LIQUID WASTE MANAGEMENT PLAN

Technical Memo #3

To:	Wastewater Advisory Committee	**Date:**	October 27, 2017
Written By:	Larry Sawchyn	**Reviewed By:**	Paul Nash
Subject:	**Historical and Projected Flows and Loads**		

1.0 POPULATION MODELLING

Predictions of future flows must be made as part of any wastewater planning exercise, and population growth is the key driver of these flows. The normal planning horizon for wastewater is for 20 years, and that is what is being used for Cumberland.

The strategy for future growth is laid out in the 2014 update to the Cumberland Official Community Plan, which contemplates future land use changes and residential developments

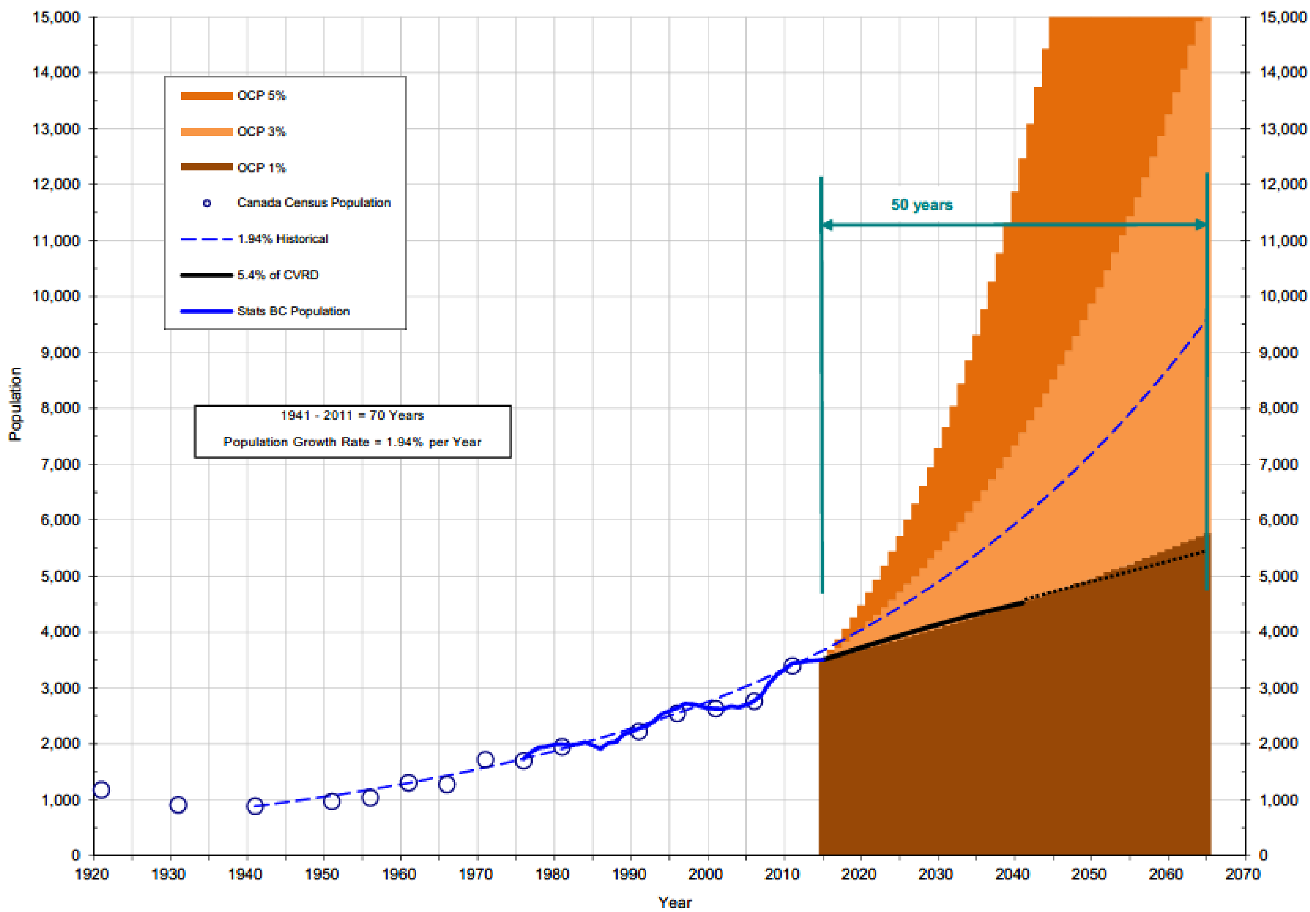
In June of 2016, Koers and Associates produced a "Long Range Water Supply Strategy", which included a detailed analysis of population growth for Cumberland, for estimating future potable water consumption. Their analysis, providing the population projections to 2065, has been used here for estimating future wastewater flows. Figure 1 below is reproduced from their Final Report, dated June 9, 2016.

