

## Technical Memorandum

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**FROM:** Chris Johnston, P.Eng., Colwyn Sunderland, ASCT  
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**RE:** **CAPITAL REGIONAL DISTRICT – CORE AREA LIQUID WASTE MANAGEMENT COMMITTEE**  
**Options to Encourage Installation of Low-Flow Household Appliances**  
**Our File 283.387**

## 1. Background

### 1.1 Purpose

The Core Area Liquid Waste Management Committee has requested a report on options for reducing wastewater flows through demand management programs that encourage installation of water efficient plumbing fixtures and appliances. This Technical Memorandum provides a summary of past and ongoing Capital Regional District (CRD) demand management programs targeting fixture and appliance replacements, and an assessment of the potential effectiveness of a renewed program for reducing sewer flows in the Core Area.

### 1.2 Potable Water Use in the CRD

The CRD's winter water use has dropped from 123 ML/d in 1995 to 97 ML/d in 2016 (21%)<sup>1</sup>. The per capita usage has dropped even more from 325 L/c/d in 1999 to 236 L/c/d in 2016 (27%)<sup>1</sup> as the region's population has grown at the same time the water use has dropped. This trend in reduced water use is consistent with other regions in North America, although the actual timing and magnitude of the reductions vary. The primary driver in these reductions is the conversion of household water fixtures and appliances with more efficient devices. This results in a composite unit rate demand as some households use older fixtures, some have partially or fully converted water-efficient fixtures, and recently constructed households are only able to install efficient fixtures under current code. The conversion rate is driven by end of life cycle replacement of aging fixtures and appliances, in combination with changing standards and codes, rebate and incentive programs, and public education. Ultimately, all households will be using similar fixtures until technology establishes a new baseline and the standards and codes are revised.

<sup>1</sup> CRD Water Use Summary 1995-2016, Capital Regional District, February 25, 2016



### 1.3 Water Conservation Standards and Codes

Toilet flushing is historically the largest residential end use of municipal water, accounting for roughly one quarter of indoor household water use. Toilets manufactured before the 1980s typically have flush volumes of 15 to 25 litres. A water conservation standard of 13.25 litres per flush was adopted throughout North America in the early 1980s, and the standard was further reduced to 6 litres per flush (LPF) in 1992 in the United States.

The flushing performance of many of the early 6 LPF toilets manufactured in North America was poor, delaying the widespread adoption of the standard in Canada. Since the early 2000s, new design and manufacturing methods have led to major improvements in the efficiency and performance of toilets, and other North American plumbing fixtures and household appliances. In 2005 the CRD opted into a provincial plumbing regulation that required all new toilets in the region to use no more than 6 LPF. In 2011, revisions to the BC Building Code mandated a maximum of 4.8 LPF for residential toilets and 6 LPF for non-residential toilets.

The water efficiency of other plumbing fixtures and appliances has similarly improved in the past 20 years. In particular, energy efficiency labeling and utility rebate programs throughout North America have prompted major improvements in the efficiency of clothes washers. A breakdown of average indoor residential end uses of water per capita in North America in existing and new homes is shown in Figure 1. The difference in water use by toilets and clothes washers between 1999 and 2016 is attributable to improvements in average fixture and appliance efficiencies of new vs. existing stock. As a result, indoor water use in new North American homes with efficient fixtures and appliances is estimated to be 140 litres per capita per day (L/c/d), vs. 222 L/c/d for existing homes. Average indoor water demand in existing North American homes has also decreased on average from approximately 270 L/c/d in the late 1990s.<sup>2</sup>

