KGS GROUP

2023 CANADIAN CONSULTING ENGINEERING AWARDS

Cockburn Sewer Relief Project

Over several years, KGS Group has successfully worked with the City of Winnipeg to study, design and implement district-wide drainage improvements in combined sewer neighbourhoods prone to basement flooding and sewer overflows to the environment.

The Cockburn Sewer Relief Project was a complex, $100 million sewer separation project located within a densely populated commercial and residential urban neighbourhood. KGS led a large multidisciplinary team to take the project from initial concepts to practical implementation with great success. State-of-the-art tunnelling technologies were used for the first time in Manitoba to address the project's unique requirements.

BACKGROUND

Combined Sewer Systems

Combined sewer separation is a challenge facing many communities as they strive to reduce sewer overflows and basement flooding caused by aging and undersized sewer systems and more extreme weather events from climate change.

Combined sewer systems are designed to collect both land drainage (rainwater and snowmelt) and wastewater (sewage from homes and businesses) in the same pipe. Commonly, combined sewer systems transport all the land drainage and wastewater to a sewage treatment plant, where it is treated and then discharged to the river. However, during periods of heavy rainfall or snowmelt, the additional volume can exceed the capacity of the sewer system. When this happens, combined sewer systems are designed to overflow and discharge the excess volumes of diluted sewage directly to the river to reduce the likelihood of basement flooding.
These overflows, called combined sewer overflows (CSOs), contain not only land drainage, but also wastewater and debris. Additionally, when combined sewers are overloaded, basements are at risk of flooding which can result in damage to private property.

The environmental and socio-economic impacts of CSOs and basement flooding are noteworthy including releases of diluted sewage to local river systems, loss of property, construction and repair expenses, hazardous health conditions of homes and increases to insurance premiums.

The Assignment

The City of Winnipeg commissioned KGS Group, with assistance from sub-consultant Jacobs, to evaluate the basement flooding and combined sewer overflow issues in the Cockburn West and Calrossie Sewer Districts, two of the city's 43 combined sewer districts with the lowest level of service in the City of Winnipeg (~22 annual CSO events per year). The scope also extended into a portion of the adjacent Southeast Jessie District that was previously separated in the 1970s.

In addition, the goal of this project was expanded to address new provincial regulations, imposed through Environmental Act (EA) License No. 3042, that requires the City of Winnipeg to capture an average of 85% runoff across all their combined sewer districts by 2045. This work has an estimated cost of $2.3 billion (in 2019 dollars).

This project focused on optimizing the degree of sewer separation to address both the local needs of the Cockburn and Calrossie Sewer Districts and the city-wide goal driven by EA License 3042.

