Appendix 9 CRD – Wastewater and Marine Environment Monitoring Program

Making a difference...together

CAPITAL REGIONAL DISTRICT

REVISED WASTEWATER AND MARINE ENVIRONMENT MONITORING PROGRAM FOR THE CRD'S MACAULAY POINT AND CLOVER POINT OUTFALLS

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FINAL

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1.0 INTRODUCTION

The Capital Regional District (CRD) owns and operates a number of municipal wastewater facilities and outfalls on southern Vancouver Island and the southern Gulf Islands. The operation of these facilities and authorizations to discharge are regulated by the British Columbia (BC) Ministry of Environment (MOE) either by permits, registrations, operational certificates, or liquid waste management plans (LWMP) as authorized under the BC Municipal Sewage Regulation (MSR) and Environmental Management Act (EMA)[1].

As part of the authorization to discharge,, the CRD is responsible for wastewater and marine environment monitoring, both for regulatory compliance and to assess the effects of the outfalls on the receiving environment. Monitoring results are used to assess potential impacts on environmental and human health in relation to the CRD wastewater discharges in a cost effective manner. CRD monitoring activities vary from location to location depending upon effluent quality and volume, sensitivity of the receiving environment, historical data and budget availability

The focus of this document is to describe the conceptual design of a comprehensive Wastewater and Marine Environment program (WMEP) that can be partly or completely applied to any CRD marine wastewater outfall. The CRD and BCMOE will work together to determine the level of monitoring appropriate for each outfall.

While the revised conceptual monitoring program focuses on the CRD's Macaulay and Clover Point discharges, the fundamental concepts can be applied broadly to the other CRD facilities. As such, the remainder of this document will describe the monitoring program conceptual design as applied to these two outfalls.

1.1 WMEP Rationale

The Macaulay Point and Clover Point outfalls are currently regulated under the CRD Core Area LWMP (CRD, 2000a) that was approved by the BC Minister of Environment in March 2003. The outfalls at Macaulay and Clover points operate under the long-term direction of the LWMP and under permits on a day-to-day basis. The permits for Macaulay (PE-270) and Clover (PE-1877) were issued by the MoE under the 2004 *BC Environmental Management Act* (formerly the *BC Waste Management Act* (BCMoE, 2004)).

On July 21, 2006, the CRD was directed by the Minister of Environment to amend the Core Area LWMP detailing a schedule for the provision of sewage treatment for the Core Area (i.e., Greater Victoria and western communities). Plans for the development of wastewater treatment are currently underway, and the first LWMP amendment (amendment #7) associated with these plans was submitted in December 2009 (CRD, 2009a). A second LWMP amendment (amendment #8) was submitted in July 2010 (CRD, 2010).

Within both of these LWMP amendments, the CRD and participating municipalities committed to:

- Work with Ministry of Environment staff to develop cost-effective and comprehensive long-term wastewater and marine environment monitoring programs tailored to each individual CRD core area discharge and to document effluent quality and the state of the marine receiving environment;
- carry out one-time investigations to provide background data to the monitoring programs and address information gaps;
- regularly report on the wastewater and marine environment program to the Ministry of Environment (MOE) and the CRD Board, following plan amendment approval; and

[1] BC MOE regulatory documents can be found at http://www.env.gov.bc.ca/epd/epdpa/mpp/msrhome.html (last accessed on February 12, 2010)

- review the wastewater and marine environment program at five year intervals, following plan amendment approval.

This monitoring program conceptual design is intended to support these commitments now and in the years to come.

The LWMP amendments also included goals for the WMEP for the CRD core area outfalls. The goals, to be met by the implementation of an appropriate monitoring program, are to:

- Monitor and assess wastewater quality and quantity;
- monitor and assess the potential effects of the wastewater discharges to the marine environment;
- monitor and assess the potential effects of the wastewater discharges to human health;
- provide information to the CRD Regional Source Control program (RSCP);
- provide information to wastewater managers regarding treatment plant and outfall diffuser performance;
- provide compliance monitoring results to regulatory agencies; and
- provide scientific assessment to the general public regarding the use of the marine environment for the disposal of municipal wastewater.

This WMEP monitoring conceptual design is intended to meet these goals.

1.2 WMEP History

Monitoring of wastewater discharges, surface waters and the seafloor environment in the vicinity of the Macaulay and Clover points outfalls has been conducted as part of the WMEP on a regular basis since the late 1980s. The program has undergone a number of changes over the years. Monitoring of wastewater, marine waters close to the outfalls, and benthic communities were conducted in the 1970s and 1980s in collaboration with the University of Victoria and independent consultants. In addition, a number of special additional investigations have been undertaken to more clearly define the effects of the outfalls on the receiving environment. In 1992, a detailed investigation of effects related to the outfalls was conducted by EVS (1992). This study included the analysis of wastewater and sediment chemistry, sediment toxicity, and the assessment of the health of biological communities near the outfalls. The 1992 study results were used to design a regular monitoring and assessment program in collaboration with the Marine Monitoring Advisory Group (MMAG) (see section 1.3.2 for more detailed information on the MMAG).

From 1992 until 1999, the program consisted of monthly wastewater analysis for conventional parameters, quarterly wastewater analysis for priority substances, monthly surface water (<1m depth) sampling for indicator bacteria, yearly sediment chemistry analysis and seafloor organisms monitoring on a three-year cycle. Starting in 2000, the WMEP was again revised in consultation with the MMAG. The major changes were not in the components of the program, but rather in the frequency of monitoring (i.e., monitoring frequency increased). Special, additional investigations continue to supplement the routine monitoring as necessary. The WMEP has been largely unchanged since 2000. A summary of the existing monitoring program can be found in CRD (2009b). Appendix C presents current (2010) surface water sampling stations for the Macaulay and Clover Point outfalls, while Appendix D shows current (2010) seafloor sampling stations.

1.3 WMEP Gaps & Recommendations

Since 2000, a number of reviews of the WMEP have been undertaken. Reviews have included formal comprehensive reviews (Golder, 2005c; MacDonald *et al.*, 2007; SETAC, 2006) and more focused component specific reviews (Avocet, 2007; Golder, 2007c; 2007d; 2008a; 2008b; 2008c; 2009d; Integral, 2006; MacDonald *et al.*, 2006a; 2006b; TTYI, 2004). The MMAG has also provided and prioritized a number of recommendations for the WMEP since 2000. The following is a summary of gaps and recommendations from these reviews.

1.3.1 Regulatory Requirements

In the 2003 Core Area LWMP approval letter, the Minister of Environment had some requirements for the WMEP including:

- Field programs to characterize endocrine disrupting chemicals, persistent organic pollutants (POPs) and other micro-contaminants and assess their potential environmental impacts;
- using new biological assays such as gene chip arrays to determine potential sub-lethal impacts of wastewater contaminants;
- field programs to assess sediment transport mechanisms and determine the fate of sediments being discharged into the environment (this requirement has since been deferred); and
- the expansion of the trigger process (CRD, 2000b) to include trigger points for sediment, benthic communities, the water column and surface waters (although this trigger process was abandoned following the Minister of Environment's mandated move to treatment in 2006, this requirement highlights the Minister's desire to see enhanced water column and surface water monitoring around CRD outfalls).

A number of the studies on the MMAG list of additional investigations (A) have already been undertaken to meet some of these requirements, while others remain outstanding.

1.3.2 Marine Monitoring Advisory Group

In 1987, the CRD formed the MMAG to advise on and provide an independent assessment of CRD marine monitoring programs. The MMAG consists of university and government scientists with expertise in the fields of marine science, oceanography, toxicology, chemistry and environmental health. Since 1987, the MMAG has been instrumental in helping the CRD to develop a comprehensive WMEP for the Macaulay and Clover Point outfalls. The MMAG has given, and continues to give, input into every aspect of the WMEP, including reviewing and commenting on all monitoring results and their interpretation, as well as identifying gaps and making recommendations for additional investigations.

On an annual basis, the MMAG reviews the WMEP annual reports. Their most recent review was of CRD (2009c) and they provided their comments to the BC MOE directly (MMAG, 2009). In general, the MMAG did not identify any new significant concerns with the WMEP. There was general support for how the wastewater, sediment chemistry, benthic community, mussel community, and mussel tissue chemistry components were being conducted, including the monitoring parameters and sampling stations. The MMAG had no outstanding concerns or comments about these components. However, the MMAG did have some outstanding concerns about the surface water monitoring component and made a number of recommendations for this component and potential new initiatives including:

- Revising surface water sampling frequency to meet the 5-in-30 day sampling requirements of the human health primary recreational contact guidelines (BCMoE, 2006) (this recommendation has been initiated via a 5 in 30 day sampling event scheduled for each summer;
- assessing the utility of *Enterococci* as an additional bacterial indicator in surface waters (this recommendation has been initiated via the pre-discharge monitoring programs that are being undertaken to satisfy Environmental Impact Study requirements for two proposed outfall locations);
- considering measuring contaminants in treatment plant screenings; and
- reviewing and reprioritizing the additional investigations list (see below for discussion) once the fate and location of treatment facilities and marine outfalls are determined.

In 2005, the MMAG initiated a comprehensive review of WMEP gaps and recommendations. This review was completed in 2006 and Appendix A presents the studies that were recommended based on a risk assessment framework including contaminant source, pathways, receptors and potential effects. For each of these categories, studies were ranked as high, medium or low priority.

It should be noted that the additional investigations presented in Appendix A were evaluated by the MMAG before the Minister of Environment mandated the move to advanced treatment in 2006. As such,

all additional investigations that had already been implemented by the receipt date of the Minister's 2006 letter were continued, but new additional investigations were put on hold because their priority may change following the installation of new treatment.

Some of the monitoring components included in this WMEP monitoring conceptual design were designed to address a number of the additional investigations listed in Appendix A. However, there are a number of additional investigation recommendations that have not yet been addressed and these will be reviewed and reprioritized following the final determination of new treatment system design and in light of this monitoring conceptual design. The MMAG will assist with the additional investigation review as necessary.

1.3.3 Golder Associates Ltd.

Since 2004, Golder Associates Ltd. (formerly EVS Consultants) has been the primary consultant to the CRD for reviewing and assessing the results of the WMEP. Over this period, reviews have included a formal comprehensive review (Golder, 2005c) and more focused component specific reviews done in conjunction with annual data assessments (Golder, 2005a; 2005b; 2006a; 2006b; 2006c; 2006d; 2007a; 2007b; 2007c; 2008a; 2008b; 2008c; 2009a; 2009b; 2009d). In addition, Golder has reviewed the CRD's analytical Quality Assurance/Quality Control program and how it is applied to WMEP results (Golder, 2007d; 2009c).

Overall, Golder has determined that the "overall design of the WMEP monitoring program… is appropriate [with the] density of sampling stations and the frequency of monitoring [being] sufficient to provide robust assessments of spatial and temporal trends in biology and chemistry metrics" (Golder, 2005c). Regardless of the program sufficiency, Golder's reviews have contained a number of recommendations to enhance the WMEP including:

- Increasing the number of reference stations and replication at outfall and "near-field" stations (Golder, 2005a; 2005c; 2009a) (this recommendation has already been implemented at the reference stations and M0. Increased replication is currently being considered for the "near-field" stations.);
- undertaking seafood tissue chemistry monitoring to support human health and environmental risk assessments (Golder, 2005c);
- evaluating the use of *Enterococci* in the surface water monitoring program, either to replace or supplement fecal coliform monitoring (Golder, 2005c);
- implementing a phased approach to assessing endocrine modulating chemicals as per recommendations by the 10,000 Years Institute (TTYI, 2004), with the "focus of the long term monitoring [being] on direct measures of environmental effects rather than metrics that require predicting effects or extrapolating toxicology across species and levels of biological organization" (Golder, 2005c; TTYI, 2004) (this recommendation has been implemented, in part through collaborations with Environment Canada and the University of Victoria – see Appendix A);
- reviewing the list of priority substances to potentially reduce sampling frequency for substances that are routinely non-detected (Golder, 2005c; 2007b; 2008c; 2009b) this recommendation has already been implemented in part);
- standardizing benthic taxonomy methodology (Golder, 2005c); this recommendation has already been implemented);
- considering toxicity testing including using a range of marine organisms in both modified sediment toxicity tests and brine diluted effluent toxicity tests (Golder, 2005c);
- refining statistical methodologies to allow for distance-direction co-effect assessments, along with the existing distance effect assessments (Golder, 2005c) (this recommendation has already been implemented);
- adding assessments of benthic invertebrate major taxonomic groupings and individual taxa profiles in conjunction with existing indicator metrics (Golder, 2005a; 2005c; 2006a) (this recommendation has already been implemented);
- reviewing the use of existing benthic invertebrate indicator indices (such as ITI and SDI) to ensure that they are used only as indices of benthic alteration as opposed to impairment (Golder, 2008b) (this recommendation has already been implemented);

- collecting field triplicates for sediment sampling rather than duplicates (Golder, 2007c) (this recommendation has already been implemented);
- focusing sediment and mussel tissue chemistry field and lab triplicate collection at stations where replication has routinely shown high variation in results (Golder, 2007b; 2008a);
- maintaining high-resolution wastewater chemistry analyses on a quarterly basis if seasonal variations are of interest (Golder, 2008a);
- emphasizing tissue-based assessments for determining risks of PCBs to aquatic organisms, using sediment data if tissue data is not available (Golder, 2008a);
- stopping comparison of wastewater PCB concentrations to PCB water quality guidelines due to the poor scientific basis of these water quality guidelines (Golder, 2008a) (this recommendation has already been implemented);
- considering the measurement of alkylated PAHs and ensuring that labs meet data quality objectives for specific indicator PAHs (Golder, 2008a; 2008c) (this recommendation has already been implemented via (Yunker, 2008));
- continuing to collect mussels greater than 50 mm in length (Golder, 2007b) (this practice has been maintained); and
- continuing to measure mussel tissue chemistry without depuration (Golder, 2008c) (this practice has been maintained).

A number of these recommendations have already been implemented, as noted, and will be maintained in this WMEP monitoring conceptual design while some of the remaining recommendations will actually be addressed by the implementation of this WMEP monitoring conceptual design.

1.3.4 SETAC

The Society of Environmental Toxicology and Chemistry (SETAC) completed a review of the CRD Core Area LWMP in 2006 (SETAC, 2006). The SETAC review panel found that the WMEP program was substantial and well designed and that continuing it would be appropriate for assessing the CRD wastewater discharge in the future. However, the panel made a number of recommendations to enhance the WMEP, including:

- Increasing the frequency of surface water monitoring to 5-in-30 days and ensuring that it covers the temporal variations in wastewater flow, tidal cycles and currents;
- using *Enterococci* as an additional bacterial endpoint;
- undertaking fish tissue chemistry monitoring including a human health risk assessment;
- assessing toxicity of whole effluent, diluted effluent, and/or sediment;
- enhancing the high-resolution analysis program in mussel tissues;
- undertaking a detailed study of mussel reproductive development over time and space;
- assessing effluent effects on water column dwelling organisms;
- assessing effluent effects on the sea surface microlayer;
- more extensive monitoring with better spatial and temporal resolution in the far-field to provide a better understanding of the fate of the surfaced sewage plume;
- reviewing the number of reference stations and the replication done at said reference stations (this recommendation has already been implemented); and
- adding some additional contaminants such as chlorinated pesticides and emerging substances to the analyte lists.

Similar to the MMAG list of additional investigation recommendations, the SETAC review was done before the Minister of Environment mandated the move to advanced treatment in 2006. As such, the implementation of SETAC recommendations was put on hold because the relevance of their recommendations may change following the installation of new treatment.

Some of the monitoring components included in this WMEP monitoring conceptual design were designed to address a number of the SETAC investigations. However, there are a number of the SETAC

recommendations that have not yet been addressed and these will be reviewed and reprioritized following the final determination of new treatment system design.