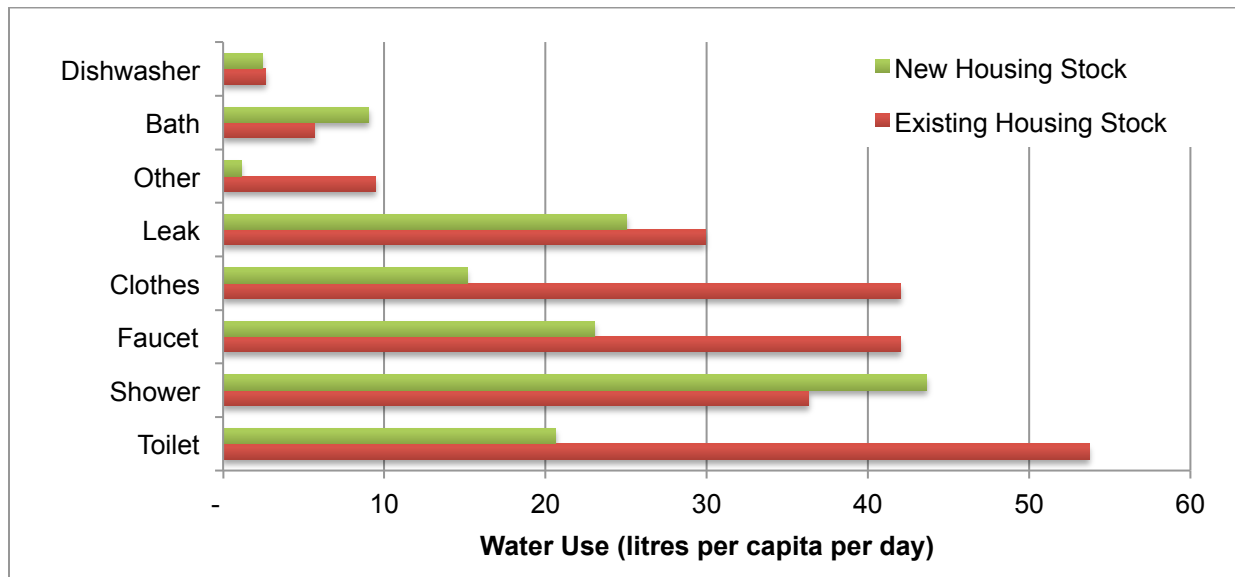


Figure 1: Typical Residential End Uses of Water Per Capita in North America<sup>2</sup>

<sup>2</sup> DeOreo et.al. *Residential End Uses of Water, Version 2*. Water Research Foundation, 2016.  
<http://www.waterrf.org/Pages/Projects.aspx?PID=4309>



## 1.4 Previous CRD Rebate Programs

Under the Regional Water Supply (RWS) service, the CRD offered rebates for the replacement of residential toilets with water efficient fixtures between 1994 and 2009. A similar program for residential washing machines was offered between 2002 and 2009, and rebate programs targeting non-residential fixtures and appliances were offered between 2007 and 2015. Rebates were also offered for programmable irrigation controllers and rain sensors; these incentives have no impact on wastewater flows and are not further discussed in this Technical Memorandum.

The rebate programs were an element of a comprehensive demand management program that also included public education and outreach initiatives that have continued since the rebate programs were discontinued.

### Program History

When the Greater Victoria Water District became part of the CRD in the early 1990s, the Province mandated the CRD to incorporate demand management in strategic planning for the RWS service. The history of the CRD's water conservation rebate programs is summarized as follows:

- Rebates of \$50 were offered in the 1990s for replacement of existing residential toilets with new fixtures having a maximum flush volume of six litres. Participation in the rebate program was initially low (i.e. tens of fixtures per year). In 1998 the overall demand management program expense was approximately \$200,000.
- The program was substantially revised ca. 2000 and rebranded as the *Fixture Rebate Program*, including an increase in the rebate amount to \$75 per toilet. Program participants were also required to install code-compliant (9.5 litres per minute) showerheads to be eligible for a toilet rebate.
- Demand management communication and education programs were increased in response to water shortages in 2001, when stage 3 watering restrictions were implemented. In 2001 the overall demand management program expense was approximately \$750,000.
- The *Smartwash Rebate Program* was added in 2002, providing rebates of \$125 to replace an existing residential clothes washer with an appliance that met the *Energy Star* criteria for water efficiency (typically front loading machines, which were much more efficient on average than contemporary top loading machines. In 2003 the overall demand management program expense was approximately \$600,000.
- Between 2004 and 2006, demand management programs targeting the Industrial, Commercial and Institutional (ICI) sectors were developed and launched. In 2007, rebate programs were launched for ICI toilets (\$75 for tank type and \$150 for flush valve type fixtures), and for retrofits to eliminate once-through cooling (OTC) in commercial refrigeration systems. Water audits were also offered to ICI customers to identify cost-effective opportunities to save water. In 2007 the overall demand management program expense was approximately \$1,350,000.
- In 2005, the BC Plumbing Conservation Code came into effect, prohibiting the installation of a toilet in Greater Victoria with a higher nominal flush volume than six litres. However, 13.25 LPF fixtures remained readily available for sale on southern Vancouver Island after 2005.
- Participation levels in all rebate programs increased steadily between 2002 and 2009. By the end of 2008, the CRD had issued 17,448 residential toilet rebates and 10,108 clothes washer rebates.



