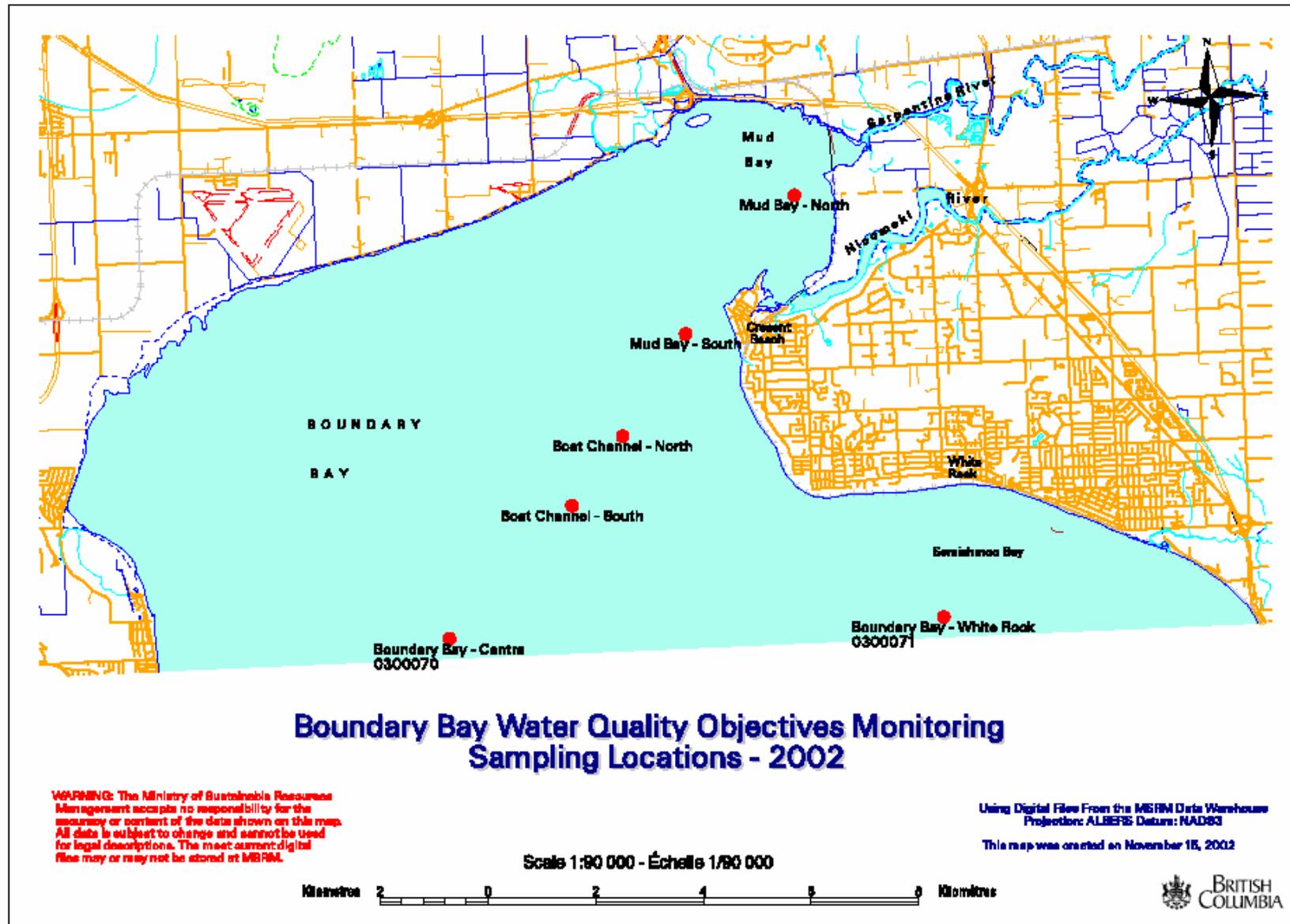


Figure 1 Boundary Bay sampling locations - 2002

**Table 1 Boundary Bay bacteriological objectives - 2002**

<b>Variable &amp; Objective</b>	<b>Site</b>	<b>Date</b>	<b>Sample size (n)</b>	<b>Range of Values &amp; Geometric Mean (gm)</b>	<b>Conclusion</b>
<b>Fecal Coliforms (Colonies/100 mL)</b> ≤200/100 mL geometric mean ≤400/100 mL 90 <sup>th</sup> percentile (April-Oct)	Boundary Bay Centre 0300070	Aug 28 Sept 4, 11, 18, 25	5	<1 - 33 gm = 2 np = 20	Objectives met
	Boundary Bay-White Rock 0300071	Aug 28 Sept 4, 11, 18, 25	5	<1 - 63 gm = 2 np = 38	Objectives Met
	Boat Channel North	Aug 28 Sept 4, 11, 18, 25	5	<1 - 40 gm = 7 np = 34	Objectives met
	Boat Channel South	Aug 28 Sept 4, 11, 18, 25	5	<1 - 24 gm = 5 np = 19	Objectives met
	Mud Bay South	Aug 28 Sept 4, 11, 18, 25	5	2 - 120 gm = 17 np = 105	Objectives met
<b>Enterococci (Colonies/100 mL)</b> ≤20/100 mL geometric mean	Boundary Bay Centre 0300070	Aug 28 Sept 4, 11, 18, 25	5	<1 - 6 gm = 2	Objective met
	Boundary Bay-White Rock 0300071	Aug 28 Sept 4, 11, 18, 25	5	<1 - 13 gm = 2	Objective met
	Boat Channel North	Aug 28 Sept 4, 11, 18, 25	5	<1 - 25 gm = 3	Objective met
	Boat Channel South	Aug 28 Sept 4, 11, 18, 25	5	<1 - 8 gm = 2	Objective met
	Mud Bay South	Aug 28 Sept 4, 11, 18, 25	5	<1 - 75 gm = 8	Objective met

