6.0 Existing System Assessment and Upgrades

6.1 Analysis of Existing Sanitary System

The results of the four existing system level of service scenarios are detailed in Sections 6.1.1, 6.1.2, 6.1.3 and 6.1.4, for the I-I of 0.29 L/s/ha, I-I of 0.60 L/s/ha, the 25 year 24 hour Q3 Huff Storm and the 50 year 24 hour Q3 Huff Storm, respectively. Longitudinal profiles of major trunks are provided in Appendix D; a longitudinal profile key plan can be viewed in Figures 6.1 and 6.2 for Cold Lake North and Cold Lake South, respectively.

6.1.1 Existing Plus I-I of 0.29 L/s/ha

The results of the constant I-I rate of 0.29 L/s/ha scenario are illustrated in Figures 6.3 to 6.6 for maximum HGL and peak discharge relative to sewer capacity, and spare capacity in Cold Lake North and Cold Lake South, respectively. The review of the derived maximum HGL elevation relative to ground and peak discharge relative to sewer capacity relationships, in conjunction with the associated spare capacities suggests that the sanitary collection system generally performs very well under this assessment scenario. A description of the areas of concern with respect to the gravity system are below in Table 6.1. Please note that sewer sections in other locations not listed in the table, which at first glance may seem to have inadequate capacity based on all or a combination of the individual assessment relationships, were determined to perform adequately once a closer look at corresponding longitudinal profiles was undertaken.

Table 6.1: Affected Sewer Sections under a Constant I-I Rate of 0.29 L/s/ha Event

Section ID	Associated Longitudinal Profile(s) (LP)	Location	Affected Sizes	Section Length	Comments
			mm	m	
1	LP #N2.1, LP#N2.2	North	400	1,210	Maximum HGL elevated due to constraint in the downstream 400 mm section of trunk between 23rd Street and 28th Street. It is noted that this section of sewer is still below the 3 m to ground surface target and is in a green space, therefore is less of a concern.
2	LP #N4.1	North	200, 250, 300, 350	641	The relatively flat maximum HGL suggests that the surcharge condition is due to the lack of pumping capacity at the BLDG 3 Lift Station. It is noted that following modelling this scenario with a free outfall condition at the BLDG 3 Lift Station, it was evident that the capacity constraints were indeed at the lift station, as the noted issues were no longer observed.
3	LP #N3.1	North	200, 375, 450, 900	250	

6.1.2 Existing Plus I-I of 0.60 L/s/ha

The results of the constant I-I rate of 0.60 L/s/ha scenario are illustrated in Figures 6.7 to 6.10 for maximum HGL and peak discharge relative to sewer capacity, and spare capacity in Cold Lake North and Cold Lake South, respectively. Generally speaking, the existing system performs adequately under this scenario. A description of the areas of concern with respect to the gravity system are below in Table 6.2. Please note that sewer sections in other locations not listed in the table, which at first glance may seem to have inadequate capacity based on all or a combination of the individual assessment relationships, were determined to perform adequately once a closer look at corresponding longitudinal profiles was undertaken.

Table 6.2: Affected Sewer Sections under a Constant I-I Rate of 0.60L/s/ha Event

Section ID	Associated Longitudinal Profile(s)	Location	Affected Sizes (mm)	Section Length (m)	Comments
1	LP #N2.1, LP #N2.2	North	400	1,210	Maximum HGL elevated due to constraint in the downstream 400 mm section of trunk between 23rd Street and 28th Street. It is noted that this section of sewer is still below the 3 m to ground surface target and is in a green space, therefore is less concerning.
2	LP #N4.1, LP #N3.1, N/A	North	200, 250, 300, 350, 375, 450, 900	1,281	The relatively flat maximum HGL suggests that the surcharge condition is due to the lack of pumping capacity at the BLDG 3 Lift Station. It is noted that following modelling this scenario with a free outfall condition at the BLDG 3 Lift Station, it was evident that the capacity constraints were indeed at the lift station, as the noted issues were no longer observed.
3	LP #S1.3, LP #S2.1, LP #S2.2, LP #S3.1, LP #S4.1, LP #S5.2, LP #5.3, LP #S6.1, LP #S7.1	South	250, 300, 375, 450, 500, 525, 600, 750	7,995	A large portion of the sewers in Cold Lake South have elevated HGLs. The relatively flat maximum HGL suggests that the surcharge condition is due to the lack of pumping capacity at the BLDG 9 Lift Station. It is noted that following modelling this scenario with a free outfall condition at the BLDG 9 Lift Station, it was evident that the capacity constraints were indeed at the lift station, as the noted issues were no longer observed.

