

To: Chris Greencorn, P.Eng.
Director
Public Works & Engineering
City of Yellowknife
4807-52 Street
P.O. Box 580
Yellowknife, NT X1A 2N4

Date: November 25, 2025

Project #: 60753577

From: Nathan Bettman Engineer-In-
Training

Lance Fradette, P.Eng.

Ryan King

CC:

Technical Memorandum 2

Subject: **City of Yellowknife- Distribution Zone 7 – Pump Station Location and Fill Main Alignment Options**

1. Proposed Pressure Zone 7 Background

The City of Yellowknife (the City) has engaged AECOM regarding servicing future development around the Yellowknife Airport and north of Frame Lake. AECOM submitted a Technical Memorandum (TM No. 1) to the City in August 2025 which identified to the City that a new pressure zone (PZ7) would be required to service the future development areas as the existing pressure zone 4 (PZ4) cannot support the future planned development. Development of PZ7 will include a new reservoir pumphouse (Pumphouse No. 7), a new supply main from the water treatment plant (WTP) to the Pumphouse No. 7 (PH7), and WTP pumping upgrades. The proposed development areas for Zone No. 7 includes a total estimated development area of 498 hectares as summarized in Figure 1-1 below. Note that AECOM has not received detailed development plans for Zone 7, including the current Airport Development Master Plan, at the time of this memorandum.

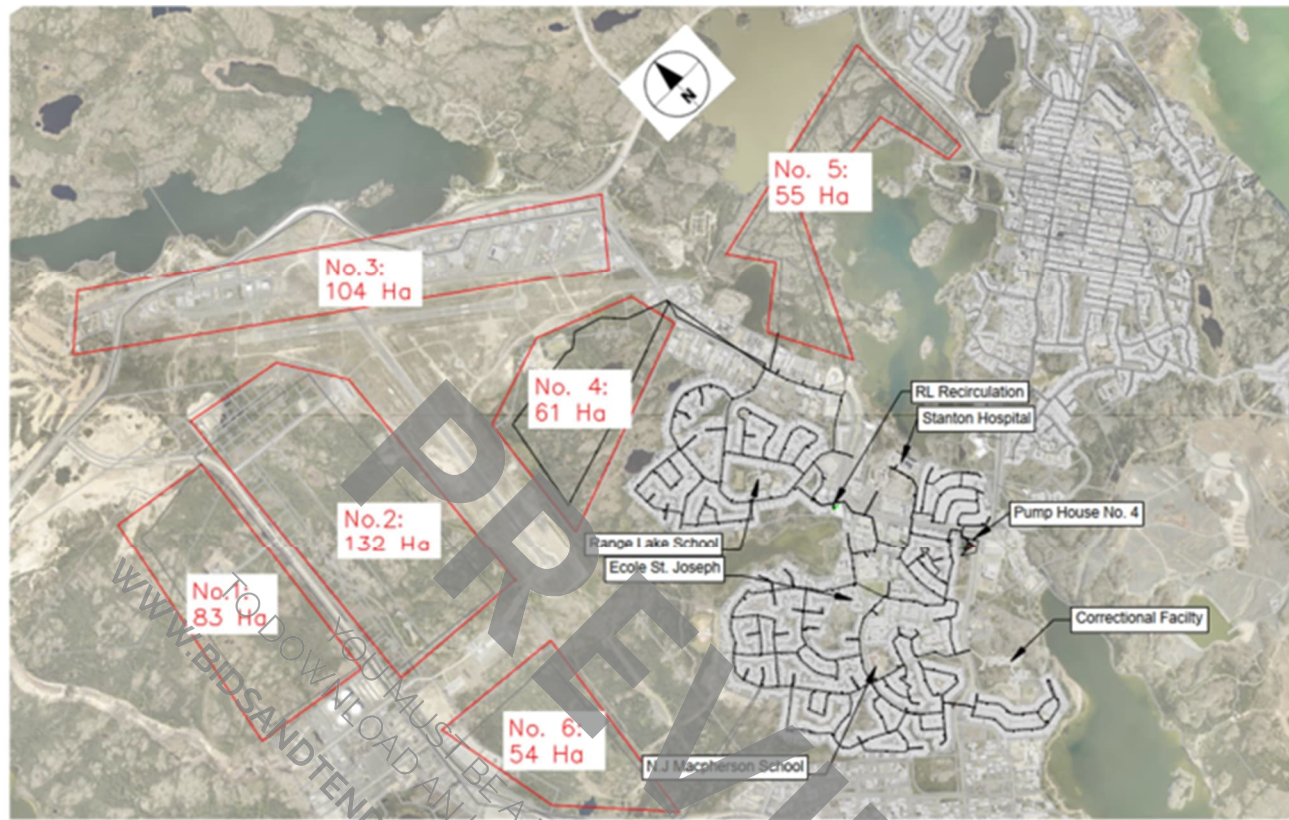


Figure 1-1: Proposed Zone 7 Development Areas

1.1 Elevation data

The City provided AECOM with LiDAR data collected in 2021 for the Yellowknife Flood Mapping project. The data was used to create an elevation contour map in ArcGIS to visualize the surface elevations within the Zone 7 development areas as shown in Figure 1-2 below. The highest surface elevations were observed within the Frame Lake parcel (Parcel No. 5) and the land between Parcels Nos. 3 and 5. The overall Zone 7 surface elevations ranged from approximately 190 m to 210 m.

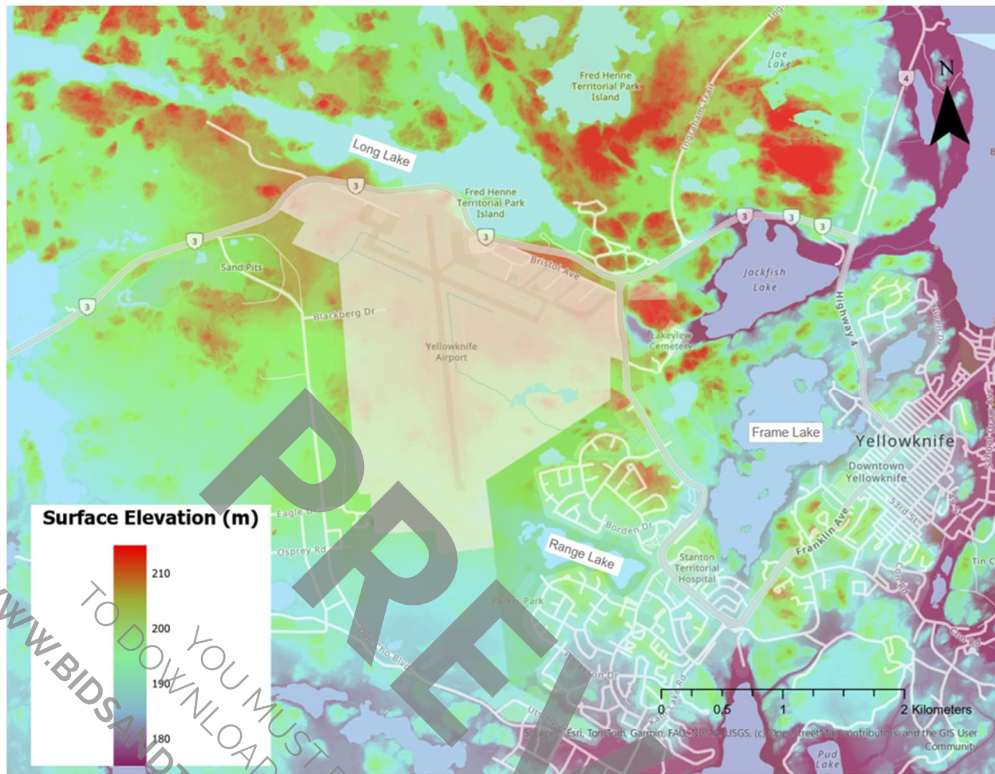


Figure 1-2: LiDAR Surface Elevation Contour Map

2. Scope and Objectives

The scope of this TM is to develop and compare siting options for the PH7 location and the PH7 fill main alignment.

The PH7 location options were selected based on the following parameters:

- ⇒ Surface elevations
- ⇒ Distance from WTP
- ⇒ Proximity to the Zone 7 development areas
- ⇒ Locations of existing infrastructure
- ⇒ Feasibility of potential fill main alignments

The PH7 fill main alignment options were selected based on the following parameters:

- ⇒ Total length of piping required
- ⇒ Location of existing underground infrastructure (water, sanitary, storm mains)
- ⇒ Right of way and easement requirements
- ⇒ Pipeline crossings including roads, railways, drainage channel and waterbodies
- ⇒ Ability to tie-into the existing system for potential fill main phasing options

The development of the PH7 and fill main options included a review of information provided by the City including:

- ⇒ LiDAR data
- ⇒ GIS data
- ⇒ Record drawings

Each PH7 location and fill main alignment were analyzed at a high level using the CoYK Zone 1 WaterCAD model currently being updated as part of the Water Master Plan project. The initial modelling results were used to determine the feasibility of the existing WTP distribution pumps to provide the required PH7 fill flow and existing system tie in locations that could be used for initial fill main phasing. More detailed hydraulic modelling will be completed for the selected PH7 location and fill main alignment during preliminary design.

3. Pumphouse No. 7 and Fill Main Location Options

We selected four site location options for PH7 based on the siting considerations described in Section 2. The site location options include:

- ⇒ East of Airport Option 1 located on the West end of Parcel No. 5
- ⇒ East of Airport Option 2 located between Parcel No. 3 and Parcel No. 5
- ⇒ Central Option located within Parcel No. 4
- ⇒ Deh Cho Blvd Option located on the south end of Parcel No. 6

The approximate size requirement for the PH7 lot was estimated using the anticipated required PH7 reservoir volume (6,900 m³ as per the Zone 7 demands and reservoir size requirements included in the Zone 4 TM) and depth of 3.5 m, truck fill and vehicle turnaround requirements, parking requirements, and setback requirements. The existing PH4 lot sizing was used as a basis for the truck fill, parking, and setback requirements as the PH7 required reservoir size is similar to the PH4 reservoir size. Note that the required PH7 lot area is site specific and will be further refined during preliminary design for the selected PH7 site. Table 3-1 shows the approximate PH7 lot size requirement.