**Table 2 Boundary Bay water quality objectives - 2002**

<b>Variable &amp; Objective</b>	<b>Site</b>	<b>Date</b>	<b>Sample size (n)</b>	<b>Range of Values</b>	<b>Conclusion</b>	
<b>Dissolved Oxygen (mg/L)</b>  6.5 mg/L minimum  <b>Long-term</b> 9.0 mg/L minimum	Boundary Bay Centre 0300070	Aug 28	5	8.8 – 9.1 (0m)	Objective met	
		Sept 4, 11, 18, 25		5.5 – 6.6 (15.3 – 17 m)	<b>Objective not met</b>	
	Boundary Bay-White Rock 0300071	Aug 28	5	8.2 – 9 (0m)	Objective met	
		Sept 4, 11, 18, 25		6.5 – 7.2 (5.7 – 8.1 m)	Objective met	
	Boat Channel North	Aug 28	5	7.4 – 8.6 (0m)	Objective met	
		Sept 4, 11, 18, 25		7.2 – 7.9 (9.3 – 11.2 m)	Objective met	
	Boat Channel South	Aug 28	5	7.8 – 8.4 (0m)	Objective met	
		Sept 4, 11, 18, 25		7.2 – 7.9 (7.7 – 9.6 m)	Objective met	
	Mud Bay South	Aug 28	5	7.2 – 8.3 (0m)	Objective met	
		Sept 4, 11, 18, 25		7.1 – 7.9 (5.9 – 7.9 m)	Objective met	
	<b>PCBs in sediments (µg/g)</b>  <0.03 µg/g average	Boundary Bay Centre 0300070	Aug 28	1	<0.02	Objective met
		Boundary Bay-White Rock 0300071	Aug 28	1	<0.02	Objective met
Boat Channel North		Aug 28	1	<0.02	Objective met	
Boat Channel South		Aug 28	1	<0.02	Objective met	
Mud Bay South		Aug 28	1	<0.02	Objective met	
Mud Bay North		Aug 28	1	<0.02	Objective met	

**Table 3 Geometric means from weekly fecal coliform sampling (colonies/100 mL) and 90<sup>th</sup> percentile values for Boundary Bay beaches in 2002 (Fraser Health Authority, 2002)**