1.3.5 MacDonald Environmental Sciences Ltd.

MacDonald Environmental Sciences Ltd. (MESL) has performed a number of reviews of the WMEP, on behalf of BC MOE, including assessing the CRD's sediment chemistry results in relation to various sediment quality guidelines (MacDonald *et al.*, 2006a; 2006b) and detailing a proposed revised WMEP (MacDonald *et al.*, 2007). MESL made a number of recommendations that include:

- Developing an electronic data management system that enhances the ability to provide data to the provincial Environmental Management System (EMS) (MacDonald et al., 2006a) (this recommendation is currently being implemented);
- undertaking a detailed site investigation including assessments of whole-sediment chemistry, whole-sediment toxicity, laboratory bioaccumulation, and invertebrate-tissue chemistry (MacDonald *et al.*, 2006a) (whole-sediment chemistry has always been a part of the WMEP; the other components will be addressed in the revised WMEP);
- revising or abandoning the seafloor trigger (MacDonald *et al.*, 2006a) (this trigger process was abandoned following the Minister of Environment's mandated move to treatment in 2006);
- Revising the WMEP to provide information that is more directly responsive to the goals and objectives that have been developed jointly by CRD and BCMOE. Specific recommendations regarding refinement of the WMEP included:
  - document the data quality objectives for the monitoring program (Data quality objectives are an important part of the WMEP and will be articulated after the monitoring program is revised);
  - maintain the excellent effluent characterization program that is currently in place;
  - revise the water quality monitoring program to facilitate evaluation of compliance with water objectives and evaluation of temporal trends (surface fecal spatial and temporal trends are currently evaluated as part of the WMEP);
  - revise the sediment quality monitoring program to further characterize the nature and extent of contamination, to evaluate acute/chronic toxicity, to assess bioaccumulation, and to determine temporal trends in sediment quality conditions;
  - revise the tissue monitoring program to include evaluation of bioaccumulation of selected chemicals of potential concern (COPCs) in fish tissues (whole body and fillets);
  - further evaluate the potential effects of endocrine disrupting chemicals, persistent organic pollutants, and micro-contaminants; (these substances are currently evaluated in tissue, sediment and wastewater both at the CRD and with collaborative research agreements with universities and DFO)
  - conduct a sediment transport study to evaluate the fate of sediments released from CRD outfalls, including sediment deposited near the outfalls prior to implementation of sewage treatment; (this item had been deferred by the MOE)
  - document the design of the revised WMEP in a monitoring program design document; and,
  - document the procedures that will be used to collect and analyze environmental samples in a Field Sampling Plan and a Quality Assurance Project Plan (CRD monitoring programs are typically documented in sampling plans).

2.0 WMEP REDESIGN PROCESS

To address the recommendations and gaps identified in the various WMEP reviews (Golder, 2005c; MacDonald et al, 2006a; SETAC, 2006) as well as the MMAG, BC MOE tasked MESL to prepare a REMP (receiving environment monitoring program) for the CRD's Macaulay and Clover Point outfalls. The REMP was presented to CRD staff in 2008. Since that time, CRD, BC MOE and MESL have been working together to redesign and refine the CRD's monitoring program by integrating many of the REMP's recommendations, while retaining key existing WMEP components. An ongoing series of meetings and discussions have identified priorities, key measurement and assessment endpoints, while balancing program cost. The culmination of these discussions is the revised, innovative WMEP design template presented in this report, which has been developed by consensus between MESL, CRD and BC MOE staff.

Considerable wastewater and receiving environment sampling has been conducted in the vicinity of the Clover and Macaulay Point outfalls. Various WMEP reviews have made recommendations and identified gaps in the present program. Building on the existing WMEP, the revised WMEP has been designed to further characterize effluent quality, surface and water column status and trends, sediment quality conditions, tissue residues in benthic organisms and fish in the vicinity of the outfalls. A focused suite of measurement and assessment endpoints were integrated into the program to provide information on the status and trends of the ecosystem as a whole producing an effective and cost-effective WMEP design.

Table 1 – Identification of Measurement Endpoints (ME), Relevant for Evaluating the Status of the Assessment Endpoints (AE) Selected for Possible Inclusion in the WMEP.

Data Type [1, 2] \ AE		Aquatic Plants	Aquatic Invertebrates		Fish		Aquatic-Dependant		Humans
			Benthic	Pelagic	Benthic	Pelagic	Birds	Mammals	
Effluent Chemistry		✔	✔	✔	✔	✔	✔	✔	✔
Effluent Toxicity		NR	✔	✔	✔	✔	NR	NR	✔
Surface Water Chemistry	- surface (≤ 1m depth)	✔	NR	✔	NR	✔	✔	✔	✔
	- water column > 1m depth)	✔	✔	✔	✔	✔	✔	✔	✔
Surface Water Toxicity		NR	NR	NR	✔	✔	NR	NR	NR
Whole-Sediment Chemistry		NR	✔	NR	✔	NR	NR	NR	NR
Porewater Chemistry		NR	✔	NR	✔	NR	NR	NR	NR
Whole-Sediment Toxicity/Porewater Toxicity		NR	✔	NR	✔	NR	NR	NR	NR
Community Structure		NR	✔	NR	NR	NR	NR	NR	NR
Tissue Chemistry (Fish and Invertebrate)		NR	✔	✔	✔	✔	✔	✔	✔
Sediment Transport		NR	✔	NR	✔	NR	NR	NR	NR
Health		NR	NR	✔	✔	✔	✔	✔	✔
Modeling		NR	✔	✔	✔	✔	✔	✔	✔

[1] NR = ME is not relevant to the AE.

[2] ✔ = ME is directly relevant to the AE.

Table 2 – Identification and Evaluation of Candidate Metrics for Possible Inclusion in the WMEP

Measurement Endpoint	Metric	Priority	Rationale
Surface water chemistry	Microbial variables	High	Comparison to WQGs; Evaluation of diffuser Performance
Surface water chemistry	Metals	High	Comparison to WQGs
Surface water chemistry	Organics	Low	Comparison to WQGs
Surface water chemistry	Conventional variables (e.g., pH, salinity, others)	High	Identification of the location of plume
Surface water chemistry	Nutrients - NH^3	High	Comparison to WQGs
	- NO^3/P	Low	Comparison to informal WQGs
Surface water chemistry	Emerging chemicals	High	Evaluation of importance of emerging chemicals
Whole-sediment chemistry (WSC)	Conventionals	High	Comparison to SQGs evaluate compliance with regulations; evaluate the fate of COPCs; and inform the Source Control program
	Metals (SEM and total)	High	
	PAHs	High	
	PBDEs	High	
	Phenolics	High	
	Phthalates	Medium	
	PCBs/Pesticides	Medium	
	SVOCs	Medium	
	VOCs	High	
	Nonylphenols	High	
	Emerging chemicals	Medium	
Pore-water chemistry	Conventionals	High	Interpretation of sediment toxicity
	COPCs	TBD	Identification of risk drivers
Whole-sediment toxicity/pore-water toxicity/whole sediment bioaccumulation	10-d toxicity tests (*Rhepoxinius abronius and Mysidopsis bahia*)	High	Evaluation of toxicity and bioavailability of COPCs in sediment; and evaluation of effects on benthic invertebrates.
	28-d toxicity tests and bioaccumulation tests with (*Nereis viren* and *Leptochirus plumulosus)*		
	48-h toxicity test (*Mytilus galloprovincealis*)		

Measurement Endpoint	Metric	Priority	Rationale
Benthic invertebrate community structure (BICS)	See list of metrics in WMEP	High	Evaluation of bioavailability of COPCs; and evaluation of effects on benthic invertebrates
Sediment transport	TBD	High	support selection of sampling stations; and evaluation of environmental fate of COPCs
Invertebrate tissue chemistry	Bioaccumulative COPCs; Typically in whole body	High	Support food web modeling for fish and wildlife; and explain sediment toxicity
Fish tissue chemistry	Bioaccumulative COPCs in whole body for ecological receptors and fillets for human health	High	Support food web modeling for wildlife; and evaluation of risks to human health
Effluent chemistry	COPCs; List refined based on monitoring results and new information	High	To guide WMEP design; and evaluate effectiveness of Source Control program
Effluent toxicity	96-h toxicity tests with RT/CO/CH with whole effluent and/or dilution series	High	Evaluation of regulatory compliance; and identify need for further source control measures
Surface water toxicity	Survival and/or growth of invertebrates or fish	Low	Evaluation of extent of toxicity if effluent toxicity is identified
Health ecological	DELT in fish (deformities, fin erosion, lesions, or tumours)	High	Contribute to regional monitoring programs
	Bird Health	Low	
	Mammal health	Low	
	Consumption advisories	Low	
Human health	Frequency of plume surfacing	High	Evaluation of risks associated with secondary contact recreation and consumption of aquatic organisms.
	Fish tissue chemistry		
	Invertebrate tissue chemistry		
	Survey of area use by recreational users		
	Fecals in surface water		
Food web model		High	Evaluation of risks to wildlife
Fate model		High	Evaluation of ultimate fate of COPCs

Measurement Endpoint	Metric	Priority	Rationale
Sediment stability model		High	To guide monitoring program design; to select station locations and frequency for various metrics; and to evaluate fate of contaminated sediments.

SEM - simultaneously extracted metals, AVS - acid volatile sulfide, VOC - volatile organic compounds, SVOC - semi-volatile organic compounds, PCB – polychlorinated biphenyl, PBDE - polybrominated diphenyl ethers, PAH - polycyclic aromatic hydrocarbons, NH^3 – ammonia nitrogen, NO^3- nitrate nitrogen, P – Phosphorus, WQG – water quality guideline, SQG – sediment quality guideline, COPC – chemicals of potential concern, TBD- to be determined

3.0 PROPOSED WMEP

Environmental monitoring provides the data and information needed to make informed management decisions regarding all uses and users of aquatic ecosystems and human health. A systematic approach to the design and implementation of an environmental monitoring program ensures effective, meaningful data which supports management decisions. Clearly defined objectives represent a fundamental component of a well-designed monitoring program. The revised WMEP outlined here is primarily designed to assess compliance with provincial water quality guidelines, evaluate potential impacts on human health, report on the status of current ecosystem health and determine trends in environmental quality. To support the WMEP, a detailed field sampling quality assurance plan will be prepared to ensure the longer term consistency and success of the program.

3.1 5-year cycle

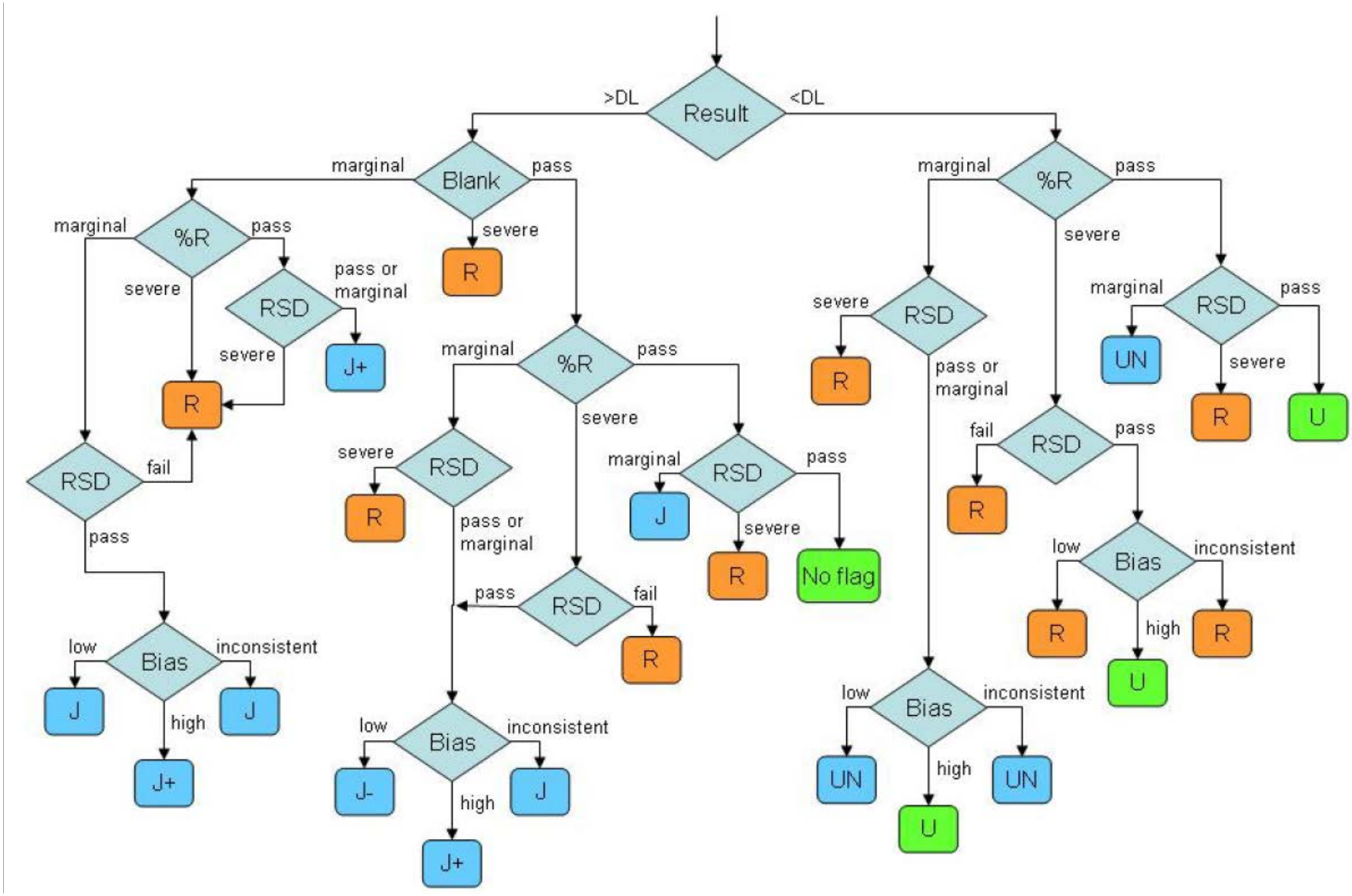
A well designed program must balance cost, while maintaining reasonable timelines and reporting structure. The revised WMEP monitoring template is based on a 5 year rotational cycle, which balances year to year workload and costs. The cycle includes a base monitoring program which will be completed and reported on annually. The remaining monitoring components will build on the base program, by addressing specific ecosystem measurement and assessment endpoints, such as fish health or the bioaccumulation of potential contaminants of concern. These components will be reported on at the end of the cycle in a comprehensive report which covers the entire 5 year program. The 5 year cycle will also include periodic joint CRD and BC MOE reviews of the ongoing effectiveness and necessity of program components as well as ensuring that field logistics are reasonable.

Table 3 – Monitoring Component Sampling Frequency within the 5-Year Cycle

Monitoring Component	Sub-component	Year 1 (2011)		Year 2 (2012)		Year 3 (2013)		Year 4 (2014)		Year 5 (2015)	
		Mac[1]	Clo[1]	Mac	Clo	Mac	Clo	Mac	Clo	Mac	Clo
WASTEWATER											
Wastewater	monthly and quarterly chemistry	√	√	√	√	√	√	√	√	√	√
	quarterly high resolution chemistry	√	√	√	√	√	√	√	√	√	√
	quarterly toxicity testing[2]	√	√	√	√	√	√	√	√	√	√
SEAFLOOR											
Sediment	sediment chemistry	√ (pilot)	√ (pilot)	√	√			√			√
	pore-water chemistry[2]	√ (pilot)	√ (pilot)	√	√			√			
	sediment toxicity[2]	√ (pilot)	√ (pilot)	√	√			√			
	sediment/benthic invertebrate bioaccumulation[2]	√ (pilot)		√				√			
Benthic Invertebrates	community structure			√				√			
Mussels	community indices and health										√
	tissue chemistry										√
Fish[2]	health indices[2]									√	√
	whole fish and fillet tissue chemistry[2]									√	√
SURFACE WATER AND WATER COLUMN											
Surface Water	bacteria	√	√	√	√	√	√	√	√	√	√
Water Column[2]	bacteria, conventionals, metals[2]	√	√	√	√	√	√	√	√	√	√
REPORTING & ADDITIONAL INVESTIGATIONS											
Additional Investigations	Dependent upon emerging environmental issues and recommendations by MMAG and others	√	√	√	√	√	√	√	√	√	√
Reporting	annual summary report	√	√	√	√	√	√	√	√		
	5 year comprehensive report									√	√

[1]Mac-Macaulay, Clo-Clover
[2]Monitoring component new to the WMEP

Figure 1 - Decision Criteria for Assessing Data Usability and Assigning Data Flags to CRD Chemistry Data (Golder, 2009c)



3.1.1 Wastewater Chemistry and Toxicity

Since 2000, Clover and Macaulay Point effluents have been routinely analyzed for key contaminants. To build on this monitoring, and in anticipation of Environment Canada's Wastewater Systems Effluent Regulations, final effluent toxicity testing will also includeRainbow Trout and *Daphnia magna* LC50 bioassays on a quarterly basis.In addition, quarterly high resolution analysis will be added to the priority substance list of parameters. Previously these analytes were only tested at high resolution from 2004 to 2007. This will allow for a more direct comparison to high resolution analysis associated with sediment and bioaccumulation studies in the vicinity of the outfalls. It will also provide information that will be potentially useful in source and fate discrimination assessments (e.g., congener ratios).

