4015 7 Street SE, Calgary, AB  T2G 2Y9  T: 403.254.0544  F: 403.254.9186

October 2, 2020

Our Reference: 27413

**The City of Cold Lake**
5513 – 48 Avenue
Cold Lake, Alberta
T9M 1A1

Attention: Lisa Nash

Dear Madam:

**Reference: Sanitary Servicing Concept Plan Update**

# 1.0 Introduction

## 1.1 Authorization

ISL Engineering and Land Services Ltd. (ISL) was retained by the City of Cold Lake (City) to undertake revisions to the existing sanitary servicing concept for their newly annexed lands. This study is comprised of a review and update of the originally proposed servicing concept, which was submitted as part of the Inflow-Infiltration Program (I-I Program) developed by ISL in 2018. The I-I Program developed servicing concepts for the following growth horizons:

- Stage 1 – Build-out of Existing System Upgrading Concept (imminent development)
- Stage 2 – Build-out to Current City Boundary Upgrading Concept (short to medium-term development)
- Stage 3 – Build-out of Annexation Areas Upgrading Concept (long-term development)
- Stage 3+ – Build-out of Annexation Areas plus Additional Three Quarter Sections in the North Upgrading Concept (long-term development)

As the City has recently annexed the lands that were considered as part of Stage 3 in the I-I Program, these quarter sections are no longer necessarily intended for solely long-term development. Timing of these areas will be dependent on the growth direction of the City, based on when developments are expected to come online. The intent of this document is to avoid limiting growth in a specific direction, and rather provide a sanitary servicing planning concept holistically for the entire annexed area, while providing a rough framework for interim connection scenarios (as and when required by development). For this reason, this memorandum does not refer to different stages of growth (as outlined in the previous master plan). The ultimate build-out horizon is evaluated only. All undeveloped parcels of land, which consists of those undeveloped as part of the pre- and post-annexation boundaries, are included in the ultimate build-out concept.

Additionally, Appendix A provides a discussion of the potential short-term development connection that could be made by the City to facilitate development in the short term, specifically near the Tri-City area, and utilization of the remaining capacity of existing sanitary infrastructure.

Updates to the original servicing concept were triggered based on the change in areas annexed, which was reduced from approximately twenty quarter sections to eleven quarter sections. The impact of the proposed developable areas to the existing system was assessed utilizing a robust hydraulic/hydrologic model, which was constructed using the state-of-the-art hydrodynamic MIKE URBAN software developed by DHI as part of the I-I Program. The intent of this memo is to be used in conjunction with the 2018 I-I Program to provide a comprehensive roadmap to Council to assess the infrastructure needs to accommodate future development in the short-term and long-term.

## 1.2 Background

The City of Cold Lake is situated on the eastern edge of central Alberta, adjacent to the Saskatchewan – Alberta provincial border. In 1996, the communities of the Town of Cold Lake, the Town of Grand Centre, and Medley (Canadian Forces Base (CFB)) were amalgamated to form what is currently known as the City of Cold Lake. Today, Cold Lake South represents what was previously known as the Town of Grand Centre, while Cold Lake North is the former Town of Cold Lake. The northern portion of the City sits on the southwestern shoreline of Cold Lake, with Cold Lake South situated east of the CFB.

The City of Cold Lake began the process to annex lands from the Municipal District of Bonnyville (the M.D.) in 2014 in order to extend their City boundary. In 2017, an agreement was reached between the City and the M.D. regarding the annexation of approximately twenty quarter sections of land, followed by an application submitted to the Municipal Government Board. Many of the lands originally considered for annexation were ultimately not annexed by the City, reducing the area added to the City to eleven quarter sections.

## 1.3 Purpose of Study

The purpose of developing a sanitary servicing plan is to examine the upgrades required to allow future growth to occur, including associated costs. Specific to this assignment, the Sanitary Servicing Concept Plan Update Study includes:

- Revision of the Previous Build-Out Concept
  - Developing a single cohesive servicing concept for the ultimate build-out horizon only, with the intent that growth is not limited in a single direction
  - Highlighting any additional infrastructure requirements needed prior to the ultimate build-out stage
  - Developing revised alignments and profiles
  - Highlighting any additional constructability risks
  - Commenting on inter-municipal overlap elements
- Confirmatory Hydraulic Modelling
  - Revising conveyance pipe diameters to account for revised contributing areas
  - Revising model boundary conditions
  - Simulating and assessing the revised model to ensure there is sufficient capacity to accommodate the new developments
- Updated Cost Estimates
  - Providing a detailed breakdown of required infrastructure to support the City's offsite levies
  - Providing a breakdown of elements which overlap with the M.D.
  - Highlighting inter-municipal cost elements

# 2.0 Study Area

## 2.1 Location

The City of Cold Lake is situated on the eastern edge of central Alberta, adjacent to the Saskatchewan – Alberta provincial border. The City is divided into three areas, including Cold Lake North, Cold Lake South, and the CFB. The City is bounded by Beaver River in the south and Cold Lake in the north. Cold Lake North and Cold Lake South are largely connected by 51st Street, which is known as the Northern Woods and Water Route south of the City and roughly continues north as 28th Street. An overall examination of the City's entire sanitary system has been taken to assess connections between the existing and proposed infrastructure. This includes the eleven quarter sections of land recently annexed by the City which are comprised of the following:

- NE 15-63-2-4
- SE 15-63-2-4
- NE 10-63-2-4
- SE 10-63-2-4
- NE 3-63-2-4
- NE 2-63-2-4
- SE 11-63-2-4
- NE 11-63-2-4
- SE 14-63-2-4
- SW 13-63-2-4
- Portions of SW 1-63-2-4
- Portions of SW 12-63-2-4
- Portions of NW 12-63-2-4

The City's pre-annexation and post-annexation boundaries are demonstrated in Figure 2.1. This figure also illustrates the eleven quarter sections that were recently annexed by the City. Topography within the pre-annexation boundary and post-annexation boundary generally falls from northeast to southwest, with the highest points within the City located along the existing north and east City boundaries and the lowest points located in proximity to Beaver River, directly south of the City. The City's topography is highlighted in Figure 2.2.

It should be noted that the study has not taken into account the Canadian Forces Base, as the base is considered its own entity in this respect, with a sanitary system separate from the City's network.

## 2.2 Land Use of Recently Annexed Areas

Proposed land uses of annexed areas were estimated using a combination of the available area structure plans, the Municipal Development Plan, the Intermunicipal Development Plan (IMDP), as well as input and feedback provided by the City. As a result, the future development areas were divided into the following land use categories with associated approximate areas:

Table 2.1: Future Land Use

| Land Use | Area | Population |
|---|---|---|
| | ha | Persons |
| **Residential** | | |
| Low Density Residential | 380 | 20,894 |
| **Non-Residential** | | |
| Commercial | 142 | - |
| Industrial | 51 | - |
| Public Services | 68 | - |
| **Total** | **641** | **20,894** |

The land uses described above are in line with those described in the I-I Program, with areas scaled back to account for the reduced annexation area. Land uses for the adjusted annexed catchments are demonstrated in Figure 2.3. Land uses for the remaining undeveloped lands not among those that were annexed are consistent with those described in the I-I Program.

The old lagoon area, near Fisher Pond, is shown as being developable in this study. As it was the City's previous lagoon, it would likely require a fair amount of remediation in order for development to proceed on the site. To adhere to the notion of allowing development to occur city-wide and to be conservative at this level of planning, sizing of infrastructure under the ultimate build-out horizon is based on the inclusion of this area. If it is ultimately deemed that this area is completely undevelopable, additional analysis may be needed to determine if a reduction in pipe sizes downstream of this location is possible.

## 2.3 Population Statistics

Population statistics were adjusted from those originally developed for the 2018 I-I Program, to reflect the revised annexation areas under ultimate build-out. A density of 37 persons per gross residential hectare value was applied. Utilizing this fixed ratio is consistent with other planning documents within the City, including the MDP and I-I Program. Population statistics for the existing and ultimate build-out scenarios which were utilized in the sanitary system analysis are thus summarized in Table 2.2.

Table 2.2: Summary of Population Horizons

| Scenario | Horizon | Total Scenario Population | Total Scenario Area (ha) |
|---|---|---|---|
| Existing[1] | 2016 | 16,725 | 507 |
| Ultimate Build-out | Long-Term | 74,075 | 2,247 |

[1] *The existing scenario was defined as per the 2018 Inflow-Infiltration Program analysis.*

## 2.4 Existing Sanitary System Overview

The City of Cold Lake's sanitary system is composed of a number of manholes, sewers, lift stations, and forcemains that convey sewage to the City's sanitary lagoon located south of the City. Sewers range in diameter from 200 mm to 900 mm, with the majority of the sewers being 200 mm. In all, there is a total of 113 km of sanitary sewers in the City, consisting of both gravity sewers and forcemains. From the sewer material data that is available for the sanitary sewers in Cold Lake, polyvinyl chloride (PVC) appears to be the most predominant. In addition to PVC, there are also concrete and asbestos cement sewers evident throughout the City. Forcemains range from 50 mm to 900 mm and have been constructed using either polyvinyl chloride or polyethylene. There are a total of five major lift stations housing thirteen pumps. The five major lift stations include Building 1, Building 3, Building 4, Building 8, and Building 9. In addition to these lift stations, there are four minor lift stations including Building 049, Building 413, Building 414, and a small lift station in Horseshoe Bay Estates.

Sanitary sewage flows within the City's sewershed generally flow from the north/south inwards in the north area of Cold Lake, after which they are conveyed west, then south towards the south area of the City. In the south portion of the City, sewage generally flows from the north/south/east/west inwards towards Building 9 Lift Station. Flows from Building 9 Lift Station are then discharged through a forcemain to the City's lagoon. There is a second forcemain to the City's lagoon, which remains in place for redundancy in the event of a failure in the main line. Proposed upgrades will follow these same general trends, also ultimately discharging to the City's lagoon by way of a proposed forcemain following a similar alignment as the existing forcemain.

The existing sanitary system performs adequately under existing conditions, noting that upgrades to the Building 3 Lift Station are possible pending further investigation of the current pumping capacity at the lift station. The total capacity required at this lift station is 86 L/s, considering ultimate build-out. In terms of inflow and infiltration (I-I), the City's system is perceived to be quite resilient. I-I can be reduced further by implementing an I-I Reduction Program; recommendations for the potential reduction measures are described in the I-I Program (ISL, 2018).

# 3.0 Hydraulic Model Update

The model that was originally developed as part of the I-I Program was utilized for this study, with adjustments provided as necessary. The primary adjustment involved incorporating the newly proposed servicing concept for the annexed lands, alignments of which were generated based on the overall topography, existing infrastructure in the study area, and the servicing concept that was originally proposed. Sewer sizes were calculated by assigning the undeveloped catchments and approximate flows generated by these catchments to their corresponding sewers. Grades were assigned to the sewers based on the corresponding recommended minimum sewer slope. Table 3.1 outlines the minimum slopes associated with each sewer size. It should be noted that forcemains were only sized utilizing an excel spreadsheet and were not incorporated into the updated hydraulic/hydrologic model. Design parameters of the proposed lift stations such as wet well sizing, start and stop elevations, and pump configurations were excluded from the scope of this study. Thus, integration into the model would require a number of assumptions, which was deemed as not feasible.

Table 3.1: Minimum Required Sewer Slopes

| Sewer Size (mm) | Slope (%) | Slope (m/m) |
|---|---|---|
| **200** | 0.40 | 0.004 |
| **250** | 0.28 | 0.0028 |
| **300** | 0.22 | 0.0022 |
| **375** | 0.15 | 0.0015 |
| **450** | 0.12 | 0.0012 |
| **525** | 0.10 | 0.001 |
| **600** | 0.08 | 0.0008 |
| **675** | 0.08 | 0.0008 |
| **750** | 0.08 | 0.0008 |

Additional calibration was not included for the updated model as existing infrastructure in the model was calibrated in 2018, with results being consistent with those in the I-I Program.

# 4.0 Design Criteria

For the purpose of this study, analysis focused on the proposed future servicing concept for the ultimate build-out concept, with a brief examination of the impact of the development of these lands on the existing sanitary system due to minimal interconnections. The design parameters applied for the future development are described below.

## 4.1 Dry Weather Flow (DWF) Generation Rates

The DWF generation rates were employed from the City of Cold Lake's Municipal Engineering Servicing Standards and Standard Construction Specifications document dated January, 2008. The following rates were therefore applied:

- Residential Areas (Population Generated) – 350 L/p/d
- Non-Residential Areas (Area Generated) – 18.0 $m^3$/ha/d

## 4.2 Peaking Factors

### Servicing Network Design (Excel Spreadsheet)

Peaking factors for the future sanitary system were calculated in accordance with the City's Municipal Standards mentioned above, and generally align with the Alberta Environment and Park's (AEP) guidelines. These include:

- Peaking factor derived based on Harmon's formula for residential areas:

$$PF = 1 + \frac{14}{4 + P^{\frac{1}{2}}}$$

  - Where, P is the design contributing population in thousands.
  - It is noted that PF must be at least 3.
- Peaking factor for non-residential areas:

$$PF = 10(Q_{Ave}^{-0.45})$$

  - Where, $Q_{Ave}$ is 0.20 L/s/ha.
  - It is noted that PF must be at least 2.5.

Consequently, the residential peaking factors ranged from 3.00 to 4.5, with an average value of 3.68. The non-residential factors ranged from 2.50 to 13.82, with an average value of 3.45.

### Assessment of the Impact on the Existing System (MIKE URBAN Model)

Peaking factors derived during the DWF calibration process, based on the observed flow monitoring data, were applied to the future growth scenario catchments for both the residential and non-residential land uses. As expected, the observed modelled peaking factors tend to be lower than those stipulated by the AEP's guidelines. The peaking factors fluctuate between 1.65 and 1.98 for residential areas, and 1.34 and 1.54 for non-residential areas.

## 4.3 Wet Weather Flow (WWF) Component

### Servicing Network Design (Excel Spreadsheet)

A constant inflow-infiltration allowance of 0.29 L/s/ha as per the City's Municipal Engineering Servicing Standards and Standard Construction Specifications document was applied to each growth catchment to simulate wet weather response.

### Assessment of the Impact on the Existing System (MIKE URBAN Model)

The wet weather flow response for all future catchments were produced based on the 50 year 24 hour Q3 Huff Storm. Catchments were assigned calibrated hydrological properties reflective of a similar hydrologic characteristics as development areas within the existing City's boundary that produced relatively conservative I-I rates. Consequently, the percent impervious area and percent area contributing to RDII of 0.40% and 15.00%, respectively, were applied. A groundwater infiltration (DWF baseflow) rate of 0.033 L/s/ha for greenfield developments was also incorporated in the model as per typical modelling guidelines.

# 5.0 Updated Ultimate Build-out Sanitary Servicing Concept

## 5.1 Servicing Concept Update

The proposed updated sanitary servicing concept for ultimate build-out horizon largely reflects the concept proposed in the I-I Program and is demonstrated in Figure 5.1 and Figure 5.2 for Cold Lake North and Cold Lake South, respectively. As per the I-I Program, it was assumed that none of the recently annexed quarter section catchments would be able to tie into the existing system (with the exception of Phase 1 of the Forest Heights Trunk) due to the longer distances to potential tie-in locations and significant topographical differences, which would result in inverts being too low to match existing elevations. Additionally, there would be sewers throughout the existing system that would lack the additional spare capacity to accommodate growth from the undeveloped areas, thus substantial upgrades would be needed. Given this, the updated servicing concept, proposing new infrastructure, was required to cover all of the annexation areas. That said, as discussed above, Appendix A provides discussion on the limited potential tie-in locations for shorter-term developments within close proximity to developed lands, such as the Tri-City area.

Infrastructure servicing of the developments on the east side of Cold Lake North are conveyed southbound by gravity sewers. These gravity sewers ultimately tie-in to a manhole along Phase 2 of the Forest Heights Trunk (shown as FUT_FHT), ultimately discharging to the BLDG 9 Lift Station. On the west side of Cold Lake North, a network of gravity sewers run along the east side of Palm Creek, generally following the alignment of the creek to convey flows to the south. One development area is located to the west of Palm Creek, which will be required to tie into infrastructure to the east of the Creek, as discussed below.

As previously noted, in Cold Lake South, flows generated from annexed areas in the northeast are conveyed via a network of gravity sewers to Phase 2 of the Forest Heights Trunk. The remainder of the annexed areas on the east side, comprised of the quarter section north of 50 Avenue, are conveyed by gravity to a proposed lift station, which pumps sewage through a twinned forcemain that discharges to another gravity sewer conveying flows south ultimately to the future lagoon lift station. In the west, flows from the annexed areas continue from Cold Lake North towards the south. At the south end of the annexed areas, the gravity sewer turns east and ties into a proposed lift station and twinned forcemain. This lift station and twinned forcemain convey sewage south through the City, to a gravity system that ties to the future lagoon lift station. All flows ultimately discharge to the sewage lagoon located south of the City by way of a twinned forcemain.

To summarize, major adjustments include removal of sewers which were servicing lands ultimately not annexed. They also involved relocating proposed northwest sewers from the west to the east of Palm Creek, which also results in a reduced number of siphons required to service the future developments. The northwest sewers generally follow the alignment of Palm Creek. This provides favourable topography and avoids the significant high point along Millenium Trail, which would result in very deep sewer installation. Based on the current grading, no siphons are needed, thus a gravity sewer is proposed for the creek crossing. However, should the grading change with development, a 150 mm siphon has been sized to service areas west of the creek, and details on this have been included in Appendix B. Additionally, reductions to sewer sizes were made to account for the smaller overall contributing area. A detailed breakdown of sanitary sewage flows, and sewer size determination for the ultimate build-out horizon is provided in Appendix C.

In all, this growth scenario consists of:

- Seven lift stations
- Seven twinned forcemains varying from 100 mm to 450 mm in size
- Gravity sewers varying from 200 mm to 900 mm in size
- An optional twinned siphon of 150 mm diameter (alternatively proposed as a 300 mm gravity sewer based on the existing grades)

The City may choose to take a staged approach, upsizing the sewers as lands are developed, or invest in the final infrastructure initially. This decision will depend on the timing of future growth. If it is anticipated that development within an area will occur in a relatively short timeline, upfront oversizing may be the most cost-effective investment.

Though if development is not anticipated for 50 to 100 years, upsizing the sewers when required would be wise due to the age of the infrastructure, which would likely need replacing or rehabilitation at that time regardless.
It is worth noting that for the purposes of laying out the conceptual network of the future sanitary system, a general grid was assumed to illustrate the intent of the servicing scheme. As a result, the proposed trunk routing may not necessarily follow within the road's right-of-way. Ultimately, it will be up to the developer to fulfill the intent of the servicing concept presented herein. Therefore, a developer may choose to adjust the alignment of the specified trunks as needed, to accommodate the sanitary system within future developments.

## 5.2 Cost Estimates For Servicing Concept

The summary of Class D cost estimates for the updated servicing option is summarized in Table 5.1. A detailed breakdown of the cost estimate is included in Appendix D.