Concrete pipe ready for install

THE SOLUTION

District-Wide Hydraulic/Hydrologic Modelling

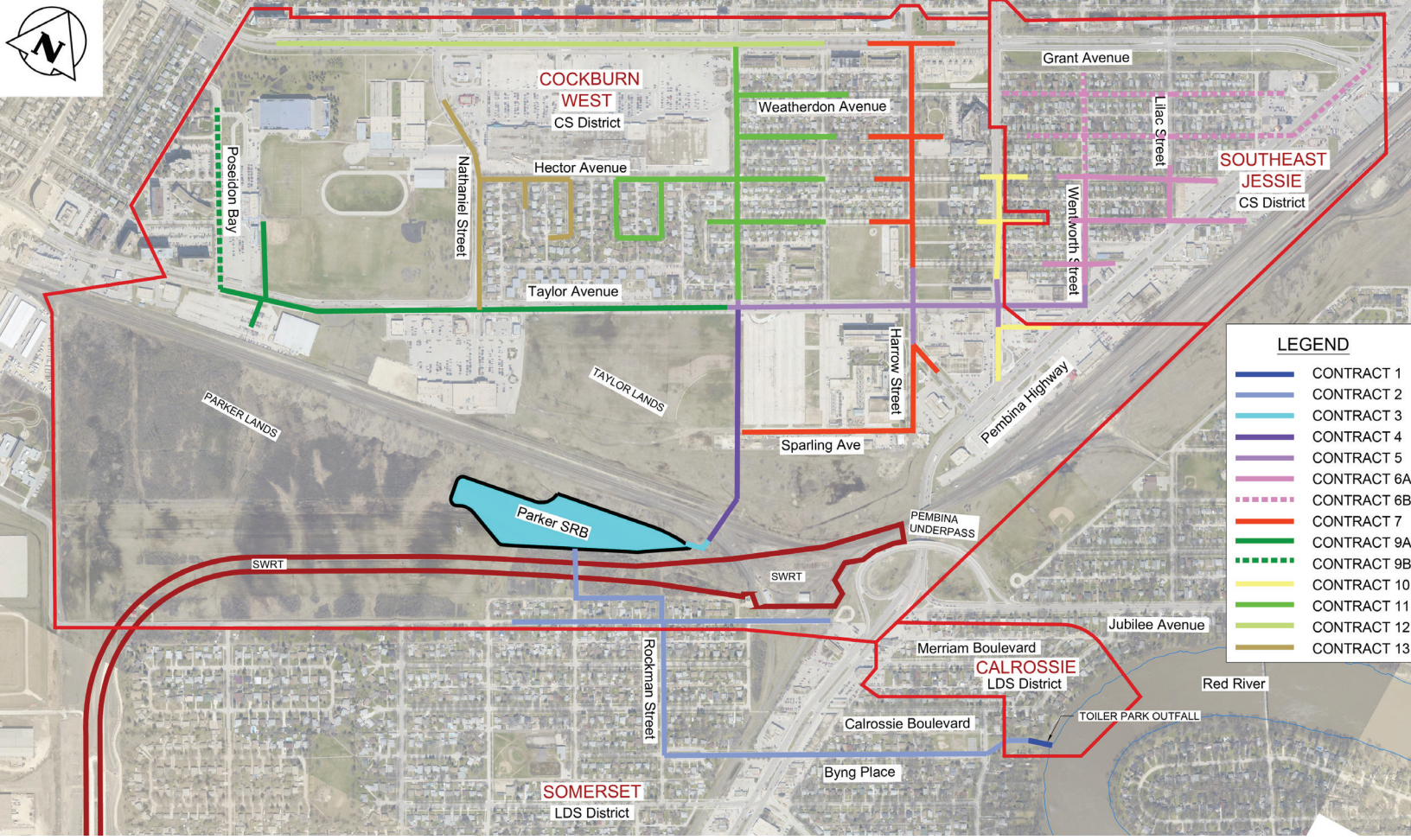
A district-wide hydraulic/hydrologic model was developed to evaluate the extent and capacity of a new land drainage sewer system. This new drainage system would provide combined sewer separation, reduce basement flooding and combined sewer overflows, and limit design pipe diameter sizes and overall project costs. The model was developed for the entirety of the Cockburn and Calrossie Sewer Districts as well as the Southeast Jessie Combined Sewer District, using both SWMM and InfoWorks ICM software, and evaluated both stormwater and wastewater inflows.

The model also considered the stormwater runoff from future private developments in the undeveloped Parker Lands (south of a CN rail line) and Taylor Lands (north of the CN rail line) as well as the runoff from the then planned Southwest Rapid Transit Project that extends through the Parker Lands. The pipe network within the model was sized to accept the additional stormwater runoff anticipated from these future developments.

New Land Drainage Sewer System

These preliminary assessments found that total separation of the existing combined sewer system was the most practical solution to achieve the required level-of-service and combined sewer overflow reduction goals in the two districts. This involved removing all storm water inputs from the existing combined sewer and connecting them to a newly constructed land drainage sewer (LDS) system. The resulting diameter of the trunk sewer (or main collector sewer) to handle the conveyance of the storm water flows for the selected total separation scheme was 2,700 mm. Tunnelling and trenchless technologies needed to be used to implement this design and limit disruption within the dense urban community.

Pipe jacking with tunnel boring machine



Cockburn and Calrossie Sewer Districts construction contract breakdown

13 Contracts

KGS Group provided design, contract administration and construction supervision for 13 construction contracts developed to stage the work and address the various project goals. This included reducing basement flooding and combined sewer overflows, minimizing construction impacts, replacing public assets where feasible and fostering further development in the project area.

