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# DISCUSSION PAPER

## Capital Regional District
## Core Area
## Wastewater Management Program

## Cost versus Benefit of Reducing Inflow and Infiltration


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Environmental Services

March 2009

**Capital Regional District**
**Core Area Wastewater Management Program**

**Cost vs. Benefit of Reducing Inflow and Infiltration**

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# 1.0 INTRODUCTION AND OVERVIEW

## 1.1 Background

The Core Area of the Capital Regional District (CRD) is a partnership of seven local governments and two First Nation areas with a total land area of about 215 square kilometers that makeup the majority of Greater Victoria, located at the southern tip of Vancouver Island. The CRD provides services that are regional in nature including the sewage system which serves some 320,000 people in the core area.

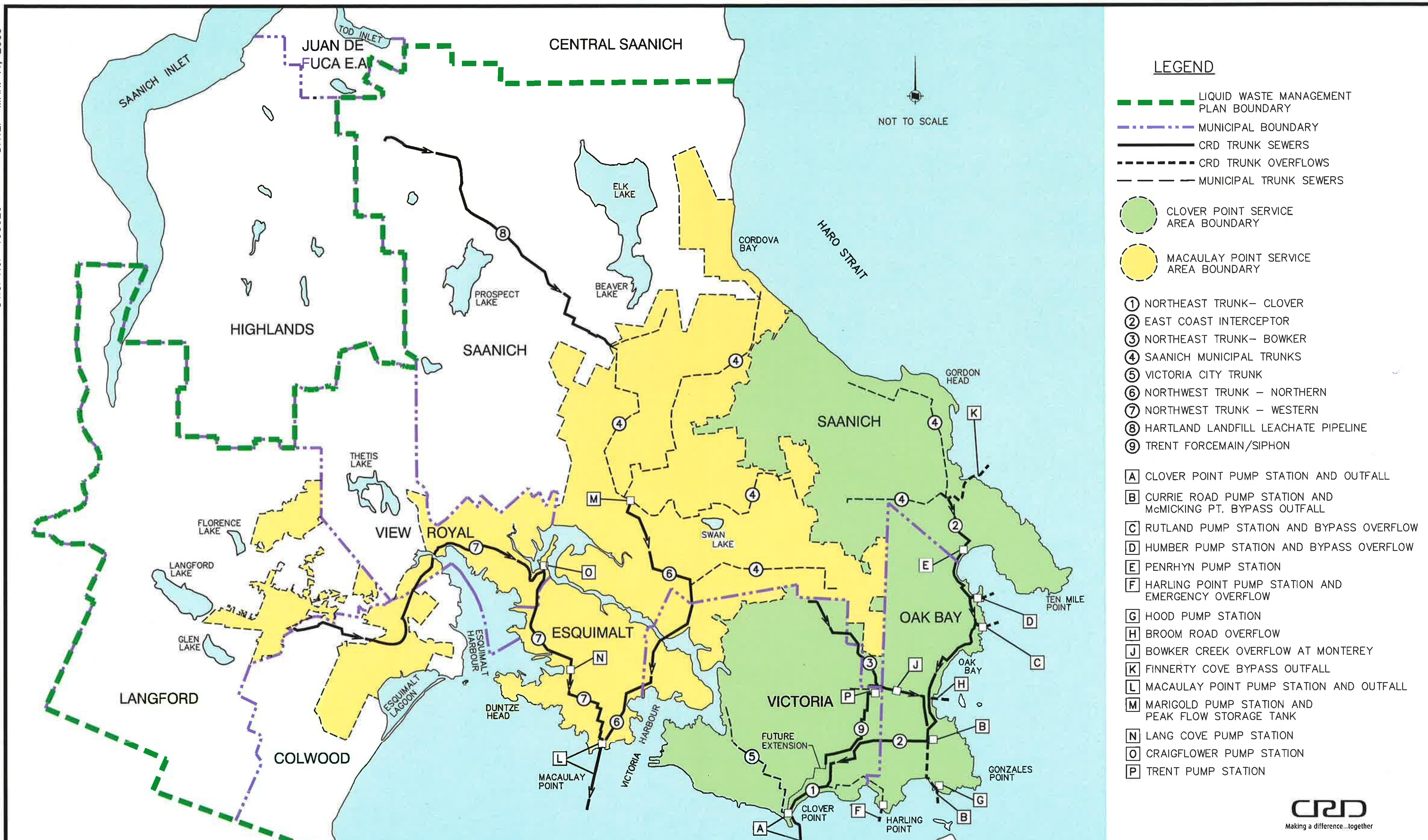
The Core Area sewerage system is primarily serviced by the northwest trunk (NWT) sewer (northern and western legs) and the northeast trunk/east coast interceptor (NET/ECI).

These trunk sewer systems have a total approximate length of 55 km, and are mostly reinforced concrete with some brick, high density polyethylene (HDPE), polyvinyl chloride (PVC), steel, and ductile iron mains (some of which are pressurized forcemains or inverted siphons). Pipe diameters range from 400mm to 1200mm. Due to undulating topography and subsurface conditions, 12 pump stations (including Macaulay Point and Clover Point pump stations/deep sea outfalls) provide service to the Macaulay and Clover Point service areas as shown on Figure 1.1.

Prior to the formation of the regional district in 1966, each municipality designed their own sanitary collection system with, in some cases, multiple outfalls discharging at the low tide mark. Over the next few decades, the CRD then designed its system to intercept all of these outfalls and convey the wastewater to the Macaulay and Clover Point deep sea outfalls. However, environmental regulations of the day permitted the regional system to have some overflows during storm events at most of the original outfalls.

The Core Area Liquid Waste Management Plan (LWMP), submitted to and approved by the Province in 2000 and 2003, respectively, triggered new design criteria for the sewage system to reduce and eventually eliminate sanitary sewer overflows that occur during 5-year storm events, consistent with the Municipal Sewage Regulation.

Therefore, in addition to meeting the commitments outlined in Chapter 13, Management of Wastewater Overflows, the CRD is also working towards its Inflow and Infiltration commitments in Chapter 8 of the LWMP, which will greatly assist in meeting the overflow requirements.

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**CORE AREA I&I PROGRAM**

**FIGURE 1.1**

**EXISTING CORE AREA WASTEWATER INFRASTRUCTURE**

### 1.2 Sanitary Sewer System

Sanitary sewer collection systems receive wastewater from buildings (i.e., from sinks, toilets, showers, washing machines, etc.) and convey it to sewage facilities. Sanitary sewers play a critical role in protecting human health and the environment in developed areas. Within the Core Area of the CRD, the collection system is generally defined and operated as follows:

- Sewer laterals convey wastewater from buildings to the municipal sewers. These "connections" are commonly constructed of vitrified clay, concrete, asbestos cement (no longer acceptable), and polyvinyl chloride (PVC) plastic pipe. Building connections are usually made on about 2% grade with 100mm or larger pipe.

  Individual private property owners are 100% responsible for the portion of the lateral that is located on their property and, with the exception of Oak Bay, the remainder of the lateral from the property line to the public sewer is owned and maintained by the municipality. In Oak Bay's case, the entire lateral from the building to the public sewer main is the private property owner's responsibility.

- Collection sewers gather flows from individual buildings and transport the sewage to a larger trunk sewer, municipal pump station or regional sewer. Collection sewers are usually located under the street on one side of the storm drain. They should be capable of conveying the peak domestic, commercial, industrial, and institutional flows plus an allowance for inflow and infiltration (I&I) of the area they are intended to serve. Manholes are normally located at changes in direction, grade, pipe size, or at intersections of collecting sewers. Generally, manholes should not be spaced farther than 120m apart to permit inspection and cleaning when necessary. Similar to sewer laterals, the pipe materials for these sewers are vitrified clay, concrete, asbestos cement and PVC plastic pipe.

  Each of the municipalities own and operate their own sanitary sewer system, including municipal sewer lines and pump stations.

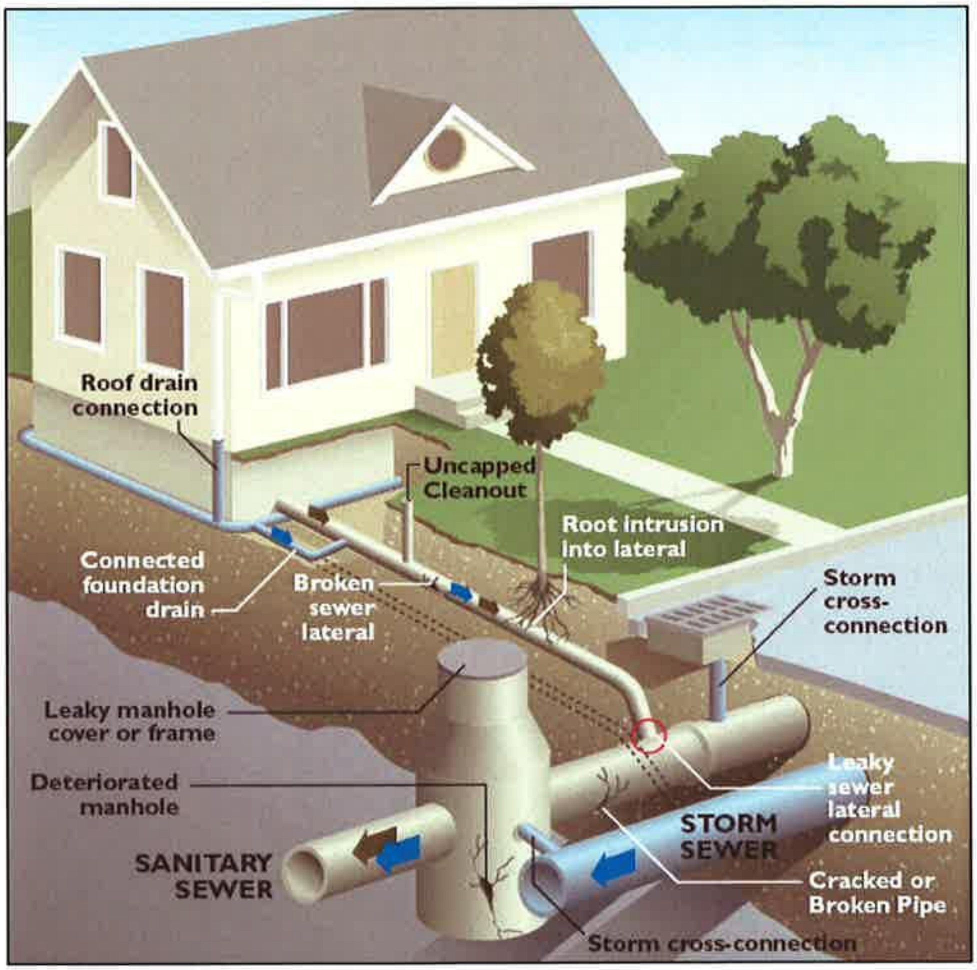
- Regional sewers are generally pipelines that convey sewage across municipal boundaries and are expected to carry flows from the collector sewers to the point of treatment and/or disposal. These sewers are obviously larger, deeper and generally installed on flatter grades. Typical pipe materials used are brick, concrete, PVC, or high density polyethylene (HDPE), and ductile iron for pressure pipe applications. These regional conveyance systems are owned and operated by the CRD.