Table 5.1: Summary of Future Sanitary Concept Cost Estimate

| Item | Quantity | Units | Cost | Total Cost |
|---|---|---|---|---|
| 200mm Gravity Sewer | 3,091 | Metres | $1,748,000 | $61,938,000 |
| 250mm Gravity Sewer | 674 | Metres | $391,000 | |
| 300mm Gravity Sewer | 845 | Metres | $551,000 | |
| 375mm Gravity Sewer | 4,197 | Metres | $3,043,000 | |
| 450mm Gravity Sewer | 2,880 | Metres | $2,506,000 | |
| 525mm Gravity Sewer | 659 | Metres | $660,000 | |
| 600mm Gravity Sewer | 2,448 | Metres | $2,804,000 | |
| 675mm Gravity Sewer | 709 | Metres | $951,000 | |
| 750mm Gravity Sewer | 2,216 | Metres | $3,294,000 | |
| 900mm Gravity Sewer | 2,974 | Metres | $5,261,000 | |
| 100mm Forcemain | 1,419 | Metres | $772,000 | |
| 200mm Forcemain | 3,770 | Metres | $2,733,000 | |
| 375mm Forcemain | 5,336 | Metres | $5,609,000 | |
| 450mm Forcemain | 4,403 | Metres | $5,427,000 | |
| FUT LS_1 (300 L/s) | 1 | Items | $6,344,000 | |
| FUT LS_2 (73 L/s) | 1 | Items | $2,175,000 | |
| FUT LS_3 (86 L/s) | 1 | Items | $2,465,000 | |
| FUT LS_4 (17 L/s) | 1 | Items | $493,000 | |
| FUT LS_5 (55 L/s) | 1 | Items | $1,595,000 | |
| FUT LS_6 (215 L/s) | 1 | Items | $5,264,000 | |
| FUT LS_Lagoon (422 L/s) | 1 | Items | $7,852,000 | |

The above costs do not include considerations for a siphon – the need for which may be triggered by regrading of the annexed area. Should a siphon be required, the associated cost would be approximately $170,000 (including materials and construction costs).

# 6.0 Assessment of Future System Upgrades

## 6.1 Future System Upgrades

Results from the impacts of the proposed updated servicing concept on existing infrastructure are illustrated in Figures 6.1 through 6.4. The results from the spreadsheet calculations and MIKE URBAN model suggest that the proposed servicing concept is sufficient to accommodate flows from future developments, though some upgrades to existing infrastructure are required.

Given the increase in wastewater flows, a lack of capacity has been noted in Building 9 Lift Station due to the additional developable areas coming online and tying into the Forest Heights Trunk. It is thus proposed that the capacity of Building 9 Lift Station be upgraded by an additional 880 L/s to 1,180 L/s. It is noted that this lift station's maximum existing pumping capacity of 300 L/s only accounts for two of the three operational pumps. This is due to the fact that only two pumps were running at a single time during the drawdown tests, as there was a threat that there would be too much pressure build up on the forcemain. With all three pumps turned on the pumping capacity will be greater, thus fewer upgrades will be required and some cost savings will be realized. This should only be considered if the additional pressure on the forcemain is no longer an issue. The City should consider the lift station having a firm capacity set to the target future peak wet weather flow. This means that the lift station should be able to pump the design flow with the largest pump being out of service.

As discussed in the I-I Program, the City could consider implementing offline storage at the Building 9 Lift Station in lieu of any pump upgrades. This would require acceptance of creating what is effectively a sewage lagoon at the location, which would sterilize land to up to a 300 m setback and need to be located a similar distance from any existing occupied building. This option was determined as not ideal, considering the elevated cost and sterilization footprint associated with the infrastructure.

Several sewer sections have been flagged as a potential risk due to surcharging conditions in the existing infrastructure as well. These were shown in red in Figures 6.1 and 6.2 or as lacking capacity (negative spare capacity) in Figures 6.3 and 6.4. Surcharging in these sewers is relatively minimal, with the maximum HGLs remaining at least 2.5 m below the surface in most cases. One sewer in Cold Lake North was noted to experience surcharging above 2.5 m below the surface, though not significantly enough to warrant upgrading. For this reason, no upgrades are recommended to existing pipe infrastructure at this time. However, these sections should be monitored by the City and the proper courses of action should be followed if any issues arise.

Directly upstream of the Building 9 Lift Station, some surcharging is noted in the 600 mm sewer situated north of 54$^{th}$ Avenue, which ultimately ties to the intersection of 54$^{th}$ Avenue and 54$^{th}$ Street. The HGL of this sewer is well below surface (~4-5 m) and in a currently undeveloped area, thus presents minimal risk to the system. That said, if this area is ultimately developed and roadworks are being completed along the alignment of this 600 mm sewer, the City could consider upsizing the sewer to mitigate the surcharging. This would require upsizing to 675 mm from 54$^{th}$ Street to 49$^{th}$ Street and to a 750 mm sewer from 49$^{th}$ Street to the lift station access road. The existing 750 mm sewer tying into the Building 9 Lift Station would require upsizing to a 1050 mm sewer. These upgrades assume sewer slopes remain consistent with existing conditions.

Other upgrades proposed in the I-I Program not discussed above remain valid. The intent of this document is to highlight changes to the I-I Program based on the revised annexation lands and amalgamating all future servicing into a single growth horizon. That said, the following upgrades noted in the I-I Program should be considered, in addition to the upgrades to the Building 9 Lift Station noted above:

- Upgrade the capacity of the Building 3 Lift Station to 86 L/s
- *It is noted that the second set of drawdown testing completed in 2018 indicated a capacity of 112.23 L/s assuming both pumps on. This is 50.97 L/s greater than the capacity determined from the 2016 drawdown testing. An additional round of drawdown testing and a review of the flow meter data could be undertaken to verify the capacity at this lift station. Essentially, if the capacity is currently greater than 86 L/s, upgrades to this lift station are not required.*
- Upgrade the capacity of the Building 4 Lift Station to 382 L/s
- Divert flows from 22nd Street to 23rd Street; noting that this interconnection has been constructed since the I-I Program with the exception of the diversion plug
- Reconnect the Building 3 Forcemain directly to the Building 4 Lift Station
- Complete Phase 2 of the Forest Heights Trunk
- Upsize a section of pipe along 47th Street and 50th Avenue to 300 mm (from 200 mm)

These upgrades are shown on Figures 6.5 and 6.6.

## 6.2 Cost Estimates for System Upgrades

Cost estimates for the upgrades to the sanitary system triggered by the development of the ultimate build-out horizon, as indicated in the I-I Program, are summarized in Table 6.1.

Table 6.1: Ultimate Build-out Servicing Concept – Overall System Cost Estimate

| Upgrade | Item | Quantity | Units | Cost | Total Cost |
|---|---|---|---|---|---|
| BLDG 3 Lift Station Upgrade – 86 L/s (Additional 25 L/s based on 2016 drawdown testing) | Capacity | 1 | Items | $363,000 | **$27,364,000** |
| BLDG 4 Lift Station Upgrade – 382 L/s from 282 L/s (Additional 100 L/s) | Capacity | 1 | Items | $1,450,000 | |
| Diversion of flows from 22nd Street to 23rd Street | 200 mm Gravity Sewer | Constructed since I-I Program | | | |
| | Plug | 1 | Items | $1,000 | |
| Reconnection of the Building 3 Forcemain directly to the Building 4 Lift Station | 300 mm Forcemain | 285 | Metres | $661,000 | |
| | 400 mm Gravity Sewer | 921 | Metres | $1,961,000 | |
| | 450 mm Gravity Sewer | 367 | Metres | $818,000 | |
| | Bypass Pumping during Extension of 300 mm Forcemain | 3 | Days | $13,000 | |
| Completion of the Forest Heights Phase 2 900 mm to 1050 mm Trunk | 900 mm Gravity Sewer | Preliminary Cost Estimate Obtained from the Forest Heights Sanitary Sewer Trunk Preliminary Design Report | | $8,336,000 | |
| | 1050 mm Gravity Sewer | | | | |
| BLDG 9 Lift Station Upgrade - 1,180 L/s from 300 L/s (Additional 880 L/s) | Capacity | 1 | Items | $12,833,000 | |
| Upsize section of pipe from 200 mm to 300 mm | 300 mm Gravity Sewer | 466 | Metres | $928,000 | |

## 6.3 Phasing of Upgrades

To provide the City input into their capital planning, the population at which each of the upgrades would be triggered has been identified. The population thresholds stipulated represent the total number of people upstream of each of these upgrades that can be serviced before the upgrades are needed. The phasing was done this way since not all upgrades are affected by all developments. For example, a sewer at the upstream end of Cold Lake South will not be impacted by increasing the population in Cold Lake North. The phasing of each upgrade will be very much dependent on which direction the City decides to grow.

To derive the populations, a residential DWF generation rate of 350 L/p/d, a population density of 37 persons per gross residential hectare, and a peaking factor of 3 was assumed. Inflow and infiltration, in the order of 0.29 L/s/ha, was also factored into the population derivations. These calculations assume an entirely residential land base, meaning that these thresholds do not account for any institutional, commercial, or industrial (ICI) developments. Thus, any capacity that ends up going to an ICI land use should be deducted from the stipulated population thresholds. At this stage the timing of the implementation of residential versus ICI parcels is unknown, therefore this estimate is only meant to provide an overall idea of when upgrades are anticipated. Detailed capacity checks should be undertaken prior to any new developments coming online to confirm the available capacity.

Population thresholds for each upgrade are provided below in Table 6.2.

Table 6.2: Upgrade Population Triggers

| Upgrade | Population Trigger | Notes |
|---|---|---|
| BLDG 3 Lift Station Upgrade – 86 L/s (Additional 25 L/s based on 2016 drawdown testing) | Immediate | Capacity constraints noted under existing conditions, in the order of 15 L/s. An additional 10 L/s is needed by ultimate build-out, so it is recommended that a single upgrade of 25 L/s is completed to meet existing condition requirements.<br><br>Note that these upgrades are based on a current capacity of 61.26 L/s based on the 2016 drawdown testing as it is more conservative. Due to the discrepancies between this capacity and the capacity determined in 2018, the current capacity is potentially 51 L/s greater (112.23 L/s). Additional drawdown testing coupled with a review of the flow metering data can verify the capacity at this lift station. If the current capacity is greater than 86 L/s, upgrades are not required. |
| BLDG 4 Lift Station Upgrade – 382 L/s from 282 L/s (Additional 100 L/s) | Additional Population of 7,300 | The existing peak inflow to this lift station under the 50 year 24 hour Q3 Huff Storm is 146 L/s. Thus, a spare capacity of 136 L/s is available at the lift station. This translates to an additional population of 7,300 being acceptable upstream of this lift station before upgrading is needed. |
| Diversion of flows from 22nd Street to 23rd Street | Immediate | The majority of this diversion has been completed, and currently only requires a plug. As a local improvement it is suggested that the City completes this when possible to close off this upgrade. |
| Reconnection of the Building 3 Forcemain directly to the Building 4 Lift Station | Immediate | There are numerous sewers downstream of the current Building 3 Forcemain that are lacking capacity under the existing 50 year 24 hour Q3 Huff Storm scenario. Completing these upgrades whenever feasible for the City would improve these conditions. That said, further development upstream of this lift station should be deferred until these upgrades are in place to avoid further surcharging. |
| Completion of the Forest Heights Phase 2 900 mm to 1050 mm Trunk | Additional Population of 550 | There is a limiting spare capacity of 11 L/s in the existing sewer (50 year 24 hour Q3 Huff Storm scenario) heading east on 75th Avenue from where the future flow split location with Phase 2 of the Forest Heights Trunk would commence. Thus, an additional population of 550 is possible upstream of the Forest Heights Trunk before upgrading is needed. |
| BLDG 9 Lift Station Upgrade – 1,180 L/s from 300 L/s (Additional 880 L/s) | Additional Population of 6,400 | Under existing conditions and applying the 50 year 24 hour Q3 Huff Storm, inflows to the lift station (316 L/s) already exceed the stipulated maximum capacity of 300 L/s. That said, the current available storage at the lift station attenuates the flows sufficiently to avoid upstream capacity constraints under existing conditions and also under the original Stage 1 conditions as stipulated in the I-I Program.<br><br>Thus, upgrades are recommended beyond the Stage 1 flows, so anything beyond 444 L/s. This provides an additional capacity of 128 L/s, for an additional population of 6,400 possible upstream of the lift station. |
| Upsize section of pipe from 200 mm to 300 mm | Additional Population of 850 | The existing spare capacity for the 50 year 24 hour Q3 Huff Storm in these sewers ranges from 17 L/s to 32 L/s. At the limiting 17 L/s, an additional population of 850 is acceptable upstream of this sewer section before upgrading is needed. |

# 7.0 Intermunicipal Development

The proposed servicing concept provides the City with the freedom to partner with the M.D. by providing a sanitary servicing opportunity for lands within close proximity to the City. The intent would be to provide areas within the M.D. the potential to connect to the City's sanitary sewer system, in turn promoting cost sharing and partnership between the City and the M.D. It is noted that, historically, the M.D. has generally not provided servicing, placing the responsibility on the developers to implement servicing systems. Developers in the M.D. may wish to proceed as such, though, allowing for the possibility of this joint servicing initiative was a consideration when developing the proposed sanitary servicing concept for full build-out of the City to allow for flexibility in future servicing options.

It is currently unknown whether any of the developers or future developers in the lands adjacent to the City's boundary would consider servicing their lands through the City's infrastructure. To suit this, the following discussion was written with the intent to provide areas within the M.D. the option of connecting to the City's sanitary system, but not as a requirement. It is noted that developers considering tying into the sanitary system would be responsible for conveying sewage to a connection point along proposed concept. In order to move forward with a joint initiative, buy-in from all parties involved would be necessary.

Additional M.D. lands would be required to connect to the new conveyance system being proposed for the ultimate build-out horizon that discharges to the future south lift station (FUT LS_Lagoon) and is pumped to the City's lagoons. This stipulation is to ensure that the integrity of the existing system is not jeopardized through the addition of flows. The assumption here is that the City's ultimate build-out infrastructure has not been constructed at the time these connections are being contemplated, thus may be upsized as needed. If M.D. ties are proposed following the implementation of the ultimate build-out infrastructure, additional analyses would be needed at that stage to determine specific changes to downstream infrastructure.

Infrastructure downstream of the connection point would potentially require upsizing to ensure sufficient capacity to accommodate the M.D. areas. Infrastructure upsizing could include increasing the pipe diameter of gravity sewers and forcemains. It is noted that forcemains would be required to maintain a velocity between 1.1 m/s and 2.0 m/s, with a preferred velocity of 1.5 m/s. The pumping capacities at the proposed lift stations must also be sufficient for the added peak flows. To ensure sufficient pumping capacity, lift stations can be designed such that there is additional space in the wet well to install pumps in the future. This would allow for a degree of phasing to ensure the lift stations are operating efficiently.

Based on a high-level plan of the M.D. areas, the following land uses in Table 7.1 have been proposed. Total flows for these land use types are provided on a per hectare basis, based on the City's DWF generation rates and an applied WWF of 0.29 L/s/ha. It is noted that this is meant to provide a generalized estimate of potential flows per developable hectare. Exact flows should be calculated on a development specific basis when joint initiatives are identified to ensure accurate flows are represented.

Table 7.1: Per Hectare Flow Estimates per Land Use Type

| Land Use | DWF Generation Rate | | Peaked DWF[1] (per Hectare) | WWF (per Hectare) | Total Flow (per Hectare) |
|---|---|---|---|---|---|
| | Value | Unit | L/s | | |
| Country Residential[2] | 350 | L/p/d | 0.14 | 0.29 | 0.40 |
| Rural Industrial | 18 | $m^3$/ha/d | 0.55 | 0.29 | 0.81 |
| Agriculture | 18 | $m^3$/ha/d | 0.55 | 0.29 | 0.81 |
| Recreation | 18 | $m^3$/ha/d | 0.55 | 0.29 | 0.81 |

[1] Peaked residential factor equivalent to the minimum value of 3, while the peaked non-residential factor equivalent to the minimum value of 2.5, as stipulated in Section 4.0.
[2] Country residential assumes one lot per acre, and a density of 3.5 persons per lot per the City's guidelines.

The following table, Table 7.2, summarizes each proposed section of trunk sewer that is independent of the existing sanitary system and the available spare capacities. This provides an indication of the amount of additional area that can be connected to the system before pipe upsizing is required. Also in the table is the additional capacity gained from upsizing to the next nominal pipe diameter. The peak flows utilized to deduce spare capacities are based on those calculated during the spreadsheet analysis. Table 7.1 in conjunction with Table 7.2 provides an estimate of the amount of area within the M.D. that can be serviced and approximately when pipe upsizing is needed.

| Pipe Section | Current Proposed Pipe | | | | Upsized Proposed Pipe | | | |
|---|---|---|---|---|---|---|---|---|
| | Pipe Diameter | Pipe Capacity[1] | Ultimate Build-out Design Flow | Spare Capacity | Pipe Increase | Pipe Capacity[1] | Increase in Capacity | Total Spare Capacity |
| | mm | L/s | | | mm | L/s | | |
| FUT NW_1 | 200 | 20.74 | 8.98 | 11.77 | 250 | 31.47 | 10.72 | 22.49 |
| FUT NW_2 | 375 | 67.91 | 58.16 | 9.74 | 450 | 98.76 | 30.86 | 40.60 |
| FUT NW_4 | 375 | 67.91 | 63.14 | 4.77 | 450 | 98.76 | 30.86 | 35.63 |
| FUT NW_6 | 525 | 136.00 | 125.98 | 10.02 | 600 | 173.67 | 37.67 | 47.69 |
| FUT NW_9 | 600 | 173.67 | 158.16 | 15.51 | 675 | 237.75 | 64.09 | 79.59 |
| FUT NW_11 | 675 | 237.75 | 207.36 | 30.39 | 750 | 314.88 | 77.13 | 107.52 |
| FUT NW_13 | 750 | 314.88 | 249.91 | 64.97 | 900 | 512.03 | 197.15 | 262.13 |
| FUT SW_1 | 750 | 314.88 | 255.31 | 59.57 | 900 | 512.03 | 197.15 | 256.73 |
| FUT SW_2 | 750 | 314.88 | 260.91 | 53.97 | 900 | 512.03 | 197.15 | 251.12 |
| FUT SW_3 | 750 | 314.88 | 267.91 | 46.97 | 900 | 512.03 | 197.15 | 244.12 |
| FUT SW_4 | 750 | 314.88 | 277.55 | 37.33 | 900 | 512.03 | 197.15 | 234.48 |
| FUT SW_6 | 750 | 314.88 | 287.01 | 27.87 | 900 | 512.03 | 197.15 | 225.02 |
| FUT SW_8 | 750 | 314.88 | 298.06 | 16.82 | 900 | 512.03 | 197.15 | 213.97 |
| FUT SW_9 | 750 | 314.88 | 304.63 | 10.25 | 900 | 512.03 | 197.15 | 207.40 |
| FUT SE_13 | 450 | 98.76 | 63.28 | 35.49 | 525 | 136.00 | 37.23 | 72.72 |
| FUT SE_1 | 450 | 98.76 | 71.32 | 27.45 | 525 | 136.00 | 37.23 | 64.68 |
| FUT SE_5 | 450 | 98.76 | 84.20 | 14.56 | 525 | 136.00 | 37.23 | 51.79 |
| FUT SE_7 | 525 | 136.00 | 101.31 | 34.68 | 600 | 173.67 | 37.67 | 72.36 |
| FUT SE_11 | 600 | 173.67 | 122.53 | 51.14 | 675 | 237.75 | 64.09 | 115.23 |
| FUT SE_12 | 600 | 173.67 | 148.66 | 25.01 | 675 | 237.75 | 64.09 | 89.09 |

[1] Pipe capacity calculated using a Manning's 'n' of 0.013, and minimum design slopes as stipulated in Table 3.1

## 8.0 Conclusions

The purpose of the Sanitary Servicing Concept Update is summarized as follows:

- Provide revisions to previous build-out concepts to account for changed areas in the annexed lands
- Perform confirmatory hydraulic modelling to review revised model boundary conditions based on the adjusted contributing areas
- Generate updated cost estimates for the ultimate build-out infrastructure and upgrades to existing infrastructure in order to support the City's offsite levies

The completed Sanitary Servicing Concept Update memo will be used in conjunction with the 2018 I-I Program to provide a comprehensive roadmap to Council to assess the infrastructure needs to accommodate future development in the short-term and long-term.

