CBCL LIMITED
Consulting Engineers

City of Saint John, New Brunswick

Safe, Clean Drinking Water Project

Canadian Consulting Engineering Awards 2017

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Owner's Engineer Team

CBCL LIMITED
Consulting Engineers

OPUS

Robinson Consultants

carollo

NCE

Kierstead Quigley and Roberts Ltd.

Conquest Engineering
Experience commitment.

DALHOUSIE UNIVERSITY

The OE team was comprised of more than 60 professional engineers from eight organizations, spanning a wide range of engineering disciplines and technical expertise.

PROJECT SUMMARY

Saint John, NB has commenced a transformational greenfield / brownfield upgrade project on its water system, one of the oldest in North America dating from the 1830's. As Owner's Engineer, CBCL Limited developed the "Blueprint" for the Safe, Clean Drinking Water Project (SCDWP) under the Public Private Partnership (PPP) model. Leveraging a unique, affordable procurement strategy, the SCDWP delivers water quality and public health improvements to consumers years earlier than would otherwise be possible.

City Works Crew (circa 1920)

Project Scope

Saint John is supplied with water from two interconnected distribution systems, East and West, divided by the Saint John River. The City's customer base includes the residents, commercial, institutional, and large industrial customers. The SCDWP, valued at approximately $215 Million, includes the following:

Design-Build-Finance-Operate-Maintain (DBFOM) concession model over 30 years for a 75 MLD Water Treatment Plant (WTP) and 33 ML of storage;

Design-Build-Finance (DBF) model -

- **Transmission system upgrades including installation of 13.6 km of new water transmission mains ranging in size from 500 mm to 900 mm in diameter to provide a secure supply of potable water to customers and separate the treated water supply from a dedicated raw water industrial supply;**
- **Rehabilitation of 10.2 km of 1800's vintage 600 mm diameter cast iron mains utilizing trenchless technologies;**
- **Development of a new Groundwater supply for West Saint John – 12.5 MLD;**
- **Water Source Improvements - Concrete and Earth Dam rehabilitation and Intake structures.**

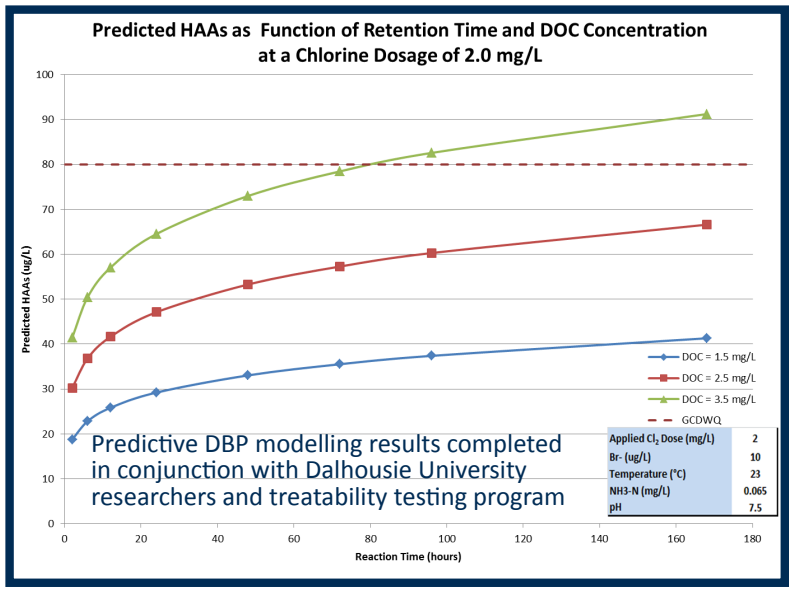
INNOVATION

The PPP model offered several advantages for the City – chief among was the fact that safe, clean drinking water would be available to customers much sooner than would otherwise be possible.

Upon selection as the Owner's Engineer, the CBCL team immediately began addressing the issues of project scope, risk transfer and technical compliance, issues that must be clearly resolved if the PPP model was to be used and the benefits achieved. What risks are best transferred to the private sector? What are best retained by the owner? How could the upgrades be integrated into the existing water system while allowing continued delivery of potable water to its customers?

After considerable study several key decisions were made that cumulatively resulted in a unique and innovative approach to the project including:

- Deliver the WTP and reservoirs via a design-build-finance-operate-maintain (DBFOM) concession.
- Deliver the transmission and source water upgrades via a design-build-finance (DBF) procurement.
- Make proponent responsible only for water quality leaving the WTP and leave distribution system water quality with the City.
- Carry out rehabilitation of key sections of linear infrastructure via trenchless technology.