  As shown in Figure 1.1, the regional trunk sewers currently convey wastewater to the Clover Point and Macaulay Point pump stations where it is screened to remove solids, plastic and floatable materials larger than 6mm, prior to discharge to deep sea outfalls.

## 1.3 Inflow and Infiltration

Inflow and Infiltration refers to rainwater and groundwater that enters the sanitary sewer collection system. A certain amount of I&I is unavoidable and is accounted for in routine sewer design. However, when I&I exceeds design allowances, sewer capacity is consumed and usually results in overflows and increased conveyance costs or a reduction in the future population service capacity. Experience has shown that the I&I allowance used in the original design of older systems is significantly below the wet-weather flows these systems experience. It is not uncommon for wet-weather peak flows to be an order of magnitude larger than the average daily flow of wastewater. Such large peak flows are primarily due to the numerous defects in the collection system caused by system deterioration and illegal connections over the years. The following figure illustrates common sources (defects) of where I&I enters the sanitary sewer system.

**Figure 1.2 Common Sources of Inflow and Infiltration**




I&I rates can be quantified by collecting sewer flow data. Typically, during dry weather periods, sewer flows follow a diurnal pattern where the flows are lowest in the middle of the night and highest during morning and evening peaks. During some rainfall events, the flow pattern will shift upward as rainwater / groundwater enters the sewer system. The amount that the flows shift upward can be quantified as I&I.

Figure 1.3 graphically displays the I&I rates that have been calculated for various catchments over the entire Core Area.

CRD Environmental Services - Mar 11, 2009 - Technologist: SR - Map Document: Five_Yr_IandI_Rates_11x17_2007-2008.mxd

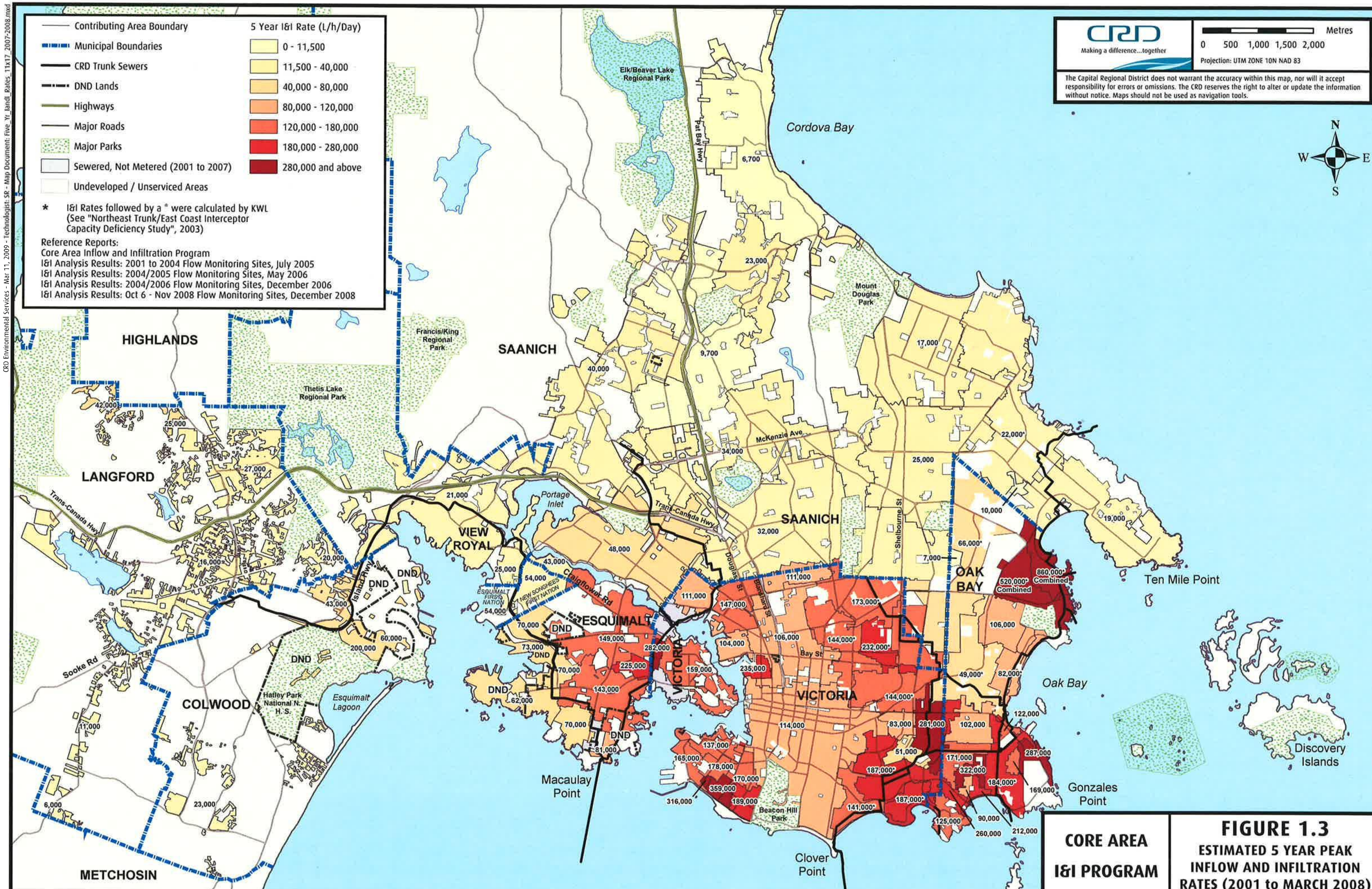



FIGURE 1.3
ESTIMATED 5 YEAR PEAK INFLOW AND INFILTRATION RATES (2001 to MARCH 2008)

## 1.4 Typical Flow, Inflow and Infiltration Terminology

There are a variety of terms that are used to define the various flow components within a sanitary sewer system. An understanding of the more common terms will help to appreciate the design criteria used to size collections systems and treatment plants.

"Sewage" or "Base Sanitary Flow" refers to water that is contaminated with waste matter of domestic, commercial, industrial, or natural origin. The average person uses almost 225 liters of water per day performing routine activities such as bathing, recreation and body waste elimination.

"Average Dry Weather Flow" is the average daily flow rate during dry weather periods and includes a small allowance for groundwater infiltration that is present year-round.

"Peak Dry Weather Flow" is the peak daily flow that usually occurs once in the morning and then again in the evening.

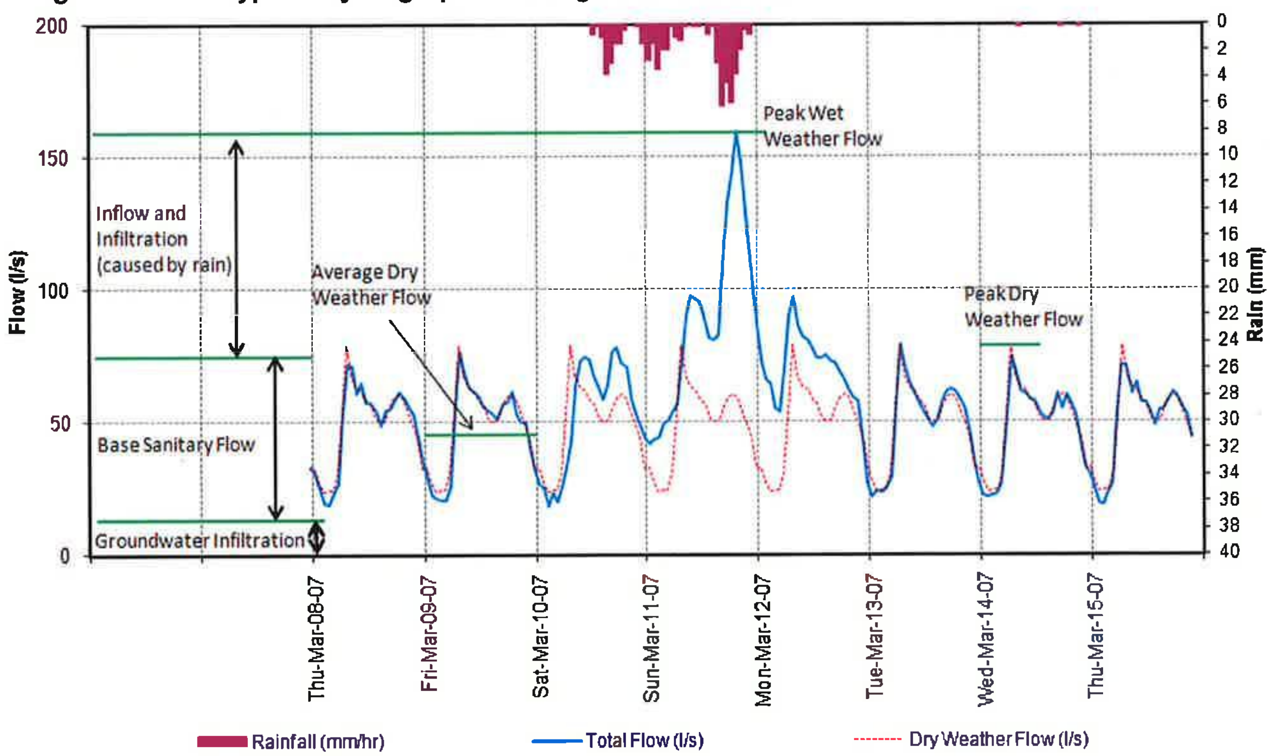
"Inflow" refers to rainwater or snowmelt water that enters the sanitary sewer through a direct (non-soil) connection. Examples of inflow include cross-connected catch basins and roof drains.