Table 3-1: Estimated Pumphouse No. 7 Lot Size Requirement

Component	Estimated Area Requirement (m ²)
Reservoir	2,000
Pumping Station Building	500
Truckfill and Parking	1,000
Setback and road access	500
Total	4,000

PH7 will ultimately be serviced by a dedicated fill main from the WTP. There were three general fill routes compared in this TM that were selected based on the four potential location options and the alignment selection parameters described above. The general fill route options are as follows:

- ⇒ Via 48th Street to service the East of Airport Option 1, East of Airport Option 2 and as an alternative to service the Central PH7 location option
- ⇒ Via 53rd Street and underneath Frame Lake as an alternative to service the Central PH7 location option
- ⇒ Via Tincan Hill and Kam Lake Road to service the Deh Cho Blvd PH7 location option

The general locations of each PH7 site option and fill main route are shown in Figure 3-1 and further described in the below sections.

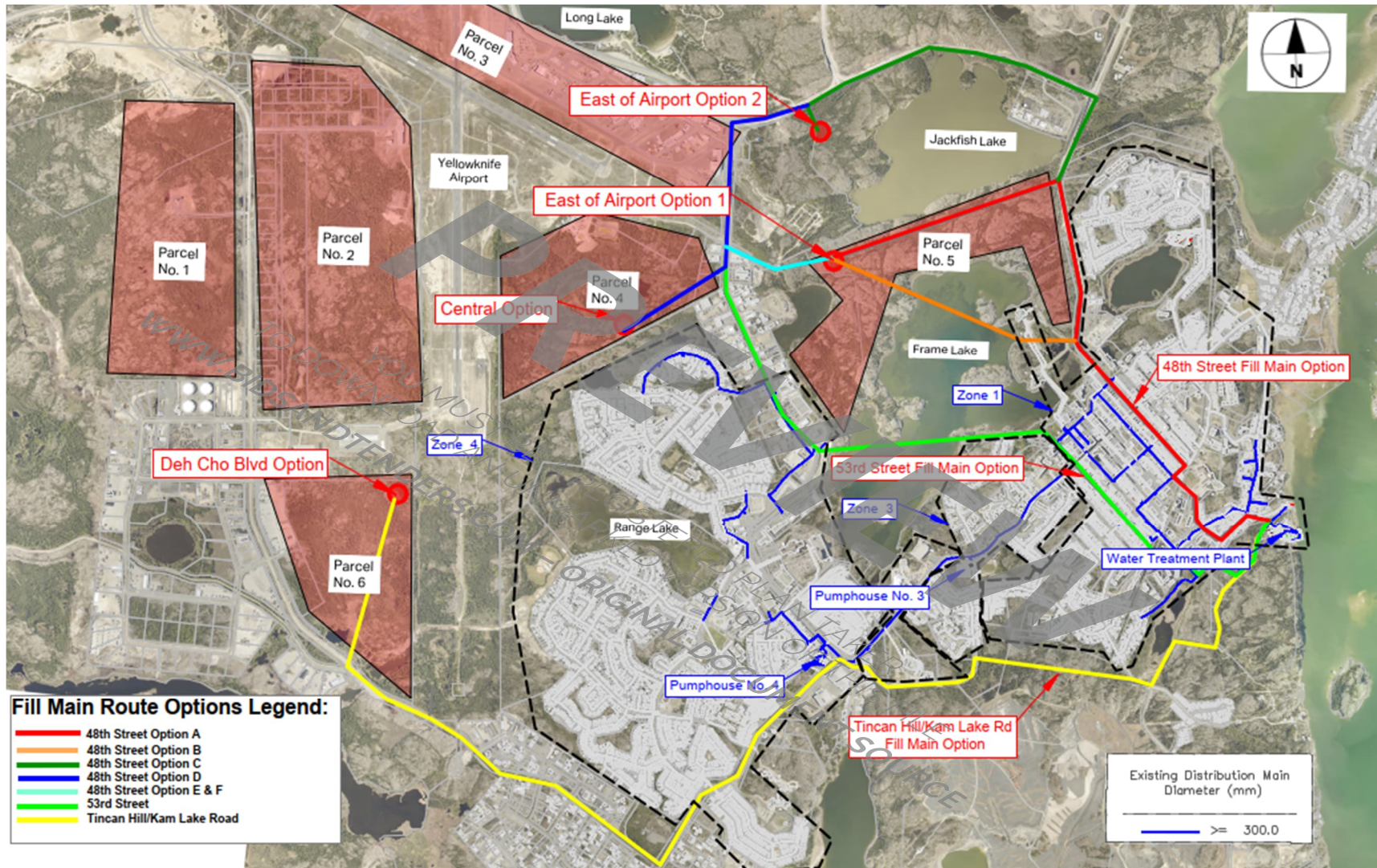


Figure 3-1: Pumphouse No. 7 Siting and Fill Main Layout Options

3.1 Pumphouse Location Options

3.1.1 East of Airport Option 1

The east of airport Option No. 1 would be located within the northwest portion of Parcel No. 5. It was selected as an option due to the surface elevation being higher at this location at approximately 210 m in elevation. This is in line with the higher surface elevations of approximately 205 m observed around the airport in Parcels No. 2 and 3 but approximately 30 m higher than the 180 m surface elevation at the WTP and 20 m higher than the 190 m surface elevation observed within Parcel No 6. Figure 3-2 shows a zoomed in location of the East of Airport Location No. 1 option.

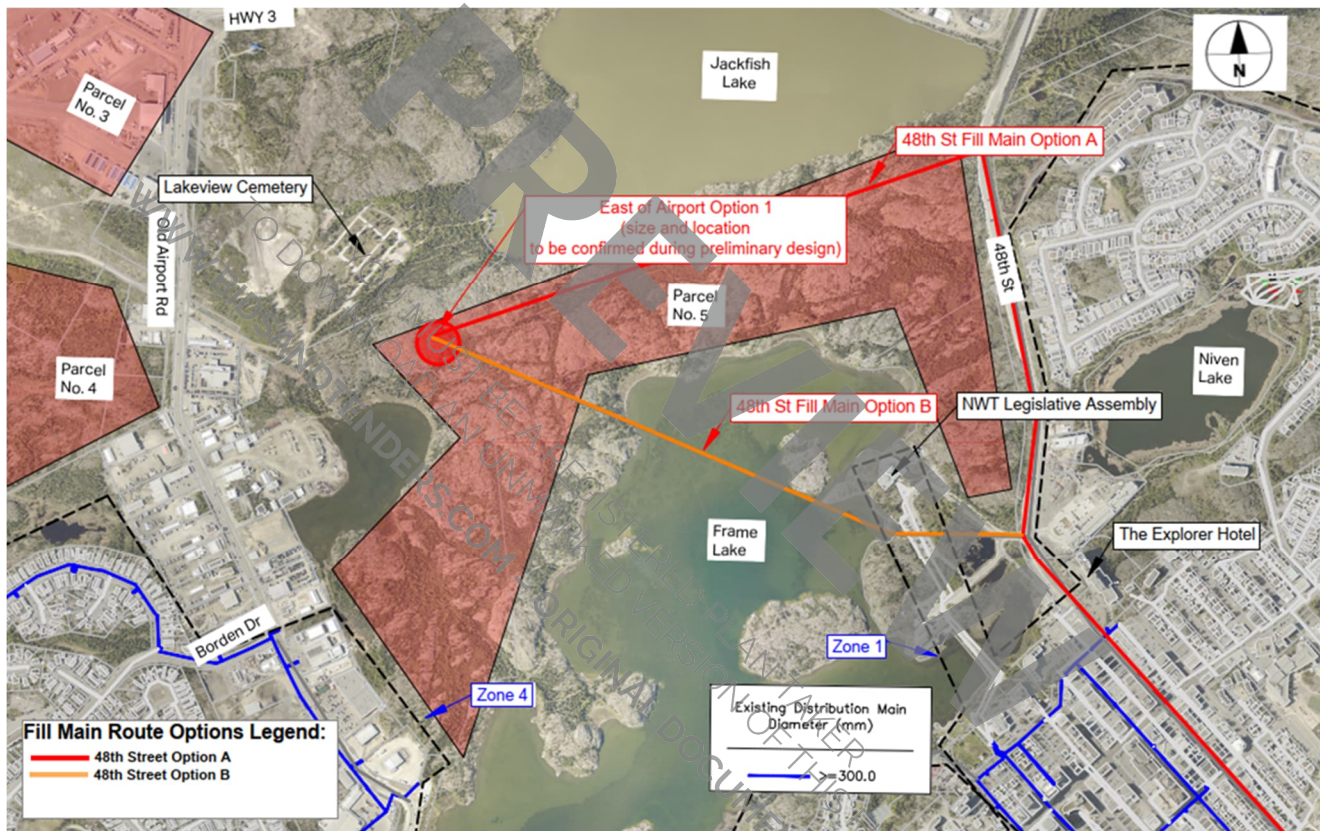


Figure 3-2: East of Airport Option 1 Location

This option has advantages and disadvantages that were considered in the Site selection process. Note that the WTP fill main routing options will be compared in Section 3.2.

Advantages

- ⇒ The higher PH7 ground elevation will result in a lower pumping head required to service the Zone 7 distribution system
- ⇒ Will require the least length of fill main piping as compared to the other three location options
- ⇒ Could support the existing Zone 4 distribution system with interconnection(s) at Old Airport Drive
- ⇒ Potential for initially connecting the fill main to the existing system as a phasing option

Disadvantages

- ⇒ The WTP fill main pumps will be required to have a larger pumping head to service the higher PH7 elevation as compared to PH7 being at a lower ground elevation
- ⇒ The pumphouse is not centralized within the Zone 7 system. This could impact the pumping head required for servicing the extents for the system (Parcel No. 6 in this case), especially during fire flows.
- ⇒ A right-of-way for the fill main will have to be constructed within Parcel No. 5 in order to service PH7; thus it will be more practical to develop Parcel No.5 in the initial Zone phasing for this location option.

