MINIMIZING WATER QUALITY ISSUES IN DEAD-ENDS THROUGH ‘RIGHT-SIZING OF WATERMAINS – A CITY OF LONDON CASE STUDY

Patricia Lupton, P.Eng.
Dan Huggins

Treated water quality is at its highest when the water leaves the treatment facility, but within distributions systems, water quality can degrade through the loss of disinfectant residual, and through interactions with the pipe wall, especially with unlined iron pipes. Water quality issues can include microbial re-growth, nitrification in chloraminated systems, increased disinfection by-products, and increased metal concentrations through corrosion of pipe walls.

Water quality degradation increases with water age; the longer the water resides in the distribution system pipes, the greater the degradation. Dead-end water mains often experience the greatest water age in distribution systems, with low flow rates and long periods of stagnation. Clearly, greater turnover rates minimize the potential for water quality degradation.

Unfortunately, our distribution systems aren’t designed to maximize water turnover, and minimize water quality issues. Our systems are primarily designed to provide adequate flows for firefighting, as well as providing for seasonal variations in demand and future growth.

But there is no need for fire flow capacity if the watermain doesn’t supply a hydrant. By placing hydrants as far as possible, generally 90 m, from the end of a dead-end main, small diameter pipe can be used between the last hydrant and the terminus of the main. Smaller diameter pipe, e.g. 50 mm, experiences much greater water turnover, and decreases the potential for water quality issues.

Design Options for minimizing water quality issues in new dead-end water mains

The practices and Design Specifications and Requirements in the City of London have evolved over the last number of years. Current requirements for subdivision design include hydraulic modeling of subdivisions to confirm that the water mains are adequately sized to address various demand conditions including Maximum day plus fireflow, peak hour demand and average day demand. It is now a requirement to address water age or water turnover as part of the hydraulic modeling carried out. And more recently the City has implemented practices and standards that require the Developer to address costs of meeting water quality requirements.

In London the hydraulic design for water age must address that water quality is met by meeting requirements for water age to be less than 72 hours under average day demand conditions (or the volume of water in a watermain is turned over in less than 3 days).
Typical design situations in subdivision design and build-out phasing, include the design of cul de sacs, which create a permanent dead end, and extension of mains with a temporary dead end condition, where the main is to be extended as a future phase of the subdivision.

To address the cul-de-sac/permanent dead end situation, design standards have changed over the last several years to require that fire hydrants be located 90 m from the end of cul-de-sac or dead end. The City of London has also changed its minimum municipal watermain size to be 50 mm or 2 inch. Previously the minimum watermain size was 100 mm or 4 inch.

Watermain size is reduced beyond the hydrant so that it meets the water quality design requirements and domestic demand requirements under peak hour and max day requirements, without needing to provide firefighting flow-rates. For situations where watermains were extended, but there was a temporary condition of a dead-end watermain until a future subdivision phase occurs, the developer’s consultant must also model how this temporary situation will be addressed. The City of London Design Requirements have been modified to allow the use of:

- Demonstrating that water quality requirements are met by uses which occur in the earlier phase, or
- Strategic location of valving, i.e. the use of additional valving so that two isolation valves which are closed are located between the temporary dead end and the active system, or
- The use of automatic flushing devices set to discharge water so that water quality requirements are met. It should be noted that the developer must also pay for and install a water meter/meter pit and pay the cost for the installation of the automatic flushing device, and its subsequent removal.

The changes in approach and design specifications have been successful in terms of having the designer/owner give consideration to water quality during subdivision design and build-out.

Addressing Water quality during extension/phasing of the municipal water distribution system

In situations where the municipal system which will have temporary or permanent dead end situation, due to building out and phasing of works, or incorporation of check valve (or PRV) connections, the City of London has utilized temporary or permanent bypass connections to address water quality. An example of a bypass connection around a check valve connection between two different pressure zones, the high level pressure zone and low level pressure zone is shown as Figure 1. Recently the City has started using an appropriately sized flow control valve to regulate the flow volume. In some previous installations where throttled valving had been used to regulate flow volume, the valves and copper piping underwent severe erosion and failed. The City has also begun to measure the flow volume transferred between the pressure zones in installations such as this for the purposes of accounting for the water.
Lessons learned with respect to the use of Automatic Flushing Devices

1) Billing system couldn’t originally accommodate water meters which did not have a municipal address. Changes were made to the billing software so that bills/accounts could be created for locations that didn’t have a municipal address.

2) Make sure that the information indicating the discharge settings/run times gets communicated through to the field staff that will install and inspect installations. We had some problems initially as the consulting engineers prepared reports and calculations for the setting of the automatic flushing devices. However these tended to be submitted during “design studies” stages of the development application process, and were not making it through to contractors and inspectors who actually needed this information. Changes were made to include settings for the automatic flushing devices on the subdivision drawings.

3) Where the automatic flushing device discharges to matters. Point of discharge is important for environmental impacts. Our standard drawing indicates that the discharge for the device is to the storm sewer. We had discussions with Pollution Control Staff and staff in the Stormwater Management Division in this regard. Chlorine levels for drinking water are below 1.0 mg/l, and typically below 0.8 mg/L. The Waste Discharge By-law indicates a maximum discharge of 1.0 mg/l of chlorine can be discharged to the storm sewer. However it is important to note that it is not acceptable to discharge any chlorine to the natural environment.

Remediation options for minimizing water quality issues in existing dead-end water mains

When watermains are scheduled for replacement through capital replacement programs, London’s new design criteria is applied.

The City of London has also been performing targeted replacement of dead-end watermains in areas when capital main replacements are not planned in the near term. In 2009, the City of London purchased a Directional Drill, which has allowed us to replace dead-end mains with greatly reduced restoration costs. Each summer, 4 to 6 dead-end watermains are being targeted for replacement.

Through these initiatives, over 40 dead-end mains have now been replaced with smaller diameter pipes.
Figure 1: Section and Plan Views of Bypass Connection for a Check Valve Installation between Two Pressure Zones