3.1.1.1 Methods

Figure 2 presents the location of the Clover and Macaulay Point pump stations. Samples will be collected from these pump stations after the wastewater has been screened.

Wastewater samples will be taken as 24-hour composites at the Macaulay and Clover Point wet wells, with grab samples taken for a few substances not suited to composite collection (e.g., fecals, sulphide, VOCs). All sampling equipment (e.g., hoses, sieves, carboys and sampling bottles) will be cleaned prior to use by a laboratory using solvents, acids and distilled water. Effluent will be collected for composite samples by an ISCO sampler programmed to collect approximately 400mL of effluent every 30 minutes. Effluent will be collected into a fluorinated pre-cleaned (acid, solvents and distilled water cleaning process) polyethylene carboys and continuously and thoroughly mixed before and during sample splitting to ensure sample homogeneity.

After collection, wastewater will be transferred to CALA certified laboratories and analyzed for a comprehensive list of parameters, including metals, halogenated compounds, polycyclic aromatic hydrocarbons (PAHs), toxicity and other parameters (Appendix B). Analytical methodologies will be chosen to provide detection limits that allow for comparison to water quality guidelines (BCMELP, 1998; BCMoE, 2006; BCMoE, 2010).

Toxicity testing will be conducted using fish (e.g., Rainbow trout and/or Chinook) and invertebrate (e.g., *Daphnia Magna* and/or *Mysidopsis bahia)* LC50 tests using Environment Canada, Puget Sound Estuary Program or US EPA guidance and test protocols. Sub-samples will be taken from the wastewater sample and submitted for toxicity tests. Samples will be tested for ammonia levels prior to the commencement of the tests to determine if test protocols must be modified for pH drift.

Figure 2 – Macaulay Point and Clover Point Outfall Locations

Table 4 – Frequency of Wastewater Sampling by Analytical Group (Appendix A provides a listing of analytes within each analytical group)

Parameter	Wastewater Priority Substances		
	Monthly Sampling	**Quarterly Sampling**	**Annual Sampling**
Conventionals	√	√	
Metals, total	√	√	
Metals, (MeHg and TBT)		√	
Metals, dissolved	√	√	
Aldehydes	√	√	
Phenolic compounds	√	√	
Chlorinated phenolics	√	√	
Non-chlorinated phenolics	√	√	
Polycyclic aromatic hydrocarbons (PAHs)	√	√	
Semi-volatile organics	√	√	
Miscellaneous semi-volatile organics	√	√	
Volatile organics	√	√	
Terpenes	√	√	
Toxicity			
Rainbow Trout 96 hr LC50		√	
Daphnia magna 48 hr LC50		√	
Chinook 30 day (survival and growth)			√
Ceriodaphnia 7 day (Survival and reproduction)			√
Top smelt 7 day (survival and growth)			√
Echinoderm fertilization (reproduction)			√
High Resolution Analysis			
Nonylphenols (NP)		√	
Organochlorine pesticides (OC Pest)		√	
Polychlorinated biphenyls (PCBs)		√	
Polybrominated diphenyl ethers (PBDEs)		√	

3.1.1.2 Sampling Frequency

Every year, the wastewater monitoring will be conducted on a monthly basis with additional tests scheduled for each quarter or annully (e.g., high resolution analysis and toxicity) (Table 3). Quarterly wastewater sampling will be paired with the first day of quarterly surface water sampling (Section 3.1.2), weather permitting.

Appendix B provides a listing of the individual analytes within each parameter group. Wastewater samples from each pump station will be analysed for the quarterly list of priority substances on a quarterly basis (January, April, July and October), and a monthly list for the months of February, March, May, June, August, September, November and December. Toxicity test samples will also be collected quarterly (January, April, July and October) in conjunction with the samples collected for chemical analyses (e.g., composite samples).

3.1.1.3 QA/QC Criteria

The CRD has developed a rigorous QA/QC protocol for both field procedures and laboratory analysis. QA/QC procedures include field triplicates and blanks, laboratory triplicates and spiked samples. All data will be carefully screened to assess relative standard deviation (RSD) and spike recoveries.

The following QA/QC will be conducted (in addition to standard laboratory QA):

- field triplicates – priority substances - full list (April, July, Oct, Dec)
- field and trip blank – priority substances - full list (October)
- method blanks – priority substances - full list (Jan, April, July, Oct) and modified list (Feb, March, May, June, Aug, Sept, Nov, Dec)
- lab replicates – priority substances - full list (Jan, April, July, Oct) and modified list (Feb, March, May, June, Aug, Sept, Nov, Dec)
- spike matrix sample – priority substances - full list (Jan, April, July, Oct) and modified list (Feb, March, May, June, Aug, Sept, Nov, Dec)

The analytical data will be reviewed using the CRD's data quality objectives (Golder, 2007d; Golder, 2009c). This QA/QC procedure will include an initial screening of the data to identify any data results that fall outside of the expected range (i.e., 0.5th to 99.5th percentiles) of historical results. Results that fall outside of these ranges will be discussed with the laboratory to ensure internal QA/QC requirements were satisfied and to determine whether any re-analyses were necessary.

Following the initial screening, the data will be evaluated (Figure 1) for precision (based on variability in lab or field replicates), bias (based on recoveries of spikes, surrogate standards or certified reference materials), and representativeness (based on blank sample contamination) using specific criteria for each analytical group.

The magnitude of precision, bias or representativeness failures will be determined (Table 5) and data with marginal failures will be flagged, while data with severe failures will be rejected. Analytical batch data, if available, will be used to link associated samples to specific blanks, spikes, replicates, etc. All data that exhibited failures will be questioned and an investigation of the potential causes will be undertaken. Rejected results will be not presented in the report and will be not used for further analyses (e.g., statistical analyses) except for the determination of frequency of detection.

Table 5 - Criteria Used to Differentiate Between Moderate and Severe QA/QC Failures (Golder, 2009c)

Objective/DQO	Analyte Group	Proposed Criteria		
		Pass	**Marginal Failure**	**Severe Failure**
Precision: Laboratory or Field Replicate RSD [or SD]	Oil & Grease	RSD<20% [SD<DL]	RSD=20-30% [SD=DL-1.5×DL]	RSD>30% [SD>1.5×DL]
	Metals (except silver)	RSD<20% [SD<DL]	RSD=20-40% [SD=DL-2×DL]	RSD>40% [SD>2×DL]
	Silver	RSD<20% [SD<DL]	RSD=20-70% [SD=DL-3.5×DL]	RSD>70% [SD>3.5×DL]
	Organics	RSD<50% [SD<2.5×DL]	RSD=50-75% [SD=2.5×DL-5×DL]	RSD>75% [SD>5×DL]
	NH_3, TKN, NO_2^-, NO_3^-	RSD<10% [SD<0.5×DL]	RSD=10-15% [SD=0.5×DL-DL]	RSD>15% [SD>DL]
	TSS, BOD, SO_4^{2-}, Hardness, COD	RSD<15% [SD<DL]	RSD=15-25% [SD=DL-1.5×DL]	RSD>25% [SD>1.5×DL]
	S^{2-}, CN^-, Phenolics, TOC, lipid	RSD<25% [SD<DL]	RSD=25-40% [SD=DL-1.5×DL]	RSD>40% [SD>1.5×DL]
Bias: Matrix Spike, Reference Sample or Surrogate Recovery	Metals, S^{2-}, CN^-, phenolics, TOC	75-125%	60-75% or 125-140%	<60% or >140%
	Organics	50-150%	25-50% or 150-175%	<25% or >175%
	NH_3, NO_2^-, NO_3^-, SO_4^{2-}, Hardness, Oil & Grease	80-120%	70-80% or 120-130%	<70% or >130%
	BOD, COD, TKN	85-115%	75-85% or 115-125%	<75% or >125%
Representativeness Lab or Field/Trip Blank Contamination	All (Sample-based)	<10% of sample	10-20% of sample	>20% of sample

Notes

Separate precision criteria given for results ≥5x DL (RSD-based) and results <5x DL, (SD-based).
Blank criteria based on DL and sample concentrations.

3.1.2 Surface Water and Edge of IDZ

Receiving waters at Macaulay and Clover Point have been monitored for indicator bacteria concentrations since the early 1980s. The indicator that has been used at both outfalls is fecal coliforms, which is used as a surrogate to assess the potential for human exposure to wastewater in the marine environment.

To monitor potential impacts on human health in the vicinity of the Macaulay and Clover Point outfalls, fecal coliform bacteria have been monitored monthly in surface waters only, since the early 1980's. However, sampling has not been designed to assess compliance with provincial guidelines for the protection of human health, which requires the collection of a minimum of 5 samples in a 30 day period. Provincial regulations further require that these guidelines are met at all depths, at the edge of the initial dilution zone (IDZ) (within 100 m of the outfall). It has also been recommended that two indicators be assessed: fecal coliforms and enterococci. The use of Enterococci is recommended by Health Canada to assess recreational water quality as it is the best available indicator of fecal contamination from warm blooded animals, may be a better survivor in marine waters than fecal coliforms and correlates well with gastrointestinal illness.

The bacteriological indicator sampling program has been re-designed to assess compliance with provincial guidelines as follows:

- Sampling stations at the edge of the IDZ (surface and at depth), including the point where the effluent plume crosses the IDZ;
- 5 samples in a 30 day period – repeated 4 times through the year. CRD will make every reasonable effort to achieve this, given the challenges imposed by local weather and sea conditions;
- fewer surface stations to balance costs; and
- enterococci measured in surface water samples.

3.1.2.1 Methods

Surface water will be sampled at 13 stations around each outfall (Table 6 and Figure 3) for parameters listed in Appendix B. In addition to the 13 fixed surface stations described above, two variable stations will be sampled at each outfall (D1 and 00 stations). The first variable station (D1) represents the recovery point of a current drogue. The drogue will be released directly over the outfall diffuser at the beginning of the sampling session and retrieved at the end of the sampling session. The second variable station (00) will only be sampled if there is visual evidence of the discharge (e.g., extreme turbidity).

Table 6 – Surface Water and Water Column Sampling Locations

Macaulay Point	Clover Point
Mac-D1	Clo-D1
Mac-00	Clo-00
Mac-01	Clo-01
Mac-14	Clo-14
Mac-16	Clo-16
Mac-18	Clo-18
Mac-20	Clo-20
Mac-22	Clo-22
Mac-24	Clo-24
Mac-26	Clo-26
Mac-28	Clo-28
Mac-30	Clo-30
Mac-32	Clo-32
Mac-34	Clo-34
Mac-36	Clo-36
+ four dynamic edge of IDZ stations (3 depths)	+ four dynamic edge of IDZ stations (3 depths)

In addition, four dynamic stations at the edge of the IDZ will be sampled for parameters listed in Table 7. These dynamic stations will be located in the path of the effluent plume (as predicted by computer modelling for each sampling event). These stations will be sampled at 3 depths (3 discrete samples), one on the surface, one in the plume and one below the plume. Attempts will be made to detect the plume with a CTD meter. If in the field the plume is not detectable with the CTD, the model predicted plume depth will be sampled.

Surface water (including the edge of the IDZ) will be sampled from a boat equipped with a differential GPS system used to ensure accurate sampling locations.A rosette sampler or similar will be used to take samples at depth with a CTD used to measure in situ water quality parameters (e.g., conductivity, temperature, depth and potentially dissolved oxygen, chlorophyll etc.).

After collection, surface water samples and water column samples will be transferred to a qualified laboratory and analyzed for the parameters listed in Appendix B. These groups of parameters were chosen based on consultation with the BC MOE.

Figure 3 – Macaulay Point and Clover Point Surface Water Sampling Locations

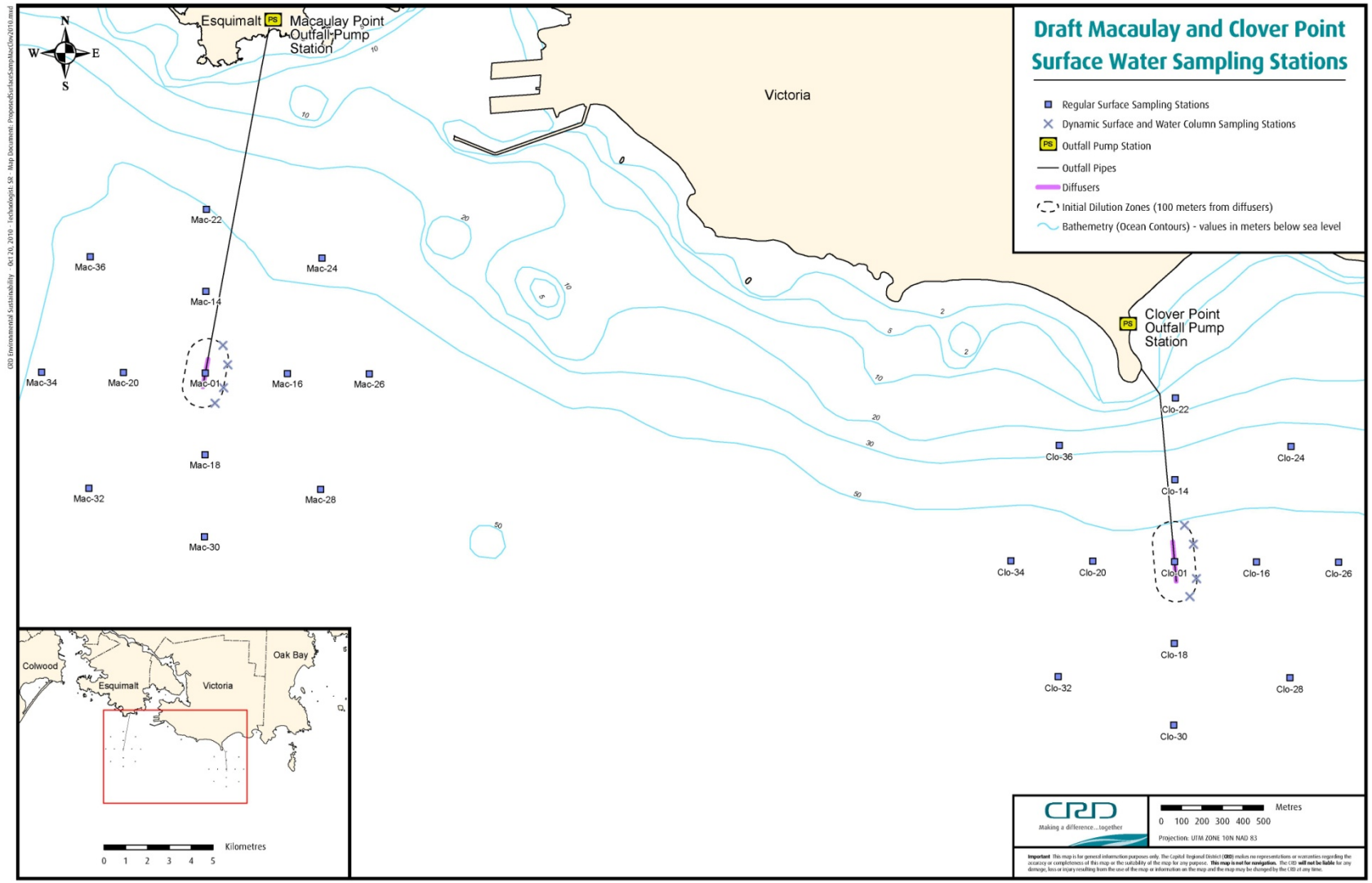


Table 7 – Surface Water Analyte Groups (Appendix B provides a listing of analytes within each analytical group)

Parameter	Surface Water	
	Surface Stations	Edge of IDZ stations (3 depths)
Conventional variables		√
Metals, total		√
Bacteria	√	√

3.1.2.2 Sampling frequency

The surface water monitoring component of the program will be conducted during each of four 30 day periods. During each of these periods, sampling will occur five times.(Table 3) (i.e., sampling will occur on 20 dates annually). Table 8 presents sampling frequency within each year for the surface water and edge of IDZ sampling. Surface and water column sampling will be conducted every quarter. The five times in 30 days sampling frequency is intended to meet the WQG requirements as described in the BC water quality guidelines for metals (BC MOE, 2010) and for human health indices (BC MoE, 2010). The first sampling day of each quarter will be sampled on the same day as the quarterly wastewater sampling.

