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Saskatoon Water Intake & Pump Station

Saskatoon, Saskatchewan

Lead Engineering Consultant : Associated Engineering

Owner/Client: City of Saskatoon
Utility Services Department

Subconsultants: Crosby Hanna & Associates
Ewards Edwards McEwen Architects
Golder Associates
Northwest Hydraulic Consultants

Associated Engineering | GLOBAL PERSPECTIVE. LOCAL FOCUS.

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Saskatoon Water Intake & Pump Station

Executive Summary

The City of Saskatoon's new Water Intake and Pump Station provide safe and secure drinking water to support the City's future population and economic growth.

The facility meets the federal Department of Fisheries and Oceans' strict regulations for design and construction of river intakes to protect aquatic life and habitat.

Displaying ingenuity, the Associated Engineering team identified an existing, in-river, deflection spur as the best location for the intake and pump station. This location resulted in less river disturbance, making an in-river design viable. Building the facility on the spur alleviated bank stability issues associated with siting the facility on the riverbank.

After reviewing several technologies, the team recommended a unique, in-river, wedge-wire drum screen. Using such screens in cold weather regions and in fast-flowing rivers like the South Saskatchewan River is a departure from conventional water intake designs which typically use mechanical travelling screens and fish return systems. The in-river, static, drum screening system design eliminates the need for fish handling and return systems that could result in fish mortality. Drum screens have no moving parts, are removable, and can be easily cleaned, thus reducing operation and maintenance costs. Drum screens sit in a deep, self-scouring channel, which mitigates sand deposition.

The team developed a three-dimensional, computational fluid dynamic (CFD) model of the river and facility. The model demonstrated to DFO and Transport Canada that the design would not have detrimental effects on aquatic life.

We also developed a physical model, which confirmed that velocities across the screens prevent sedimentation, fish impingement on the screens, and potential fish mortality. Physical modelling helped to develop a design to minimize swirl potential at pump inlets and optimize pump efficiency.

The City of Saskatoon's new Water Intake and Pump Station project demonstrates the successful implementation of an in-river project, meeting regulatory requirements, minimizing environmental impacts, and helping to secure a safe and reliable water supply for the future.

Introduction

Located in central Saskatchewan, the City of Saskatoon is the province's largest city, with a population of 239,000. In recent years, the City of Saskatoon has experienced significant population growth, spurred in part by the potash industry, as well as the expansion of oil, coal, and diamond production throughout Saskatchewan. As a result, population growth has taken off in Saskatoon. Saskatoon's population is projected to reach almost 390,000 by 2032.

A secure water supply is paramount to support economic development and population growth. For decades, the City of Saskatoon has leased its water supply from the SaskPower Corporation. With a growing population and to support continued economic development, the City's long-term infrastructure development plan identified a new, City-owned water supply system as essential to sustain future growth. The City retained Associated Engineering to provide planning, design, construction, commissioning, and project management services for a new water intake and pump station.

Background

The City of Saskatoon receives its drinking water supply from SaskPower Corporation's Queen Elizabeth Power Station. SaskPower has an intake and pump station at the Queen Elizabeth Pump Station. Water is withdrawn from the South Saskatchewan River through this intake, and pumped three kilometres upstream to the City's Avenue H Water Treatment Plant. Over the years, the water intake and pump station grew increasingly inefficient and lacked sufficient capacity to meet the City's long-term water demand.

Project Objectives

The City's primary objective was to develop a secure water supply for the city and surrounding area that could support the community well into the future. To achieve this, Associated Engineering's role included:

- Obtaining regulatory approvals for a new water intake, pump station, and pipeline
- Providing assistance with obtaining necessary land holdings, easements, and legal surveys
- Assisting with siting a new intake and pump station
- Completing detailed design, tendering, construction services, start-up and commissioning services
- Assisting in pre-purchasing major equipment
- Assisting to maintain the existing operations at the water treatment plant during tie-ins
- Minimizing environmental impact of the new works.

Project Challenges

The main project challenges included identifying a suitable water intake location on the South Saskatchewan River, identifying the appropriate intake and screening technology, and minimizing environmental impact of the new works.

The siting and design of the intake had to meet the federal Department of Fisheries and Oceans (DFO)'s stringent regulations governing river intake projects to protect aquatic life, wildlife, land, and the environment. Current regulations prevent the following:

- Any harmful alteration, disruption, or destruction of fish habitat
- Deposition of deleterious substances in water frequented by fish
- Construction of any work through or in any navigable water without approval
- Killing species and damaging residences of listed species

Regulations also require the following:

- Environmental impact screening assessment to the development of all public land
- Limited construction windows and limits on the amount of the river's width that can be obstructed during construction.

