Appendix A

Corrosion Control Plan - Backgrounder

The implementation of a Corrosion Control Plan (CCP) is an essential component of Toronto Water's Lead in Drinking Water Mitigation Strategy to ensure that lead levels are below the regulatory limits.

Toronto Water was required by Ontario Ministry of the Environment (MOE) Regulation 170/03, made under the *Safe Drinking Water Act, 2002*, to begin sampling the lead concentrations in-premise plumbing twice a year beginning in the Fall of 2007. During each round of sampling, lead samples were collected from 100 residential plumbing sites, 10 non residential plumbing sites, and 20 distribution system sites. Lead was measured above 10 µg/L in more than ten percent of premise samples in both rounds 2 and 4, and therefore Toronto Water was required to prepare a CCP for its drinking water system. The CCP assessed corrosion control options and identified a preferred option to reduce the potential for lead leaching from lead water services, internal plumbing containing lead solder joints and brass fixtures, thereby reducing lead levels in household tap water and reducing the potential health risk from exposure to this source of lead.

Corrosion control options investigated included lead source reduction (lead service line replacement) and treatment alternatives based either on lead carbonate passivation with upward pH adjustment (using either sodium hydroxide or potassium hydroxide) or phosphate inhibition (using phosphate products with and without pH adjustment).

a) *Lead Service Line Replacement*
   Corrosion control by lead source reduction alone would not be sufficient to achieve regulatory compliance for the following reasons:
   - The large number of lead services in the City (estimated at 65,000 on the public side as of 2008)
   - Long timeline to achieve 100 percent replacement on the public side
   - Widespread presence of private side lead services outside of regulatory control, lead solder joints and brass plumbing fixtures.

b) *Lead Carbonate Passivation*
   For Toronto's drinking water, regulatory compliance was not assured with carbonate passivation, and secondary effects including precipitation and elevated sodium concentrations were considered likely.

c) *Phosphate Inhibition*
   Based on the experience from other Great Lakes cities achieving compliance with lead regulations from the United States Environmental Protection Agency (US EPA), expected performance, and with consideration given to potential secondary impacts, phosphate based corrosion control using phosphoric acid at ambient pH, was considered feasible for Toronto and was recommended as the preferred corrosion control option.

Corrosion control, using phosphate inhibition through the addition of phosphoric acid during the water treatment process, is the most cost-effective strategy available to water utilities to address lead concerns in drinking water. It is endorsed as a lead reduction measure by authorities such as Health Canada and the United States Environmental Protection Agency. One of the key advantages of corrosion control is that the health benefits are experienced by all Toronto residents (population level health benefits) regardless of their socioeconomic status.

Toronto Public Health has participated in the development of the Lead in Drinking Water Mitigation Strategy including corrosion control and supports it as a critical component to reduce lead exposure to the residents of the City.

The CCP was submitted to the MOE in October 2010 to comply with the deadlines as prescribed in the Regulation. In February 2011, City Council approved the Lead in Drinking Water Mitigation Strategy which includes the CCP. The MOE acknowledged receipt and accepted the CCP in April 2011. Following acceptance of the CCP by the MOE, Toronto Water proceeded with engaging the services of a consulting engineering firm in May 2011.

Reducing Lead Concentrations in Drinking Water

In the water treatment plants, phosphate is typically added in small doses in the form of food-grade phosphoric acid, which is a clear, odourless liquid. The amount of phosphate in drinking water represents only a small fraction of the phosphate in the Canadian diet, where phosphate is found in many foods, including dairy and meat products and soft drinks.

Phosphate works by forming a protective coating inside water pipes. This coating reduces corrosion and the leaching of lead from surfaces in contact with drinking water.