- The Fixture Rebate program and Smartwash Rebate Program were cancelled in 2009, effective December 31. In 2009 alone, the CRD issued 9,226 residential toilet rebates and 3,862 clothes washer rebates. In 2009 the overall demand management program expense was approximately \$1,950,000.
- The ICI toilet rebate program continued through 2011, with declining participation after 2009. The ICI cooling equipment rebate program was discontinued in 2014. An estimated 800 fixtures were replaced under the ICI toilet rebate program, at a total rebate cost of \$77,000.

## CRD Rebate Program Performance

In total, approximately 27,500 toilets and 14,000 residential clothes washers were replaced under the CRD rebate programs. The total value of rebates issued was approximately \$2.1 million for toilets, and \$1.75 million for clothes washers. Although it is difficult to isolate program administration expense for the rebate programs alone, it is roughly estimated that on average over the program life cycle, rebate administration employed a clerk full-time, and a coordinator at 25% of full time. The direct program administration cost is estimated as follows:

$$15 \text{ years} \times ( \$50,000 + 0.25 \times \$90,000 ) = \$1.1 \text{ million (rounded)}$$

The direct program life cycle cost for issuing toilet and clothes washer rebates is therefore estimated to be roughly \$4.9 million. The rebate program was supported by several other elements of the CRD's demand management program, including advertising and participation in community events. The cumulative cost of the demand management programs during the period that the residential rebates were in effect was approximately \$11 million.

The direct water savings achieved by retrofitting residential toilets and clothes washers is estimated using the following assumptions:<sup>3</sup>

- The average toilet is estimated to be flushed 5 times daily;
- The average flush volume of toilets removed was 11.5 L;
- The average flush volume of toilets installed was 6 L;
- The average annual water use by clothes washers removed under the program was 65 m<sup>3</sup>; and
- The average water savings achieved by clothes washer rebates was 28%.

Based on these assumptions, it is estimated that the total water savings achieved by the CRD's toilet and washing machine rebate programs was as follows:

- **Toilet rebates:**  $5 \times (11.5 - 6) \times 365 / 1000 = 10.0 \text{ m}^3/\text{year}$  per retrofit  
 $10 \text{ m}^3/\text{year} \times 27,500 \text{ rebates} = \mathbf{275,000 \text{ m}^3/\text{year total direct savings}}$
- **Clothes washer rebates:**  $65 \text{ m}^3/\text{year} \times 28\% \times 14,000 = \mathbf{255,000 \text{ m}^3/\text{year total direct savings}}$

The estimated unit cost of water savings based on direct program expenses is estimated to be:

$$\$4.9 \text{ million} / (255,000 + 275,000) \text{ m}^3/\text{year} = \mathbf{\$9.25 / m}^3/\text{year}$$

<sup>3</sup> Based on several sources, and used in water demand forecasts for the CRD's 2004 Strategic Plan for Water Supply and Demand, and for the 2008 Water Use and Conservation Update.