"Infiltration" is water that flows through the ground and drains into the sanitary sewer system via cracked pipes, deteriorated manholes, leaky joints, root intrusion, etc. During periods of rain and/or snowmelt, the ground becomes more saturated causing the water table to rise and leak into the sanitary sewer at a much greater rate.

"Peak Wet Weather Flow" is the peak flow rate that occurs at the height a rainfall or snowmelt event.

To help clarify the various flow terms, Figure 1.4 shows a typical hydrograph illustrating flow components.

**Figure 1.4 Typical Hydrograph Showing Flow Definitions**



## 1.5 LWMP Goals and Commitments

The goal of the CRD and its municipal partners is to reduce inflow and infiltration that minimizes total conveyance, treatment and disposal system costs, coincident with reduction of I&I induced overflows to acceptable levels.

The joint commitments made by the CRD and participating municipalities to reach the goal, as noted in the LWMP, are as follows:

The **Capital Regional District** and the **participating municipalities** commit:

- to develop implementation plans for staged reduction of inflow and infiltration over the 25-year life of the Liquid Waste Management Plan
- to recommend to future councils that they commit funds for I&I reduction that are economically justified by avoidance of future costs to treat and convey inflow and infiltration
- to measure flows before and after carrying out work on sewers to reduce I&I, to document I&I expenditures and achievements, and to use this information to refine cost benefit curves developed to optimize expenditures

A complete copy of Chapter 8 of the Core Area LWMP and the March 26, 2003 approval letter is included in Appendix A.

The CRD and the participating municipalities have been measuring flows, documenting expenditures and achievements, and submitting this information to the Ministry every two years. The partners are currently preparing a long-term inflow and infiltration management plan.

## 1.6 Regulatory Requirements

The Municipal Sewage Regulation (MSR) states that no person allows inflow and infiltration so that the maximum average daily flow exceeds 2.0 times average dry weather flow (ADWF) to occur during a storm or snowmelt with less than a 5-year return period, unless a liquid waste management plan is developed to address inflow and infiltration.

The above noted LWMP goal and commitments are being met and with respect to the future Core Area treatment plants, the following philosophy has been submitted to the Ministry for their approval.

Provide secondary treatment for all flows up to 2 times ADWF.

Provide primary treatment for flows between 2 times and 4 times ADWF with the ability to blend the primary and secondary effluent.

Provide 6-mm screening for flows that exceed 4 times ADWF.

## 2.0 CURRENT FLOW DATA AT CLOVER AND MACAULAY POINT OUTFALLS

Figures 2.1 and 2.2 (on the following two pages) display the entire year (2008) of flow data at Clover and Macaulay Point pump stations and deep sea outfalls.

As expected, these figures graphically show that the flow varies by season in direct correlation to rainfall, but that the flow remains below 2 times ADWF a majority of the time.

Some interesting data to note about these two pump stations and outfalls include:

| | Clover | Macaulay |
|---|---|---|
| o Maximum daily flow (2008) = | 118,600 $m^3$/day | 81,700 $m^3$/day |
| o Minimum daily flow (2008) = | 40,700 $m^3$/day | 37,400 $m^3$/day |
| o Average dry weather flow = | 52,000 $m^3$/day | 45,000 $m^3$/day |
| o Maximum pumping capacity = | 216,000 $m^3$/day | 151,200 $m^3$/day |

It is clear that both pump stations can screen and discharge about 3 - 4 times their average dry weather flow. Even so, there can be times when the flow exceeds their maximum pumping capacity. When this occurs, the excess quantity is discharged out through an emergency bypass outfall.

To get a better understanding of how frequent the flow rate varies at each of these pump stations, the following Tables 2.1 and 2.2 document the number of times in the past three years that the flow:

- did not exceed 2 times ADWF,
- exceeded 2 times but was less than 4 times ADWF, and
- exceeded 4 times ADWF.

**Table 2.1 Statistical Flow Data from Clover Point Pump Station**

| Flow Range | 2006 | 2007 | 2008 |
|---|---|---|---|
| Number of days flow did not exceed 2xADWF | 345 | 349 | 362 |
| Number of days flow was between 2xADWF and 4xADWF | 20 | 16 | 3 |
| Number of days flow exceeded 4xADWF [1] | 0 | 0 | 0 |
| TOTAL | 365 | 365 | 365 |

1. Not all of the flow reaches Clover Point during times of excessive flow due to the upstream system being throttled back. If all the flow was permitted to reach Clover pump station it could exceed 4xADWF.

**Table 2.2 Statistical Flow Data from Macaulay Point Pump Station**

| Flow Range | 2006 | 2007 | 2008 |
|---|---|---|---|
| Number of days flow did not exceed 2xADWF | 357 | 358 | 365 |
| Number of days flow was between 2xADWF and 4xADWF | 8 | 7 | 0 |
| Number of days flow exceeded 4xADWF | 0 | 0 | 0 |
| TOTAL | 365 | 365 | 365 |

**Figure 2.1: Clover Point Pump Station Daily Flows - 2008**

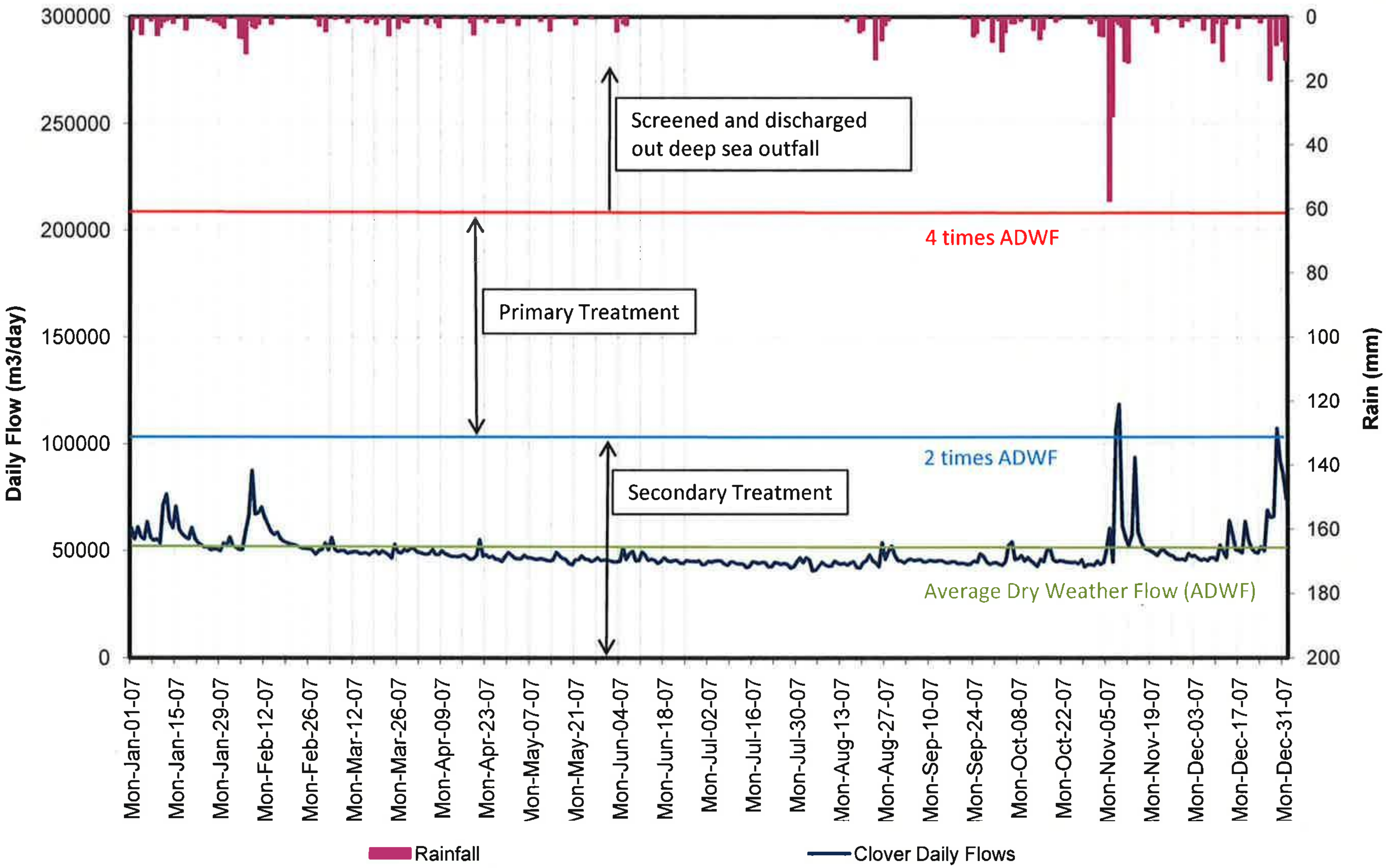
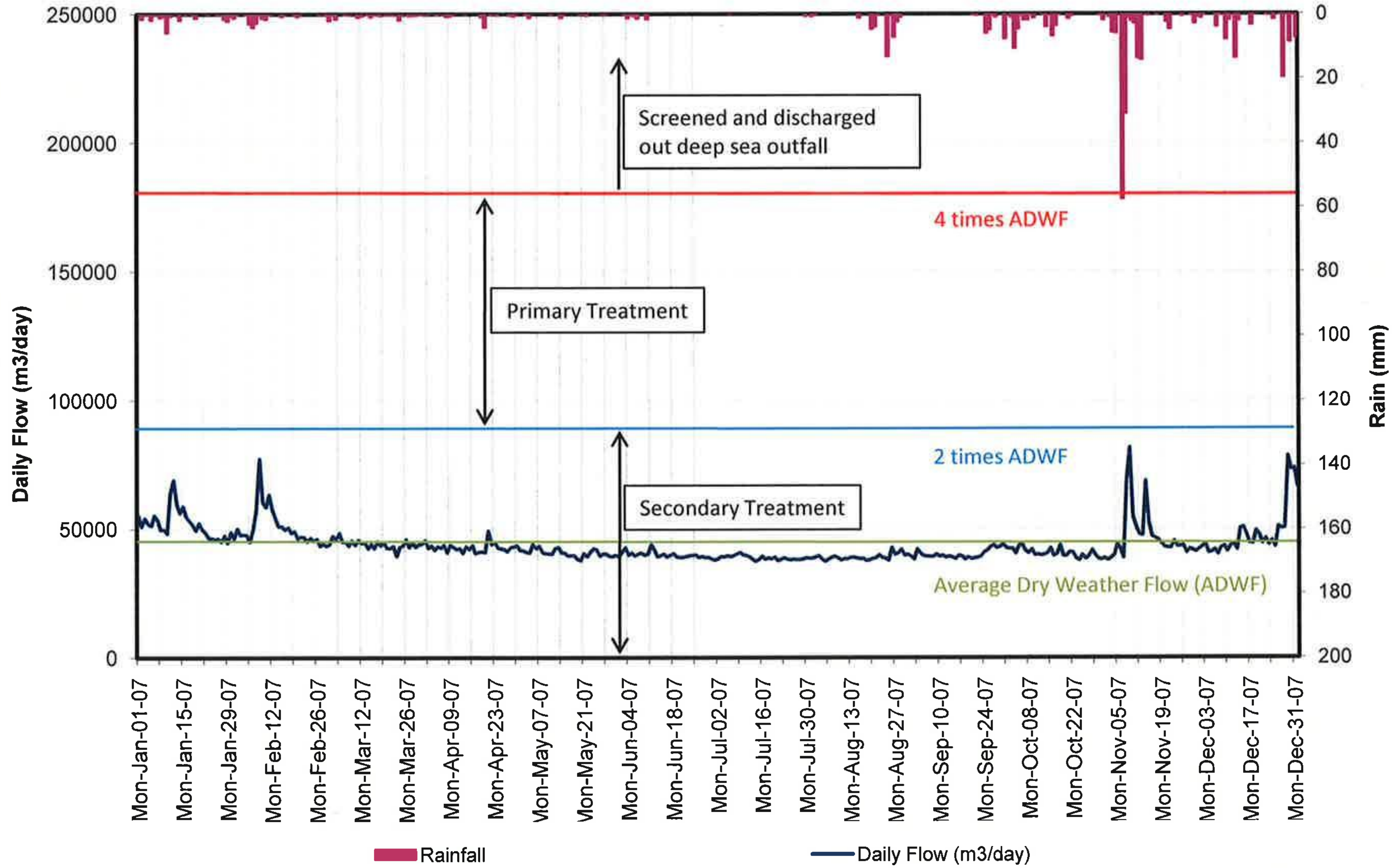