Based on system assessment under the 50 year 24 hour Q3 Huff storm, the following recommendations can be made for the updated servicing concept:

- The proposed ultimate build-out infrastructure consists of:
  - Seven additional lift stations
  - Seven twinned forcemains varying from 100 mm to 450 mm in size
  - Gravity sewers ranging from 200 mm to 900 mm in diameter
- No siphons are currently proposed to service the ultimate build-out lands, based on the existing site grading. Should the development of the annexed lands result in significant grading changes and triggers the needs for a siphon, a 150 mm diameter siphon is proposed to cross Palm Creek.
- Revised upgrades required to existing system infrastructure based on the changes to the annexed areas include:
  - Increasing the capacity of Building 9 Lift Station by 880 L/s for a total capacity of 1,180 L/s
  - Monitoring of flagged existing gravity sewers experiencing surcharging
- Other upgrades proposed in the I-I Program also remain valid, including:
  - Upgrade the capacity of the Building 3 Lift Station to 86 L/s (if needed after verifying lift station capacity with an additional drawdown test)
  - Upgrade the capacity of the Building 4 Lift Station to 382 L/s
  - Divert flows from 22nd Street to 23rd Street; noting that this interconnection has been constructed since the I-I Program
  - Reconnect the Building 3 Forcemain directly to the Building 4 Lift Station
  - Complete Phase 2 of the Forest Heights Trunk
  - Upsize a section of pipe along 47th Street and 50th Avenue to 300 mm (from 200 mm)
- The total cost of implementing the aforementioned infrastructure and upgrades are as follows:
  - Servicing – Total cost of $61,938,000
  - Upgrades – Total cost of $27,364,000

It is recommended that this document, along with the I-I Program, be revisited after significant periods of growth or every five years to update the hydrodynamic model and analysis with any capital upgrades completed by Cold Lake, the most up-to-date growth plans, and new available rain gauge and flow monitoring data.

## 9.0 References

Alberta Environment. 2011. Standards and Guidelines for Municipal Waterworks, Wastewater, and Storm Drainage Systems.

City of Cold Lake. August, 2007. Municipal Development Plan 2007 – 2037.

City of Cold Lake. January, 2008. Municipal Engineering Servicing Standards and Standard Construction Specifications.

City of Cold Lake. 2014. Cold Lake Annexation Proposal: Public Open House Presentation.

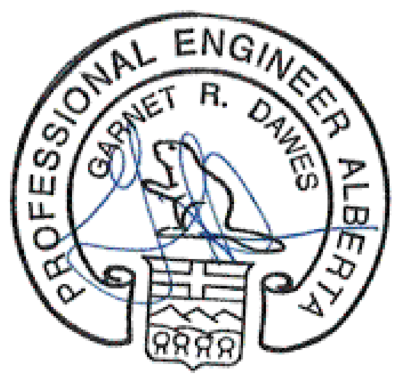
ISL Engineering and Land Services Ltd. September 2018. City of Cold Lake Inflow-Infiltration Program.

## 10.0 Authorization

This document entitled "Sanitary Servicing Concept Plan Update" has been prepared by ISL Engineering and Land Services Ltd. (ISL) for the use of the City of Cold Lake. The information and data provided herein represent ISL's professional judgment at the time of preparation. ISL denies any liability whatsoever to any other parties who may obtain this report and use it, or any of its contents, without prior written consent from ISL.


2020-10-02

Sarah Barbosa, P.Eng., ENV SP
Technical Author

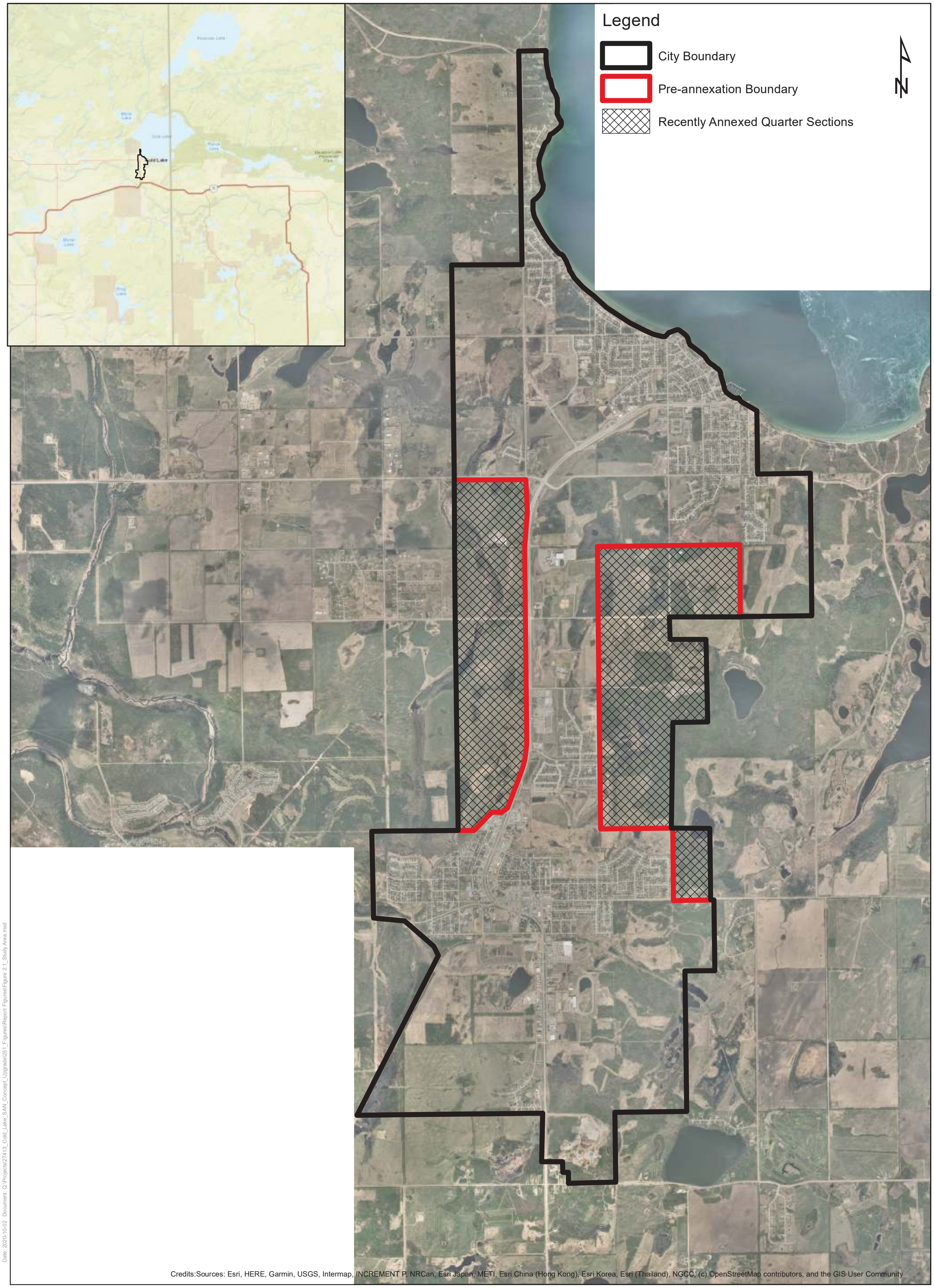



2020-10-02

Garnet Dawes, P.Eng., DBIA
Project Manager

**Permit to Practice**
*ISL Engineering and Land Services Ltd.*
RM Signature:
RM APEGA ID: 66731
Date: 2020-10-02
**Permit Number P4741**
The Association of Professional Engineers and Geoscientists of Alberta

Geoffrey Schulmeister, P.Eng., SCPM
Manager, Water and Environment




Date: 2020-10-02 Document: Q:\Projects\27413_Cold_Lake_SAN_Concept_Upgrade\251_Figures\Report Figures\Figure 2.1_Study Area.mxd

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FIGURE 2.1
STUDY AREA
CITY OF COLD LAKE
SANITARY CONCEPT UPGRADE

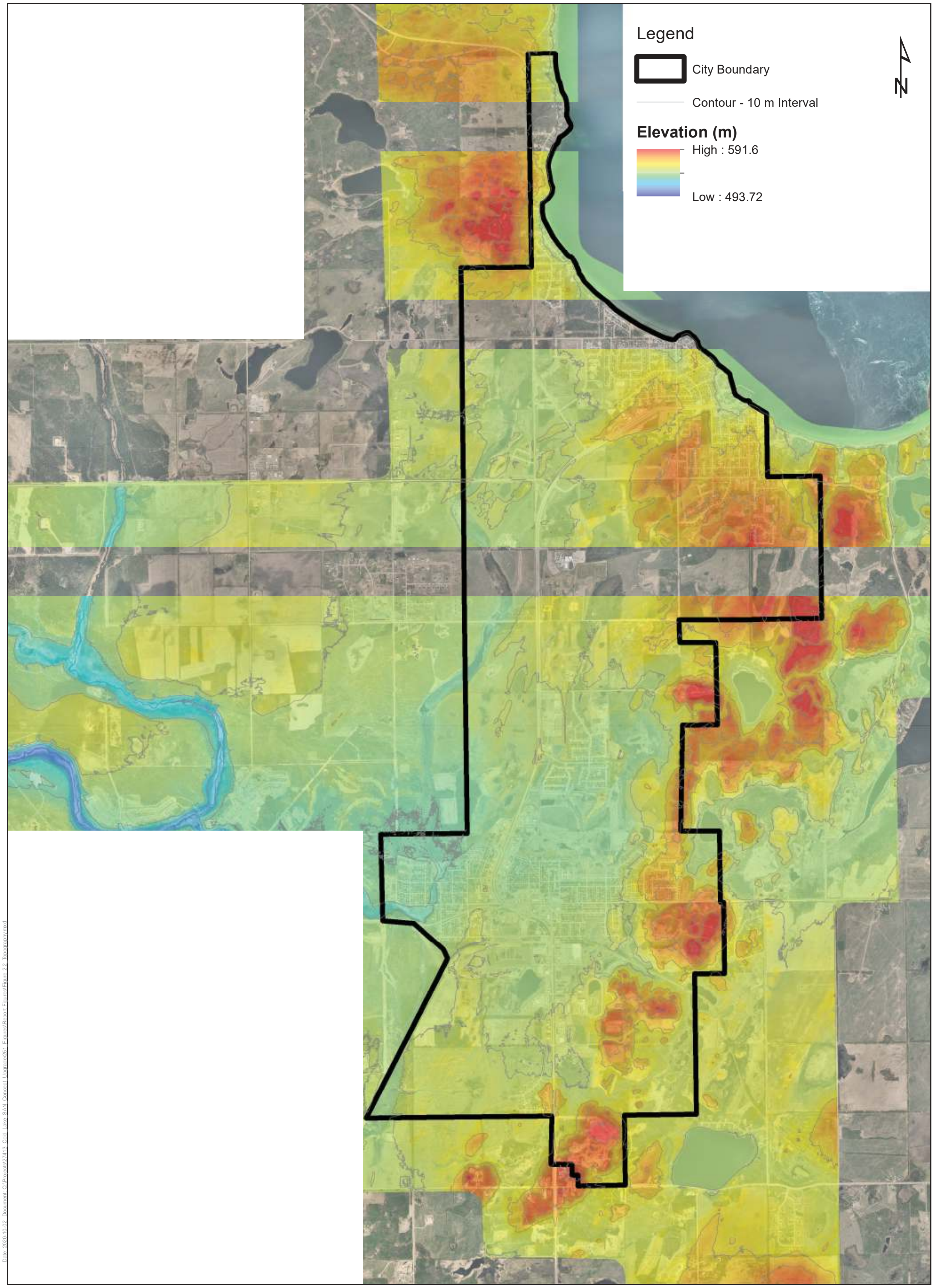


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FIGURE 2.2
TOPOGRAPHY
CITY OF COLD LAKE
SANITARY CONCEPT UPGRADE

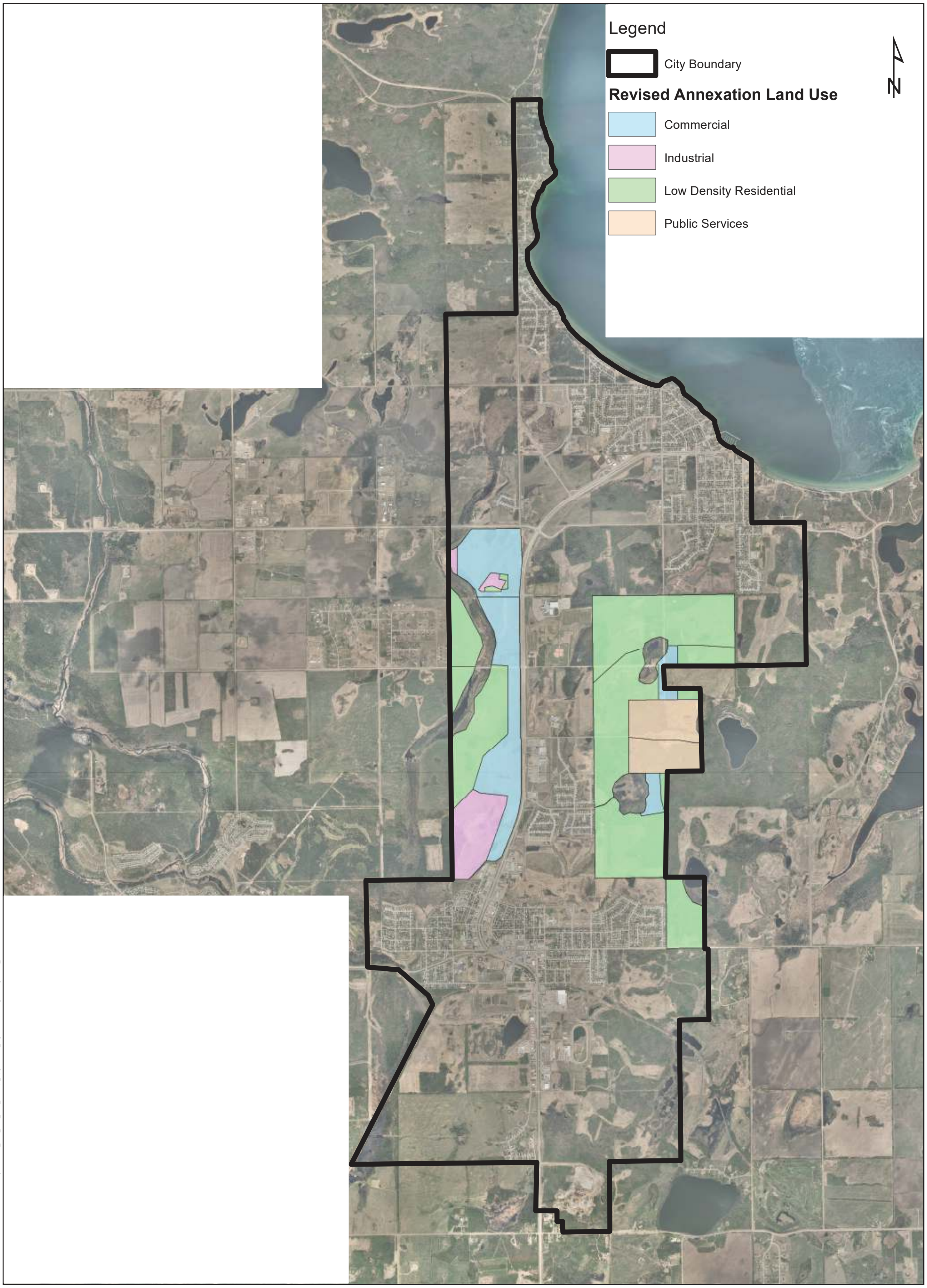


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FIGURE 2.3
REVISED ANNEXATION LAND USE
CITY OF COLD LAKE
SANITARY CONCEPT UPGRADE

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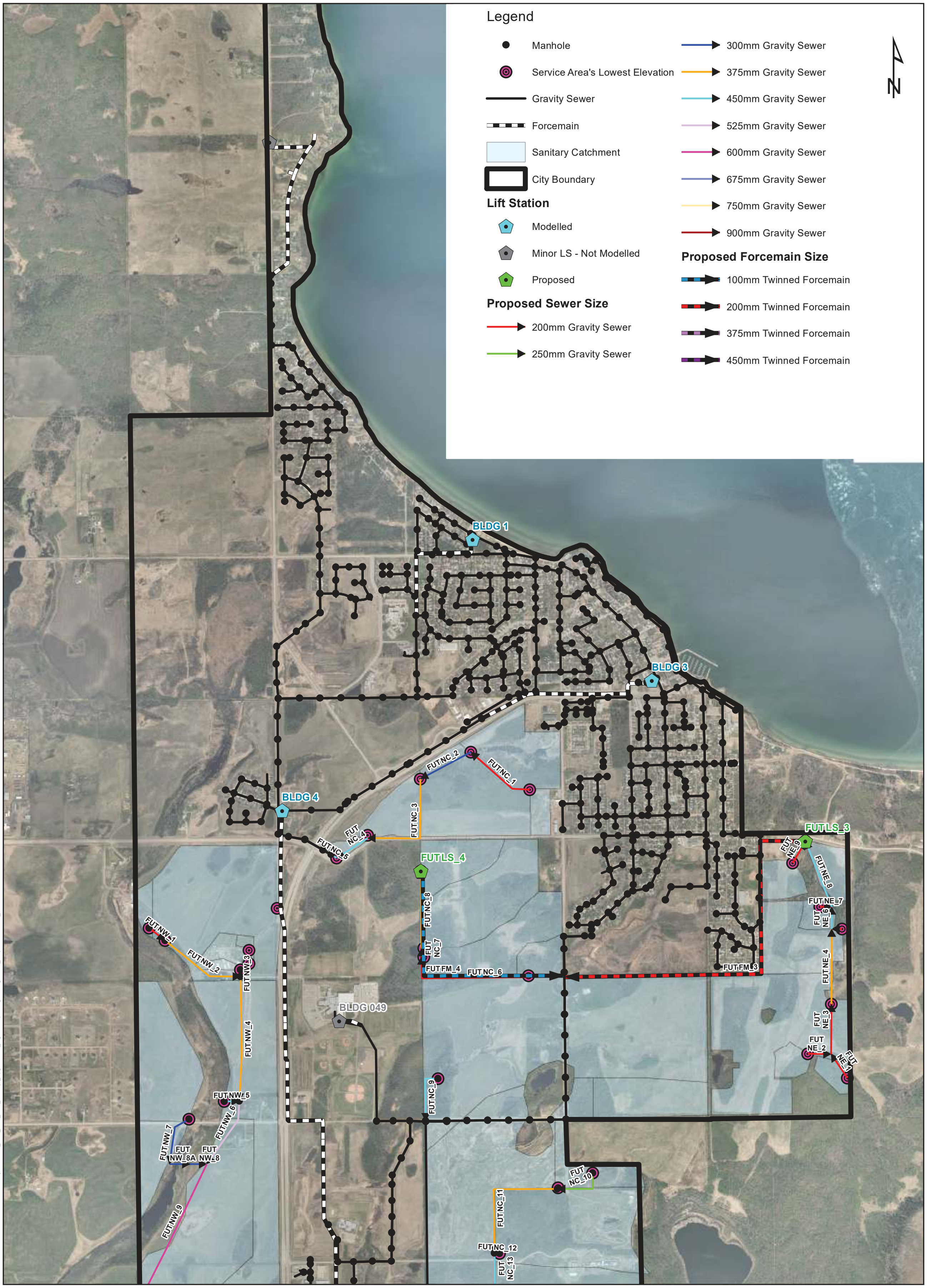


