The Chief Crowfoot Water Treatment Plant

Mini Capstone Project Report

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Introduction

Chestermere background

In the early 20th century, a group of farmers settled on the banks of Chestermere Lake in Alberta, Canada. As the population increased, settlers focused on development projects that facilitated irrigation and water usage.

By 1992, Chestermere was recognized as an official town with over 1000 permanent residents. The population rapidly increased reaching 17203 residents by 2014. It then changed its status to city in 2015.

The increase in population has caused serious demand for a more developed and sustainable water treatment system, especially in the eastern bloc of the city.

In fact, there has been an outcry for years in the city over the rise of utility costs, especially domestic water bills. Chestermere residents are expected to pay almost twice what residents in nearby Calgary pay for their utility bills.

After many complaints and petitions submitted, the provincial government established oversight over a city-owned utility company Chestermere Utilities Incorporated (CUI) which found that customers are paying less than what would cover the operational costs. This is mostly because the company doesn't own any water treatment plants. It instead pipes water from Calgary and pumps the drinking water back to there. [1]

The status quo has proved to be both inefficient and expensive for the residents of Chestermere. That is why this project will focus on building water treatment plant wholly owned by the city that will provide more affordable and sustainable water treatment system. [2]

The east side of Chestermere, a booming part of the city, also lacks adequate distribution systems and quality water services. The newly developed east end of the town is calling the city council to approve a project to establish a water treatment plant that addresses the needs of its residents and can be an alternative as distrust grows around the excessive reliance on Calgary's water treatment facilities.

Water Treatment Plan with a focus on the Pumping Station

Through detailed analysis, this report will explore the critical role of the pumping station within the Chestermere water treatment plant, focusing on its functionality and technical specifications. The pumping station ensures consistent water flow across treatment stages, including filtration, disinfection, and storage, while maintaining adequate pressure for distribution to the community. Its design incorporates advanced features such as energy-efficient pumps, automated control systems, and backup power supplies to ensure uninterrupted operation. These components not only enhance reliability but also contribute to cost savings and environmental sustainability. By examining its operational processes and equipment performance, the report will evaluate how the pumping station supports the treatment facility in meeting both municipal water demand and stringent quality standards.

Furthermore, this report will assess the station's compliance with local and national regulatory requirements. Adherence to these regulations ensures the safety and reliability of the water supply

while minimizing environmental impact. The report will also address potential challenges, such as aging infrastructure, fluctuating water demand due to population growth, and the need for resilience against climate change impacts like droughts and extreme weather events. Finally, it will explore future opportunities for enhancing the station's operations, including the integration of smart technologies, renewable energy sources, and predictive maintenance systems to improve efficiency, reduce operational costs, and support long-term water resource management in Chestermere.

Project Formulation

Demand Estimation

The objective of this section is to determine the current water demand characteristics and to project future demand requirements that will establish system component adequacy and sizing needs for the city of Chestermere.

Water Demand Definitions

System water demand is the quantity of water that the treatment plant must produce to meet all water needs in the community. Water demand includes water delivered to the system to meet the needs of consumers, water supply for fire fighting and system flushing, and water required to properly operate the treatment facilities. Additionally, virtually all systems have a certain amount of leakage that cannot be economically removed, and thus total demand typically includes some leakage. The difference between the amount of water sold and the amount delivered to the system is referred to as unaccounted water. Unaccounted water can result from system flushing, leakage, fire fighting, meter inaccuracies, and other non-metered usage.

Water demand varies seasonally with the lowest usage in winter months and the highest usage during summer months. Variations in demand also occur with respect to time of day. Diurnal peaks typically occur during the morning and early evening periods, while the lowest usage occurs during nighttime hours. The following terms are needed to describe the water demand and take the different variations above into consideration.

Average Annual Demand (AAD) - The total volume of water delivered to the system in a full year expressed in gallons. When demand fluctuates up and down over several years, an average is used.

Average Daily Demand (ADD) - The total volume of water delivered to the system over a year divided by 365 days. The average use in a single day expressed in gallons per day.

Maximum Month Demand (MMD) - The gallons per day average during the month with the highest water demand. The highest monthly usage typically occurs during a summer month.

Peak Weekly Demand (PWD) - The greatest 7-day average demand that occurs in a year expressed in gallons per day.

Maximum Day Demand (MDD) - The largest volume of water delivered to the system in a single day expressed in gallons per day. The water supply, treatment plant and transmission lines should be designed to handle the maximum day demand.

Peak Hourly Demand (PHD) - The maximum volume of water delivered to the system in a single hour expressed in gallons per day.

Existing Water Demand



Figure 1: City of Chestermere Demand Catchment Area

According to the city of Chestermere - Engineering Design and Construction Standards (2024), the following water demand factors were obtained. [3]

Table 1: Potable Water Design Factors for City of Chestermere

Average Daily Demand (ADD)	**250 l/c/d**
Maximum Daily Demand (MDD)	ADD x 2.0
Peak Hour Demand (PHD)	ADD x 3.7

Fire flow - residential without multi- dwellings	83 L/s for 2 hours + MDD
Fire flow - residential with multi-family dwellings	120 L/s for 2.5 hours + MDD
Fire flow - industrial commercial & institutional (ICI)	200 L/s for 2.5 hours + MDD

Units used:
l/c/d - litres/capita/day
L/s - litres/second

Distribution systems should be designed to adequately handle the peak hourly demand. During peak hourly flows, storage reservoirs supply the demand more than the maximum day demand.

According to the official website of Chestermere, the current population of the city in 2024 is 28,129. [4] Environment Canada estimates that an average of 13 percent of municipal water is unaccounted in Alberta municipalities. [5] These are due to leaks that result in significant water loss and are often due to ageing infrastructure. Therefore, the maximum daily demand (MDD) and the peak hour demand (PHD) including the unaccounted water are given by:

MDD = 250 x 2.0 x 1.13 x 28,129 = 15.9 x 10^6 l/d
PHD = (250 x 3.7 x 1.13 x 28,129)/24 = 1.23 x 10^6 l/hr
Demands described above are the current water demands in 2024.

Projected Water Demand

According to Statistics Canada 2020, the average expected useful life of new municipally owned potable water assets in urban municipalities in Alberta are given below. [6]

Table 2: Design Period of Various Components of Water Supply Project

Units	Design Parameters	Design Period
Water Treatment Plans	MDD	50 years
Water Reservoirs	MDD	30 years
Water Pump Stations	MDD	32 years
Local Water Pipes	PHD	69 years
Transmission Pipes	MDD	75 years

The Water pipeline system project including the water treatment plant will be designed to serve for a minimum of 30 years. The 30 years should be counted after project completion period of about 2 to 3 years (i.e. starting 2027). The water treatment's initial water demand would be the demand in 2027, and the design demand will be based on the water demand of city of Chestermere in 2057. Water demand estimates for future years are determined by multiplying the current unit demand values (l/c/d) by the projected number of future users in the water system. It is assumed new users added to the system will consume water at the same rate as current users.

Based on the available information, we'll provide an estimate of the projected population of Chestermere, Alberta from 2024 to 2057. As of 2024, Chestermere has an estimated population of 28,129. The city has shown significant growth in recent years. According to Canada census date 2021,

the enumerated population of Chestermere (City) in 2021, was 22,163, which represents a change of 11.4% from 2016. This compares to the provincial average of 4.8% and the national average of 5.2%. [4]

According to Chestermere Social Needs Assessment 2023, past annual growth rates as well as predicted annual growth rates from year 2016 to 2041 are given: 2016 – 2021 (2.19%), 2021 – 2026 (3.48%), 2026 – 2032 (2.61%), 2032 – 2036 (2.31%), 2036 – 2041 (2.09%). [4] We input these values in a graph with 2016 being year 0. A trendline with the power option is chosen because the formula for annual growth rate is in the power form. After getting an equation of the trendline, we were able to forecast the annual population growth rate from year 25 (2041) to year 41 (2057) which was 2.325%. Now taking the average of all six annual growth rates gives us 2.5%.

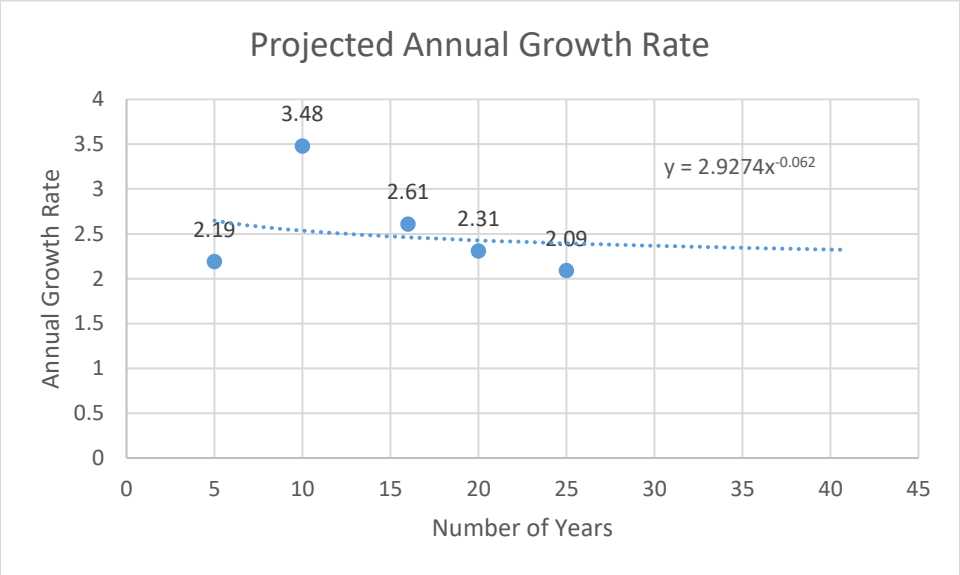


Figure 2: Projected annual growth rate trendline

To estimate the projected population from 2024 to 2057, we'll assume a constant annual growth rate of 2.5%. This assumption may not accurately reflect future trends but provides a reasonable starting point for estimation.

The number of years from 2024 to 2057 is 33 years. The projected population for each year is given using the compound interest formula:

$$Future\ value = Present\ value * (1 + r)^n$$

Where r is the annual growth rate (2.5%)

n is the number of years (0 to 33)

present value is 28,129

Based on this parameter, the following projected populations and water demand projections were estimated. Thus, the water distribution system (in this case, pipes and suction pumps) should be

designed to handle a peak hourly demand of 2.77 million liters per hour. As for the water treatment, it should be designed with a capacity of 35.90 million litres per day.

Table 3: Water Demand Projections from 2024 - 2057

Year	Population	MDD (in 10^6 l/d)	PHD (in 10^6 l/hr)
2024	**28,129**	**15.89**	**1.23**
2027	**30,292**	**17.11**	**1.32**
2032	34,272	19.36	1.49
2037	38,776	21.91	1.69
2042	43,872	24.79	1.91
2047	49,637	28.04	2.16
2052	56,159	31.73	2.45
2057	**63,539**	**35.90**	**2.77**

Environmental Considerations

Water Source Protection and Quality Monitoring

For the planning of any project, two points need to be considered, the environmental and social aspects. Environmental and social impact assessments are fundamental for planning any design and cannot be simply overlooked.

This report will highlight these considerations particularly for municipal wastewater treatment plants in Alberta, Canada. The assessment will break down the socio-economic components and project-specific effects on the human welfare and surrounding ecosystems.

The ecosystem components affected by the project are as follows:

- Air quality
- Human health
- Noise
- Land use
- Soils and terrain
- Vegetation and wetlands
- Wildlife
- Surface water quality and quantity
- Groundwater
- Aquatic resources
- Historical resources
- Socio-economic factors

Environmental regulations on water treatment industries are governed by the Environmental Protection and Enhancement Act [3]. The provincial department in charge of monitoring such regulations and ensuring their execution are two institutions. Alberta Energy Regulator, that deals with the energy side of the project, and Alberta Environment and Parks that watches over the environmental assessment process.

The design of the water plant will include an environmental assessment report based on surveys conducted around Chestermere by specialized and licensed environmental researchers and sociologists. The report would examine the environmental, social, economic, and health implications.

The report will then be published and sent for review by the regulatory board or Minister of interest. Conditional approval is then granted by the regulators allowing for the project to commence. The boards supervising the project would then have to ensure compliance with the environmental and legal requirements and constraints [4].

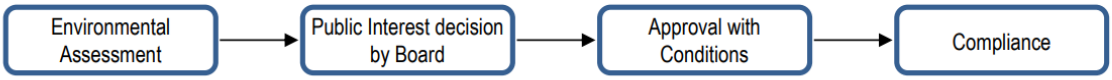


Figure 3: Process Flow for Environmental Project Approval

The environmental assessment report will contain the legal land description presenting all areas of development approved by the regulatory board as well as any area that would be affected as a result of the project [5].

The study will also encompass detailed research on air quality and noise contribution. Air quality parameters used in the analysis are primarily SO2, CO, H2S, THC, Nox and O3 among others. These parameters should be within the limits outlined CCME National Emission Guidelines [6] and the Alberta Ambient Air Quality Objectives [7].

From a geological standpoint, the worst-case scenario should be presented in the water withdrawal process which will impact water solubility and groundwater quality. The design team will also conduct hydrological studies to assure the water flow changes do not significantly damage aquatic life [5].

Surface water quality would respect the guidelines on parameters metals, dissolved oxygen, suspended, suspended and dissolved solids, nutrients, pH levels and temperature [5]. Too many nutrients can cause algal blooms affecting water taste, odor, and safety. The project would also maintain nutrient levels and manage upstream land use [8].

Hence, ensuring the quality of Chestermere Lake, the likely source, is crucial. The project will be implementing a watershed management plan can help control pollutants and ensure long-term water quality.

Construction and operation can disrupt local ecosystems, including aquatic life in Chestermere Lake and surrounding wetlands. This is why an environmental impact assessment (EIA) can identify sensitive species and ecosystems that need protection [9].

Water is another significant environmental factor, as the treatment process generates sludge and other by-products. This waste, which can contain concentrated contaminants, needs to be handled with care and disposed of safely to avoid soil and water pollution. Additionally, chemical use, including chlorine and alum, requires strict safety protocols for storage and disposal to prevent accidental releases into the environment. Alternatives such as UV or ozone disinfection could be explored to reduce reliance on hazardous chemicals, though they come with their own considerations in terms of cost and infrastructure [10].

The energy consumption and carbon footprint of the water treatment plant also present environmental challenges. Treatment processes, especially pumping, aeration, and filtration, are energy intensive. To minimize the environmental impact, integrating renewable energy sources like solar or wind power, and using energy-efficient equipment, can help reduce greenhouse gas emissions. The plant could also be designed with green infrastructure elements, such as green roofs and rainwater capture systems, which not only improve efficiency but also lessen the plant's overall carbon footprint [11].

Energy Efficiency

In our water treatment plant, we have installed the MFF series pump due to its energy-efficient design and its ability to handle a variety of challenging materials. The pump's design includes a large clearance between the impeller and the pump casing, which allows it to efficiently manage solids and fibers without the risk of clogging. This feature contributes significantly to its energy efficiency by maintaining smooth operation even with demanding fluids [7].

The pump's stainless-steel construction and investment cast components ensure durability and resistance to wear, which is essential for long-term performance in a water treatment facility. Additionally, the Monoblock execution with standard IEC motors helps to reduce maintenance needs, further enhancing operational efficiency [8].

The sustainability of the pump is reinforced by its FDA-approved mechanical seals and balanced O-ring seals, which reduce the need for frequent replacements. This design minimizes downtime and supports the eco-friendly goals of the plant by reducing waste and energy consumption [9].

A more detailed explanation of the pump design, along with its integration into our water treatment system, will be provided later in the report.

Waste Management

A comprehensive waste management plan is essential for the environmental sustainability of a water treatment plant in Canada. Such a plan outlines the proper handling, treatment, and disposal of waste generated during the plant's lifecycle, ensuring compliance with Canadian environmental regulations such as the *Fisheries Act* and the *Canadian Environmental Protection Act, 1999 (CEPA)* [10].

The primary solid waste generated by a water treatment plant includes sludge, composed of organic and inorganic materials removed during sedimentation and filtration processes. Additionally, debris collected during the screening phase, such as plastics and organic matter, must be managed appropriately to prevent environmental contamination. In Canada, sludge treatment typically involves dewatering and stabilization through methods like lime addition or anaerobic digestion, with the resulting biosolids either sent to regulated landfills or repurposed as agricultural soil amendments if they meet provincial quality standards [11].

Liquid waste primarily consists of backwash water from filtration systems, which contains suspended solids, chemical residues, and other impurities. Treatment for backwash water may involve sedimentation and recycling to reduce water consumption and environmental discharge. Canadian regulations mandate that treated liquid effluents must meet stringent water quality standards, such as those outlined in the *Wastewater Systems Effluent Regulations (WSER)*, before being discharged into natural water bodies [12].

Hazardous waste generated by water treatment plants often includes residual chemicals, such as coagulants, disinfectants, and cleaning agents. These materials must be handled carefully due to their toxicity and potential environmental risks. Canadian standards, such as those from the *Hazardous Products Regulations (HPR)* and provincial guidelines, require proper storage using secondary containment systems to prevent spills or leaks. Disposal of hazardous waste must occur at licensed facilities, ensuring adherence to federal and provincial hazardous waste management protocols [13].

Monitoring and reporting are crucial for ensuring compliance with Canadian environmental laws. Water treatment plants must conduct regular audits and submit reports to federal and provincial regulatory bodies, such as Environment and Climate Change Canada (ECCC). Comprehensive documentation of waste generation, treatment, and disposal enhances transparency and accountability, supporting continuous improvement in waste management practices [10].

In conclusion, implementing a waste management plan for a water treatment plant in Canada involves the systematic identification, segregation, treatment, and disposal of various waste streams. The plan ensures the plant's environmental sustainability and operational compliance with Canadian regulations while minimizing adverse impacts on ecosystems and public health [11].

Biodiversity Preservation

Constructing and operating a water treatment plant in Chestermere, Alberta, requires a comprehensive approach to preserve the biodiversity of Chestermere Lake. The lake supports a vibrant aquatic ecosystem, including fish populations that play a crucial role in maintaining ecological balance. Among the most common fish species in the lake are Northern Pike (*Esox Lucius*) and Yellow Perch (*Perce flavescens*). Northern Pike typically measure between 50 and 70 centimeters in length, with some individuals reaching up to 150 centimeters, while Yellow Perch generally range from 10 to 25 centimeters. These fish are essential to the lake's food web and are highly susceptible to harm from improper water intake systems [14].



Figure 4: Northern Pike [15]



Figure 5: Yellow Perch [16]

The intake pipes for the water treatment plant, which draw water from Chestermere Lake, must be designed to prevent the entrainment (drawing in) or impingement (trapping against screens) of aquatic organisms, particularly these fish species. To achieve this, the pipe screens must comply with the **Interim Code of Practice for End-of-Pipe Fish Protection** established by Fisheries and Oceans Canada. The code specifies that intake screens should be designed to minimize harm to fish, with a maximum screen opening size of 2.54 millimeters to prevent juvenile fish from being drawn into the system. Additionally, the intake velocity near the screens must not exceed 0.15 meters per second to allow fish to swim away from the intake area safely [17].

For Chestermere Lake, a practical solution would be the use of wedge-wire circular screens. These screens are highly effective in reducing the risk of fish entrainment and impingement while ensuring efficient water intake. Wedge-wire screens are durable, resistant to clogging, and can be customized to meet the specific flow requirements of the treatment plant. Proper placement of the intake pipes is also essential. Locating the pipes at an appropriate depth and away from fish spawning or feeding areas can further mitigate environmental impacts [18], [19].

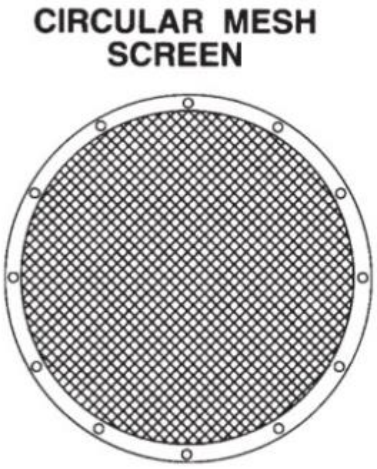


Figure 6: Circular Screen for Intake Pipe [17]

Air and Noise Pollution Control

To effectively mitigate noise pollution, we have designed sound barrier systems. When constructing sound barriers, designers focus on both the acoustic performance and the structural integrity of the system. To achieve that, noise barriers like PVC panels and photovoltaic noise barriers were installed.