DFO established design criteria for maximum intake screen approach velocity and maximum intake screen slot width to minimize impact on fish. DFO preferred in-river screening to eliminate the need for any form of fish handling system. The overall screen area needed to be large to produce the required low-flow velocities, while also ensuring a minimum depth below ice cover when the river level was at its minimum level.

A number of site issues compounded the challenge of siting a new water intake. Due to bank stability issues, siting an intake on the riverbank would pose significant issues for the design of the building foundations. The geotechnical consultant also identified potential for landfill leachate on the west bank of the river.

The South Saskatchewan River has a natural high silt load that causes sand deposition throughout the river basin; this would impact an in-river intake solution. Also, cold weather conditions create the potential for frazil ice to block the fine slotted screens.

In addition to federal requirements, the design team also had to obtain approvals from provincial, regional, and municipal agencies. The project required approvals from eleven different agencies, including:

- Department of Fisheries and Oceans
- Transport Canada (Navigable Waters Protection Branch)
- Saskatchewan Heritage Resources
- Saskatchewan Watershed Authority
- Saskatchewan Ministry of Environment
- SaskPower Corporation
- Saskatchewan Agriculture and Food
- Meewasin Valley Authority
- Rural Municipality of Corman Park
- City of Saskatoon
- Community Planning

The design of the intake had to consider the City's plan to construct a new water treatment plant in the future. Ideally, the City wanted one intake and pump station that could be expanded to serve both the existing Avenue H Water Treatment Plant and the planned East Side Water Treatment Plant.

Project challenges included identifying intake location, developing screen design, minimizing environmental impact, & coordinating with multiple stakeholders.

Solution

Siting Intake

The design team assessed seven prospective sites for the intake, in consultation with the City, DFO, and Transport Canada. The selected site was the tip of an existing river deflection spur that had been constructed to protect the riverbank. The spur protrudes from the east bank of the South Saskatchewan River, and is located directly across from the Queen Elizabeth Pump Station, which would facilitate connection to the pipeline to the Avenue H Water Treatment Plant. The spur was located on a secondary thalweg (low point) in the river, making it a good location for an in-river intake.

To confirm the location would not adversely affect river flow conditions and operation of the existing Queen Elizabeth Pump Station, subconsultant Northwest Hydraulic Consultants constructed a full scale, full width, river bed physical model based on bathymetric and river valley surveys. Using the model, the team could assess impacts at various river flow conditions. The model showed that the position of the intake on the spur, with an upstream wing wall would ensure scouring conditions sufficient to keep the in-river screen area free from sediment build-up. The model also demonstrated to SaskPower that flow conditions across the existing pier intakes

at the Queen Elizabeth Pump Station would not be adversely affected.

Department of Fisheries and Oceans (DFO) personnel also witnessed the model, which confirmed that fish habitat in the area of the new facility would not be disrupted by long-term sedimentation caused by modifications to the spur.

Selected intake site reduces impact on fish habitat.

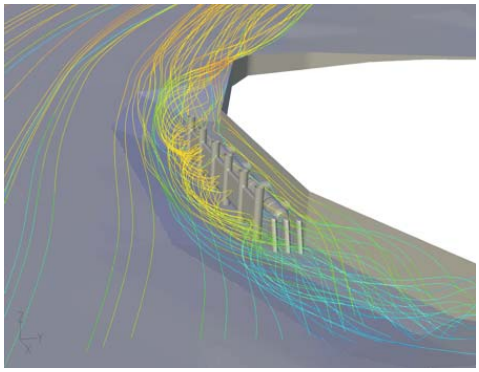
Intake Design

After review of available screening systems, the team recommended in-river, cylindrical, drum screens, which eliminates the need for fish handling equipment. Four, 1.5 metre diameter by 5 metre long wedge-wire drum screens are installed on slide rails so that they can be easily removed. Screens are located at the west end of the facility, below a portion of the building which extends out over the river.

This unique configuration allows the screens to be lifted up into the building through large floor hatches.

When in operation, the screens sit in a deep, self-scouring channel which provides a deepened area, and mitigates sand deposition in the area of the screens. The design reduces silt loading to the water treatment plant compared with other types of intakes. Upstream concrete bollards protect the screens from large debris while also conditioning the flow pattern across the screens.

The team developed a three-dimensional, Computational Fluid Dynamic (CFD) model of the river and intake screens to demonstrate to regulatory authorities that the screen would not deleteriously impact fish. The 3-D CFD model demonstrated that the approach velocities through the screens and sweeping velocities across the screens complied with DFO guidelines, which stipulated that the design had to prevent fish from impinging on the screens. The CFD model also confirmed the physical model results, which demonstrated scouring flow through the screen channel area for transport of sand and silt downstream.