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FIGURE 5.1
PROPOSED NETWORK - NORTH
ULTIMATE BUILD-OUT
CITY OF COLD LAKE
SANITARY CONCEPT UPGRADE

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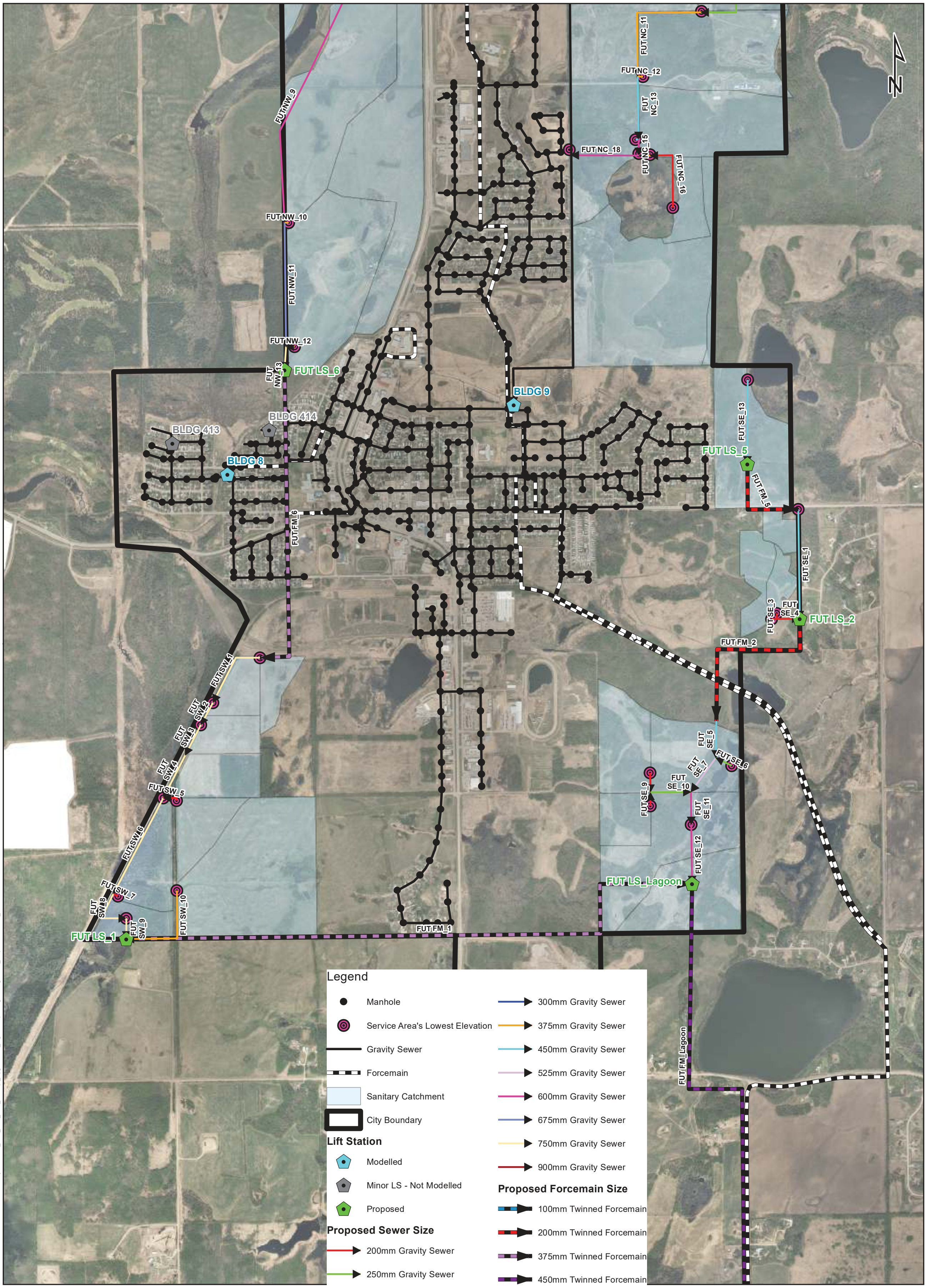


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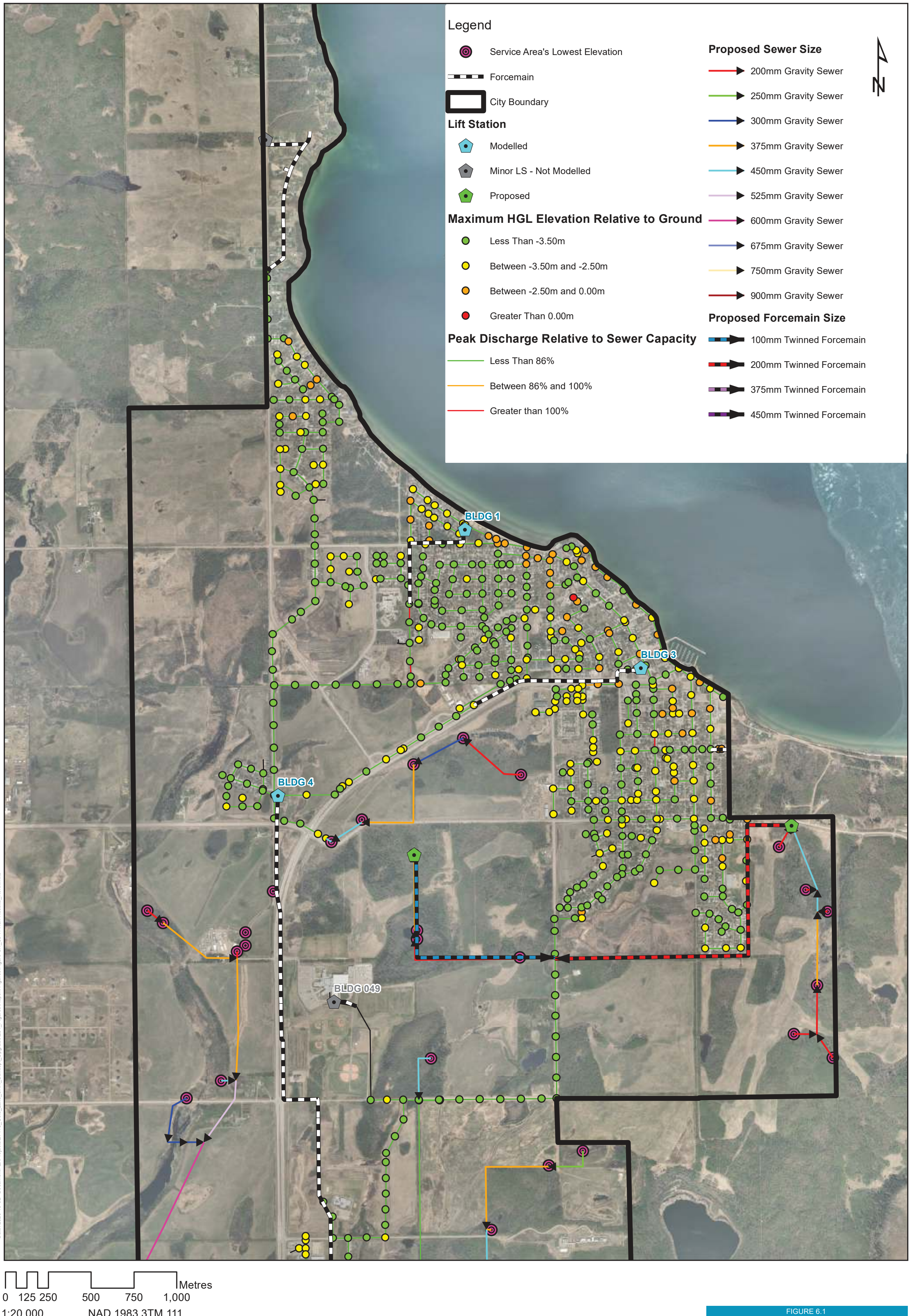
FIGURE 5.2
PROPOSED NETWORK - SOUTH
ULTIMATE BUILD-OUT
CITY OF COLD LAKE
SANITARY CONCEPT UPGRADE




Date: 2020-10-02 Document: Q:\Projects\27413_Cold_Lake_SAN_Concept_Upgrade\251_Figures\Report Figures\Figure 6.1_50 Yr Huff Results_North.mxd

FIGURE 6.1
PROPOSED NETWORK - NORTH
PEAK DISCHARGE RELATIVE TO SEWER CAPACITY
AND MAXIMUM HGL RELATIVE TO GROUND
50 YEAR 24 HOUR Q3 HUFF STORM
CITY OF COLD LAKE
SANITARY CONCEPT UPGRADE

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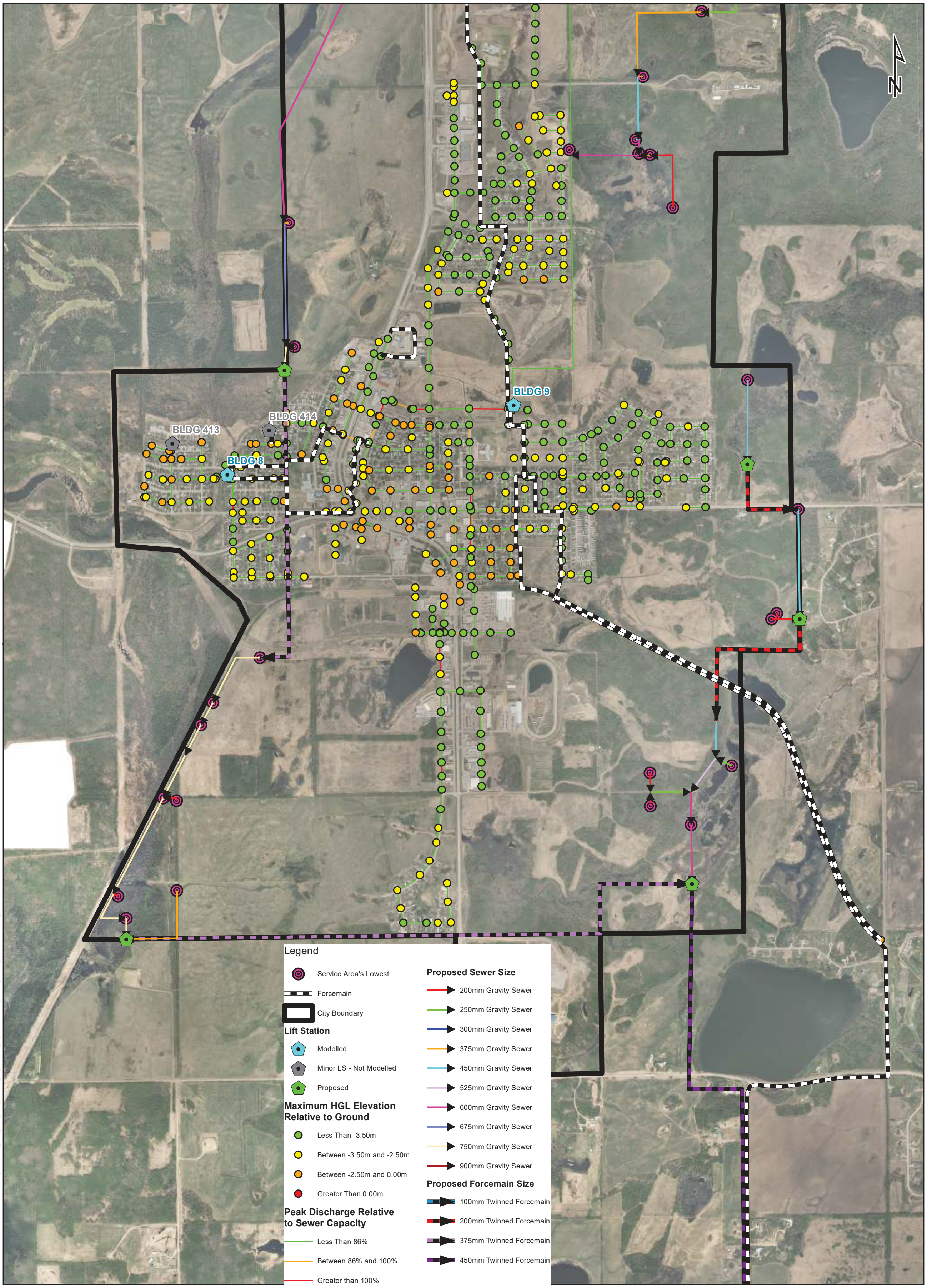


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FIGURE 6.2
PROPOSED NETWORK - SOUTH
PEAK DISCHARGE RELATIVE TO SEWER CAPACITY
AND MAXIMUM HGL RELATIVE TO GROUND
50 YEAR 24 HOUR Q3 HUFF STORM
CITY OF COLD LAKE
SANITARY CONCEPT UPGRADE

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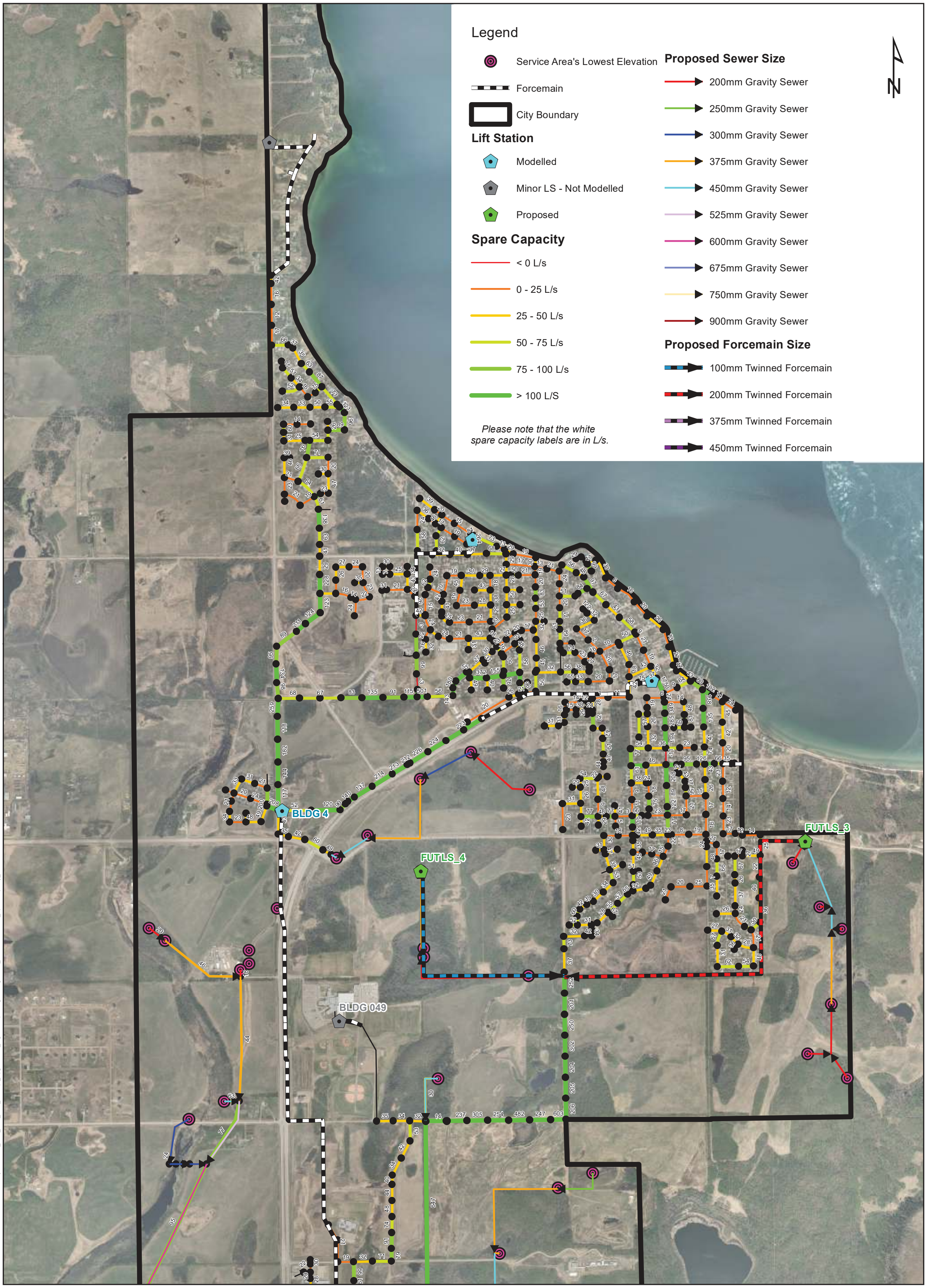


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FIGURE 6.3
PROPOSED NETWORK - NORTH
SPARE CAPACITY
50 YEAR 24 HOUR Q3 HUFF STORM
CITY OF COLD LAKE
SANITARY CONCEPT UPGRADE

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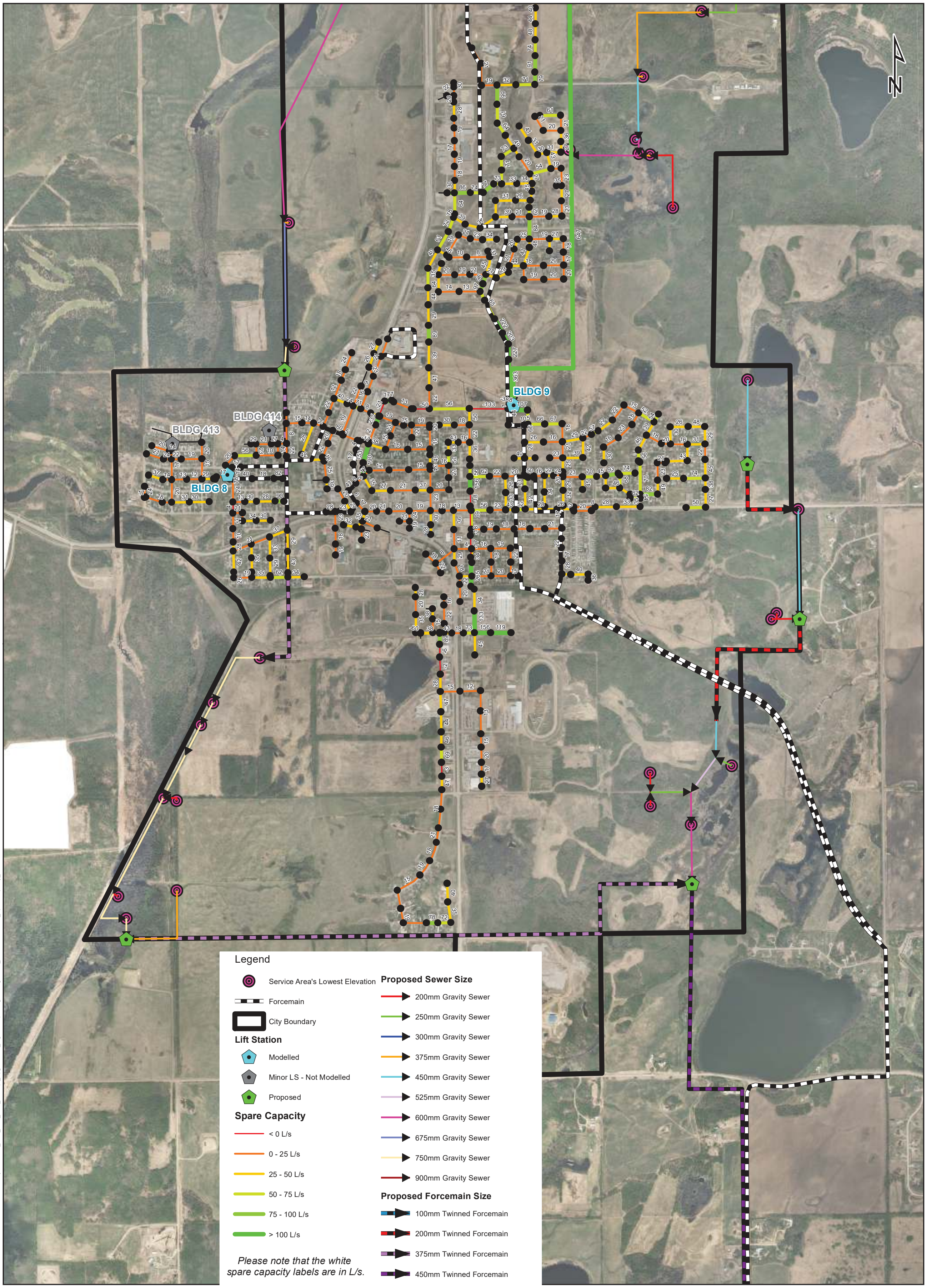