After the panels are placed, they are connected using a locking system, and the foundation is adjusted to guarantee the walls are level and secure. The joints between the panels are sealed to prevent water penetration and to enhance the wall's noise reduction capabilities. This ceiling also improves the long-term durability of the sound barriers by preventing environmental damage.

For PVC sound barriers, as shown in **Figure 1**, which are lightweight and easier to handle than concrete, the construction process is similar but involves the assembly of prefabricated panels that are connected to supporting posts. These posts are usually made from materials such as steel or wood, and the PVC panels are mounted onto them, typically with clips or screws. The PVC material is designed to reduce noise transmission and can be engineered with varying thicknesses and textures to optimize sound absorption. [20]



Figure 7: PVC Noise Barriers

In the case of photovoltaic noise barriers (PVNBs), as depicted in figure 2, which combine sound absorption with solar energy generation, the construction process is more complex. Designers integrate solar panels into the barrier structure, creating a multifunctional solution. The PVNBs are typically installed in sections, with posts and panels mounted along the barrier's length. These systems not only reduce noise but also harness solar energy, contributing to sustainability goals.

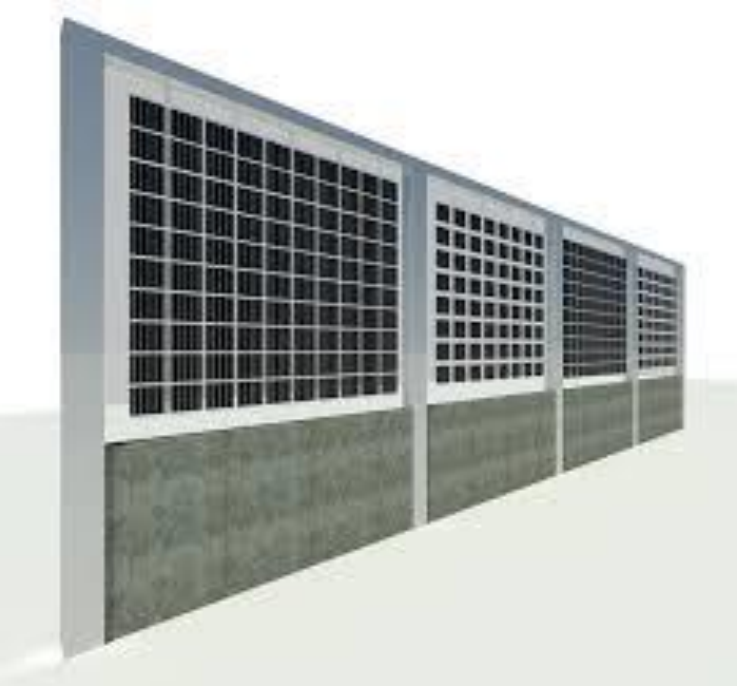


Figure 8: PVNBs Sound Barriers

Sustainable Landscaping

Sustainable landscaping is a crucial aspect of constructing a water treatment plant in Chestermere, Alberta, as it addresses both environmental and water conservation concerns. In the context of a water treatment facility, using drought-resistant plants can significantly reduce water usage, minimize the need for irrigation systems, and enhance the resilience of the landscaping in arid or drought-prone regions. Plants like Lavender (Lavandula angustifolia), Black-eyed Susan (Rudbeckia Herta), and Sagebrush (Artemisia tridentata) are ideal choices for such projects. These native plants require minimal water once established, making them perfect for a sustainable landscaping design that conserves local water resources while promoting biodiversity [21].

Additionally, incorporating drought-tolerant plants in the landscaping design of the water treatment plant can help to improve soil quality and support local wildlife by providing habitat and food sources. According to the Alberta Native Plant Council, native species like Western Red Columbine (Aquilegia canadensis) and Yarrow (Achillea millefolium) are well-suited for the region's climate, offering long-term benefits for both aesthetics and ecosystem health. These plants are adapted to local soil and climate conditions, ensuring that the landscaping remains low-maintenance and ecologically sound. By integrating such plants, the project aligns with sustainable development goals and contributes to environmental stewardship in the Chestermere area [22].

Verification of Lake Replenishment

To ensure project sustainability, the rate of consumption must be confirmed to be below the natural replenishment rate of Lake Chestermere. If this not the case, artificial replenishment must be considered to recover used water. According to the Chestermere Lake Report of 2022, Lake Chestermere receives enough water to replace the lake’s volume in 8 days. [23] Given this, the inflow of water per day into lake

can be found given its volume. Lake Chestermere is found to be 5.3 million m^3 according to the same report. With this, the inflow is found by dividing the volume by rate of replenishment giving an inflow of **662 000 m^3 /day**. The ADD of 2057 is calculated to be **15 880 m^3 /day**, chosen to consider future expansion and water use. This data shows that the inflow of water is considerably greater than the town's future. Thus, no artificial replacement must be considered to recover used water.

Social Considerations

Community Engagement

In an effort to gather community input on the proposed construction of a new water treatment plant, we conducted a survey among the residents of Chestermere, Alberta. The goal was to understand how the community felt about the idea and to gauge their level of support. The survey asked residents various questions regarding the importance of having an upgraded water treatment system and their concerns about the project.

The survey revealed that a majority of respondents were in favor of building the new plant, seeing it as a necessary step to improve water quality and ensure the town's long-term sustainability. The positive feedback highlighted a collective recognition of the benefits of having a modern, reliable water treatment facility.

In addition to the survey, we organized a town hall event to further engage with the community and provide a space for residents to voice their questions and concerns. At the town hall, we invited experts in the field of water treatment to address any technical questions and explain the details of the proposed plant. The presence of these experts was crucial in providing the community with accurate, in-depth information and reassuring them about the project's feasibility and environmental considerations.

Sarah Thompson, a long-time resident, asked how the new plant would affect water bills. In response, experts explained that the costs would be spread overtime to minimize any significant increase in monthly bills. Mark Johnson, a local business owner, was concerned about the environmental impact of the plant. The experts reassured him that the design of the plant was eco-friendly, and steps had been taken to minimize disruption to local wildlife and ecosystems.

Lisa Patel, a young parent, asked about the safety of the town's water during construction. The experts assured her that water quality would be closely monitored throughout the process and any potential risks would be managed before work began. Tom Richards, a retiree, inquired about the timeline for the plant's construction. Experts shared that the project would take around two to three years to complete, with an additional six months to a year for testing and commissioning. Lastly, Emma Clark, a concerned resident, asked about job opportunities. The experts confirmed that both during construction and once the plant was operational, residents would have access to various job openings.

The town hall event proved to be an effective platform for open dialogue, and many residents, like Sarah and Mark, felt reassured by the expert responses. The support from the community was clear, and with the combined feedback from the survey and the town hall, it was evident that most residents favored the new plant. The feedback will be used to fine-tune the planning and ensure that the project addresses the concerns and needs of the community.

Economic Benefits

The proposed water treatment plant not only promises to improve water quality but also brings significant economic benefits to the Chestermere community. One of the most notable advantages is the creation of over 50 local jobs during the construction and operation phases of the plant. These jobs will span various fields, including construction, engineering, project management, and technical support.

For example, Sarah Miller, a resident of Chestermere, recently transitioned from working as a construction laborer to a full-time position with the project as a site supervisor. Sarah's new role offers stable employment, allowing her to provide for her family while contributing to a vital community project. Additionally, James Roberts, a local electrical engineer, has been employed by the project team to oversee the installation of the plant's electrical systems. His expertise, along with that of many others from Chestermere, will be instrumental in ensuring the plant is operational and efficient.

The economic impact also extends to the local businesses in and around Chestermere. To support the project, we collaborated with several well-established engineering and construction companies from the region, ensuring that the benefits of the new plant were felt throughout the local economy. Notable collaborations include working with NRC Construction, a well-regarded construction firm based in nearby Calgary. NRC Construction specializes in large-scale infrastructure projects and has been selected to handle the civil construction and site preparation for the water treatment plant. Their experience in handling complex projects makes them an ideal partner for the project.

We also teamed up with Stantec Engineering, a global engineering and consulting firm with a strong presence in the Chestermere area. Stantec's expertise in water treatment plant design and management was invaluable, as they helped develop the plant's detailed blueprints and contributed to environmental assessments. Their work ensures that the plant is both technically sound and environmentally responsible.

Another key partner was McElhanney Engineering, a civil engineering firm with a branch in Calgary. McElhanney provided geotechnical and environmental engineering services to ensure the plant's site was suitable for construction, while also conducting critical environmental impact assessments. Their involvement ensured the project adhered to environmental regulations, minimizing potential risks to the surrounding areas.

The collaboration with these local companies not only helped advance the project but also provided opportunities for local workers to gain experience and secure long-term employment. The water treatment plant will continue to create jobs in its operational phase, with positions available for maintenance staff, plant operators, and environmental monitors. These ongoing job opportunities will support Chestermere's workforce and further strengthen the town's economy.

Moreover, the construction and operation of the plant will benefit local suppliers, contractors, and service providers, creating a ripple effect throughout the community. For instance, Chestermere-based businesses like Chestermere Hardware and Chestermere Auto Service have provided materials and equipment to support the project, contributing to the local supply chain.

Cultural Sensitivity and Inclusivity

Throughout the planning and development of the project, we made a concerted effort to engage with Chestermere's multicultural communities. The town's population includes a wide range of cultural backgrounds, and it was important to ensure that the perspectives of all residents were included. To facilitate this, we held community meetings and outreach programs in multiple languages, including Arabic, Farsi, and Somali. These initiatives ensured that non-English-speaking residents could fully participate in discussions and have their concerns addressed.

For example, Hiba Al-Jabari, a member of the local Multicultural Association, helped organize sessions where immigrant families could ask questions about the project in their native languages. This approach ensured that all cultural groups felt included in the decision-making process and had a voice in shaping the future of Chestermere's water system.

In addition to cultural inclusiveness, the project focuses on making the water treatment plant accessible to all residents, especially those from low-income communities. One of the key priorities was ensuring that the cost of water would remain affordable for everyone. To address concerns about potential increases in water bills, the town committed to keeping any rate adjustments gradual and manageable. This will help ensure that low-income households are not disproportionately impacted by the new infrastructure.

To further support low-income residents, the town worked with local organizations to provide financial assistance programs for families who may struggle with utility bills. These programs aim to make sure that essential services like clean water remain accessible to everyone, regardless of income level.

In addition to affordable pricing, the water treatment plant was designed with accessibility in mind. The plant will provide a reliable and consistent water supply to all neighborhoods in Chestermere, including those in underserved areas that previously faced water quality concerns. The new plant will ensure that every household, regardless of their socioeconomic status, has access to high-quality drinking water. This is especially important for low-income communities where access to clean water can sometimes be a challenge.

Ongoing Education

As part of the development of the new water treatment plant, we recognized the importance of not only improving water infrastructure but also educating the Chestermere community about the sustainable use and preservation of water resources. In addition to the technical aspects of the project, we organized a series of workshops, teach-ins, and educational programs to engage residents in understanding the vital role of water conservation and the protection of Chestermere's local lakes and natural water sources.

To ensure broad participation, we held interactive workshops and teach-ins throughout the community, designed to inform residents of all ages about the importance of water preservation. These events focused on practical tips for reducing water usage in everyday life, such as fixing leaks, using water-efficient appliances, and adopting sustainable practices in gardening and landscaping. Local environmental experts and water conservationists led these sessions, providing hands-on demonstrations and real-world examples of how small changes can make a big difference.

One such workshop was held at the Chestermere Community Center, where families learned how to install rain barrels, reduce water waste, and protect local water sources. Participants were shown how to collect and store rainwater for gardening, a practice that not only conserves potable water but also reduces the strain on local water supplies. This workshop was especially popular among local gardeners and families with young children, who took part in the hands-on activities and left with practical tools to implement water-saving techniques at home.

Understanding that educating the younger generation is key to long-term water conservation, we worked closely with local schools to implement water and lake preservation programs for students. These programs included classroom presentations, educational games, and field trips to local water bodies, where students could learn about the science of water ecosystems and the importance of preserving them.

In collaboration with the Chestermere High School Environmental Club, we launched a campaign encouraging students to take part in water conservation efforts at school and home. The students were involved in creating posters, conducting surveys, and spreading awareness about the need to conserve water and protect local lakes. Through these programs, young people were empowered to become advocates for water sustainability and took pride in their role as stewards of the local environment.

Legal Considerations

Land Use Map

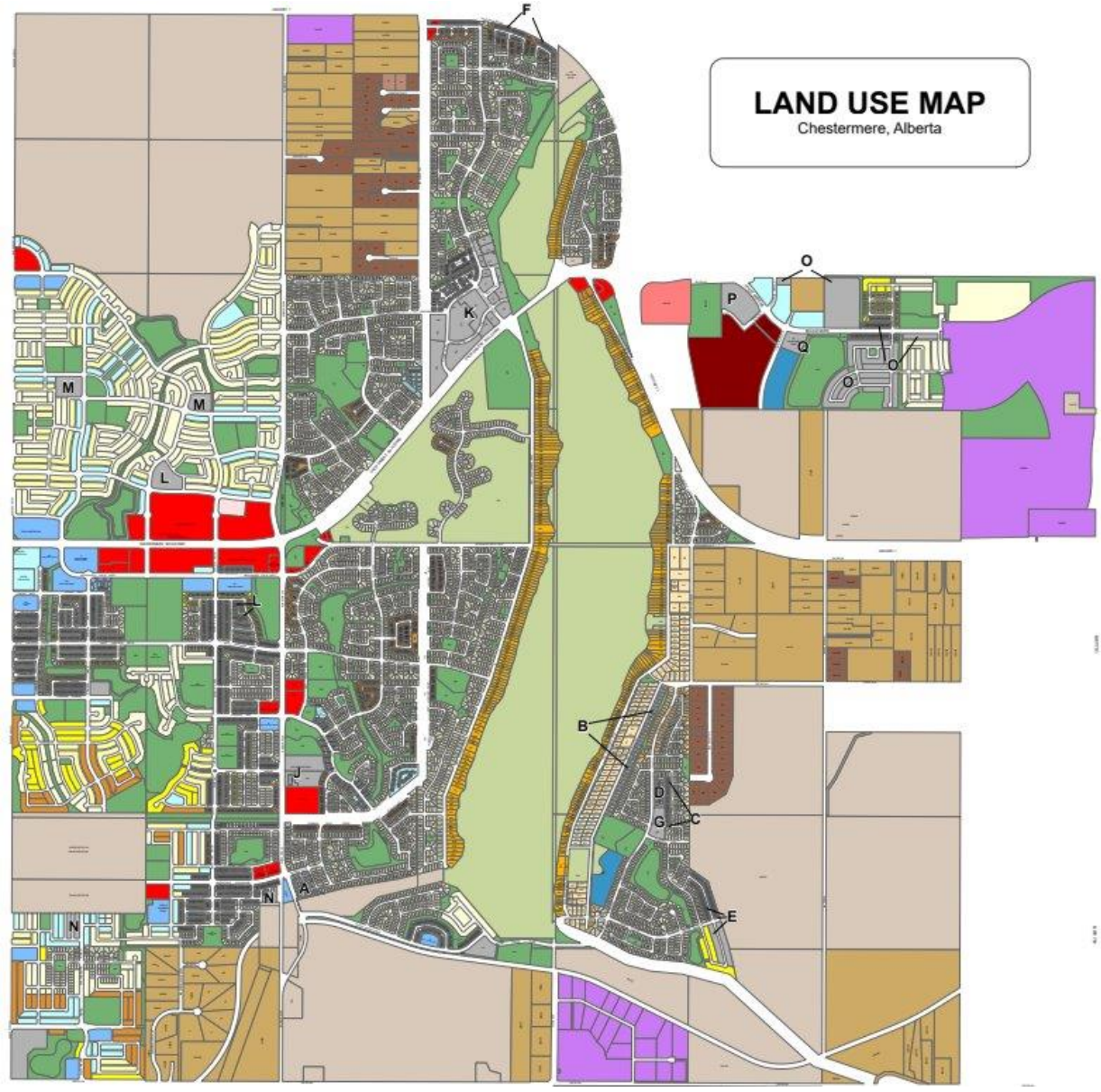


Figure 9: Land Use Map

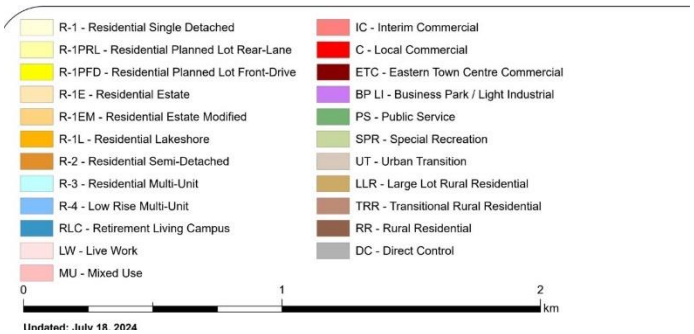


Figure 10: Labels for Land Use Map



Figure 11: PS Service Block

The land use map shown provides an overview of the zoning designations in Chestermere, Alberta, indicating permissible uses for land in the area. Specific zones are marked with different colors to delineate residential, commercial, industrial, and other types of land use. For the water plant, the highlighted areas lined with red is the designated location. The orange color represents the area which is open to future expansion. The red color represents the present construction site of the plant.

Permitted Uses

The site is designated for specific uses that align with the project's scope. These include:

- Public utilities: Facilities necessary for infrastructure, such as water treatment plants.
- Government services: Offices or centers for public administration that support utilities.
- Research facilities: Areas dedicated to environmental or technological studies relevant to water management.

Key Site Requirements

These requirements ensure the design and construction of the plant comply with local regulations:

- Setbacks: A minimum of 6.0 meters is required from the front, side, and rear boundaries of the lot. This ensures safety, aesthetics, and separation from adjacent properties.
- Building Height:
- Public utility buildings: Maximum height of three storeys or 12 meters.
- Accessory buildings: Height limited to 4.5 meters.
- Lot Coverage: The total built-up area must not exceed 40% of the total lot area, preserving open space and minimizing environmental impact.

Permits needed

Constructing a water treatment plant in Chestermere, Alberta requires adherence to various municipal and provincial regulations, along with obtaining specific permits. Below is an overview of the necessary permits and applicable regulations:

Municipal Permits:

Development Permit: Before construction, secure a development permit from the City of Chestermere's Community Growth & Infrastructure department. This permit ensures the proposed project aligns with local land use bylaws and zoning requirements.

Building Permit: After obtaining the development permit, apply for a building permit. This permit confirms that the construction plans comply with the Alberta Building Code and other relevant standards.

Utility Permits: Depending on the project's scope, additional permits for electrical, gas, and plumbing systems may be required. These ensure that utility installations meet safety and technical standards.

Provincial Approvals:

Environmental Approval: Alberta Environment and Protected Areas oversees the province's drinking water program. You must obtain approval to ensure the plant's design, operation, monitoring, and reporting meet provincial standards.

Applicable Regulations:

Alberta Building Code: This code sets the standards for building safety and integrity, which your construction must adhere to.

Alberta Safety Codes Act: This act governs the safety standards for building, electrical, gas, and plumbing systems.

City of Chestermere Land Use Bylaw: This bylaw outlines zoning regulations and land use requirements specific to Chestermere.

Environmental Protection and Enhancement Act (Alberta): This act regulates activities that may impact the environment, including water treatment operations.

Additional Considerations:

Engineering Design and Construction Standards: Ensure compliance with Chestermere's engineering standards for infrastructure projects.

Public Consultation: Engaging with the local community and stakeholders may be necessary, depending on the project's scale and impact.

Inspections: Schedule necessary inspections at various construction stages to ensure compliance with all codes and standards.

Insurance Considerations: [24] [25]

- Builder's **Risk Insurance:** Also known as Course of Construction insurance, this policy covers property during construction, including renovations or repairs. It protects against losses such as fire, lightning, wind, and vandalism. It's advisable to secure this insurance before construction commences to ensure comprehensive coverage.
- **Commercial General Liability (CGL) Insurance:** This policy safeguards against claims of bodily injury or property damage arising from construction activities. It is essential for both contractors and project owners to maintain adequate CGL coverage.
- **Wrap-Up Liability Insurance:** For large-scale projects, a wrap-up liability policy provides unified liability coverage for all parties involved, including owners, contractors, subcontractors, and consultants. This approach ensures consistent coverage limits and simplifies claims management.
- **Environmental Liability Insurance:** Given the potential environmental risks associated with water treatment operations, this insurance covers liabilities arising from pollution incidents, including cleanup costs and third-party claims. Specialized insurers like Watercolor Management offer tailored programs for water treatment facilities.