**Figure 2.2: Macaulay Pump Station Daily Flows - 2008**



Based on the data in the tables and graphs, it is apparent that the flow remains under 2xADWF for about 95-99% of the time. Therefore, based on the proposed wastewater treatment strategy, the flow would receive secondary treatment 95-99% of the time.

When the flow starts to exceed 2xADWF it is proposed that it would receive primary treatment up to 4xADWF and the effluent would be blended with the secondary effluent. It is estimated that this wet weather primary treatment plant would only be used about 90 hours (on average) for the whole year.

If the flow starts to exceed 4xADWF, which might only be for a few hours each year, it would be screened and discharged out the deep sea outfalls as has been the previously approved practice for many decades.

The data in the previous tables has occurred with the given amount of inflow and infiltration that is currently draining into the system. Given that the proposed wastewater treatment plants would be designed for secondary treatment for flows up to 2xADWF and primary treatment up to 4xADWF, it is apparent that the only way to reduce the size and capital cost of the plants would be to reduce inflow and infiltration to at least to 2xADWF.

## 3.0 COST TO REDUCE INFLOW AND INFILTRATION

To determine the cost of reducing inflow and infiltration down to where there could be some benefit in reducing the treatment plant sizes, one has to first determine what areas would need to be rehabilitated to reduce inflow and infiltration down to 4xADWF and/or 2xADWF.

A simple methodology to determine the approximate rehabilitation areas can be done as follows:

- Convert 4 and 2xADWF in to an equivalent allowable inflow and infiltration rate in litres/hectare /day.
- Compare the allowable I&I rate versus the known I&I rates determined by flow monitoring.
- Any areas that exceed the allowable I&I rate would need to be rehabilitated.

To determine the equivalent allowable I&I rates to reduce flows down to 4 and 2xADWF, the following calculation was performed.

The total ADWF for the Clover and Macaulay areas are 52,000 + 45,000 = 97,000 $m^3$/day (which equals 97,000,000 L/day). The total sewered catchment area for Clover and Macaulay are about 8,000 hectares.

Therefore, the maximum allowable I&I rate for 2xADWF would equal 97,000,000/8,000 = 12,500 L/ha/day. However, taking into account that not all catchments peak and respond at the same time, and to be conservative, it is recommended to double the rate to 25,000 L/ha/day.

This same methodology was completed for 4xADWF and is summarized in Table 3.1.

**Table 3.1 Maximum I&I Rates to Reduce Flow to 4xADWF and 2xADWF**

| | **Maximum I&I Rate (L/ha/day)** |
|---|---|
| Maximum I&I rate needed to maintain a flow of 4xADWF | 65,000 L/ha/day |
| Maximum I&I rate required to reach a flow of 2xADWF | 25,000 L/ha/day |

Note: Typical I&I design allowance for a brand new sewer is 11,200 L/ha/day.

Numerous studies now confirm that the text book design allowance of 11,200 L/ha/day is set too low. Other studies indicate that a completely rehabilitated sewer catchment on both public and private land may reduce I&I down to about 25,000 L/ha/day.

Therefore, by comparing the maximum allowable I&I rates in the above table with actual I&I rates measured over the Clover and Macaulay catchments, the rehabilitation areas were identified to maintain a flow of 4xADWF and 2xADWF,as shown in Figures 3.1 and 3.2.

It is not too surprising that the proposed rehabilitation areas coincide with the same areas of where the oldest sewer infrastructure is located.

CRD Environmental Services - Mar 11, 2009 - Technologist: SR - Map Document: Clov_Mac_Catchments_4xAvgDryWeatFlw.mxd

