APPENDIX E

FECAL COLIFORM SAMPLING QUALITY ASSURANCE AND QUALITY CONTROL PROGRAM 2004 - 2006

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1.0 INTRODUCTION

Quality Assurance and Quality Control (QA/QC) programs are a set of protocols that are adopted to ensure that the results of any study are valid, internally consistent and comparable with other similar projects. These protocols are set out in writing and are based on the most current and relevant research on the related topics. This appendix discusses:

- field sampling methods
- sample handling procedures
- analytical procedures
- field and laboratory replication (quality control)
- data assessment

The data collected for the quality assurance program are used to ensure consistency in field handling and analytical methods. If the data exceed a specified precision criterion then the lab is notified of a potential problem in the procedure and steps are taken to resolve the issue. The QA protocols presented in this appendix are based on two Capital Regional District (CRD) memorandums (Drinnan, 1995; Hutcheson, 1995).

2.0 METHODS FOR FECAL COLIFORM SAMPLING

All water samples were collected in 250 mL wide-mouth polypropylene bottles supplied by the analytical laboratories (MB Laboratories Ltd. in Victoria). Bottles supplied by MB Laboratories Ltd. were washed, rinsed and autoclaved after each use and re-supplied to the CRD as needed. Labelled samples were stored in an insulated cooler with ice packs for protection from prolonged exposure to UV light and delivered the same day to the laboratory. Fecal coliform bacteria were analyzed following the procedures in Standard Methods (APHA, 1998) and reported as colony forming units per 100 mL (CFU/100 mL). However, to assist the reader the more commonly used reporting of fecal coliform per 100 milliliters (FC/100 mL) is used in this survey.

Care was taken to ensure that the weather on sampling days could be considered representative of the season. Conditions such as "first flush", major storms or any other effect that might tend to prejudice the results were avoided.

2.1 Stormwater Discharge Sampling

Where possible, stormwater samples were collected from the point of discharge. Where this was not possible, the stormwater system was followed back to the nearest point where samples could be taken. A five metre inflatable boat was used to visit discharges located in areas difficult to access from the shore.

2.2 Quality Assurance

2.2.1 Stormwater Sample Replicates (Field Splits)

Ten per cent of the total number of samples collected were replicated in the field (field replicates) and are identified in this report as field splits. A single sample was collected in a laboratory prepared one litre (1 L) sample bottle and inverted 30 times to ensure that the sample was homogeneous. The sample was

then split evenly into two separate sample bottles. The two bottles were then labelled and sent to the lab for analysis as separate samples but not identified as field splits.

2.2.2 Quality Control Assessment

To establish the precision criteria (Section 2.3.4) for the field splits collected in 2004, 2005 and 2006, each year 18 replicates (field splits) were analyzed for fecal coliform bacteria. These field splits were collected from six stormwater discharges on the Saanich Peninsula (the QA assessment was for the CRD Saanich Peninsula and Southern Gulf Islands Electoral Area sampling programs). The discharges were chosen based on previous (on the Saanich Peninsula) high, moderate or low levels of fecal coliform concentrations. Two discharges were sampled for each of the three categories to represent the varying fecal coliform counts that would be analyzed during the sampling program.

Field split sampling in 2004, 2005 and 2006 was undertaken to meet QA requirements for all fecal coliform samples analyzed by MB Laboratories Ltd. for each of the three years. For summer sampling, winter QA data was used. Three individual grab samples were taken at each of the six stations and split into two replicate 250 mL sample bottles. Three blank samples of potable water were also collected in 250 mL sample bottles as part of the assessment. All samples were supplied to the lab with individual numbers.

2.2.3 Calculation of Quality Assurance Results

Laboratory precision for fecal coliform analysis (e.g., a measure of consistency by the lab) is determined by analyzing several pairs of field samples (field splits). The following procedure is from Standard Methods, 20th edition (APHA, 1998).

The data are arranged in pairs (D1 and D2). The log of each field measurement is determined (L1, L2) and the difference (range) in the log value between each pair of field splits is calculated: R = (L2 - L1). An average range (Mean-R) is then determined for all of the pairs.

The precision criterion is calculated by multiplying the Mean-R by 3.27 and is rounded to one decimal place.

