KERR WOOD LEIDAL
consulting engineers

Section 5

Inflow and Infiltration

5. Inflow and Infiltration

This section describes I&I components, and presents how the area-based I&I rates are developed. I&I characterization through a hydrological modeling exercise and discussion of the results is also presented.

I&I represents the ground and stormwater that invariably shows up in sanitary sewer systems. Studies have shown that older systems typically have greater amounts of I&I compared with newer systems. Additionally, studies have shown that the rate of I&I will increase with time if efforts are not made to reduce or prevent I&I.

5.1 Flow and Rainfall Data

5.1.1 The City's Pump Stations

The City's pump station influent flow data, which was converted from the pump stations' SCADA records, was provided for I&I analysis and model loading development. The flow data period is from November, 2010 to November 2011 for each sewer pump station except the Belmont PS for which only Jun, 2011 to January, 2012 is available. The provided data is considered consistent with the existing development conditions and the 2011 Census population.

The flow data was reviewed and analysed to determine catchment flow characteristics. The provided flow data was in 1-hour time step for most of the pump stations except for the Belmont PS, where 5-minute flow data was provided. Though using the hourly flow data will lose some level of accuracy when developing peak 1-hour rainfall dependent I&I, it is still considered acceptable in development of I&I using the I&I envelope method.

5.1.2 Major Property Pump Station

Flow data was provided by the CRD for some of the major property pump stations including Juan de Fuca, Royal Roads University, DND Belmont, and F Jetty (DND Colwood) pump stations. The data was converted from the pump's start / stop records and pumping rate based on draw-down tests conducted in earlier years (2004 – 2006). Only the DND Belmont PS was provided with pump station influent flow data (1-hour time step), while the rest were provided with pumped flow only (5-minute time step). Therefore I&I analysis was carried out for DND Belmont only.

5.1.3 Rainfall Data

The University of Victoria School-Based Weather Station Network operates a rain gauge at Wishart School for research purposes. The rainfall data collected at this rain gauge was used to analyse how the sewer system responds to storm events.

For DND Belmont I&I analysis, rainfall data collected at the nearby Langford Municipal Hall rain gauge was used instead, as the Wishart rain data period does not overlap the flow data period.

Rainfall Intensity-Duration-Frequency data (IDF) was previously derived from the Langford Municipal Hall rain gauge based on historical rainfall data. The return period rainfall amounts (mm) are summarized in Table 5-1 below.

Table 5-1: Langford Municipal Hall Rainfall Statistics (mm)

Return Period	1 hour Total	2 hour Total	6 hour Total	12 hour Total	24 hour Total
2 year	10.2	15.8	29.4	46.8	64.8
5 year	12.5	19.4	39	60	91.2
10 year	14.8	21.8	46.8	68.4	110.4
25 year	17.0	25.4	55.2	81.6	129.6
50 year	17.7	27.6	57.6	88.8	141.6

5.2 Development of I&I Rates

5.2.1 Basic Definitions

For the purposes of this analysis, I&I is categorized in the following standard definitions, adopted from the Metro Vancouver's I&I Task Force report, "I&I Detection: The First Step" (August 1993).

Groundwater Infiltration (GWI)
Groundwater Infiltration (GWI) is typically regarded as infiltration not directly influenced by a particular rainfall event, but more long-term, seasonal rainfall patterns. As noted in the GVRD report: "GWI results from the movement of groundwater in the saturated zone into the sewer system through defects in the components of the sewer system located below the water table".

Stormwater Inflow (SWI)
The Stormwater Inflow (SWI) is generated by rainwater entering the sanitary collection system through "direct connection" such as roof leaders and catch basins and surface runoff entering through manhole lids.

Rainfall Induced Infiltration (RII)
Rainfall induced infiltration (RII) is the entry of extraneous water into the sewer system indirectly through the ground. Typically, the soil must be completely saturated in order for RII to fully occur. RII enters the system once the water level in the service connection and mainline trenches reaches the level of defects in the system. The effects of this type of infiltration do not show up immediately at a downstream flow monitor, but rather over a number of days. In many cases the effects of the infiltration are still measurable days after a storm event.

Rainfall-Dependent Inflow and Infiltration (RDI&I)
RDI&I is the sum of the SWI and RII (i.e. it does not distinguish between the two mechanisms, but shows in the data as the extra flow that occurs during a storm event).