Corrosion Control Plan Implementation

The corrosion control project is proceeding on schedule with full implementation by the end of 2014, as previously reported in Toronto Water's Public Works and Infrastructure Committee staff report dated February 25, 2013. The estimated capital cost to install the new infrastructure at all four water treatment plants is $8 million. Progress on delivery of key activities is provided in Table 1 below:

Activity	Date	Status
Corrosion Control Plan:		Completed
Submission to MOE	October 2010	
Approved by Council via Lead in Drinking Water Mitigation Strategy	February 2011	
Received and accepted by MOE	April 2011	
Engineering Consultant engaged for design and contract administration	May 2011	Completed
Construction Tender:		Completed
Issued	December 2012	
Awarded	June 2013	
Construction:		
R. L. Clark WTP	March 2014	Commissioned
R.C. Harris WTP	May 2014	Commissioned
F.J. Horgan WTP	Fall 2014	On-going
Island WTP	Fall 2014	On-going
Resume regulatory lead sampling and monitoring	June 2015	On Time

Corrosion Control Testing

During the design and construction phases of the CCP, Toronto Water undertook a series of corrosion control tests to ensure that lead concentrations at the tap were reduced to meet regulations and protect public health. Testing began in December 2011 to confirm the effectiveness of phosphoric acid, optimize how phosphoric acid is applied and anticipate operational issues for full scale dosing. The test program included the use of pipe loops, various bench tests and the use of the pilot plant.

- **Pipe Loops**
  A special pipe rack was installed at the R.C. Harris Water Treatment Plant in 2012 to confirm the performance of the recommended corrosion control measure. The pipe rack is designed as a flow through system that contains several individual lead pipe loops that were constructed of existing lead service pipes harvested from the City's distribution system during lead service line replacement activities. These test pipe loops simulate household plumbing and can used to evaluate lead levels under various operating conditions.

  The pipe loops were conditioned for approximately 6 months so that the lead concentrations were similar to the samples taken at residential taps. Following conditioning, several of the loops received different dosages of phosphoric acid to determine their impact on lead levels.

- **Bench Tests**
  The bench tests are being used to explore phosphate effectiveness under more controlled conditions to help determine if the phosphate dose can be fine-tuned. Other tests have studied phosphate stability in treated water, pH effects, alternative chemicals, temperature effects and disinfection stability.

- **Pilot Plant**
  The R. C. Harris Water Treatment Plant is equipped with a pilot plant which can mimic, at a much smaller scale, the performance of the full-scale plant. The use of the pilot plant allows Toronto Water to test the impacts of various treatment changes on the treated water quality prior to implementing the changes at full-scale.

  The pilot plant has been used to investigate the effects of phosphate addition before and after filtration. Through this work, we have been able to assess how plant operations will be affected by the new chemical system and have developed operating strategies to minimize chemical costs and impacts to the full scale operations.

Figure A-1 below shows some of the results from the lead pipe loop tests. In summary, results from the various tests undertaken by Toronto Water to date indicate:

(i) higher lead levels are observed in warm water compared to cold water, as observed in the distribution system. This trend is also evident following the addition of phosphate but at a smaller magnitude

(ii) a rapid reduction in lead levels was observed a few months following the addition of phosphate

(iii) greater lead reduction levels are observed with higher phosphate dosages

(iv) the addition of phosphate can effectively reduce lead concentrations in drinking water

(v) there may be opportunities to minimize the phosphate dose for further cost savings while still ensuring compliance with lead regulations