The Koers analysis recommended the "moderate growth" scenario, of a 3% annual increase in population. With the project horizon at 20 years, and a starting year of 2018, the various growth scenarios are quantified in Table 1. If the community growth continues at the historical rate, population is the 7000 mark would not be reached until 2049, and conversely, at 5% growth, it would be at 2030. The large growth scenario would likely be a result of large community development that may include some decentralization of sewage services, and would also accumulate significant Developer Cost Charges (DCC's) to help pay for an earlier than planned expansion, thus designing to the maximum projected growth is overly conservative and the 20-year project should match population growth and equipment replacement due to mechanical wear.

Table 1 Koers Population Models

Year	Historical Growth	Moderate Growth	High Growth
	1.94%	**3%**	5%
2019	4000	**4000**	4000
2029	4755	**5219**	6205
2039	5762	**7014**	10108
2049	6983	**9426**	16465

Figure 1 Koers' Village of Cumberland Population Growth Projection



In early 2017, after the Koers study was written, the official 2016 Census data was been released, showing a Census population of Cumberland at 3,753 people. This is a 10% increase over the 2011 population of 3,398, and 36 % increase from the 2006 population of 2,762.

A special distinction needs to be made in the case of the wastewater system, in that not all houses and business are connected to the sewer system. There are numerous houses at Comox lake, and on Union Road that are not connected, in addition to some of the commercial industrial areas on Cumberland Road and East of Hwy 19. To make a modest allowance for these, a population deduction of 100 has been assumed.

For the purposes of flow modelling:

1. The connected population is set at 3650 for 2016
2. A growth rate of 3% per annum has been used
3. The starting year is 2019, the earliest a treatment system could be commissioned, with a population of 4000
4. The final year is 2038, a 20-year period, with a population of 7000

2.0 DESIGN FLOWS

In setting design flows, consideration must be made of the maximum and minimum flow states, for the starting year, and the 20 year horizon. These are known as the “current” and “design” flows.

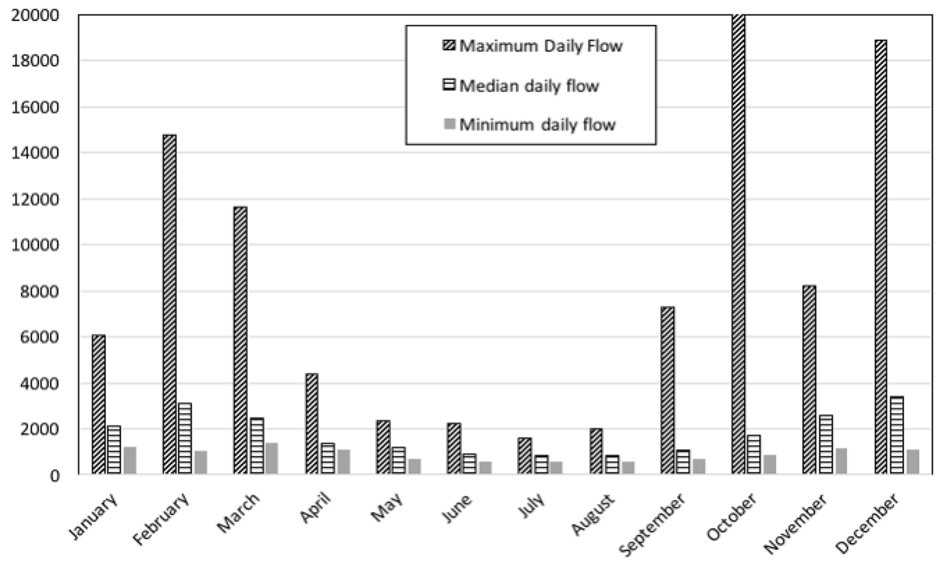
The “minimum” flow state for a wastewater plant is the Average Dry Weather Flow (ADWF), which is the average daily flow during an extended dry period where stormwater *Inflow* and groundwater *Infiltration* (called “I&I”) have been reduced to the greatest extent practicable. It represents the period where the greatest proportion of the water coming in is actual wastewater from the drains of the residents and industry. Since the ADWF is predominantly generated by people, it is used for modelling the biological load coming into the treatment plant. Cumberland’s current Permit limit is 910cu.m/day for ADWF.