3.1.2 East of Airport Option 2

The east of airport Option No. 2 would be located north of Parcel No. 5 and east of Parcel No. 3. It was selected as an option due to it being at a high elevation of approximately 200 m and that the PH7 fill main can run along Highway No. 3. Similar to the east of airport Option 1 location, the Option 2 location's surface elevation is in line with the higher surface elevations of approximately 205 m observed around the airport in Parcels No. 2 and 3 but approximately 20-30 m higher than the surface elevations at the WTP and within Parcel No 6. Figure 3-3 shows a zoomed in location of the East of Airport Location No. 2 option.

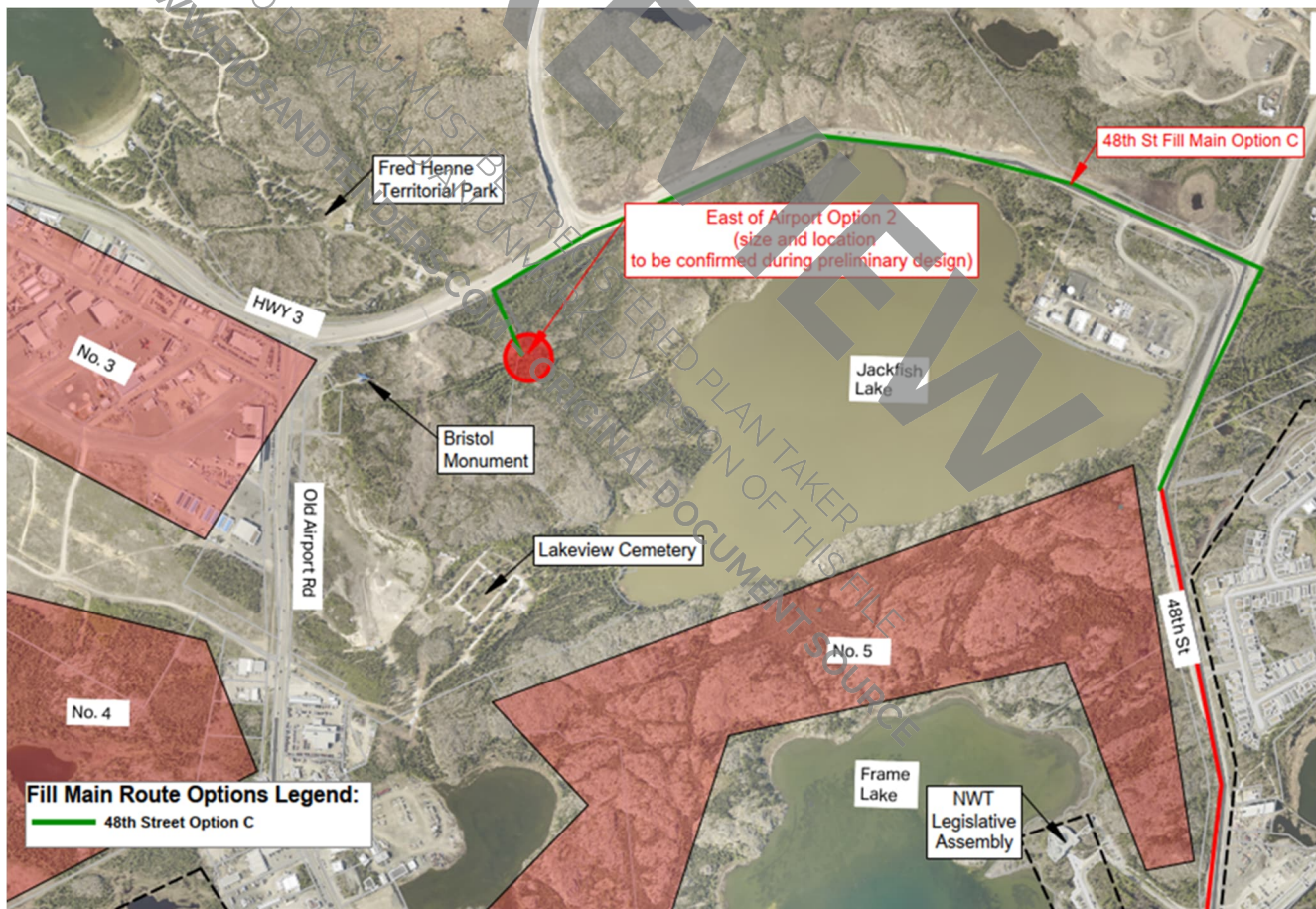


Figure 3-3: East of Airport Location 2 Option

This option has advantages and disadvantages as follows:

Advantages

- ⇒ The higher PH7 ground elevation will result in a lower pumping head required to service the Zone 7 distribution system as compared to pumping from a lower ground elevation.
- ⇒ The PH7 fill main can be constructed within HWY 3 which could potentially decrease the amount of bedrock blasting required as compared to what would be required for the East of Airport location 1 option.
- ⇒ Constructing the fill main within existing right-of-ways offers more flexibility for which Parcel within Zone 7 can be developed first.
- ⇒ Potential for initially connecting the fill main to the existing system as a phasing option

Disadvantages

- ⇒ The WTP fill main pumps will be required to have a larger pumping head to service the higher PH7 elevation as compared to PH7 being at a lower ground elevation.
- ⇒ There is more WTP fill main piping required for this option as compared to the East of Airport Location 1 option.

3.1.3 Central Location Option

The Central location option would be located within Parcel No. 4 north of the Range Lake North subdivision. It was selected as an option due to being centrally located within Zone 7. The surface elevation observed with the proposed central location option is approximately 200 m which is in line with the higher elevation observed near the airport and Parcel No. 5. The surface elevation is approximately 15-25 m higher than the surface elevations at the WTP and within Parcel No 6. Figure 3-4 shows a zoomed in location of the Central Location option.

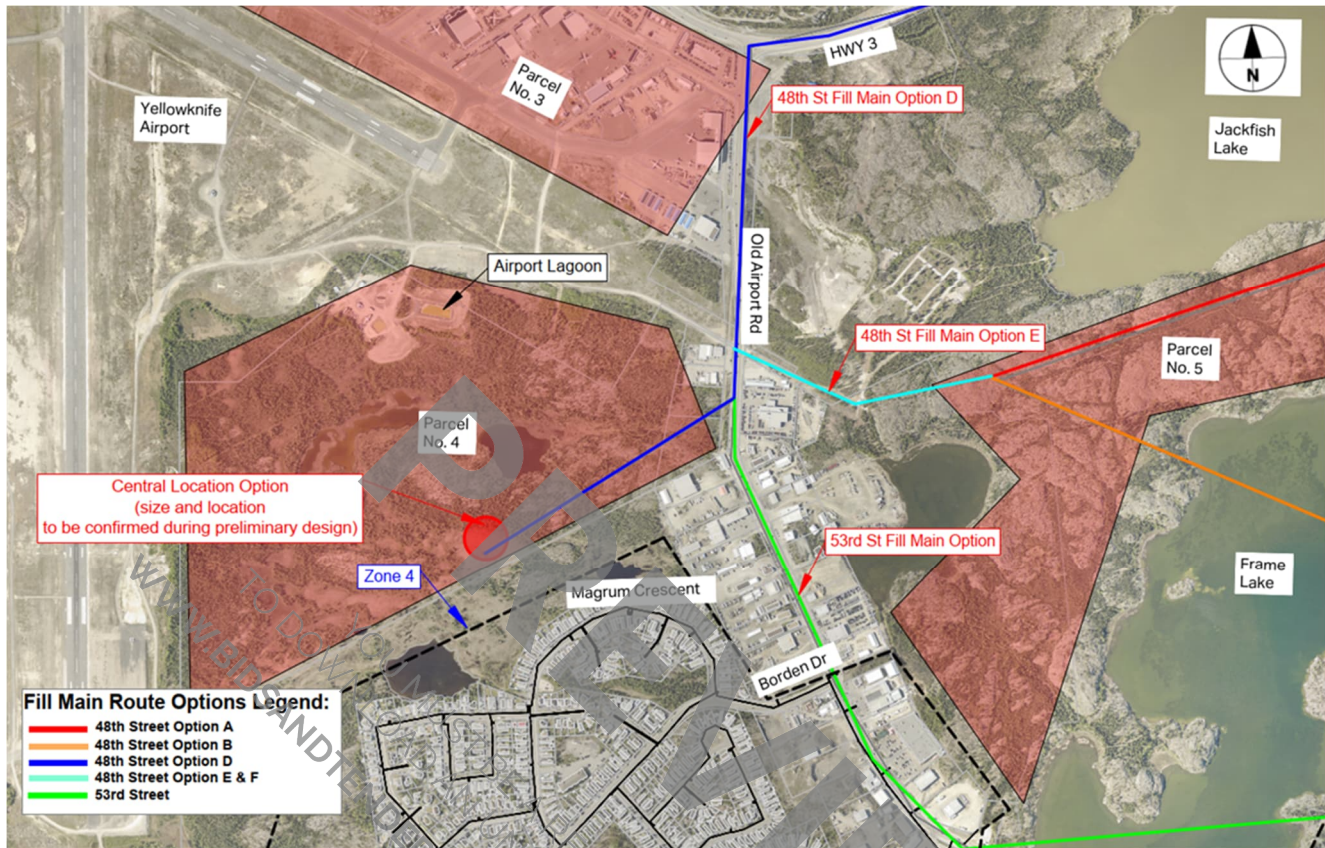


Figure 3-4: Central Location Option

This option has advantages and disadvantages including:

Advantages

- ⇒ The pumphouse is centralized within the Zone 7 system which could be advantageous in terms of the Zone 7 pumping requirements.
- ⇒ The site ground elevation is approximately 200 m which is in the middle of the initial 190-210 m elevation range observed within Zone 7. This more evenly distributes the pumping requirements for the WTP and PH7.
- ⇒ Could support the existing Zone 4 distribution system with interconnection(s) at Magrum Crescent.
- ⇒ Potential for initially connecting the fill main to the existing system as a phasing option

Disadvantages

- ⇒ There is more fill main piping required for this option as compared to the East of Airport Location 1 option.
- ⇒ The PH7 pumps will be required to have a larger pumping head to service Zone 7 as compared to the East of Airport Location options.