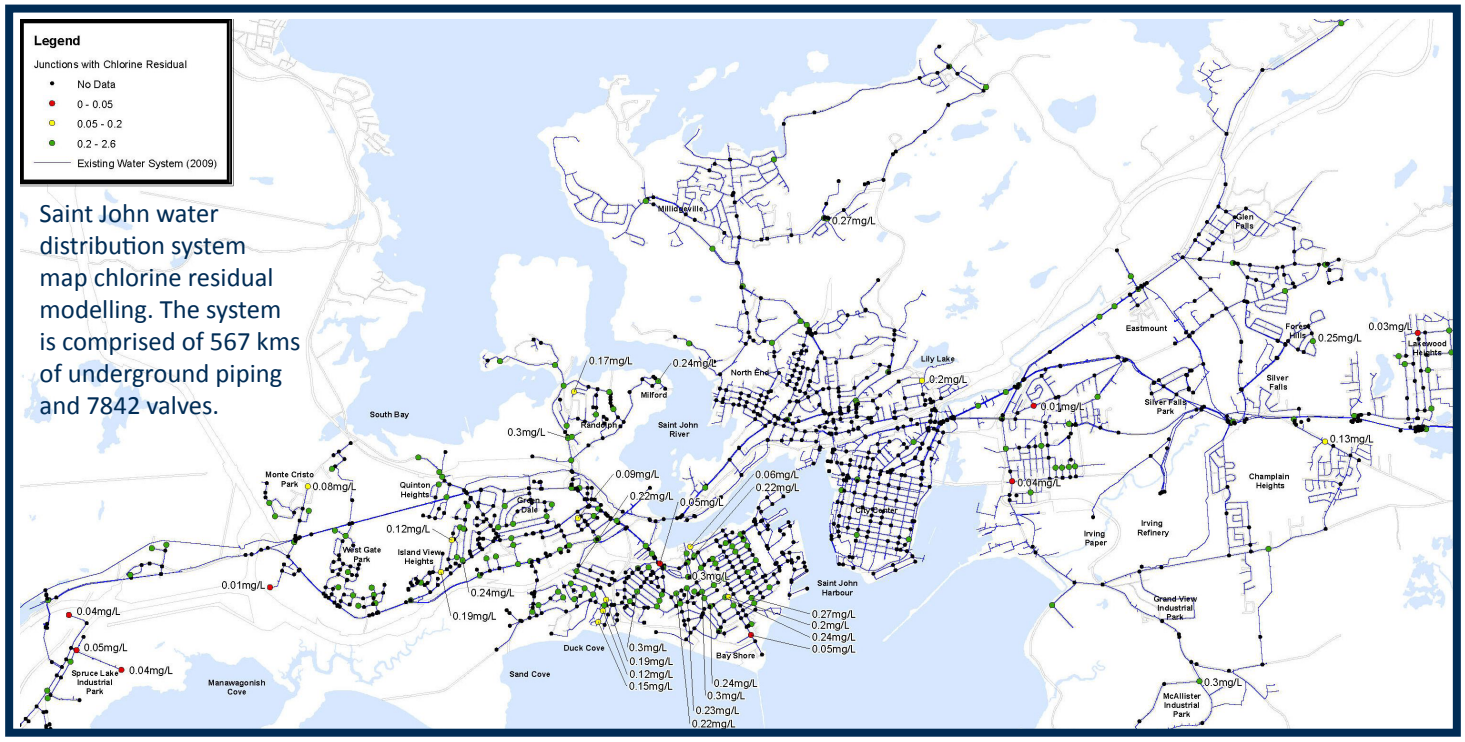


Predictive DBP modelling results completed in conjunction with Dalhousie University researchers and treatability testing program

Allowing major components of the project to be delivered under different procurement strategies (DBFOM and DBF) was untested in the Canadian market. This required unique and innovative approaches to defining the project technical requirements.