Total I&I
By adding the GWI to the RDI&I, the total I&I is determined.

5.2.2 Return Period and Duration

As expected, I&I rates increase as the precipitation intensity increases. The CRD's LWMP[5] states the following:

> *In accordance with the policy for overflow to receiving environments, the Capital Regional District policy is to design new or replacement trunk sewer for the flows generated by a storm with a return period of 100 years in areas where there is a potential for a wastewater spill to an area of high sensitivity. This policy was applied to the design of new trunk sewer extending into Colwood and Langford and was adopted for planned upgrades to the northwest trunk (NWT) sewer.*
>
> *In the NWT, every overflow point upstream of the Macaulay pump station, with the exception of the Sea Terrace storm drain in West Bay, discharges to a highly sensitive location.*

Therefore, to be consistent with the CRD's LWMP, the design criteria (proposed infrastructure) will be for the 100-year return period I&I event.

The CRD's LWMP goes on to say the following regarding triggers for upgrades of existing portions of the NWT:

> *No section of the trunk meets the proposed design standard, but it was judged impractical to upgrade sewers that are in good condition based solely on that criterion. The concept of a trigger return period was conceived to determine when section of the trunk should be replaced. A trigger return period was determined for each a section of the NWT based on the consequences of a spill, i.e. spills to some locations further upstream in the system were determined to have more serious consequences than spills to other downstream locations. Applying this philosophy, a section of pipe will be upgraded when predicted flows will trigger a spill more frequently than the trigger return period for that section.*

The CRD's LWMP then provides an application of this philosophy including a table of overflow locations and trigger return periods. This table includes Gorge Waterway – 10 year return period, Cecelia Creek – 25 year return period, and Colquitz Creek – 100 year return period. The table does not provide information for any of the watercourses in Colwood.

Overflow from the existing Colwood sewer system would most likely discharge to either Colwood Creek or Bee Creek, both of which discharge to Esquimalt Lagoon. In reviewing information available from the CRD regarding fish presence[6] both Colwood Creek and Colquitz Creek have points of known fish presence, while both Bee Creek and Cecelia Creek do not. This indicates that the existing infrastructure within the Colwood Creek watershed should be able to convey (without overflow) the 100-year return period event and within the Bee Creek watershed the infrastructure should be able to convey the 25-year return period event. To simplify the analysis we have selected the 100-year event for all of the City (this is conservative in the Bee Creek watershed).

Therefore, to be consistent with the CRD's LWMP, the existing infrastructure evaluation criteria will be for the 100-year return period I&I event (same as the design criteria for proposed infrastructure).

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[5] Core Area Liquid Waste Management Plan, July 12, 2000, Capital Regional District, Environmental Services Department

[6] CRD Regional Community Atlas, Natural Areas Atlas > Fish Presence (layer), http://viewer.crdatlas.ca/public#/Home (February 15, 2012)

5.2.3 I&I Analysis Procedure

In order to develop the I&I rates, the following process is followed:

- determine an estimate of the GWI for each catchment during the winter;
- use the RDI&I envelope method in order to make estimates of the RDI&I rates for each site; and
- combine the RDI&I and GWI for each site into total I&I rates.

This report uses a graphical method based on a summary of rainfall and sewer flow events taken from the flow monitoring period. By plotting these results, the relationship between rainfall and RDI&I can be developed. It is then possible to develop 'return-period' design values for RDI&I, based on the rainfall analysis. KWL refers to this specific methodology as the RDI&I Envelope. The RDI&I envelopes for the pump station catchments are presented in Appendix B.

5.3 Calculation of Total I&I Rates

Inflow & infiltration (I&I) loads are modelled as area-based loads representing the additional loading on the sanitary sewer system during wet weather. The I&I rate is calculated by dividing the total I&I flow by the gross area of the contributing catchment. Figure 5-1 illustrates the delineated sub-catchments for calculating I&I rates. Table 5-2 below summarizes I&I for each of the pump station sub-catchments.