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FIGURE 6.4
PROPOSED NETWORK - SOUTH
SPARE CAPACITY
50 YEAR 24 HOUR Q3 HUFF STORM
CITY OF COLD LAKE
SANITARY CONCEPT UPGRADE

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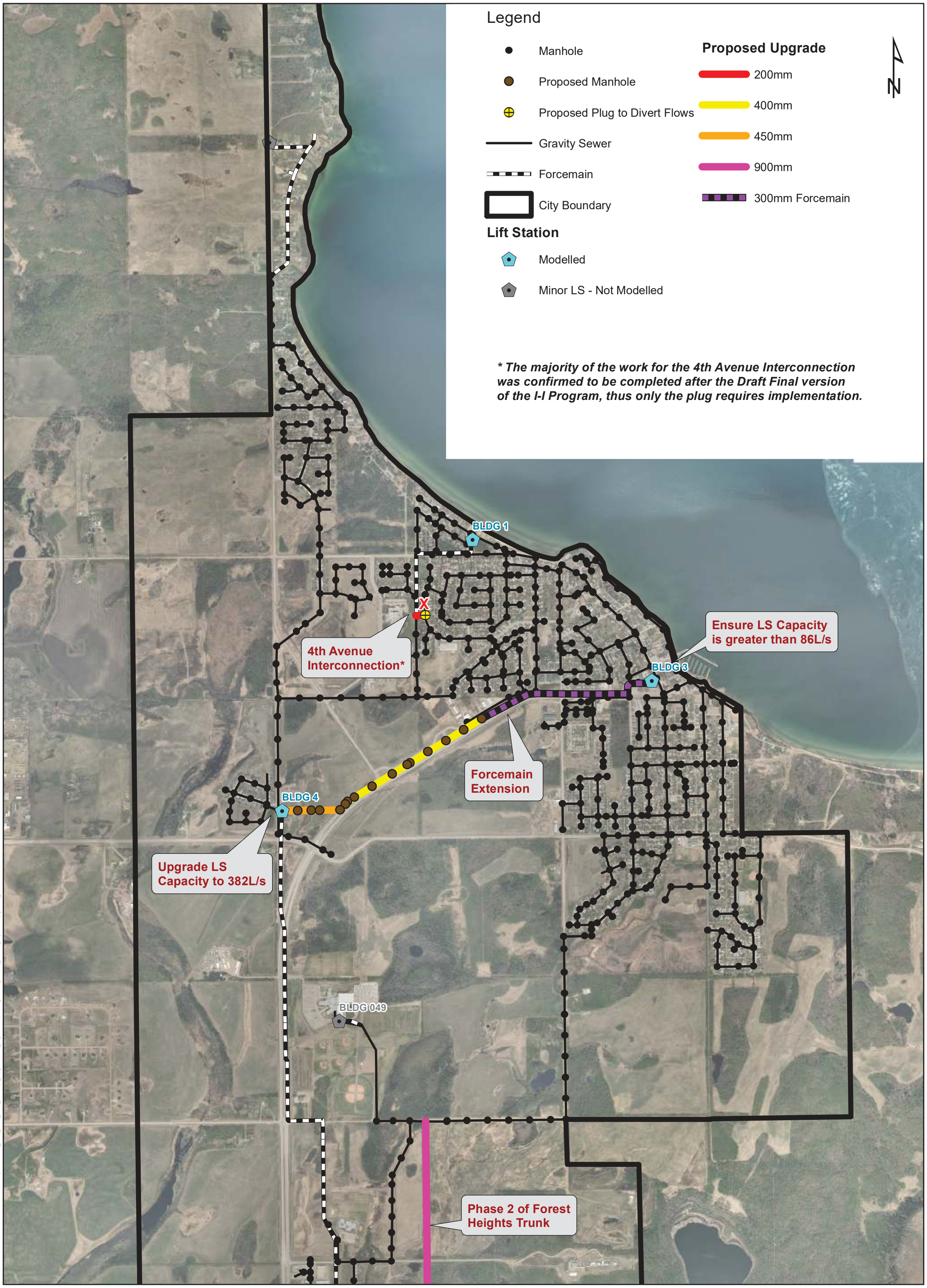


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FIGURE 6.5
PROPOSED UPGRADES - NORTH
ULTIMATE BUILD-OUT
CITY OF COLD LAKE
SANITARY CONCEPT UPGRADE

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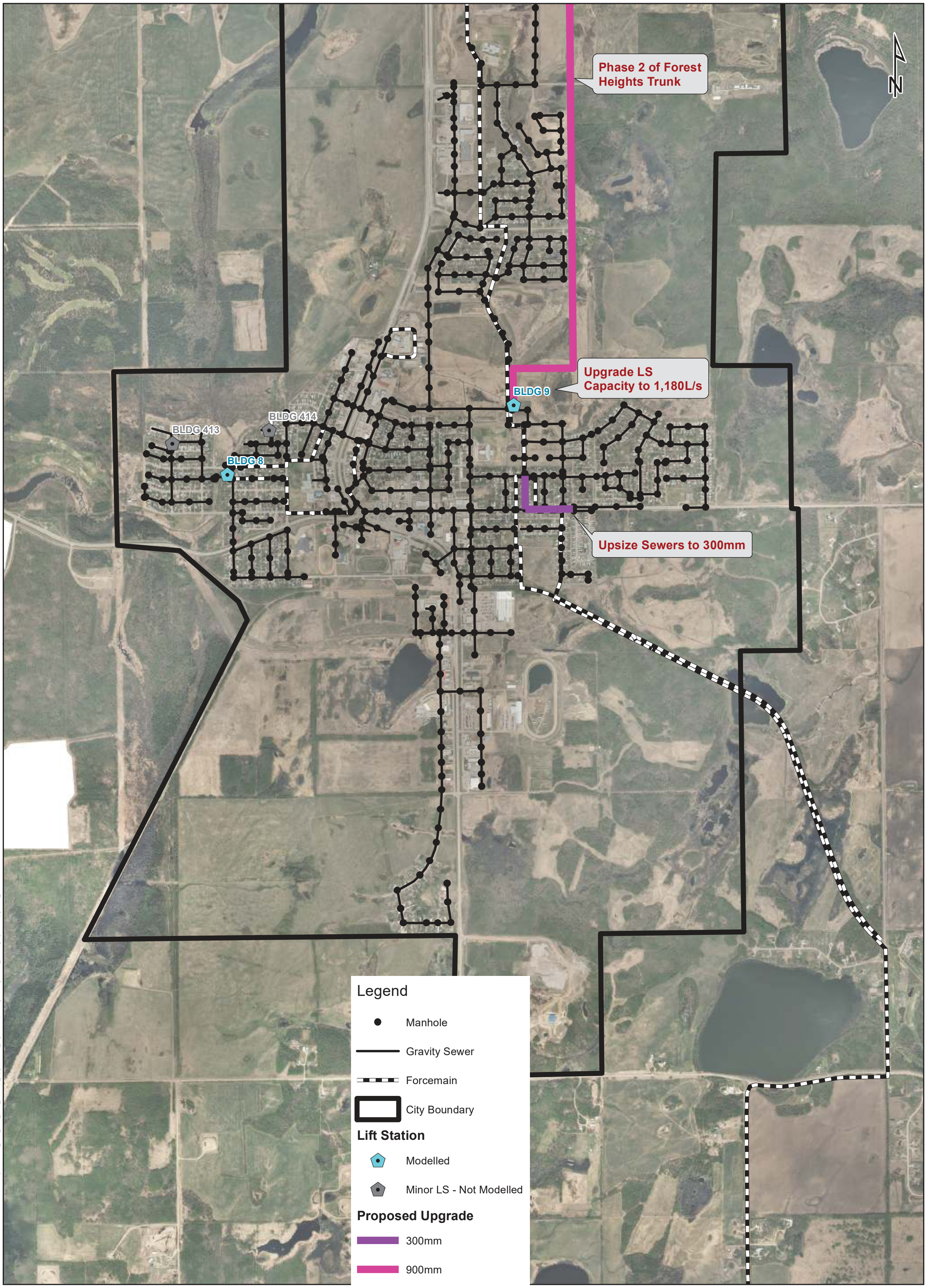


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FIGURE 6.6
PROPOSED UPGRADES - SOUTH
ULTIMATE BUILD-OUT
CITY OF COLD LAKE
SANITARY CONCEPT UPGRADE

**APPENDIX**
Interim Development Servicing

# A

## Servicing Interim Developments

The ultimate servicing concept proposed in this document, as well as in the I-I Program, consists of a significant amount of new infrastructure in order to convey flows to the City's lagoon. This is due to a number of constraints, including limited spare capacities in the existing infrastructure, unfavourable topography from developable areas to the existing system, and the distance to existing infrastructure from the lowest points within the catchments. Some developable nodes, such as along the west side of 51st Street, would result in large upfront costs in order to convey flows to the lagoon if they were to come online prior to any of the developments in Cold Lake South. These areas would require gravity sewers and pumping spanning the entirety of Cold Lake South, plus the construction of a large lift station and twinned forcemain to the lagoons. This would not be ideal for short-term development.

The intent of this document is not to limit growth in a specific direction, thus interim measures could be implemented to allow growth to occur in these upstream developable nodes. This would defer the large capital costs to a later date, when additional funding may be available. Once a larger portion of the ultimate build-out servicing concept is constructed, these developments would have the opportunity to tie back into the system shown in Figures 5.1 and 5.2.

One of the key areas of interest for short-term growth is the Tri-City area, as indicated by the City. This area is shown in green on Figure A.1 below, while existing and ultimate build-out areas are shown in yellow and purple, respectively. This area is intended to be routed to the south through an entirely new system, however for development to occur in the interim, there is some limited capacity in the existing system. Developers would be responsible for conveying flows to the tie-in points to the existing system, which due to topographical constraints would likely require sewage to be pumped. The exact schematics of the sanitary system within these catchments should be assessed further during the conceptual planning and detailed design stages of each development.

The capacity of existing gravity sewers and lift stations discussed below is based on the 50 year 24 hour Q3 Huff storm (Figures 6.17 and 6.18 of the I-I Program), as noted in Section 4.3. This is due to the fact that constant I-I rate scenarios are generally not used to assess the performance of lift stations and forcemains, as the ensuing indefinite inflow rate is likely to always inundate each pumping facility. Maximum pumping capacities were obtained from the drawdown testing performed during the I-I Program.

Of the Tri-City area, there is the potential to tie the southern two quarter sections (West of 51st Street, south of 69th Avenue) to the existing system along 61st Avenue, to route flows south then east ultimately to the Building 9 Lift Station. Elevations are relatively unfavourable for a gravity system to the east, thus would require a pumped system. It is also noted that other existing sanitary sewers in the area have insufficient spare capacity to service these catchments (i.e., spare capacities as low as 7 L/s). The limiting capacity of the downstream infrastructure is 38 L/s under existing conditions. Any development which exceeds the 38 L/s would require select upgrades to the existing infrastructure. A flow of 38 L/s is equivalent to one of the following, noting these consider peaked wet weather flows:

- 32 ha of industrial or commercial development
- 45 ha of low density residential development (1,665 people assuming a density of 37 persons per gross residential hectare)

The northernmost quarter section could be conveyed north to the Building 4 Lift Station. Based on existing conditions, there is approximately 136 L/s of spare capacity at the Building 4 Lift Station, indicating that this quarter section could be accommodated. There is the potential for the two central quarter sections in the Tri-City area to be routed east along 75th Avenue, and ultimately connect to Phase 2 of the Forest Heights Trunk once it is built. This trunk would need to be constructed in order to make this connection feasible. These catchments could also be routed north towards Building 4 Lift Station along with the most northern quarter section.

Figure A.2 illustrates the potential tie-in points noted above.

Connecting to the existing system at any of the discussed tie-in points would result in flows being conveyed to the Building 9 Lift Station. This lift station would require additional pumping capacity in order to service these areas, based on the recorded drawdown test pumping capacity of 295 L/s. It is however noted that this considers only two pumps running simultaneously at the lift station. A test was not performed with all three pumps running simultaneously due to concerns of too much pressure on the forcemain. If the concerns of forcemain failures are mitigated, allowing three pumps to run simultaneously, the maximum pumping capacity at the lift station could in fact be larger than recorded and capable of accommodating some of the additional development. Alternatively, the City could consider adding a storage tank at the Building 9 Lift Station or upstream of the lift station to offset some of the flows.

Further analysis would be needed on a per development basis to ensure sufficient capacity exists. This would include the following tasks:

- Review the development plans and/or reports to confirm compliance with the City's standards, Provincial standards, existing technical documents, and any other relevant documents related to the servicing strategy.
- Update the existing model if needed to account for newly installed/upgraded and critical sanitary infrastructure.
- Assess the feasibility of tying into the existing system by reviewing the capacities of the downstream sections of pipe.
- Markup plans and/or reports with suggested revisions and provide a technical memorandum to the City summarizing the findings.

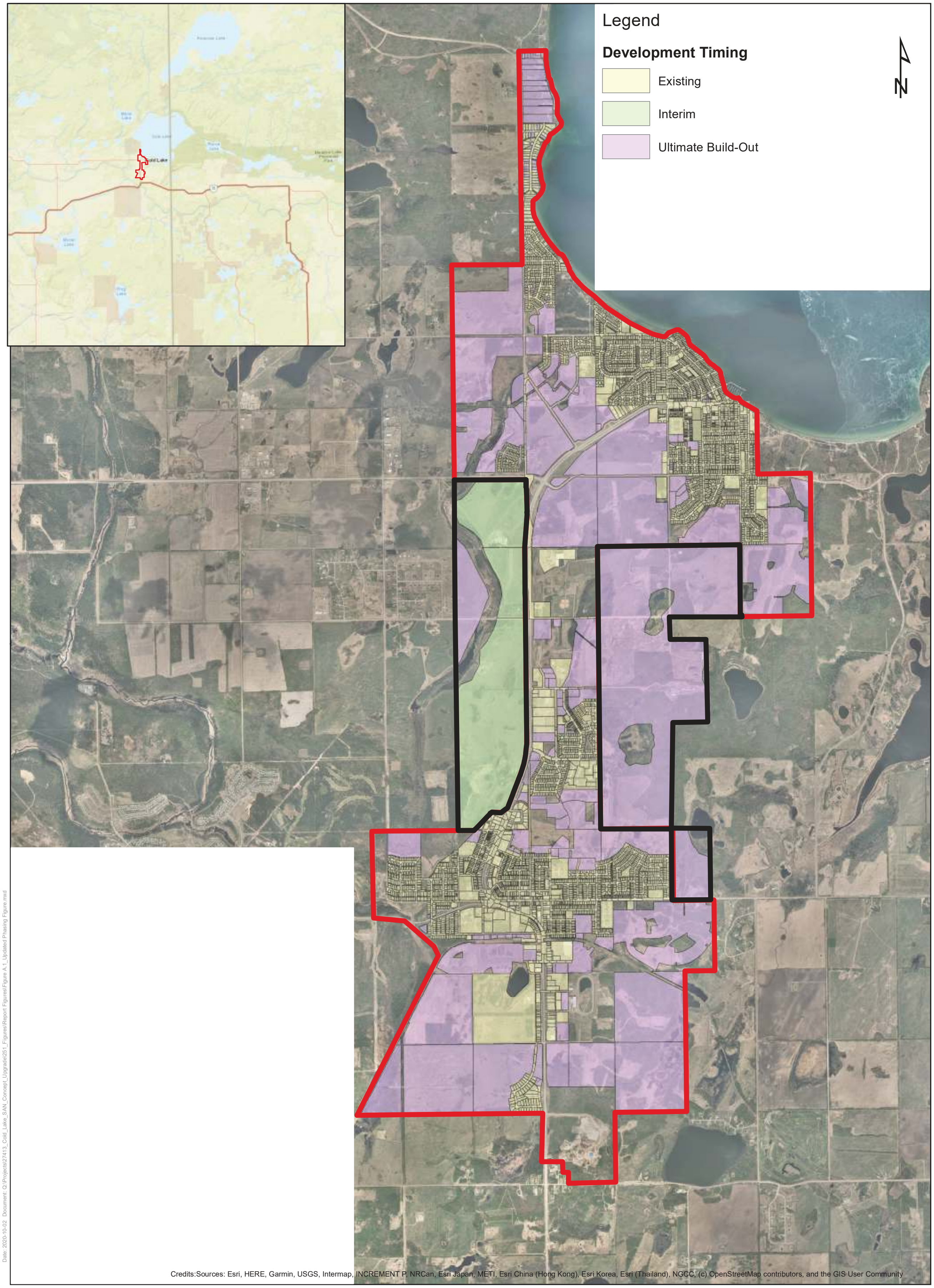


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FIGURE A.1
DEVELOPMENT TIMING
CITY OF COLD LAKE
SANITARY CONCEPT UPGRADE