6.1.3 Existing Plus 1 in 25-year 24-hour 3rd Quartile Huff Storm

The results of the 25 year 24 hour Q3 Huff Storm scenario are illustrated in Figures 6.11 to 6.14 for maximum HGL and peak discharge relative to sewer capacity, and spare capacity, for Cold Lake North and South, respectively. Generally speaking, the existing system performs well under this scenario. As a result, there are no major areas of concern to note. Any sewers which at first glance may seem to have inadequate capacity based on all or a combination of the individual assessment relationships, were determined to perform adequately once a closer look at corresponding longitudinal profiles was undertaken.

6.1.4 Existing Plus 1 in 50-year 24-hour 3rd Quartile Huff Storm

The results of the 50 year 24 hour Q3 Huff Storm scenario are illustrated in Figures 6.15 to 6.18 for maximum HGL and peak discharge relative to sewer capacity, and spare capacity, for Cold Lake North and South, respectively. Generally speaking, the existing system performs well under this scenario. A description of the areas of concern with respect to the gravity system are below in Table 6.3. Please note that sewer sections in other locations not listed in the table, which at first glance may seem to have inadequate capacity based on all or a combination of the individual assessment relationships, were determined to perform adequately once a closer look at corresponding longitudinal profiles was undertaken.

Table 6.3: Affected Sewer Sections under a 50 Year 24 Hour Q3 Huff Storm Event

Section ID	Associated Longitudinal Profile(s)	Location	Affected Sizes (mm)	Section Length (m)	Comments
1	LP #N3.1	North	375	41	The relatively flat maximum HGL suggests that the surcharge condition is due to the lack of pumping capacity at the BLDG 3 Lift Station. This capacity constraint quickly dissipates upstream. It is noted that following modelling this scenario with a free outfall condition at the BLDG 3 Lift Station, it was evident that the capacity constraints were indeed at the lift station, as the noted issues were no longer observed.

6.1.5 Pressurized System

The dry weather and wet weather flow results for the City's six major forcemains are presented in Tables 6.4 and 6.5 below.

Table 6.4: Forcemain Dry Weather Flow Results

Name	Type	Peak DWF		Meets Design Criteria?
		Velocity	Flow	
		m/s	L/s	
Building 1 FM	300 mm PVC	1.78	126	Yes
Building 3 FM	300 mm PVC	0.87	61	Marginal Fail
Building 4 FM	500 mm PVC	0.54	86	No
Building 8 FM	350 mm PVC	1.77	170	Yes
Building 9 FM	900 mm PVC	0.59	378	No
	800 mm PE	1.08	544	Yes

The model results suggests that the target instantaneous velocity of 1.0 m/s is generally met under the peak DWF and WWF conditions for Building 1 forcemain, Building 8 forcemain, and the 800 mm polyethylene forcemain at Building 9, with the Building 3 forcemain recording value marginally below it. The velocities in the Building 4 forcemain as well as the 900 mm PVC forcemain at Building 9 do not fall within the recommended velocity range of 1.0 to 3.0 m/s. For velocities below the recommended minimum velocity of 1.0 m/s, it is possible that sedimentation along the forcemain could occur over time, or potentially has already occurred.

It is recommended that the City makes an inquiry with Public Works to confirm if there are any current issues pertaining to the observed pumping flows both under day-to-day conditions and wet periods during rainfall events. If not, the City may simply monitor the performance of the system until the observed discharge drops over time indicating potential issues with the forcemains or pumps. Otherwise, the City may wish to perform further analysis on the forcemains' hydraulics in order to determine if the Building 3, Building 4, and 900 mm Building 9 forcemains are candidates for pigging of the forcemains to increase the capacity of the forcemains.