Table 8 - Frequency of Surface Water and Edge of IDZ sampling

	Jan	Feb	Apr	May	July	Aug	Oct	Nov
Sampling Stations	xxxxx		xxxxx		xxxxx		xxxxx	

x-sampling event

3.1.2.3 QA/QC Criteria

Analyses will be conducted at a CALA CAEAL ?certified laboratory. The CRD follows a rigorous QA/QC procedure for both field sampling and laboratory analyses. Field QA/QC procedures will include field duplicates, field blanks and careful sampling techniques (i.e., careful manipulation of bottles to avoid contamination of inner surfaces, including the lid of the fecal coliform sample bottle). Additional laboratory QA/QC procedures will include:

- Laboratory duplication, spike recovery, reagent blanks and standards
- Temporal trend analysis on duplicates and spike recoveries
- Routine monitoring of laboratory equipment accuracy
- Heat sensitive indicator tape for the sterilization of the bacteria bottles

The analytical data will be reviewed using the CRD's data quality objectives (Golder 2007d; Golder 2009c). Following the initial screening, the data will be evaluated (Figure 6) for precision (based on variability in lab or field replicates), bias (based on recoveries of spikes, surrogate standards or certified reference materials), and representativeness (based on blank sample contamination) using specific criteria for each analytical group (Table 5). The extremity of precision, bias or representativeness failures will be determined (Table 6) and data with marginal failures will be flagged, while data with severe failures will be rejected. Analytical batch data, if available, will be used to link associated samples to specific blanks, spikes, replicates, etc. Rejected results will not be presented in the report and will not be used for further analyses.

3.1.3 Sediment Chemistry, Toxicity and Bioaccumulation

Sediment provides habitat for many aquatic organisms and can be a major sink for many of the more persistent, toxic inorganic and organic chemicals introduced into surface waters. Contaminated sediment may be directly toxic to aquatic life or can be a pathway for bioaccumulation. Concentrations of contaminants in sediment may be several orders of magnitude higher than those in overlying water. However, the relationships between sediment contaminants and bioavailabilty are very complex and difficult to predict. As a result, determining the effects of contaminants associated with sediment requires the application of controlled toxicity and bioaccumulation tests. In conjunction with sediment quality guidelines, integration of multiple lines of evidence can reduce uncertainty and improve confidence in sediment management decisions.

To assess the potential effects of the wastewater discharges on the marine receiving environment, the sediments in the vicinity of the Macaulay and Clover Point outfalls will be analyzed for whole sediment and pore water chemistry, toxicity and bioaccumulation. Toxicity and bioaccumulation are new to the WMEP and in order to balance costs with the increased number of analytical samples, and sediment toxicity and bioaccumulation assessments the number of outfall stations has been reduced from 28 to 12 at Macaulay Point, and from 28 to 9 at Clover. The number of reference stations has also been reduced from 5 to 3 at both Parry Bay (Mac ref) and Constance bank (Clo ref). In addition, high resolution chemistry will be added to the program to allow for better comparison to wastewater and mussel high resolution assessments and potentially allow for better source and fate discrimination assessments (e.g., congener ratios).

3.1.3.1 Methods

Table 9 and Figures 5 and 6 present Macaulay and Clover sediment sampling stations. The outfall is located 1.8 km from the shore off Macaulay Point and at an approximate depth of 60 meters. Macaulay Point stations are located from 0 to 800 metres off the initial dilution zone (IDZ) of the outfall. The reference stations associated with Macaulay are located approximately 10 km off Macaulay Point at Parry Bay. The Clover Point outfall is located 1.2 km from the shore off Clover Point and the associated reference stations are at Constance Bank (CB), located approximately 5.5 km off Clover Point.

Sediment chemistry and toxicity will be assessed at twelve stations at Macaulay Point and ten stations at Clover Point. These stations represent outfall, near, mid and far field stations along an effects gradient identified by Golder (2009a). In addition, six reference stations will be sampled; the locations of these sampling stations have yet to be determined, but will include some or all of the existing Constance Bank (CB) or Parry Bay (PB) reference stations. Bioaccumulation assessments will be conducted at 6 Macaulay Point stations (1 outfall, 2 near field, 1 mid and 2 far field) (grouping assessments as per Golder (2009a).

Table 9 – Sediment Sampling Stations

Macaulay	Clover
Outfall	**Outfall**
M0	C0
Near Field	**Mid Field**
M100SE	C200E
M100E	C100E
M200SE	**Far Field**
Mid Field	C100S
M100W	C100W
M100SW	C100SE
M100S	C100SW
M200NE	C100NW
M200E	C100NE
M400E	C200S
M400SE	**Reference**
Far field	Constance Bank Reference Station #1
M100NW	Constance Bank Reference Station #2
Reference	Constance Bank Reference Station #3
Parry Bay Reference Station #1	
Parry Bay Reference Station #2	
Parry Bay Reference Station #3	

Figure 5 - Macaulay Point Seafloor Sampling Locations (Benthic Invertebrates and Sediment)

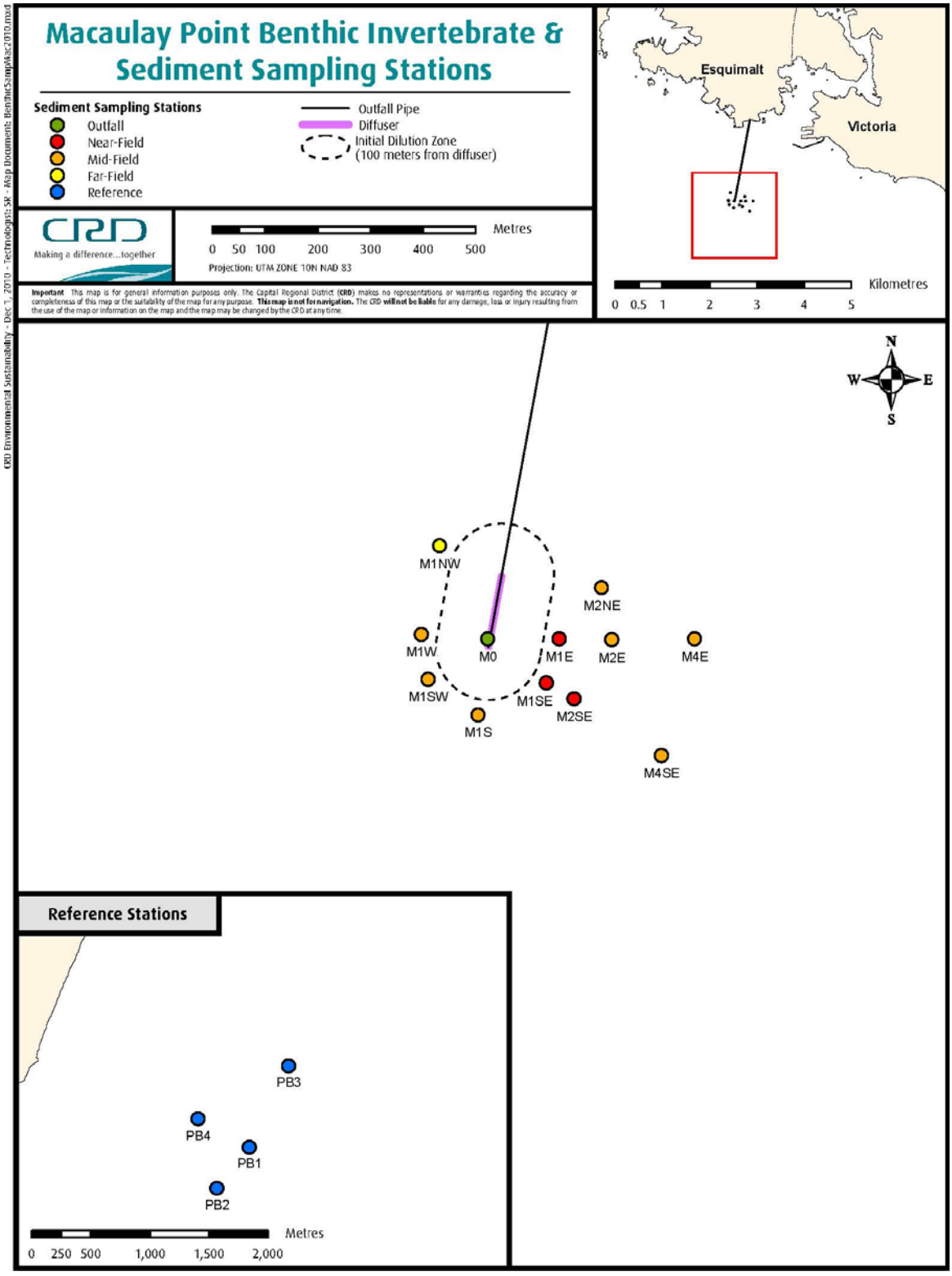


Figure 6 – Clover Point Seafloor Sampling Stations (Mussels and Sediment)

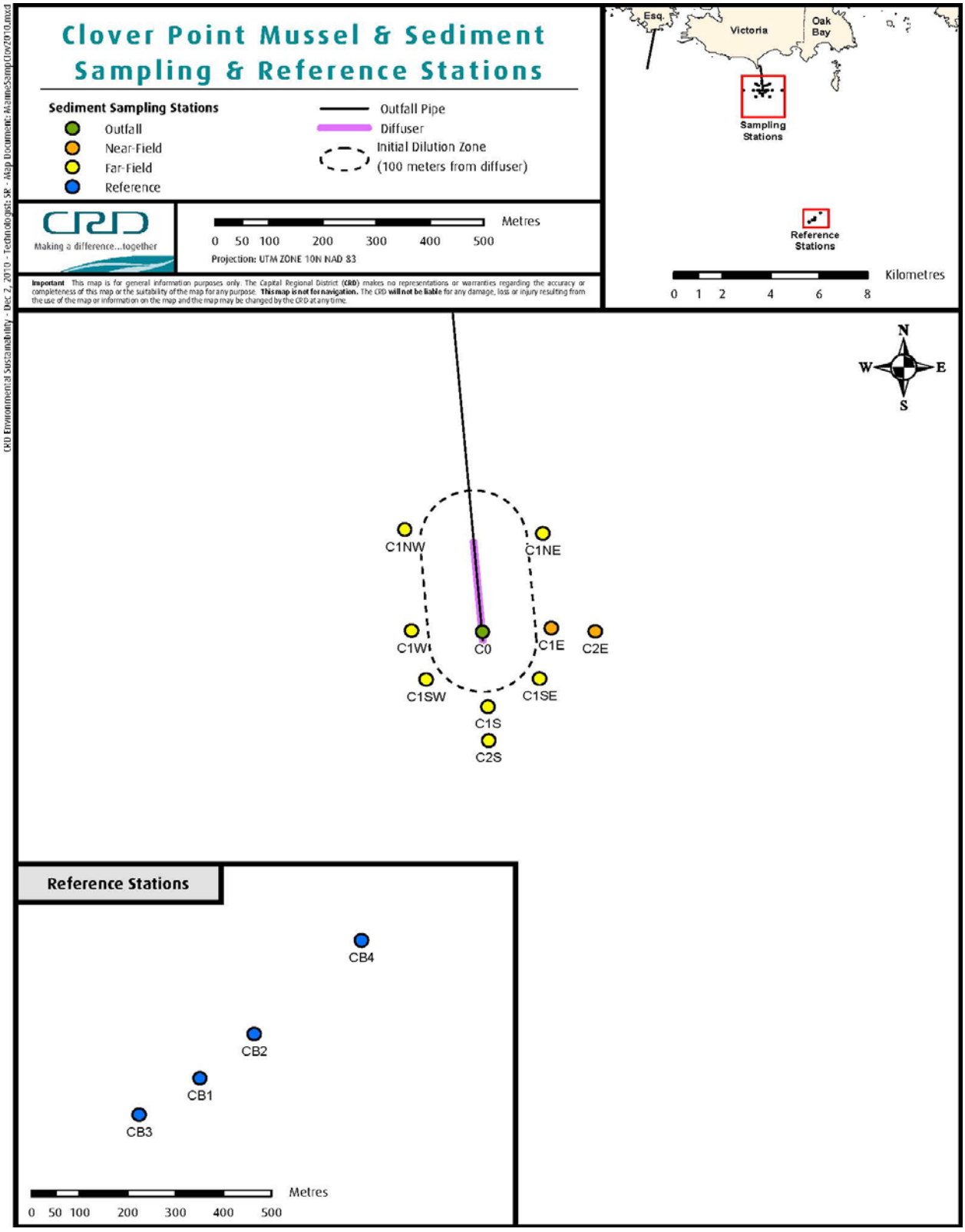


Table 10 – Sediment and Benthic Invertebrate Bioaccumulation Analytical Groups (Appendix B provides a listing of analytes within each analytical group)

Parameter	Sediment Pore Water	Sediment	Benthic Invertebrate Bioaccumulation Organisms
Conventional variables	√	√	√
Metals, total		√	√
Metals, SEM		√	
Metals, (MeHg and TBT)		√	√
Aldehydes		√	
Phenolic compounds		√	
Chlorinated phenolics		√	√
Non-chlorinated phenolics		√	
Polycyclic aromatic hydrocarbons (PAHs)		√	
Miscellaneous semi-volatile organics		√	√
Volatile organics		√	
Phthalates		√	√
Terpenes		√	
High Resolution Analysis			
Nonylphenols (NP)		√	
Polycyclic aromatic hydrocarbons (PAHs)			√
Organochlorine pesticides (OC Pest)		√	√
Polychlorinated biphenyls (PCBs)		√	√
Polybrominated diphenyl ethers (PBDEs)		√	√

Sediment sampling will be conducted using a research vessel of suitable size and capability to safely deploy bottom sampling equipment. A differential GPS system will be used to locate stations. Sediment samples will be retrieved using a 0.1 m^2 Young-modified Van Veen grab sampler or similar. At each station, three grab samples will be composited into a single sediment sample (or more to facilitate volume needs). At least three additional grabs will be composited for sediment toxicity and bioaccumulation. Sampling will follow the protocols outlined by the Puget Sound Estuary Program (PSAMP, 2002). In addition, sediments targeted for toxicity and bioaccumulation tests, will be sieved to 1 cm to remove debris and larger rocks.

After collection, sediment chemistry samples will be transferred to a qualified CALA certified laboratory and analyzed for a comprehensive list of substances (Table 10; Appendix B), including metals, halogenated compounds and PAHs. This group of parameters was originally chosen based on the US Environmental Protection Agency National Recommended Water Quality Criteria, Priority Substances List (US EPA, 2002) and in consultation with the BC Ministry of Environment staff.

Bioaccumulation testing will be conducted to provide a basis for developing sediment-biota bioaccumulation functions. Sediment toxicity and bioaccumulation will be assessed with three toxicity tests and one bioaccumulation test based on the results of the pilot study (Appendix E). Tissue COPC and lipid concentrations will be measured on Day 0 and 28 of the bioaccumulation test and the concentrations of COPCs and conventionals in sediment will be measured in sub-samples of these larger samples.