STATE-OF-THE-ART TUNNELLING TECHNOLOGY

State-of-the-art tunnelling technology was used for construction of the new trunk sewer (main collector pipe) because the required pipe lengths, pipe diameters and site constraints were well outside the capabilities of conventional installation methods. While this technology has been used in some areas of Canada, it had not been used in Manitoba or within the area's unique soil conditions before. This project was the first large-diameter pipe project in Manitoba to use microtunnelling and two-pass tunnelling technology, and the first tunnelling project to include a reverse S curve alignment.

Hundreds of metres of trunk sewer were installed using tunnelling and trenchless technologies within tight rights-of-way, minimizing impacts to neighbouring buildings, rail lines and existing surface infrastructure such as roads and sidewalks. The overall project included 15 km of new sewers, with 9 km installed using various tunnelling technologies including microtunnelling, two pass tunnelling and pipe jacking with rotary tunnel boring machine (TBM).

The Cockburn Sewer Relief Project introduced several new design and construction technologies and innovations to the City of Winnipeg including:

- First large diameter microtunnelling project in Manitoba (2,700 mm dia. tunnel)
- First use of two-pass tunnelling and CCFRPM piping in Manitoba
- Geotechnical baseline reports – first time application in Manitoba
- Risk sharing construction contract strategies to reduce capital costs
- Settlement analysis, design and construction monitoring for large diameter tunnels in clays
- Redevelopment of an historic rail yard into a storm retention basin and new public park space

Lowering the tunnel boring machine into the launch shaft

CHALLENGES OVERCOME

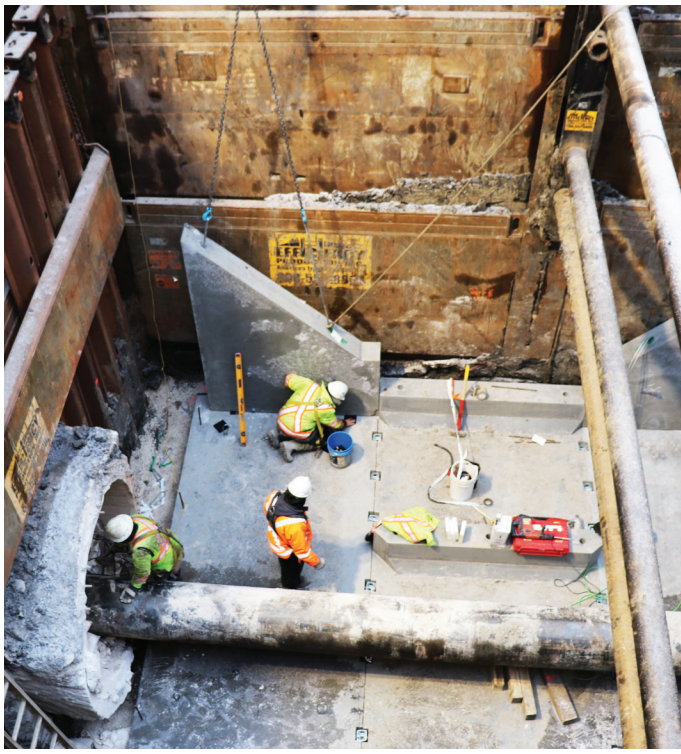
The KGS design team overcame several complex challenges associated with large diameter tunnelling through a fully developed neighbourhood. These challenges included restrictive rights-of-ways, unique soil conditions, sensitive utilities, overhead transmission lines, vertical conflicts, proximity to businesses and residences and site laydown requirements.

Another challenge was navigating the impact of tunnelling on sensitive utilities, high-traffic CN railway main lines and adjacent buildings. Careful planning and settlement monitoring was required at every stage of the project. The design team imposed strict settlement tolerances and developed a stringent construction monitoring program that included arrays of surface and sub-surface monitoring points, utility monitoring points, building monitoring points and vibration monitoring sensors.

Taylor Avenue site development and launch shaft: The alignment of the tunnel drive was constructed near Manitoba Hydro transmission lines, private residences and businesses, and required crossing below critical infrastructure.