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Table 6.5: Forcemain Wet Weather Flow Results

Name	Forcemain Type	Capacity at 2.0 m/s	Peak WWF (L/s)				Resultant Velocity (m/s)			
			0.29 L/s/ha	0.60 L/s/ha	25yr 24hr Q3 Huff	50yr 24hr Q3 Huff	0.29 L/s/ha	0.60 L/s/ha	25yr 24hr Q3 Huff	50yr 24hr Q3 Huff
Building 1 FM	300mm PVC	141	126	126	126	126	1.78	1.78	1.78	1.78
Building 3 FM	300mm PVC	141	61	61	61	61	0.87	0.87	0.87	0.87
Building 4 FM	500mm PVC	393	283	283	151	157	1.44	1.44	0.86	0.88
Building 8 FM	350mm PVC	192	219	219	219	219	2.27	2.27	2.27	2.27
Building 9 FM	900mm PVC	1272	200	200	318	378	0.31	0.31	0.5	0.59
	800mm PE	1005	95	95	563	584	0.19	0.19	1.12	1.16

6.2 Recommended Existing System Upgrades

On the basis of the existing system assessment, upgrades to rectify areas of concern were developed. Figure 6.19 shows the identified upgrades. Improvements to the sanitary system have been detailed in the following table, Table 6.6.

Table 6.6: Recommended Upgrades to the Existing Sanitary System

Map ID	Triggered Design Storm	Location	Upgrade
EX Upgrade 1 & 2	• Constant I-I of 0.29 L/s/ha • Constant I-I of 0.60 L/s/ha • 25yr 24hr Q3 Huff Storm • 50yr 24hr Q3 Huff Storm	10th Street between 7th Avenue and 8th Avenue & Corner of Tamarak Street and Pine Avenue	• Install pressure gauges at all headers at both the Building 1 and Building 3 Lift Stations.
EX Upgrade 3	• Constant I-I of 0.29 L/s/ha • Constant I-I of 0.60 L/s/ha	10th Street between 7th Avenue and 8th Avenue	• Upgrade the capacity of the Building 3 Lift Station by 15 L/s, for a total capacity of 76 L/s.

EX Upgrade 3 is proposed based on the pump capacities determined during the 2016 drawdown tests. During 2018, a higher pumping capacity of 112.23L/s (assuming both pumps on) was recorded. This is a difference of 50.97L/s compared to the 61.26L/s that was recorded in 2016. Note that the second measurement was obtained with the installation of the pressure gauge. Due to the large discrepancy between the two tests, it is recommended that the upgrade is postponed until further analysis is completed at the Building 3 Lift Station to determine the cause of the large variance.

Under assessment of the growth horizons, this lift station must be further upgraded to provide an ultimate pumping capacity of 86 L/s (upgraded by 5 L/s for a total capacity of 81 L/s in Stage 1, and upgraded by another 5 L/s for a total capacity of 86 L/s in Stage 2). If the City chooses to implement this upgrade, it is recommended that a single upgrade of 25 L/s for a total capacity of 86 L/s is made instead of choosing a staged approach. The proposed forcemain extension from Building 3 to Building 4 Lift Station as stipulated under the growth conditions will result in higher a Total Dynamic Head (TDH) required to convey the estimated future peak wet weather flows due to an increase in frictional and minor losses. A more detailed analysis should be undertaken as recommended below.

It is important to note that although capacity constraints are present in the Building 3 Lift Station, these issues only arise under the constant I-I of 0.29 L/s/ha and constant I-I of 0.60 L/s/ha scenarios. Typically, constant I-I rate scenarios are not used to test the performance of lift stations and forcemains, as the ensuing indefinite inflow rate is likely to always inundate each pumping facility.

6.3 Cost Estimates – Recommended Existing System Upgrades

A summary of the costs associated with the recommended existing system upgrades are detailed below in Table 6.7. A full breakdown of the costs has been provided in Appendix E.