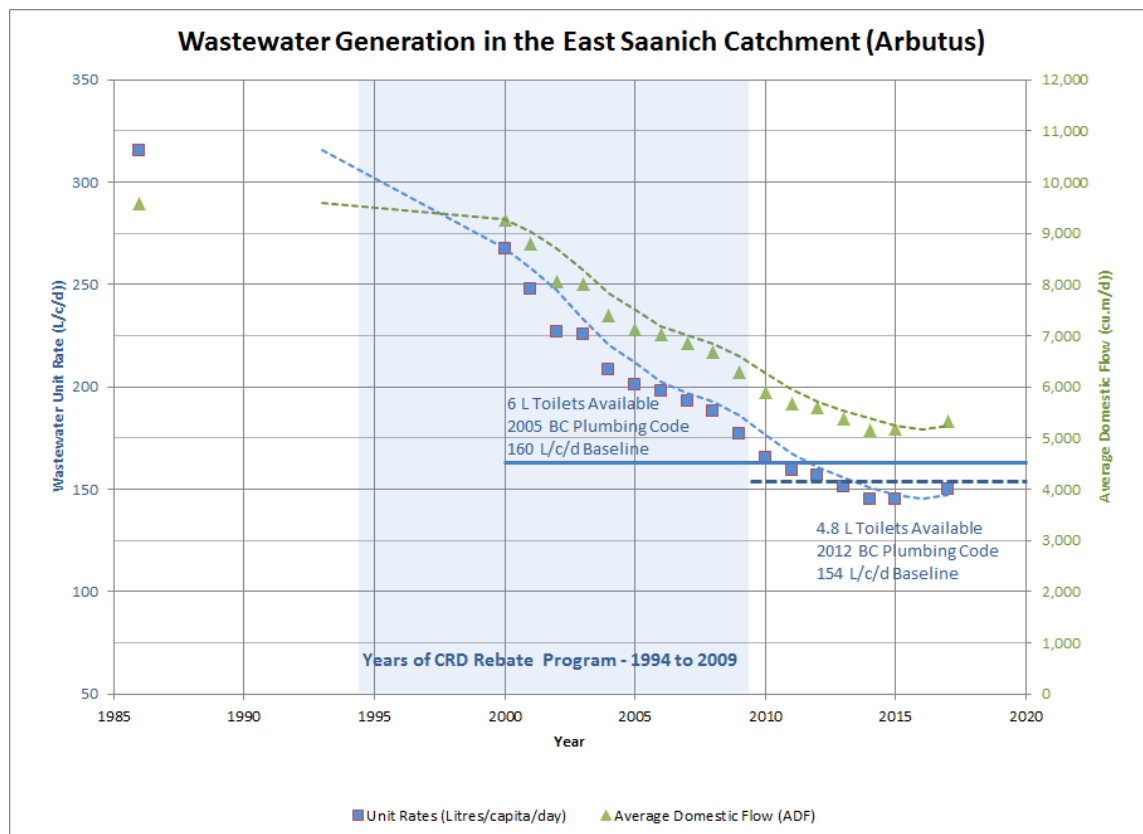


The toilet and washing machine rebates completed under the CRD's programs were likely only a fraction of the total number of replacements that occurred during the program timeframe. If it is assumed that there are two toilets per dwelling, and roughly 150,000 dwellings in the Victoria CMA, there are roughly 300,000 residential toilets in the region. The average life expectancy of a toilet is estimated to be 20 to 30 years. At a 30 year replacement interval, it may be estimated that 10,000 residential toilets are replaced annually in Greater Victoria, roughly equivalent to the number replaced under the rebate program in 2009. Similarly, assuming roughly 80% of dwellings have a clothes washer and they have an average life expectancy of 15 years, roughly 8,000 clothes washers are replaced in Greater Victoria annually. These replacements occur, with the associated water savings, whether rebates are available or not.

## 1.5 Impact on Wastewater Flows

Wastewater flows have also decreased in the region, and in many cases the reductions have been greater than the potable water reductions. Figure 2 shows the reduction history of a typical CRD wastewater collection area over time. The Figure illustrates the East Saanich Catchment tributary to the Arbutus Flow Monitoring Station. Wastewater generation was 315 L/c/d in 1986 and has dropped to 150 L/c/d in 2017 (52%). The CRD's 2005 adoption of the 6 L toilets results in a 160 L/c/d baseline. The further adoption of the 2012 BC Plumbing Code requiring 4.8 L toilets lowers the baseline to 154 L/c/d.