Beach	Sampling Location	Jun 3 - Jul 1	Jun 10 - Jul 8	Jun 17 - Jul 15	Jun 24 - Jul 22	Jul 1 - Jul 29	Jul 8 - Aug 5	Jul 15 - Aug 12	Jul 22 - Aug 19	90 <sup>th</sup> perc (n=12)
White Rock East Beach	Balsam Street	17	39	27	39	27	64	28	41	286
	Beach Road	19	28	28	88	38	104	70	147	1603
	Finlay Street	19	16	16	19	20	27	36	24	112
	Parker Street	39	47	43	68	29	32	25	19	160
White Rock West Beach	Anderson Street	30	27	27	40	31	48	42	60	212
	Foster Street	20	28	29	31	20	39	28	15	108
	High Street	17	18	19	26	35	73	55	98	174
	Oxford Street	20	36	28	41	44	75	58	48	154
	Vidal Street	33	27	30	28	28	26	22	16	54
Crescent Beach	Beecher Street	15	19	17	39	22	22	18	12	84
	Sullivan Street	9	9	6	6	5	7	7	10	31
Centennial Beach	Concession	6	5	7	10	10	12	15	12	20
	1A Avenue	9	6	7	7	9	8	10	8	20
	3 <sup>rd</sup> Avenue	8	7	9	9	7	7	7	5	19
	Beach – Foot of 12 <sup>th</sup> Ave	9	7	8	9	9	9	9	8	26
Tsawwassen Beach	Causeway – Light	7	7	6	9	9	7	7	7	15
	Causeway – Porta Potti	6	6	9	7	9	9	9	6	10

**Table 4 Boundary Bay raw field and water quality data – 2002**

Site	Date	Tide	Depth (m)	Water Temperature (°C)	Conductivity (µS/cm)	Salinity (ppt)	Dissolved Oxygen (mg/L)	Fecal Coliforms (CFU/100 mL)	Enterococci (CFU/100 mL)
Boundary Bay Centre 0300070	Aug 28	Ebb	0	18.2	44.5	28.4	9.12	<1	2
			16.3	11.5	47.7	30.4	<b>5.50</b>		
	Sept 4	Ebb	0	15.8	44.2	28.0	9.05	<1	6
			15.5	12.6	46.9	29.9	<b>5.47</b>		
	Sept 11	Ebb	0	16.1	43.3	27.4	8.96	33	<1
17.0			11.5	45.9	29.2	<b>5.63</b>			
Sept 18	Ebb	0	13.6	42.8	26.9	8.82	<1	<1	
		15.3	11.8	46.4	29.2	6.45			
Sept 25	Ebb	0	13.9	44.6	28.2	8.85	<1	<1	
		17.0	11.8	45.7	28.9	6.55			
Boundary Bay- White Rock 0300071	Aug 28	Ebb	0	18.6	44.9	28.7	8.95	<1	<1
			7.5	12.9	46.7	29.7	6.48		
	Sept 4	Ebb	0	16.6	44.5	28.5	8.66	<1	13
			5.7	16.3	46.4	29.5	6.96		
	Sept 11	Ebb	0	16.0	43.0	27.1	8.70	63	<1
8.1			12.1	45.8	28.9	6.75			
Sept 18	Ebb	0	14.2	42.8	27.0	8.23	<1	1	
		6.2	13.3	43.1	27.0	7.23			
Sept 25	Ebb	0	14.6	44.3	28.1	8.33	<1	<1	
		7.9	11.8	45.7	28.8	6.91			
Boat Channel North	Aug 28	Ebb	0	20.6	44.7	28.7	8.58	<1	1
			9.3	14.7	46.0	29.3	7.49		
	Sept 4	Ebb	0	17.2	41.5	26.1	7.79	25	14
			9.5	17.2	42.4	26.8	7.26		
	Sept 11	Ebb	0	16.6	42.5	27.0	8.42	40	<1
11.2				43.1	27.1	7.90			
Sept 18	Ebb	0	15.0	42.3	26.7	7.35	15	25	
		10.0	14.9	43.0	27.2	7.24			
Sept 25	Ebb	0	15.2	44.2	28.0	8.34	<1	<1	
		11.2	12.8	45.1	28.5	7.57			
Boat Channel South	Aug 28	Ebb	0	20.0	44.5	28.5	8.4	<1	<1
			9.1	14.3	46.2	29.4	7.87		
	Sept 4	Ebb	0	17.2	41.7	26.2	7.76	9	4
			7.7	17.0	42.4	26.8	7.39		
	Sept 11	Ebb	0	16.4	42.6	27.0	8.40	24	<1
9.6				43.2	27.2	7.75			
Sept 18	Ebb	0	14.7	42.6	26.9	7.90	11	8	
		8.2	13.9	42.9	27.1	7.19			
Sept 25	Ebb	0	15.8	43.5	27.5	8.06	1	<1	
		9.4	12.4	45.2	28.6	7.45			
Aug 28	Ebb	0	19.8	44.6	28.6	8.25	<1, 2, 5	<1, 51, 46	
		7.1	18.6	44.8	29.7	7.93			