Emergency Plans [26] [27] [28]

Developing a comprehensive Emergency Response Plan (ERP) is crucial for effectively managing potential emergencies and ensuring the safety of both personnel and the public.

- **Identification of Potential Emergencies:** Assess and document possible emergency scenarios, such as equipment failures, chemical spills, natural disasters, or contamination events.
- **Response Procedures:** Establish clear, step-by-step protocols for addressing each identified emergency, including immediate actions, containment measures, and mitigation strategies.
- **Communication Plans:** Define communication channels and notification procedures for alerting staff, emergency responders, regulatory agencies, and the public as necessary.
- **Resource Allocation:** Ensure availability and accessibility of emergency equipment and personal protective equipment (PPE). Designate trained personnel responsible for executing emergency response duties.
- **Training and Drills:** Conduct regular training sessions and simulated emergency exercises to maintain readiness and ensure that all personnel are familiar with ERP protocols.

CAPEX

We will get our total construction Chestermere water treatment plant cost with 2 main aspects. Firstly, we will make a table of many of the water treatment plants in different provinces in Canada. Then, we will get their total water treatment plant construction cost. Afterwards, we will get their Capacity million liters per day (MLD) either by getting it from a reference or calculating it by getting their population and doing the calculations used in the current water demand section.

Then, we create a trendline figure where we will start it from (0,0) coordinates. Y-axis will represent the Total construction WTP cost for each WTP. X-axis will represent the Million liters/day (MLD) for each WTP. The equation we get is y=(4*10^6) (x) ,where x is the capacity million liter/day for Chestermere.

Table 4: Different water Treatment plants in Canada with their Total WTP cost with Capacity MLD [29] [30] [31] [32] [33] [34] [35]

Water Treatment Plant	Location	Total Construction cost	Capacity (MLD)
N. A	N. A	0	0
Rose Valley Water Treatment Plant	West Kelowna, BC	75000000	70
North Shore Wastewater Treatment Plant	North Vancouver, BC	3860000000	102
Lethbridge Water Treatment Plant	Lethbridge, AB	41000000	150
Comox Valley Water Treatment Plant	Comox Valley, BC	126000000	71
Bonnybrook Wastewater Treatment Plant	Calgary, AB	1500000000	950
Iona Island Wastewater Treatment Plant	Vancouver, BC	10000000000	1200
North End Sewage Treatment Plant	Winnipeg, MB	1800000000	600
Regina Wastewater Treatment Plant	Regina, SK	181000000	92
Saskatoon Water Treatment Plant	Saskatoon, SK	80000000	150
Edmonton E.L. Smith Water Treatment Plant	Edmonton, AB	200000000	680
Pine Creek Wastewater Treatment Plant	Calgary, AB	430000000	100
Englishman River Water Treatment Plant	Parksville, BC	37000000	24
Selkirk Water Treatment Plant	Selkirk, MB	35200000	50
Perth Wastewater Treatment Plant	Perth, ON	15000000	30
Hanlan Feedermain Project	Peel Region, ON	500000000	140
Don River and Central Waterfront WTP	Toronto, ON	3000000000	1000
Southeast Collector Trunk WTP	York Region, ON	550000000	900
Lions Gate Secondary Wastewater Treatment Plant	North Vancouver, BC	700000000	500
Okotoks Water WTP Project	Okotoks, AB	40000000	40

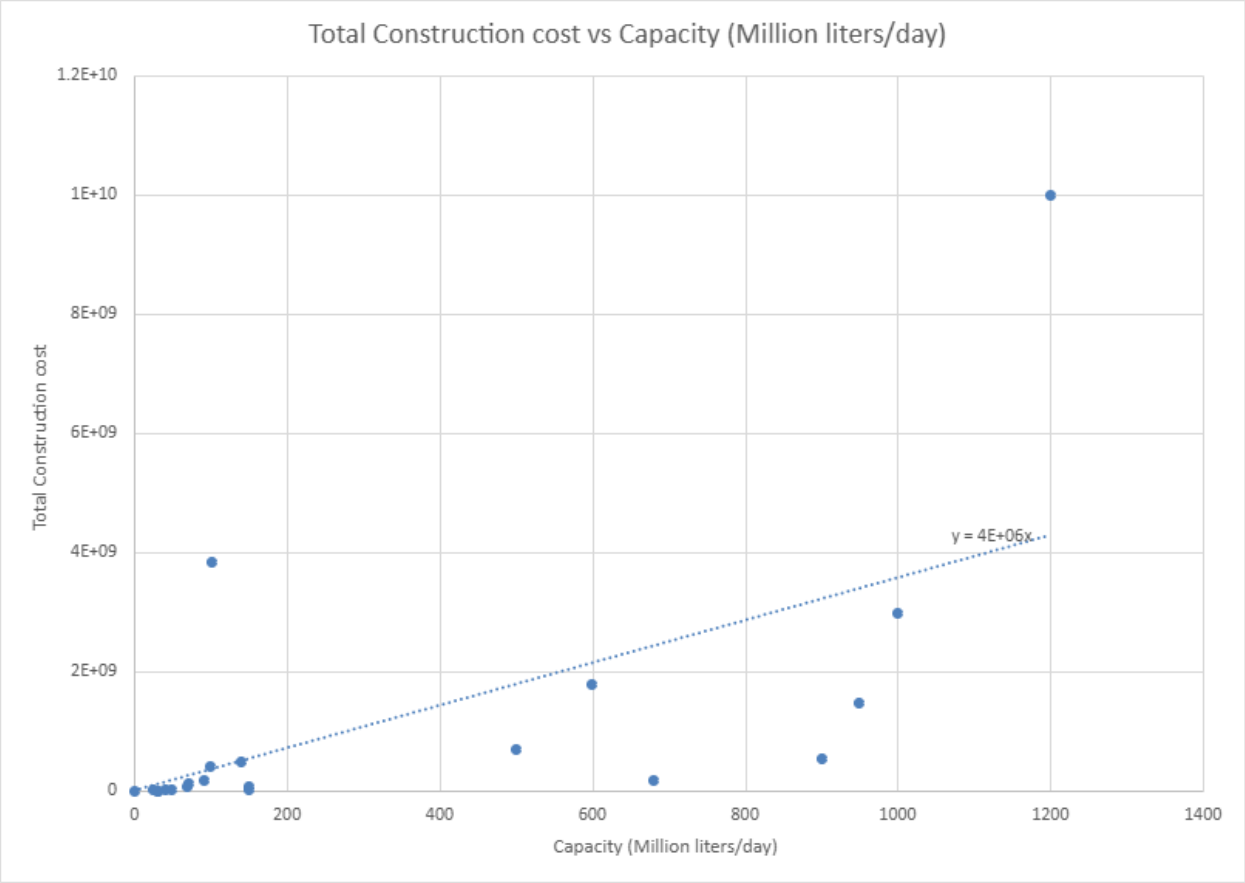


Figure 12: Trendline equation for the data in table

Total Water treatment plant construction cost of Chestermere= (4*10^6) (35.9)=143.6 million CAD

The building of the water treatment plant would get funding, approximately CAD 143.6 million. This would include constructing treatment buildings, such as sedimentation tanks, filtration units, UV or chlorine disinfection systems, and perhaps chemical treatment facilities for certain pollutants. The capacity of the facility would have to be planned to meet the potential peak demand of several million liters per day. To provide reliable service during outages, emergency backup facilities such as water storage reservoirs and on-site power generators would also be installed.

With a CAD 143.6 million budget, we must carefully invest a lot of funds to meet the infrastructure, building, and regulatory needs of a new water treatment facility in Chestermere. This breakdown shows how the funding might be allocated efficiently while guaranteeing the plant satisfies present and future demand as we consider the capacity million liters per day.

1. Construction of a water treatment plant (CAD 64.62 million) (45%) [36] [37]

The building of the actual water treatment facility will accept the majority of the expenditure, which is 64.62 million. This estimate was based on the percentage taken in similar water treatment plant project

where they accounted for 45% of the total cost [8]. Chestermere will have important systems such as water intake structures, sophisticated filtration systems (such membrane filtration or reverse osmosis), and UV or chlorine treatment for disinfection. The water will also be treated chemically to fulfill the stringent requirements outlined in Alberta's Guidelines for Canadian Drinking Water Quality. Along with sludge management systems to manage the treatment process's byproducts, the facility will also need storage tanks to keep purified water prior to distribution. This will include Site evacuation (Excavation and disposal of fill, Backfill, Asphalt driveway) which accounts for 4% of the project. Secondly, Process Equipment (e.g. Intake pipe, intake crib, low lift pumps, filtration system, UV disinfection, high lift pumps) which accounts for 31%. Lastly, Structural (reinforced concrete, waterproofing) accounts for 10% of the project.

2. Water Distribution System and Pipelines (24.412 million) (17%) [36] [37]

24.412 million will be needed to connect the new plant to Chestermere's current municipal water system. The expense of installing water pipes and pumping stations is high. Depending on the distance between the plant and the city, installing kilometers of new pipes in Chestermere would cost between CAD 1,000 and 2,000 per meter. To maintain sufficient pressure, pumping stations must also be erected, especially if the plant is situated at a lower elevation or far from residential areas. For the new plant to successfully expand the city's water supply capacity, integration with the current water infrastructure will also need certain changes. Finally, it will account for 17% of the total cost for the water treatment plant construction cost of Chestermere.

3. Site preparation and land acquisition (CAD 11.488 million) (8%) [36] [37]

An estimated CAD of 11.488 million will be spent on land acquisition and site preparation. Land prices in Chestermere might be high due to its expansion and proximity to Calgary. Costs associated with acquiring land and preparing the site, which includes clearing, grading, and installing foundations, can account for a sizable portion of the overall budget for projects of this nature. Selecting a suitable site as the one we chose which is really close to Chestermere's lake which could account for a high expenses, but this stage is still required to guarantee the plant's placement. Finally, this will be 8% of our total estimated cost for Chestermere WTP.

4. Design, Environmental Evaluations, and Permitting (CAD 8.616 million) (6%) [36] [37]

The project is expected to cost CAD 8.616 million, and obtaining the required licenses and performing environmental studies will be essential to its success. Enormous expenditure is necessary for following provincial laws, as demonstrated by facilities such as the wastewater treatment facility in Wetaskiwin. The following steps will involve obtaining the required permissions of Alberta Environment and Parks and conducting studies on the environment to make certain that the plant will not have a detrimental effect on nearby ecosystems. As a way to guarantee that the layout of the facility continues to be operational and comply with legal standards, expert expenditures for engineers and architects will also be paid at this phase. This will allocate 6 % of the total cost of Chestermere WTP project.

Mechanical and Electrical Systems (18.668 million CAD) (13%) [36] [37]

In order for the factory to function, electrical as well as mechanical systems are necessary, and they ought to price around CAD 18.668 million. Supervisory Control and Data Acquisition, or

SCADA, platforms are among the automation and oversight capabilities included in these systems, which aid in real-time monitoring and management of the plant's operations. Along with the mechanical infrastructure required to run the filtration and pumping systems, the facility will also require dependable backup power generators to guarantee uninterrupted operation during outages. Also, the cost will include Installing pumps, filtration units, automation, and electrical wiring, Setting up control panels and energy systems. This will allocate 13% of the total Chestermere cost.

Contingency Fund (11.488 million CAD) (8%) [36] [37]

To cover any unanticipated expenses that may come up throughout the project, a contingency reserve of CAD 11.488 million is necessary. Large infrastructure projects typically use this allocation because of unforeseen issues like construction delays, material price fluctuations, or the need for extra upgrades—occur frequently. Wetaskiwin was able to keep costs down by reusing part of its existing infrastructure, but having a contingency gives for flexibility in handling unforeseen costs. The project's financial stability may be maintained by setting aside between 5% and 10% of the overall budget as a contingency. It will be allocated for 8% of the total Chestermere WTP cost.

Commissioning, Training, and the total (CAD 4.308 million) (3%) [36] [37]

An estimated CAD 4.308 million will be required for plant commissioning, training, and staffing when construction is finished. Employing and educating personnel to operate the plant effectively and in accordance with provincial regulations is part of this. Before the facility is completely operational, it will also go through a thorough testing and commissioning process. These last actions guarantee that the systems are operating correctly and that the generated water satisfies the required quality criteria. Also, Hiring and onboarding personnel for daily operations will take part of the cost. This will allocate 3% of the total WTP cost.

Table 5: Breakdown of project construction costs

Section Name	Total Cost (million CAD) from the 129.6 million
Construction of the Water Treatment Plant	64.620
Water Distribution System and Pipelines	24.412
Site Preparation and land acquisition	11.488

Design, Environmental Evaluations, and Permitting	8.616
Mechanical and Electrical Systems	18.668
Contingency fund	11.488
Commissioning, Training, and Staffing	4.308
	Σ 143.6

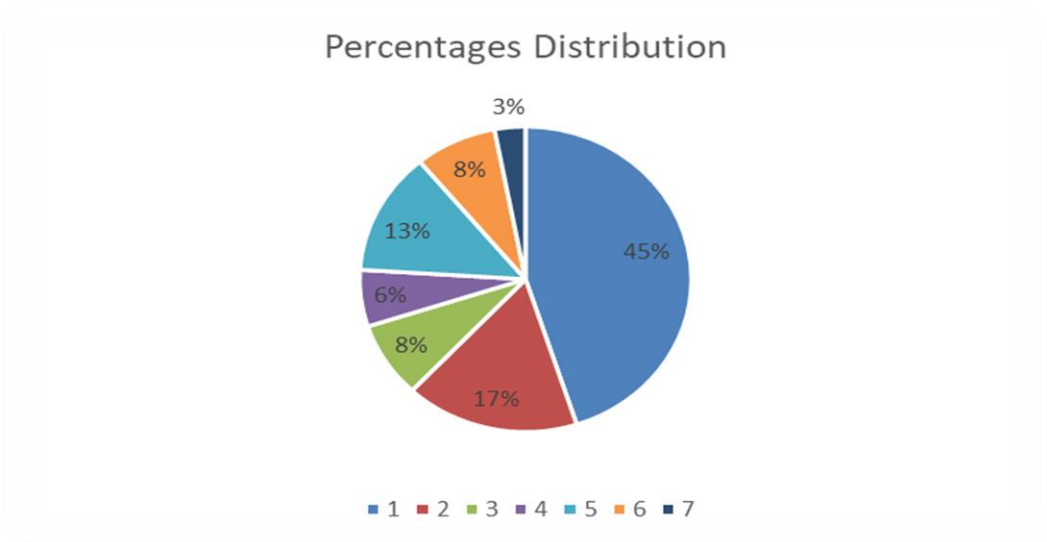


Figure 13: Percentage allocation summary from the 100%

OPEX

Before diving into the details of the Chief Crowfoot Water Treatment Plant operation and maintenance costs, it is important to understand the context of where the data is coming from and how it was used to produce the OPEX in its current form.

Biennial Drinking Water Plants Survey (DKWP)

The Biennial Drinking Water Plants Survey (from now on referred to as DKWP) is a national survey undertaken by Statistics Canada [38]. It is a mandatory survey for all drinking water plants in Canada serving more than 300 people and takes place every two years. The OPEX was developed using Statistics Canada's rich data on this topic, as a whole section of the survey's report is dedicated to the operating and maintenance of these water treatment plants across Canada. A combination of both the latest published report for 2021 data and older more detailed reports were used to arrive at our numbers. All currency was adjusted for inflation for our projections using the two percent inflation rate as per Bank of Canada recommendations [39].

Operational Expense Categories

The DKWP organizes operational expenses into four main categories: Materials, Labour, Energy, and Other. Material expenses include chemicals and replacement parts. Labour includes internal and external staff, including laboratory personnel. The costs falling under the "other" category include a variety of expenses such as "waste disposal and residuals handling, analytical/sampling costs, any associated administration and service costs directly related to operation and maintenance (consultants and contractors)" and "costs related to waste treatment processes (that is, backwash processing and residuals disposal)" [38]. For example, see the table below on total operational and maintenance costs for each province in the year 2011, according to the DKWP.

Table 6: Operation and Maintenance per Province, Year 2011

Operation and maintenance costs of drinking water plants — Province and territory

	Materials [1]	Labour [2]	Energy	Other [3]	Total
	millions of dollars				
Canada	**213.4** A	**338.4** A	**200.4** A	**129.7** A	**881.9** A
Newfoundland and Labrador	4.8 A	6.3 A	4.7 A	1.0 B	16.9 A
Prince Edward Island	0.4 A	0.9 A	0.7 A	1.1 A	3.1 A
Nova Scotia	8.2 A	6.7 A	4.6 B	3.6 C	23.1 A
New Brunswick	3.7 A	5.2 A	2.8 A	1.8 B	13.5 A
Quebec	49.7 A	79.7 A	56.8 A	20.2 A	206.4 A
Ontario	64.9 A	114.1 A	73.0 A	63.6 A	315.7 A
Manitoba	16.6 A	15.0 A	5.9 A	2.9 A	40.4 A
Saskatchewan	14.7 A	22.3 A	8.4 A	6.7 A	52.2 A
Alberta	30.1 A	48.0 A	29.2 A	15.5 A	122.9 A
British Columbia	18.5 A	34.0 A	11.3 A	12.7 B	76.4 A
Yukon	0.3 A	0.9 A	0.8 A	0.1 A	2.1 A
Northwest Territories	1.0 D	3.7 D	1.7 C	F	7.0 D
Nunavut	0.4 C	1.5 A	0.5 C	0.0 Es	2.3 B

1. Includes chemicals and replacement parts.
2. Includes internal and external staff including laboratory personnel.
3. Includes costs such as waste disposal and residuals handling, analytical/sampling costs, any associated administration and service costs directly related to operation and maintenance (consultants and contractors) and costs related to waste treatment processes (that is, backwash processing and residuals disposal).

Note(s): Includes costs related to the acquisition and treatment, but not the distribution, of water. Figures may not add up to totals due to rounding.
Source(s): Statistics Canada, Environment Accounts and Statistics Division, CANSIM table 153-0108.

Drinking Water Cost Per Unit Volume Relationship

Examining the Statistics Canada data, it became clear that there was an interesting relationship between the production volume of the water treatment plant itself and the unit cost of water production (dollars per 1 million liters). The cost of drinking water per unit volume actually decreases as treatment plants produce more water, so the cost and production actually have an inversely proportional relationship. This relationship is primarily due to the fact that larger volumes benefit from economies of scale, meaning that fixed costs are spread across the entire plant, like maintenance, staffing, and energy, while the output is not fixed. Operations at a larger scale are also more efficient, like purchasing chemicals in bulk. To explain it in a mathematical sense, the denominator (liters) gets bigger, while the cost (dollars) doesn't change. On the other hand, smaller production capacities often have higher costs per megaliter since their capacity is underutilized and their fixed costs serve the unit volume a lot less. See Table 2 on the following page for the detail of this relationship according to the DKWP). Notice on the right side, the unit costs decreases as the volume production increases. In its base year, the Crowfoot Treatment Plant will be producing 7.27 megalitres per day, falling in the category of between 5 and 10 thousands of cubic metres per day (the same as one megalitre, or million litres).

Table 7: Inverse relationship between production volume and unit cost

Operation and maintenance costs of drinking water plants — Treating primarily surface water, by production volume

	Total costs					Unit costs				
	Materials [1]	Labour [2]	Energy	Other [3]	Total	Materials [1]	Labour [2]	Energy	Other [3]	Total
	millions of dollars					dollars per thousand cubic metres				
Production volume category (thousands of cubic metres per day [4])										
All categories	**170.4** A	**260.3** A	**155.1** A	**85.2** A	**671.0** A	**38.2** A	**58.3** A	**34.8** A	**19.1** A	**150.4** A
1.5 or less	16.1 A	30.4 A	11.5 A	10.6 A	68.5 A	189.7 A	358.9 A	135.3 A	124.6 A	808.5 A
more than 1.5 to 5	18.5 A	28.5 A	14.4 A	11.7 A	73.1 A	97.8 A	151.2 A	76.0 A	62.2 A	387.2 A
more than 5 to 10	15.5 A	23.6 A	14.9 A	10.8 B	64.8 A	82.4 A	125.8 A	79.6 A	57.7 B	345.5 A
more than 10 to 20	12.5 A	20.7 A	10.3 A	6.8 B	50.3 A	51.0 A	84.2 A	42.0 A	27.8 B	205.0 A
more than 20 to 50	33.3 A	45.2 A	27.3 A	10.9 B	116.6 A	55.2 A	75.0 A	45.2 A	18.1 B	193.6 A
more than 50 to 100	21.6 A	27.7 A	21.9 A	7.0 B	78.3 A	37.0 A	47.4 A	37.5 A	11.9 B	133.9 A
more than 100	53.0 A	84.1 A	54.9 A	27.4 A	219.4 A	20.6 A	32.8 A	21.4 A	10.7 A	85.4 A

1. Includes chemicals and replacement parts.
2. Includes internal and external staff including laboratory personnel.
3. Includes costs such as waste disposal and residuals handling, analytical/sampling costs, any associated administration and service costs directly related to operation and maintenance (consultants and contractors) and costs related to waste treatment processes (that is, backwash processing and residuals disposal).
4. One thousand cubic metres is equal to one mega litre.