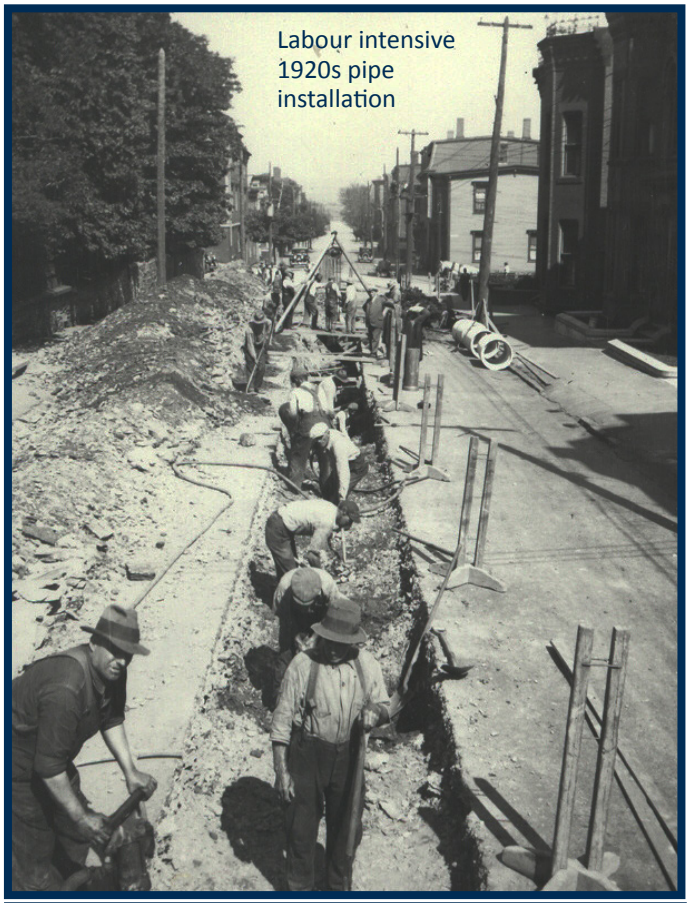
A predictive modelling tool was developed (utilizing testing done in conjunction with Dalhousie University) to assess water quality evolution in the complex distribution system. This allowed the compliance limits to be set at the WTP fenceline, a unique contractual and technical approach in Canada. Water quality project requirements were focused at the WTP site. Proponents indicated reluctance about taking on water quality risks in the transmission/distribution system. Water quality at the fence line was fundamental to their acceptance of the project risks and entice them to bid the project.

Allowing much of the transmission and distribution work to be carried out via trenchless technology greatly reduces the negative traffic and commercial impacts to the community. The size and age of many of the pipelines to be replaced makes this an innovative application for reuse. Delivering the required transmission system upgrades via a DBF approach was embraced by both the proponents and the City as it allowed leveraging the local construction resources of the private sector in one large contract for all the distribution system upgrades while maintaining overall City operational responsibility.



Saint John water distribution system map chlorine residual modelling. The system is comprised of 567 kms of underground piping and 7842 valves.

COMPLEXITY



Labour intensive 1920s pipe installation

The City has never had water treatment beyond chlorination of surface water. Following the SCDWP, water quality in the City will be transformed. Assessing the probability of unintended negative impacts from changes in water quality is technically complex.

Determining rates of buried pipe corrosion, degradation of existing tuberculation, and disinfection by-product (DBP) formation under changing water quality in very old infrastructure presents complex risks.

The project will integrate state of the art water treatment processes with pipes that have remained unchanged for 150 years - comparable to building a high rise building over a wooden structure built by the nation's founders.

The team conducted experiments on water mains harvested from the network to evaluate the nature and stability of existing pipe lining, and measure the impacts from treated water parameters. The outcomes were incorporated into the corrosion control strategy of the project requirements.

CBCL completed extensive treatability testing through Dalhousie University. The disinfection by-product (DBP) modelling focused on identifying surrogate parameters for DBP formation to predict DBP's in the distribution system. Surrogates must be sensitive enough to reflect distribution system chemical reactions, while also being accepted by industry.

Final project documents utilize a combination of organic matter indicators, including dissolved organic carbon, UV absorbance, and color as surrogates for DBPs.

The project requirements ensure the maintenance of the existing water system and transportation corridors during construction, while minimizing interruptions to businesses and residents. With upwards of a dozen construction sites across the City, this required complex consideration of construction sequencing.

Modern pipe laying techniques on some of the large water transmission main interconnections

Interior condition of 80 year old cast iron watermain in the city system

SOCIAL AND ECONOMIC BENEFITS

Water transmission main installation (1930s)

The SCDWP will improve public health, remove potentially harmful pathogens through filtration and treatment, reduce disinfection by-products (DBP), provide corrosion control, and minimize water loss. This project will enable these benefits to be delivered to customers years earlier than would have otherwise been possible representing a substantial benefit to the community.