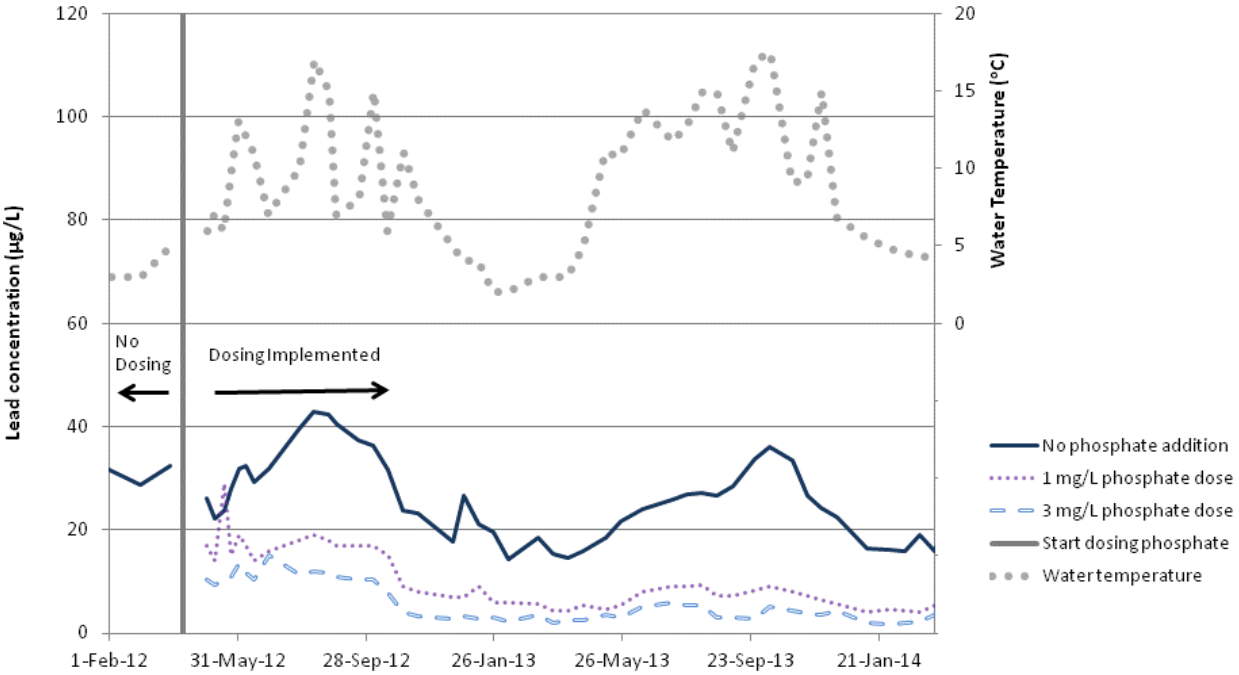

Figure A-1: Lead Pipe Loop Test Results Pre and Post Phosphate Addition

Notes:

1. The lead concentrations measured in the lead pipe loop prior to the addition of phosphoric were higher than those encountered when the pipe was in service in the field. As a result, it is believed that the lead levels post-implementation of phosphoric acid are higher than what would be found in the field.
2. The lead concentration values should not be taken as absolute values but rather used to show a trend of what is to be expected once phosphoric acid is implemented at full-scale.

The pipe loops will continue to operate after full scale implementation of phosphate addition, serving as an easily accessible test location and for phosphate dosage optimization.

Conclusion

Toronto Water has proactively been implementing the Lead in Drinking Water Mitigation Strategy through the continued implementation of its CCP and by undertaking corrosion control studies to estimate anticipated results, optimize the chemical dosing system and address operational issues that may arise.

Based on the results from Toronto Water's corrosion control tests and from other municipalities that have implemented phosphoric acid systems for corrosion control, Toronto Water anticipates being in full compliance with MOE's Regulation 170/03 with less than 10% of its samples exceeding the 10 µg/L lead regulatory limit.

Regulatory lead sampling will resume in June 2015. Due to the complexity of the distribution system, it is anticipated that the phosphate conditioning period can take between 1 to 2 years before full compliance with the lead regulation is achieved. Results from the lead sampling will be reviewed and the performance of the corrosion control system will be assessed and optimized over time in consultation with Toronto Public Health.

Corrosion control will mitigate the potential health risk of lead in drinking water where lead services have not been replaced, and internal plumbing that may contain lead solder joints or brass plumbing fixtures. Lead service replacement alone is not sufficient to achieve regulatory compliance.

Corrosion control is an effective long term solution to mitigate the potential health risk of lead in drinking water while the removal of lead services (both public and private) throughout the distribution system continues over the next few decades. Corrosion control provides health benefits to all Toronto residents regardless of their socioeconomic status and protects against all sources of lead in the water, not just lead service lines.