3.1.4 Deh Cho Blvd Option

The Deh Cho Blvd option would be located on the northeast corner of Parcel No. 6. It was selected as an option due to decreasing the pumping requirements for the WTP fill main and the option of twinning the fill main along

a portion of the route to provide reservoir fill redundancy and flexibility to PH4. The surface elevation observed at the De Cho Blvd option was 188 m which is approximately 12 m lower than the higher elevations at the airport and Parcel No. 5 and approximately 10 m higher than the surface elevation at the WTP. Figure 3-5 shows a zoomed in location of the De Cho Blvd option.

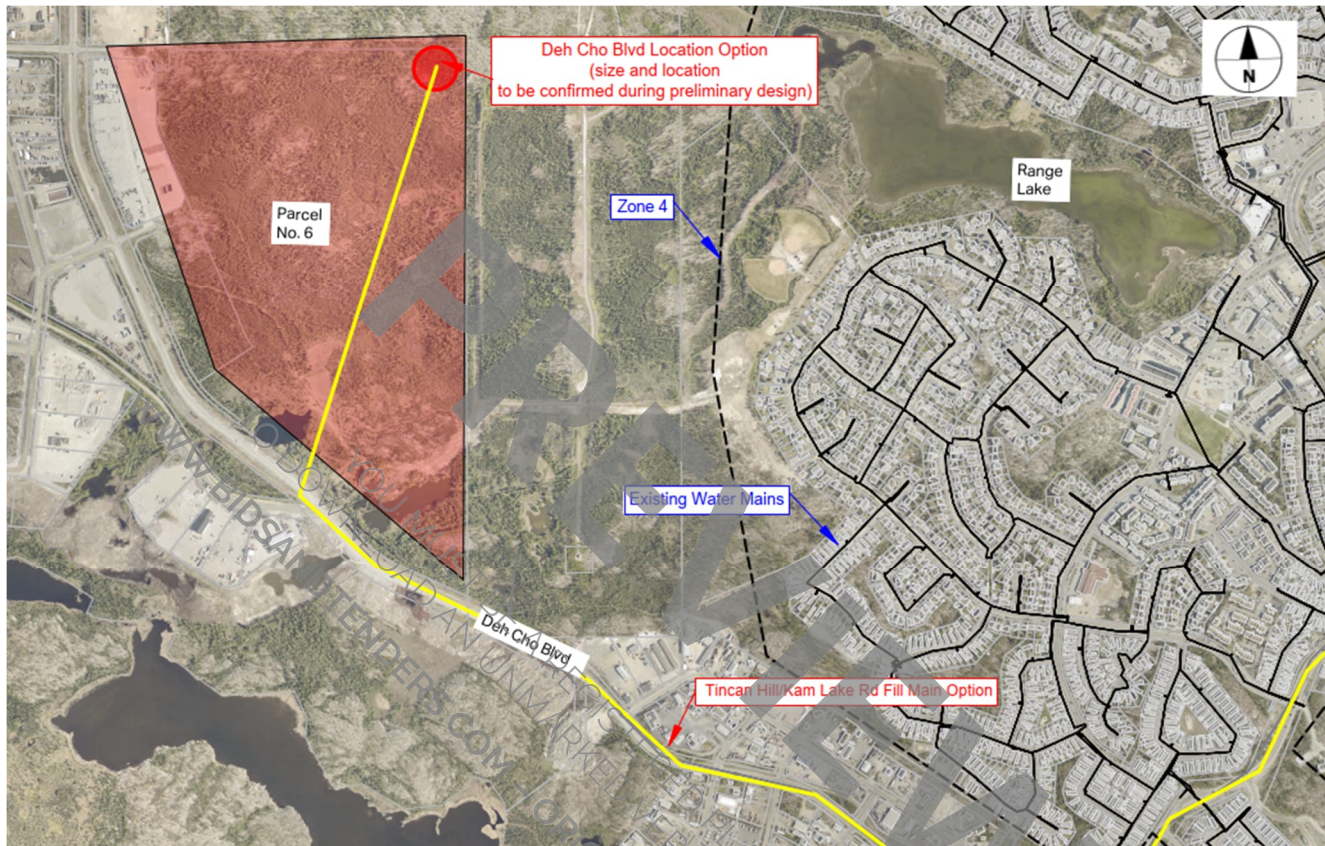


Figure 3-5: De Cho Blvd Option

Advantages and disadvantages for this option include:

Advantages

- ⇒ The site ground elevation is approximately 190 m which lowers the pumping requirements from the WTP
- ⇒ This location is closest to Parcels nos 2 and 6 which are expected to be in the first phase of Zone 7 development based on assumptions and current information available to AECOM.
- ⇒ The initial portion of the fill main from the WTP can be used to PH4 to provide redundancy for the PH4 fill main
- ⇒ Servicing the De Cho Blvd industrial area from PH7 can be included as an added benefit

Disadvantages

- ⇒ There is more fill main piping required for this option as compared to the other 3 location options
- ⇒ The lower elevation at this location leads to the lowest PH7 hydraulic advantage compared to the other location options. This will lead to larger pumping requirements at PH7. Initial hydraulic modelling for Zone 7 showed that it is not feasible to service Parcel No. 5 from this PH7 location. If the City chooses this location option, AECOM will determine alternative servicing options such as

servicing Parcels No. 5 from the Niven Lake booster station. Initial modelling results showed that Parcel No. 5 can be serviced from the Niven Lake Booster Station which is situated within Pressure Zone 1 with pumping upgrades required at both the Niven Lake Booster Station and WTP.

3.2 Pumphouse No. 7 Fill Main Routing Options

3.2.1 48th Street Fill Main Option

The initial approximately 1,900 m of fill main from the WTPs to the NWT Legislature access road is the same for each of the 48th Street fill main A through E alignment options.

The 48th Street fill main route options start by connecting to existing 500 mm distribution main outside of the WTP. The fill main then travels west from the WTP along 48th Street and School Draw Avenue then north along 49th Street until 52nd Avenue. This route jogs one block east along 52nd Avenue and continues north through the central business development area via 48th Street. This initial 48th Street alignment has several advantages and disadvantages as compared to the other two alignment options. Figure 3-6 shows the initial 1,900 m of the proposed 48th Street fill main alignment.

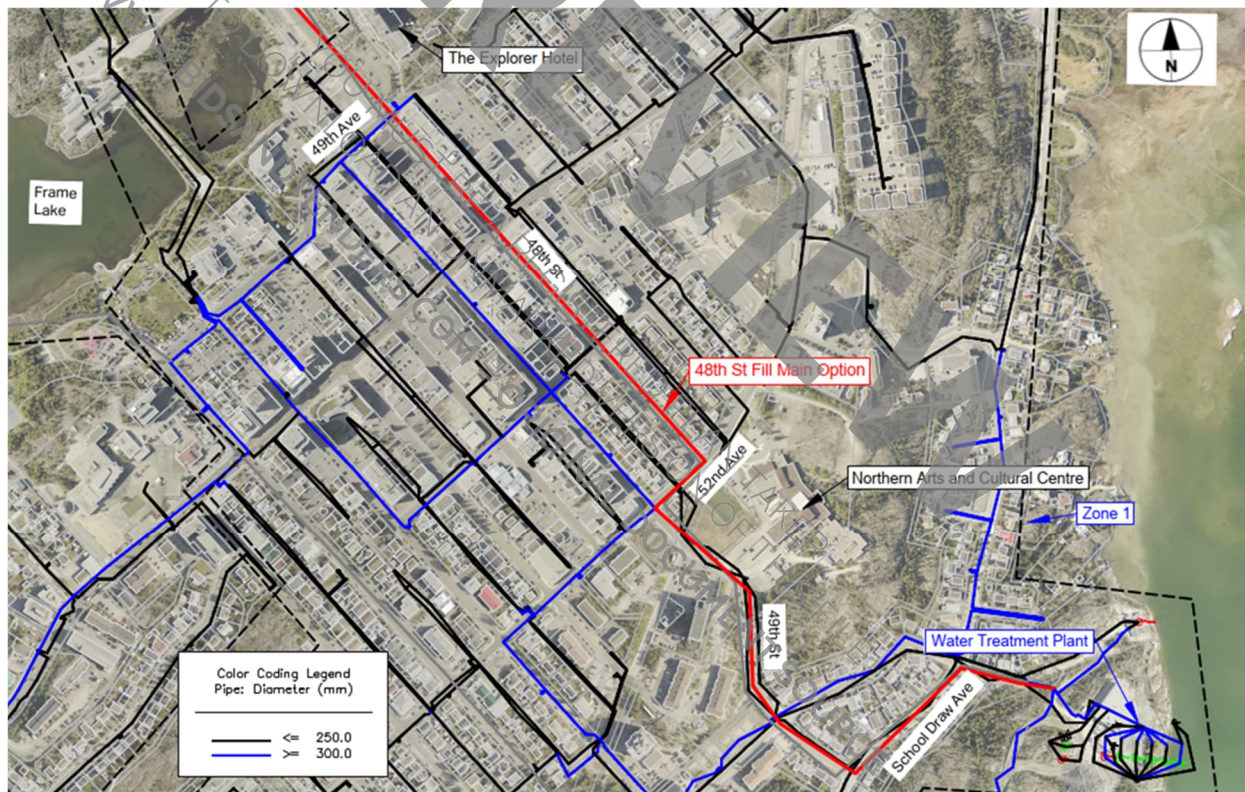


Figure 3-6: 48th Street PH7 Fill Main Option

Advantages

- ⇒ The 48th Street right-of-way from 52nd Street north to Parcel No. 5 has no existing water, sanitary, or storm mains.
- ⇒ The fill main can tie into the existing 300 mm main located at 48th Street and 49th Avenue to provide a phasing option. The potential phasing options are discussed further in Section 4.