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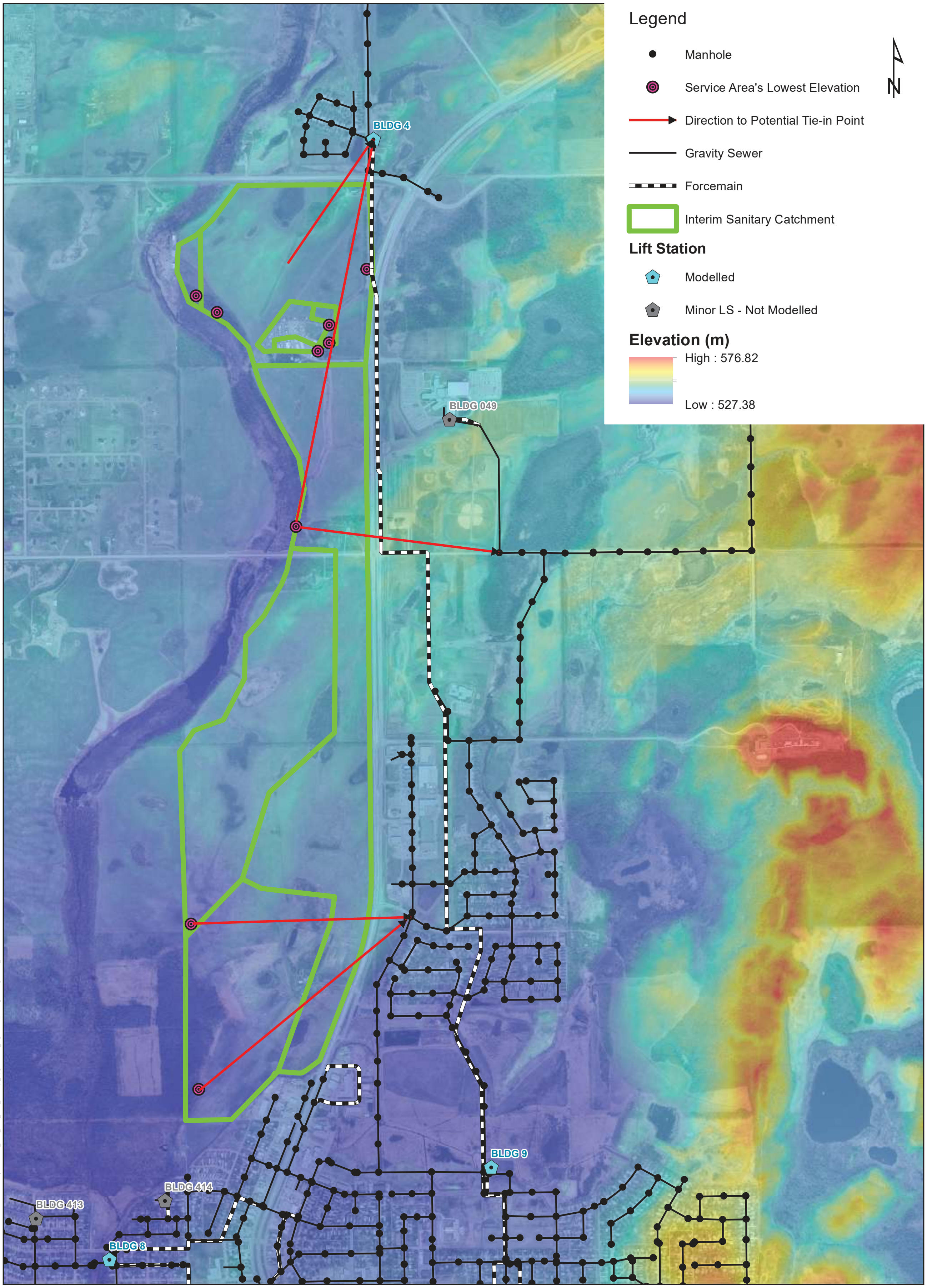


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FIGURE A.2
INTERIM HORIZON
POTENTIAL TIE IN LOCATIONS
CITY OF COLD LAKE
SANITARY CONCEPT UPGRADE

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# APPENDIX B
Siphon Sizing

| Assumed Number of Bends: | 2 |
|---|---|

## Flows

| Siphon ID | Stage 3 Average DWF | Stage 3 Peak DWF | Stage 3 Peak WWF |
|---|---|---|---|
| | L/s | L/s | L/s |
| FUT Siphon_1 | 1.33 | 5.41 | 7.99 |

## Pipe Parameters

| Siphon ID | Pipe Size | Pipe Type | Material | Roughness Manning's | Roughness C-Value | Length | Cross-sectional Area | Hydraulic Radius | Stage 3 ADWF Flow | Stage 3 ADWF Velocity | Stage 3 PDWF Flow | Stage 3 PDWF Velocity | Stage 3 PWWF Flow | Stage 3 PWWF Velocity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | | | | m | $m^2$ | m | L/s | m/s | L/s | m/s | L/s | m/s |
| FUT Siphon_1 | 0.150 | Single | HDPE | 0.011 | 135 | 150 | 0.0177 | 0.0375 | 1.33 | 0.1 | 5.41 | 0.3 | 7.99 | 0.5 |

## Max Allowable Head Loss

| Siphon ID | U/S Invert | D/S Invert | U/S Pipe Size | D/S Pipe Size | Target Max U/S HGL (75% or 100%) | Target Max D/S HGL (75% or 100%) | Design U/S Max HGL Elevation | Design D/S Max Elevation | Max Allowable Total Head Loss |
|---|---|---|---|---|---|---|---|---|---|
| | m | m | mm | mm | | | m | m | m |
| FUT Siphon_1 | 533.85 | 529.75 | 300 | 525 | 1 | 0.75 | 534.15 | 530.15 | 4.000 |

## Inlet Control

| Siphon ID | U/S Invert | U/S Target Ponding Elev | Max Depth at Inlet | Discharge Coefficient | Pipe Size | Cross-sectional Area | Capacity | Capacity Check |
|---|---|---|---|---|---|---|---|---|
| | m | m | m | | m | $m^2$ | L/s | |
| FUT Siphon_1 | 534.18 | 534.48 | 0.48 | 0.6 | 0.150 | 0.0177 | 30.00 | OK |

## Pipe Head Loss

| Siphon ID | Stage 3 ADWF $H_{exit-entrance}$ | $H_{bends}$ | $H_{f\ (Manning's)}$ | $H_{f\ (Hazen-Williams)}$ | Total Head Loss (Manning's) | Total Head Loss (Hazen-Williams) | Stage 3 PDWF $H_{exit-entrance}$ | $H_{bends}$ | $H_{f\ (Manning's)}$ | $H_{f\ (Hazen-Williams)}$ | Total Head Loss (Manning's) | Total Head Loss (Hazen-Williams) | Stage 3 PWWF $H_{exit-entrance}$ | $H_{bends}$ | $H_{f\ (Manning's)}$ | $H_{f\ (Hazen-Williams)}$ | Total Head Loss (Manning's) | Total Head Loss (Hazen-Williams) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | m | m | m | m | m | m | m | m | m | m | m | m | m | m | m | m | m |
| FUT Siphon_1 | 0.001 | 0.000 | 0.014 | 0.009 | 0.015 | 0.010 | 0.007 | 0.002 | 0.129 | 0.244 | 0.137 | 0.253 | 0.019 | 0.005 | 0.357 | 0.244 | 0.381 | 0.268 |

## Acceptable Head Loss Values

| Siphon ID | Max Allowable Total Head Loss | Stage 3 ADWF Total Head Loss (Manning's) | Stage 3 ADWF Total Head Loss (Hazen-Williams) | Stage 3 ADWF Status | Stage 3 PDWF Total Head Loss (Manning's) | Stage 3 PDWF Total Head Loss (Hazen-Williams) | Stage 3 PDWF Status | Stage 3 PWWF Total Head Loss (Manning's) | Stage 3 PWWF Total Head Loss (Hazen-Williams) | Stage 3 PWWF Status |
|---|---|---|---|---|---|---|---|---|---|---|
| | m | m | m | | m | m | | m | m | |
| FUT Siphon_1 | 4.000 | 0.015 | 0.010 | HW OK; MAN OK | 0.137 | 0.253 | HW OK; MAN OK | 0.381 | 0.268 | HW OK; MAN OK |

