TORONTO

# STAFF REPORT
# ACTION REQUIRED

# Implementation of Findings from Comparative Analysis of Pipe Materials Study for Large Diameter Transmission Watermains

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| **Date:** | October 19, 2011 |
| **To:** | Public Works and Infrastructure Committee |
| **From:** | General Manager, Toronto Water and Executive Director, Technical Services |
| **Wards:** | All Wards |
| **Reference Number:** | P:\2011\Cluster B\TW\pw11016 |

## SUMMARY

This report recommends City Council approve the use of alternative pipe materials for large diameter transmission watermains. Presently, the standard used by the City of Toronto for large diameter transmission watermains (typically 750mm or larger) is cement mortar lined steel pipe with continuously welded joints, fully encased in poured concrete. This has been the standard pipe material used for large diameter transmission watermains since the 1950s.

The findings of a recent study completed by Cole Engineering Group Ltd. and titled "2011 Comparative Analysis of Pipe Materials Study for Large Diameter Transmission Mains" concludes that although the present City of Toronto standard is very durable, no one pipe material is conclusively better than another. The study recommends that future construction tenders allow multiple pipe materials which meet performance specifications, such as pre-stressed concrete cylinder pipe (PCCP), steel welded pipe, polyvinyl chloride (PVC) pipe, and high density polyethylene (HDPE) pipe.

In addition, it is recognized that critical or high risk locations, require additional protection from external forces. Specifically, all pipe materials may require the additional protection provided by welded or restrained joints and be encased in material (i.e. concrete or special liners) to protect the pipe in geographic locations where failure or damage to the pipe is unacceptable. Examples of these types of areas include, but are not

limited to, locations close to critical infrastructure and other major utilities; significant institutional and commercial neighbourhoods; poor local ground conditions; watercourse and protected areas; and areas without redundancy in the water supply network.

In summary, this report proposes a broader group of pipe materials to be allowed for large diameter transmission watermains, provided they can meet the designed performance standard required in that specific situation, and in locations that are considered high risk or operationally critical, that a standard be developed to provide a higher level of protection to the pipe in those locations thus ensuring safe operations and security of water supply. This approach promotes competition and realizes potential capital cost and construction time savings while ensuring the system performance needs are met.

## RECOMMENDATIONS

**The General Manager of Toronto Water and the Executive Director of Technical Services recommend that:**

1. City Council approve the use of alternative pipe materials for large diameter transmission watermains including (i) pre-stressed concrete cylinder pipe (PCCP); (ii) polyvinyl chloride (PVC); (iii) high density polyethylene (HDPE); (iv) steel; and (v) continuously welded steel pipe with a mortar lining, all designed in accordance with American Water Works Association (AWWA) standards.

2. Should recommendation 1 be adopted, City Council direct staff to:

    a. develop and implement a design standard requiring an additional level of protection to the above noted alternative pipe material in locations and areas of the City that are deemed high risk and where failure or damage is unacceptable; and

    b. identify these high risk locations or areas requiring additional protection during the Environmental Assessment phase and/or the pre-design phase of any specific large diameter transmission watermain project.

3. City Council direct staff to fully implement the above recommendations, if approved, within 90 days of the passing of this report by Council and that this process be applied to all future large diameter transmission watermain projects within the City of Toronto.

### Financial Impact

Approval of the recommendations in this report may achieve potential cost savings on large diameter transmission watermain projects with little or no reduction in the performance of these pipes, while at the same time limiting risk exposure to the City. This will be accomplished by allowing greater competition between several pipe material suppliers that can meet the City's desired performance standards all in an open and transparent bidding process.

It is estimated that the City could conservatively save 5% in the overall bid prices of large diameter transmission watermain projects by allowing greater competition. Bid prices for recent transmission main projects in Toronto range from $10 million to $20 million per kilometre, depending on the diameter size and complexity of the work location. Therefore, for a $20 million per kilometre watermain that is 5km long, the net savings to the City could be in the order of $5 million.

The Deputy City Manager and Chief Financial Officer have reviewed this report and agree with the financial impact information.