Disadvantages

- ⇒ There are existing water, sanitary, and storm mains located within 48th Street near the WTP, School Draw Avenue, and 49th Street. The existing mains introduce physical limitations to where the fill main can be located within the right-of-way and additional costs due the amount of required pipeline crossings.

48th Street Option A

This fill main alternative services the East of Airport 1 PH7 location option by continuing north along 48th Street and then west along Parcel No. 5 (see Figure 3-2). The advantages and disadvantages of this alternative include:

Advantages

- ⇒ One of the shortest routes with approximately 4,050 m of piping required.
- ⇒ No submarine/below lake pipeline is required.

Disadvantages

- ⇒ A significant amount of bedrock blasting is likely required for the approximately 1,350 m portion of alignment that goes west along Parcel No. 5.
- ⇒ An initial 1,350 m right-of-way would have to be constructed within Parcel No.5. This limits the phasing options as developing Parcel No. 5 in the initial phase of Zone 7 development would be recommended.

48th Street Option B

The 48th Street Option B alternative also services the East of Airport 1 PH7 location option (see Figure 3-2). The fill main would head northeast along the NWT Legislature access road from 48th Street and continue underneath Frame Lake towards PH7. The fill main would continue for approximately 450 m to PH7 after crossing the lake.

The advantages and disadvantages of this option include:

Advantages

- ⇒ The shortest fill main route with approximately 3,300 m of piping required.
- ⇒ Less bedrock blasting is expected as compared to 48th Street Option A.

Disadvantages

- ⇒ Crossing underneath Frame Lake poses several challenges including:
 - A bathymetric survey of Frame Lake would be required to determine the lake depth and lake bottom terrain. This is a more involved and costly survey requirement than would be required for the alignment options that do not cross underneath a waterbody.
 - The installation of the fill main underneath the lake involves more complicated and costly construction methods.
 - Maintaining the portion of the fill main underneath Frame Lake would require more time, and specialized equipment and workers. This will add significant maintenance and future replacement costs for this section of fill main.
- ⇒ An initial 450 m right-of-way would have to be constructed within Parcel No.5. This limits the phasing options as developing Parcel No. 5 in the initial phase of Zone 7 development would be the most cost effective.

48th Street Option C

This alternative services from the East of Airport option 2 PH7 location (see Figure 3-3). The fill main would continue north along 48th Street and then head west along Highway No. 3 to PH7. This option has several advantages and disadvantages as compared to the other route alternatives.

Advantages

- ⇒ All except for 100 m of the fill main is located within existing road rights-of-ways. This is expected to significantly decrease the amount of bedrock blasting as compared to 48th Street Options A and B. Constructing the fill main within existing right of ways will allow for more flexibility for Zone 7 phasing as no additional right-of-ways are required to be constructed for the fill main.
- ⇒ No submarine/below lake pipeline is required

Disadvantages

- ⇒ An additional approximately 1,000 and 1,800 linear meters of fill main piping is required for this option as compared to 48th Street Option A and Option B respectively.

48th Street Option D

The 48th Street Option D is one of the four routing alternatives for servicing the Central PH7 location option. This route would continue along Highway 3 as per the 48th Street Option C alternative instead of supplying the East of Airport Option 2 PH7 location. The fill main would then head south on Old Airport Road and then west towards the Central PH7 location. This option has the largest length of required fill main at 6,970 linear meters.

48th Street Option E and F

The 48th Street Option E and F are a second and third alternative to servicing the Central PH7 location option. Alignment option E and F would be a continuation of 48th Street Option A or 48th Street Option B respectively. For both options, the fill main would continue west until Lakeview Cemetery Road instead of supplying the East of Airport Option 1 location. The fill main would then head west along Lakeview Cemetery Road, South along Old Airport Road, and west again within Parcel No. 4 to the Central PH7 location. Options E and F have the same advantages and disadvantages as 48th Street Option A and B respectively, except they both require an additional approximately 1,350 linear meters of fill main.

3.2.2 53rd Street Fill Main Option

The 53rd Street fill main alternative would service the Central PH7 location option (see Figure 3-4). Similar to the 48th Street location option, the fill main would tie into the 500 mm diameter distribution main leaving the WTP. The fill main would then head south and west along Tin Can Way, through a right-of-way south of School Draw Avenue, and northwest on 52nd Street until 53rd Avenue. The fill main would then continue northwest along 53rd Street past 49th Avenue and underneath Frame Lake to Old Airport Road. Finally, the main would head north along Old Airport Road and west within Parcel No. 4 to the Central PH7 location. Figure 3-7 below shows the proposed alignment from the WTP to Frame Lake.

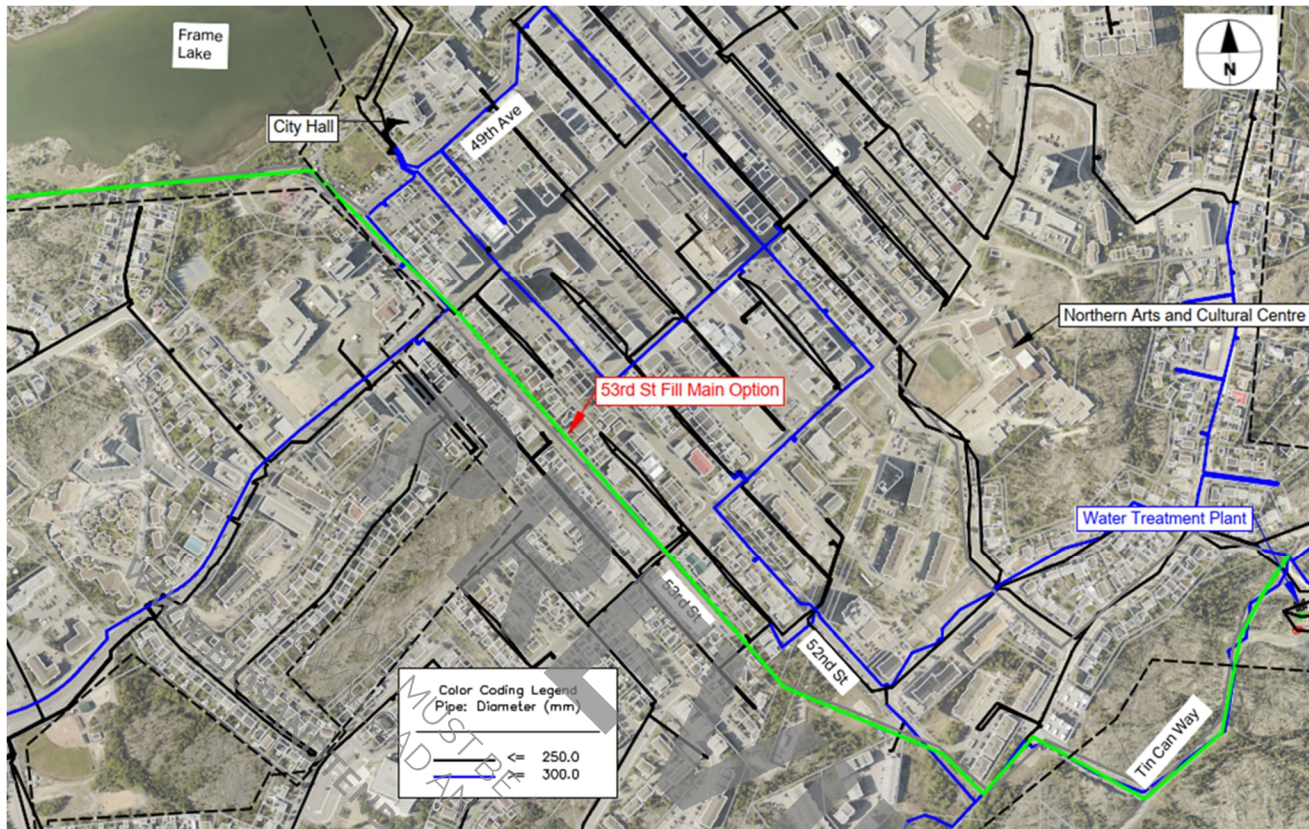


Figure 3-7: 53rd Street Fill Main Option

The 53rd Street fill main can be tied into existing 300 mm diameter water main located at the 53rd Street and 49th Avenue intersection for an initial phasing option. The phasing options are discussed in Section 4 below. The 53rd Street fill main has several advantages and disadvantages as compared to the other two fill main alignment options to the Central PH7 location option.

Advantages

- ⇒ The majority of the fill main is located within existing road rights-of-ways. This is expected to significantly decrease the amount of bedrock blasting as compared to the 48th Street Option E alignment alternative.
- ⇒ Similar length of fill main required to service the Central PH7 location option as compared to the 48th Street Option E alignment alternative.
- ⇒ Three blocks of 53rd Street, from 53rd Avenue to 50th Avenue, have no existing water, sanitary, or storm mains.

Disadvantages

- ⇒ Crossing underneath Frame Lake poses several challenges that are summarized in the 48th Street Option B alternative.
- ⇒ There are existing water mains along Tin Can Way, 53rd Street between 50th Avenue and 49th Avenue, and along Old Airport Road north to Byrne Road, that will have to be considered in the fill main alignment and design.

3.2.3 Tincan Hill / Kam Lake Road Fill Main Option

The Tincan Hill / Kam Lake Road fill main route services the Deh Cho Blvd PH7 location option (see Figure 3-5). The fill main would tie-into the 500 mm diameter fill main leaving the WTP and then head south along Tin Can Way and Tin Can Hill Trail towards Con Road. The main then would go south on Con Road for approximately 250 m before heading west to Taylor Road. Finally, the fill main would continue south within Kam Lake Road and west within Deh Cho Blvd to the Deh Cho Blvd PH7 location. Figure 3-8 shows the Tincan Hill/Kam Lake Road fill main route alternative from the WTP to PH4. Figure 3-9 shows the fill main route from PH4 to the Deh Cho Blvd PH7 location option.