Figure 2: Wastewater Generation Trends





It is interesting to note that the reduction amounts appear to have levelled out. From 2000 to 2009, during the years of the CRD's rebate program, the rate of reduction averaged 4.5% per year. Between 2010 and 2017, the average rate of reduction declined to 2% per year, but is essentially flat since 2013. Since measured 150 L/c/d unit flows have dropped slightly below the 154 L/c/d baseline and have begun to level out, it can be concluded that most of the catchment has been fully retrofitted and further reductions are not likely until a new technology is adopted by a future plumbing code.

Based on the above, and using a 154 L/c/d baseline (2012 BC Plumbing Code), it appears that the conversion within the East Saanich catchment is essentially complete in its retrofit. However, it should be noted that innovation is continuing in the water industry, particularly in the appliance area, so it is possible that a lower baseline of 140 L/c/d is achievable over time.

To date, the CRD's master planning for wastewater infrastructure has used the 6 L toilet baseline of 160 L/c/d and a 0.75% adoption rate. It is noteworthy that the adoption rate has been significantly exceeded in the East Saanich area and likely other areas as well. This suggests that the CRD's 1994 to 2009 incentive program together with public education and outreach programs have been a success at gaining public acceptance.

## 1.6 Authority to Regulate Fixture Efficiency

With the exception of the City of Vancouver, local governments in British Columbia do not have legal authority to impose more stringent requirements for building construction than those set out in the BC Building Code. Building Codes apply to new construction or renovation, and changes to code do not impose a requirement to modify existing buildings or components to meet the current code. Local governments have powers to enter a premise for the purpose of building inspection only at the time of construction or renovation, under an open building or plumbing permit. The CRD has no legal means to regulate or enforce changes to the water efficiency of existing plumbing fixtures or appliances.

## 2. Rebate Comparison with Other Jurisdictions

Water efficient toilet and clothes washer rebate programs were offered by many North American water utilities in the 1990s and 2000s. Most of these programs have been discontinued as demands have decreased in recent years due to the maturity of the programs in achieving their goals. Not surprisingly, after the fixtures have been replaced, rebate programs were found to be less cost-effective than other conservation programs. However, well-designed financial incentives can be an effective social marketing instrument by drawing enough attention to a practice to achieve a critical mass of adoption within a community. The rebate programs offered by utilities across North America in the past 20 years, and the advertising and education that complemented them, played a prominent role in the market transformation that has driven reductions in water demand.

The City of Austin, TX offered toilet replacement rebates between 1992 and 2009, and cancelled its program in 2010 after participation levels sharply increased and the program budget was exceeded.<sup>4</sup> As of 2007, 50,000 toilets had been replaced under the program, with corresponding estimated savings of 970,000 m<sup>3</sup>/year. Non-industrial water demands in Austin decreased by 38 L/c/d in the same time period.<sup>5</sup> By 2010, the City estimated that it had achieved 75% replacement of inefficient toilets in single-

<sup>4</sup> <http://www.statesman.com/news/local/toilet-rebates-not-cost-effective-city-says-canceling-program/cgeZCNCHlxAJp0zLdImHfM/>

<sup>5</sup> Gregg et.al. "Water Efficiency in Austin, TX, 1983-2005 – an Historical Perspective." *Journal AWWA*, February 2007. [https://www.austintexas.gov/sites/default/files/files/Water/Conservation/Planning\\_and\\_Policy/JAW200702\\_well03gregg.pdf](https://www.austintexas.gov/sites/default/files/files/Water/Conservation/Planning_and_Policy/JAW200702_well03gregg.pdf)



family homes and 95% replacement in multi-family homes. After discontinuing the rebates, the City shifted its program budget to increased education and outreach.<sup>6</sup>