Mud Bay South (triplicate results shown)	Sept 4	Ebb	0 5.9	18.0 17.5	41.3 42.6	26.0 26.9	7.71 7.23	100, 120, 140	36, 75, 88
	Sept 11	Ebb	0 7.9	17.5	42.1 42.8	26.7 27.2	8.24 7.72	96, 83, 60	<1, 1, <1
	Sept 18	Ebb	0 6.3	14.7 14.7	41.3 41.6	26.1 26.2	7.22 7.05	26, 28, 27	10, 9, 13
	Sept 25	Ebb	0 7.6	15.8 14.4	43.5 44.3	27.5 28.0	7.91 7.49	3, 3, 2	<1, <1, <1
Mud Bay North (triplicate results shown)	Aug 28	Ebb							
Field Blank	Aug 28							<1	<1
	Sept 4							<1	<1
	Sept 11							<1	<1
	Sept 18							<1	<1
	Sept 25							<1	<1

**Table 5 Boundary Bay raw sediment data – 2002**

Variable	Boundary Bay - Centre 0300070	Boundary Bay-White Rock 0300071	Boat Channel South	Mud Bay South	Mud Bay North (triplicate results shown)
<b>Particle size distribution (% w/w)</b>					
>2.0 mm (gravel)	0.40	0	0.02	0.29	0, 0, 0
<2.00 & >0.063 mm (sand)	1.29	97.20	93.43	97.29	81.40, 81.28, 81.16
<0.063 & >0.004 mm (silt)	51.47	1.00	3.79	0.91	13.96, 13.89, 14.06
<0.004 mm (clay)	46.84	1.80	2.76	1.51	4.64, 4.83, 4.78
<b>Polychlorinated biphenyls (µg/g)</b>					
Total PCB's	<0.02	<0.02	<0.02	<0.02	<0.02, <0.02, <0.02

**Table 6 Raw fecal coliform (colonies/100 mL) data for Boundary Bay beaches in 2002  
(Fraser Health Authority, 2002)**

Beach	Sampling Location	Wk 1 Jun 3	Wk 2 Jun 10	Wk 3 Jun 17	Wk 4 Jun 24	Wk 5 Jul 1	Wk 6 Jul 8	Wk 7 Jul 15	Wk 8 Jul 22	Wk 9 Jul 29	Wk 10 Aug 5	Wk 11 Aug 12	Wk 12 Aug 19
White Rock East Beach	Balsam Street	5	159	5	80	5	300	23	32	14	355	5	145
	Beach Road	5	55	5	327	5	35	55	1700	5	732	5	2200
	Finlay Street	10	40	120	10	5	5	36	264	15	20	20	5
	Parker Street	20	159	15	370	5	50	100	160	5	9	14	25
White Rock West Beach	Anderson Street	15	50	15	90	25	9	45	110	25	223	5	250
	Foster Street	5	100	35	40	5	25	109	50	5	132	5	5
	High Street	32	45	15	14	5	40	60	70	65	186	10	1050
	Oxford Street	5	214	25	23	5	95	64	160	35	70	27	25
	Vidal Street	30	41	55	15	40	10	77	36	15	27	5	14
Crescent Beach	Beecher Street	5	70	5	85	5	15	45	325	5	5	5	5
	Sullivan Street	5	55	5	10	5	5	5	5	5	32	5	20
Centennial Beach	Concession	15	5	5	5	5	5	20	36	5	15	15	5
	1A Avenue	55	5	5	5	10	5	15	5	15	5	20	5
	3 <sup>rd</sup> Avenue	10	5	5	20	5	5	30	5	5	5	5	5
	Beach – Foot of 12 <sup>th</sup> Ave	27	5	20	5	5	5	10	59	5	5	5	5
Tsawwassen Beach	Causeway – Light	5	10	5	5	15	5	5	35	5	5	5	5
	Causeway – Porta Potti	5	5	10	5	5	5	36	5	10	5	5	5