## DECISION HISTORY

By adoption of Clause No. 2 of the Works Committee Report No. 2 on February 22, 1977, Metropolitan Toronto Council approved the engagement of Chisholm, Fleming and Associates to undertake the design, general administration and preparation of an evaluation report relating to the construction of a 36 inch (900mm) watermain on McCowan Road from Passmore Avenue to 14$^{th}$ Avenue.

The evaluation concluded that using continuously welded steel pipe with cement mortar lining and concrete encasement was the preferred large diameter transmission watermain system for Metropolitan Toronto.

## ISSUE BACKGROUND

High pressure transmission watermains are a significant infrastructure investment. Bid prices for recent projects in Toronto range from $10 million to $20 million per kilometre, depending on the diameter size of the pipe and complexity of the work location.

Originally, dating back to the late 1800s, the water distribution and transmission systems in the City were constructed with cast iron pipes. By the 1940s, it was recognized that cast iron had several limitations as a pipe material for larger diameter (900mm or greater) sizes required to service the growing Metropolitan area. In the 1950s, the newly formed Metropolitan Toronto government investigated and developed a standard for large diameter transmission watermains which became known in the GTA and Southern Ontario as the “Metro Main”. This standard remains today and is comprised of fabricated

continuously welded steel pipe which has been cement mortar lined on the inside and fully encased in concrete during installation. The technical specifications of the Metro Main are as per the current American Water Works Association (AWWA) Design Manual M11 and AWWA Standard C604. A unique feature of the Metro Main is the use of 200mm to 300mm of concrete encasement to reinforce the steel pipe. The concrete provides added strength to the entire assembly as well as providing long term corrosion protection and a protective barrier against accidental penetrations. Currently, there is approximately 460 km of Metro Main and 60 km of cast iron transmission mains operated and maintained by Toronto Water.

On several occasions, suppliers of other pipe materials have requested their pipe materials be considered as an alternate to the existing standard with potential cost and construction duration benefits to the City. Metro Works (now Toronto Water) has continued to specify the Metro Main standard while adapting to current field construction best practices.

The welded steel watermain system is recognized as one of the best available technologies for high pressure transmission mains within the industry and is currently in widespread use in other jurisdictions such as New York City and the western United States. However, outside of the City of Toronto, the most common large diameter pipe material in use within the Greater Toronto Area is pre-stressed concrete cylinder pipe (PCCP) though other materials such as polyvinyl chloride (PVC) pipe, and high density polyethylene (HDPE) pipe are also used in varying degrees. Where warranted, many jurisdictions apply a level of additional protection through the application of joint support and/or pipe encasement systems.

## COMMENTS

### Comparative Analysis of Transmission Watermain Pipe Materials

In January 2011, staff met with the Ontario Concrete Pipe Association represented by Munro Concrete Products Ltd. to discuss the merits of reviewing the City's existing standard for constructing large diameter transmission watermains. A formal request letter, dated January 12, 2011, was received asking the City to consider using Pre-stressed Concrete Cylinder Pipe (PCCP) for large diameter transmission watermains citing the benefits of shorter and less disruptive construction periods combined with significant capital cost savings.

The City responded in letters dated January 14, 2011 and February 10, 2011 to Munro Concrete Products Ltd. noting that PCCP is currently specified in City contracts in diameters ranging from 400mm to 600mm inclusive within the City's distribution system. However, it was agreed that the City would engage an engineering consultant to undertake an independent analysis of pipe materials for large diameter transmission watermain pipes.

Cole Engineering Group Ltd. (CEG) was retained to carry out the study of pipe materials as they were the lowest bidder from the City's pre-approved Watermain Design Consultants' roster. The terms of reference for this assignment included a comparative analysis on the Metro Main versus PCCP, and other pipe materials including Polyvinyl Chloride (PVC) and High Density Polyethylene (HDPE). The scope of work specified pipe sizes of 900mm, 1500mm and 2100mm in diameter be reviewed.

The Cole Engineering study was completed on October 7, 2011 and includes an analysis of life cycle costs, market price trends for each material, impact of disruption during construction, repair ability, quality control of pipe manufacturing in a plant versus field welding of HDPE and steel pipe, and connection joints for PCCP and PVC pipe. It also provides for an analysis of various geographical areas within the City of Toronto including highly dense urban, urban and green field locations.