A study of the cost-effectiveness of water conservation programs in several Arizona water utilities conducted in the early 2000s concluded that, “passive conservation is occurring and ongoing everywhere with ordinances, code changes, natural replacement of fixtures, and new technologies, so there will be diminishing savings to be achieved with water conservation actions taken now compared to times past.”<sup>7</sup> The study reviewed 8 clothes washer rebate programs that issued a combined 1,034 rebates between 2001 and 2003, and estimated that the average water savings achieved by the rebates was 12 m<sup>3</sup>/year at an average cost of US\$130 per participant (US\$10.83 per m<sup>3</sup>/year saved). The study also reviewed 6 toilet rebate programs that issued a combined 569 rebates between 2001 and 2003. The toilet rebate programs achieved an estimated average water savings of 26 m<sup>3</sup> per participant per year, at an average cost of US\$151 per participant (US\$5.80 per m<sup>3</sup>/year saved).

DeOreo et.al. found that the average flush volume of residential toilets in North America decreased from 13.8 litres to 9.8 litres between 1999 and 2016, accounting for a reduction in water demand of 20 L/c/d. It is also estimated that the average water use by residential clothes washers has decreased from 155 litres per load to 117 litres per load in the same period, resulting in a reduction in water demand of 20 L/c/d. The combined water savings resulting from these improvements in average fixture and appliance efficiencies is 40 L/c/d, accounting for the entire reduction in average residential indoor water demand during that period. The North American average conversion rate for efficient toilets (less than 8 LPF) was estimated to have increased from 5% in 1999 to 37% in 2016. The North American average conversion rate for efficient clothes washers (less than 114 litres per load) was estimated to have increased from 6% to 46% in the same period.<sup>8</sup> Water demands in the CRD, and average dry weather sewer flows in the East Saanich (Arbutus) catchment, have both decreased by more than 100 L/c/d in the same period. The conversion rate for efficient fixtures and appliances in the Arbutus catchment is likely approaching 100%.

### 3. Key Findings

- The CRD is significantly ahead of the North American rate of conversion of existing building stock to water efficient fixtures and appliances, and some areas are likely approaching complete conversion.
- The CRD's water conservation rebates and supporting education and advertising programs were effective in accelerating reductions in indoor water demand between 2000 and 2016.
- The CRD's residential toilet and clothes washer rebate programs were discontinued at the appropriate time, as the conversion of fixtures and appliances approached 90% and rebates began to yield diminishing returns in water savings.
- Due to the relatively high degree of conversion of existing stock to efficient fixtures and appliances, new rebate programs would be less effective than the previous programs.

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<sup>6</sup> Austin Water 140 GPCD Conservation Plan, December 2010, City of Austin, TX.

<sup>7</sup> *Evaluation and Cost Benefit Analysis of Municipal Water Conservation Programs*. Water Conservation Alliance of Southern Arizona, undated (ca. 2004).

<sup>8</sup> De Oreo et.al., 2016





- The accelerated reductions in water demand that were achieved by the CRD's conservation programs in the past decade provide opportunities today to size new water and wastewater infrastructure more accurately and avoid unnecessary costs of overbuilding infrastructure.

## 4. Recommendations

- Since fixture and appliance replacement is nearing 100% saturation in some areas (i.e. East Saanich), it is not likely that a re-introduction of residential financial incentives will yield additional benefit. Therefore, it is recommended that the CRD continue its focus on demand management education and outreach programs at the current level of effort.
- Although all of the major capital planning programs on the CRD's wastewater systems have taken into account the impact of water reduction programs, it does appear that the adoption of the new fixtures and appliances has happened more quickly in Greater Victoria than other regions. As a result, it is recommended that the timing of future upgrades beyond the current wastewater treatment project and associated conveyance and storage projects reflect the higher acceptance rates. It is also recommended that the 160 L/c/d unit rate baseline (6 L toilets) be lowered to 154 L/c/d (4.8 L toilets), and that the CRD investigate if a further lowering to 140 L/c/d is possible.

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### Revision History

| Revision # | Date             | Status | Revision Description           | Author |
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| A          | October 24, 2017 | DRAFT  | Partial draft                  | CPS    |
| 1.0        | October 25, 2017 | FINAL  | Revised based on client review | CPS    |