The “maximum” flow state is called the Peak Wet Weather Flow (PWWF or Peak Flow), it represents the state where there is the most inflow and infiltration occurring. This is used for sizing the hydraulic components of both the collection and treatment systems. Cumberland’s current Permit allows for a PWWF of 7600 cu.m/day, and this is to be reduced to 2730cu.m/day by 2026.

The ratio of PWWF to ADWF is called the “peaking factor” and is typically from 1.5: to 3:1. It is usually desirable to reduce the I&I as much as possible, to minimise oversizing of hydraulic components, and energy use in pumping and treating what is, effectively, clean water. Cumberland’s Permit peaking factor of 8.3:1 (7600:910) is unusually high, in recognition of the large wet weather flows. The Permit requirement to reduce to 2730 represents a peaking factor of 3:1, which is the high end of the normal range. The BC MWR targets a peaking factor of 2:1, but will allow 3:1 under specific circumstances.

Figure 2 shows the comparisons of maximum, minimum and median daily flows by month, from 2013 to 2016.

Figure 2 Cumberland Daily Wastewater Flows by Month, 2013-2016



Cumberland clearly faces very high *Inflow* and I*nfiltration*. Figure 2 shows that the large flows, from rainwater inflow, can occur any time from September to March. Some of these flows are well over the maximum permitted discharge flow of 7600 cu.m/day.

Dry Weather Flows

The ADWF (average dry weather flow) is the best indication of the amount of true wastewater coming into the treatment system. It consists of “baseflow”, which is groundwater infiltration even under dry conditions, and the actual wastewater generated by users on the collection system.

Using actual flow data from 2013 to 2016, the ADWF's are as shown in Table 2:

Table 2 Average Dry Weather Flows 2013-2016

Year	2013	2014	2015	2016	Average
ADWF cu.m/day	950	750	650	820	793
Lowest winter 7 day flow (cu.m/day)	1200	1100	1400	1400	1280

Table 1 shows the ADWF has fluctuated in recent years, with 2015 being very low due to a prolonged drought, and the imposition of water restrictions. This would lower both the base flow and the human flow, and makes this an unusually low year. The data from 2013 appears to be unusually high, and may have been the result of some human caused leakage, or groundwater infiltration, that was corrected in the following year. The 2016 ADWF is in the middle of the range, and close to the average. It is also the flow for the baseline year connected population of 3,650 people, from which the per capita ADWF has been calculated at 225 litres per capita per day(l/c/day). This is a relatively low per capita flow, with the normal industry standard being 250L/c/day, in the absence of aggressive water conservation. It is possible to lower the per capita flow through targeted water conservation initiatives (including reclaimed water), and if the LWMP flow model is based on implementing water reduction measures, there must be detailed studies and appropriate conservation bylaws in place. The water conservation options are considered in a separate Technical Memo. Given the fluctuations in flow, the industry standard number of 250L/c/day has been assumed for flow modelling. During the detailed design stage, prior to construction, this flow model should be reviewed again, in the light of more data and direction on water conservation initiatives.

Dry weather also occurs in winter, and Table 2 shows that in winter, the "dry weather" flow is significantly higher than in summer. This represents groundwater infiltration into the system, from the higher winter groundwater tables. The same "baseflow recession" pattern is seen as in the summer, but does not reach the same low level as in summer.