Table 11- Toxicity and Bioaccumulation Test Selection and Endpoints

	Endpoint	Test	Year 1 Pilot	Year 2	Year 4	Year 5
20-day polychaete (*Neanthes aceodentata*)	Chemistry, survival, growth, and biomass	T=0, 14, 28, 42 and 56 days Chemistry (Appendix B)	x	x	x	x
56-day bivalve (*Macoma nasuta*)	Chemistry, survival, growth, and biomass	T=0, 14, 28, 42 and 56 days Chemistry (Appendix B)	x	x	x	x
28- day bivalve (*Macoma nasuta*)	Chemistry, survival, growth, and biomass	T=0 and 28 days Chemistry (Appendix B)	x			
10- day mysid shrimp (*Americanmysis bahia*)	Survival	LC50	x	x	x	x
28- day amphipod (*Leptochirns plumulosus*)	Survival, growth, biomass and reproduction	Various measurements and LC50	x			
48-hour mollusc (*Mytilus galloprovincealis)*	Survival and normal development	Various measurements and LC50	x	x	x	x
10- day amphipod (*Eohaustorius estuarius*)	Survival	LC50	x	x (4 stations only)	x (4 stations only)	x (4 stations only)

T=time

Standard protocols and methodologies will be used as test methods. While several of these tests can be run successfully using standard protocols, certain refinements to the ASTM or USEPA standard methods are recommended (MESL, pers. comm.) to increase the utility of certain tests, including:

- For the 28-d *L. plumulosus* assay, it is recommended that the size of the animals at the beginning of the test be restricted and the feeding rates be reduced in accordance with the USACE (2010) protocol;
- For the 48-h *M. galloprovincealis* assay, it is recommended that the test be run with screens to facilitate exposure to contaminated sediments; and,
- For all toxicity tests, a 24-h equilibrium-adjusted period is recommended. Recent experience suggests that a 7-d equilibrium-adjusted period would be better to help re-establish conditions that are more indicative of those that existed in field.
- Ensure lipid content is high enough in the test organisms to accumulate hydrophobic contaminates.

Pore water will be tested for nutrients and most conventionals (Appendix B) in conjunction with the sediment toxicity assessments. Pore water will be collected in the lab by centrifugation and will be analyzed for the parameters listed in Appendix B.

3.1.3.2 Sampling Frequency

The sediment monitoring component will be conducted twice per outfall in the 5 year cycle (Table 3) (i.e., Year 2 (Clover and Macaulay), Year 4 (Macaulay) and Year 5 (Clover).

3.1.3.3 Sediment Bioaccumulation and Toxicity Testing

A sediment bioaccumulation, toxicity and chemistry pilot study was conducted in Year 1 (see Appendix E). The results of the pilot study were analyzed and used as a basis for selecting the benthic tests to use in years two through five of the sampling cycle (Table 11). Rationale for the test selection can be found in Golder (2012). Use of these tests will begin in 2012, at Year 2 of the five year cycle.

3.1.3.4 QA/QC Criteria

The CRD follows a rigorous QA/QC procedure for both field sampling and laboratory analyses. Field QA/QC procedures will include field duplicates, field blanks and careful sampling techniques. Additional QA/QC procedures will include (in addition to standard laboratory QA):

- Ten percent or more of samples will be run as lab triplicates
- Ten percent or more of samples will be run as field triplicates

The analytical data will be reviewed using the CRD's data quality objectives (Golder 2007d; Golder 2009c). This QA/QC procedure will include an initial screening of the data to identify any data results that fall outside of the expected range (i.e., 0.5^{th} to 99.5^{th} percentiles) of historical results. Results that fall outside of these ranges will be discussed with the laboratory to ensure internal QA/QC requirements were satisfied and to determine whether any re-analyses were necessary.

Following the initial screening, the data will be evaluated (Figure 1) for precision (based on variability in lab or field replicates), bias (based on recoveries of spikes, surrogate standards or certified reference materials), and representativeness (based on blank sample contamination) using specific criteria for each analytical group (Table 5). The extremity of precision, bias or representativeness failures will be determined and data with marginal failures will be flagged, while data with severe failures will be rejected. Analytical batch data, if available, will be used to link associated samples to specific blanks, spikes, replicates, etc. All data that exhibited failures will be questioned and an investigation of the potential causes will be undertaken. Rejected results will not be presented in the report and will not be used for further analyses (e.g., statistical analyses) except for the determination of frequency of detection.

QA/QC criteria for the toxicity and bioaccumulation test results will be detailed in a QA plan prepared prior to undertaking the pilot study.

3.1.4 Benthic Invertebrates

To assess the potential effects of the waste stream on the marine receiving environment, native communities of benthic invertebrates found in the soft mud bottom at and around Macaulay Point outfall have been used as indicators since the late 1970s. In order to balance costs from increased effort in other components of the monitoring program, sampling frequency will be reduced from annually to twice every five years and the number of benthic invertebrate sampling stations will be reduced from 23 stations to 18(is it not 16) stations

3.1.4.1 Methods

The benthic sampling program will involve the collection of three replicate samples at each of 12 Macaulay Point benthic stations (Table 12; Figure 5) and 4 reference stations (to be determined) with the sediment chemistry, toxicity, bioaccumulation and pore water assessments (Section 3.1.3).

Benthic community health will be assessed, using benthic indicator tools or methods typically used to assess the potential effects of wastewater discharges. The assessment of the Macaulay Point benthic communities will include use of the following indicators:

- Total Abundance (TA): benthic abundance helps provide an indication of the health of the community.
- Taxa Richness (TR): the total number of individual taxa provides a measure of the biodiversity in the benthic community.
- Mean abundance of all species of major taxa including polychaete abundance (PA) and other major taxa such as amphipods, molluscs, echinoderms, etc. These measures provide additional information on biodiversity.
- Swartz Dominance Index (SDI): the minimum number of species accounting for 75% of the abundance. This measure gives an indication of whether the abundance at a station is evenly spread across taxa or dominated by only a few taxa. Low SDI values indicate that the abundance is dominated by only a few taxa.
- Abundances of individual indicator organisms and their changes in abundance with distance and direction from the outfall.
- Infaunal Trophic Index (ITI): a quantitative measure of the distribution of dominant feeding groups of the benthic fauna.

Golder (2009a) provides more detailed descriptions and rationale for these endpoints.

Table 12 – Benthic Invertebrate Sampling Stations

Macaulay Point Sample and Reference Stations	
M0	M200E
M100W	M200SE
M100SW	M400E
M100S	M400SE
M100SE	Parry Bay Reference Station #1
M100E	Parry Bay Reference Station #2
M100NW	Parry Bay Reference Station #3
M200NE	Parry Bay Reference Station #4

3.1.4.2 Sampling Frequency

The benthic invertebrate monitoring component will be conducted in Years 2 and 4 of the 5-year cycle (Table 3). Samples will be collected once in each of these years concurrent with the sediment sampling program (Section 3.1.3).

3.1.4.3 QA/QC Criteria

At least 10% of the submitted samples will be re-sorted by another person to ensure that no more than 5% of a given sample was missed by the sorter (i.e., a sample sorting efficiency of 95%). Five percent of all samples will be re-identified by a second taxonomist. These quality control measures will ensure that identifications are correct and consistent. A reference collection will be and preserved for future comparisons.

3.1.5 Mussels

To monitor the potential effects of the waste stream on the marine receiving environment, native communities of deep-sea horse mussels (*Modiolus* modiolus) found on the hard, rocky substrate in the vicinity of the Clover Point outfall have been used as indicators of potential effects since the early 1990s. In order to balance costs due to increased efforts in other monitoring components (i.e., sediment toxicity and bioaccumulation) sampling stations will be reduced from 28 to 15 (I think its 14) and tissue chemistry sampling frequency will be reduced from annually to once in the five year cycle. Additional high resolution parameters have been added to the analyte list to allow for enhanced comparison to wastewater and sediment high resolution chemistry and to potentially allow for refined contaminant source and fate discrimination (e.g., congener ratio assessment).

3.1.5.1 Methods

Mussel samples will be collected from ten Clover Point stations and four associated reference stations (Table 14; Figure 9) in conjunction to the sediment chemistry and toxicity sampling in Year 5. Samples will be collected by boat, using a $0.1m^2$ Van Veen grab sampler. Mussels of a minimum size of 50mm will be randomly selected from three grabs and composited to represent a single, 25 mussel sample, per station. Additional mussels will be collected from 10% of sampling stations for field replicates. Mussels are randomly selected from the composite for biological and chemical analyses. Mussel tissue chemistry analyses will be conducted at a CALA certified laboratory. Tissue samples from the same 14 mussel sampling stations will be analyzed for routine and high resolution parameters (Table 14; Appendix B).

Mussel morphology and health will be assessed through measurement of a number of community and health indices, including:

- Growth metrics: shell length, shell width, shell weight, tissue wet weight, age distribution
- Reproductive metrics: gonad index, reproductive timing index, sex
- Pathology assessment

Table 13 – Clover Point Mussel Sampling Stations

Clover Point Sample and Reference Stations	
C0	C200E
C100S	C100NE
C100W	C200S
C100SE	Constance Bank Reference Station #1
C100SW	Constance Bank Reference Station #2
C100NW	Constance Bank Reference Station #3
C100E	Constance Bank Reference Station #4

Table 14 – Mussel tissue chemistry analytical groups (Appendix B provides a listing of analytes within each analytical group)

Parameter	Mussels
Conventionals	√
Metals, total	√
Chlorinated phenolics	√
Organochlorine pesticides (OC Pest)	√
Miscellaneous semi-volatile organics	√
Volatile organics	√
Phthalates	√
High Resolution Chemistry	
Polychlorinated biphenyls (PCBs)	√
Polycyclic aromatic hydrocarbons (PAHs)	√
Polychlorinated dibenzodioxins (PCDDs)	√
Polybrominated diphenyl ethers (PBDEs)	√

3.1.5.2 Sampling Frequency

Mussels will be sampled once in the five year sampling cycle (year five), with samples collected once during the sampling year (usually in Sept), as presented in Table 3, concurrent with the sediment chemistry and toxicity sampling.

3.1.5.3 QA/QC Criteria

The CRD follows a rigorous QA/QC procedure for both field sampling and laboratory analyses. Field QA/QC procedures for mussel sampling include triplicate sampling and careful sampling techniques. Additional QA/QC procedures include (in addition to standard laboratory QA):

- Laboratory duplication, spike recovery, reagent blanks and standards
- Analysis of reference or surrogate standards for each batch
- All data reported to the CRD is uncorrected for blank or deuterated recoveries

Data is then screened and assessed with respect to three types of data quality objectives (DQOs); precision, bias and representativeness (see Section 3.1.1.3). When these measures exceed the acceptable defined ranges then that value is considered to be a DQO failure. The magnitude of the failure determines whether the data point is rejected outright and excluded from the data set or retained but annotated with data qualifier flags. Laboratory re-analyses are conducted where necessary.

3.1.6 Fish

To assess the potential effects of the waste stream on the marine receiving environment, fish sampling and analysis will be added to the WMEP. Fish testing has previously been identified as a gap in the WMEP. Fish sampling will allow for a holistic determination of contaminate fate, through the food chain. Such data will also be used to assess risks to fish, aquatic dependant wildlife and human health.
Fish will be sampled at in the vicinity of each outfall, with the focus on benthic fish with small home ranges (most likely English Sole).

3.1.6.1 Methods

Fish sampling will be collected from sampling areas, rather than from specific sampling sites by seine and trawling. The areas will include one each from Macaulay Point, Clover Point, Constance Bank and Parry Bay (Figure 7) with the exact location dependent on fish availability. Fish will likely be sampled using the recommended guidelines for sampling Soft-Bottom Demersal Fishes by Beach Seine and Trawl in Puget Sound (PSAMP (2002). Alternative methods (e.g., long lining) may be used based on recommendations by commercial fishermen

Ten samples will be taken from the outfall areas (Macaulay and Clover Point) and 5 samples from each of the reference areas (Constance Bank and Parry Bay); each sample will be comprised of a 10 fish composite. Two types of samples will be taken, fish fillet and the remaining fish carcass (remaining fish carcass result + fish fillet result = whole fish result) from both Macaulay and Clover Points areas and will be analyzed for routine and high resolution parameters (Table ; Appendix B). Health indices will be assessed on all individual fish (i.e., 150 fish).

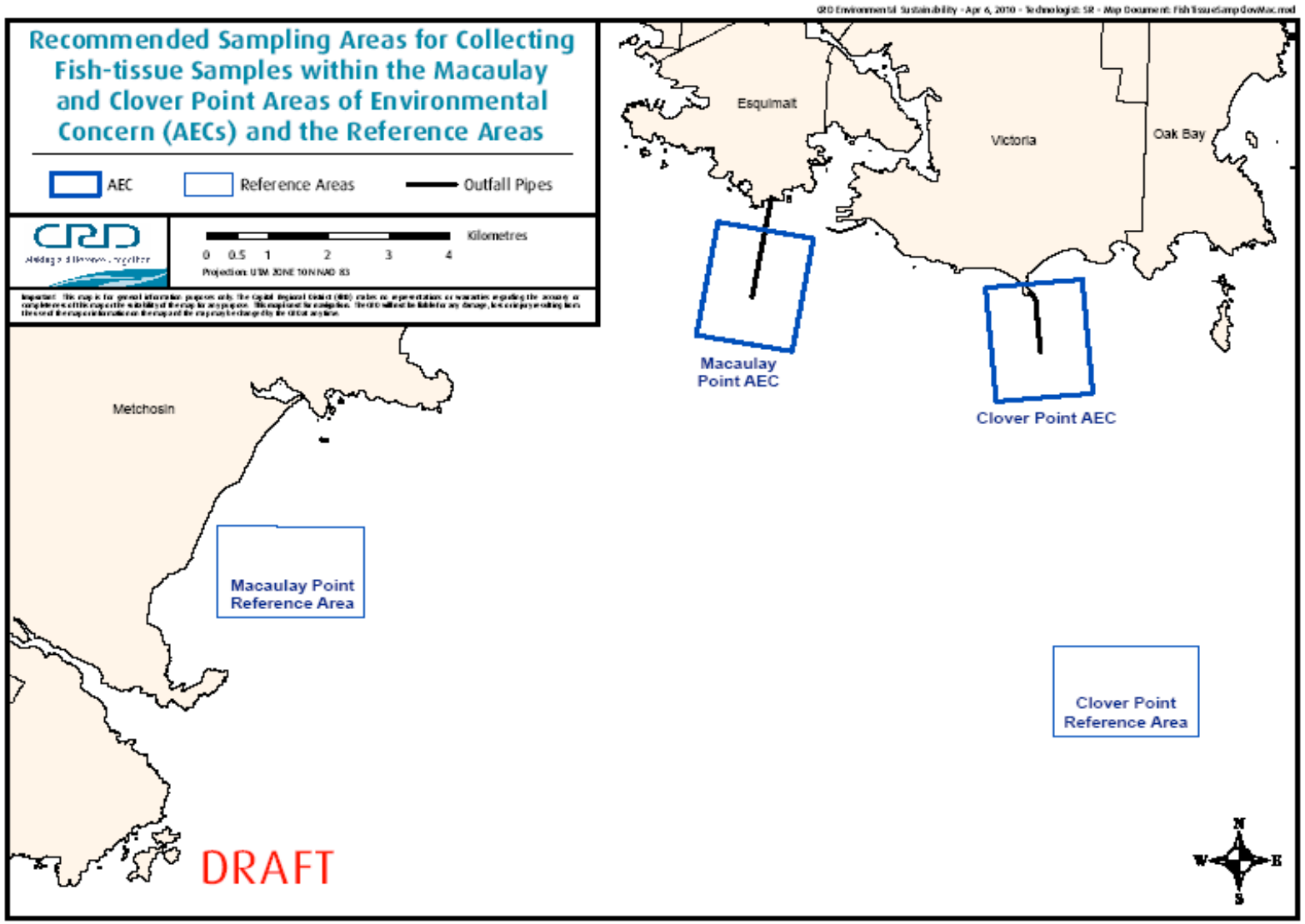
Table 15 – Fish Tissue Chemistry Analytical Groups (Appendix B provides a listing of analytes within each analytical group)

Parameter	Fish Fillet	Remaining Fish Carcass
Conventionals	√	√
Metals, total	√	√
Chlorinated phenolics	√	√
Organochlorine pesticides	√	√
Miscellaneous semi-volatile organics	√	√
Volatile organics	√	√
Phthalates	√	√
High Resolution Chemistry		
Polychlorinated biphenyls (PCBs)	√	√
Polycyclic aromatic hydrocarbons (PAHs)	√	√
Polychlorinated dibenzodioxins (PCDDs)	√	√
Polybrominated diphenyl ethers (PBDEs)	√	√
Biological		
Age	√	√
Health Indices	√	√

Fish morphology and health will be evaluated using a number of indices, including condition factors, physical size measurements, frequency of deformities, fin erosion, lesions and tumours as described in EPA Rapid Bioassessment protocols (Barbour, 1999). Other assessment endpoints will include gonado-somatic index (GSI), liver-somatic index (LSI) and fish health assessment (e.g., size, weight, and condition). Fish will be filleted and both the fillet and the remaining carcass will be analyzed for parameters listed in Table 15. These results will be integrated to estimate whole body concentrations of COPCs in fish. Fish composites will be sorted to limit the size range of each composite to no more than 1.5 times the minimum length and 2 times minimum weight.