The screens are regularly and automatically backflushed with compressed air to keep them clear of debris, silt and frazil ice. Silt pumps located

in the forebay between the screens and the low lift pump wells are used to control deposition of river silt inside the forebays and pump wells. Electrically actuated slide gates allow operators to regularly isolate forebays and pump wells for maintenance and cleaning. This helped meet the requirement for minimum depth below ice, and addressed issues around sand deposition.

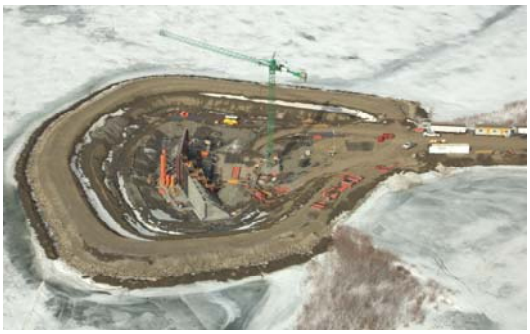
In-river screens reduce impact on fish.

Pump Station Design

The team developed a design for the pump station that optimizes facility design for current and future water demands, and also considers future requirements for pumping to the planned East Side Water Treatment Plant. The pump station includes three pumps, with space for an additional three pumps. The facility provides up to 350 million litres per day of raw water to the existing water treatment plant, with capability of increasing capacity to 545 million litres per day in the future. A natural gas generator provides stand-by power in case of a power outage.

Pump station design facilitates future expansion.

Construction



For construction, the team investigated a number of cofferdam isolation methods to determine a cost effective, low impact means of constructing the new raw water system while meeting regulatory requirements for sediment control, considering the highly variable river flow conditions. The team recommended earthen cofferdams, which provided a robust and safe solution for isolating construction of the intake, pump station, and river crossing with appropriate river water quality monitoring, sediment curtains, and fish protection procedures.

An earthen cofferdam was used for the 24-month period required to construct the intake and pump station. To minimize infiltration into the cofferdam, a bentonite clay wall plug was installed around the perimeter. The bentonite successfully reduced water inflow and virtually eliminated dewatering requirements from the work area.

Earthen cofferdams also allowed for the two-staged installation of a 1.5 metre diameter raw water pipeline across the river. Appropriate buoys and signage were used to direct river traffic and to ensure safe passage around the construction site.

Construction method was cost effective, controlled sediment, and protected fish.

Innovation

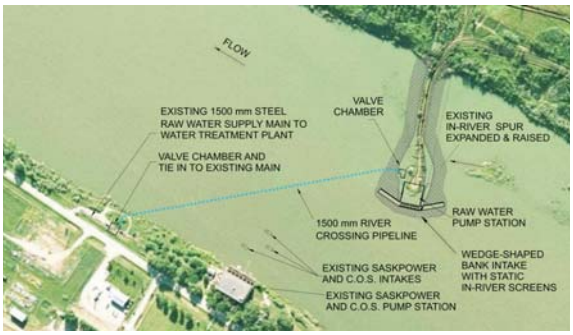
Identifying the existing, in-river, deflection spur as a possible location for the intake and pump station demonstrated ingenuity. Physical and computer modelling showed this location resulted in less river disturbance, making an in-river design viable. Building the facility on the spur alleviated bank stability issues associated with siting the facility on the riverbank.

The team's recommendation of an in-river, wedge-wire drum screen was a unique application of this technology. Using such screens in cold weather regions and in fast-flowing rivers like the South Saskatchewan River is a departure from conventional water intake designs which typically use mechanical travelling screens and fish return systems. The in-river, static, drum screening system design eliminates the need for fish handling and return systems that could result in fish mortality. Drum screens have no moving parts, are removable, and can be easily cleaned, thus reducing operation and maintenance costs. Drum screens sit in a deep, self-scouring channel, which mitigates sand deposition.

The three-dimensional, computational fluid dynamic model of the river and facility demonstrated to DFO and Transport Canada that the design would not have detrimental effects on aquatic life. We developed a physical model to confirm that velocities across the screens prevent sedimentation, fish impingement on the screens, and potential fish mortality. Physical modelling helped to develop a design to minimize swirl potential at pump inlets and optimize pump efficiency.

The project demonstrates use of in-river, drum screens in cold regions and fast-flowing rivers.

Complexity



In order for the project to proceed, the team had to obtain approvals from eleven agencies, including the federal Department of Fisheries and Oceans and Transport Canada (Navigable Waters Protection Branch, as well as provincial, regional, and municipal authorities.

Associated Engineering established dialogue with DFO and Transport Canada very early in the process to discuss their requirements. DFO provided input into the siting and design options. We included DFO, Transport Canada, and key stakeholders in meetings and visits to alternative intake sites. As a result of this involvement, authorities granted their initial buy-in and ultimate approval of the selected alternative.