The scope of the work included a comprehensive literature review of relevant pipe leakage and failure case studies for large diameter watermains, a review of the local industry with regard to trades and material suppliers, a risk assessment, operation and maintenance requirements, and conclusions and recommendations.

As part of the study, the neighbouring Regions of Peel, York and Durham were asked to provide their recent transmission watermain material and failure histories. The large diameter water transmission mains within all three municipalities (400mm to 2100mm) are pre-stressed concrete cylinder pipe (PCCP) based. All three municipalities indicated an overall satisfaction with the performance and durability of this pipe material. Each jurisdiction has experienced some failures though the numbers of failures has been relatively few when considering the number of kilometres of pipe that have been installed over the past four decades. The predominant causes of failure were either installation related or damage due to external forces.

Toronto Water has been overall satisfied with the performance and durability of the 'Metro Main' system and no failures have occurred.

**Findings of the Comparative Analysis**

The findings of the study completed by Cole Engineering Group Ltd. and titled "2011 Comparative Analysis of Pipe Materials Study for Large Diameter Transmission Mains" is as follows:

- Literature reviews have not produced conclusive data or evidence to prove that one pipe material is superior over other pipe materials based on key performance indicators such as life expectancy, leak rate, and failure rate.

- From a technical perspective, there is no single pipe material that is optimal for all applications. The most suitable pipe materials for a given project should be determined based on the particular requirements of the project.

- For the same type of installation, there is insufficient cost data available from a competitive bid process that can clearly demonstrate the overall cost savings of one particular pipe material as opposed to other pipe materials.

- It is recognized that the additional mechanical protection provided by the "Metro Main" standard in the form of welded joints and concrete encasement has produced a durable system with no pipe failure, but at a cost and construction duration premium.

- Other things being equal, dense urban construction will be more expensive than compared to rural or green field construction.

- There is no competition between suppliers of multiple pipe materials with the City's current practice of pre-purchasing the steel pipe and supplying it to the installation contractor.

By allowing greater competition between several pipe material suppliers that meet the City's desired performance standards, it is estimated that the City could conservatively save 5% in the overall bid prices of large diameter transmission watermain projects. The anticipated financial savings are in part due to reduced construction durations that will also directly reduce public disruption due to construction.

Based on these findings, Cole Engineering Ltd. has made two recommendations as follows:

- The City should allow multiple pipe materials to be included in future tenders, subject to consideration of the vulnerability of the location and/or the risk of failure (i.e. leading to the use of minimum risk pipe material to promote a competitive environment and to realize potential cost saving opportunities).

- The City should develop a risk assessment methodology and a risk matrix for establishing risk tolerance levels for large diameter transmission watermains.

As part of the study, Cole Engineering hosted a Risk Assessment Workshop which included participation from staff of Toronto Water and Technical Services Divisions and several other consulting engineering firms. The goal of the Workshop was to consider the framework for developing a risk assessment methodology and a risk matrix. During the Workshop, it was determined that Toronto has unique areas within the City which require a higher standard of care to reduce potential significant costs and adverse impacts of localized transmission watermain failures and/or damage from external forces. Examples of these types of areas include, but are not limited to, locations close to critical infrastructure and other major utilities; significant institutional and commercial neighbourhoods; poor local ground conditions; watercourse and protected areas; and areas without redundancy in the water supply network.

In these high risk locations, the City will need to specify an additional level of protection for the watermain, specifically that joints of whichever pipe material is submitted in a particular bid be welded or restrained, and the pipe be encased in concrete or protected by some other means (i.e. installed in a steel liner filled with grout). This will protect the pipe from catastrophic failures and other external forces such as augers and excavating equipment thereby reducing risk while extending the life expectancy of the pipe. The various design engineers, consultants or City staff assigned to individual projects will determine the necessary performance requirements and establish the additional levels of protection in "high risk" areas during the Environmental Assessment phase and/or the pre-design phase of any specific project.

In summary, the practice of specifying only welded steel concrete encased pipe in transmission watermain contracts reduces the number of bidders, eliminates competition, and has the potential to increase the cost of large transmission watermain projects. Engineered products using other materials can produce watermains that have the ability to meet the City's performance standards for large diameter transmission watermains at potentially lower costs and reduced construction duration.

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