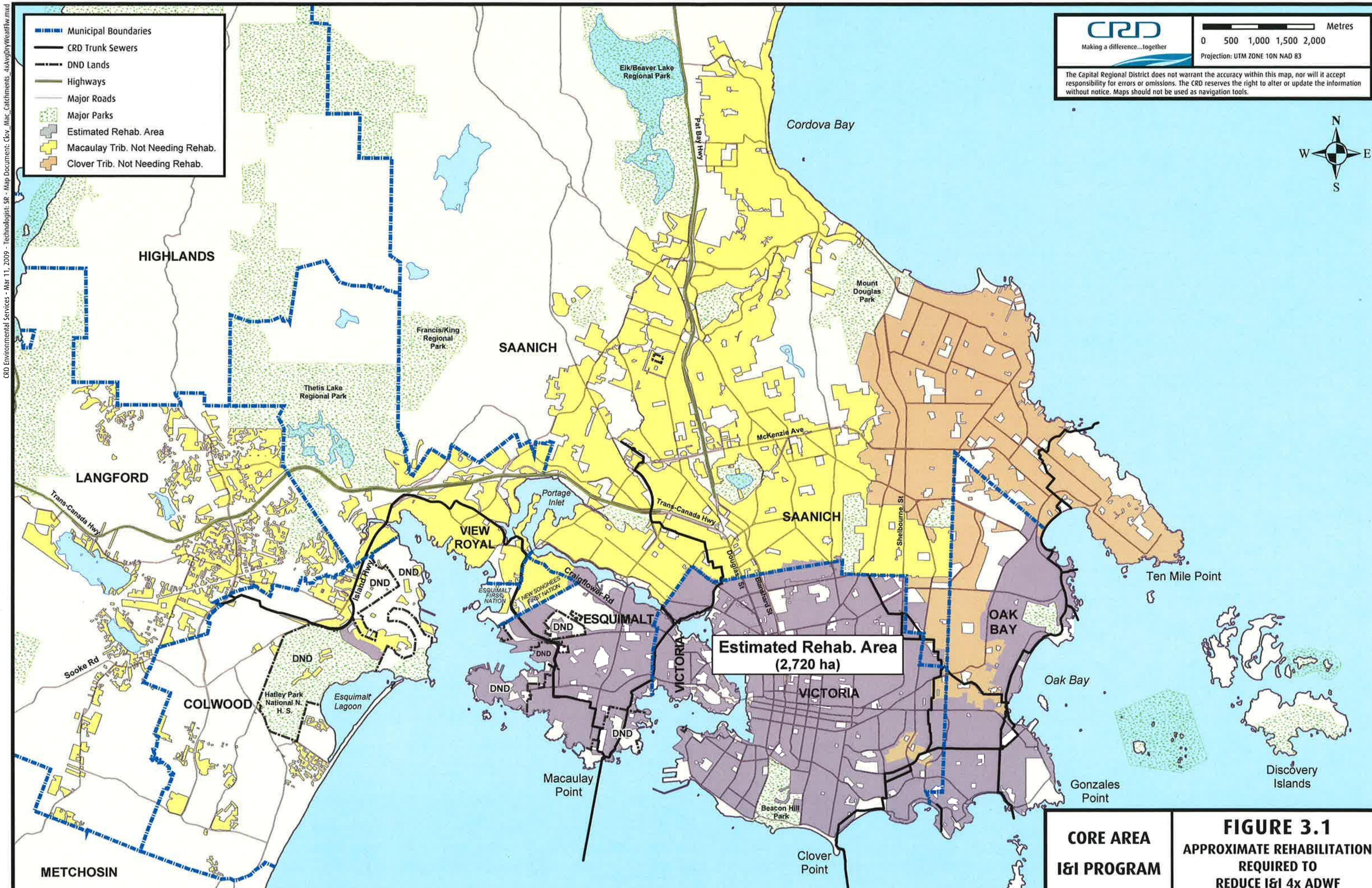
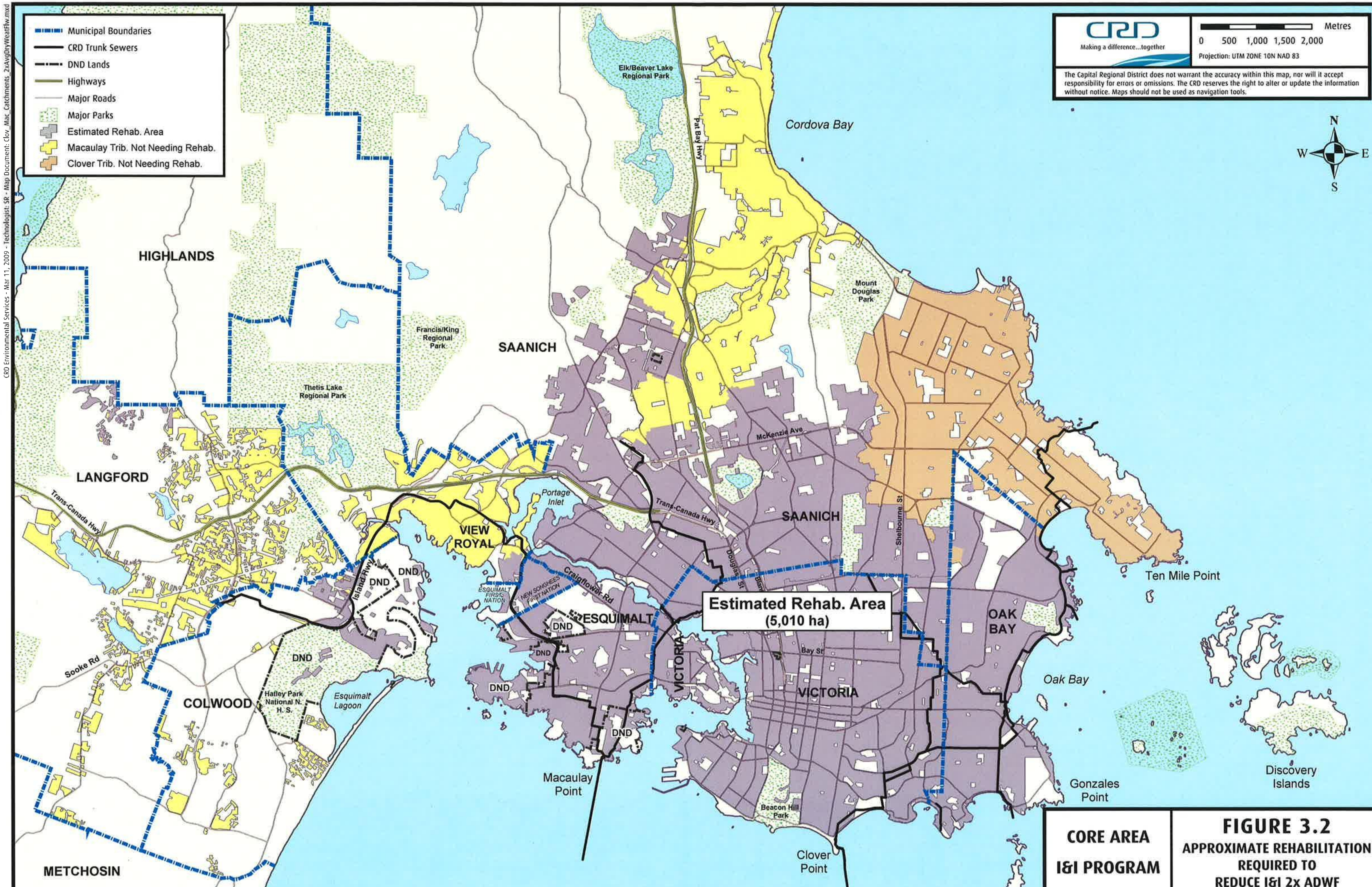



FIGURE 3.1
APPROXIMATE REHABILITATION REQUIRED TO REDUCE I&I 4x ADWF




CORE AREA I&I PROGRAM

FIGURE 3.2
APPROXIMATE REHABILITATION REQUIRED TO REDUCE I&I 2x ADWF

CRD Environmental Services - Mar 11, 2009 - Technologist: SR - Map Document: Clov_Mac_Catchments_2xAvgDryWeatFlw.mxd

Based on the actual sewer infrastructure data stored within our geographic information system, (GIS), the following quantities of infrastructure types were determined to be located within the rehabilitation areas shown in Figures 3.1 and 3.2:

**Table 3.2 Estimated Quantities of Infrastructure to be Rehabilitated**

| Infrastructure Description | Quantity located within the 2,270 ha Rehab Area (Fig. 3.1) | Quantity located within the 5,010 ha Rehab Area (Fig. 3.2) |
|---|---|---|
| Total number of manholes | 4,750 | 8,330 |
| Total number of vents (City of Victoria) | 890 | 910 |
| Total length of public collection sewers | 365 km | 685 km |
| Total number of private sewer laterals | 20,900 | 35,600 |
| Total number of private storm laterals | 20,900 | 35,600 |

The private storm laterals have been noted because in many parts of the old system, the storm sewer is higher than the sanitary sewer. This is because the storm sewer was built by enclosing ditches. As a result, many of the roof leaders and foundation drains are tied to the sanitary sewer because it is deeper, and the storm sewer is too shallow. So in addition to rehabilitating a leaky sanitary sewer, some of the private storm laterals would need to be raised (which could also require a sump pump to connect the perimeter drains).

Now that the total estimated quantities of infrastructure are known within the proposed rehabilitation areas, some initial assumptions have to be made on what percentage of the quantities would need rehabilitation and what type of rehabilitation technologies/costs would be utilized.

As previously noted, past case studies have indicated that a completely rehabilitated basin (100% of all sewer infrastructure) can reduce I&I down to about 25,000 L/ha/day. In order to not over-estimate the rehabilitation costs, initially, it shall be assumed that only 60% and 70% of the above noted infrastructure would need to be rehabilitated to meet 4xADWF and 2xADWF, respectively. Also, it is assumed that only 30% of the storm laterals would need to be corrected. A higher rehabilitation percentage of 70% is assumed for the greater I&I reduction based on the research noted above to get to an I&I rate of about 25,000 L/ha/day.

With respect to rehabilitation technologies, there are many different types each with their own merit and specific application. Some technologies include: grouting, lining, point repairs, pipe bursting, and pipe replacement. The unit rate for each of these technologies varies so an average of all options shall be used as follows:

Unit rate to rehabilitate manholes = $2,500 each

Unit rate to rehabilitate vents = $2,000 each

Unit rate to rehabilitate public sewers = $500/m

Unit rate to rehabilitate private sewer laterals = $4,500 each

Unit rate to raise and reconnect private storm laterals = $5,000 each

Based on the above noted quantities, assumptions and unit rates the following cost estimates are determined.

**Table 3.3 Cost Estimate to Rehabilitate 2,270 ha to Reduce Flow to 4xADWF**

| Item Description | Quantity | Percent Requiring Rehabilitation | Unit Rate | Total Cost (million) |
|---|---|---|---|---|
| Manholes | 4,750 no. | 60% | $2,500 | $7.13 |
| Vents | 890 no. | 60% | $2,000 | $1.07 |
| Public Sewers | 365 km | 60% | $500 | $109.50 |
| Private Sewer Laterals | 20,900 no. | 60% | $4,500 | $56.43 |
| Private Storm Laterals | 20,900 no. | 30% | $5,000 | $31.35 |
| | | | **TOTAL** | **$205.48** |

**Table 3.4 Cost Estimate to Rehabilitate 5,010 ha to Reduce Flow to 2xADWF**

| Item Description | Quantity | Percent Requiring Rehabilitation | Unit Rate | Total Cost (million) |
|---|---|---|---|---|
| Manholes | 8,330 no. | 70% | $2,500 | $14.58 |
| Vents | 910 no. | 70% | $2,000 | $1.27 |
| Public Sewers | 685 km | 70% | $500 | $239.75 |
| Private Sewer Laterals | 35,600 no. | 70% | $4,500 | $112.14 |
| Private Storm Laterals | 35,600 no. | 30% | $5,000 | $53.40 |
| | | | **TOTAL** | **$421.14** |

# 4.0 BENEFITS FROM REDUCING INFLOW AND INFILTRATION

There are a variety of potential benefits that can be realized by reducing inflow and infiltration, but unfortunately it usually takes quite some time before the benefits come to fruition. There are many possible solutions that utilities may consider using to reduce inflow and infiltration. Effective management, maintenance, operation, capacity enhancement and rehabilitation of collection system will inevitably reduce inflow and infiltration. While any single solution would prove useful under a certain set of circumstances, there is no single and universal solution that works to reduce inflow and infiltration in each catchment. Combinations of solutions are normally required to bring about the expected results.