While the sampling is likely to take place in September, commercial fishermen will be surveyed to help determine the optimal sampling period.. Regardless, sampling season will be consistent from 5 year cycle to 5 year cycle.

Figure 7 – Macaulay Point and Clover Point Potential Fish Sampling Locations



3.1.6.2 Sampling Frequency

Fish will be sampled in four sample areas, once in the five year cycle (year 5) as presented in Table 3.

3.1.6.3 QA/QC Criteria

The fish tissue chemistry analytical data will be reviewed using the CRD's data quality objectives (Golder 2007d; Golder 2009c). Following the initial screening, the data will be evaluated (Figure 6) for precision (based on variability in lab or field replicates), bias (based on recoveries of spikes, surrogate standards or certified reference materials), and representativeness (based on blank sample contamination) using specific criteria for each analytical group (Table 6). The extremity of precision, bias or representativeness failures will be determined (Table 7) and data with marginal failures will be flagged, while data with severe failures will be rejected. Analytical batch data, if available, will be used to link associated samples to specific blanks, spikes, replicates, etc. Rejected results will not be presented in the report and will not be used for further analyses.

4.0 Analyses, Reporting and Review

4.1 Annual Review

On an annual basis, the monitoring activities of the previous year will be reviewed by CRD and BC MOE staff. To assist in this review, the CRD will prepare a brief annual report that summarizes the monitoring activities for that year and any available results. As needed, individual components will be assessed for their effectiveness from regulatory, and environmental perspectives as well as cost effectiveness. CRD and BC MOE staff will meet annually to review this report and to determine whether any WMEP monitoring components need to be adjusted. It is anticipated that a more substantial review and potential program refinement will be completed at the end of each 5 year cycle (section 4.2).

Consultants will be also retained by the CRD on an annual basis to undertake more detailed statistical assessments of individual components as needed. The scope of these assessments will be similar to those undertaken previously by Golder Associates Ltd. (e.g. (Golder, 2007c; Golder, 2008a; Golder, 2009a; Golder, 2009b; Golder, 2009d) and others (e.g. (Integral, 2006). The CRD will also continue to solicit review from the MMAG on a regular basis, but the MMAG will no longer report directly to BC MOE. Recommendations from these detailed assessments and reviews will also be included in the brief annual reports.

4.2 5-Year Review

At the end of each five year cycle, the CRD will prepare a comprehensive report that summarizes all of the monitoring activities and results of the cycle. The scope of this report will be similar to the existing WMEP annual reports (e.g. (CRD, 2009c) and will include a summary of the monitoring activities as well as detailed temporal and spatial trend assessments similar to (Golder, 2007c; Golder, 2008b; Golder, 2008c; Golder, 2009d). The report will also make recommendations for future monitoring.

The CRD will also solicit MMAG review of this report. This comprehensive report will be submitted to BC MOE following completion of the five year cycle.

5.0 REFERENCES

Avocet (2007) Sediment Quality Guideline Reliability Analysis. Avocet Consulting, Puyallup, WA, USA.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

BCMELP (1998) British Columbia Working Water Quality Guidelines (Criteria). 1998 Edition., Queens Printer for British Columbia, Victoria, BC, Canada. pp.

BCMoE (2004) Environmental Management Act. Formerly the Waste Management Act and the Environment Management Act. British Columbia Ministry of Environment, Victoria, BC, Canada.

BCMoE (2006) A Compendium of Working Water Quality Guidelines for British Columbia. Science and Information Branch, British Columbia Ministry of Environment, Victoria, BC, Canada.

BC MOE (2010) British Columbia Approved British Columbia Water Quality Guidelines (Criteria). http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html#approved.

CRD (2000a) Core Area Liquid Waste Management Plan. Capital Regional District, Environmental Services Department, Victoria, BC, Canada.

CRD (2000b) The Trigger Process: An Early Warning of Adverse Environmental Effects for the Clover and Macaulay Point Outfalls. Capital Regional District, Victoria, BC, Canada.

CRD (2009a) Core Area Liquid Waste Management Plan Amendment #7. Capital Regional District, Environmental Sustainability Department, Victoria, BC, Canada.

CRD (2009b) Macaulay and Clover Point Wastewater and Marine Environment Program 2008 Annual Report. Capital Regional District, Environmental Services Department, Victoria, BC, Canada.

CRD (2009c) Macaulay and Clover Points Wastewater and Marine Environment Annual Report 2008. Capital Regional District, Environmental Services Department, Victoria, BC, Canada.

EVS (1992) Sediment and Related Investigations off the Macaulay and Clover Point Sewage Outfalls. EVS Consultants Ltd., North Vancouver, BC, Canada.

Golder (2005a) 2004 Benthic Macroinvertebrate Analyses for the Macaulay Point Outfall. Report Number 05-1421-026. Golder Associates Ltd., North Vancouver, BC, Canada.

Golder (2005b) Analysis of 2004 Clover Point Outfall Mussel Monitoring Data. Report Number 05-1421-025. Golder Associates Ltd., North Vancouver, BC, Canada.

Golder (2005c) Potential Environmental Effects of the Macaulay and Clover Point Outfalls and Review of the Wastewater and Marine Environment Program. Golder Associates Ltd., North Vancouver, BC, Canada.

Golder (2006a) 2005 Benthic Macroinvertebrate Analyses for the Macaulay Point Outfall. Golder Associates Ltd., North Vancouver, BC, Canada.

Golder (2006b) Analysis of 2005 Clover Point Outfall Mussel Monitoring Data. Golder Associates Ltd., North Vancouver, BC, Canada.

Golder (2006c) Macaulay and Clover Point Additional Investigations - High Resolution Chemical Analyses. Golder Associates Ltd., North Vancouver, BC, Canada.

Golder (2006d) Trend Assessment for Substances in Macaulay Point and Clover Point Wastewater (1990-2005). Golder Associates Ltd., North Vancouver, BC, Canada.

Golder (2007a) 2006 Benthic Macroinvertebrate Analyses for the Macaulay Point Outfall. Golder Associates Ltd., North Vancouver, BC, Canada.

Golder (2007b) Analysis of 2006 Clover Point Outfall Mussel Monitoring Data. Report Number 07-1421-0024. Golder Associates Ltd., North Vancouver, BC, Canada.

Golder (2007c) Detailed Sediment Chemistry Analysis - 1990 to 2006 Data. Golder Associates Ltd., North Vancouver, BC, Canada.

Golder (2007d) Wastewater and Marine Environment Programs Quality Assurance and Quality Control Analytical Program Review. Golder Associates Ltd., North Vancouver, BC, Canada.

Golder (2008a) 2007 Assessment of Macaulay and Clover Point Additional Investigations - High Resolution Chemical Analyses. Golder Associates Ltd., Burnaby, BC, Canada.

Golder (2008b) 2007 Benthic Macroinvertebrate Analysis and Multi-Year Trend Assessment for the Macaulay Point Outfall.

Golder (2008c) 2007 Mussel Community and Tissue Chemistry Analyses and Multi-Year Trend Assessment.

Golder (2009a) 2008 Benthic Macroinvertebrate Analyses for the Macaulay Point Outfall.

Golder (2009b) 2008 Mussel Community and Tissue Data Analysis.

Golder (2009c) DRAFT Wastewater and Marine Environment Programs Updated Guidance Manual for Assessment and Analysis of WMEP Data. 09-1421-0017. Golder Associates Ltd., Burnaby, BC, Canada.

Golder (2009d) Trend Assessment for Substances in the Macaulay and Clover Point Wastewaters and the Saanich Peninsula Wastewaters and Biosolids. 08-1421-0105. Golder Associates Ltd., Burnaby, BC, Canada.

Golder (2012) Evaluation of Sediment Bioaccumulation and Toxicity Tests. 11-1421-0051. Golder Associates Ltd., Burnaby, BC, Canada.

Integral (2006) Evaluation of Spatial and Temporal Patterns in Fecal Coliform Concentrations at the Macaulay and Clover Point Outfalls. Integral Consulting Ltd., Mercer Island, WA, USA.

MacDonald, D. D. and D. E. Smorong (2006a) An Evaluation of Sediment Quality Conditions in the Vicinity of the Macaulay Point and Clover Point Outfalls. MacDonald Environmental Sciences Ltd., Nanaimo, BC, Canada.

MacDonald, D. D., D. E. Smorong, J. J. Jackson, and Y. K. Muirhead (2006b) Supplemental Evaluation of Sediment Quality Conditions in the Vicinity of the Macaulay Point and Clover Point Outfalls. MacDonald Environmental Sciences Ltd., Nanaimo, BC, Canada.

MacDonald, D. D., D. E. Smorong, J. J. Jackson, Y. K. Muirhead, and C. G. Ingersoll (2007) Receiving Environmental Monitoring Program (REMP) for the Capital Regional District (CRD) Core Area Liquid

Waste Management Plan (LWMP) for the Macaulay Point and Clover Point Outfalls. MacDonald Environmental Sciences Ltd., Nanaimo, BC, Canada.

MMAG (2009) Marine Monitoring Advisory Group Review of the 2008 Macaulay and Clover Point Wastewater and Marine Environment Program - Letter Report. Submitted to Randy Alexander, Regional Environmental Protection Manager, Vancouver Island Regional Office, BC Ministry of Environment. 12 November 2009,

PSAMP (2002) Puget Sound Protocols and Guidelines. http://www.wa.gov/puget_sound/publications/protocols/protocol.html. Last accessed August 7, 2007.

SETAC (2006) Scientific and Technical Review: Capital Regional District Core Area Liquid Waste Management Plan. Society of Environmental Toxicology and Chemistry, SETAC Scientific and Technical Review Panel,

TTYI (2004) Methods for Assessing the Potential Effects of Emerging Chemicals from Municipal Outfalls on the Marine Environment. Ten Thousand Years Institute, Bainbridge Island, WA, USA.

US EPA (2002) Clean Water Act. Section 307: 107-202.

Yunker, M. B. (2008) Assessment of the Contribution of Coal to the PAH Inventory in Marine Sediments Adjacent to Esquimalt and Victoria. Mark B. Yunker, Ph.D., Brentwood Bay, BC, Canada.

Appendix A - Macaulay and Clover Points Additional Investigations Prioritization (2006)

Category	Investigation	Description and Characteristics	2006 Rating	Status/ Anticipated Initiation Date	Anticipated Completion Date
Contaminant Source	1. Study to address the presence of endocrine disrupting compounds and pharmaceuticals and personal care products in wastewater and the potential effects on the receiving environment.	The first part of an overall phased-approach to study these substances will be to measure the concentrations of a group of substances in wastewater and potentially sediment and mussel tissue (depending on funding to develop methodology to analyze for these substances). This is an area of emerging concern related to human health and potential environmental effects (from the chemical, biological and toxicological aspects).	High	Initiated in 2004	Summary information presented in CRD (2010). Potential scientific publications in 2011.
	2. Assessment of contaminants associated with oil and grease.	Determination of contaminants associated with oil and grease originating from the outfalls. Relates to the potential human health and environmental effects issues (e.g., windsurfers, seagulls, etc.). The first phase of this investigation will be to undertake a literature review.	Medium	Not yet initiated	TBD
	3. Identification of pathogens in wastewater and the presence of these in surface waters around the outfalls.	Analysis of wastewater for different types of pathogens that have the potential to affect human health and determine if these pathogens are present in the receiving environment around the outfalls (related to die-offs, etc. in marine waters).	Low	Not yet initiated	2011/2012
	4. Bacteria source identification.	Determine the different sources of fecal coliform to differentiate between various mammals such as cows, dogs and humans.	Low	Not yet initiated	TBD

continued

Category	Investigation	Description and Characteristics	2006 Rating	Status/ Anticipated Initiation Date	Anticipated Completion Date
Pathways	5. Sediment transport/deposition/re-suspension.	The first step in this investigation would include a determination of the different particle size fractions in wastewater (this could be conducted through a literature review and/or through laboratory experiments). The second phase would include the determination of the settling of particles from the discharge onto sediments. Results from these analyses would be used in the overall assessment of sediment particle deposition and the subsequent movement of sediments around the outfalls.	High	Feasibility study initiated in 2005. Implementation on hold in light of the move to new treatment.	Deferred by Ministry of Environment
	6. Conduct a sediment core sampling program	Determination of sedimentation and mixing rates and the fluxes of contaminants near the outfalls and at reference sites. A mass balance approach could be used where rates of contaminant accumulation in sediments are compared with the rate of contaminant discharge from the outfalls in an attempt to determine the proportion of each contaminant captured by and stored in the sediments. A sediment trap study could be added to study contaminant transport in the near bottom nepheloid layer.	Medium	Initiated in 2006 and ongoing	Masters student expanding on this study. Potential scientific publications in 2011/2012. Summary information will be included in the 2010 WMEP annual report

continued

Category	Description	Description and Characteristics	2006 Rating	Status/ Anticipated Initiation Date	Anticipated Completion Date
Receptors and Potential Effects	7. Effects of EDCs and PPCPs on the receiving environment.	As part of a phased-approach to study effects of EDCs, laboratory exposures, bioassay and/or caged studies (or an organism found around the outfall) could be conducted to assess the potential effects of these substances on the receiving environment around the outfalls.	High	Collaborative study with UVic on toxicogenomic effects on mussels initiated in 2007	Results can be found in Veldhoen *et al*., (2009) Aquatic Toxicology A93. Additional publications are currently in draft.
	8. Assessment of chemical concentrations in tissue of different trophic level organisms (including higher trophic levels).	Measurement of contaminants in crab, finfish or other organisms near the outfalls would provide a basis for a food-ingestion human health risk assessment. This information could also be used to model bioconcentration and biomagnification of contaminants to higher trophic levels near the outfalls.	High	2015	2016
	9. Identification of biological resources.	Identification of the harvestable organisms around the outfalls.	Low	Not yet initiated	TBD
	10. Clover Point mussel population biology.	Conduct some additional studies on the mussel population around the Clover Point outfall (e.g., reproductive cycle, health, etc.). Additional data relates to the current monitoring and to potential studies on emerging chemicals.	Low	Not yet initiated	TBD
	11. Levels of pathogens in biota (epibenthic, etc.).	Assess the presence and concentration of pathogens in biota near the outfalls.	Low	Not yet initiated	TBD

	12. Assess potential risks associated with pathogens/antibacterial resistance.	A literature review, risk assessment or a pilot study could be conducted to study antibiotic bacteria and the relevance as a potential emerging concern to human health, wildlife and domestic animals.	Low	Not yet initiated	TBD
	13. Investigate the structure of algal plankton communities.	Assess the potential effects of the wastewater discharges on algal communities (planktonic and benthic).	Low	Not yet initiated	TBD

TBD - to be determined

Appendix B Parameters for Analysis for Each Component of the Revised Wastewater and Marine Environment Program

Parameter	Wastewater Priority Substances	Surface Water/Edge of IDZ (3 depths)		Sediment and Pore Water	Bioaccumulation	Mussels	Fish
		1st day of 5 in 30	2nd to 5th day of 5 in 30				
CONVENTIONAL VARIABLES							
acid volatile sulphide				√			
alkalinity	√						
biochemical oxygen demand	√						
carbonaceous biochemical oxygen demand	√						
chemical oxygen demand	√						
chloride	√						
conductivity	√	√b	√b				
cyanide (strong acid dissociable)	√						
cyanide (weak acid dissociable)	√						
cyanide, total				√			
dissolved solids, total							
enterococci		√ and √b	√ and √b				
fecal coliform	√	√ and √b	√ and √b				
hardness (as $CaCO_3$)	√	√b	√b	√c			
hardness (as $CaCO_3$), dissolved	√						
hydrogen sulfide				√c			
moisture				√	√ and √d	√	√
lipids					√ and √d	√	√
ammonia (NH3)	√	√b	√b	√c			
ammonia, unionized				√c			
ammonium (NH4)	√						
total Kjeldahl nitrogen	√	√b					