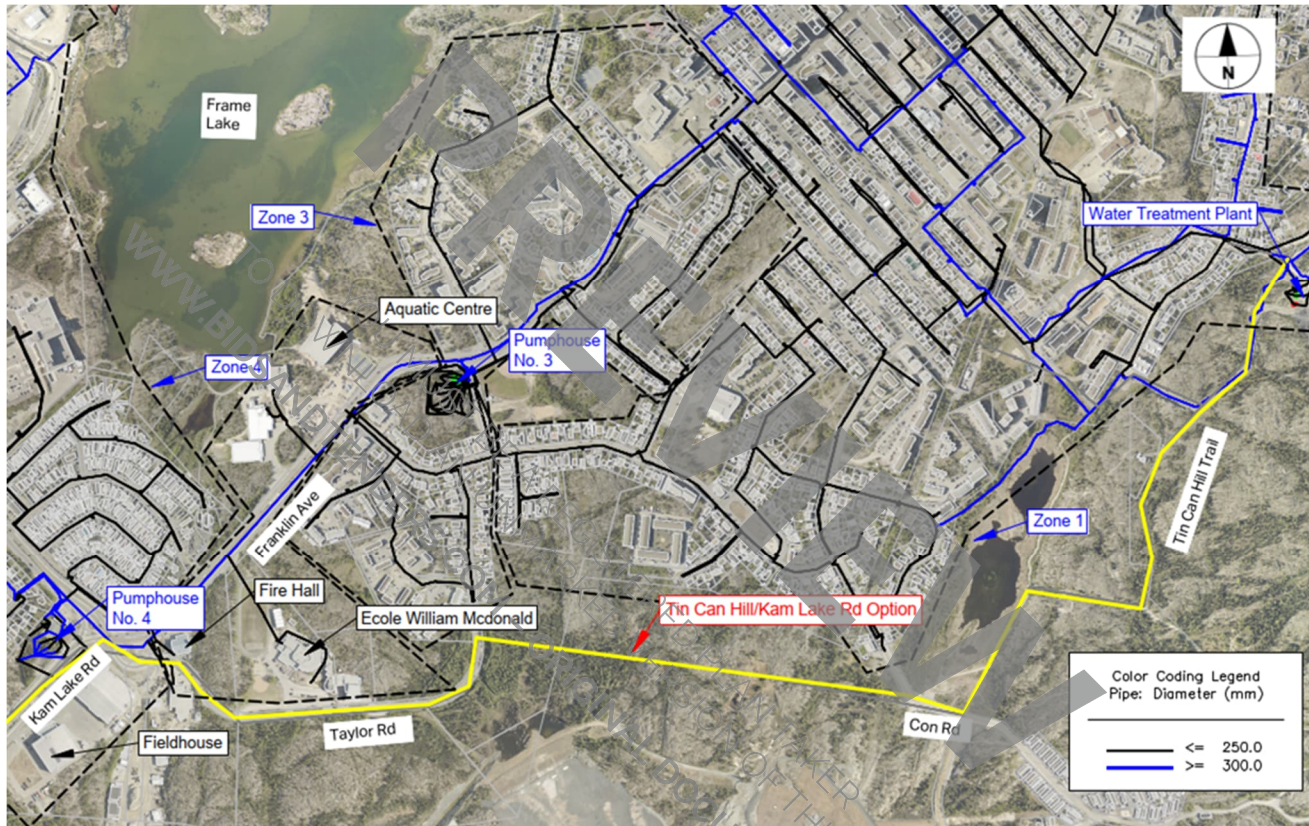


Figure 3-8: Tin Can Hill / Kam Lake Rd Fill Main Option: WTP to PH4



Figure 3-9: Tin Can Hill/Kam Lake Rd Fill Main Option: PH4 to Parcel No. 6

The Tincan Hill/Kam Lake Road fill main has several advantages and disadvantages as compared to the other two general fill main alignment options.

Advantages

- ⇒ The majority of the fill main is located within existing road rights-of-ways. This is expected to decrease the amount of bedrock blasting required
- ⇒ There are no existing water, sanitary, or storm mains located along Tin Can Hill Trail, Con Road, Taylor Road, Kam Lake Road, and Deh Cho Blvd.
- ⇒ The initial approximately 3,200 linear meters of PH7 fill main can be used as an additional PH4 fill main that provides redundancy for the existing PH4 fill main. Note that this initial fill main will be a larger diameter to provide the required PH4 fill main flow in addition to the PH7 fill main flow.

Disadvantages

- ⇒ The total length of fill main required is approximately 7,700 linear meters which is more than double the required for the shortest alternative (48th St-B)

4. Fill Main Phasing

Initially tying in the PH7 fill main to the existing Zone 1 distribution system could be an option for decreasing the amount of piping required for the first phase of the Zone 7 project. The CoYK Zone 1 hydraulic model currently being updated as part of the Water Master Plan project was used to assess the ability of the existing Zone 1 system to supply adequate flow and pressures to PH7. The available fill main flow and pressures, as well the existing Zone 1 distribution pressures, were analyzed under the following scenarios:

- ⇒ Zone 1 Average Day Demand (ADD) plus PH3, PH4, and PH7 filling
- ⇒ Zone 1 Maximum Day Demand (MDD) plus PH3, PH4, and PH7 filling
- ⇒ Zone 1 Peak Hour Demand (PHD) plus PH3, PH4, and PH7 filling

Sections 4.1 and 4.2 below summarize the results of the 48th Street Fill Main and 53rd Street Fill Main tie-in analysis. Note that the analysis including a PH7 fill rate were conducted with the addition of one distribution pump at the WTP sized the same as the existing distribution pumps.

4.1 48th Street Fill Main Option

The 48th Street Fill Main could initially be tied into the existing 300 mm main located at the 48th Street and 49th Avenue intersection; with future phasing to the WTP as PH7 demands increase. Table 4-1 below summarizes the Zone 1 hydraulic results for the ADD, MDD, and PHD scenarios.

Table 4-1: Initial 48th Street Tie-In Hydraulic Results

Scenario	PH7 Fill Rate (L/s)	PH7 Fill Main Pressure Range (kPa)(psi)	PH3, PH4 Fill Rate (L/s) ¹	Total WTP Output (L/s)	Tie-In Node Pressure (kPa) (psi)	Zone 1 Pressure Range (kPa) (psi)	PH3 -PH4 Fill Main Inlet Pressure (kPa) (psi)
Zone 1 ADD- Prior to PH7	0	273-469 (39-68)	18,63	133	485 (70)	373-787 (54-114)	366 (53)
Zone 1 ADD- With PH7 ²	60	205-426 (29-61)	18,63	193	446 (64)	337-772 (48-112)	330 (47)
Zone 1 MDD- Prior to PH7	0	244-440 (35-63)	18,63	154	456 (66)	343-759 (49-109)	336 (48)
Zone 1 MDD- With PH7 ²	45	222-428 (32-62)	18,63	207	446 (64)	335-766 (48-111)	328 (47)
Zone 1 PHD- Prior to PH7 ²	0	248-443 (35-64)	5,40	204	460 (66)	351-770 (50-112)	361 (52)
Zone 1 PHD- With PH7 ³	25	230-429 (33-62)	5,40	229	446 (64)	341-770 (49-111)	349 (50)

Notes (1) ADD Fill Rates as Observed during July 2025 Hydrant Testing, PHD fill rates as per SCADA minimum fill rates (2) Four WTP distribution pumps ON (3) With one additional WTP distribution pump (five total)

The initial 48th Street tie-in hydraulic results showed that the PH7 fill main could be connected the existing Zone 1 distribution system up to a maximum fill rate of 60 L/s during ADD without significantly impacting the existing distribution pressures. Note that one additional distribution pump would be required to be installed at the WTP to service the additional fill main flows. The PH7 fill rate will be designed to fill at the Zone 7 MDD during the Zone 1 ADD scenario. Therefore, based on the estimated Zone 7 water demands established in TM No. 1, the City can service up to an anticipated 188 ha of commercial development. If the proposed residential parcel No. 5 is

developed in the initial phase, an additional 125 ha of commercial development could be developed in the first phase with the 48th Street tie-in phasing option.

4.2 53rd Street Fill Main Option

The 53rd Street Fill Main would initially be tied into the existing 300 mm main located at the 53rd Street and 49th Avenue intersection. Table 4-2 below summarizes the Zone 1 hydraulic results for the ADD, MDD, and PHD scenarios.

Table 4-2: Initial 53rd Street Tie-In Hydraulic Results

Scenario	PH7 Fill Rate (L/s)	PH7 Fill Main Pressure Range (kPa)(psi)	PH3, PH4 Fill Rate (L/s) ¹	Total WTP Output (L/s)	Tie-In Node Pressure (kPa) (psi)	Zone 1 Pressure Range (kPa) (psi)	PH3 -PH4 Fill Main Inlet Pressure (kPa) (psi)
Zone 1 ADD-Prior to PH7	0	314-480 (45-69)	18,63	133	451 (65)	373-787 (54-114)	366 (53)
Zone 1 ADD-With PH7 ²	45	257-440 (37-63)	18,63	178	341 (49)	333-776 (48-112)	327 (47)
Zone 1 MDD-Prior to PH7	0	284-451 (41-65)	18,63	154	421 (61)	343-759 (49-109)	336 (48)
Zone 1 MDD-With PH7 ²	25	277-449 (40-65)	18,63	187	420 (61)	341-772 (49-112)	334 (48)
Zone 1 PHD-Prior to PH7 ²	0	292-458 (42-66)	5,40	204	429 (62)	351-770 (50-112)	361 (52)
Zone 1 PHD-With PH7 ³	15	280-449 (40-65)	5,40	219	419 (60)	347-755 (50-109)	352 (51)

Notes (1) ADD Fill Rates as Observed during July 2025 Hydrant Testing, PHD fill rates as per SCADA minimum fill rates (2) Four WTP distribution pumps ON (3) With one additional WTP distribution pump (five total)

The initial 53rd Street tie-in hydraulic results showed that the PH7 fill main could be connected the existing Zone 1 distribution system up to a maximum fill rate of 45 L/s during ADD without significantly impacting the existing distribution pressures. Note that one additional distribution pump would be required to be installed at the WTP to service the additional fill main flows. The PH7 fill rate will be designed to fill at the Zone 7 MDD during the Zone 1 ADD scenario. Therefore, based on the estimated Zone 7 water demands established in TM No. 1, the City can service up to an anticipated 141 ha of commercial development. If the proposed residential parcel No. 5 is developed in the initial phase, an additional 78 ha of commercial development could be developed in the first phase with the 53rd Street tie-in phasing option.