The question has been asked - what kind of savings can be realized by reducing inflow and infiltration such that the:

- operational cost of conveyance (ie. pumping) is reduced
- size and capital cost the impending treatment plants is reduced
- operational cost of treatment and disposal can be reduced

This analysis could be quite complex and detailed, but for the purposes of this discussion paper and in relative comparison to the rehabilitation cost estimates noted in section 3, it has been somewhat simplified as follows.

## 4.1 Conveyance Benefits

With respect to conveyance, the average wet weather versus dry weather electrical cost to operate all of the Core Area pump stations was compared. The cost difference between the two is assumed to be the extra cost of pumping more wastewater due to inflow and infiltration, although an allowance has been made for increased heating costs during the wet (winter) months.

The eleven Core Area pump stations taken into consideration for this analysis includes: Clover Point, Craigflower, Currie, Harling, Hood, Humber, Lang Cove, Macaulay Point, Marigold, Penrhyn, and Rutland (Trent was not included since it is brand new and no data was available).

The average monthly wet weather versus dry weather power consumption cost for all of these stations is summarized in Table 4.1.

**Table 4.1 Wet Weather vs. Dry Weather Electrical Cost of All Core Area Pump Stations**

| Average Monthly Wet Weather Electrical Cost | Average Monthly Dry Weather Electrical Cost |
|---|---|
| $25,000 | $20,000 |

Note: An allowance was deducted off the wet weather cost for heating.

As noted above, it is assumed that the monthly cost difference between the wet weather vs dry weather electrical cost are associated with increased pumping, etc. due to inflow and infiltration.

Therefore, knowing that we typically only get 4-5 wet weather months, (November to February), the total yearly cost savings from reduced I&I and conveyance would be about $20,000.

There are also about 140 municipal pump stations located within the Core Area, but most of them are quite small in size (say 10 to 20 horsepower pumps). Therefore, the estimated power consumption for all of these smaller pump stations is approximately one half of the large CRD pump stations, so the total yearly cost savings including all the municipal conveyance would be about $30,000.

In addition to the operational benefits from reduced electricity, maintenance, etc. there is likely be some conveyance upgrades that could be deferred due to I&I reduction. Currently, as part of the proposed trunk sewer upgrades noted in Chapter 16 of the LWMP, there is about $80 million dollars of planned upgrades. It is assumed that about half of these capital upgrades would not be required if I&I was reduced to 4xADWF and the other half would not be required if I&I was reduced to 2xADWF.

### 4.2 Treatment and Disposal Benefits

With respect to the size and capital cost of the impending treatment plants, as noted in section 1.6 of this discussion paper, the proposed treatment strategy is to provide:

- secondary treatment for all flows up to 2 times ADWF,
- primary treatment for flows between 2 times and 4 times ADWF with the ability to blend the primary and secondary effluent, and
- 6-mm screening for flows that exceed 4 times ADWF.

On that basis, the sizing and capital cost of the proposed treatment plants can not be reduced any further with respect to secondary treatment unless inflow and infiltration can be reduced to less than 2 times average dry weather flow (2xAWDF), which based on research, would be very difficult to achieve using rehabilitation techniques.

However, if inflow and infiltration can be reduced down to 2xADWF, then it would be possible to eliminate the primary treatment wet weather plants. The capital cost of the proposed wet weather plants at Clover and Macaulay Points are estimated to be about $150 million.

With respect to the operational cost saving of reduced treatment, this too could not be reduced any further unless inflow and infiltration could be reduced to less than 2xADWF, but if it was reduced down to 2XADWF then the proposed operational costs of the wet weather plants could be reduced or eliminated.

Since the wet weather plants would only operate for a few days each year, the estimated cost savings from reducing or eliminating their operation would only be about $10,000 per year, maximum.

To compare the operational cost savings of reduced conveyance and treatment in 2009 dollars, it was assumed that this saving would be extended over a 30 year period using a discount rate of 3% (cost of inflation minus cost of interest).

Therefore, Table 4.3 summarizes the potential cost savings from reducing I&I to 4 times and 2 times ADWF (this includes capital cost savings as well as the net present value of operational savings).

**Table 4.3 Potential Cost Saving from Reducing I&I to 4 and 2xADWF**

| Potential Benefit Category | Cost Saving from Reducing I&I to 4xADWF | Cost Saving from Reducing I&I to 2xADWF |
|---|---|---|
| Reduced Conveyance [1] | $200,000 | $590,000 |
| Defer Planned Conveyance Upgrades | $40,000,000 | $80,000,000 |
| Eliminate Wet Weather Plants | $0 | $150,000,000 |
| Reduced Treatment and Disposal [1] | $0 | $200,000 |
| **TOTAL** | **$40,200,000** | **$230,790,000** |

Note: 1. Net Present Value of yearly saving over a 30-year period with a 3% discount rate.

Aside from the potential cost saving benefits of reducing inflow and infiltration, there are many other very tangible benefits such as: environmental, hydraulic, safety and asset management.

### 4.2 Environmental/Social Benefits

Within the Core Area, a majority of overflows and back-ups are generally caused by excessive inflow and infiltration entering the sewer system during heavy rainstorms.

Although the overflows are heavily diluted by rainwater, they still contain sewage and, thus are a concern to public health and the environment.

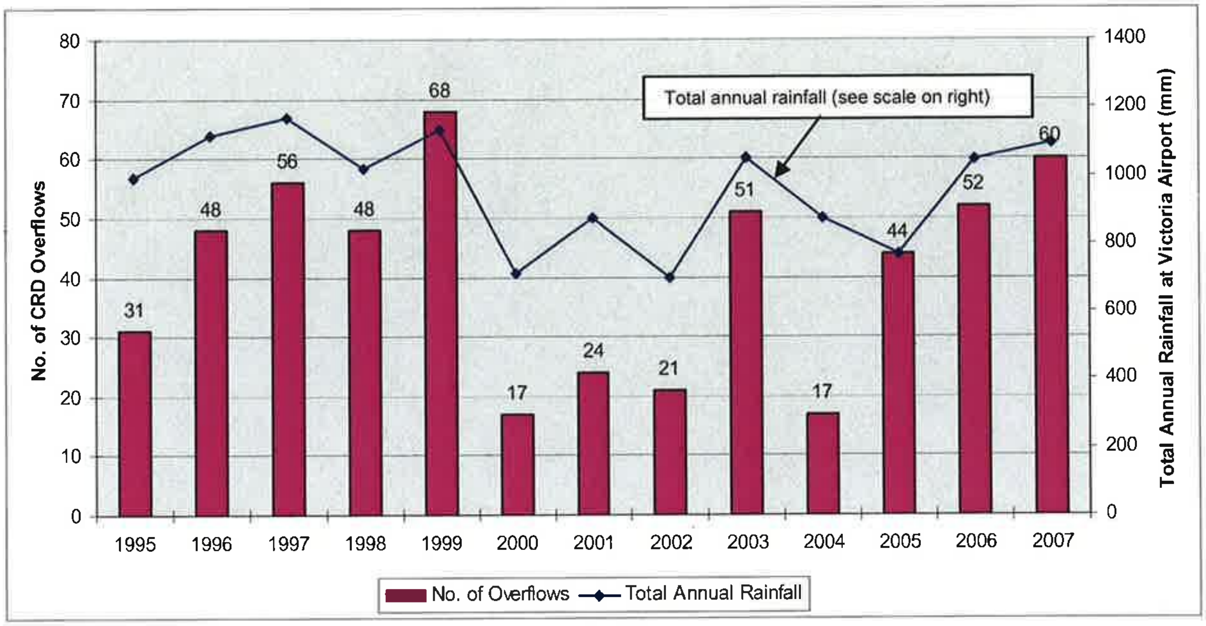
As shown in the picture, when the flow exceeds the capacity of the system it results in a sewer overflow usually at low lying areas and/or back-ups into basements, etc.

A sewer overflow from a surcharging manhole.

Consequently, receiving environments are adversely affected and back-ups can result in extensive decontamination measures and compensation claims not to mention the emotional impact of destroyed personal affects.

As expected, most capacity-related overflows are generally wet-weather related events. This relationship is shown graphically on Figure 4.1 by plotting the number of overflows from the CRD facilities versus the total annual rainfall recorded at Victoria International Airport (AES Rain Gauge) from 1995 to 2007.

**Figure 4.1 Graphical Comparison of Rainfall vs. Number of Overflows**




As can been in Figure 4.1, the number of overflows rise and fall in relation to the amount of rainfall that had fallen for the year. Significant improvements to CRD sewerage collection facilities started in 2003 which could account for the overflow decrease in 2004. The subsequent rise in overflows from 2005 to 2007, aside from the increased rainfall, was primarily due to the northeast trunk-Bowker sewer overflow at Monterey Avenue. This sewer was transferred to the CRD in 2003 and monitoring equipment was installed in 2005 (prior to that the overflows were not monitored). The construction of Trent pump station in 2008 has now eliminated potential overflows at Monterey for up to a 5-year storm event.

Fortunately, due to the design of the original trunk sewer system, most of the CRD overflow points are located at relatively low impact areas and discharge out well beyond the foreshore coast line.

Even so, work still needs to be undertaken, (particularly in regards to reducing inflow and infiltration), to meet the overflow regulations as specified in the Municipal Sewage Regulation which is to reduce and eventually eliminate sanitary sewer overflows that occur during 5-year storm events.

The CRD and all of its municipal partners have made long-term commitments to reduce the frequency and quantity of overflows to meet the regulations by reducing their inflow and infiltration.

### 4.3 Hydraulic Benefits

Design criteria for sewer systems and treatment plants usually include flow allowance for growth and expansion. Without I&I control, sewage collection and treatment facilities may require premature and costly upgrades to meet the hydraulic loads.

Conversely, I&I that is controlled and/or reduced will free up peak flow capacity and extend the design life of conveyance and treatment facilities. This in-turn provides additional financial social benefits of not having to expand the facilities until when they are actually needed.

### 4.4 Safety Benefits

As previously noted, basement and street flooding can present a serious health risk. Furthermore, contamination of water courses, beaches and shorelines can also pose health hazards to the public and natural environment.