Parameter	Wastewater Priority Substances	Surface Water/Edge of IDZ (3 depths)		Sediment and Pore Water	Bioaccumulation	Mussels	Fish
		1st day of 5 in 30	2nd to 5th day of 5 in 30				
nitrate	√	√b	√b				
nitrite	√	√b	√b				
nitrogen, total		√b					
oil & grease, mineral	√	√b					
oil & grease, total	√	√b					
organic carbon, dissolved				√c			
organic carbon, total	√	√b		√			
particle size				√			
pH	√	√b	√b	√ and √c			
phosphate, dissolved		√b					
phosphate, total		√b					
salinity		√b	√b	√c			
sulphate	√	√b					
sulphide	√	√b					
suspended solids, total	√	√b	√b				
temperature	√	√b	√b				
CTD parameters		√b	√b				
METALS TOTAL							
aluminum	√	√b		√	√ and √d	√	√
antimony	√	√b		√	√ and √d	√	√
arsenic	√	√b		√	√ and √d	√	√
barium	√	√b		√	√ and √d	√	√
beryllium	√	√b		√	√ and √d	√	√
bismuth	√	√b		√	√ and √d	√	√

Parameter	Wastewater Priority Substances	Surface Water/Edge of IDZ (3 depths)		Sediment and Pore Water	Bioaccumulation	Mussels	Fish
		1st day of 5 in 30	2nd to 5th day of 5 in 30				
cadmium	√	√b		√	√ and √d	√	√
calcium	√	√b		√	√ and √d	√	√
chromium	√	√b		√	√ and √d	√	√
chromium VI	√	√b		√	√ and √d	√	√
cobalt	√	√b		√	√ and √d	√	√
copper	√	√b		√	√ and √d	√	√
iron	√	√b		√	√ and √d	√	√
lead	√	√b		√	√ and √d	√	√
lithium	√	√b		√	√ and √d	√	√
magnesium	√	√b		√	√ and √d	√	√
manganese	√	√b		√	√ and √d	√	√
mercury	√	√b		√	√ and √d	√	√
mercury, methylated	√ a	√b		√	√ and √d	√	√
molybdenum	√	√b		√	√ and √d	√	√
nickel	√	√b		√	√ and √d	√	√
phosphorus	√	√b		√			
potassium	√	√b		√			
selenium	√	√b		√	√ and √d	√	√
silver	√	√b		√	√ and √d	√	√
sodium	√	√b		√	√ and √d	√	√
strontium	√	√b		√	√ and √d	√	√
thallium	√	√b		√	√ and √d	√	√
tin	√	√b		√	√ and √d	√	√
tin, tributyl	√a	√b		√	√ and √d	√	√
titanium	√	√b		√	√ and √d	√	√

Parameter	Wastewater Priority Substances	Surface Water/Edge of IDZ (3 depths)		Sediment and Pore Water	Bioaccumulation	Mussels	Fish
		1st day of 5 in 30	2nd to 5th day of 5 in 30				
vanadium	√	√b		√	√ and √d	√	√
zinc	√	√b		√	√ and √d	√	√
METALS EXTRACTABLE							
cadmium				√			
copper				√			
lead				√			
mercury				√			
nickel				√			
zinc				√			
METALS DISSOLVED							
aluminum	√						
antimony	√						
arsenic	√						
barium	√						
beryllium	√						
cadmium	√						
calcium	√						
chromium	√						
cobalt	√						
copper	√						
iron	√						
lead	√						
magnesium	√						
manganese	√						
mercury	√						

Parameter	Wastewater Priority Substances	Surface Water/Edge of IDZ (3 depths)		Sediment and Pore Water	Bioaccumulation	Mussels	Fish
		1st day of 5 in 30	2nd to 5th day of 5 in 30				
molybdenum	√						
nickel	√						
phosphorus	√						
potassium	√						
selenium	√						
silver	√						
thallium	√						
tin	√						
zinc	√						
ALDEHYDES							
acrolein	√			√			
PHENOLIC COMPOUNDS							
total phenols	√			√			
CHLORINATED PHENOLICS							
2-chlorophenol	√			√	√	√	√
2,4 & 2,5 -dichlorophenol	√			√	√	√	√
2,4,6-trichlorophenol	√			√	√	√	√
4-chloro-3-methylphenol	√			√			
pentachlorophenol	√			√	√	√	√
NON CHLORINATED PHENOLICS							
2,4-dimethylphenol	√			√			
2,4-dinitrophenol	√			√			
2-methyl-4,6-dinitrophenol	√			√			
2-nitrophenol	√			√			
4-nitrophenol	√			√			

Parameter	Wastewater Priority Substances	Surface Water/Edge of IDZ (3 depths)		Sediment and Pore Water	Bioaccumulation	Mussels	Fish
		1st day of 5 in 30	2nd to 5th day of 5 in 30				
phenol	√			√			
ORGANOCHLORINE PESTICIDES							
2,4-DDD							
2,4-DDE							
2,4-DDT							
4,4-DDD							
4,4-DDE							
4,4-DDT							
aldrin							
alpha-chlordane							
alpha-endosulfan							
alpha-HCH							
beta-endosulfan							
beta-HCH							
chlordane							
delta-HCH							
dieldrin							
endosulfan sulphate							
endrin							
endrin aldehyde							
gamma-chlordane							
gamma-HCH							
heptachlor							
heptachlor epoxide							
methoxyclor							

Parameter	Wastewater Priority Substances	Surface Water/Edge of IDZ (3 depths)		Sediment and Pore Water	Bioaccumulation	Mussels	Fish
		1st day of 5 in 30	2nd to 5th day of 5 in 30				
mirex							
octachlorostyrene							
total endosulfan							
toxaphene							
POLYCHLORINATED BIPHENYLS							
PCB Aroclor 1016							
PCB Aroclor 1221							
PCB Aroclor 1232							
PCB Aroclor 1242							
PCB Aroclor 1248							
PCB Aroclor 1254							
PCB Aroclor 1260							
total PCBs							
POLYCYCLIC AROMATIC HYDROCARBONS							
2-chloronaphthalene	√			√			
2-methylnaphthalene	√			√			
acenaphthene	√			√			
acenaphthylene	√			√			
anthracene	√			√			
benzo(a)anthracene	√			√			
benzo(a)pyrene	√			√			
benzo(b)fluoranthene	√			√			
benzo(g,h,i)perylene	√			√			
benzo(k)fluoranthene	√			√			
chrysene	√			√			

Parameter	Wastewater Priority Substances	Surface Water/Edge of IDZ (3 depths)		Sediment and Pore Water	Bioaccumulation	Mussels	Fish
		1st day of 5 in 30	2nd to 5th day of 5 in 30				
dibenzo(a,h)anthracene	√			√			
fluoranthene	√			√			
fluorene	√			√			
ideno(1,2,3-c,d)pyrene	√			√			
naphthalene	√			√			
phenanthrene	√			√			
pyrene	√			√			
total high molecular weight – PAHs	√			√			
total low molecular weight – PAHs	√			√			
total PAHs	√			√			
SEMIVOLATILE ORGANICS							
bis(2-ethylhexyl)phthalate	√			√	√	√	√
butylbenzyl phthalate	√			√	√	√	√
diethyl phthalate	√			√	√	√	√
dimethyl phthalate	√			√	√	√	√
di-n-butyl phthalate	√			√	√	√	√
di-n-octyl phthalate	√			√	√	√	√
MISCELLANEOUS SEMIVOLATILE ORGANICS							
1,2,4-trichlorobenzene	√			√	√	√	√
1,2-diphenylhydrazine	√			√			
2,4-dinitrotoluene	√			√			
2,6-dinitrotoluene	√			√			
3,3-dichlorobenzidine	√			√			
4-bromophenyl phenyl ether	√			√	√	√	√
4-chlorophenyl phenyl ether	√			√	√	√	√

Parameter	Wastewater Priority Substances	Surface Water/Edge of IDZ (3 depths)		Sediment and Pore Water	Bioaccumulation	Mussels	Fish
		1st day of 5 in 30	2nd to 5th day of 5 in 30				
benzidine	√			√			
bis(2-chloroethoxy)methane	√			√	√	√	√
bis(2-chloroethyl)ether	√			√	√	√	√
bis(2-chloroisopropyl)ether	√			√	√	√	√
hexachlorobenzene	√			√			
hexachlorobutadiene	√			√	√	√	√
hexachlorocyclopentadiene	√			√			
hexachloroethane	√			√	√	√	√
isophorone	√			√			
nitrobenzene	√			√			
N-nitrosodimethylamine	√			√			
N-nitrosodi-n-propylamine	√			√			
N-nitrosodiphenylamine	√			√			
VOLATILE ORGANICS							
Monocyclic Aromatic Hydrocarbons							
1,2-dichlorobenzene	√			√	√	√	√
1,3-dichlorobenzene	√			√	√	√	√
1,4-dichlorobenzene	√			√	√	√	√
benzene	√			√			
chlorobenzene	√			√			
ethylbenzene	√			√			
styrene	√			√			
toluene	√			√			
m & p xylenes	√			√			
o-xylene	√			√			

Parameter	Wastewater Priority Substances	Surface Water/Edge of IDZ (3 depths)		Sediment and Pore Water	Bioaccumulation	Mussels	Fish
		1st day of 5 in 30	2nd to 5th day of 5 in 30				
xylenes	√			√			
Aliphatic							
acrylonitrile	√			√			
methyl tertiary butyl ether	√			√			
Chlorinated Aliphatic							
1,1,1,2-tetrachloroethane	√			√			
1,1,1-trichloroethane	√			√			
1,1,2,2-tetrachloroethane	√			√			
1,1,2-trichloroethane	√			√			
1,1-dichloroethane	√			√			
1,1-dichloroethene	√			√			
1,2-dichloroethane	√			√			
1,2-dichloropropane	√			√			
2-chloroethylvinyl ether	√			√			
bromomethane	√			√			
chloroethane	√			√			
chloroethene	√			√			
chloromethane	√			√			
cis-1,2-dichloroethene	√			√			
cis-1,3-dichloropropene	√			√			
dibromoethane	√			√			
dibromomethane	√			√			
dichloromethane	√			√			
tetrabromomethane	√			√			
tetrachloroethene	√			√			

Parameter	Wastewater Priority Substances	Surface Water/Edge of IDZ (3 depths)		Sediment and Pore Water	Bioaccumulation	Mussels	Fish
		1st day of 5 in 30	2nd to 5th day of 5 in 30				
tetrachloromethane	√			√			
trans-1,2-dichloroethene	√			√			
trans-1,3-dichloropropene	√			√			
trichloroethene	√			√			
trichlorofluoromethane	√			√			
Trihalomethanes							
bromodichloromethane	√			√			
bromoform	√			√			
chlorodibromomethane	√			√			
tribromomethane	√			√			
trichloromethane	√			√			
Ketones							
4-methyl-2 pentanone	√			√			
dimethyl ketone	√			√			
endrin ketone	√			√			
methyl ethyl ketone	√			√			
TERPENES							
alpha-terpineol	√			√			
High Resolution Parameter List							
NONYLPHENOLS (NP)							
nonylphenol (NP)	√a			√			
4-nonylphenol monoethoxylate (NP1EO)	√a			√			
4-nonylphenol diethoxylate (NP2EO)	√a			√			
ORGANOCHLORINE PESTICIDES (OCP)							

Parameter	Wastewater Priority Substances	Surface Water/Edge of IDZ (3 depths)		Sediment and Pore Water	Bioaccumulation	Mussels	Fish
		1st day of 5 in 30	2nd to 5th day of 5 in 30				
hexachlorobenzene	√a			√	√	√	√
HCH, alpha	√a			√	√	√	√
HCH, beta	√a			√	√	√	√
HCH, gamma	√a			√	√	√	√
heptachlor	√a			√	√	√	√
aldrin	√a			√	√	√	√
chlordane, oxy-	√a			√	√	√	√
chlordane, gamma (trans)	√a			√	√	√	√
chlordane, alpha (cis)	√a			√	√	√	√
nonachlor, trans-	√a			√	√	√	√
nonachlor, cis-	√a			√	√	√	√
2,4'-DDD	√a			√	√	√	√
4,4'-DDD	√a			√	√	√	√
2,4'-DDE	√a			√	√	√	√
4,4'-DDE	√a			√	√	√	√
2,4'-DDT	√a			√	√	√	√
4,4'-DDT	√a			√	√	√	√
mirex	√a			√	√	√	√
technical toxaphene	√a			√	√	√	√
hexachlorobutadiene	√a			√	√	√	√
octachlorostyrene	√a			√	√	√	√
chlorobenzenes	√a			√	√	√	√
HCH, delta	√a			√	√	√	√
heptachlor Epoxide	√a			√	√	√	√
alpha-Endosulphan	√a			√	√	√	√

Parameter	Wastewater Priority Substances	Surface Water/Edge of IDZ (3 depths)		Sediment and Pore Water	Bioaccumulation	Mussels	Fish
		1st day of 5 in 30	2nd to 5th day of 5 in 30				
dieldrin	√a			√	√	√	√
endrin	√a			√	√	√	√
beta-endosulphan	√a			√	√	√	√
endosulphan sulphate	√a			√	√	√	√
endrin aldehyde	√a			√	√	√	√
ndrin ketone	√a			√	√	√	√
methoxychlor	√a			√	√	√	√
POLYCHLORINATED BIPHENYLS (PCBs)							
PCB-1	√a			√	√ and √d	√	√
PCB-3	√a			√	√ and √d	√	√
PCB-4/10	√a			√	√ and √d	√	√
PCB-5/8	√a			√	√ and √d	√	√
PCB-15	√a			√	√ and √d	√	√
PCB-18	√a			√	√ and √d	√	√
PCB-19	√a			√	√ and √d	√	√
PCB-23/34	√a			√	√ and √d	√	√
PCB-28	√a			√	√ and √d	√	√
PCB-31	√a			√	√ and √d	√	√
PCB-37	√a			√	√ and √d	√	√
PCB-40	√a			√	√ and √d	√	√
PCB-44	√a			√	√ and √d	√	√
PCB-43/49	√a			√	√ and √d	√	√
PCB-52/73	√a			√	√ and √d	√	√
PCB-54	√a			√	√ and √d	√	√

Parameter	Wastewater Priority Substances	Surface Water/Edge of IDZ (3 depths)		Sediment and Pore Water	Bioaccumulation	Mussels	Fish
		1st day of 5 in 30	2nd to 5th day of 5 in 30				
PCB-56/60	√a			√	√ and √d	√	√
PCB-66/80	√a			√	√ and √d	√	√
PCB-77	√a			√	√ and √d	√	√
PCB-81	√a			√	√ and √d	√	√
PCB-87/115/116	√a			√	√ and √d	√	√
PCB-89/90/101	√a			√	√ and √d	√	√
PCB-93/95	√a			√	√ and √d	√	√
PCB-99	√a			√	√ and √d	√	√
PCB-104	√a			√	√ and √d	√	√
PCB-105/127	√a			√	√ and √d	√	√
PCB-106/118	√a			√	√ and √d	√	√
PCB-110	√a			√	√ and √d	√	√
PCB-114	√a			√	√ and √d	√	√
PCB-123	√a			√	√ and √d	√	√
PCB-126	√a			√	√ and √d	√	√
PCB-138/163/164	√a			√	√ and √d	√	√
PCB 139/149	√a			√	√ and √d	√	√
PCB-151	√a			√	√ and √d	√	√
PCB-153	√a			√	√ and √d	√	√
PCB-155	√a			√	√ and √d	√	√
PCB-156	√a			√	√ and √d	√	√
PCB-157	√a			√	√ and √d	√	√
PCB-167	√a			√	√ and √d	√	√
PCB-169	√a			√	√ and √d	√	√
PCB-170/190	√a			√	√ and √d	√	√