## APPENDIX
Ultimate Build-out Pipe Sizing

C

ISL

| Pipe | Contributing Service Area | Population | Area | | | | | DWF Rate | | | | Average DWF (L/s) | | | | | Peaking Factors | | RES Peak DWF | Non-RES Peak DWF | Total Peak DWF | I-I | Inflow - Infiltration | Total Peak WWF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Residential (Persons) | Residential (ha) | Commercial (ha) | Industrial (ha) | Institutional (ha) | Total (ha) | Residential (L/p/d) | Commercial m³/ha/d | Industrial m³/ha/d | Institutional m³/ha/d | Residential | Commercial | Industrial | Institutional | Total | Residential | Non-Residential | (L/s) | (L/s) | (L/s) | Flow Rate (L/s/ha) | (L/s) | (L/s) |
| FUT NC_1 | FUT Buildout_28 | 112 | 3 | 0 | 0 | 0 | 3 | 350 | 18 | 18 | 18 | 0.45 | 0.00 | 0.00 | 0.00 | 0.45 | 4.23 | 2.50 | 1.92 | 0.00 | 1.92 | 0.29 | 0.88 | 2.80 |
| FUT NC_2 | FUT Buildout_28 & FUT Buildout_64 | 112 | 3 | 17 | 0 | 0 | 20 | 350 | 18 | 18 | 18 | 0.45 | 3.49 | 0.00 | 0.00 | 3.95 | 4.23 | 5.80 | 1.92 | 20.26 | 22.18 | 0.29 | 5.74 | 27.92 |
| FUT NC_3 | FUT Buildout_28, FUT Buildout_64 & FUT Buildout_43 | 1,050 | 28 | 17 | 0 | 0 | 45 | 350 | 18 | 18 | 18 | 4.25 | 3.49 | 0.00 | 0.00 | 7.74 | 3.79 | 5.80 | 16.10 | 20.26 | 36.36 | 0.29 | 13.09 | 49.45 |
| FUT NC_4 | FUT Buildout_28, FUT Buildout_64, FUT Buildout_43, & FUT Buildout 35 | 1,467 | 40 | 17 | 0 | 0 | 56 | 350 | 18 | 18 | 18 | 5.94 | 3.49 | 0.00 | 0.00 | 9.43 | 3.69 | 5.80 | 21.90 | 20.26 | 42.16 | 0.29 | 16.35 | 58.51 |
| FUT NC_5 | FUT Buildout_66, FUT Buildout_67, FUT Buildout_5, FUT Buildout_65, FUT Buildout_28, FUT Buildout_35, & FUT Buildout_8 | 1,520 | 41 | 17 | 0 | 0 | 58 | 350 | 18 | 18 | 18 | 6.16 | 3.49 | 0.00 | 0.00 | 9.65 | 3.68 | 5.80 | 22.64 | 20.26 | 42.89 | 0.29 | 16.78 | 59.67 |
| FUT NC_6 | FUT Buildout_66 | 226 | 6 | 0 | 0 | 0 | 6 | 350 | 18 | 18 | 18 | 0.91 | 0.00 | 0.00 | 0.00 | 0.91 | 4.13 | 2.50 | 3.77 | 0.00 | 3.77 | 0.29 | 1.77 | 5.54 |
| FUT NC_7 | FUT Buildout_66 & FUT Buildout_67 | 315 | 8 | 0 | 0 | 0 | 8 | 350 | 18 | 18 | 18 | 1.27 | 0.00 | 0.00 | 0.00 | 1.27 | 4.07 | 2.50 | 5.19 | 0.00 | 5.19 | 0.29 | 2.21 | 7.40 |
| FUT NC_8 | FUT Buildout_66, FUT Buildout_67 & FUT Buildout_5 | 759 | 12 | 0 | 0 | 0 | 12 | 350 | 18 | 18 | 18 | 3.08 | 0.00 | 0.00 | 0.00 | 3.08 | 3.87 | 2.50 | 11.92 | 0.00 | 11.92 | 0.29 | 3.50 | 15.42 |
| FUT FM_4 | FUT Buildout_66, FUT Buildout_67, FUT Buildout_5 & FUT Buildout_65 | 759 | 16 | 0 | 0 | 0 | 16 | 350 | 18 | 18 | 18 | 3.08 | 0.00 | 0.00 | 0.00 | 3.08 | 3.87 | 2.50 | 11.92 | 0.00 | 11.92 | 0.29 | 4.57 | 16.49 |
| FUT NC_9 | FUT Annex_17 | 3,854 | 104 | 0 | 0 | 0 | 104.16 | 350 | 18 | 18 | 18 | 15.61 | 0.00 | 0.00 | 0.00 | 15.61 | 3.35 | 2.50 | 52.26 | 0.00 | 52.26 | 0.29 | 30.21 | 82.47 |
| FUT NC_10 | FUT Annex_3 | 692 | 19 | 0 | 0 | 0 | 18.71 | 350 | 18 | 18 | 18 | 2.80 | 0.00 | 0.00 | 0.00 | 2.80 | 3.90 | 2.50 | 10.93 | 0.00 | 10.93 | 0.29 | 5.43 | 16.36 |
| FUT NC_11 | FUT Annex_3 & FUT Annex_2 | 692 | 19 | 8 | 0 | 0 | 27 | 350 | 18 | 18 | 18 | 2.80 | 1.77 | 0.00 | 0.00 | 4.57 | 3.90 | 7.88 | 10.93 | 13.93 | 24.86 | 0.29 | 7.89 | 32.75 |
| FUT NC_12 | FUT Annex_14 | 0 | 0 | 0 | 0 | 37 | 37 | 350 | 18 | 18 | 18 | 0.00 | 0.00 | 0.00 | 7.64 | 7.64 | 4.50 | 4.08 | 0.00 | 31.17 | 31.17 | 0.29 | 10.64 | 41.80 |
| FUT NC_13 | FUT Annex_3, FUT Annex_2 & FUT Annex_14 | 692 | 19 | 8 | 0 | 37 | 64 | 350 | 18 | 18 | 18 | 2.80 | 1.77 | 0.00 | 7.64 | 12.21 | 3.90 | 3.71 | 10.93 | 34.95 | 45.88 | 0.29 | 18.52 | 64.40 |
| FUT NC_14 | FUT Annex_16 | 2,609 | 71 | 0 | 0 | 0 | 71 | 350 | 18 | 18 | 18 | 10.57 | 0.00 | 0.00 | 0.00 | 10.57 | 3.49 | 2.50 | 36.92 | 0.00 | 36.92 | 0.29 | 20.45 | 57.36 |
| FUT NC_15 | FUT Annex_3, FUT Annex_2, FUT Annex_14 & FUT Annex_16 | 3,301 | 89 | 8 | 0 | 37 | 134 | 350 | 18 | 18 | 18 | 13.37 | 1.77 | 0.00 | 7.64 | 22.78 | 3.41 | 3.71 | 45.56 | 34.95 | 80.51 | 0.29 | 38.97 | 119.48 |
| FUT NC_16 | FUT Annex_1 | 0 | 0 | 8 | 0 | 0 | 8 | 350 | 18 | 18 | 18 | 0.00 | 1.70 | 0.00 | 0.00 | 1.70 | 4.50 | 8.02 | 0.00 | 13.63 | 13.63 | 0.29 | 2.36 | 16.00 |
| FUT NC_17 | FUT Annex_1 & FUT Annex_13 | 0 | 0 | 8 | 0 | 31 | 39 | 350 | 18 | 18 | 18 | 0.00 | 1.70 | 0.00 | 6.51 | 8.21 | 4.50 | 3.95 | 0.00 | 32.42 | 32.42 | 0.29 | 11.43 | 43.85 |
| FUT NC_18 | FUT Annex_3, FUT Annex_2, FUT Annex_14, FUT Annex_16, FUT Annex_1 & FUT Annex_13 | 3,301 | 89 | 17 | 0 | 68 | 174 | 350 | 18 | 18 | 18 | 13.37 | 3.47 | 0.00 | 14.15 | 30.99 | 3.41 | 2.80 | 45.56 | 49.35 | 94.91 | 0.29 | 50.40 | 145.31 |
| FUT SE_13 | FUT Annex_27 | 2,466 | 67 | 0 | 0 | 0 | 67 | 350 | 18 | 18 | 18 | 9.99 | 0.00 | 0.00 | 0.00 | 9.99 | 3.51 | 2.50 | 35.09 | 0.00 | 35.09 | 0.29 | 19.33 | 54.42 |
| FUT FM_5 | FUT Annex_27 | 2,466 | 67 | 0 | 0 | 0 | 67 | 350 | 18 | 18 | 18 | 9.99 | 0.00 | 0.00 | 0.00 | 9.99 | 3.51 | 2.50 | 35.09 | 0.00 | 35.09 | 0.29 | 19.33 | 54.42 |
| FUT SE_1 | FUT Buildout_180, FUT Annex_27 | 2,910 | 71 | 0 | 0 | 0 | 71 | 350 | 18 | 18 | 18 | 11.79 | 0.00 | 0.00 | 0.00 | 11.79 | 3.45 | 2.50 | 40.72 | 0.00 | 40.72 | 0.29 | 20.62 | 61.33 |
| FUT SE_2 | FUT Buildout_172 | 468 | 5 | 0 | 0 | 0 | 5 | 350 | 18 | 18 | 18 | 1.89 | 0.00 | 0.00 | 0.00 | 1.89 | 3.99 | 2.50 | 7.56 | 0.00 | 7.56 | 0.29 | 1.56 | 9.12 |
| FUT SE_3 | FUT Buildout_122 | 232 | 3 | 0 | 0 | 0 | 3 | 350 | 18 | 18 | 18 | 0.94 | 0.00 | 0.00 | 0.00 | 0.94 | 4.12 | 2.50 | 3.87 | 0.00 | 3.87 | 0.29 | 0.77 | 4.64 |
| FUT SE_4 | FUT Buildout_122 & FUT Buildout_172 | 699 | 8 | 0 | 0 | 0 | 8 | 350 | 18 | 18 | 18 | 2.83 | 0.00 | 0.00 | 0.00 | 2.83 | 3.89 | 2.50 | 11.03 | 0.00 | 11.03 | 0.29 | 2.34 | 13.37 |
| FUT FM_2 | FUT Buildout_180, FUT Buildout_122, FUT Buildout_172& FUT Annex_27 | 3,610 | 80 | 0 | 0 | 0 | 80 | 350 | 18 | 18 | 18 | 14.62 | 0.00 | 0.00 | 0.00 | 14.62 | 3.37 | 2.50 | 49.32 | 0.00 | 49.32 | 0.29 | 23.10 | 72.42 |
| FUT SE_5 | FUT Buildout_180, FUT Buildout_122, FUT Buildout_172 & FUT Annex_27 | 3,610 | 80 | 0 | 0 | 0 | 80 | 350 | 18 | 18 | 18 | 14.62 | 0.00 | 0.00 | 0.00 | 14.62 | 3.37 | 2.50 | 49.32 | 0.00 | 49.32 | 0.29 | 23.10 | 72.42 |
| FUT SE_6 | FUT Buildout_129 | 744 | 20 | 0 | 0 | 0 | 20 | 350 | 18 | 18 | 18 | 3.01 | 0.00 | 0.00 | 0.00 | 3.01 | 3.88 | 2.50 | 11.69 | 0.00 | 11.69 | 0.29 | 5.83 | 17.52 |
| FUT SE_7 | FUT Buildout_180, FUT Buildout_122, FUT Buildout_172, FUT Buildout_129 & FUT Annex_27 | 4,354 | 100 | 0 | 0 | 0 | 100 | 350 | 18 | 18 | 18 | 17.64 | 0.00 | 0.00 | 0.00 | 17.64 | 3.30 | 2.50 | 58.20 | 0.00 | 58.20 | 0.29 | 28.93 | 87.13 |
| FUT SE_8 | FUT Buildout_68 | 623 | 17 | 0 | 0 | 0 | 17 | 350 | 18 | 18 | 18 | 2.52 | 0.00 | 0.00 | 0.00 | 2.52 | 3.92 | 2.50 | 9.90 | 0.00 | 9.90 | 0.29 | 4.88 | 14.78 |
| FUT SE_9 | FUT Buildout_173 | 329 | 9 | 0 | 0 | 0 | 9 | 350 | 18 | 18 | 18 | 1.33 | 0.00 | 0.00 | 0.00 | 1.33 | 4.06 | 2.50 | 5.41 | 0.00 | 5.41 | 0.29 | 2.58 | 7.99 |
| FUT SE_10 | FUT Buildout_68 & FUT Buildout_173 | 952 | 26 | 0 | 0 | 0 | 26 | 350 | 18 | 18 | 18 | 3.86 | 0.00 | 0.00 | 0.00 | 3.86 | 3.81 | 2.50 | 14.71 | 0.00 | 14.71 | 0.29 | 7.46 | 22.17 |
| FUT SE_11 | FUT Buildout_180, FUT Buildout_122, FUT Buildout_172, FUT Buildout_129, FUT Buildout_68, FUT Buildout_173 & FUT Annex_27 | 5,306 | 125 | 0 | 0 | 0 | 125 | 350 | 18 | 18 | 18 | 21.49 | 0.00 | 0.00 | 0.00 | 21.49 | 3.22 | 2.50 | 69.23 | 0.00 | 69.23 | 0.29 | 36.15 | 105.37 |
| FUT SE_12 | FUT Buildout_180, FUT Buildout_122, FUT Buildout_172, FUT Buildout_129, FUT Buildout_68, FUT Buildout_173, FUT Buildout_132 & FUT Annex_27 | 6,457 | 158 | 0 | 0 | 0 | 158 | 350 | 18 | 18 | 18 | 26.16 | 0.00 | 0.00 | 0.00 | 26.16 | 3.14 | 2.50 | 82.14 | 0.00 | 82.14 | 0.29 | 45.70 | 127.85 |
| FUT FM_Lagoon | FUT Annex_26, FUT Annex_25, FUT Annex_28, FUT Annex_30, FUT Annex_24, FUT Annex_10, FUT Annex_22, FUT Annex_9, FUT Annex_11, FUT Annex_23, FUT Buildout_166, FUT Buildout_113, FUT Buildout_120, FUT Buildout_164, FUT Buildout_111, FUT Buildout_168, FUT Buildout_124, FUT Buildout_131, FUT Buildout_165, FUT Buildout_180, FUT Buildout_122, FUT Buildout_172, FUT Buildout_68, FUT Buildout_173, FUT Buildout_132, FUT Buildout_129, FUT Buildout_169 & FUT Annex_27 | 14,211 | 364 | 125 | 51 | 0 | 541 | 350 | 18 | 18 | 18 | 57.57 | 26.13 | 10.61 | 0.00 | 94.31 | 3.00 | 2.50 | 172.70 | 91.87 | 264.57 | 0.29 | 156.75 | 421.32 |
| FUT NW_1 | FUT Annex_24 | 0 | 0 | 0 | 2 | 0 | 2 | 350 | 18 | 18 | 18 | 0.00 | 0.00 | 0.51 | 0.00 | 0.51 | 4.50 | 13.82 | 0.00 | 7.01 | 7.01 | 0.29 | 0.71 | 7.72 |
| FUT NW_2 | FUT Annex_24, FUT Annex_30 | 0 | 0 | 46 | 2 | 0 | 48 | 350 | 18 | 18 | 18 | 0.00 | 9.48 | 0.51 | 0.00 | 9.99 | 4.50 | 3.62 | 0.00 | 36.12 | 36.12 | 0.29 | 13.90 | 50.02 |
| FUT NW_3 | FUT Annex_25, FUT Annex_28, FUT Annex_26 | 76 | 2 | 0 | 3 | 0 | 5 | 350 | 18 | 18 | 18 | 0.31 | 0.00 | 0.71 | 0.00 | 1.01 | 4.27 | 11.91 | 1.31 | 8.41 | 9.73 | 0.29 | 1.58 | 11.31 |
| FUT NW_4 | FUT Annex_25, FUT Annex_28, FUT Annex_26, FUT Annex_24, FUT Annex_30 | 76 | 2 | 46 | 6 | 0 | 53 | 350 | 18 | 18 | 18 | 0.31 | 9.48 | 1.21 | 0.00 | 11.00 | 4.27 | 3.51 | 1.31 | 37.50 | 38.81 | 0.29 | 15.48 | 54.30 |
| FUT NW_5 | FUT Annex_10 | 0 | 0 | 80 | 0 | 0 | 80 | 350 | 18 | 18 | 18 | 0.00 | 16.65 | 0.00 | 0.00 | 16.65 | 4.50 | 2.87 | 0.00 | 47.84 | 47.84 | 0.29 | 23.18 | 71.02 |
| FUT NW_6 | FUT Annex_25, FUT Annex_28, FUT Annex_26, FUT Annex_24, FUT Annex_30, FUT Annex_10 | 76 | 2 | 125 | 6 | 0 | 133 | 350 | 18 | 18 | 18 | 0.31 | 26.13 | 1.21 | 0.00 | 27.65 | 4.27 | 2.50 | 1.31 | 68.37 | 69.68 | 0.29 | 38.66 | 108.34 |
| FUT NW_7 | FUT Annex_9, FUT Annex_22 | 1,214 | 33 | 0 | 0 | 0 | 33 | 350 | 18 | 18 | 18 | 4.92 | 0.00 | 0.00 | 0.00 | 4.92 | 3.74 | 2.50 | 18.42 | 0.00 | 18.42 | 0.29 | 9.52 | 27.94 |
| FUT NW_8 | FUT Annex_22, FUT Annex_9 | 1,214 | 33 | 0 | 0 | 0 | 33 | 350 | 18 | 18 | 18 | 4.92 | 0.00 | 0.00 | 0.00 | 4.92 | 3.74 | 2.50 | 18.42 | 0.00 | 18.42 | 0.29 | 9.52 | 27.94 |
| FUT NW_9 | FUT Annex_22, FUT Annex_9, FUT Annex_10, FUT Annex_24, FUT Annex_30, FUT Annex_25, FUT Annex_28, FUT Annex_26 | 1,290 | 35 | 125 | 6 | 0 | 166 | 350 | 18 | 18 | 18 | 5.23 | 26.13 | 1.21 | 0.00 | 32.57 | 3.73 | 2.50 | 19.48 | 68.37 | 87.84 | 0.29 | 48.18 | 136.02 |
| FUT NW_10 | FUT Annex_11 | 2,034 | 55 | 0 | 0 | 0 | 55 | 350 | 18 | 18 | 18 | 8.24 | 0.00 | 0.00 | 0.00 | 8.24 | 3.58 | 2.50 | 29.50 | 0.00 | 29.50 | 0.29 | 15.94 | 45.44 |
| FUT NW_11 | FUT Annex_22, FUT Annex_9, FUT Annex_10, FUT Annex_24, FUT Annex_30, FUT Annex_25, FUT Annex_28, FUT Annex_26, FUT Annex_11 | 3,325 | 90 | 125 | 6 | 0 | 221 | 350 | 18 | 18 | 18 | 13.47 | 26.13 | 1.21 | 0.00 | 40.81 | 3.40 | 2.50 | 45.85 | 68.37 | 114.21 | 0.29 | 64.12 | 178.33 |
| FUT NW_12 | FUT Annex_23 | 0 | 0 | 0 | 45 | 0 | 45 | 350 | 18 | 18 | 18 | 0.00 | 0.00 | 9.40 | 0.00 | 9.40 | 4.50 | 3.72 | 0.00 | 34.93 | 34.93 | 0.29 | 13.09 | 48.02 |
| FUT NW_13 | FUT Annex_11, FUT Annex_23, FUT Annex_22, FUT Annex_9, FUT Annex_10, FUT Annex_24, FUT Annex_30, FUT Annex_25, FUT Annex_28, FUT Annex_26 | 3,325 | 90 | 125 | 51 | 0 | 266 | 350 | 18 | 18 | 18 | 13.47 | 26.13 | 10.61 | 0.00 | 50.21 | 3.40 | 2.50 | 45.85 | 91.87 | 137.71 | 0.29 | 77.21 | 214.92 |
| FUT FM_6 | FUT Annex_11, FUT Annex_23, FUT Annex_22, FUT Annex_9, FUT Annex_10, FUT Annex_24, FUT Annex_30, FUT Annex_25, FUT Annex_28, FUT Annex_26 | 3,325 | 90 | 125 | 51 | 0 | 266 | 350 | 18 | 18 | 18 | 13.47 | 26.13 | 10.61 | 0.00 | 50.21 | 3.40 | 2.50 | 45.85 | 91.87 | 137.71 | 0.29 | 77.21 | 214.92 |
| FUT SW_1 | FUT Buildout_166, FUT Annex_11, FUT Annex_23, FUT Annex_22, FUT Annex_9, FUT Annex_10, FUT Annex_24, FUT Annex_30, FUT Annex_25, FUT Annex_28, FUT Annex_26 | 3,563 | 96 | 125 | 51 | 0 | 272 | 350 | 18 | 18 | 18 | 14.43 | 26.13 | 10.61 | 0.00 | 51.18 | 3.38 | 2.50 | 48.75 | 91.87 | 140.62 | 0.29 | 78.95 | 219.56 |
| FUT SW_2 | FUT Buildout_166, FUT Buildout_113, FUT Annex_11, FUT Annex_23, FUT Annex_22, FUT Annex_9, FUT Annex_10, FUT Annex_24, FUT Annex_30, FUT Annex_25, FUT Annex_28, FUT Annex_26 | 3,842 | 101 | 125 | 51 | 0 | 277 | 350 | 18 | 18 | 18 | 15.57 | 26.13 | 10.61 | 0.00 | 52.31 | 3.35 | 2.50 | 52.13 | 91.87 | 143.99 | 0.29 | 80.39 | 224.38 |
| FUT SW_3 | FUT Buildout_166, FUT Buildout_113, FUT Buildout_120, FUT Annex_11, FUT Annex_23, FUT Annex_22, FUT Annex_9, FUT Annex_10, FUT Annex_24, FUT Annex_30, FUT Annex_25, FUT Annex_28, FUT Annex_26 | 4,147 | 109 | 125 | 51 | 0 | 285 | 350 | 18 | 18 | 18 | 16.80 | 26.13 | 10.61 | 0.00 | 53.54 | 3.32 | 2.50 | 55.76 | 91.87 | 147.62 | 0.29 | 82.78 | 230.40 |
| FUT SW_4 | FUT Buildout_166, FUT Buildout_113, FUT Buildout_120, FUT Buildout_164, FUT Annex_11, FUT Annex_23, FUT Annex_22, FUT Annex_9, FUT Annex_10, FUT Annex_24, FUT Annex_30, FUT Annex_25, FUT Annex_28, FUT Annex_26 | 4,570 | 120 | 125 | 51 | 0 | 297 | 350 | 18 | 18 | 18 | 18.51 | 26.13 | 10.61 | 0.00 | 55.26 | 3.28 | 2.50 | 60.74 | 91.87 | 152.60 | 0.29 | 86.09 | 238.70 |
| FUT SW_5 | FUT Buildout_168 | 409 | 11 | 0 | 0 | 0 | 11 | 350 | 18 | 18 | 18 | 1.66 | 0.00 | 0.00 | 0.00 | 1.66 | 4.02 | 2.50 | 6.66 | 0.00 | 6.66 | 0.29 | 3.21 | 9.87 |
| FUT SW_6 | FUT Buildout_166, FUT Buildout_113, FUT Buildout_120, FUT Buildout_164, FUT Buildout_111, FUT Buildout_168, FUT Annex_11, FUT Annex_23, FUT Annex_22, FUT Annex_9, FUT Annex_10, FUT Annex_24, FUT Annex_30, FUT Annex_25, FUT Annex_28, FUT Annex_26 | 4,988 | 132 | 125 | 51 | 0 | 308 | 350 | 18 | 18 | 18 | 20.21 | 26.13 | 10.61 | 0.00 | 56.95 | 3.25 | 2.50 | 65.59 | 91.87 | 157.46 | 0.29 | 89.37 | 246.83 |
| FUT SW_7 | FUT Buildout_124 | 493 | 13 | 0 | 0 | 0 | 13 | 350 | 18 | 18 | 18 | 2.00 | 0.00 | 0.00 | 0.00 | 2.00 | 3.98 | 2.50 | 7.95 | 0.00 | 7.95 | 0.29 | 3.87 | 11.81 |
| FUT SW_8 | FUT Buildout_166, FUT Buildout_113, FUT Buildout_120, FUT Buildout_164, FUT Buildout_111, FUT Buildout_168, FUT Buildout_124, FUT Annex_11, FUT Annex_23, FUT Annex_22, FUT Annex_9, FUT Annex_10, FUT Annex_24, FUT Annex_30, FUT Annex_25, FUT Annex_28, FUT Annex_26 | 5,482 | 145 | 125 | 51 | 0 | 322 | 350 | 18 | 18 | 18 | 22.21 | 26.13 | 10.61 | 0.00 | 58.95 | 3.21 | 2.50 | 71.23 | 91.87 | 163.10 | 0.29 | 93.24 | 256.34 |
| FUT SW_9 | FUT Buildout_166, FUT Buildout_113, FUT Buildout_120, FUT Buildout_164, FUT Buildout_111, FUT Buildout_168, FUT Buildout_124, FUT Buildout_165, FUT Annex_11, FUT Annex_23, FUT Annex_22, FUT Annex_9, FUT Annex_10, FUT Annex_24, FUT Annex_30, FUT Annex_25, FUT Annex_28, FUT Annex_26 | 5,777 | 153 | 125 | 51 | 0 | 329 | 350 | 18 | 18 | 18 | 23.40 | 26.13 | 10.61 | 0.00 | 60.15 | 3.19 | 2.50 | 74.56 | 91.87 | 166.43 | 0.29 | 95.55 | 261.98 |
| FUT SW_10 | FUT Bulidout_131 | 1,977 | 53 | 0 | 0 | 0 | 53 | 350 | 18 | 18 | 18 | 8.01 | 0.00 | 0.00 | 0.00 | 8.01 | 3.59 | 2.50 | 28.74 | 0.00 | 28.74 | 0.29 | 15.49 | 44.24 |