Structural defects in the sewer system can be the source of excessive inflow and infiltration. Continued deterioration can lead to the surrounding pipe soil to be washed into the pipe which, in turn, can lead to pipe blockages, voids, sewer collapses and sinkholes. Voids and/or sinkholes can cause serious damage to adjacent infrastructure such as watermains, hydro, gas lines and road structures. Such damage is not only costly, but highly dangerous to the public.

### 4.5 Asset Management Benefits

Much of the infrastructure installed in older parts or the Core Area are about 80 to 100 years old, so many of the sewers need to be rehabilitated or they will eventually fail.

Therefore, as has been the practice of most major cities throughout North America, a capital rehabilitation fund of 1% has been established to reduce the average age of sewer infrastructure to about 50 years.

This kind of asset investment will ensure that the system will be well maintained and to keep inflow and infiltration from escalating out of control.

## 5.0 PRELIMINARY CONCLUSIONS

Inflow and infiltration is unavoidable and must be accounted for in routine sewer and treatment plant design. It has been shown through previous studies that I&I typically increases with time as the sewer system ages and decays. Due to the average age of the existing Core Area infrastructure, inflow and infiltration is quire high (in the order of 4-8 times the average dry weather flow).

However, due to the wastewater treatment strategy of,

- secondary treatment for all flows up to 2 times ADWF,
- primary treatment for flows between 2 times and 4 times ADWF, and
- 6-mm screening for flows that exceed 4 times ADWF,

it is unlikely that reduced I&I flows will result in making the new treatment plants smaller or less expensive. This is due to the fact that the actual flows (as measured at Clover and Macaulay Point pump stations) are below 2xADWF 95-99% of the time. The only real potential cost saving would be to reduce the flow down to a maximum of 2xADWF so that the wet weather, primary treatment facilities would not be required.

Rehabilitation to reduce I&I in the Core Area does not appear cost effective based on capital costs, or even present worth of operational costs.

However, there are other motivations/requirements that justify investing in I&I rehabilitation as follows:

**Environmental/Social** – Receiving environments are adversely affected by sanitary sewer overflows and basement back-ups can result in extensive decontamination measures and compensation claims. Overflow requirements dictate that I&I must be reduced, over the long-term, to meet the Municipal Sewage Regulation.

**Hydraulic** - Reduction in peak flows will free up peak flow capacity for future growth and may extend the design life of conveyance and treatment facilities.

**Safety** – Reduced overflows and back ups limit the risk of being exposed to raw sewage and addressing structural defects in deteriorated sewers can prevent sinkholes and/or serious damage to adjacent infrastructure.

**Asset Management** - Old infrastructure that is decaying and needs to be rehabilitated anyways. Annual investment into the maintenance of infrastructure assets will ensure that the system is maintained and prevent I&I from escalating out of control.

Table 5.1 below summarizes the cost versus benefit to reduce inflow and infiltration to 4 times and 2 times average dry weather flow, including the other benefits as noted.

**Table 5.1 Cost vs. Benefit Summary from Reducing I&I to 4 and 2xADWF**

| **Cost vs. Savings** | | **Reduce I&I to 4xADWF (million)** | **Reduce I&I to 2xADWF (million)** |
|---|---|---|---|
| Cost to Reduce I&I | | $205.48 | $421.14 |
| Savings from Reduced I&I [1] | | ($40.20) | ($230.79) |
| **Net Cost Difference** | | **$165.28** | **$190.35** |
| Annual cost over 100 years [2] | | $2.05 | $4.21 |
| **Other Benefits** | | | |
| **Reduction in Annual Overflows** | | | |
| Current avg. no. of overflows per year | **60** | **5** | **0** |
| **Reduction in Average Age of Infrastructure** | | | |
| Current avg. age | **75** | **50** | **40** |

Note: 1. The savings are a combination of capital cost savings plus the net present value of operational savings over a 30-year period with a 3% discount rate.

2. The annual cost assumes that if $2.05 to $4.21 million were spent over 100 years then we would eventually reduce I&I over time to meet the LWMP and Municipal Sewage Regulation requirements. This level of expenditure is currently being spent within the Core Area.

The net cost difference noted in Table 5.1 is over and above the treatment plant capital cost. For example, (assuming that the capital cost of treatment is $1.2 billion), then the cost to implement treatment and reduce I&I to 4xADWF would be $1,200 million plus $165 million for a total of $1,365 million.

This analysis concurs with past recommendations, that I&I programs are effective when implemented in a holistic manner. That is to determine which areas have chronic overflow locations, critical sewers, old sewers, high I&I rates, and can be planned concurrently with other infrastructure upgrades (ie. roads, storm sewers, watermains, etc.). When those areas have been identified and prioritized for I&I rehabilitation then multiple cost-effective benefits can be achieved at the same time while working towards the long-term goal of I&I reduction.

**CAPITAL REGIONAL DISTRICT**
**CORE AREA LIQUID WASTE MANAGEMENT PLAN**

# CHAPTER 8

# MANAGEMENT OF INFLOW AND INFILTRATION

## GOAL

The goal of the program is to reduce inflow and infiltration to levels that minimize total conveyance, treatment and disposal system costs, coincident with reduction of I&I induced overflows to acceptable levels.

## COMMITMENTS

The **Capital Regional District** and the **participating municipalities** commit:

- to develop implementation plans for staged reduction of inflow and infiltration over the 25-year life of the Liquid Waste Management Plan
- to recommend to future councils that they commit funds for I&I reduction that are economically justified by avoidance of future costs to treat and convey inflow and infiltration
- to measure flows before and after carrying out work on sewers to reduce I&I, to document I&I expenditures and achievements, and to use this information to refine cost benefit curves developed to optimize expenditures

Subject to approval of this Liquid Waste Management Plan by the minister of environment, lands and parks, the **Capital Regional District** commits to undertake a four year program to accelerate the identification of priority areas and projects, including expanded flow monitoring, development of sewer models and preparation of cost estimates, at an additional annual cost of approximately $290,000.

## BACKGROUND

I&I affects the sizing of wastewater conveyance, treatment and disposal facilities. Significant levels of I&I can have a significant effect on the cost of those facilities. As the cost of I&I reduction may also be substantial it is prudent to plan for facilities which will minimize total expenditures, prior to embarking on design and construction of major wastewater facilities.

The CRD and municipalities began working to prepare an I&I reduction program in 1993 when a subcommittee was established to coordinate work on the program. In 1994, the CRD began research of available data and I&I reduction methods, costs, and success rates in other jurisdictions. The CRD and municipalities also undertook municipal and regional programs to determine the sources and amount of inflow and infiltration in specific systems. Based on the information generated from research and pilot studies, detailed cost-benefit curves will be completed in 2001 and used in developing the implementation plan.

## STRATEGY AND SCHEDULE FOR INFLOW AND INFILTRATION REDUCTION

### 1. Set up and organize I&I subcommittee (Established in 1993)

- membership from CRD and municipalities
- CRD coordinates, convenes meetings, assembles and distributes information

### 2. Collect and review existing information; fill information gaps (Ongoing)

- make an inventory of existing systems including key components (pump stations, flow meters)
- collect available information (reports, flow records, design data, anecdotal information, population figures) required to determine flows and I&I in sewerage reaches
- pool information and identify inconsistencies
- identify sewer reaches where additional information is required to define system capacity, flows, and the extent of I&I
- develop an action plan and methodology to obtain information
- complete information gathering
- develop a study methodology for I&I identification, analysis and reduction efforts
- determine flow capacity of sewers
- determine flow and the extent of I&I at key points, where possible, and identify information gaps
- document current programs
- undertake pilot studies to define problems and characterize the extent and type of I&I
- review I&I reduction methodology (part of information being developed for I&I subcommittee)
- refine study methodology based on results of pilot studies
- determine frequency and location of I&I related overflows
- document expenditures on I&I, measure flows before and after making improvements that reduce I&I in order to document achievements, and use this information to refine cost benefit curves developed to optimize expenditures
- conduct reviews at five-year intervals

### 3. Develop implementation plans area by area (1999 - 2025)

- determine priority areas and target levels for I&I reduction based on acceptable frequency of I&I related overflows, apparent opportunities for reduction of I&I and priortization of cost-effective reduction of I&I sources
- review existing information on condition of sewers in priority areas, including maintenance records
- survey physical condition of sewers in priority areas where required to supplement existing information
- estimate costs for I&I reduction in priority areas, relate cost to degree of reduction
- incorporate information obtained on known costs of local I&I reduction programs undertaken to date
- incorporate information obtained on system conveyance and treatment costs from other programs
- redefine priorities, taking into account acceptable frequency of overflows and minimization of total system costs (including new treatment and conveyance costs)
- continue to document expenditures on I&I, to measure flows before and after making improvements that reduce I&I in order to document achievements, and to use this information to refine cost benefit curves developed to optimize expenditures
- create implementation plan

**4. Implement and monitor for effectiveness** **(2002 - 2025)**

- municipalities for collection systems
- Capital Regional District for trunks

## STRATEGY TO DETERMINE APPROPRIATE EXPENDITURE ON I&I

### Comments

The strategy for reduction or elimination of overflows may impact the balance between expenditures on I&I reduction and on new conveyance and treatment facilities. It will be necessary to determine whether the point of optimum expenditure provides sufficient attenuation of flows to achieve the strategy for reduction and elimination of overflows. A shift to the additional expenditure for reduction of inflow and infiltration may be required.