Structural lining of 1850's cast iron water mains ensures developed brownfield water main utility corridors experience minimal service disruption to customers. The "Social Costs" of intrusive linear excavation in an urban environment are minimized with the structural rehabilitation of 10.2 km of old cast iron mains.

The SCDWP is currently the largest active water infrastructure project in the Maritime region. The local labour force has benefited greatly from the project. The SCDWP is projected to create 250 person-years of employment during construction and more than 200 person-years during the 30 year operating period.

Saint John, Canada's first incorporated City, is a vibrant tourism destination and a major port of call for cruise ship traffic. Through public education, Saint John aims to encourage responsible and sustainable water consumption by promoting conservation. Consumer confidence will be gained as local residents, businesses and visitors to Saint John will safely rely on the water supply.

Water main replacement

Water sampling characterization of environmentally significant areas

Structural relining of existing 1850s vintage cast iron water mains with high density polyethylene pipe

ENVIRONMENTAL BENEFITS

Water transmission main installation using a cable excavator (1930s)

The importance of protecting the environment during construction and operation of SCDWP is a priority for Saint John. The SCDWP corridor extends approximately 30 km across the City from the Loch Lomond watershed in the East to the Spruce Lake and Musquash watersheds in the West. The CBCL team completed an Environmental Constraints Assessment across the City that established a baseline of valued ecological features that could potentially interface with the SCDWP. These features included bird sanctuaries, wetlands, watercourse crossings, geological features, population density, highways, railroads, trails, and recreation areas. Field work was performed for wetland delineation, fish and fish habitat assessments, bird studies, and flora / fauna studies.

Water quality sampling

The SCDWP leverages trenchless technologies for water transmission main rehabilitation to minimize:

- Excavation, backfilling and reinstatement requirements;
- Carbon footprint and greenhouse gas emissions;
- Social and environmental impact to residents.

The potential impacts to recreation areas such as the Little River Reservoir adjacent the new WTP, and interruption of service to local business, institutions, and industry were factored into the project Technical Requirements and Key Performance Indicators (KPIs). For example, the WTP employs a near zero liquid discharge of waste stream residuals to protect the receiving waters and downstream sewer collection systems.

As part of the Quality Management Systems (QMS) for the project, an Environmental Management System was established to monitor construction activities and potential impacts to environmental features.

Fish habitat assessment

MEETING CLIENT NEEDS

Water transmission main installation near the City's water source (early 1900s)

The new water treatment plant under construction

Saint John live stream:
https://www.youtube.com/watch?v=XkDuGj-eCnY

To meet the Client's needs as the Owner's Engineer, the CBCL team was responsible to:

- Clearly define Technical Requirements of the SCDWP,
- Identify and allocate the key project risks,
- Preserve and enhance the level of competition and innovation,
- Minimize disruption to customers and stakeholders during construction,
- Develop requirements that satisfy the affordability threshold.

Technical Requirements were prepared to provide sufficient flexibility to allow private sector innovation and potential cost savings, while ensuring the process complies with all water quality requirements and protects the City from undue risk. Testing programs, such as bench-scale and treatability testing, satisfied the needs of the client to predict future outcomes related to water quality after project completion.

Technical requirements for facilities including the WTP were based on a "post-disaster" designation requiring a more stringent design approach. Building envelope requirements consider energy efficiency. Quality and Integrated Management Systems requirements including the ISO 50001 Standard for Energy Management to improve energy performance were developed. The WTP is required to have an effective thermal resistance that exceeds the model National Energy Code of Canada by a minimum of 25%.

Saint John required assurance that the SCDWP could be constructed within 36 months with a scheduled completion late 2018. The OE team developed a project sequencing plan to ensure the project could be constructed and commissioned within the stipulated project schedule. The OE team's understanding of the local conditions and project requirements minimized project risks such as corridor routing, conflicts with existing infrastructure, and service disruption to water customers.

Owner's Engineer Team activities

- **Surveys, Investigations and Data Collection to map existing infrastructure;**
- **Hydraulic modeling of the water system;**
- **Preliminary design development and cost estimates for major water system upgrades including source improvements, water treatment, storage, intakes, pumping, and transmission;**
- **Constructability review and preliminary routing of SCDWP components;**
- **Water quality analyses, water treatability testing, and corrosion control testing in the distribution system;**
- **Water system storage analysis;**
- **Review of trenchless rehabilitation options for reuse of 1800's cast iron water mains;**
- **Development of project sequencing minimizing service disruption to customers;**
- **Identify environmental features along project corridors;**
- **Geotechnical investigations;**
- **Legal surveys and review of easements and available lands**