Table 5-2: Sub-Catchment I&I Rates

Item	Catchment Name								
	Pelican	Metchosin (less Pelican)	Ocean Blvd	Ports-mouth	Wilfert	DND Belmont	Bel-mont	Hatley	Se-well
5-yr 24-hr RDII (L/s)	1.9	2.4	1.7	0.7	2.3	28.0	-	-	-
5-yr Peak 1-hr RDII (L/s)	2.9	4.5	2.6	1.4	4.2	59.4	-	-	-
25-yr Peak 1-hr RDII (L/s)	3.8	6.0	3.5	1.9	6.0	84.3	-	-	-
GWI (L/s)	0.04	0.2	0.2	0.1	0.4	2.4	0.07	0.02	-
5-yr 24-hr I&I (L/s)	2.0	2.6	1.9	0.8	2.7	30.5	-	-	-
5-yr Peak 1-hr I&I (L/s)	2.9	4.7	2.8	1.4	4.6	61.8	-	-	-
25-yr Peak 1-hr I&I (L/s)	3.9	6.3	3.7	2.0	6.3	86.8	-	-	-
Catchment Area (ha)	15.5	32.6	36.7	8.6	21.4	47.9	5.7	5.5	1.7
GWI Rate (L/ha/day)	200	600	500	500	1,400	4,400	1,000	300	-
5-yr 24-hr I&I Rate (L/ha/day)	11,000	6,900	4,500	7,900	10,700	55,300	-	-	-
5-yr Peak 1-hr I&I Rate (L/ha/day)	16,200	12,400	6,700	14,400	18,500	112,200	-	-	-
25-yr Peak 1-hr I&I Rate (L/ha/day)	21,400	16,600	8,600	19,800	25,500	157,500	-	-	-
100-yr Peak 1-hr I&I Rate (L/ha/day)	24,900	19,400	9,900	23,100	30,000	187,700			
Notes: - Development of I&I rates for Belmont, Hatley, and Sewell PS catchments is not successful in this assignment - All DND lands use I&I rates from DND Belmont									

The weighted average (weighted based on catchment area) of the I&I rates for the Pelican, Metchosin, Ocean Boulevard, Portsmouth and Wilfert Pump Stations is 19,400 L/ha/day for the 100-year peak 1-hr I&I rate. This compares well with past analysis work KWL has completed for the CRD which calculated the 100-year I&I rate at the Aldeane meter to be 23,000 L/ha/day. Based on these values, the 100-year I&I rate used for existing system modelling is 20,000 L/ha/day. This includes 800 L/ha/day of GWI.

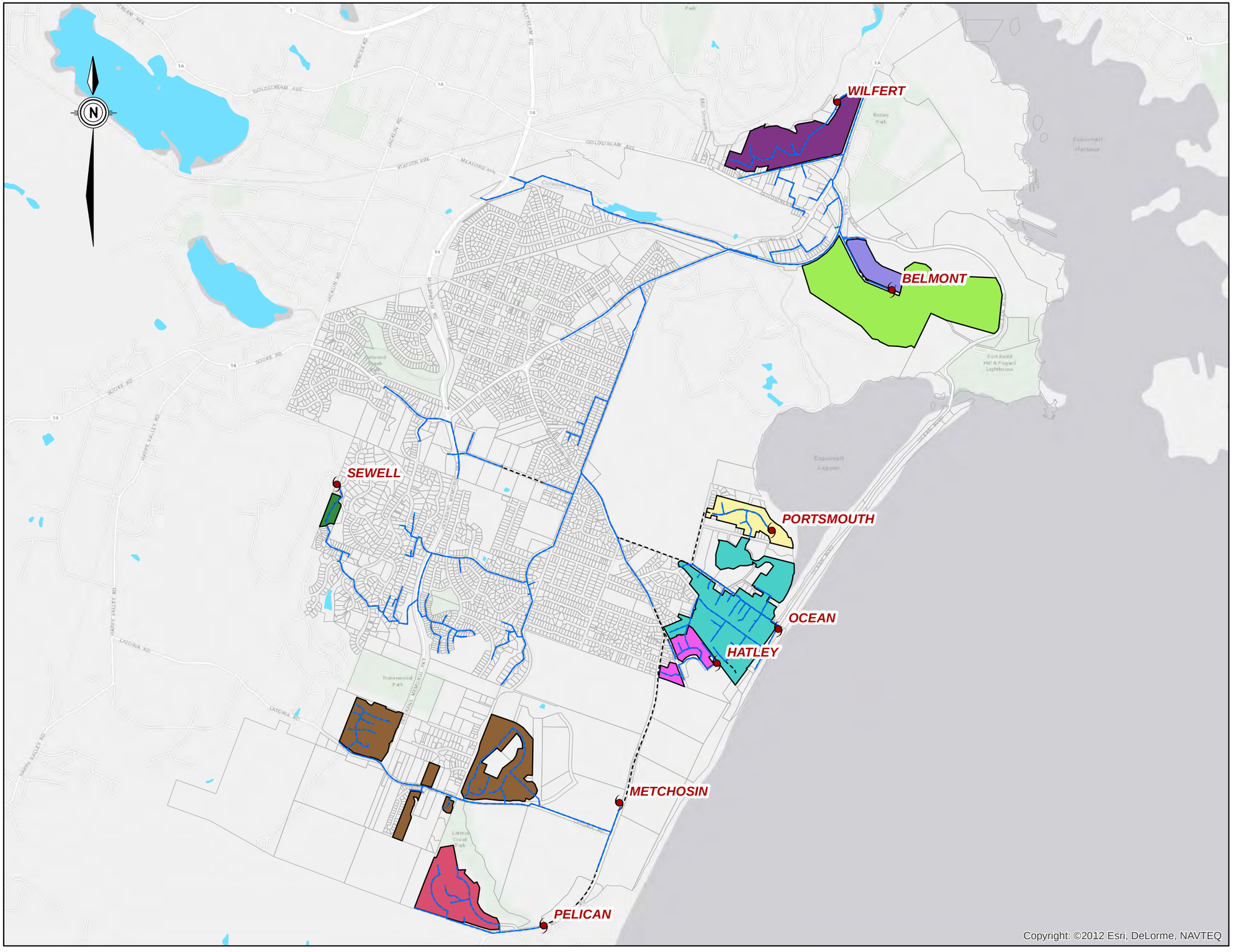
The I&I rate for newly serviced areas may initially be less than 20,000 L/ha/day, as is the case for the catchment to the Ocean Boulevard Pump Station. However, it has been shown that I&I increases as a system ages. We have assumed that through ongoing I&I reduction and general maintenance programs, the I&I rate of 20,000 L/ha/day will be maintained for the life of the sewer.