Note(s): Cost per unit volume will vary within each category due to various sizes and configurations of plants. Includes plants treating 90% or more surface water and costs related to the acquisition and treatment, but not the distribution, of water. Figures may not add up to totals due to rounding.

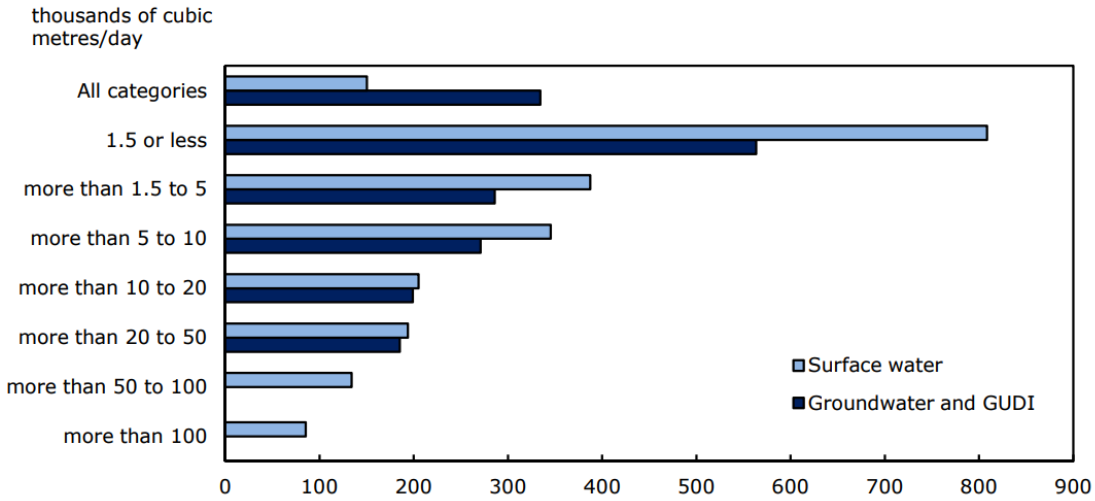
Source(s): Statistics Canada, 2013, Environment Accounts and Statistics Division, Survey of Drinking Water Plants (survey number 5149).

Out of all the treated drinking water in Canada, 89% percent comes from surface water. The Crowfoot Treatment plant will also be treating surface water, not groundwater, which greatly affects the operation and maintenance costs.

As previously mentioned, a number of factors influence operation and maintenance costs, such as the plant size, but also the source water type and method of treatment. Costs per unit of volume tend to be lower for surface water plants because they belong to the category of plants that are producing at high volume, while groundwater plants tend to be lower-volume producers. For both source water types, costs per unit volume went down as production volumes went up.

Table 8: OPEX per unit volume and source water type

Operation and maintenance costs per unit volume by plant production volume and main source water type, 2011



In this spirit, the OPEX for Chief Crowfoot Water Treatment Plant was designed in a way to use both ends of this relationship. On the one hand, the maximum daily demand was used in order to be able to design the plant to serve the community in its maximum need. However, to be conservative, the average daily demand was also calculated and used to account for the maximum cost the plant might have per megaliter. This means that the cost per megaliter is actually within a range. If the plant were to hit its average every day, the unit cost would be $577.42 per megaliter, but if it were to produce more volume or even hit its maximum demand, the price per unit could go as low as $342.61 per megaliter, as described in Table 4 below.

Table 9: Cost per Megalitre in 2027

Cost Type	Maximum Cost, Producing between 5-10 ML per day ($/ML)	Minimum Cost, Producing between 10-20 ML per day ($/ML)
Materials	$ 137.71	$ 85.23
Labour	$ 210.25	$ 140.72
Energy	$ 133.03	$ 70.19
Other	$ 96.43	$ 46.46
Total	**$ 577.42**	**$ 342.61**

Inflation and Projections

Table 4 bases itself on the year 2027, as that is the first year the plant is expected to be active after construction. The population of Chestermere will be 30,292 producing between 7.57 and 17.11 megaliters per day. Projecting costs for the future requires projecting the population, as the costs depend on the maximum and average daily demands of volume, but now also inflation. Multiplying the maximum unit cost by the maximum daily demand by the number of days in one year brings the total cost for year 2027 to up to 3.6 million. Leap years were considered by assuming one year to equal 365.25 days, as excluding them would mean costs would be off by almost $10,000. The specific base costs for year 2027 were taken from Table 2 of the DKWP with two percent inflation applied. The following years were also calculated using the two percent inflation rate up until year 2039 when the Crowfoot Treatment Plant will reach the next tranche of average production volume (between 10 and 20 megaliters per day) to where the survey's model says the costs will actually decrease sharply and then increase again in the following years due to inflation. This will be the case if the treatment plant can streamline or increase capacity for a part of the treatment process, for example, the addition of another treatment tank. The summary for this work is represented in Table 5 below, and the full calculation table (Table 6) is available for reference following it.

Table 10: Yearly Projected OPEX Costs

Year	Population	ADD (ML/d)	MDD (ML/d)	Max Unit Cost $/ML	Min Unit Cost $/ML	Cost per day	Cost per year
2027	30292	7.57	17.11	**577.42**	**342.61**	$ 9,883	**$ 3,609,625**
2028	31049	7.76	17.54	**588.97**	**349.46**	$ 10,332	**$ 3,773,863**
2029	31826	7.96	17.98	**600.75**	**356.45**	$ 10,802	**$ 3,945,573**
2030	32621	8.16	18.43	**612.77**	**363.58**	$ 11,294	**$ 4,125,097**
2031	33437	8.36	18.89	**625.02**	**370.85**	$ 11,808	**$ 4,312,789**
2032	34273	8.57	19.36	**637.52**	**378.27**	$ 12,345	**$ 4,509,021**
2033	35129	8.78	19.85	**650.27**	**385.84**	$ 12,907	**$ 4,714,181**
2034	36008	9.00	20.34	**663.28**	**393.55**	$ 13,494	**$ 4,928,677**
2035	36908	9.23	20.85	**676.55**	**401.42**	$ 14,108	**$ 5,152,931**
2036	37831	9.46	21.37	**690.08**	**409.45**	$ 14,750	**$ 5,387,390**
2037	38776	9.69	21.91	**703.88**	**417.64**	$ 15,421	**$ 5,632,516**
2038	39746	9.94	22.46	**717.96**	**425.99**	$ 16,123	**$ 5,888,795**
2039	40739	10.18	23.02	**452.07**	**336.89**	$ 10,406	**$ 3,800,639**
2040	41758	10.44	23.59	**461.11**	**343.63**	$ 10,879	**$ 3,973,568**
2041	42802	10.70	24.18	**470.33**	**350.50**	$ 11,374	**$ 4,154,366**
2042	43872	10.97	24.79	**479.74**	**357.51**	$ 11,892	**$ 4,343,389**
2043	44969	11.24	25.41	**489.33**	**364.66**	$ 12,433	**$ 4,541,014**
2044	46093	11.52	26.04	**499.12**	**371.95**	$ 12,998	**$ 4,747,630**
2045	47245	11.81	26.69	**509.10**	**379.39**	$ 13,590	**$ 4,963,647**
2046	48426	12.11	27.36	**519.28**	**386.98**	$ 14,208	**$ 5,189,493**
2047	49637	12.41	28.04	**529.67**	**394.72**	$ 14,855	**$ 5,425,615**
2048	50878	12.72	28.75	**540.26**	**402.61**	$ 15,530	**$ 5,672,480**
2049	52150	13.04	29.46	**551.07**	**410.66**	$ 16,237	**$ 5,930,578**
2050	53454	13.36	30.20	**562.09**	**418.88**	$ 16,976	**$ 6,200,419**
2051	54790	13.70	30.96	**573.33**	**427.26**	$ 17,748	**$ 6,482,538**
2052	56160	14.04	31.73	**584.80**	**435.80**	$ 18,556	**$ 6,777,494**
2053	57564	14.39	32.52	**596.49**	**444.52**	$ 19,400	**$ 7,085,870**
2054	59003	14.75	33.34	**608.42**	**453.41**	$ 20,283	**$ 7,408,277**
2055	60478	15.12	34.17	**620.59**	**462.48**	$ 21,206	**$ 7,745,354**
2056	61990	15.50	35.02	**633.00**	**471.72**	$ 22,170	**$ 8,097,767**
2057	63540	15.88	35.90	**645.66**	**481.16**	$ 23,179	**$ 8,466,216**

Table 11: OPEX Additional Calculations

				Producing 5-10 ML/Day					Producing 10-20 ML/Day						
Year	Population	ADD(ML/d)	MDD (ML/d)	Materials ($/ML)	Labour ($/ML)	Enery ($/ML)	Other ($/ML)	Max Unit Cost $/ML	Materials ($/ML)	Labour ($/ML)	Enery ($/ML)	Other ($/ML)	Min Unit Cost $/ML	Cost per day	Cost per year
2027	30292	7.57	17.11	137.71	210.25	133.03	96.43	**577.42**	85.23	140.72	70.19	46.46	**342.61**	$ 9,883	**$ 3,609,625**
2028	31049	7.76	17.54	140.47	214.45	135.69	98.36	**588.97**	86.94	143.54	71.60	47.39	**349.46**	$ 10,332	**$ 3,773,863**
2029	31826	7.96	17.98	143.28	218.74	138.41	100.33	**600.75**	88.68	146.41	73.03	48.34	**356.45**	$ 10,802	**$ 3,945,573**
2030	32621	8.16	18.43	146.14	223.11	141.18	102.33	**612.77**	90.45	149.33	74.49	49.31	**363.58**	$ 11,294	**$ 4,125,097**
2031	33437	8.36	18.89	149.06	227.58	144.00	104.38	**625.02**	92.26	152.32	75.98	50.29	**370.85**	$ 11,808	**$ 4,312,789**
2032	34273	8.57	19.36	152.05	232.13	146.88	106.47	**637.52**	94.11	155.37	77.50	51.30	**378.27**	$ 12,345	**$ 4,509,021**
2033	35129	8.78	19.85	155.09	236.77	149.82	108.60	**650.27**	95.99	158.47	79.05	52.32	**385.84**	$ 12,907	**$ 4,714,181**
2034	36008	9.00	20.34	158.19	241.51	152.81	110.77	**663.28**	97.91	161.64	80.63	53.37	**393.55**	$ 13,494	**$ 4,928,677**
2035	36908	9.23	20.85	161.35	246.34	155.87	112.99	**676.55**	99.87	164.88	82.24	54.44	**401.42**	$ 14,108	**$ 5,152,931**
2036	37831	9.46	21.37	164.58	251.26	158.99	115.25	**690.08**	101.86	168.17	83.89	55.53	**409.45**	$ 14,750	**$ 5,387,390**
2037	38776	9.69	21.91	167.87	256.29	162.17	117.55	**703.88**	103.90	171.54	85.57	56.64	**417.64**	$ 15,421	**$ 5,632,516**
2038	39746	9.94	22.46	171.23	261.41	165.41	119.90	**717.96**	105.98	174.97	87.28	57.77	**425.99**	$ 16,123	**$ 5,888,795**
2039	40739	10.18	23.02	112.47	185.68	92.62	61.30	**452.07**	96.10	130.58	78.69	31.51	336.89	$ 10,406	**$ 3,800,639**
2040	41758	10.44	23.59	114.71	189.39	94.47	62.53	**461.11**	98.03	133.19	80.27	32.14	**343.63**	$ 10,879	**$ 3,973,568**
2041	42802	10.70	24.18	117.01	193.18	96.36	63.78	**470.33**	99.99	135.85	81.87	32.79	**350.50**	$ 11,374	**$ 4,154,366**
2042	43872	10.97	24.79	119.35	197.04	98.29	65.06	**479.74**	101.99	138.57	83.51	33.44	**357.51**	$ 11,892	**$ 4,343,389**
2043	44969	11.24	25.41	121.74	200.98	100.25	66.36	**489.33**	104.03	141.34	85.18	34.11	**364.66**	$ 12,433	**$ 4,541,014**
2044	46093	11.52	26.04	124.17	205.00	102.26	67.69	**499.12**	106.11	144.17	86.88	34.79	**371.95**	$ 12,998	**$ 4,747,630**
2045	47245	11.81	26.69	126.65	209.10	104.30	69.04	**509.10**	108.23	147.05	88.62	35.49	**379.39**	$ 13,590	**$ 4,963,647**
2046	48426	12.11	27.36	129.19	213.29	106.39	70.42	**519.28**	110.39	149.99	90.40	36.20	**386.98**	$ 14,208	**$ 5,189,493**
2047	49637	12.41	28.04	131.77	217.55	108.52	71.83	**529.67**	112.60	152.99	92.20	36.92	**394.72**	$ 14,855	**$ 5,425,615**
2048	50878	12.72	28.75	134.41	221.90	110.69	73.26	**540.26**	114.85	156.05	94.05	37.66	**402.61**	$ 15,530	**$ 5,672,480**
2049	52150	13.04	29.46	137.10	226.34	112.90	74.73	**551.07**	117.15	159.17	95.93	38.41	**410.66**	$ 16,237	**$ 5,930,578**
2050	53454	13.36	30.20	139.84	230.87	115.16	76.22	**562.09**	119.49	162.36	97.85	39.18	**418.88**	$ 16,976	**$ 6,200,419**
2051	54790	13.70	30.96	142.63	235.49	117.46	77.75	**573.33**	121.88	165.60	99.80	39.97	**427.26**	$ 17,748	**$ 6,482,538**
2052	56160	14.04	31.73	145.49	240.20	119.81	79.30	**584.80**	124.32	168.92	101.80	40.76	**435.80**	$ 18,556	**$ 6,777,494**
2053	57564	14.39	32.52	148.40	245.00	122.21	80.89	**596.49**	126.81	172.29	103.84	41.58	**444.52**	$ 19,400	**$ 7,085,870**
2054	59003	14.75	33.34	151.36	249.90	124.65	82.51	**608.42**	129.34	175.74	105.91	42.41	**453.41**	$ 20,283	**$ 7,408,277**
2055	60478	15.12	34.17	154.39	254.90	127.15	84.16	**620.59**	131.93	179.25	108.03	43.26	**462.48**	$ 21,206	**$ 7,745,354**
2056	61990	15.50	35.02	157.48	259.99	129.69	85.84	**633.00**	134.57	182.84	110.19	44.13	**471.72**	$ 22,170	**$ 8,097,767**
2057	63540	15.88	35.90	160.63	265.19	132.28	87.56	**645.66**	137.26	186.50	112.39	45.01	**481.16**	$ 23,179	**$ 8,466,216**

Maintenance Schedule and lifetimes

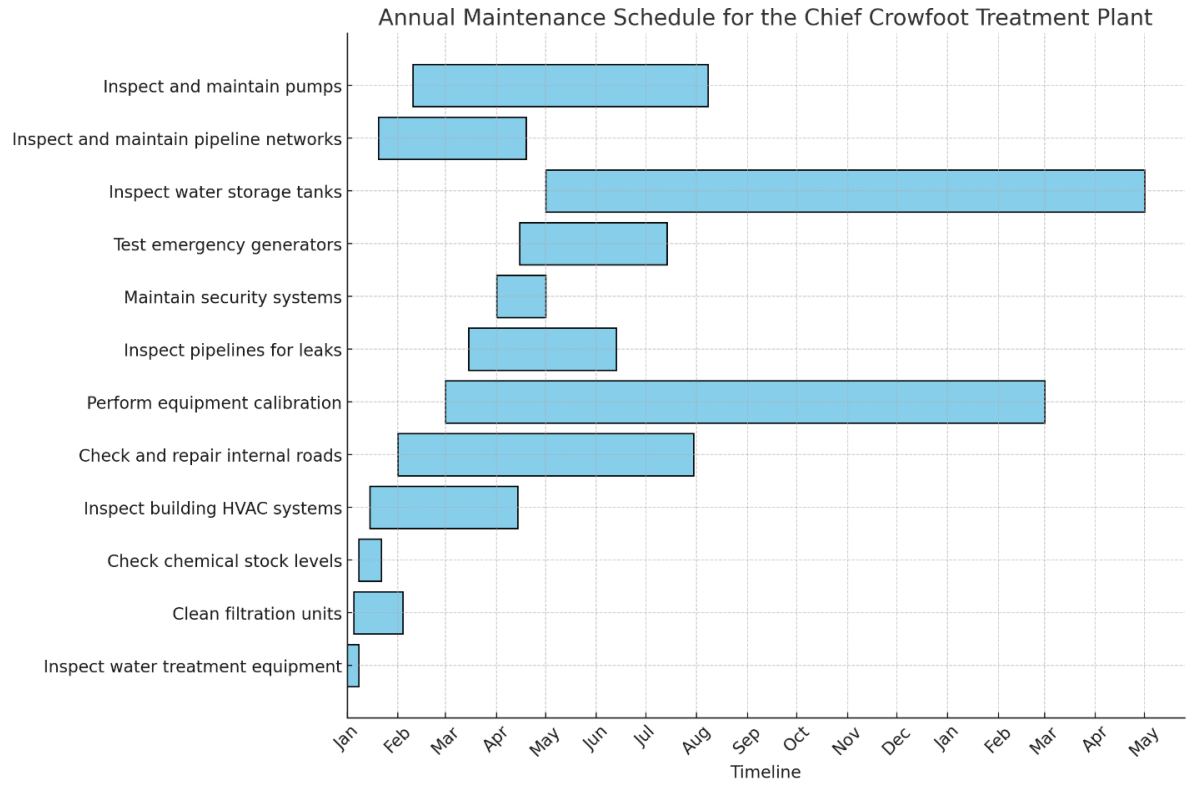


Figure 14: Annual Maintenance Schedule

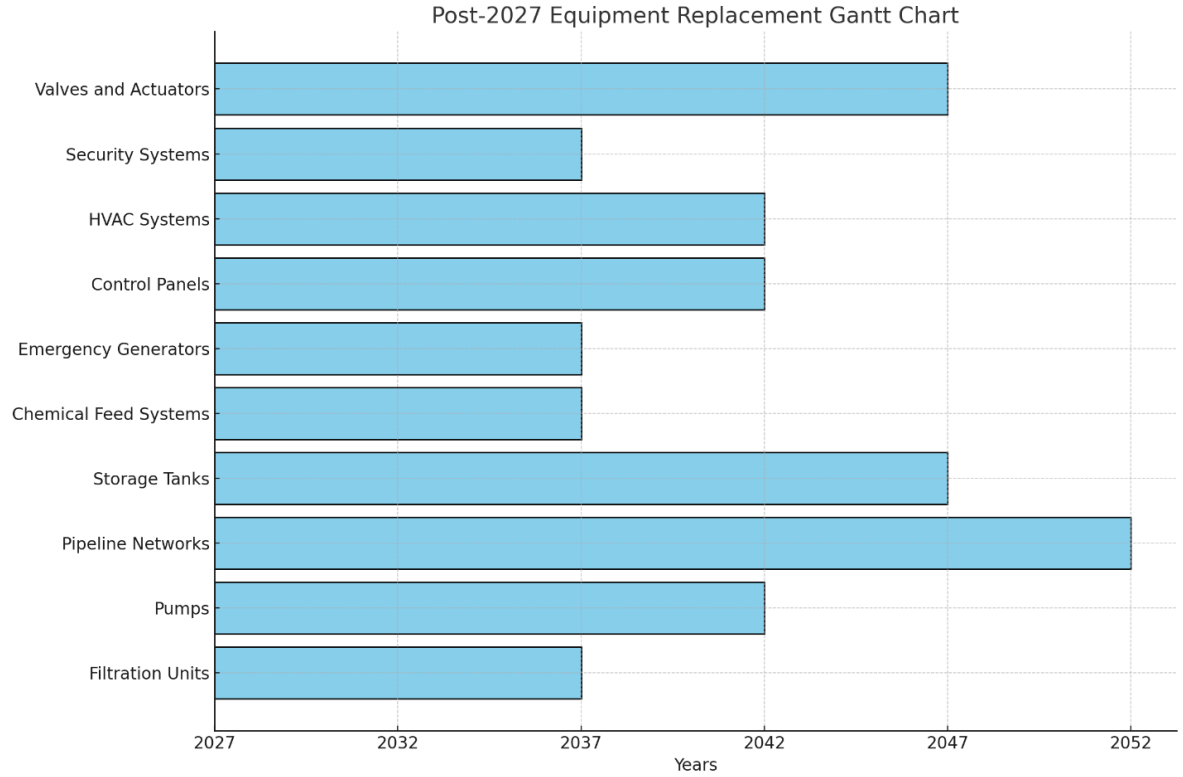


Figure 15: Equipment Replacement Schedule

Equipment Lifetimes

Table 12: Equipment lifetimes and reasons for deterioration

Equipment	Lifespan (Years)	Reason	Source
Filtration Units	10	Regular media and equipment replacement due to wear and tear.	American Water Works Association (AWWA), "Filtration Facilities Design Manual"
Pumps	15	Average lifespan for industrial pumps with regular maintenance.	Hydraulic Institute Standards and Equipment Manufacturer Guidelines
Pipeline Networks	25	Lifespan depends on material and operating conditions.	EPA, "Water Distribution System Materials and Lifespans"
Storage Tanks	20	Dependent on material and exposure to environmental factors.	National Fire Protection Association (NFPA) 22, "Water Tanks for Private Fire Protection"
Chemical Feed Systems	10	Corrosion and wear from chemical exposure.	Equipment Manufacturer Maintenance Manuals
Emergency Generators	10	Lifespan varies by usage frequency and maintenance.	National Electrical Code (NEC) Guidelines and Manufacturer Recommendations
Control Panels	15	Electrical wear and technological obsolescence.	IEEE Standards for Electrical Equipment Maintenance
HVAC Systems	15	Operational wear and environmental exposure.	ASHRAE Handbook, "Heating, Ventilating, and Air-Conditioning Systems and Equipment"
Security Systems	10	Advances in technology and operational wear.	Equipment Manufacturer Recommendations
Valves and Actuators	20	Mechanical fatigue and corrosion.	Valve Manufacturer Association (VMA) Guidelines

Financing

Financing this project will be obtained through four different sources: federal grants, provincial grants, a federally combined grant and loan, and finally a private investment loan.