**Table 7 Boundary Bay raw water quality data – 2001**

Parameter	PAH Criteria	Boundary Bay - Centre 0300070 Aug 1	Boundary Bay - White Rock 0300071 Aug 1	White Rock – East Aug 1	White Rock – Dock Aug 1	White Rock – West July 26	White Rock – West Inshore Aug 1	Ocean Park July 26	Point Roberts Aug 1
<b>Water Column - Polycyclic Aromatic Hydrocarbons (µg/L)</b>									
Acenaphthene	6 <sup>a</sup>				<0.02		<0.02		
Acenaphthylene					<0.02		<0.02		
Anthracene					<0.02		<0.02		
Benzo(a)anthracene					<0.02		<0.02		
Benzo(a)pyrene	0.01 <sup>a</sup>				<0.02		<0.02		
Benzo(b)fluoranthene					<0.02		<0.02		
Benzo(g,h,i)perylene					<0.02		<0.02		
Benzo(k)fluoranthene					<0.02		<0.02		
Chrysene	0.1 <sup>a</sup>				<0.02		<0.02		
Dibenzo(a,h)anthracene					<0.02		<0.02		
Fluoranthene					<0.02		<0.02		
Fluorene	12 <sup>a</sup>				<0.02		<0.02		
Indeno(1,2,3,c,d)pyrene					<0.02		<0.02		
Naphthalene	1 <sup>a</sup>				0.01		0.013		
Phenanthrene					<0.02		<0.02		
Pyrene					<0.02		<0.02		
<b>Fecal coliforms (Colonies/100 mL)</b>		<1	<1	1	<1	<1, <1	2	<1, <1	<1
<b>Sediments - Polycyclic Aromatic Hydrocarbons (µg/g)</b>									
Acenaphthene	0.15 <sup>a</sup> , 0.007 <sup>b</sup>	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Acenaphthylene	0.006 <sup>b</sup>	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Anthracene	0.047 <sup>b</sup>	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Benzo(a)anthracene	0.075 <sup>b</sup>	<0.02	0.03	<0.02	<0.02	0.03	<0.02	<0.02	<0.02
Benzo(a)pyrene	0.06 <sup>a</sup> , 0.089 <sup>b</sup>	<0.02	0.02	<0.02	<0.02	0.02	<0.02	<0.02	<0.02
Benzo(b)fluoranthene	2.3 <sup>c</sup>	<0.02	0.04	0.02	<0.02	0.03	<0.02	0.03	<0.02
Benzo(g,h,i)perylene	0.31 <sup>c</sup>	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Benzo(k)fluoranthene	2.3 <sup>c</sup>	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chrysene	0.2 <sup>a</sup> , 0.108 <sup>b</sup>	<0.02	0.03	<0.02	<0.02	0.02	<0.02	<0.02	<0.02
Dibenzo(a,h)anthracene	0.006 <sup>b</sup>	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Fluoranthene	0.113 <sup>b</sup>	<0.02	0.08	0.03	0.03	0.06	0.02	0.07	<0.02
Fluorene	0.2 <sup>a</sup> , 0.021 <sup>b</sup>	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Indeno(1,2,3,c,d)pyrene	0.34 <sup>c</sup>	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Naphthalene	0.01 <sup>a</sup> , 0.035 <sup>b</sup>	<0.02	0.03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Phenanthrene	0.087 <sup>b</sup>	<0.02	0.05	<0.02	<0.02	0.03	<0.02	0.04	<0.02
Pyrene	0.153 <sup>b</sup>	<0.02	0.08	0.03	0.03	0.06	0.02	0.06	<0.02

<sup>a</sup> Approved water quality and sediment criteria, to protect aquatic life (MOELP, 1998)  
<sup>b</sup> B.C. Interim Sediment Quality Guidelines (ISQG) (MOELP, 2001)  
<sup>c</sup> No adverse effect on biota (MOELP, 2001)

**Table 8 Relationship between CCME Water Quality Index (WQI) values and rankings, and descriptions of rankings (CCME, 2001)**

<b>Ranking</b>	<b>CCME WQI Value</b>	<b>Description</b>
Excellent	95-100	Water quality is protected with a virtual absence of threat or impairment Conditions very close to natural or pristine levels
Good	80-94	Water quality is protected with only a minor degree of threat or impairment Conditions rarely depart from natural or desirable levels
Fair	65-79	Water quality is usually protected but occasionally threatened or impaired Conditions sometimes depart from natural or desirable levels
Marginal	45-64	Water quality is frequently threatened or impaired Conditions often depart from natural or desirable levels
Poor	0-44	Water quality is almost always threatened or impaired Conditions usually depart from natural or desirable levels