When applying I&I loads to the model, a net area factor (NAF) is used to adjust the contributing lot area. The net area factor is the ratio of total area of the catchment to the active lot area of the catchment. The net area factor is necessary to account for the difference between the gross flow monitoring area (including roads) used to calculate I&I rates, and the net area used in the model (the lot area) to apply I&I flows. For the existing developed lands outside the I&I catchment areas, a typical NAF of 1.25 is applied.

As indicated in Table 5-2 above, the I&I rate for DND Belmont is significantly higher than the I&I rate for the other Colwood catchments. Between 1998 and 2001 approximately 54 % of the sewers within DND Belmont were replaced with PVC pipes in an effort to reduce I&I. The extent of the rehabilitation and the resulting I&I rates are recorded in a 2007 CRD I&I Analysis Report[7]. This study also recommended that the remaining original sewers at DND Belmont be rehabilitated.

As the CRD proceeds with the core area wastewater treatment plant project, the costs for treating stormwater will increase resulting in a greater need to reduce I&I. Following discussions with the City Engineer, we understand that the City will support and encourage I&I reduction programs for the areas with high rates of I&I. Therefore, it is assumed that DND Belmont and other areas with potentially high I&I rates (DND Colwood and Royal Roads University) will undergo I&I reduction programs. As these properties are owned by a single land owner, the I&I program could include the full extent of the mains and service laterals. Therefore, we have assumed a 100-year I&I rate for the future modelling scenario of 20,000 L/ha/day for the DND and Royal Roads University catchments (assuming a fully rehabilitated sanitary sewer system). For the existing scenario, the 100-year I&I rate of 187,700 L/ha/day will be used for the DND and Royal Roads catchments.

[7] Inflow and Infiltration Analysis Results: 2005/2006 and 2006/2007 Flow Monitoring Sites in Colwood, Capital Regional District Environmental Services, November 2007.



City of Colwood
Sewer Master Plan

Legend

- Sanitary Pump Station
- Existing Gravity Mains
- Forcemains

Pump Station Catchment

- Belmont
- DND Belmont
- Metchosin
- Ocean
- Pelican
- Hatley
- Portsmouth
- Sewell
- Wilfert

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Existing Subcatchment Areas for I&I Calculations

Figure 5-1

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