Reverse S Curve Alignment

One of the most complex challenges was to design an unconventional pipe alignment with a complex horizontal and vertical curve (reverse S curve). This complex curved alignment was necessary due to infrastructure conflicts, changing right-of-way widths along the tunnel path and buried infrastructure that supports a critical Manitoba Hydro facility. There also were vertical conflicts with an existing gravity wastewater interceptor sewer that required an innovative solution including a first-of-its-kind, pre-cast pass-through chamber. The chamber modified the pipe from a round pipe to a shorter/widened pipe providing the equivalent flow capacity while lowering the pipe elevation to facilitate tunnelling work. The tunnelling design to address these challenging alignments required an exceptional understanding of the tunnel boring machine (TBM) cutting head design for expected soil conditions, skin friction on pipe string and thrust, settlement from overcut, steering/curvature capabilities, laydown requirements and equipment loading.



Passthrough chamber floor construction

SOCIAL AND ECONOMIC BENEFITS

The sewer districts in this area regularly suffered from both basement flooding and untreated sewage overflows to the Red River. Because of this, the socio-economic impacts were significant including loss of property, construction and repair expenses, hazardous health conditions of family homes and increases to insurance premiums. This project helped mitigate these social and economic impacts through the design and construction of a completely separated system that reduces basement flooding and sewage overflows.

Aiding Future Development

The new trunk sewer also provided additional storm water capacity to support current and future development. As an example, the Taylor Avenue area is a densely populated neighbourhood, with many successful businesses. This area will see significant commercial and residential growth in the coming years, and because of the work done by KGS and the added infrastructure, that growth can now occur.

Minimizing Disruption to Residents and Businesses

In addition to the project benefits, the design incorporated several innovative techniques to minimize disruption to residents and businesses during construction. State-of-the-art tunnelling technologies were used to minimize the impact to roads and sidewalks throughout the project area. For example, on busy Taylor Avenue, manholes were installed in small diameter shafts so that the majority of the work could happen within the tunnel, avoiding large excavations on this regional street. To further limit surface disruption, trenchless methods, manholes and stub out connections were used to connect from side streets underground to the main trunk tunnel. Traffic continued to flow and businesses could continue to operate as normal during construction because of the advanced design considerations done by KGS.

ENVIRONMENTAL BENEFITS

Prior to the project, combined sewer overflows from the Cockburn Sewer District to the Red River occurred an average of 22 times per year, releasing diluted sewage to our local river systems. In line with the fundamental basis for the project, the Cockburn Sewer Relief Project addressed the local needs of these sewer districts and contributed to the city-wide goal of eliminating most combined sewer overflows.

Naturalized Storm Retention Basin

In addition, a naturalized storm retention basin was constructed on the downstream end of the system ahead of the river outfall. This storm retention basin provides settlement of sediment, reducing impacts to the river. The naturalized water planting within the storm retention basin provides nutrients that further improve water quality.

Addressing a Former Railyard

Furthermore, one of the contracts involved work within a former CN railyard. The KGS project team developed an environmental soil sampling and testing plan to determine if contaminated soils were present. This prepared the team if any of the excavated material needed to be transported to a soil treatment and processing facility (rather than a conventional landfill). The plan included collecting and testing samples for metals analysis (metals, polycyclic hydrocarbons and petroleum hydrocarbons). While the tested soil samples did not exceed guideline levels, adjacent soils within the historic rail yard and soils removed from beneath the current CN rail lines during tunnelling could potentially have higher concentrations. As such, the project team developed provisions within the construction contract for onsite environmental testing and sampling of the soils, and proper disposal of contaminated soils if identified during construction.

MEETING CLIENT NEEDS

The project team employed several modern management practices to ensure that the selected solution met the client's needs in an economical and functional manner. The project was completed on schedule with no loss of service or impact to existing critical infrastructure. While projects of this magnitude often carry a significant cost, the project's scope, constraints and associated risks were well defined and this project was delivered within the City's expected budget.

In addition, utility owners, various City of Winnipeg departments and nearby property owners were all consulted throughout the design and construction phases of the project. Together with the City, KGS identified and successfully navigated several stakeholder concerns and issues that included access/egress to properties, development of an alternate active transportation route, impacts to buildings, services and buried infrastructure, relocation of private utilities, and noise and light pollution from 24-hour operation.

Challenges experienced from design through construction were addressed and mitigated by KGS Group's innovative, multi-disciplined engineering designs, high-level project management and resident engineer's quality assurance.

The final result protects two of Winnipeg's combined sewer districts from property and environmental damage. Furthermore, the KGS team's exploration and use of advanced tunnelling technologies bolsters the local market's ability to accommodate new and exciting infrastructure possibilities for years to come.