For flow modelling purposes; the following have been assumed for dry weather flows

1. The per capita ADWF is assumed to be 250L/c/day
2. Design ADWF at population of 7000 is 1800 cu.m/day.

<u>Wet Weather Flows</u>

Cumberland sees significant flow response to rainfall (inflow), particularly during the winter months, this results in high peak flows (PWWF) during consecutive days of rain. After the rain stops, the flows initially drop quickly, and then there is a gradual decrease in flow over days or weeks. This steadily decreasing flow after major rain events is the same flow pattern for creeks and rivers, where it is called a "baseflow recession". It is from groundwater infiltrating into the sewer collection system, but the rate of infiltration gradually declines as the groundwater level drops. In summer, where there are prolonged dry periods, the infiltration flows reach a steady state 9though not necessarily zero), representing the ADWF.

For these years, the peaking factors have been calculated in Table 3. They are well above the typical level of 2:1!

Table 3 Flow Peaking Factors

Year	2013	2014	2015	2016	Average
PWWF cu.m/day	7,254	18,890	14,700	14,100	13,736
ADWF cu.m/day	950	750	650	820	793
Peaking Factor	7.6	25	23	17	17
Month of peak period	Sep	Dec	Feb	Oct	

The wet weather flows are very high in comparison to other municipalities, where peaking factors may get up to 6:1, but are rarely over 10. Cumberland has been following a traditional approach of infiltration reduction, replacing old sewer pipes and gradually eliminating stormwater connections to sanitary sewer. However, the program will take at least another decade to complete pending funding for the design and construction of required upgrades. Thus, any treatment systems must plan for handling these high flows, indeed, they are a defining characteristic of the Cumberland system.

Newly installed sewer collection systems are assumed to have a wet weather peaking factor (for daily flows) of 2:1. So, as population is added, there will be extra wet weather flow being added, even as stormwater connections are being reduced.

The standard peaking factor used in the BC Municipal Wastewater Regulation is 2x ADWF. Where the peaking factor is higher than this, the municipality is to implement an I&I reduction plan to reduce the wet weather flows down to a peaking factor of 2. In review of historical data, flows during extreme storm events can result in flows coming into the plant at over 20,000 cu.m./day. Designing to these maximum flows would not be prudent as equipment becomes very large, and future stormwater separations are expected to achieve significant reductions. Based on historical data for a "wet" and "dry" winter, the days in a year that a given peaking factor will be exceeded are shown in Table 3 roughly starting at two times the current average flows up to 14,400 cu.m/day. This provides a basis for limiting the cost for biological treatment by meeting most of the inflow:

Table 3 Days per year above peak flow thresholds

Flow	Design Peaking Factor	Days Per Year Exceeded "Dry" Year (2013-2014)	Days Per Year Exceeded "Wet" Year (2015-2016)
1,800 (design ADWF)	1	92	156
3,600	**2**	**41**	**71**
7,200	4	18	44
14,400 (design PWWF)	**8**	**0**	**3**

It is obvious that there is a long way to go to get the peaking factor down to 2, and it is likely this target not be reached in the 20-year timeframe, and possibly not ever.

For flow modelling purposes, the following have been assumed for wet weather flows;

1. Peak wet weather flow of 14,400 cu.m/day (peaking factor of 8)
2. PWWF to decrease by 500 cu.m/day, per year, as the storm separation program proceeds.
3. Incremental population growth will increase PWWF by peaking factor of 2:1 compared to incremental ADWF
4. Peak flow factor does not go below 4:1

Using the population model and design flows, the design flow model is calculated. This is detailed in Table 4.

Table 4 Flow Projections for Plant Design

Year	Population	ADWF	PWWF	Peaking Factor	Comments
	3% growth	cu.m/day	cu.m/day		
2016	3650	820	14,100	17	Baseline year
2017	3760	940	14400	15	
2018	3872	968	14400	15	
2019	3988	997	14400	14	**Commissioning Year**
2020	4108	1027	13900	14	Permit ADWF (910 cu.m/day) exceeded
2023	4489	1122	12400	11	Permit +10% (1001 cu.m/day) exceeded
2025	4762	1191	11400	10	
2030	5521	1380	8900	6.4	
2035	6400	1600	6400	4.0	Minimum Peaking factor reached
2038	6994	1800	7200	4.0	**End of 20 year Design Horizon**