Federal Grants

- The Investing in Canada Infrastructure Program is a federal funding program to improve the quality of life of Canadians through the upkeep of infrastructure. This program will provide funds for up to 40% of the project's costs, given that all federal grants pay for a maximum of 66.66% of the project's expected cost. [40]
- The Clean Water and Wastewater Fund Program (CWWF) is a federally endorsed program promoting the rehabilitation of water treatment centers in Canada. It allocates up to 50% of the total project's funding in accordance with cost sharing rules of all programs. [41] Due to the cost

sharing programs of the Investing in Canada Infrastructure Program, 25.66% of the project will be funded through the CWWF.

- The Canada-Community-Building Fund is a predictable and yearly funding of community supporting projects in Canada. It will provide 1% of the funding given the previous year's funding data for the municipality of Chestermere. [42]

Provincial Grants

- The Alberta Municipal Water/Wastewater Partnership (AMWWP) is a provincial initiative to promote safe drinking water conditions for Alberta communities. It is allocated on a per capita basis according to the table below:

Table 13: AMWWP Funding Determination

Official population	Funding
Less than 1,000	75 % of eligible project cost
1,000 to 3,000	Grant = [(0.5 X Population) + 250] X 100 / Population Example: Population = 2,300 [(0.5 X 2,300) + 250] X 100 / 2,300 = 60.87 Grant = 60.87% of projects costs
3,001 to 10,000	Grant = [(0.25 x Population) + 1,000] X 100 / Population Example: Population = 5,300 [(0.25 X 5,300) + 1,000] X 100 / 5,300 = 43.87 Grant = 43.87% of projects costs
10,001 to 45,000	Grant = 35 – [0.001 X (Population - 10,000)] Example: Population = 15,300 35 – [0.001 X (15,300 – 10,000)] = 29.7 Grant = 29.7% of project costs

Based on the expected Chestermere population of approximately 28,129, the allocated funding of the AMWWP for this project is 18%, or $25.8 million. [43]

- The Local Government Fiscal Framework Program (LGFF) is a program to provide capital funding to infrastructure within Alberta. Based on previous years' Chestermere project allocations, it can be assumed that $2.6 million will be provided for this project, or 1.8%. [44]

Federally Combined Grant and Loan

- The program titled Capital Project: Construction of New Sustainable Municipal and Community Buildings allocates funding to municipal community buildings in Canada. It will offer competitive loans as well as a grant based on a percentage of that amount, up to a maximum of $10 million. [45]

This combined grant and loan will account for 7**%** or **$10 million**.

The grant component of this funding mechanism will be allotted 15% of this value, or $1,300,000. This leaves $8.7 million total to be paid off as a competitive loan along the OPEX, and the following private loan, yearly.

Private-Public Partnership (P3)

To account for the remaining funds, ATB Financial will be privately funding this project at a competitive interest rate. They will be providing **6.6%** of the project or **$9.44 million.** [46]

Table 14: Funding Allocation Breakdown Table

Program		**Dollar-Value Allotted ($)**	**Percentage of Project (%)**
Investing in Canada Infrastructure Program		57,440,000	40
Clean Water and Wastewater Fund Program		36,847,760	25.66
Canada-Community-Building Fund		1,436,000	1
Total		**95781200**	**66.7**
Alberta Municipal Water/Wastewater Partnership		25,848,000	18
Local Government Fiscal Framework Program		2,584,800	1.8
Total		**28,432,800**	**19.8**
Capital Project: Construction of New Sustainable Municipal and Community Buildings	**Loan**	8,695,000	6.1
	Grant	1, 305, 000	0.9
ATP Financial Loan		9,443,440	6.6
Grand Total		**143600000**	**100**

Repayment of Loan

Given the interest rates of government loans cannot be accessed, an expected average of 4.2% monthly can be assumed, based on Alberta government website, semi-monthly, to pay off both the ATP Financial loan and the Federal loan. [47] Given a 15-year payment plan, Chestermere would be paying approximately $25 million on the $18 million loan over the 15-year period, therefore paying **$1,659,299** million per year for 15 years, shown in the table below.

Table 15: Loan Repayment Schedule

Year	Annual Payment	Interest Paid	Principal Paid	Remaining Balance
2027	$1,659,299	$773,628	$885,671	$17,214,329
2028	$1,659,299	$735,773	$923,526	$16,290,803
2029	$1,659,299	$696,300	$962,999	$15,327,804
2030	$1,659,299	$655,139	$1,004,160	$14,323,644
2031	$1,659,299	$612,220	$1,047,079	$13,276,565
2032	$1,659,299	$567,466	$1,091,834	$12,184,731
2033	$1,659,299	$520,799	$1,138,501	$11,046,230
2034	$1,659,299	$472,137	$1,187,162	$9,859,068
2035	$1,659,299	$421,395	$1,237,904	$8,621,164
2036	$1,659,299	$368,485	$1,290,814	$7,330,350
2037	$1,659,299	$313,313	$1,345,986	$5,984,364
2038	$1,659,299	$255,783	$1,403,516	$4,580,848
2039	$1,659,299	$195,794	$1,463,505	$3,117,343
2040	$1,659,299	$133,241	$1,526,058	$1,591,285
2041	$1,659,299	$68,015	$1,591,285	$0

Municipal Return and Payments

Given the previous utility rates according to the city of Chestermere, the total average monthly utility bill is approximately $100, given the average consumption rate of 15.1 cubic meters/household/month, according to the Government of Alberta. [48] [49] The rates that can be affected by this change in clean water access are the Water Service Basic Charge and the Water Service Consumption Change, which together account for approximately $45 of the $100 a month. This project will halve this monthly bill from $45 to $22.5 and therefore reduce the total utility bill from approximately $100 to $77.5 a month.

The comprehensive return for the city of Chestermere can be calculated by determining the number of residential households which is multiplied by the monthly payment of $22.5/month. The number of households can be calculated according to the city of Chestermere website, given there are on average 3.5 people per household. [4] This breakdown is demonstrated in the table below for each given year.

Table 16: Chestermere Yearly Water Utility Returns

Year	Population	Number of households	Yearly Return ($)
2027	30292	8655	194734
2028	31049	8871	199601
2029	31825	9093	204589
2030	32621	9320	209706

2031	33437	9553	214952
2032	34272	9792	220320
2033	35129	10037	225829
2034	36007	10288	231474
2035	36908	10545	237266
2036	37830	10809	243193
2037	38776	11079	249274
2038	39746	11356	255510
2039	40739	11640	261894
2040	41758	11931	268444
2041	42802	12229	275156
2042	43872	12535	282034
2043	44968	12848	289080
2044	46093	13169	296312
2045	47245	13499	303718
2046	48426	13836	311310
2047	49637	14182	319095
2048	50878	14537	327073
2049	52150	14900	335250
2050	53453	15272	343626
2051	54790	15654	352221
2052	56159	16045	361022
2053	57563	16447	370048
2054	59002	16858	379299
2055	60478	17279	388787
2056	61989	17711	398501
2057	63539	18154	408465

Using the table above, data can be extrapolated to determine in what year the $25 million dollar loan would be paid off. It is found that in the year 2084 the city would have generated enough to refund the entire loan, as seen in the table below.

Table 17: Payback Period Determination

Year	Population	Number of Households	Yearly Return ($)	Total Return ($)
2083	120743	34498	776206	24,591,262
2084	123762	35360	795611	**25,386,873**

Cash Flow Analysis

The following diagram shows the cash flowing in and out of the project, on a yearly basis.

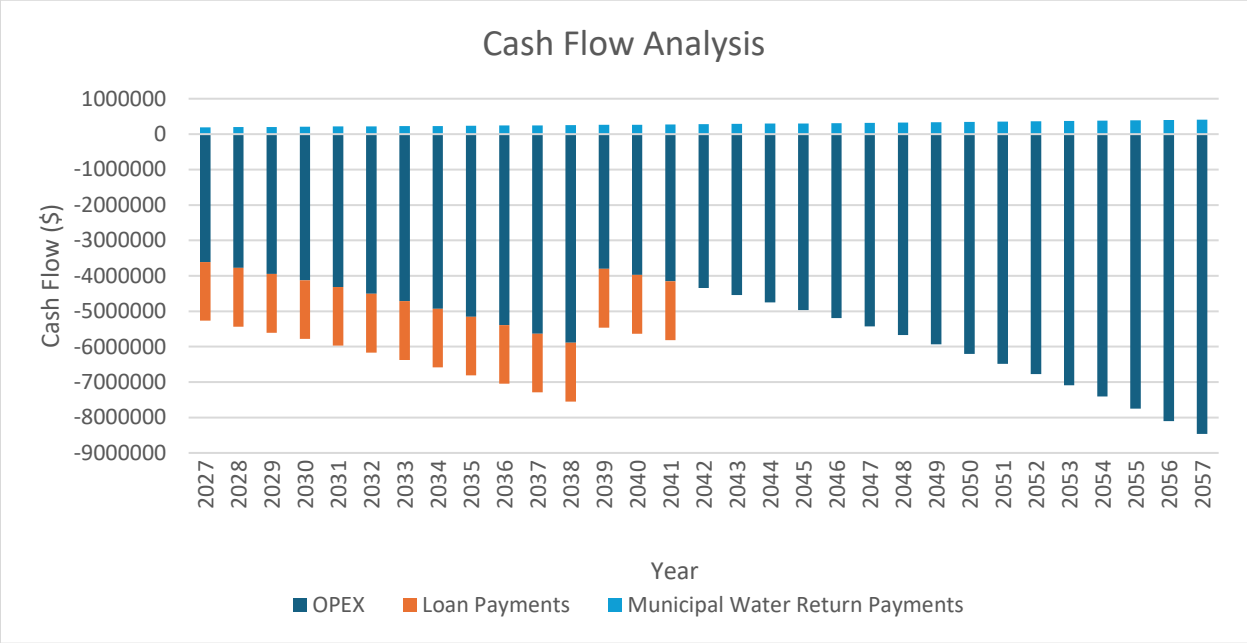


Figure 16: 2027-2057 Cash Flow Analysis

Municipal Contributions

As seen in Cash Flow Analysis above, the project is not creating profits year-by-year. It will be heavily subsidized by the municipal government of Chestermere detailed below. This subsidy has been confirmed and approved by the local government to be considered in the future budget.

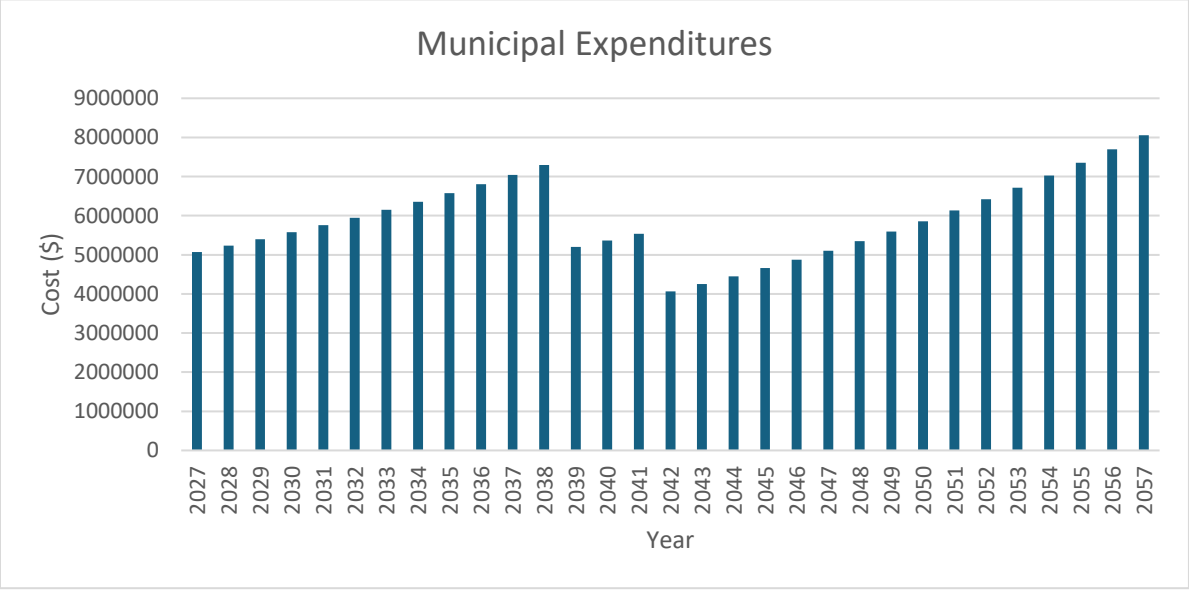


Figure 17: Chestermere Yearly Fund Diagram

Project Design

The Project Design is focused in three parts, first with the soft conceptual designs of the pipeline and overall water treatment plant, then in detail for the pumping station which is the focus for the main design portion of this report.

Pipeline



Figure 18: Path of Pipeline from Lake Chestermere to Water Treatment Plant

Water Treatment Plant



Figure 19: Aerial View of the Water Treatment Plant

The water treatment facility in Chestermere, Alberta, comprises several key structures, each playing a crucial role in the treatment process and overall functionality of the plant. The **Primary Clarifiers** (2 units) are circular with a diameter of 25 meters each, occupying a total area of 981.8 square meters. These clarifiers facilitate the initial sedimentation process, where heavy particles settle to the bottom, separating solids from the water.

The **Secondary Clarifier**, also circular with a diameter of 25 meters and an area of 490.9 square meters, plays a critical role in further treating wastewater by allowing fine particles and biological solids to settle. The **Main Treatment Building**, rectangular in shape with dimensions of 70 by 20 meters and an area of 1400 square meters, serves as the central hub for advanced treatment processes, including filtration and chemical treatments. Adjacent to this, the **Sludge Digesters** (2 units) are circular, each with a diameter of 15 meters, covering a total area of 353.4 square meters. These digesters are responsible for breaking down organic matter in the sludge through microbial activity, reducing its volume and producing biogas.

The **Chlorine Contact Chamber**, a rectangular structure measuring 60 by 10 meters with an area of 600 square meters, ensures adequate disinfection of the treated water by allowing chlorine to mix thoroughly and kill pathogens. Supporting administrative and operational activities, the **Administration Building** is rectangular, measuring 20 by 10 meters and occupying 200 square meters. Finally, the **Pumping Station**, also rectangular with dimensions of 15 by 21 meters and an area of 315 square meters, provides the hydraulic force necessary to move water through the treatment process and distribute it to the community.

The total area of the block, as indicated by the zoning information, is approximately 13,756.38 square meters. Internal roads within the block measure a total length of 471.763 meters, providing access to all critical structures and ensuring smooth operational logistics. The well-organized layout ensures optimal use of space, seamless workflow, and efficient maintenance of the facility.

The internal road network is strategically connected to **Range Road 282**, the main public road providing access to the facility. A designated entrance/exit point is located on the western side of the block, near the administrative building and control tower, to facilitate direct access to Range Road 282. This connection allows for seamless movement of service vehicles, delivery trucks, and emergency response teams, ensuring that operations remain uninterrupted. The internal roads are aligned to maximize efficiency, minimizing travel time between structures while adhering to safety and zoning standards for public service facilities.

Table 18: Dimensions of Structures

Structure	Shape	Dimensions (m)	Area (m^2)
Primary Clarifiers (2 units)	Circular	Diameter: 25 each	981.8
Secondary Clarifier	Circular	Diameter: 25	490.9
Main Treatment Building	Rectangular	70 x 20	1400
Sludge Digesters (2 units)	Circular	Diameter: 15 each	353.4
Chlorine Contact Chamber	Rectangular	60 x 10	600
Administration Building	Rectangular	20 x 10	200
Pumping Station	Rectangular	15 x 21	315

Pumping Station

Type of Structure

The pumping station is a major part of the water treatment plant as it is the last place the water will be before being pumped out to the community. The pumping station is a 21x15-meter building

made of reinforced concrete. Reinforced concrete was chosen because of its durability and weather resistance, but mainly for the affordability given that the building is relatively small and not very tall (3m underground, 4 meters above ground) [50]. The underground part of the building was added in order to accommodate the entrance and exit pipes. The outside portion of the building remains in accordance with the Chestermere height code and is 4m tall.

Design Software

Both SAP2000 and Revit were used to model the pumping station. SAP2000 was used to design the frame and model the loads, while Revit was used to model the architecture and cost estimation. These designs will both be explored further.

SAP Design

The pumping station has 30 columns, 44 beams, and 16 slabs. The following images show various views of the pumping station from extruded, to frame section views, as well as the design check view. The design of the pumping station also includes a trussed roof.

The loads applied as well as the load combination used in our were obtained from the National Building Code of Canada (2020) as follows. [51]

Table 19: Specified uniformly distributed live load for pump rooms

Table 4.1.5.3.
Specified Uniformly Distributed Live Loads on an Area of Floor or Roof
Forming Part of Sentence 4.1.5.3.(1)

Use of Area of Floor or Roof	Minimum Specified Load, kPa
Equipment areas and *service rooms* including Generator rooms Mechanical equipment exclusive of elevators Machine rooms Pump rooms Transformer vaults Ventilating or air-conditioning equipment	3.6(4)

Table 20: Factored load combinations

Table 4.1.3.2.-A
Load Combinations Without Crane Loads for Ultimate Limit States
Forming Part of Sentences 4.1.3.2.(2) and (5) to (10), and 4.2.4.1.(3)

Case	Load Combination(1)	
	Principal Loads	Companion Loads
1	1.4D(2)	—
2	(1.25D(3) or 0.9D(4)) + 1.5L(5)	1.0S(6) or 0.4W
3	(1.25D(3) or 0.9D(4)) + 1.5S	1.0L(6)(7) or 0.4W
4	(1.25D(3) or 0.9D(4)) + 1.4W	0.5L(7) or 0.5S
5	1.0D(4) + 1.0E(8)	0.5L(6)(7) + 0.25S(6)

The loads applied on the first floor include dead and live load (3.6 kN/m^2), while the load on the roof include snow load (1.25 kN/m^2) and dead load of the self weight. Loads were factored according to 1.25 DL + 1.5 LL and 1.25 DL + 1.5 LL + 1.0 SL, respectively, through the SAP software.