### Strategy

1. Determine sources and amounts of inflow and infiltration, categorize by type.
2. Determine extent of work required to reduce I&I by various degrees.
3. Determine cost of work to reduce I&I; determine relationship between I&I reduction and cost.
4. Estimate cost of conveyance, treatment and disposal facilities, including operating costs, for various degrees of I&I reduction, using life-cycle costs.
5. Determine relationship between I&I reduction and cost of facilities to transport and treat wastewater.
6. Determine point of minimum total cost.
7. Document expenditures on I&I, measure flows before and after making improvements that reduce I&I in order to document achievements, and use this information to refine cost benefit curves developed to optimize expenditures.
8. Consider cost sharing arrangements with senior governments and evaluate whether these would shift the optimum design value based on cost to CRD taxpayers.
9. If selection of the optimum cost point results in unacceptable overflows, determine the additional cost to comply with the policy for reduction or elimination of overflows in this document.
10. Select the appropriate balance between expenditures on I&I reduction and on conveyance and treatment facilities. If there is a significant difference between the optimum cost point and the costs determined by item 9, enter into negotiations with the province to reach agreement on an appropriate course of action.

## IMPACT OF OTHER PROGRAMS

A number of programs have been initiated by the Capital Regional District, aimed at determining system capacities, impacts of existing system overflows and options for sewage treatment. The results of these studies will be used to finalize the cost-benefit analysis for I&I reduction and to establish a reduction strategy. The programs of interest are as follows:

1. Northwest Trunk Sewer (NWT) options study;
2. NWT overflow environmental evaluation
3. Clover and Macaulay Point treatment options study
4. East Coast Interceptor / Northeast Trunk Sewer (ECI/NET) flow estimates
5. ECI overflow environmental evaluation

## MUNICIPAL PROGRAMS

During the period of plan development, individual municipal programs have been identified and funded. Work on some of these programs is scheduled for completion in year 2000; others are ongoing. It is anticipated that the overall I&I reduction strategy will identify a continuing requirement for municipalities to conduct investigation and rehabilitation programs to meet local individual needs. Such programs may shift the emphasis away from priority areas identified within the plan.

Examples of municipal programs undertaken or currently underway are as follows:

1. City of Victoria evaluation programs (Hollywood, Haultain and Raynor areas);
2. Township of Esquimalt evaluation and rehabilitation program (Grafton area);
3. Township of Esquimalt township-wide evaluation and rehabilitation program;
4. Distinct of Saanich evaluation program (Dysart area);
5. Town of View Royal I&I evaluations; and
6. District of Oak Bay evaluation and rehabilitation program.

Complete details of the current municipal level of effort for these programs will be included in the I&I implementation plan.

MAR 26 2003

BRITISH COLUMBIA

CRD ADMINISTRATION

MAR 27 2003

RECEIVED

2010 VANCOUVER

Reference: 65246

Judy Brownoff, Chair, and Directors
Capital Regional District
PO Box 1000, 524 Yates St
Victoria BC V8W 2S6

Dear Ms Brownoff and Directors:

I have made a decision on your Core Area Liquid Waste Management Plan (LWMP), based on a review of all the information that you have presented, a report received from an independent consultant, and review by ministry staff of the LWMP and supporting information.

I am satisfied that there has been adequate public review and consultation during stage three of the plan development. I commend you for the commitments in the plan to pursue liquid waste management programs dealing with source control, inflow and infiltration reduction, storm water quality management, management of trucked liquid wastes and the management of on-site systems. I fully support the enhanced programs proposed in the LWMP.

The LWMP does not provide a plan and schedule for provision of primary and secondary treatment for the discharges at Macaulay Point and Clover Point, which is contrary to the direction provided to you by past ministers. However, I am satisfied that a trigger process can be used in lieu of a firm schedule to provide treatment as long as the trigger process results in the provision of treatment within three years of a trigger point being reached. I understand that the Capital Regional District (CRD) and ministry staff are preparing a revised trigger point for sediment and the benthic community which will be complete in three months. There is also agreement to expand the trigger point to the water column and the water surface. This work is to be completed in the next two years. In order for you to establish a treatment plant within three years of being triggered, you will have to carry out pilot testing of the proposed treatment technology and acquire a site for sludge processing as soon as possible. Approval of the plan is on the basis that these activities are commenced immediately.

While your commitment to carry out an extensive marine monitoring program is commendable, I am not satisfied that the existing monitoring program will be effective in detecting all potential impacts. A rigorous regime of receiving environment investigation, beyond that proposed in the plan needs to be pursued. .../2

In accordance with Section 18 (7) of the *Waste Management Act,* I hereby approve the Capital Regional District Core Area Liquid Waste Management Plan, dated July 12, 2000, This approval is made with the following conditions, that the CRD shall:

1. On or before June 30, 2003 continue the Marine Monitoring Advisory Group with invited membership from Environment Canada, Ministry of Water, Land and Air Protection, Fisheries and Oceans Canada, University of Victoria, Royal Roads University and Camosun College. The terms of reference for the group are to review, on an annual schedule, all environmental monitoring programs and provide recommendations for improving the programs. The group will also review all data and reports associated with the environmental monitoring including the programs identified below, and will prepare their own report. The report, for the preceding year, shall be submitted to the CRD and the Regional Environmental Protection Manager (manager), Vancouver Island Region by June 30 of each year with the first report due by June 30, 2004.

   The environmental monitoring programs shall include a field program to study endocrine disrupting chemicals, persistent organic pollutants and other micro-contaminants such as pharmaceutical drugs found in CRD liquid waste, and their potential environmental impacts. This should include, but is not limited to effluent characterization to identify and quantify the contaminants and biological assays using new techniques such as gene chip arrays to determine their sub-lethal impacts. This program must be started by March 31, 2004. The CRD is encouraged to work with the Greater Vancouver Regional District LWMP Environmental Monitoring Committee to develop compatible partnership programs.

   The environmental monitoring program must include a field program to assess sediment transport mechanisms at the Macaulay Point and Clover Point outfalls to determine the fate of the sediments being discharged into the environment. The Marine Monitoring Advisory Group is to recommend the time frame for implementing this project. The results of the assessment shall be submitted to the manager on or before December 31, 2008 unless required sooner as determined by the Marine Monitoring Advisory Group.

   Within three months of receipt of the Marine Monitoring Advisory Group's annual report, the CRD shall develop an implementation action plan to address the reports recommendations, with firm schedules and submit it to the manager.

2. Revise and expand the trigger process, with input from the Marine Monitoring Advisory Group, to set trigger points that will result in the provision of primary (or equivalent) treatment within three years of a trigger point being reached. The process shall be expanded to include surface water and water column triggers. Revisions to the process shall be developed in conjunction with, and be acceptable to, ministry staff. The trigger

levels shall, in part, reflect the requirements of the Waste Management Act Municipal Sewage Regulation which requires that discharges do not or will not cause water quality parameters outside the initial dilution zone to exceed water quality guidelines.

3. Immediately commence the pilot testing of treatment technology that will provide primary or equivalent treatment for the removal of suspended solids consistent with the Municipal Sewage Regulation.
4. Immediately commence the process to acquire a site for the processing of sludge from future treatment works at Macauley and Clover Points. There shall be adequate public consultation during the selection of the site.
5. On or before June 30, 2003, provide me with a revised trigger process for sediment and benthic monitoring.
6. On or before March 31, 2005, provide me with a trigger process for surface water and water column monitoring.
7. On or before March 31, 2005, provide me with the following:
   - a progress report that details the actions taken toward securing a sludge processing site, including the documentation of the results of public consultation on site selection:
   - a sludge management plan, and
   - the results of pilot testing of treatment technology.
8. On or before March 31, 2004, in consultation with ministry staff, develop a plan amendment process for minor and major amendments. Include provisions for public consultation for major amendments.
9. Provide an opportunity for the public to have meaningful input into the implementation of the plan. On or before March 31, 2006 and, thereafter; every five years, a report shall be prepared that provides the results of an independent audit on the commitments contained in the plan. Within two months of the publication of the audit report, the CRD shall notify the public of the existence of the report and receive comments and submissions from the public. The CRD shall forward a copy of the audit report and copies of any submissions from the public to the manager.
10. On or before March 31, 2008, develop a short term schedule and estimate of cost for the elimination of sanitary sewer overflows within the CRD to be consistent with the Municipal Sewage Regulation.
11. On or before March 31, 2008, complete cost/benefit studies and an implementation schedule directed at the elimination of combined sewers in Oak Bay to be consistent with the Municipal Sewage Regulation.
12. On or before March 31, 2013, review the need to acquire additional land for the provision of secondary treatment. The review shall include but not be limited to the findings of the Marine Monitoring Advisory Group, and the results of the public consultation process.

I have the following comments corresponding to the specific sections of the plan:

- Chapter 7, Source Control: This important component of the waste reduction strategy is acknowledged and supported. The annual report on the program achievements should be provided to the manager.
- Chapter 8, Inflow and Infiltration: The commitment to a four year program to accelerate the identification of priority areas and projects is acknowledged and supported. In the absence of a specific schedule for the implementation plans, the CRD shall provide the manager with a report every two years that provides details of the measures taken in the preceding two years to reduce inflow and infiltration.
- Chapter 10, Storm Water Quality Management: The LWMP recognizes the impact of non-point source pollution in the plan area and provides an ongoing course of action to address this issue. The five-year report on program achievements and changes shall be submitted to the manager. For your reference, the ministry has established a website that contains guidelines for storm water management. The website address is http://wlapwww.gov.bc.ca/epd/epdpa/mpp/stormwater/stormwater.html.
- Draft operational certificates: the operational certificates for the Macaulay Point and Clover Point discharges shall be reworded to delete the authorization of overflows (overflows at the treatment facility and combined/sanitary sewer overflows), which are reportable spills under the Spill Reporting Regulation.

Approval of this LWMP does not authorize entry upon, crossing over, or use for any purpose of private or Crown lands or works, unless and except as authorized by the owner of such lands or works. The responsibility for obtaining such authority shall rest with the local government. This LWMP is approved pursuant to the provisions of the *Waste Management Act* which makes it an offence to discharge waste without proper authorization. It is also the regional district's responsibility to ensure that all activities conducted under this LWMP are carried out with regard to the rights of third parties and comply with other applicable legislation that may be in force.

Please work with ministry staff in Nanaimo in the implementation of your plan and the above conditions.

Best regards,

Joyce Murray
Minister