The flow model is unusual in that the PWWF decreases with time. The model has been developed assuming the I&I reduction efforts will reduce the peaking factor down as to 4:1. Past this point, the actual PWWF starts to increase with population while the peaking factor remains the same. In reality, it is the maximum PWWF during the modelling period that sets the design criteria, which in this case is as at the start. So, the system will be built to handle these flows, regardless of whether the I&I reduction program proceeds faster or slower. However, controlling stormwater flows reduces the total volume of water being treated, which reduces operational costs for the system.

The Flow model should be reviewed as new data becomes available, and before undertaking detailed design of improvements. It is possible to reduce the ADWF's by water conservation and targeted infiltration reduction. Indeed, since the Permit limit for dry weather flow will be reached before the limit for wet weather flow, consideration should be given to making Infiltration reduction equal or greater priority than reducing stormwater Inflow.

3.0 DESIGN LOADINGS AND INFLUENT CRITERIA

The "load" in wastewater represents the amount of contaminants contained within, or more simply, the amount of "waste" in the "wastewater". Loadings are used to size biological and chemical treatment components, and estimate chemical consumptions and sludge production.

The biological loadings are calculated using industry standard per capita loadings. The calculated concentrations at current ADWF were compared to influent measurements taken in the summer of 2017, and found to be equal to or 10-20% above the observed values, so the standard values are retained for design purposes. Table 4 provides the complete "Flow and Load" model, which sets the influent conditions for treatment system design:

Table 5 Design Flows and Loads

Parameter	Units	Current	Design
Year		**2019**	**2038**
Connected population	capita	4,000	7,000
Total Annual Flow	m^3/d	820,000	770,000
Average dry weather flow (ADWF)	m^3/d	900	1800
Per capita ADWF	L/c/d	250	250
Maximum Day Flow	m^3/d	>14,400	14,400
Maximum hourly Flow (125% Max Day Flow)	L/s	210	210
Wastewater pH	-----	6.5 - 7.5	6.5 - 7.5
Assumed alkalinity deficiency of wastewater	mg/L as $CaCO_3$	200	200
Maximum Summer Wastewater Temperature	ºC	22	22
Minimum Winter Wastewater Temperature	ºC	7	7
Biochemical Oxygen Demand (cBOD5)			
- Per Capita Loading	g/c/d	80	80
- Average Day Loading	kg/d	320	560
- Concentration at ADWF	mg/L	355	355
- Maximum Month Peak Factor	------	1.2	1.2
- Maximum Day Peaking Factor	-----	1.8	1.8
- Maximum Month Loading	kg/d	384	672
- Maximum Day Loading	kg/d	576	1008
TSS	-----		
- Per Capita Loading	g/c/d	90	90
- Average Day Loading	kg/d	360	630
- Concentration at ADWF	mg/L	400	400
- Maximum Month Peak Factor	-----	1.3	1.3
- Maximum Day Peaking Factor	-----	1.8	1.8
- Maximum Month Loading	kg/d	438	819
- Maximum Day Loading	kg/d	648	1134
TKN			
- Per Capita Loading	g/c/d	18	18
- Average Day Loading	kg/d	72	126
- Concentration at ADWF	mg/L	80	80
- Maximum Month Peak Factor	-----	1.3	1.3
- Maximum Day Peaking Factor	-----	1.8	1.8
- Maximum Month Loading	kg/d	94	164
- Maximum Day Loading	kg/d	130	227
TP			
- Per Capita Loading	g/c/d	3	3
- Average Day Loading	kg/d	12	21
- Concentration at ADWF	mg/L	13.3	13.3
- Maximum Month Peak Factor	-----	1.3	1.3
- Maximum Day Peaking Factor	-----	1.8	1.8

- Maximum Month Loading	kg/d	16	27
- Maximum Day Loading	kg/d	22	38
Grit			
- Estimated Grit Quantities	$m^3/10^3m^3$	0.2	0.2

4.0 EFFLUENT CRITERIA

Refer to TM#1 for the water quality requirements to meet current and future regulatory conditions.