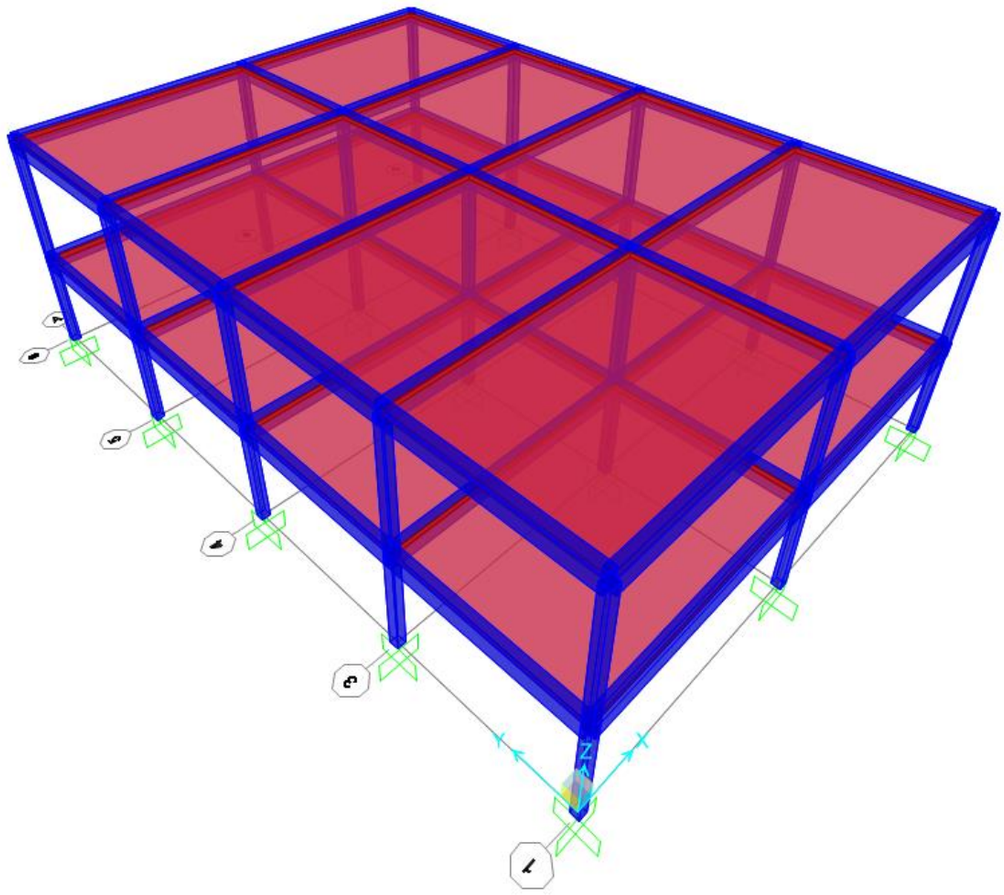


Figure 20: Extruded View of SAP Design

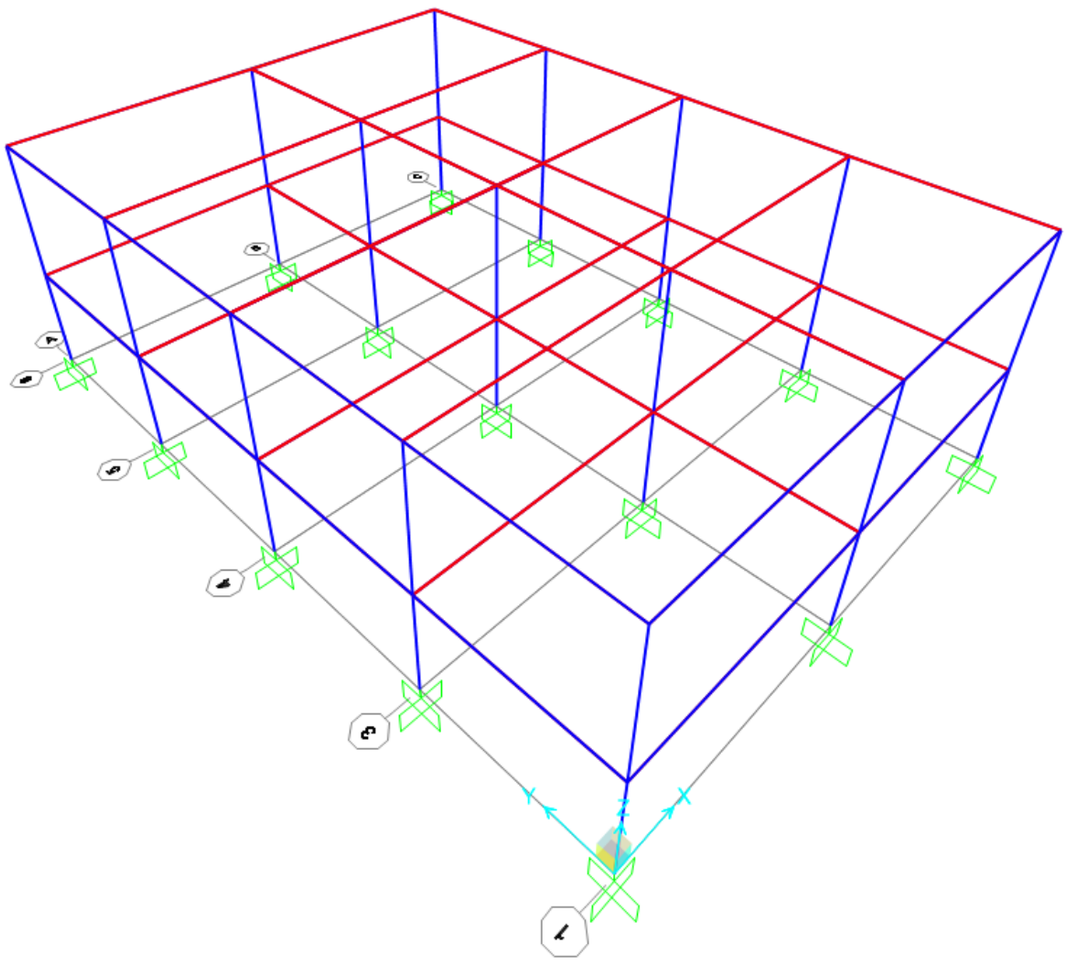


Figure 21: 3-D View Basic Frame SAP Design

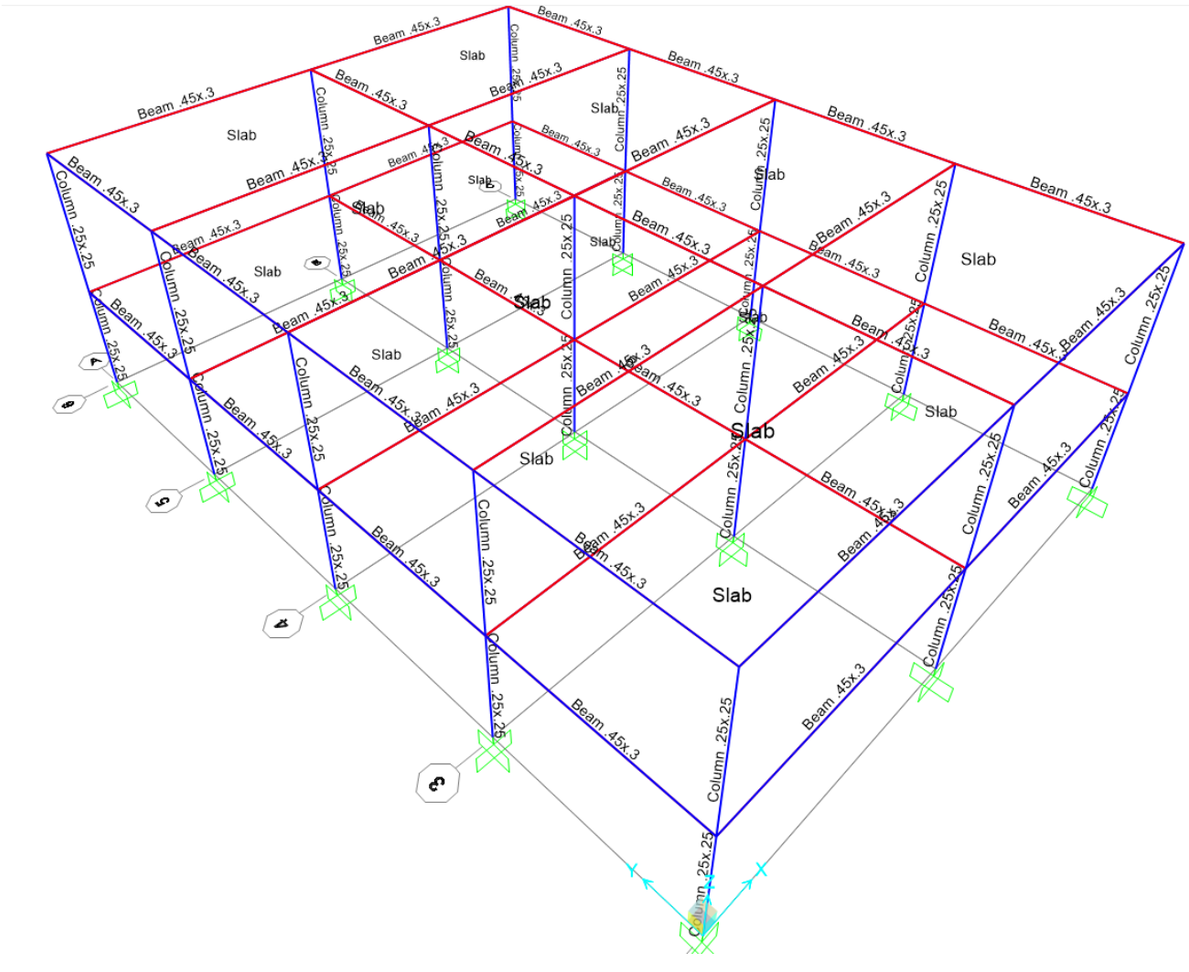


Figure 22: 3-D View with Section Names

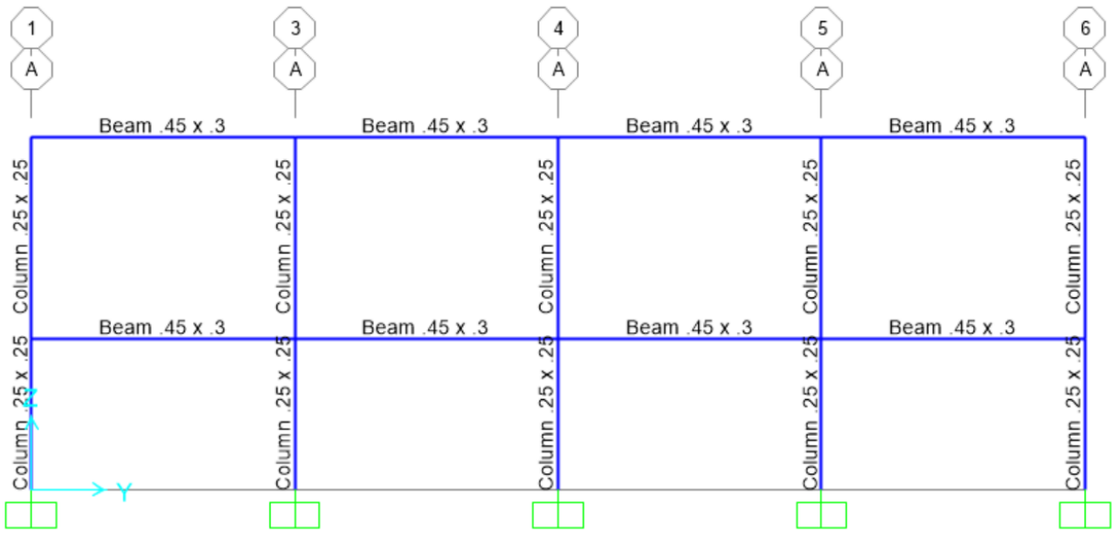


Figure 23: Elevation View

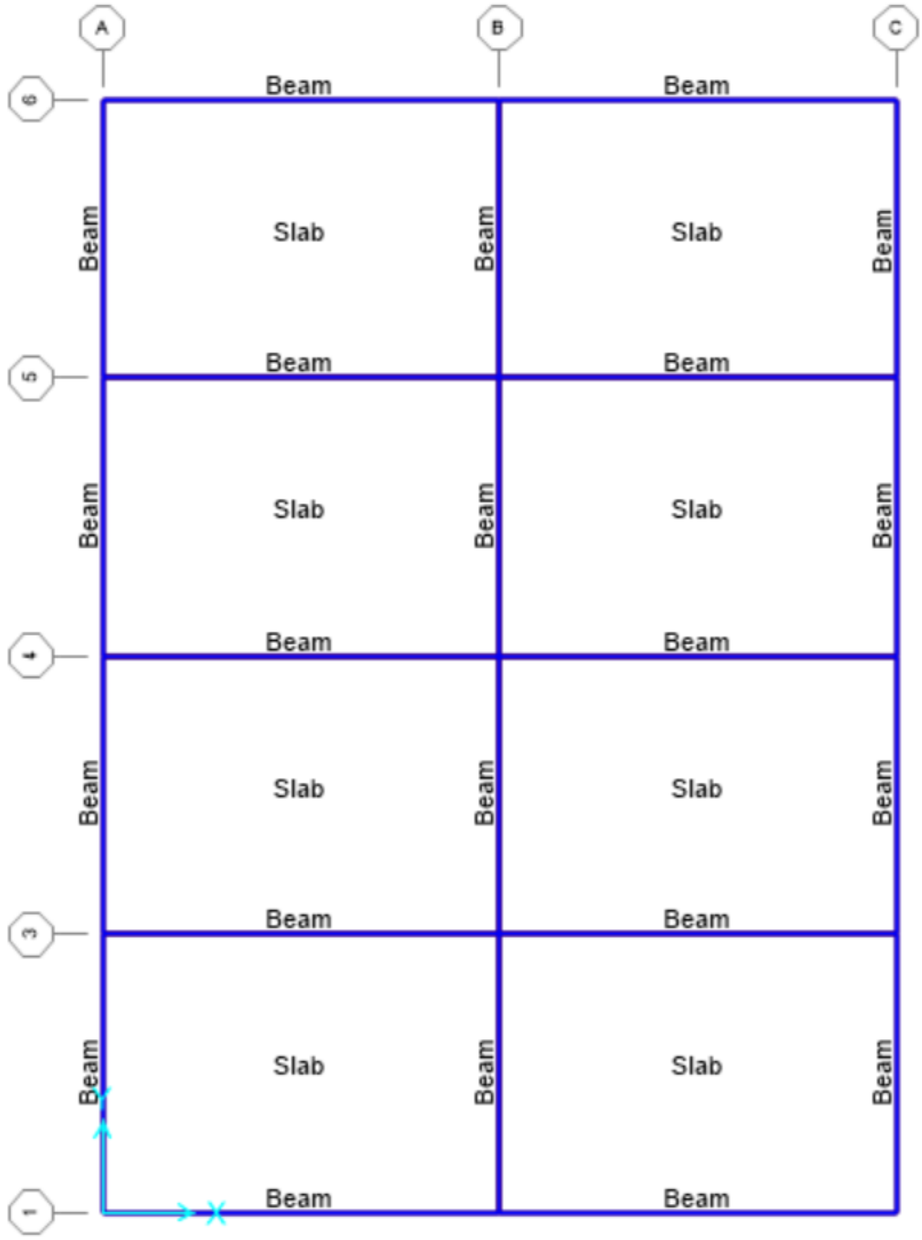


Figure 24: Plan View

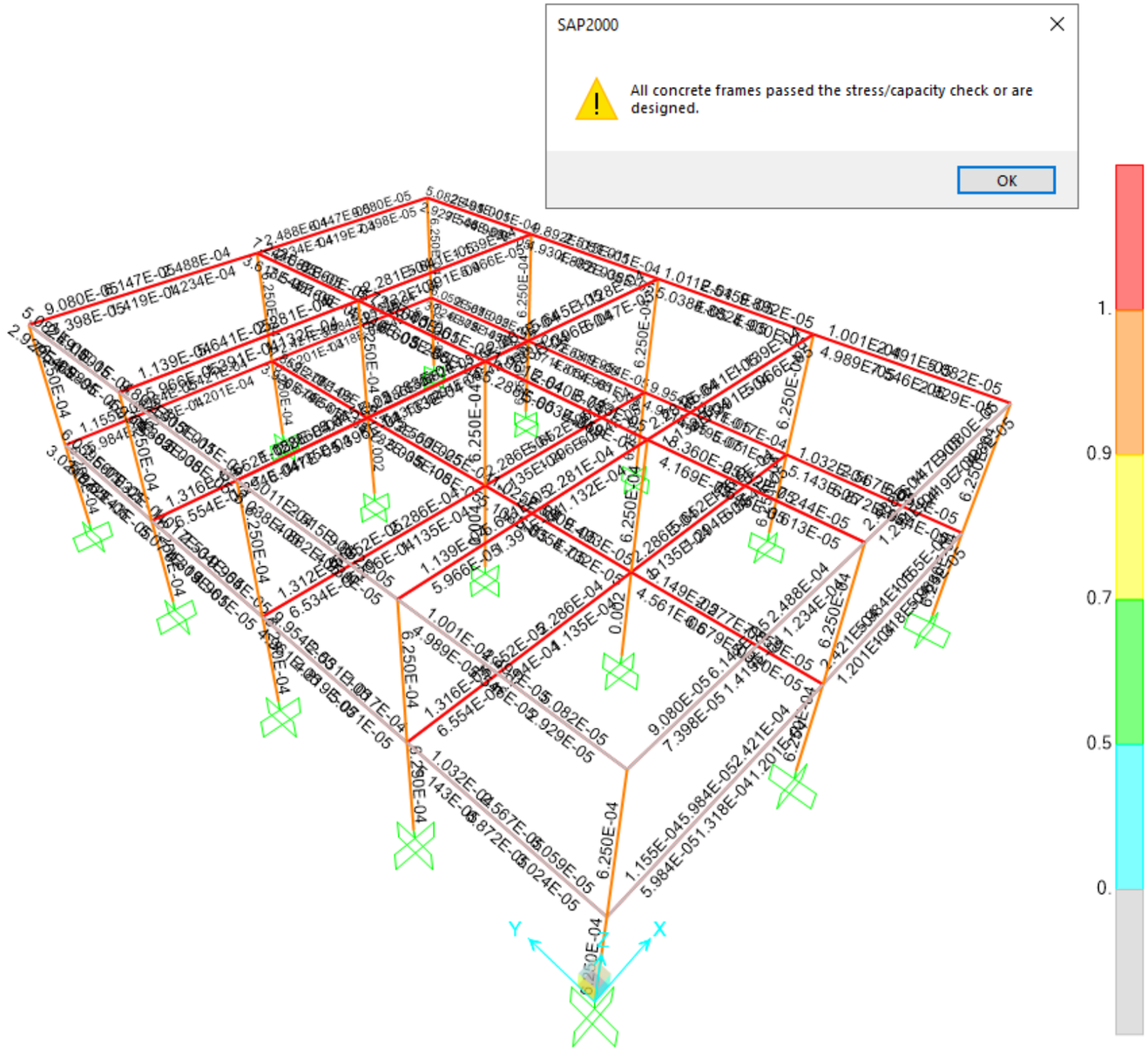


Figure 25: All concrete frames pass the design check

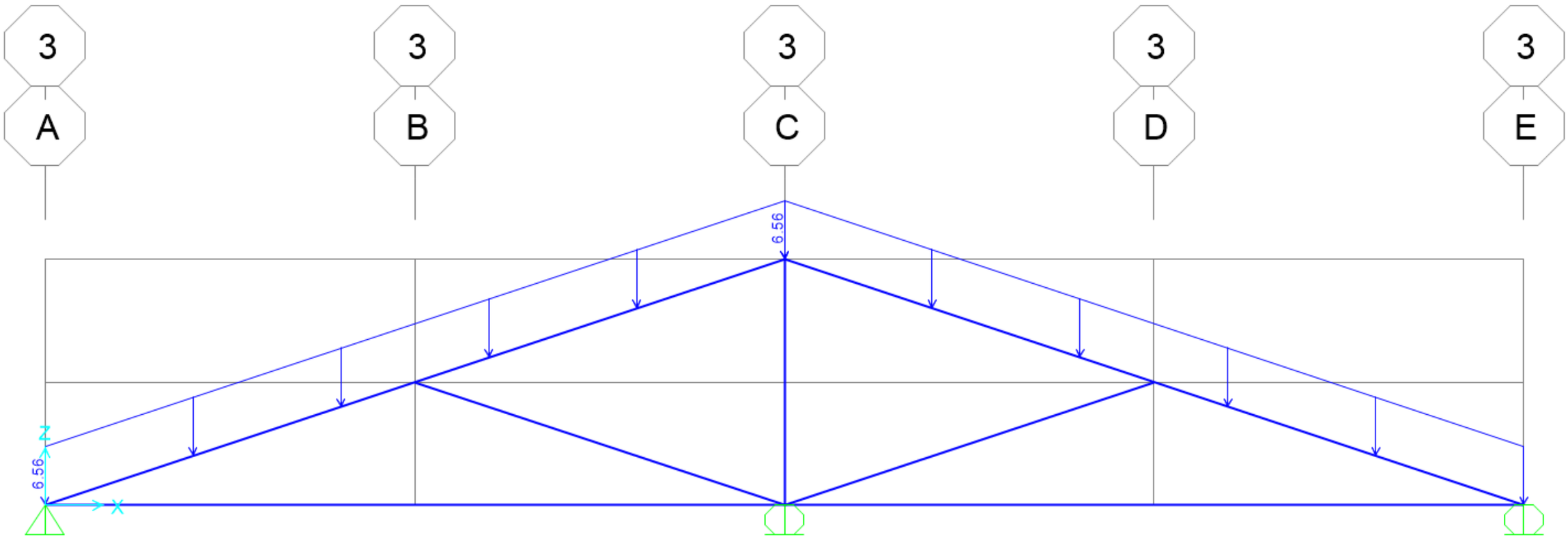


Figure 26: Truss Model with Load Applied

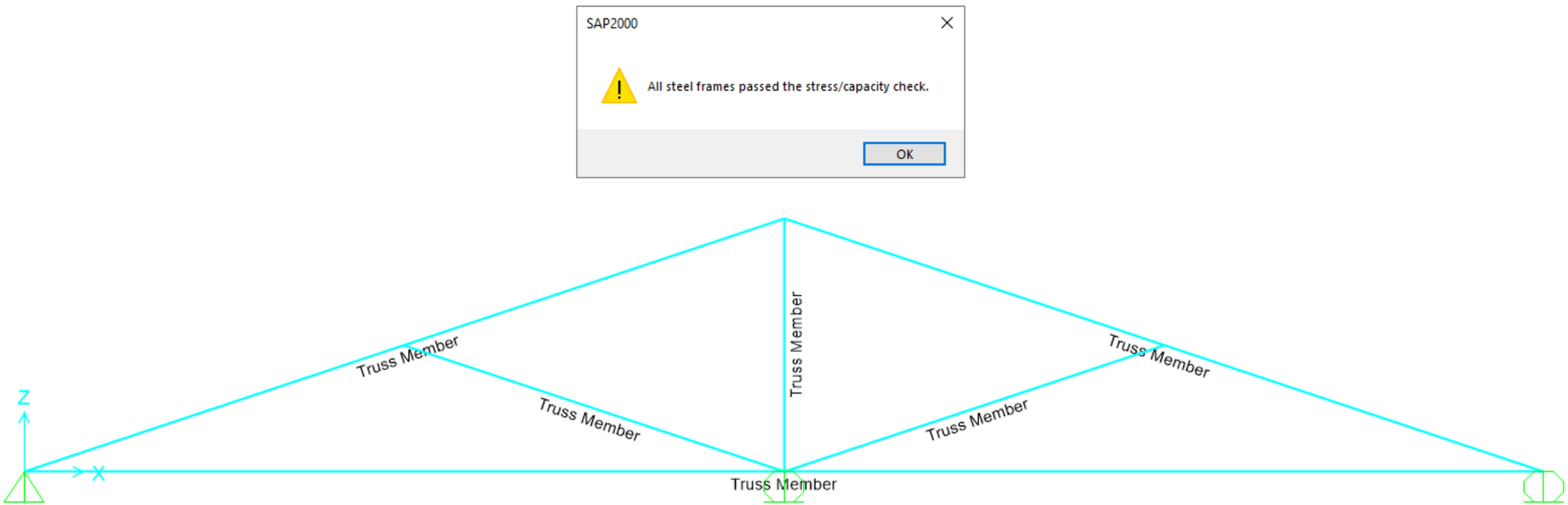


Figure 27: All Members Passed Truss Load Model

Design Calculations

Beam Design Calculations

Beam 1 (l = 5.25 m)
Tributary area = 7.5 m
LL = 3.6 KN/m2 * (7.5 m)= 27 KN/m
Clear Span, In = 5250 - 2 (200/2) = 5050 mm
both-end continuous
h_{min} > In/28 > 5050/28 > 180.36 mm

Beam 2 (l=7.5m)
Tributary area = 5.25 m
LL = 3.6 KN/m2 * (5.25 m)= 18.9 KN/m
Clear Span, In = 7500 - 2 (200/2) = 7300 mm
one-end continuous
h_{min} > In/24 > 7300/24 > 304 mm

Thus beam 2 is the critical beam
h is always recommended be greater than 350 mm
Let h= 450 mm, h/b ~ 1.5 to 2 , b = 300 mm use 10-M stirrups and 30- M steel bars
d=h-cc-ds-db/2
=450-30-10-30/2=395 mm

DL = self weight = γ (bh) = 24 (0.45 *0.3) = 3.24 kN/m
Wf = 1.25DL + 1.5LL = 1.25 (3.24) + 1.5 (18.9) =32.4 KN/m
Mf = (Wf x l^2)/ 8 = (32.4 * 7.5^2)/ 8 = 8 227.8 KN.m

Area of steel required:
As =0.0015 fc'b (d - (d^2 - 3.85Mf/ fc'b)$^{1/2}$) = 2220 mm^2
Area of steel provided:
Use 5-25 M bars, As = 5 * 500 mm2 = 2,500 mm^2
d= h-cc-ds-db/2= 450-30-10-25/2= 397.5 mm ~ 400 mm

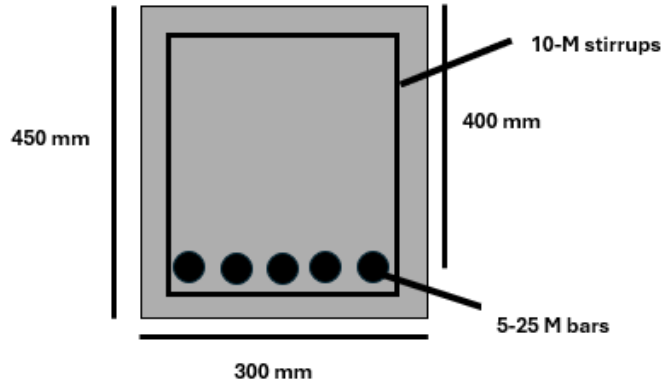


Figure 28: Designed beam cross section

Checks

Bending moment check (Mr> Mf):

$$a = \frac{\emptyset s f y A_s}{\emptyset c \alpha_1 f c' b} = \frac{0.85 * 400 * 2500}{0.65 * 0 \cdot 8 \times 25 * 300} = 218 \text{ mm}$$

$$Mr = A_s f y \emptyset s \, (d - a/2) = 2500 * 400 * 0.85 \left(397.5 \; - \frac{218}{2}\right) = 245.23 \text{ KN. m}$$

Mr > Mf (227.8 KN.m)

Check if steel yields:

$$\frac{c}{d} \leq \frac{700}{700 + fy}, \; c = \frac{a}{\beta} = \frac{218}{0.9} = 242.2 \text{ mm}$$

$$\frac{242.2}{397.5} = 0.609 \leq \; \frac{700}{700 + 400} = 0.636$$

Shear check (Vr > Vf)

$$V_f = \frac{\omega_f l_n}{2} = \frac{32.4(7.5)}{2} = 121.5 \text{ KN}$$

$$v_{r,max} = 0.25 \emptyset c f c' b_\omega dv$$

= 0.25 * 0.65 * 25 * 300 * 357.75 = 436 KN

$$d_v = \max \text{of} \begin{matrix} 0.9\,d = 357.75 \text{ mm} \\ 0.72\,h = 324 \text{ mm} \end{matrix}$$

Vr > Vf

Therefore, the above design meets all the requirements according to CSA A23.3. [52]

Column Design Calculations

$$Pf_1 = \omega_{\frac{f1 * l_1}{2}} = \frac{32.4 \frac{KN}{m} * 7.5m}{2} = 121.5 \text{ KN}$$

$$Pf_2 = \omega_{\frac{f2 * l_2}{2}} = \frac{44.55 \; \frac{\text{KN}}{\text{m}} * 5.25 \text{ m}}{2} = 117 \text{ KN}$$

Pf_T =2 (Pf1 + Pf2) = 477 KN

$$Ag > \frac{P_f}{0.5 f c'} = \frac{477 * \; 10^3}{0.5(25)} = 38{,}160 mm^2$$

(As a sqaure: 195.35 mmx 195.35 mm)

Recommended to take above 200 x 200

Thus, take 250 x 250

Let's use 10 M ties (dt = 11. 3mm) & 25M bars (db = 25.2 mm)

$$\gamma = \frac{h - 2cc - 2\,d_t - d_b}{h} = \frac{250 - 2(40) - 2(11.3) - 25.2}{250} = 0.489 \approx 0.5$$

Mf = Pf_T. e = 477KN (0.1m) = 47.7 KN.m

$$\text{For } \frac{Pf}{A_g} = \frac{477x1000}{250^2} = 7.63 \text{ and } \frac{Mf}{Agh} = \frac{47.7 * 10^6}{250^3} = 3.05$$

$$\text{For } \gamma = 0.5 \text{ and } fc' = 25\text{: } \rho_t = 0.002$$

$$\text{Required } A_{st} = \rho_t Ag = 0.02\ (250^2) = 1250\ mm^2$$

Use 4-25 M bars, provided A_{st} = 4(500) = 2000 mm^2

Design for the tie spacing (S):

S will be the least of:

16 db = 16 (25.2) = 403.2 mm

48 dt = 48 (11.3) = 542.4 mm

400 mm

Therefore, the ties will be used every 400 mm.

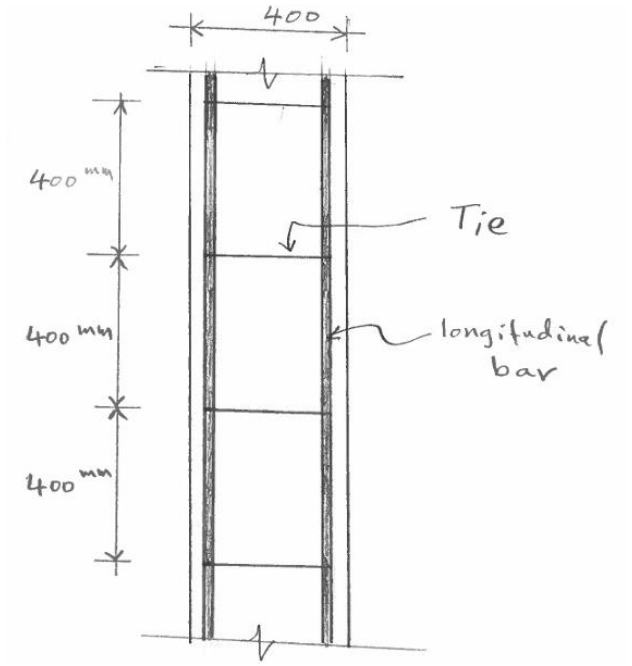


Figure 29: Designed column side section view

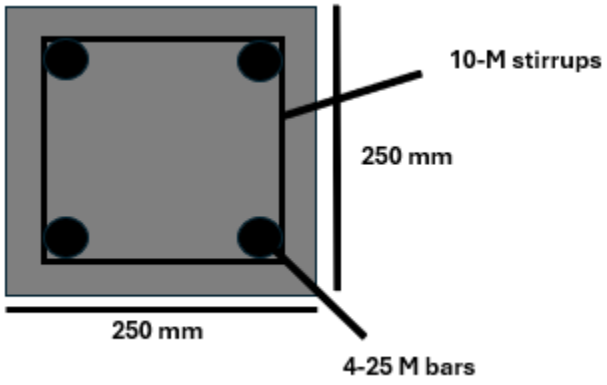


Figure 30: Designed column cross section

Check

• Factorial Axial Load resistance check

$$A_g = (b * h) = 250 \times 250 = 62{,}500\ mm^2$$

$$\rho_{r,max} = 0.8[0.8 * \emptyset c * fc' * (Ag - A_{st}) + \emptyset s * fy * A_{st}]$$

$$= 0.8[0.8 * 0.65 * 25(62{,}500 - 2000) + 0.85 * 400 * 2000]$$

= 1173.2 KN > Pf (477 KN)

Thus, the above design meets all requirements according to CSA A23.3. [52]

Truss Member Selection Calculations

For the compression members in the truss, the axial load was extracted from SAP and compared with the factored compression resistance of the HSS 254 x 254 x 9.5 section as seen in the table below from the CISC Steel Handbook [53]. Please refer to the nodes on Figure 20 below. Both Cr and Tr loads exceed applied axial loads so, the check is good.

Table 21: Steel Member Check