5. Pumphouse No. 7 Fill Main Routing Option Comparison

The eight PH7 fill main route alternatives range in a total required fill main length of 3,300 m (48th St-B) to 7,650 m (Tin Can Hill / Kam Lake Road) as shown in Table 5-1 below.

Table 5-1: PH7 Fill Main Piping Length Comparison

Route Option	Approximate Total Fill Main Length (lin. m)	Approximate Length: Roads/Right of Ways with existing watermain (m)	Approximate Length: Roads/Right of Ways without existing watermain (m)	Approximate Length: Highway/main thoroughfare (m)	Approximate Length: without existing development (greenfield) (m)	Approximate Length: under waterbodies (m)
48 th St-A	4,000	850	950	900	1,300	N/A
48 th St-B	3,300	850	1,250	N/A	550	650
48 th St-C	5,100	850	950	3,200	100	N/A
48 th St-D	7,000	850	1,800	3,650	700	N/A
48 th St-E	5,400	850	1,050	900	2,600	N/A
48 th St-F	4,700	850	1,350	N/A	1,850	650
53 rd St	4,900	1,550	2,050	N/A	700	600
Tin Can Hill/Kam Lake Road	7,650	400	950	4,450	1,950	N/A

Based on total fill main length alone, both 48th St Option A and Option B require the least amount of piping. This corresponds to the East of Airport No. 1 location being the most efficient location in terms of total fill main length. However, the total fill main length does not consider the additional costs for constructing the fill main underneath Frame Lake, anticipated additional bedrock blasting for the fill main constructed outside of existing right-of-ways, and reconstruction of existing roadways. Therefore, a high-level cost estimate for each of the fill route alternatives was completed to more accurately compare each routing option. The 2022 CoYK submarine pipeline project was used as a cost basis for the estimated fill main costs with unit costs adjusted for inflation. The total estimated fill main cost for each option is summarized in Table 5-2 below.

Table 5-2: PH7 Fill Main Class D Opinion of Cost Comparison

Route Option	Total Estimated Cost
48 th St-A	\$ 26,800,000
48 th St-B	\$ 23,800,000
48 th St-C	\$ 22,600,000
48 th St-D	\$ 33,600,000
48 th St-E	\$ 37,200,000
48 th St-F	\$36,400,000
53 rd St	\$30,800,000
Tin Can Hill/Kam Lake Road	\$ 43,000,000

Notes: (1) AECOM prepared the cost estimates by applying the Association for the Advancement of Cost Engineering (AACE) International Recommended Practice No. 18R-97 "Cost Estimate Classification System – As Applied in Engineering, Procurement and Construction for Process Industries" Cost Estimate Classification Matrix. The estimates were based on a Class 4 (Class D) estimate Class as described below in Table 5-4.

(2) Cost estimates include 2.5 m width of pavement street restoration where the fill main would be installed within existing roadways

(3) Assumed no bedrock blasting is required within existing roadways and 2.5 m depth of bedrock blasting required within the greenfield (no existing development) areas

5.1 Pumphouse No. 7 Opinion of Cost

A Class 4 (Class D) opinion of cost for PH7, including civil site works, building structure, reservoir, and foundation requirements, and process, mechanical and electrical requirements is shown in Table 5.3 below. The cost was estimated based on recent pump and lift station project tender results, including the CoYK Lift Station No. 1 project currently under construction. A 30% contingency was added to the opinion of cost, as there are multiple site and design variables that will impact the PH7 cost including:

- ⇒ Site Location
- ⇒ Site Conditions
- ⇒ Reservoir style and structural design
- ⇒ Pumphouse footprint that will be impacted by factors including if water tempering and/or chlorine dosing will be required, and the general building layout

Table 5-3: PH7 Class D Opinion of Cost

Component	Total Estimated Cost
Civil	\$ 6,000,000
Structural	\$6,000,000
Architectural	\$5,000,000
Process	\$5,000,000
Building Mechanical & HVAC	\$3,000,000
Electrical & IC	\$5,000,000
General Requirements (10%)	\$2,225,000
Construction Sub-Total	\$33,000,000
Soft Costs (Permits, Bonding, Mob/Demob. etc.)	\$5,000,000
Subtotal	\$38,000,000
Contingency (30%)	\$11,400,000
Total PH7 Opinion of Cost	\$49,400,000

Notes: (1) AECOM prepared the cost estimates by applying the Association for the Advancement of Cost Engineering (AACE) International Recommended Practice No. 18R-97 "Cost Estimate Classification System – As Applied in Engineering, Procurement and Construction for Process Industries" Cost Estimate Classification Matrix. The estimates were based on a Class 4 (Class D) estimate Class as described below in Table 5-4.

Table 5-4: AACE Cost Estimate Classification Guidelines

Estimate Class	Primary Characteristic Maturity Level of Project Definition Deliverables Expressed as % of Complete Definition	Secondary Characteristics		
		End Usage Typical Purpose of Estimate	Methodology Typical Estimating Method	Expected Accuracy Range Typical Variation in Low and High Ranges ¹
Class 5	0% to 2%	Functional area of concept screening	SF or m2 factoring, parametric models, judgment, or analogy	Low: -20% to -30% High: +30% to +50%
Class 4	1% to 15%	Schematic design or concept study	Parametric models, assembly driven models	Low: -10% to -20% High: +20% to +30%
Class 3	10% to 40%	Design development, budget authorization, feasibility	Semi-detailed unit costs with assembly level line items	Low: -5% to -15% High: +10% to +20%
Class 2	30% to 75%	Control or bid/tender, semi-detailed	Detailed unit cost with forced detailed take-off	Low: -5% to -10% High: +5% to +15%
Class 1	65% to 100%	Check estimate or pre-bid/tender, change order	Detailed unit cost with detailed take-off	Low: -3% to -5% High: +3% to +10%

Notes: (1) The state of construction complexity and availability of applicable reference cost data affect the range markedly. The +/- value represents typical percentage variation of actual cost from the cost estimate after application of contingency (typically at a 50% level of confidence) for given scope.

Adapted from AACE International Recommended Practice No. 56R-08 "Cost Estimate Classification System – As Applied For the Building and General Construction Industries" (2012).

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5.2 PH7 Siting and Fill Main Ranking

AECOM ranked the PH7 location option and fill main alignments based on the opinion of cost and added value provided by each option. First, the PH7 location option rankings are shown in Table 5-5 below.

Table 5-5: PH7 Location Ranking

Location Option	Ranking
Deh Cho Blvd	1
East of Airport 2	2
East of Airport 1	3
Central	4

The Deh Cho Blvd option is the top ranked option due to it being closest to the first phase of Zone 7 development (Parcels no. 2 and no. 6). This location also provides the most added value with the option of twinning a portion of the fill main to provide redundancy to the PH4 fill main, servicing the Deh Cho industrial area and also providing opportunity for servicing on Taylor Road.

It is important to note that Parcel No. 5 is not feasible to be serviced from the Deh Cho Blvd pump station location due to the hydraulic disadvantages of the location including the anticipated reservoir elevation and distribution main length requirements. Pumping upgrades to the Niven Lake pumping station (located in Pressure Zone 1) will be required to service Parcel No. 5.

Next, the PH7 fill main routing options were ranked based on opinion of cost and value added as shown in Table 5-6 below.

Table 5-6: PH7 Fill Main Route Ranking

Fill Main Route	Ranking
Tincan Hill / Kam Lake Road	1
48 th St C	2
48 th St A	3
48 th St D	4
48 th St B	5
48 th St E & F	6
53 rd St	7

The Tincan Hill / Kam Lake Road fill main route was selected as it is required to service the De Cho Blvd location option and it can be used as an additional PH4 fill main that provides redundancy for the existing PH4 fill main.

This added redundancy is important to the City for the following reasons:

- ⇒ Zone 4 services several critical facilities and users in the City, including the Stanton Hospital.
- ⇒ The existing PH4 fill main services large users, including the aquatic centre, curling rink, and two high schools.

6. Water Treatment Plant Capacity Review

The existing WTP capacity, including raw water pumping, treatment capacity, reservoir volume, and distribution pumping, has been reviewed to determine, at a high level, the anticipated upgrades required to service PH7. The required WTP upgrades, including distribution pumping requirements, will be further reviewed during the PH7 preliminary design.

6.1 Raw Water Pumping and Treatment Capacity

The WTP raw water pumping and treatment capacity was initially reviewed as part of the ongoing Submarine Waterline Replacement project (last reviewed in 2023). The WTP capacity analysis will be updated as part of

the Water Master Plan project. Table 6-1 summarizes the current WTP raw water and treatment capacity compared to the 2025 distribution system demand and total demand with Zone 7.

Note that the future distribution system demand projections outside of Zone 7 will be determined during the Water Master Plan. Only the additional demands expected from Zone 7 will be included in the WTP capacity review for the purposes of this TM. The projected future Zone 7 demands from the available land use types and areas provided by the City were established in the Zone 4 TM submitted by AECOM in August 2025. The total Zone 7 MDD was estimated to be 137.7 L/s at full build of the approximately 489 hectares planned to be developed.