Parameter	Wastewater Priority Substances	Surface Water/Edge of IDZ (3 depths)		Sediment and Pore Water	Bioaccumulation	Mussels	Fish
		1st day of 5 in 30	2nd to 5th day of 5 in 30				
PCB-180	√a			√	√ and √d	√	√
PCB-182/187	√a			√	√ and √d	√	√
PCB-183	√a			√	√ and √d	√	√
PCB-188	√a			√	√ and √d	√	√
PCB-189	√a			√	√ and √d	√	√
PCB-194	√a			√	√ and √d	√	√
PCB-196/203	√a			√	√ and √d	√	√
PCB-202	√a			√	√ and √d	√	√
PCB-205	√a			√	√ and √d	√	√
PCB-206	√a			√	√ and √d	√	√
PCB-208	√a			√	√ and √d	√	√
PCB-209	√a			√	√ and √d	√	√
Aroclor 1016	√a			√	√ and √d	√	√
Aroclor 1221	√a			√	√ and √d	√	√
Aroclor 1232	√a			√	√ and √d	√	√
Aroclor 1242	√a			√	√ and √d	√	√
Aroclor 1248	√a			√	√ and √d	√	√
Aroclor 1254 (estimated)	√a			√	√ and √d	√	√
Aroclor 1260	√a			√	√ and √d	√	√
POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)							
acenaphthene					√ and √d	√	√
acenaphthylene					√ and √d	√	√
acenaphthylene d-8					√ and √d	√	√
anthracene					√ and √d	√	√

Parameter	Wastewater Priority Substances	Surface Water/Edge of IDZ (3 depths)		Sediment and Pore Water	Bioaccumulation	Mussels	Fish
		1st day of 5 in 30	2nd to 5th day of 5 in 30				
benz[a]anthracene					√ and √d	√	√
benzo[a]anthracene d-12					√ and √d	√	√
benzo[a]pyrene					√ and √d	√	√
benzo[a]pyrene d-12					√ and √d	√	√
benzo[b]fluoranthene					√ and √d	√	√
benzo[b]fluoranthene d-12					√ and √d	√	√
benzo[ghi]perylene					√ and √d	√	√
benzo[ghi]perylene d-12					√ and √d	√	√
benzo[j,k]fluoranthenes					√ and √d	√	√
benzo[k]fluoranthene d-12					√ and √d	√	√
chrysene					√ and √d	√	√
chrysene d-12					√ and √d	√	√
dibenz[a,h]anthracene					√ and √d	√	√
dibenzo[a,h]anthracene d-14					√ and √d	√	√
fluoranthene					√ and √d	√	√
fluoranthene d-10					√ and √d	√	√
fluorene					√ and √d	√	√
indeno[1,2,3-cd]pyrene					√ and √d	√	√
indeno[1,2,3-cd]pyrene d-12					√ and √d	√	√
naphthalene					√ and √d	√	√
naphthalene d-8					√ and √d	√	√
phenanthrene					√ and √d	√	√
phenanthrene d-10					√ and √d	√	√
pyrene					√ and √d	√	√

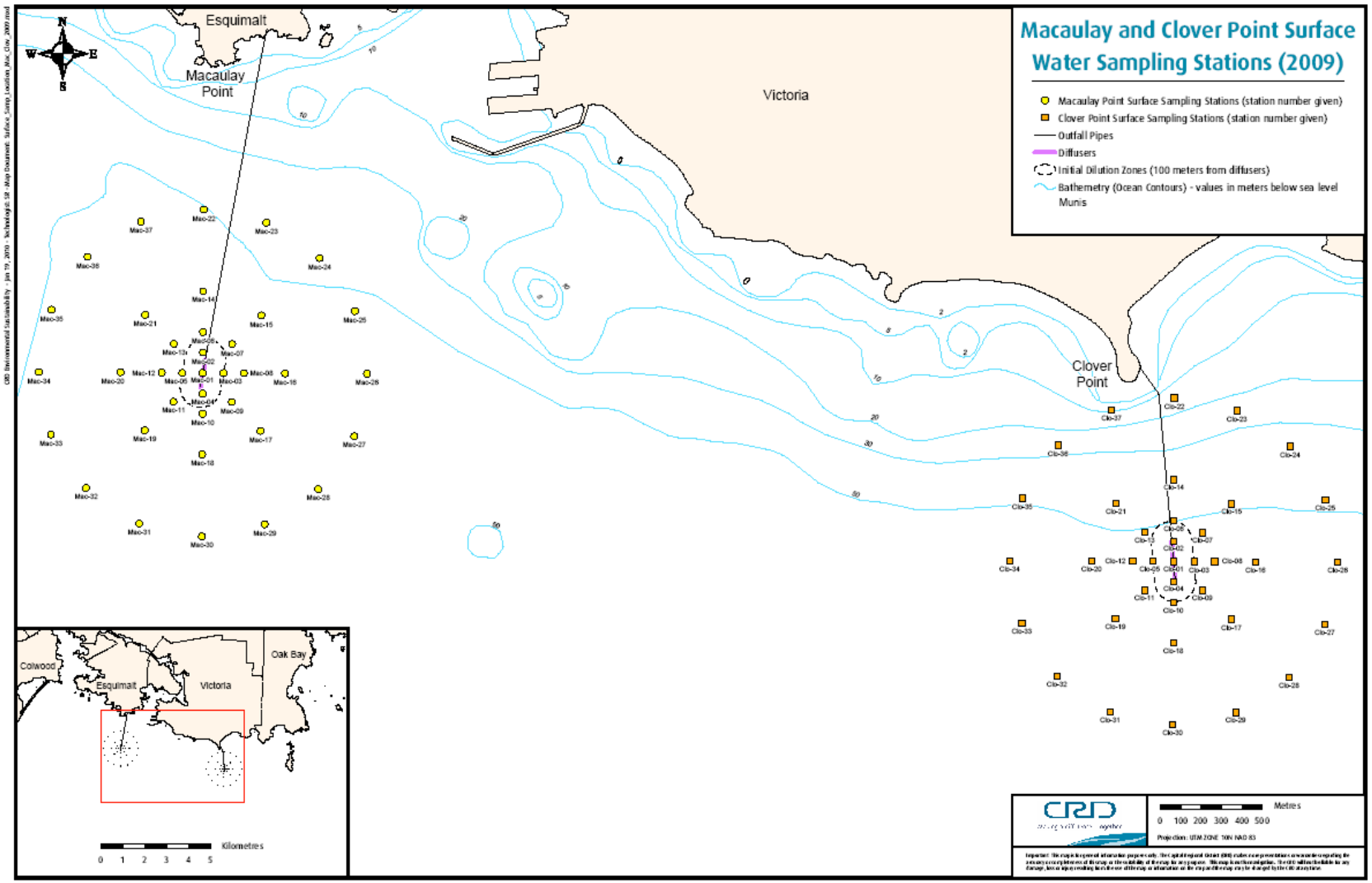
Parameter	Wastewater Priority Substances	Surface Water/Edge of IDZ (3 depths)		Sediment and Pore Water	Bioaccumulation	Mussels	Fish
		1st day of 5 in 30	2nd to 5th day of 5 in 30				
POLYCHLORINATED DIBENZODIOXINS (PCDDs)							
2,3,7,8-TCDD						√	√
1,2,3,7,8-PECDD						√	√
1,2,3,4,7,8-HXCDD						√	√
1,2,3,6,7,8-HXCDD						√	√
1,2,3,7,8,9-HXCDD						√	√
1,2,3,4,6,7,8-HPCDD						√	√
OCDD						√	√
dibenzo-p-dioxin						√	√
POLYBROMINATED DIPHENYL ETHERS (PBDEs)							
BR2-DPE-7	√a			√	√	√	√
BR2-DPE-8/11	√a			√	√	√	√
BR2-DPE-10	√a			√	√	√	√
BR2-DPE-12/13	√a			√	√	√	√
BR2-DPE-15	√a			√	√	√	√
BR3-DPE-17/25	√a			√	√	√	√
BR3-DPE-28/33	√a			√	√	√	√
BR3-DPE-30	√a			√	√	√	√
BR3-DPE-32	√a			√	√	√	√
BR3-DPE-35	√a			√	√	√	√
BR3-DPE-37	√a			√	√	√	√
BR4-DPE-47	√a			√	√	√	√
BR4-DPE-49	√a			√	√	√	√

Parameter	Wastewater Priority Substances	Surface Water/Edge of IDZ (3 depths)		Sediment and Pore Water	Bioaccumulation	Mussels	Fish
		1st day of 5 in 30	2nd to 5th day of 5 in 30				
BR4-DPE-51	√a			√	√	√	√
BR4-DPE-66	√a			√	√	√	√
BR4-DPE-71	√a			√	√	√	√
BR4-DPE-75	√a			√	√	√	√
BR4-DPE-77	√a			√	√	√	√
BR4-DPE-79	√a			√	√	√	√
BR5-DPE-85	√a			√	√	√	√
BR5-DPE-99	√a			√	√	√	√
BR5-DPE-100	√a			√	√	√	√
BR5-DPE-105	√a			√	√	√	√
BR5-DPE-116	√a			√	√	√	√
BR5-DPE-119/120	√a			√	√	√	√
BR5-DPE-126	√a			√	√	√	√
BR6-DPE-128	√a			√	√	√	√
BR6-DPE-138/166	√a			√	√	√	√
BR6-DPE-140	√a			√	√	√	√
BR6-DPE-153	√a			√	√	√	√
BR6-DPE-154	√a			√	√	√	√
BR6-DPE-155	√a			√	√	√	√
BR7-DPE-181	√a			√	√	√	√
BR7-DPE-183	√a			√	√	√	√
BR7-DPE-190	√a			√	√	√	√
BR8-DPE-203	√a			√	√	√	√
BR9-DPE-206	√a			√	√	√	√
BR9-DPE-207	√a			√	√	√	√

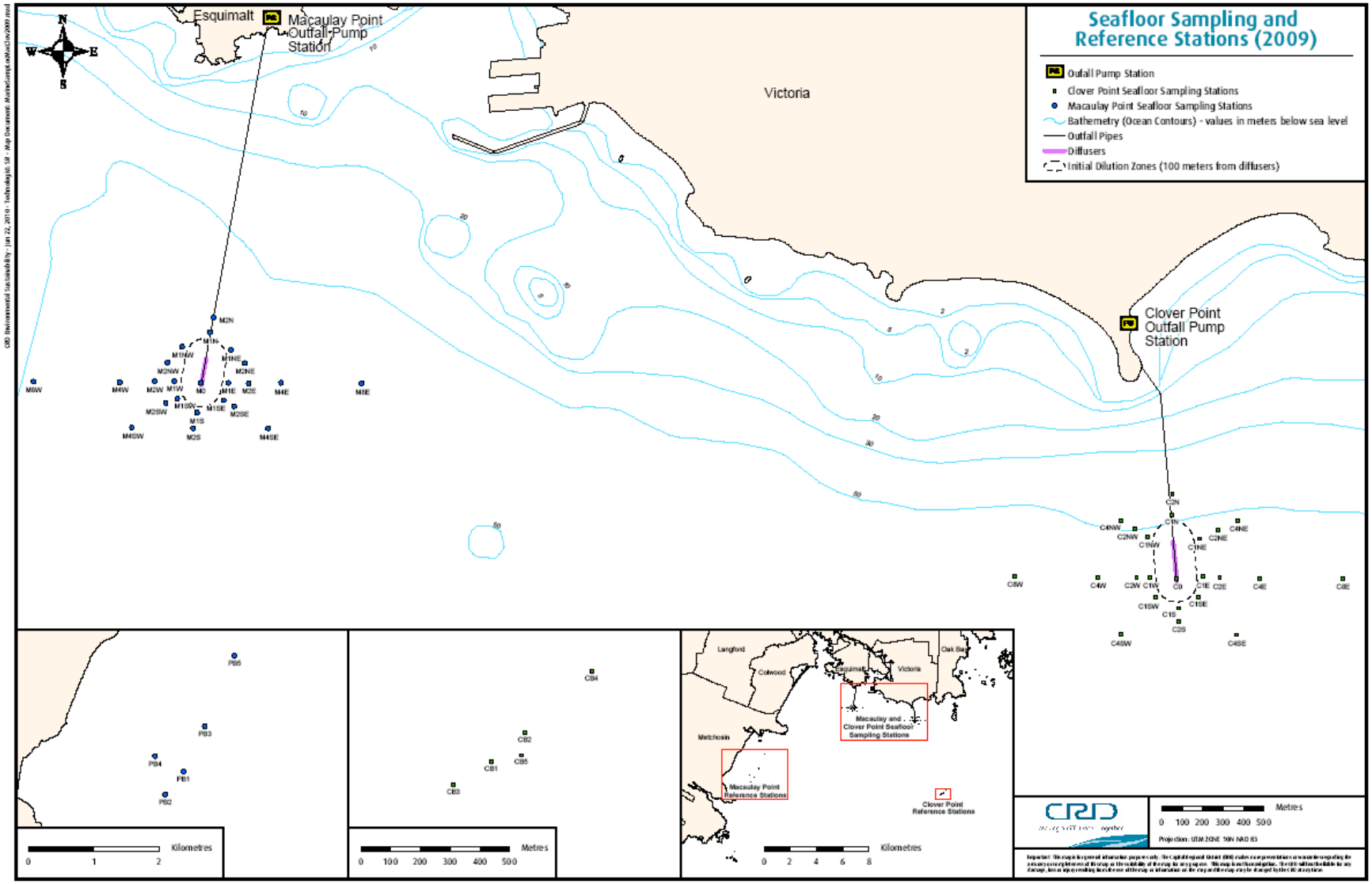
Parameter	Wastewater Priority Substances	Surface Water/Edge of IDZ (3 depths)		Sediment and Pore Water	Bioaccumulation	Mussels	Fish
		1st day of 5 in 30	2nd to 5th day of 5 in 30				
BR9-DPE-208	√a			√	√	√	√
BR10-DPE-209	√a			√	√	√	√
pentabromoethylbenzene (PBEB)	√a			√	√	√	√
hexabromobenzene (HBB)	√a			√	√	√	√
1,2-Bis(2,4,6-tribromophenoxy)ethane (BTBPE)	√a			√	√	√	√
decabromodiphenylethane (DBDPE)	√a			√	√	√	√

√a□- will be analyzed on a quarterly basis only, √b – at edge of IDZ only, √c - will be analyzed in sediment pore water only, √d analysed as part of pilot

Appendix C Original WMEP Surface Sampling Stations



Appendix D Original WMEP Seafloor Sampling Stations



Appendix E Year 1 Pilot Study

A sediment toxicity, bioaccumulation, chemistry and pore water pilot study was conducted in Year 1. The original plan for the study is detailed below:

In addition to supporting selection of a suite of toxicity tests for use in the WMEP, the results of the pilot study will also provide a basis for selecting the routine bioaccumulation test for the program. To generate the requisite data, large volume sediment samples will be collected at a total of six stations in the vicinity of the Macaulay Point outfall, three at Clover and three at associated reference stations for toxicity (but only three stations in the vicinity of the Macaulay Point outfall for bioaccumulation). These stations will be selected based on their sediment COPC concentrations such that stations with low, moderate and high concentrations of select COPCs will be sampled in sediment. Toxicity and bioaccumulation tests will be conducted using organisms presented in Table E. During the 56 day bioaccumulation tests, concentrations of COPCs will be measured on day 0, 14, 28, 42 and Day 56 and the resultant data will be used to determine the time to steady state for each COPC in each species. Test selection in subsequent years, will be conducted by assessing the results of the pilot study and by using future guidance documents (e.g., the in prep document entitled The Federal Contaminated Sites Action Plan Supplemental Guidance for Ecological Risk Assessment (Toxicity Test Selection and Interpretation as provided by Golder Associates Ltd. (Golder, 2012)).

Table E- Pilot Study Toxicity and Bioaccumulation Test Selection and Endpoints

	Endpoint	Test	Pilot	Year 2	Year 4	Year 5
56-day polychaete (*Neries virens* or *Neanthes aceodentata*)	Chemistry, survival, growth, and biomass	T=0, 14, 28, 42 and 56 days Chemistry (Appendix B)	x			
56-day bivalve (*Macoma nasuta*)	Chemistry, survival, growth, and biomass	T=0, 14, 28, 42 and 56 days Chemistry (Appendix B)	x			
20- day or 28- day polychaete *(Neries virens)* or bivalve (*Macoma nasuta*)	Chemistry, survival, growth, and biomass	T=0 and 28 days Chemistry (Appendix B)	x	x	x	x
10- day mysid shrimp (*Mysidopsis bahia*)	Survival	LC50	x			
28- day amphipod (*Leptochirns plumulosus*)	Survival, growth, biomass and reproduction	Various measurements and LC50	x			
48-hour mollusc (*Mytilus galloprovincealis)*	Survival and normal development	Various measurements and LC50	x			
10- day amphipod (*Rhepoxynius abronius*)	Survival and reburial	Various measurements and LC50	x			
3 of the above tests chosen based on pilot results				x	x	x

T=time