Member	Span (mm)	Load (kN)	Axial Force	Cr (kN)	Tr = phi*Ag*Fy (kN)
13-14	7900	84.889	Tension	1940	2822.445
15-14	7900	84.889	Tension	1940	2822.445
13-15	15000	34.554	Tension	692	2822.445
16-17	3950	-111.627	Compression	2790	2822.445
16-18	3950	-111.627	Compression	2790	2822.445
16-14	2500	-115.489	Compression	2850	2822.445

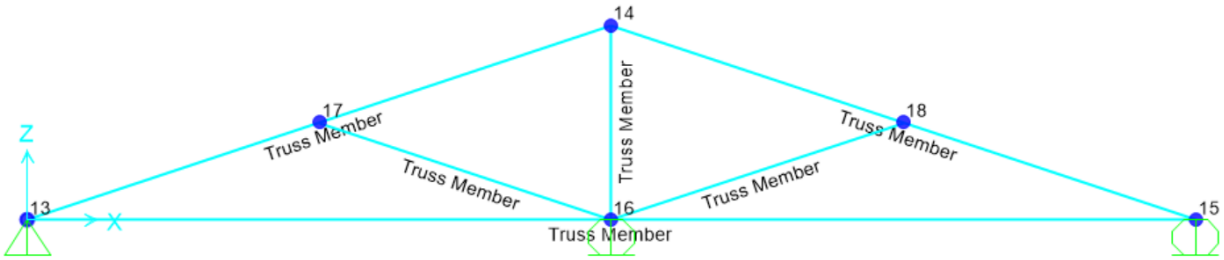


Figure 31: Truss with Nodes for Reference to Members

```
AXIAL FORCE & BIAXIAL MOMENT DESIGN   (H1.2,H1-1b)
    Factor                K          K1          K2          B1          B2          Cm
    Major Bending      0.500       1.000       1.000       1.000       1.000       1.000
    Minor Bending      1.000       1.000       1.000       1.000       1.000       1.000

                        Lltb        Kltb          Cb
    LTB                1.000       1.000       1.343

                          Pu     phi*Pnc     phi*Pnt
                       Force    Capacity    Capacity
    Axial             34.554     641.801    2882.664

                          Mu     phi*Mn      phi*Mn      phi*Mn
                      Moment    Capacity     No LTB       Cb=1
    Major Moment      -9.474     264.437     264.437     264.437
    Minor Moment       0.000     264.437

                          Tu          Tn     phi*Tn
                      Moment    Capacity    Capacity
    Torsion            0.000     234.252     210.827
```

Figure 32: Example of Axial Force Extraction on SAP2000 per member

Pumps and Suction Pipe Design Calculations

The Chestermere Engineering Design and Construction Standards mandates materials used for water distribution system in the city of Chestermere shall be in accordance with the City of Calgary specifications.

Pumps

As per the City of Calgary Water Resources, the distribution system by pumping should be designed with at least two pumps. With one pump out of service, the remaining pumps should be able to deliver the maximum hourly design flow at not less than 150 kPa.

In our case the peak hour demand (PHD) is 2.77 x 10^6 litres per hour or 2770 m^3 per hour in the metric system. In our pumping station, we will be using a total of 5 pumps with maximum flow rate of 750 m^3 per hour each. Four of these pumps will provide a total maximum flow rate of 3000 m^3 per hour (higher than the PHD 2770 m^3 per hour), while one pump will be on standby in case there is a malfunction with anyone of the other pumps. To supply water economically during low demand periods, the pumps will be provided with a variable speed motor. The material of the pumps is stainless steel to resist corrosion.

Suction Pipes

Suction Pipes are large pipes that transport water from a water source, in our case the Chestermere Lake to the treatment plant. The peak hour demand 2770 m^3 per hour comes down to 0.77 m^3 per second. The flow speed should be less than 2 m/s. Thus, given a 1.5 m/s speed:

$$Q = vA$$

$$\mathrm{A} = \frac{\mathrm{Q}}{\mathrm{v}} = \frac{0.77\mathrm{m}^{3}/_{\mathrm{s}}}{1.5\,\mathrm{m}/_{\mathrm{s}}} = 0.513\mathrm{m}^2$$

$$\mathrm{A} = \frac{\pi\,\mathrm{d}^2}{4}$$

$$\mathrm{d} = \sqrt{\frac{4\mathrm{A}}{\pi}} = \sqrt{\frac{4(0.513)}{\pi}} = 0.81\mathrm{m}, \text{ use d = 900mm}$$

Having a flow speed less than 2 m/s and diameter higher than minimum diameter insures an efficient laminar water flow to the treatment plant and reduces risk of pipe damage. The material of the pipes will be PVC which is very durable and highly resistant to corrosion.

Detailed Project Schedule and CPM

All activities are accounted for and properly organized when the project scope is arranged into hierarchical tiers using our work breakdown structure (WBS). In our WBS we included the earliest start, earliest finish, latest start, latest finish, and the slug for each activity. Then by looking at that information, we highlighted the critical tasks in red. After tasks have been determined, their durations and dependencies are plotted on a timetable using a Gantt chart, which provides a visual depiction of the project's progression. For instance, to maximize resource use, processes such as Site Selection, Civil

Works, and Equipment Installation in a water treatment plant project might be planned concurrently where practical.

The tasks that define the project's minimum completion time are identified using CPM. In infrastructure projects, tasks like testing, civil works, and regulatory approvals frequently occur on the critical route and need careful attention to prevent delays. When used in tandem, these techniques facilitate efficient scheduling, risk mitigation, and timely project completion. Using the WBS, and its information we gave a visualization that highlights our critical path along with the other activities.