The log range (R) is calculated for each of the field splits and compared to the precision criterion, to determine whether the sample is acceptable or not, according to the following criteria:

Acceptable (A) - If the calculation is less than the precision criterion, then the field data are within normal variability.

Unacceptable (U) - If the calculation is greater than the precision criterion, then the field data are outside of the normal variability. All data collected after the last "acceptable" set of data should be discarded and no further analysis should be done until the source of the problem is identified by the lab.

It is important not to put too severe an interpretation on the results from the QA calculation, especially when they are close to the "unacceptable" guideline. Each result represents a value within a 95% confidence interval, which gets proportionately larger as the actual result gets smaller. Therefore, one can expect, through randomness, 5% of the samples to be outside of the precision criterion. Also, any fecal coliform count under 200 is considered too small an amount to accurately calculate or compare to a precision criterion (APHA, 1998). It is also important to note that discharges with fecal coliform counts lower than 200 FC/100 mL receive a low public health concern rating.

The results should be rounded to one decimal place and compared to the precision criterion (e.g., 0.3). If the calculated value from the duplicate results still exceeds the criterion (e.g., 0.35 or greater) then an informal investigation of the laboratory should be initiated. If only a few duplicates are unacceptable (e.g., one out of every 20 pairs of duplicates) the lab is probably meeting the guideline.

The overall process is intended to act as an alarm, alerting the study group to potential problems with the sampling and analytical procedures. As part of the review, the following elements are considered:

- the number of pairs exceeding the criterion
- the actual fecal coliform value of the pairs of data
- field notes on the "field split" procedure
- comments from the laboratory

3.0 RESULTS

3.1 Quality Assurance Results

For the 2004, 2005 and 2006 QA program, 18 pairs of stormwater samples were collected from six discharges having high, moderate or low levels of fecal coliform bacteria in January and/or February of each year. The samples were sent to the lab for analysis of the fecal coliform concentration and the data used to calculate the precision criteria.

3.1.1 Blanks

Three blank samples (Greater Victoria tap water) were also submitted to the lab each year as part of the QA/QC and analyzed for fecal coliform bacteria. All blanks were reported as having <10 FC/100 mL. Therefore, the results meet the QA requirements.

3.1.2 Precision Criteria

2004

Table 1 shows the lab results of the 18 pairs of samples used to determine the precision criteria for 2004 stormwater monitoring program. The calculated precision criterion for this laboratory, using these 18 sets of duplicates, was 0.36127. For comparison with subsequent field replicates this result was rounded to 0.4.

2005

Table 2 shows the lab results of the 18 pairs of samples used to determine the precision criteria for 2005 stormwater monitoring program. The calculated precision criterion for this laboratory, using these 18 sets of duplicates, was 0.51594. For comparison with subsequent field replicates this result was rounded to 0.5.

2006

Table 3 shows the lab results of the 18 pairs of samples used to determine the precision criteria for 2006 stormwater monitoring program. The calculated precision criterion for this laboratory, using these 18 sets of duplicates, was 0.77785. For comparison with subsequent field replicates this result was rounded to 0.8.

Table 1. Laboratory Quality Assurance Exercise Results for 2004

CRD Data, Batch Samples: 18 pairs, January 22 – February 2, 2004						
Discharge No.	**Pair No.**	**1st Duplicate D1**	**2nd Duplicate D2**	**Log D1 L1**	**Log D2 L2**	**Range of Logs (Rlog) (Log L1 - Log L2)**
3087	1	210	180	2.32222	2.25527	0.06695
	2	190	189	2.27875	2.27646	0.00229
	3	190	150	2.27875	2.17609	0.10266
3084	4	6880	4960	3.83759	3.69548	0.14211
	5	8160	5760	3.91169	3.76042	0.14749
	6	4480	3840	3.65128	3.58433	0.06695
449	7	162	127	2.20952	2.10380	0.10572
	8	155	147	2.19033	2.16732	0.02301
	9	155	94	2.19033	1.97313	0.21720
446	10	2	0	0.30103	0.00000	0.30103
	11	0	0	0.00000	0.00000	0.00000
	2	0	0	0.00000	0.00000	0.00000
458A	13	3400	1600	3.53148	3.20412	0.32736
	14	6000	4000	3.77815	3.60206	0.17609
	15	4200	3800	3.62325	3.57978	0.04347
450	16	178	126	2.25042	2.10037	0.15005
	17	346	290	2.53908	2.46240	0.07668
	18	310	283	2.49136	2.45179	0.03957
Mean - Rlog (Sum Rlog/18)						0.11048
Precision Criterion (3.27 x Mean-Rlog)						**0.36127**