We worked with agencies to develop design criteria and an intake design that

would be acceptable to all parties. This cooperative effort allowed the project team to propose initial designs, refine designs through positive feedback, and to achieve a final design that satisfied the regulatory agencies.

Involving regulators early in the project facilitated the approval process.

Social & Economic Benefits

The City of Saskatoon's significant economic and population growth drove the need for a new water intake and pump station to meet future demands. Sufficient, safe drinking water is the life blood of communities, sustaining population and economic growth.

The additional capacity provided by the new intake and pump station provides the city with a safe, secure, and robust water supply well into the future. The pump station design offers the flexibility for expansion from 350 to 545 million litres per day. The intake and pump station can supply water to the existing water treatment plant or to the East Side Water Treatment Plant in the future. This flexibility eliminates the need for another intake and pump station, and associated in-river construction in the future.

The pump station design is hydraulically and energy efficient, reduces sand intake, requires less maintenance, and facilitates remote operations. The pump station's design has significantly reduced the City's operational cost—by six full time maintenance positions compared to the previous pump station.

The design team participated in extensive consultations with the Meewasin Valley Authority to integrate the water intake and pump station facility with the planned river trail system—part of the Trans Canada Trail. As a result, the project team integrated the facility landscaping and architectural design with the planned river trail system. Landscaping incorporates existing vegetation, where possible, and planting dryland grass, native shrubs, trembling aspens, and prairie spire green ash during site restoration.

Connecting the water intake and pump station facility to the public trail opens the area to the public, providing opportunities to enhance public understanding about where our drinking water comes from, and what happens to water before it reaches our taps. The facility will incorporate public education on the water supply, including storyboards on where drinking water comes from, how it is treated, and the importance of water conservation and protection of our raw water resources.

The new intake & pump station provides safe, secure drinking water to sustain growth.

Environmental Impact

Mitigating the environmental impact of the in-river intake and pump station was paramount from planning and siting of the facility, through to selection of the appropriate screening technology, detailed design and construction. The intake's location on an existing, in-river deflection spur minimizes the intake's impact on the river. The carefully selected location also helped to reduce sedimentation, which in turn reduces the potential impact on aquatic life and habitat. The selected intake technology, in-river drum screens, also reduces the potential for silt and sand build-up around the screen itself. Without any moving parts, the zero-energy input, in-river drum screens are fish-friendly and reduce the potential for fish mortality.

In addition to cost savings, the energy and hydraulically efficient pump design reduces energy use.

Following the Fisheries Act "No Net Loss" requirement, the design team developed a compensation plan to account for any fish habitat lost or disturbed due to the construction. A portion of the river area adjacent to the water treatment plant was identified as a remediation site. Construction included clean-up of a ferric sludge deposit. During construction, a residuals handling facility was also installed to reduce the environmental impact. A compensation project was also carried out at a tributary to Lake Diefenbaker, where an abandoned rail grade was removed to allow smooth fish passage into the lake.

The intake location and design minimizes impact to wildlife, fish and habitat.

Conclusion

Meeting Client Needs

Associated Engineering met the City of Saskatoon's goal of delivering a new raw water intake and pump station facility to meet their current and future water demands. The design team completed the following key tasks to achieve the City's goal:

- Obtaining regulatory approvals from 11 agencies
- Assisting the City to obtain land holdings, easements, and legal surveys
- Completing conceptual design, pre-design, detailed design and tender packages

- Preparing documents for pre-purchasing major equipment
- Providing contract administration and resident engineering services
- Assisting with start-up and commissioning, helping to maintain operations at the water treatment plant so that delivery of safe drinking water was not impaired

Meeting regulations for the design and construction of the facility was critical. Early in the project, the design team initiated communications with all parties. We involved key stakeholders in selecting the intake site and the optimum intake technology. We used computerized and physical modelling to demonstrate that the intake design would meet regulatory requirements.

Ultimately, the success of this $40 million project is measured by our client's satisfaction. Krystyna Kotowski, P.Eng., M.Sc., Senior Project Management Engineer for the City of Saskatoon states, "Utilization of the newest engineering techniques, quality control reviews, and the close relationship between the City and design team helped overcome project challenges. The team's effort to provide the highest quality service resulted in the successful and timely completion of this very demanding project, meeting all original objectives. The intake and pump station provides reliable service for the City and a safe and pleasant working environment for the staff."

Project Team with City of Saskatoon Project Manager, Krystyna Kotowski, accept Consulting Engineers of Saskatchewan Award of Excellence for the Saskatoon Water Intake & Pump Station