Table 22: WBS table and Critical activities

– CRITICAL ACTIVITIES

		DURATION in days															
		PREDECESSOR ACTIVITIES									EXPECTED	EARLY START	EARLY FINISH	LATE START	LATE FINISH	
ID	ACTIVITY DESCRIPTION	PA – enter separately in columns									DURATION	ES	EF	LS	LF	SLACK
1	START										0.00	0.00	0.00	0.00	0.00	0.00
1.1	Feasibility Study	1									60.00	0.00	60.00	0.00	60.00	0.00
1.2	Site Selection and Survey	1.1									45.00	60.00	105.00	60.00	105.00	0.00
1.3	Regulatory and Environmental	1.2									90.00	105.00	195.00	105.00	195.00	0.00
2.1	Conceptual Design	1.3									50.00	195.00	245.00	195.00	245.00	0.00
2.2	Detailed Design	2.1	1.3								90.00	245.00	335.00	245.00	335.00	0.00
2.3	Procurement Planning	2.2									45.00	335.00	380.00	935.00	980.00	600.00
3.1	Tendering and Bid Evaluation	2.2	1.3								60.00	335.00	395.00	335.00	395.00	0.00
3.2	Contract Award	3.1									30.00	395.00	425.00	395.00	425.00	0.00
3.3	Procurement of Equipment and Ma	3.2									120.00	425.00	545.00	545.00	665.00	120.00
4.1	Site Preparation	3.2	2.2								60.00	425.00	485.00	425.00	485.00	0.00
4.2	Civil Works	4.1									180.00	485.00	665.00	485.00	665.00	0.00
4.3	Installation of Mechanical Systems	4.2	3.3								120.00	665.00	785.00	665.00	785.00	0.00
4.4	Installation of Electrical Systems	4.3									90.00	785.00	875.00	785.00	875.00	0.00
4.5	Testing and Commissioning	4.4									60.00	875.00	935.00	875.00	935.00	0.00
5.1	Staff Recruitment and Training	4.3									30.00	785.00	815.00	905.00	935.00	120.00
5.2	Start-up and Operational Testing	5.1	4.5								30.00	935.00	965.00	935.00	965.00	0.00
5.3	Handover to Operations	5.2									15.00	965.00	980.00	965.00	980.00	0.00
6	FINISH	2.3	5.3								0.00	980.00	980.00	980.00	980.00	0.00

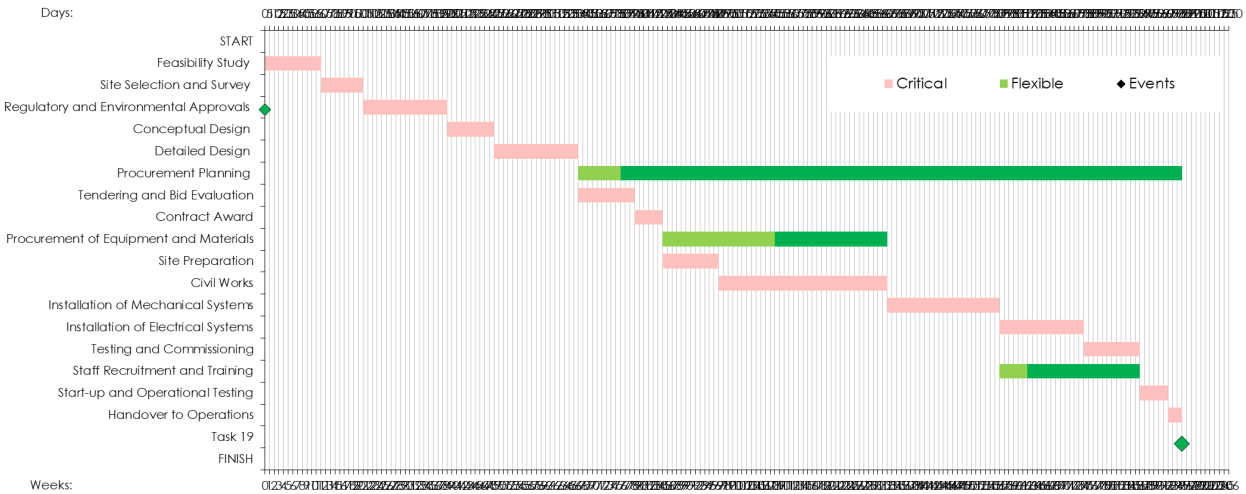


Figure 33: Gantt chart of the activities

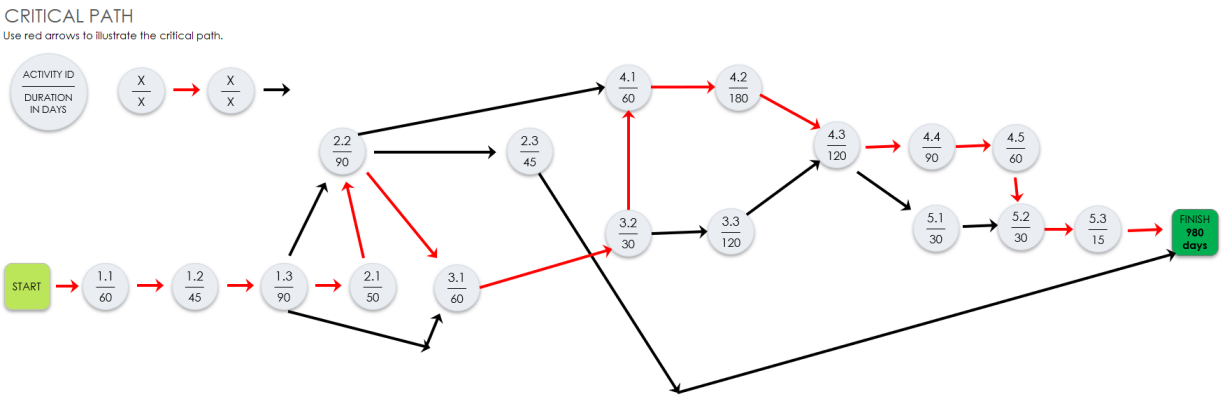


Figure 34: CPM visualization

Revit Design

For the Revit design, we will showcase the three most important views in Revit which are plan view, 3-D view, and Section view.

We have 7 rooms in the pumping station:

1. Pump room (most important)
2. Electrical room
3. Mechanical room
4. Chemical room
5. Storage room
6. Control room
7. Bathrooms room

See *Figure 35* on the following page for the plan view.

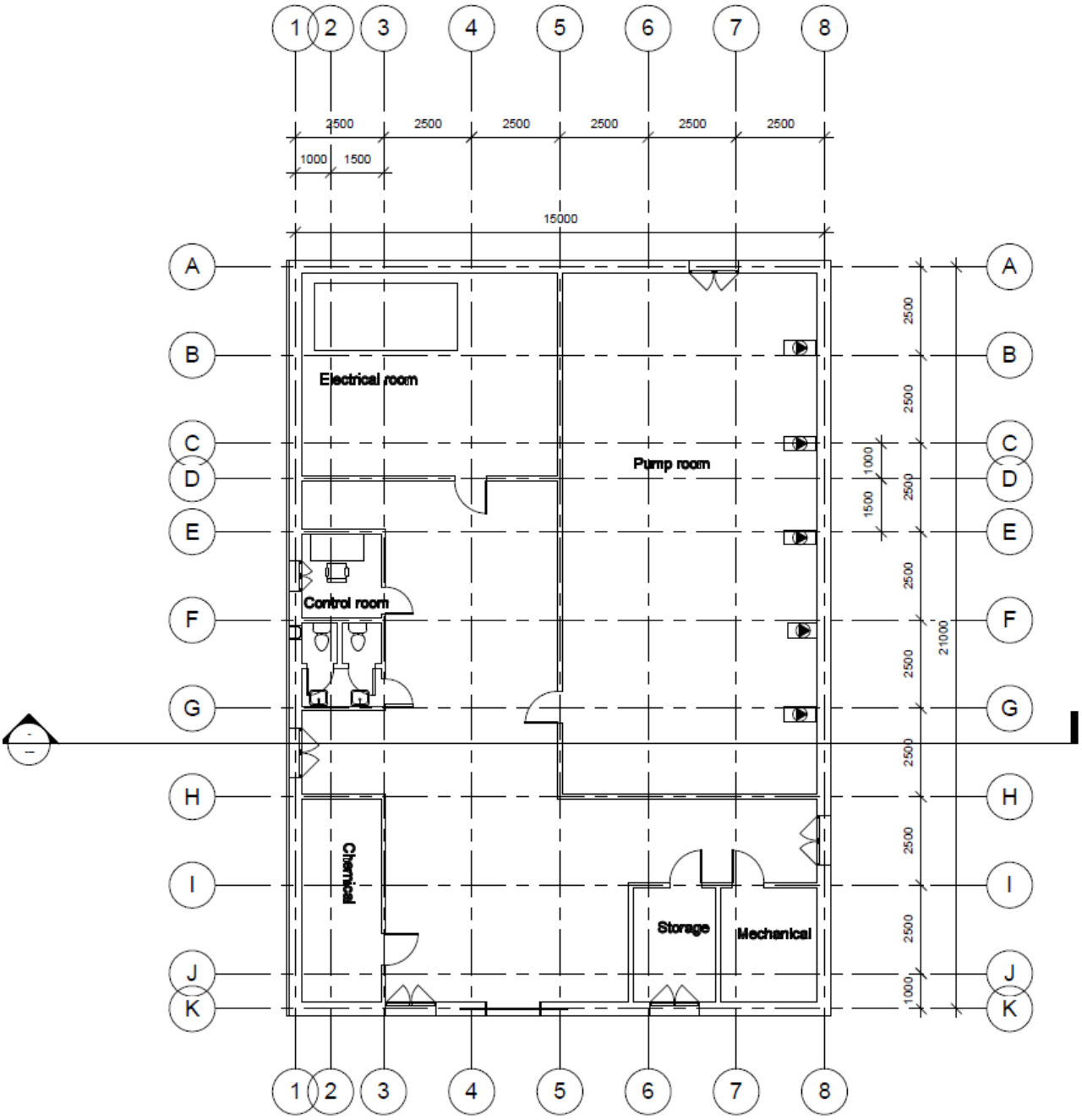


Figure 35: Plan view of pumping station

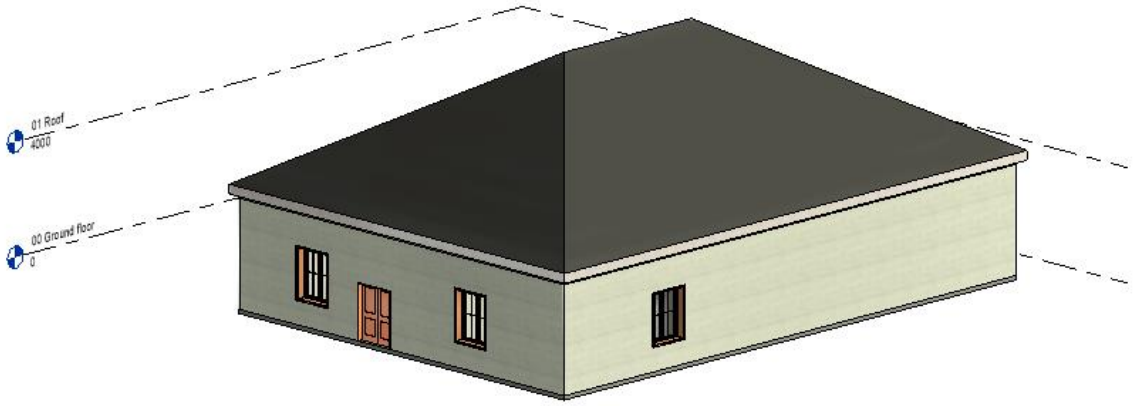


Figure 36: 3-D eat-top view of pumping station building



Figure 37: Sectional view of the pumping station building

Material Cost Estimation for Pumping Station Building

Concrete, wood, steel, glass, and composite materials are just a few of the materials that may be given to any element from Revit's extensive library. By connecting material quantities to unit costs—which may be manually entered or connected to an external database—the program facilitates thorough cost analysis. For example, walls may include brick, drywall, and insulation layers; the thickness and area of each layer determine the cost. Like this, roofs may include tiles, waterproof membranes, and structural decking, each of which adds to the overall cost. Doors are assessed by material (e.g., wood, metal) and style, whereas floors might be examined by kind, such as concrete, laminate, or hardwood. Revit assists engineers and architects in creating accurate cost estimates by automating these computations, which guarantees effective budget planning throughout the design. We will use material takeoff for walls and roofs as we are getting the material cost. For doors and floors, we will use Schedules/Quantities which gives the unit cost. For roofs and walls, we will add another column in our schedule which it the total material cost; we add it by creating a formula in the field section where we multiply Material Volume(m^3) by Material cost (CAD/m^3).

Table 23: Roof Materials and costs [54] [55] [56] [57] [58]

<Roof Material Identification and Cost Estimation>				
A	B	C	D	E
Material: Name	Material: Area	Material: Volume	Material: Cost	Total Material Cost
Asphalt, Bitumen	400 m²	8.01 m³	740.02	$5925
Rigid insulation	400 m²	20.02 m³	516.67	$10342
Concrete, Sand/Ce	400 m²	20.02 m³	420.00	$8407
Concrete, Cast In S	400 m²	70.06 m³	210.00	$14712
Grand total				$39386

Table 24: Truss HSS Steel Costs [59]

Truss HSS steel	# of trusses	Total Length (m)	Total Length (feet)	Unit Cost ($/ft)	Total Cost ($)
41.2	5	206	676	39	$26,500.20

Grand total material roof cost= $ **65,886.20 CAD**

Table 25: Walls (Interior and Exterior) Materials and costs [60] [61] [62] [63]

<Wall Material Identification and Cost Estimation>						
A	B	C	D	E	F	G
Material: Name	Base Constraint	Family and Type	Material: Area	Material: Volume	Material: Cost	Total material cost
00 Ground floor						
Basic Wall: Exterior - Block on Mtl. Stud						
Concrete Masonry Units						
Concrete Masonry	00 Ground floor	Basic Wall: Exterior	63 m²	12.38 m³	226.00	$2798
Concrete Masonry	00 Ground floor	Basic Wall: Exterior	87 m²	17.18 m³	226.00	$3883
Concrete Masonry	00 Ground floor	Basic Wall: Exterior	55 m²	10.86 m³	226.00	$2455
Concrete Masonry	00 Ground floor	Basic Wall: Exterior	84 m²	16.59 m³	226.00	$3750
Concrete Masonry Units						$12885
Gypsum Wall Board						
Gypsum Wall Boar	00 Ground floor	Basic Wall: Exterior	64 m²	0.84 m³	2086.54	$1744
Gypsum Wall Boar	00 Ground floor	Basic Wall: Exterior	89 m²	1.16 m³	2086.54	$2421
Gypsum Wall Boar	00 Ground floor	Basic Wall: Exterior	57 m²	0.74 m³	2086.54	$1537
Gypsum Wall Boar	00 Ground floor	Basic Wall: Exterior	86 m²	1.12 m³	2086.54	$2340
Gypsum Wall Board						$8041
Metal Stud Layer						
Metal Stud Layer	00 Ground floor	Basic Wall: Exterior	64 m²	9.66 m³	743.56	$7186
Metal Stud Layer	00 Ground floor	Basic Wall: Exterior	89 m²	13.41 m³	743.56	$9974
Metal Stud Layer	00 Ground floor	Basic Wall: Exterior	57 m²	8.51 m³	743.56	$6325
Metal Stud Layer	00 Ground floor	Basic Wall: Exterior	86 m²	12.96 m³	743.56	$9638
Metal Stud Layer						$33122
Plywood, Sheathing						
Plywood, Sheathin	00 Ground floor	Basic Wall: Exterior	63 m²	1.19 m³	5098.69	$6088
Plywood, Sheathin	00 Ground floor	Basic Wall: Exterior	87 m²	1.66 m³	5098.69	$8449
Plywood, Sheathin	00 Ground floor	Basic Wall: Exterior	56 m²	1.05 m³	5098.69	$5351
Plywood, Sheathin	00 Ground floor	Basic Wall: Exterior	84 m²	1.60 m³	5098.69	$8162
Plywood, Sheathing						$28051
Basic Wall: Exterior - Block on Mtl. Stud						$82099
Basic Wall: Interior - 138mm Partition (1-hr)						
Gypsum Wall Board						
Gypsum Wall Boar	00 Ground floor	Basic Wall: Interior	50 m²	0.78 m³	2086.54	$1619
Gypsum Wall Boar	00 Ground floor	Basic Wall: Interior	37 m²	0.58 m³	2086.54	$1210
Gypsum Wall Boar	00 Ground floor	Basic Wall: Interior	37 m²	0.58 m³	2086.54	$1210
Gypsum Wall Boar	00 Ground floor	Basic Wall: Interior	27 m²	0.43 m³	2086.54	$888
Gypsum Wall Boar	00 Ground floor	Basic Wall: Interior	48 m²	0.75 m³	2086.54	$1567
Gypsum Wall Boar	00 Ground floor	Basic Wall: Interior	26 m²	0.40 m³	2086.54	$836
Gypsum Wall Boar	00 Ground floor	Basic Wall: Interior	26 m²	0.40 m³	2086.54	$836
Gypsum Wall Boar	00 Ground floor	Basic Wall: Interior	27 m²	0.43 m³	2086.54	$888
Gypsum Wall Boar	00 Ground floor	Basic Wall: Interior	60 m²	0.94 m³	2086.54	$1954
Gypsum Wall Boar	00 Ground floor	Basic Wall: Interior	13 m²	0.21 m³	2086.54	$434
Gypsum Wall Boar	00 Ground floor	Basic Wall: Interior	17 m²	0.26 m³	2086.54	$536
Gypsum Wall Boar	00 Ground floor	Basic Wall: Interior	88 m²	1.37 m³	2086.54	$2852
Gypsum Wall Boar	00 Ground floor	Basic Wall: Interior	171 m²	2.65 m³	2086.54	$5531
Gypsum Wall Boar	00 Ground floor	Basic Wall: Interior	81 m²	1.26 m³	2086.54	$2620
Gypsum Wall Board						$22982

Metal Stud Layer						
Metal Stud Layer	00 Ground floor	Basic Wall: Interior	17 m²	1.54 m³	743.56	$1142
Metal Stud Layer	00 Ground floor	Basic Wall: Interior	12 m²	1.15 m³	743.56	$853
Metal Stud Layer	00 Ground floor	Basic Wall: Interior	12 m²	1.15 m³	743.56	$853
Metal Stud Layer	00 Ground floor	Basic Wall: Interior	9 m²	0.84 m³	743.56	$626
Metal Stud Layer	00 Ground floor	Basic Wall: Interior	16 m²	1.49 m³	743.56	$1105
Metal Stud Layer	00 Ground floor	Basic Wall: Interior	9 m²	0.79 m³	743.56	$590
Metal Stud Layer	00 Ground floor	Basic Wall: Interior	9 m²	0.79 m³	743.56	$590
Metal Stud Layer	00 Ground floor	Basic Wall: Interior	9 m²	0.84 m³	743.56	$626
Metal Stud Layer	00 Ground floor	Basic Wall: Interior	20 m²	1.85 m³	743.56	$1378
Metal Stud Layer	00 Ground floor	Basic Wall: Interior	4 m²	0.41 m³	743.56	$306
Metal Stud Layer	00 Ground floor	Basic Wall: Interior	6 m²	0.51 m³	743.56	$378
Metal Stud Layer	00 Ground floor	Basic Wall: Interior	29 m²	2.70 m³	743.56	$2011
Metal Stud Layer	00 Ground floor	Basic Wall: Interior	57 m²	5.24 m³	743.56	$3899
Metal Stud Layer	00 Ground floor	Basic Wall: Interior	27 m²	2.48 m³	743.56	$1847
Metal Stud Layer						$16203
Basic Wall: Interior - 138mm Partition (1-hr)						$39185
00 Ground floor						$121284
Grand total						$121284

Grand total material exterior wall cost= 82,099 CAD

Grand total material interior wall cost= 39,185 CAD

Grand total walls cost= 84,099+ 39,185= **121,284 CAD**

Table 26: Cost of Rebar [64]

Rebar	Number of Frame Member	Number of Rebar	Longitude of Frame Member (m)	Total Length (m)	Total Length (ft)	Unit Cost ($/ft)	Total Cost ($)
Columns	15	4	7	420	1377.95276	2.199	$ 3,030.12
Beams x	3	5	21	630	2066.92913	2.199	$ 4,545.18
Beams y	5	5	15	750	2460.62992	2.199	$ 5,410.93
Total				1800	5905.51181	2.199	$ 12,986.22

Grand total rebar cost = **12,986.22 CAD**

Table 27: Doors Materials and costs [65] [66]

<Door Material Identification and Cost Estimation>

A	B	C	D	E	F	G	H
Level	Family and Type	Type Mark	Height	Width	Thickness	Count	Cost
00 Ground floor	M_Single-Flush: 09	D1	2134	915	51	1	$1118
00 Ground floor	M_Single-Flush: 09	D1	2134	915	51	1	$1118
00 Ground floor	M_Single-Flush: 09	D1	2134	915	51	1	$1118
00 Ground floor	M_Single-Flush: 09	D1	2134	915	51	1	$1118
00 Ground floor	M_Single-Flush: 09	D1	2134	915	51	1	$1118
00 Ground floor	M_Single-Flush: 07	D2	2032	762	51	1	$786
00 Ground floor	M_Single-Flush: 07	D2	2032	762	51	1	$786
00 Ground floor	M_Single-Flush: 07	D2	2032	762	51	1	$786
00 Ground floor	M_Single-Flush: 07	D2	2032	762	51	1	$786
00 Ground floor	M_Door-Interior-Dou	D3	2000	1500	35	1	$1875
Grand total: 10							$10609

Grand total unit doors cost= **10,609 CAD**

Table 28: Floors Materials and costs [67]

<Floor Material Identification and Cost Estimation>						
A	B	C	D	E	F	G
Level	Family and Type	Area	Elevation at Top	Default Thickness	Count	Cost
00 Ground floor	Floor: Generic 150	329 m²	0	150	1	$5200
01 Roof	Floor: Generic 150	329 m²	4000	150	1	$5200
Grand total						$10400

Grand total unit floors cost= **10,400 CAD**

Table 29: Pumping station cost estimation breakdown

Materials	Estimated Material Costs
Roof material	65,886.20 CAD
Wall material	121,284.00 CAD
Rebar material	12,986.22 CAD
Door material	10,609.00 CAD
Floor material	10,400.00 CAD
Grand total	224,010.42 CAD

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