Table 2. Laboratory Quality Assurance Exercise Results for 2005

CRD Data, Batch Samples: 18 pairs, January 13 and 14, 2005						
Discharge No.	**Pair No.**	**1st Duplicate D1**	**2nd Duplicate D2**	**Log D1 L1**	**Log D2 L2**	**Range of Logs (Rlog) (Log L1 - Log L2)**
428	1	18	50	1.25527	1.69897	0.44370
	2	79	69	1.89763	1.83885	0.05878
	3	53	49	1.72428	1.69020	0.03408
447	4	18	44	1.25527	1.64345	0.38818
	5	17	16	1.23045	1.20412	0.02633
	6	60	28	1.77815	1.44716	0.33099
458A	7	323,200	476,800	5.50947	5.67834	0.16887
	8	313,600	316,800	5.49638	5.50078	0.00440
	9	230,400	422,400	5.36248	5.62572	0.26324
3077	10	21,600	20,800	4.33445	4.31806	0.01639
	11	19,200	35,200	4.28330	4.54654	0.26324
	12	20,800	31,200	4.31806	4.49415	0.17609
3087	13	440	390	2.64345	2.59106	0.05239
	14	600	500	2.77815	2.69897	0.07918
	15	340	380	2.53148	2.57978	0.04830
3118	16	35	28	1.54407	1.44716	0.09691
	17	34	27	1.53148	1.43136	0.10012
	18	35	18	1.54407	1.25527	0.28880
Mean - Rlog (Sum Rlog/18)						0.15778
Precision Criterion (3.27 x Mean-Rlog)						**0.51594**

Table 3. Laboratory Quality Assurance Exercise Results for 2006

CRD Data, Batch Samples: 18 pairs, January 16,18 and 27, 2006						
Discharge No.	**Pair No.**	**1st Duplicate D1**	**2nd Duplicate D2**	**Log D1 L1**	**Log D2 L2**	**Range of Logs (Rlog) (Log L1 - Log L2)**
464	1	179	141	2.25285	2.14922	0.10363
	2	167	50	2.22272	1.69897	0.52375
	3	210	167	2.32222	2.22272	0.09950
3021A	4	1800	1800	3.25527	3.25527	0.00000
	5	1600	1400	3.20412	3.14613	0.05799
	6	1200	1000	3.07918	3.00000	0.07918
3084	7	3800	400	3.57978	2.60206	0.97772
	8	6600	4000	3.81954	3.60206	0.21748
	9	5400	4400	3.73239	3.64345	0.08894
3077	10	780	520	2.89209	2.71600	0.17609
	11	1330	903	3.12385	2.95569	0.16816
	12	1200	947	3.07918	2.97635	0.10283
3087	13	1600	1000	3.20412	3.00000	0.20412
	14	800	224	2.90309	2.35025	0.55284
	15	800	346	2.90309	2.53908	0.36401
3100B	16	30	25	1.47712	1.39794	0.07918
	17	26	20	1.41497	1.30103	0.11394
	18	33	14	1.51851	1.14613	0.37239
Mean - Rlog (Sum Rlog/18)						0.23788
Precision Criterion (3.27 x Mean-Rlog)						**0.77785**

3.1.3 Field Splits

2004

Wet Weather Sampling

Table 4 presents the results for the six field splits collected during the wet period (winter) of 2004 stormwater sampling program. All of the data were compared to the precision criterion of 0.4, as described in Section 3.1.2.

Of the six field splits analyzed, one exceeded the precision criterion. This field split had fecal coliform levels below 200 FC/100 mL. Fecal coliform counts lower than 200 FC/100 mL are not expected to meet the precision criteria due to the small numbers (refer to Section 2.3.4). Therefore, the results meet the QA requirements for the winter of 2004.

Dry Weather Sampling

Due to very low precipitation levels and lack of stormwater flows, only five fecal coliform samples were collected from the Southern Gulf Islands Electoral Area during the summer of 2004. Therefore, since there were not enough samples collected to initiate the quality assurance program, no field splits were collected.