The primary water source for the WTP is currently the Yellowknife River. The raw water system includes intake pipes from the Yellowknife River to Pumphouse No. 2 (PH2), pumping from PH2 to Pumphouse No. 1 (PH1) via a submarine pipeline across Yellowknife Bay, and pumping via booster pumps from PH1 to the WTP. The current raw water pumping capacity at PH2 and PH1 is 214 L/s and 330 L/s respectively. The Submarine Pipeline project recommended raw water pumps sized at 284 L/s at PH2 with an option to install a third pump to increase the raw water pumping capacity to 568 L/s. The WTP currently has three membrane treatment racks designed to produce 231 L/s of treated water with all three racks in service. There is space for a future fourth membrane rack at the WTP and 10 unused membrane module spaces out of the total 110 available spaces in each rack. Adding the fourth membrane rack and using the unused module spaces will increase the treated capacity to 325 L/s with all four racks in service.

The raw water pumping and treatment capacity at the WTP is required to supply the raw water MDD of the entire CoYK distribution system including the Zone 1, Zone 3, Zone 4, and the proposed Zone 7 systems. The 2023 Submarine Pipeline Preliminary Design Report used a 2021 raw water MDD of 146.9 L/s and projected the 20-year (2041) raw water MDD to be 216.5 L/s. AECOM was provided the August 2024 to August 2025 WTP treated water consumption records at the time of this report. The treated MDD from the most recent water consumption records was 141.2 L/s. The 2025 raw MDD was estimated to be 162.4 L/s by adding 15% to the treated water demand to account for the typical backwash and WTP waste volumes observed in previous WTP raw water consumption records.

Table 6-1: Water Treatment Plant Raw Water and Treatment Capacities

	Pumphouse No. 2 Raw Water Pumps Capacity (L/s)	Pumphouse No. 1 Raw Water Booster Pumps Capacity (L/s)	Treatment System (membrane racks) Capacity (L/s)	Current Day (2025) MDD (L/s)	Current Day + Zone 7 Full Build MDD (L/s)
Existing	214	330	231	162.4	300.1
Future	568 ¹	504 ¹	325		

Notes (1) As per 2023 Submarine Pipeline Project PDR raw water pumping upgrades recommendations

Based on the current day (2025) MDD and estimated Zone 7 demands, both the PH2 raw water pumps and treatment system will have to be upgraded prior to full build of Zone 7. The following WTP upgrades phasing is recommended based on the initial WTP raw water and treatment capacity assessment. Note that this does not include any future demands in the remainder of the distribution system.

- ⇒ Upgrade the PH2 raw water pumps to have a firm capacity of 284 L/s as per the 2023 Submarine Project PDR.
- ⇒ When the Zone 7 demand reaches 68 L/s or approximately 213 hectares of commercial development: Install fourth membrane rack and fill remaining 10 membrane module space.

6.2 Water Treatment Plant Storage Capacity

The WTP storage capacity was reviewed to determine the currently available storage and the expected storage available with the addition of Zone 7. The WTP reservoirs currently have a total treated water capacity of 9,000 m³. The available potable water storage at the WTP, both with the current day demands and the addition of PH7, is summarized in Table 6-2 below.

As established in the August 2024 PH4 TM, the reservoirs are required to provide fire storage, operating storage, and emergency storage for the distribution system. The required fire storage is equal to the volume of water used during a 3-hour period at a 265 L/s rate specified for a commercial fire in the Yellowknife Design Standards. This equates to a fire storage requirement of 2,862 m³. In addition, the reservoirs are required to provide operating storage equal to 25% of the MDD and emergency storage equal to 15% of the ADD as per Part 2 of the Alberta Guidelines for Municipal Waterworks (Government of Alberta, 2012).

The WTP supplies potable water to PH3, PH4, and the future PH7, thus the volume of water required to fill the remote reservoirs also should be considered in the WTP storage requirement. The WTP outflow – return consumption records were used to determine the current day operating and emergency storage requirements as the PH3 and PH4 fill volumes are included in the overall WTP demand. For the purposes of the WTP storage assessment, the estimated Zone 7 MDD was added to the WTP ADD while the estimated Zone 7 ADD was added to the to the WTP MDD. The Zone 7 demands were added to be conservative and to be in line with a typical reservoir fill operating philosophies recommended by AECOM.

Table 6-2: City of Yellowknife WTP Reservoir Storage Assessment

Scenario	Fire Storage Requirement (m ³)	Operating Storage Requirement (m ³)	Emergency Storage Requirement (m ³)	Total Storage Requirement (m ³)	Available Storage - Required Storage (m ³)
2025 (Current Day)-Zone 1 plus PH3 and PH4 reservoir fill	2,862	3,050	1,477	7,389	1,611
2025 (Current Day)-Zone 1 plus PH3, PH4, future PH7 reservoir fill	2,862	4,800	3,262	10,924	-1,924 (deficient)

The WTP currently has sufficient storage capacity based on the commercial fire storage requirement and overall demands from the WTP. However, when adding the estimated Zone 7 reservoir fill volume requirements, the WTP does not have sufficient storage capacity. The existing WTP storage is estimated to have sufficient storage capacity for an additional approximately 188 hectares of commercial development within Zone 7 or the Parcel 5 residential development plus 114 hectares of commercial development within Zone 7.

The WTP storage upgrade options and phasing will be developed during the PH7 preliminary design.

6.3 Water Treatment Plant Distribution Pumping Capacity

The WTP distribution pumping currently consists of one jockey pump with a capacity of 40 L/s @ 60.0 m TDH and three distribution pumps with a capacity of 75 L/s @ 60 m TDH. The current firm pumping capacity of the WTP distribution pumps are 190 L/s.

There are also two fire pumps, each with a capacity of 158 L/s @ 80.8 m TDH. The jockey and distribution pumps are required to provide a sufficient flow rate for the Zone 1 water demands as well providing flow for filling the PH3, PH4 and the future PH7 reservoirs. The pumping requirements for the following design scenarios were used to assess the WTP distribution pumping requirement based on typical design requirements used by AECOM for pumping station design:

- ⇒ Zone 1 ADD and fill reservoirs at their respective MDD
- ⇒ Zone 1 MDD and fill reservoirs at their respective ADD
- ⇒ Zone 1 PHD and fill reservoirs at their respective minimum flows indicated in SCADA.

Table 6-3 summarizes the estimated WTP distribution pumping requirements based on the current day (2025) demands and full build of Zone 7.

Table 6-3: City of Yellowknife WTP Distribution Pumping Assessment

Scenario	Year	Current WTP Firm Capacity (L/s)	Required Flow Requirement (L/s)	Firm Capacity-Required Flow (L/s)
Zone 1 ADD, reservoirs MDD	Current Day (2025)	190	160.3	29.7
	Current Day plus Zone 7 full build		298.0	-108.0 (deficient)
Zone 1 MDD, reservoirs ADD	Current Day (2025)		212.3	-22.3 (deficient)
	Current Day plus Zone 7 full build		293.3	-103.3 (deficient)
Zone 1 PHD, reservoirs minimum flow	Current Day (2025)		189.0	1.0
	Current Day plus Zone 7 full build		214.0 ¹	-24 (deficient)

Notes: (1) Assuming a minimum fill rate of 25 L/s to PH7

The existing distribution pumps do not have sufficient capacity to meet the current day Zone 1 MDD plus filling PH3 and PH4 at ADD. With the additional required PH7 fill rate, the distribution pumps do not have sufficient capacity to meet any of the three scenarios. It is recommended that either additional distribution pumps be installed and connected to the WTP distribution header or dedicated pumps and header for the PH7 fill main be installed to provide the required fill flow to PH7. The WTP distribution pumping upgrade layout and design will be determined during preliminary design based on the selected PH7 siting location and fill main alignment.

7. Conclusion and Recommendations

AECOM reviewed four siting location options for Pumphouse No. 7 and eight alignment options for the fill main from the WTP to PH7. The feasibility for each fill main option to supply sufficient flow to PH7 at full build of the fill main was confirmed at a high level using the CoYK Zone 1 water distribution hydraulic model currently being updated as part of the Water Master Plan project. The model also determined preliminary phasing options for the 48th St and 53rd St routes including initially connecting the fill main to the existing system until there is a large enough Zone 7 demand to trigger the construction of the remaining fill main to the WTP.

Based on the PH7 siting and fill main selection criteria described in section 2, including the surface elevation of the PH7 location, total length and cost of the fill main, and phasing options for both the Zone 7 development area and fill main, AECOM recommends that the City of Yellowknife select the Deh Cho Blvd PH7 location and the Tincan Hill / Kam Lake Road fill main route option. These options are recommended for the following reasons:

- ⇒ The Pumphouse location is adjacent to parcel No. 2 and parcel No. 6 which is understood to be included in the first phase of Zone 7 development.
- ⇒ The Deh Cho industrial area can be serviced by this PH7 location as an added benefit.
- ⇒ The Tincan Hill/Kam Lake Road fill main route can be used as an additional PH4 fill main to provide redundancy for the existing PH4 fill main
- ⇒ The fill main route provides opportunity for servicing along Taylor Road in conjunction with the fill main implementation
- ⇒ The fill main route avoids submarine construction within Frame Lake. AECOM does not recommend submarine construction of the fill main due the difficult and cost prohibitive maintenance requirements that are introduced.
- ⇒ The fill main route avoids construction within the downtown area of the City.

A Class 4 (Class D) cost estimate for both the PH7 fill main and PH7 site and building were included in this TM. The PH7 fill main opinion of costs ranged from approximately \$23 million to \$43 million depending on the route option. The PH7 site and building opinion of cost is \$50 million (with a 30% contingency). Deh Cho Blvd and Tin Can Hill/Kam Lake Road PH7 site and fill main route option has an opinion of cost of approximately \$93 million.

AECOM is currently working on the pre-design report in order to service the Pressure Zone 7 development and the full capital cost of development for Pressure Zone 7 (full build out) would need to include a Water Plant Expansion and Raw Water Supply Upgrade (Submarine Pipeline from YK River). These upgrades will be developed and presented in the Pre-Design Report.

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