| Pipe | PIPE DESIGN | | | | | | | | | | | FORCEMAIN DESIGN (TWIN PIPES) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | System Type | Pipe Roughness "n" | Min. Slope (m/m) | Design Flow ($Q_{design}$ / 0.86) (L/s) | Actual Pipe Size (mm) | Design Pipe Size (mm) | Pipe Size/Min. Slope Check | Full-Flow Capacity (L/s) | Full-Flow Pipe Area (m²) | Full-Flow Velocity (m/s) | Design Q-Capacity Check | Required Capacity (100% of $Q_{design}$) (L/s) | Required Capacity per FM (100% of $Q_{design}$) (L/s) | Design Velocity (m/s) | Actual Pipe Size (mm) | Design Pipe Size (mm) | Resultant Pipe Area (m²) | Resultant Velocity (m/s) |
| FUT NC_1 | Gravity | 0.013 | 0.004 | 3.3 | 99.9 | **200** | **OK** | 20.743555 | 0.031 | 0.66 | OK | | | | | | | |
| FUT NC_2 | Gravity | 0.013 | 0.0022 | 32.5 | 264.6 | **300** | **OK** | 45.356676 | 0.071 | 0.64 | OK | - | - | - | - | - | - | - |
| FUT NC_3 | Gravity | 0.013 | 0.0015 | 57.5 | 352.3 | **375** | **OK** | 67.905072 | 0.110 | 0.61 | OK | - | - | - | - | - | - | - |
| FUT NC_4 | Gravity | 0.013 | 0.0012 | 68.0 | 391.3 | **450** | **OK** | 98.763664 | 0.159 | 0.62 | OK | | | | | | | |
| FUT NC_5 | Gravity | 0.013 | 0.0012 | 69.4 | 394.2 | **450** | **OK** | 98.763664 | 0.159 | 0.62 | OK | - | - | - | - | - | - | - |
| FUT NC_6 | Gravity | 0.013 | 0.004 | 8.4 | 129.0 | **200** | **OK** | 20.743555 | 0.031 | 0.66 | OK | - | - | - | - | - | - | - |
| FUT NC_7 | Gravity | 0.013 | 0.004 | 8.6 | 143.8 | **200** | **OK** | 20.743555 | 0.031 | 0.66 | OK | - | - | - | - | - | - | - |
| FUT NC_8 | Gravity | 0.013 | 0.0028 | 17.9 | 202.4 | **250** | **OK** | 31.467258 | 0.049 | 0.64 | OK | - | - | - | - | - | - | - |
| FUT FM_4 | Forcemain | 0.013 | 0.0015 | - | - | - | - | - | - | - | - | 16.49 | 8.24 | 1.5 | 83.7 | **100** | 0.008 | 1.05 |
| FUT NC_9 | Gravity | 0.013 | 0.0012 | 95.9 | 445.1 | **450** | **OK** | 98.76 | 0.159 | 0.62 | OK | - | - | - | - | - | - | - |
| FUT NC_10 | Gravity | 0.013 | 0.0028 | 19.0 | 207.0 | **250** | **OK** | 31.467258 | 0.049 | 0.64 | OK | - | - | - | - | - | - | - |
| FUT NC_11 | Gravity | 0.013 | 0.0015 | 38.1 | 301.9 | **375** | **OK** | 67.905072 | 0.110 | 0.61 | OK | - | - | - | - | - | - | - |
| FUT NC_12 | Gravity | 0.013 | 0.0015 | 48.6 | 330.8 | **375** | **OK** | 67.905072 | 0.110 | 0.61 | OK | - | - | - | - | - | - | - |
| FUT NC_13 | Gravity | 0.013 | 0.0012 | 74.9 | 405.6 | **450** | **OK** | 98.763664 | 0.159 | 0.62 | OK | - | - | - | - | - | - | - |
| FUT NC_14 | Gravity | 0.013 | 0.0012 | 66.7 | 388.4 | **450** | **OK** | 98.763664 | 0.159 | 0.62 | OK | - | - | - | - | - | - | - |
| FUT NC_15 | Gravity | 0.013 | 0.0008 | 138.9 | 551.8 | **600** | **OK** | 173.66869 | 0.283 | 0.61 | OK | - | - | - | - | - | - | - |
| FUT NC_16 | Gravity | 0.013 | 0.004 | 18.6 | 192.0 | **200** | **OK** | 20.743555 | 0.031 | 0.66 | OK | - | - | - | - | - | - | - |
| FUT NC_17 | Gravity | 0.013 | 0.0015 | 51.0 | 336.8 | **375** | **OK** | 67.905072 | 0.110 | 0.61 | OK | - | - | - | - | - | - | - |
| FUT NC_18 | Gravity | 0.013 | 0.0008 | 169.0 | 593.8 | **600** | **OK** | 173.66869 | 0.283 | 0.61 | OK | - | - | - | - | - | - | - |
| FUT SE_13 | Gravity | 0.013 | 0.0012 | 63.3 | 380.8 | **450** | **OK** | 98.763664 | 0.159 | 0.62 | OK | - | - | - | - | - | - | - |
| FUT FM_5 | Forcemain | 0.013 | 0.001 | - | - | - | - | - | - | - | - | 54.42 | 27.21 | 1.5 | 152.0 | **200** | 0.031 | 0.87 |
| FUT SE_1 | Gravity | 0.013 | 0.0012 | 71.3 | 398.3 | **450** | **OK** | 98.763664 | 0.159 | 0.62 | OK | - | - | - | - | - | - | - |
| FUT SE_2 | Gravity | 0.013 | 0.004 | 10.6 | 155.5 | **200** | **OK** | 20.74 | 0.031 | 0.66 | OK | - | - | - | - | - | - | - |
| FUT SE_3 | Gravity | 0.013 | 0.004 | 5.4 | 120.7 | **200** | **OK** | 20.74 | 0.031 | 0.66 | OK | - | - | - | - | - | - | - |
| FUT SE_4 | Gravity | 0.013 | 0.004 | 15.5 | 179.5 | **200** | **OK** | 20.74 | 0.031 | 0.66 | OK | - | - | - | - | - | - | - |
| FUT FM_2 | Forcemain | 0.013 | 0.001 | - | - | - | - | - | - | - | - | 72.42 | 36.21 | 1.5 | 175.3 | **200** | 0.031 | 1.15 |
| FUT SE_5 | Gravity | 0.013 | 0.0012 | 84.2 | 423.9 | **450** | **OK** | 98.76 | 0.159 | 0.62 | OK | - | - | - | - | - | - | - |
| FUT SE_6 | Gravity | 0.013 | 0.0028 | 20.4 | 212.4 | **250** | **OK** | 31.47 | 0.049 | 0.64 | OK | - | - | - | - | - | - | - |
| FUT SE_7 | Gravity | 0.013 | 0.001 | 101.3 | 470.1 | **525** | **OK** | 136.00 | 0.216 | 0.63 | OK | - | - | - | - | - | - | - |
| FUT SE_8 | Gravity | 0.013 | 0.004 | 17.2 | 186.4 | **200** | **OK** | 20.74 | 0.031 | 0.66 | OK | - | - | - | - | - | - | - |
| FUT SE_9 | Gravity | 0.013 | 0.004 | 9.3 | 148.0 | **200** | **OK** | 20.74 | 0.031 | 0.66 | OK | - | - | - | - | - | - | - |
| FUT SE_10 | Gravity | 0.013 | 0.0028 | 25.8 | 232.0 | **250** | **OK** | 31.47 | 0.049 | 0.64 | OK | - | - | - | - | - | - | - |
| FUT SE_11 | Gravity | 0.013 | 0.0008 | 122.5 | 526.4 | **600** | **OK** | 173.67 | 0.283 | 0.61 | OK | - | - | - | - | - | - | - |
| FUT SE_12 | Gravity | 0.013 | 0.0008 | 148.7 | 566.0 | **600** | **OK** | 173.67 | 0.283 | 0.61 | OK | - | - | - | - | - | - | - |
| FUT FM_Lagoon | Forcemain | 0.013 | | - | - | - | - | - | - | - | - | 421.32 | 210.66 | 1.5 | 422.9 | **450** | 0.159 | 1.32 |
| FUT NW_1 | Gravity | 0.013 | 0.004 | 9.0 | 146.1 | **200** | **OK** | 20.743555 | 0.031 | 0.66 | OK | - | - | - | - | - | - | - |
| FUT NW_2 | Gravity | 0.013 | 0.0015 | 58.2 | 353.8 | **375** | **OK** | 67.905072 | 0.110 | 0.61 | OK | - | - | - | - | - | - | - |
| FUT NW_3 | Gravity | 0.013 | 0.004 | 13.1 | 168.6 | **200** | **OK** | 20.743555 | 0.031 | 0.66 | OK | - | - | - | - | - | - | - |
| FUT NW_4 | Gravity | 0.013 | 0.0015 | 63.1 | 364.9 | **375** | **OK** | 67.905072 | 0.110 | 0.61 | OK | - | - | - | - | - | - | - |
| FUT NW_5 | Gravity | 0.013 | 0.0012 | 82.6 | 420.8 | **450** | **OK** | 98.763664 | 0.159 | 0.62 | OK | - | - | - | - | - | - | - |
| FUT NW_6 | Gravity | 0.013 | 0.001 | 126.0 | 510.1 | **525** | **OK** | 135.99763 | 0.216 | 0.63 | OK | - | - | - | - | - | - | - |
| FUT NW_7 | Gravity | 0.013 | 0.0022 | 32.5 | 264.7 | **300** | **OK** | 45.356676 | 0.071 | 0.64 | OK | - | - | - | - | - | - | - |
| FUT NW_8 | Gravity | 0.013 | 0.0022 | 32.5 | 264.7 | **300** | **OK** | 45.356676 | 0.071 | 0.64 | OK | - | - | - | - | - | - | - |
| FUT NW_9 | Gravity | 0.013 | 0.0008 | 158.2 | 579.3 | **600** | **OK** | 173.66869 | 0.283 | 0.61 | OK | - | - | - | - | - | - | - |
| FUT NW_10 | Gravity | 0.013 | 0.0015 | 52.8 | 341.3 | **375** | **OK** | 67.905072 | 0.110 | 0.61 | OK | - | - | - | - | - | - | - |
| FUT NW_11 | Gravity | 0.013 | 0.0008 | 207.4 | 641.3 | **675** | **OK** | 237.75423 | 0.358 | 0.66 | OK | - | - | - | - | - | - | - |
| FUT NW_12 | Gravity | 0.013 | 0.0015 | 55.8 | 348.5 | **375** | **OK** | 67.905072 | 0.110 | 0.61 | OK | - | - | - | - | - | - | - |
| FUT NW_13 | Gravity | 0.013 | 0.0008 | 249.9 | 687.7 | **750** | **OK** | 314.88229 | 0.442 | 0.71 | OK | - | - | - | - | - | - | - |
| FUT FM_6 | Forcemain | 0.013 | 0.0008 | - | - | - | - | - | - | - | - | 214.92 | 107.46 | 1.5 | 302.0 | **375** | 0.110 | 0.97 |
| FUT SW_1 | Gravity | 0.013 | 0.0008 | 255.3 | 693.3 | **750** | **OK** | 314.88229 | 0.442 | 0.71 | OK | - | - | - | - | - | - | - |
| FUT SW_2 | Gravity | 0.013 | 0.0008 | 260.9 | 698.9 | **750** | **OK** | 314.88229 | 0.442 | 0.71 | OK | - | - | - | - | - | - | - |
| FUT SW_3 | Gravity | 0.013 | 0.0008 | 267.9 | 705.9 | **750** | **OK** | 314.88229 | 0.442 | 0.71 | OK | - | - | - | - | - | - | - |
| FUT SW_4 | Gravity | 0.013 | 0.0008 | 277.6 | 715.3 | **750** | **OK** | 314.88229 | 0.442 | 0.71 | OK | - | - | - | - | - | - | - |
| FUT SW_5 | Gravity | 0.013 | 0.004 | 11.5 | 160.2 | **200** | **OK** | 20.74 | 0.031 | 0.66 | OK | | | | | | | |
| FUT SW_6 | Gravity | 0.013 | 0.0008 | 287.0 | 724.4 | **750** | **OK** | 314.88229 | 0.442 | 0.71 | OK | - | - | - | - | - | - | - |
| FUT SW_7 | Gravity | 0.013 | 0.004 | 13.7 | 171.4 | **200** | **OK** | 20.743555 | 0.031 | 0.66 | OK | | | | | | | |
| FUT SW_8 | Gravity | 0.013 | 0.0008 | 298.1 | 734.7 | **750** | **OK** | 314.88229 | 0.442 | 0.71 | OK | - | - | - | - | - | - | - |
| FUT SW_9 | Gravity | 0.013 | 0.0008 | 304.6 | 740.8 | **750** | **OK** | 314.88229 | 0.442 | 0.71 | OK | - | - | - | - | - | - | - |
| FUT SW_10 | Gravity | 0.013 | 0.0015 | 51.4 | 337.9 | **375** | **OK** | 67.905072 | 0.110 | 0.61 | OK | - | - | - | - | - | - | - |

| Pipe | Contributing Service Area | Population: Residential (Persons) | Area: Residential (ha) | Area: Commercial (ha) | Area: Industrial (ha) | Area: Institutional (ha) | Area: Total (ha) | DWF Rate: Residential (L/p/d) | DWF Rate: Commercial $m^3/ha/d$ | DWF Rate: Industrial $m^3/ha/d$ | DWF Rate: Institutional $m^3/ha/d$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **FUT FM_1** | FUT Buildout_131, FUT Buildout_165, FUT Buildout_124, FUT Buildout_111, FUT Buildout_168, FUT Buildout_164, FUT Buildout_120, FUT Buildout_113, FUT Buildout_166, FUT Annex_23, FUT Annex_10, FUT Annex_11, FUT Annex_9, FUT Annex_22, FUT Annex_10, FUT Annex_24, FUT Annex_30, FUT Annex_25, FUT Annex_28, FUT Annex_26 | 7,753 | 207 | 125 | 51 | 0 | 383 | 350 | 18 | 18 | 18 |
| **FUT NE_1** | FUT Buildout_11 | 371 | 3 | 0 | 0 | 0 | 2.95 | 350 | 18 | 18 | 18 |
| **FUT NE_2** | FUT Buildout_12 | 435 | 3 | 0 | 0 | 0 | 3.45 | 350 | 18 | 18 | 18 |
| **FUT NE_3** | FUT Buildout_11 & FUT Buildout_12 | 806 | 6 | 0 | 0 | 0 | 6.40 | 350 | 18 | 18 | 18 |
| **FUT NE_4** | FUT Buildout_11, FUT Buildout_12 & FUT Buildout_6 | 2,992 | 38 | 0 | 0 | 0 | 37.90 | 350 | 18 | 18 | 18 |
| **FUT NE_5** | FUT Buildout_40 | 711 | 10 | 0 | 0 | 0 | 10.25 | 350 | 18 | 18 | 18 |
| **FUT NE_6** | FUT Buildout_11, FUT Buildout_12, FUT Buildout_6, FUT Buildout_40 | 3,703 | 48 | 0 | 0 | 0 | 48.15 | 350 | 18 | 18 | 18 |
| **FUT NE_7** | FUT Buildout_10 | 404 | 3 | 0 | 0 | 0 | 3.21 | 350 | 18 | 18 | 18 |
| **FUT NE_8** | FUT Buildout_11, FUT Buildout_12, FUT Buildout_6, FUT Buildout_40 & FUT Buildout_10 | 4,107 | 51 | 0 | 0 | 0 | 51.35 | 350 | 18 | 18 | 18 |
| **FUT NE_9** | FUT Buildout_16 | 239 | 3 | 0 | 0 | 0 | 3.45 | 350 | 18 | 18 | 18 |
| **FUT FM_3** | FUT Buildout_11, FUT Buildout_12, FUT Buildout_6, FUT Buildout_40, FUT Buildout_10, FUT Buildout_16 & FUT Buildout_9 | 4,347 | 55 | 0 | 0 | 5 | 59.80 | 350 | 18 | 18 | 18 |

| Pipe | Average DWF (L/s): Residential | Average DWF (L/s): Commercial | Average DWF (L/s): Industrial | Average DWF (L/s): Institutional | Average DWF (L/s): Total | Peaking Factors: Residential | Peaking Factors: Non-Residential | RES Peak DWF (L/s) | Non-RES Peak DWF (L/s) | Total Peak DWF (L/s) | I-I Flow Rate (L/s/ha) | Inflow - Infiltration (L/s) | Total Peak WWF (L/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **FUT FM_1** | 31.41 | 26.13 | 10.61 | 0.00 | 68.15 | 3.06 | 2.50 | 96.22 | 91.87 | 188.09 | 0.29 | 111.05 | 299.13 |
| **FUT NE_1** | 1.50 | 0 | 0 | 0 | 1.50 | 4.04 | 2.50 | 6.07 | 0 | 6.07 | 0.29 | 0.85 | 6.92 |
| **FUT NE_2** | 1.76 | 0 | 0 | 0 | 1.76 | 4.00 | 2.50 | 7.05 | 0 | 7.05 | 0.29 | 1.00 | 8.05 |
| **FUT NE_3** | 3.26 | 0 | 0 | 0 | 3.26 | 3.86 | 2.50 | 12.59 | 0 | 12.59 | 0.29 | 1.85 | 14.45 |
| **FUT NE_4** | 12.12 | 0 | 0 | 0 | 12.12 | 3.44 | 2.50 | 41.74 | 0 | 41.74 | 0.29 | 10.99 | 52.73 |
| **FUT NE_5** | 2.88 | 0 | 0 | 0 | 2.88 | 3.89 | 2.5 | 11.21 | 0 | 11.21 | 0.29 | 2.97 | 14.18 |
| **FUT NE_6** | 15.00 | 0 | 0 | 0 | 15.00 | 3.36 | 2.5 | 50.45 | 0 | 50.45 | 0.29 | 13.96 | 64.41 |
| **FUT NE_7** | 1.64 | 0 | 0 | 0 | 1.64 | 4.02 | 2.5 | 6.58 | 0 | 6.58 | 0.29 | 0.93 | 7.51 |
| **FUT NE_8** | 16.64 | 0 | 0 | 0 | 16.64 | 3.32 | 2.5 | 55.29 | 0 | 55.29 | 0.29 | 14.89 | 70.18 |
| **FUT NE_9** | 0.97 | 0 | 0 | 0 | 0.97 | 4.12 | 2.5 | 3.99 | 0 | 3.99 | 0.29 | 1.00 | 5.00 |
| **FUT FM_3** | 17.61 | 0 | 0 | 1.04 | 18.65 | 3.30 | 10 | 58.12 | 10.42 | 68.54 | 0.29 | 17.34 | 85.88 |

| Pipe | PIPE DESIGN: System Type | Pipe Roughness "n" | Min. Slope (m/m) | Design Flow ($Q_{design}$ / 0.86) (L/s) | Actual Pipe Size (mm) | Design Pipe Size (mm) | Pipe Size/Min. Slope Check | Full-Flow Capacity (L/s) | Full-Flow Pipe Area ($m^2$) | Full-Flow Velocity (m/s) | Design Q - Capacity Check | FORCEMAIN DESIGN (TWIN PIPES): Required Capacity (100% of $Q_{design}$) (L/s) | Required Capacity per FM (100% of $Q_{design}$) (L/s) | Design Velocity (m/s) | Actual Pipe Size (mm) | Design Pipe Size (mm) | Resultant Pipe Area ($m^2$) | Resultant Velocity (m/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **FUT FM_1** | Forcemain | 0.013 | 0.004 | - | - | - | - | - | - | - | - | 299.13 | 149.57 | 1.5 | 356.3 | **375** | 0.110 | 1.35 |
| **FUT NE_1** | Gravity | 0.013 | 0.004 | 8.1 | 140.2 | 200 | OK | 20.743555 | 0.031 | 0.660 | OK | - | - | - | - | - | - | - |
| **FUT NE_2** | Gravity | 0.013 | 0.004 | 9.4 | 148.4 | 200 | OK | 20.743555 | 0.031 | 0.660 | OK | | | | | | | |
| **FUT NE_3** | Gravity | 0.013 | 0.004 | 16.8 | 184.8 | 200 | OK | 20.743555 | 0.031 | 0.660 | OK | - | - | - | - | - | - | - |
| **FUT NE_4** | Gravity | 0.013 | 0.0015 | 61.3 | 360.9 | 375 | OK | 67.905072 | 0.110 | 0.615 | OK | - | - | - | - | - | - | - |
| **FUT NE_5** | Gravity | 0.013 | 0.004 | 16.5 | 183.5 | 200 | OK | 20.743555 | 0.031 | 0.660 | OK | - | - | - | - | - | - | - |
| **FUT NE_6** | Gravity | 0.013 | 0.0012 | 74.9 | 405.7 | 450 | OK | 98.763664 | 0.159 | 0.621 | OK | - | - | - | - | - | - | - |
| **FUT NE_7** | Gravity | 0.013 | 0.004 | 8.7 | 144.6 | 200 | OK | 20.743555 | 0.031 | 0.660 | OK | - | - | - | - | - | - | - |
| **FUT NE_8** | Gravity | 0.013 | 0.0012 | 81.6 | 418.9 | 450 | OK | 98.763664 | 0.159 | 0.621 | OK | - | - | - | - | - | - | - |
| **FUT NE_9** | Gravity | 0.013 | 0.004 | 5.8 | 124.1 | 200 | OK | 20.743555 | 0.031 | 0.660 | OK | - | - | - | - | - | - | - |
| **FUT FM_3** | Forcemain | 0.013 | 0.001 | - | - | - | - | - | - | - | - | 85.88 | 42.94 | 1.50 | 190.91 | 200.00 | 0.03 | 1.37 |

APPENDIX

D

Detailed Cost Estimate Breakdown

| Detailed Breakdown of Cost Estimates - Future Conditions - Servicing Concepts | | | | | | | |
|---|---|---|---|---|---|---|---|
| Item | Quantity | Units | Unit Cost | Sub-Total | Contingency (30%) | Engineering (15%) | Total Cost |
| 200mm Gravity Sewer | 3,091 | Metres | $ 390.00 | $1,205,619 | $361,686 | $180,843 | $1,748,000 |
| 250mm Gravity Sewer | 674 | Metres | $ 400.00 | $269,586 | $80,876 | $40,438 | $391,000 |
| 300mm Gravity Sewer | 845 | Metres | $ 450.00 | $380,309 | $114,093 | $57,046 | $551,000 |
| 375mm Gravity Sewer | 4,197 | Metres | $ 500.00 | $2,098,588 | $629,576 | $314,788 | $3,043,000 |
| 450mm Gravity Sewer | 2,880 | Metres | $ 600.00 | $1,728,250 | $518,475 | $259,238 | $2,506,000 |
| 525mm Gravity Sewer | 659 | Metres | $ 690.00 | $454,883 | $136,465 | $68,232 | $660,000 |
| 600mm Gravity Sewer | 2,448 | Metres | $ 790.00 | $1,934,083 | $580,225 | $290,112 | $2,804,000 |
| 675mm Gravity Sewer | 709 | Metres | $ 925.00 | $656,095 | $196,829 | $98,414 | $951,000 |
| 750mm Gravity Sewer | 2,216 | Metres | $ 1,025.00 | $2,271,894 | $681,568 | $340,784 | $3,294,000 |
| 900mm Gravity Sewer | 2,974 | Metres | $ 1,220.00 | $3,628,114 | $1,088,434 | $544,217 | $5,261,000 |
| 100mm Forcemain | 1,419 | Metres | $ 375.00 | $532,306 | $159,692 | $79,846 | $772,000 |
| 200mm Forcemain | 3,770 | Metres | $ 500.00 | $1,884,988 | $565,496 | $282,748 | $2,733,000 |
| 375mm Forcemain | 5,336 | Metres | $ 725.00 | $3,868,443 | $1,160,533 | $580,266 | $5,609,000 |
| 450mm Forcemain | 4,403 | Metres | $ 850.00 | $3,742,611 | $1,122,783 | $561,392 | $5,427,000 |
| 150mm Siphon* | 117 | Metres | $ 375.00 | $43,875 | $13,163 | $6,581 | $64,000 |
| Siphon Trenchless Pits* | 1 | Pairs | $ 75,000.00 | $75,000 | $22,500 | $11,250 | $109,000 |
| FUT LS_1 (300 L/s) | 1 | Items | $ 4,375,000.00 | $4,375,000 | $1,312,500 | $656,250 | $6,344,000 |
| FUT LS_2 (73 L/s) | 1 | Items | $ 1,500,000.00 | $1,500,000 | $450,000 | $225,000 | $2,175,000 |
| FUT LS_3 (86 L/s) | 1 | Items | $ 1,700,000.00 | $1,700,000 | $510,000 | $255,000 | $2,465,000 |
| FUT LS_4 (17 L/s) | 1 | Items | $ 340,000.00 | $340,000 | $102,000 | $51,000 | $493,000 |
| FUT LS_5 (55 L/s) | 1 | Items | $ 1,100,000.00 | $1,100,000 | $330,000 | $165,000 | $1,595,000 |
| FUT LS_6 (215 L/s) | 1 | Items | $ 3,630,000.00 | $3,630,000 | $1,089,000 | $544,500 | $5,264,000 |
| FUT LS_Lagoon (422 L/s) | 1 | Items | $ 5,415,000.00 | $5,415,000 | $1,624,500 | $812,250 | $7,852,000 |
| **Ultimate Servicing Concept Sub-Total:** | | | | **$42,716,000** | **$12,814,000** | **$6,407,000** | **$61,938,000** |

*Not included in the cost total - Only included if future grading triggers the need for siphon.