Table 4. Laboratory Quality Assurance Results – Wet Period - 2004

Date	Flow Number	Fecal Coliform Counts for Field Splits	Log	Log Range	A/U
17-Mar-04	7002A	6	0.77815	0.77815	U[2]
		0	0.00000		
17-Mar-04	7003A	40	1.60206	0.25964	A
		22	1.34242		
22-Mar-04	7800	14	1.14613	0.14613	A
		10	1.00000		
29-Mar-04	7402	11	1.04139	0.04139	A
		10	1.00000		
01-Apr-04	7620	0	0.00000	0.00000	A
		0	0.00000		
01-Apr-04	7632	37	1.56820	0.13684	A
		27	1.43136		

[1] It is possible, due to randomness, that 5% of the samples may exceed the precision criteria.

[2] Any fecal coliform count under 200 is considered too small an amount to calculate a precision criterion (APHA, 1992). However, any flow lower than 200 FC/100 mL receives a lower rating for public health concern.

2005

Wet Weather Sampling

Table 5 presents the results for the three field splits collected during the wet period (winter) of 2005 stormwater sampling program. All of the data were compared to the precision criterion of 0.5, as described in Section 3.1.2. None of the three field splits analyzed exceeded the precision criterion. Therefore, the results meet the QA requirements for the winter of 2005.

Dry Weather Sampling

Table 6 presents the results for the single field split collected during the dry weather period (summer) of 2005 stormwater sampling program. This data was compared to the precision criterion of 0.5, as described in Section 3.1.2 and was below the accepted level. Therefore, the results meet the QA requirements for the summer of 2005.

Table 5. Laboratory Quality Assurance Results – Wet Period - 2005

Date	Flow Number	Fecal Coliform Counts for Field Splits	Log	Log Range	A/U
06-Apr-05	7408	10	1.00000	0.09691	A
		8	0.90309		
20-Apr-05	7004	0	0.00000	0.00000	A
		0	0.00000		
20-Apr-05	7005	8	0.90309	0.12494	A
		6	0.77815		

Table 6. Laboratory Quality Assurance Results – Dry Period - 2005

Date	Discharge Number	Fecal Coliform Counts for Field Splits	Log	Log Range	A/U
18-Aug-05	7004	134	2.12710	0.00000	A
		134	2.12710		

2006

Wet Weather Sampling

Table 7 presents the results for the six field splits collected during the wet period (winter) of 2006 stormwater sampling program. All of the data were compared to the precision criterion of 0.8, as described in Section 3.1.2. None of the six field splits analyzed exceeded the precision criterion. Therefore, the results meet the QA requirements for the winter of 2006.

Dry Weather Sampling

Table 8 presents the results for the single field split collected during the dry weather period (summer) of 2006 stormwater sampling program. This data was compared to the precision criterion of 0.8, as described in Section 3.1.2 and both filed splits were below the accepted level. Therefore, the results meet the QA requirements for the summer of 2006.

Table 7. Laboratory Quality Assurance Results – Wet Period - 2006

Date	Flow Number	Fecal Coliform Counts for Field Splits	Log	Log Range	A/U
27-Mar-06	7002	4	0.60206	0.00000	A
		4	0.60206		
27-Mar-06	7412	70	1.84510	0.31362	A
		34	1.53148		
27-Mar-06	7413	4	0.60206	0.60206	A
		0	0.00000		
28-Mar-06	7600	37	1.56820	0.024134	A
		35	1.54407		
28-Mar-06	7614	8000	3.90309	0.15490	A
		5600	3.74819		
28-Mar-06	7820	15	0.00000	0.00000	A
		15	0.00000		

Table 8. Laboratory Quality Assurance Results – Dry Period - 2006

Date	Discharge Number	Fecal Coliform Counts for Field Splits	Log	Log Range	A/U
18-Jul-06	7600	800	2.90309	0.12494	A
		600	2.77815		
14-Aug-06	7413-1	245	2.38917	0.11041	A
		190	2.27875		

4.0 CONCLUSIONS

All requirements for the Stormwater, Harbours and Watersheds program QA/QC program were carried out in 2004, 2005 and 2006. All QA/QC results were acceptable for rating stormwater discharges for public health concerns.