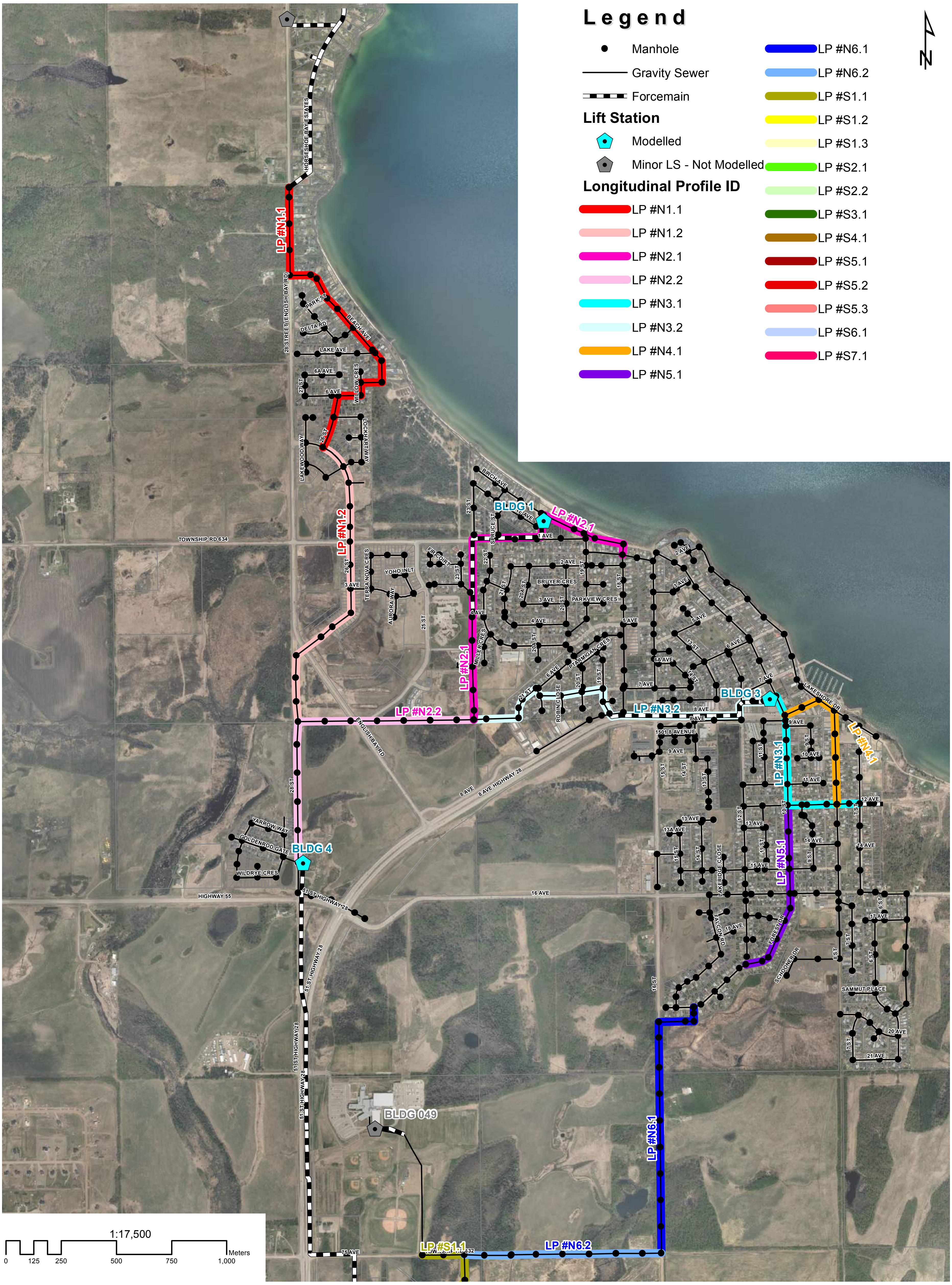
Table 6.7: Class D Cost Estimates for Recommended Upgrades to the Existing Sanitary System

Item Number	Upgrade	Total Cost
EX Upgrade 1	Pressure Gauge at BLDG 1 LS	$7,250
EX Upgrade 2	Pressure Gauge at BLDG 3 LS	$7,250
EX Upgrade 3[1]	BLDG 3 Lift Station Upgrade – 76 L/s from 61 L/s (Additional 15 L/s)	$217,500[2]
	Total	**$232,000**[2]

[1] *Further investigation is required in order to determine the exact pumping capacity at the Building 3 Lift Station due to discrepancies observed between the two drawdown tests.*

[2] *This lift station is further upgraded to a total pumping capacity of 86 L/s under the future growth horizons. If the City decides to upgrade this lift station to the required ultimate pumping capacity, the cost would be in the range of $365,000. To accommodate the lower intermediate flows, an appropriate VFD setting should be used.*

FIGURE 6.1



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SANITARY COLLECTION SYSTEM
EXISTING NETWORK - NORTH
LONGITUDINAL PROFILE KEY PLAN

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Date: 10/19/2017 Document: M:\26300\26367_Cold_Lake_I-I_Program\02_CADD\20_Drafting\201_GIS Figures\6.0 Existing System Assessment\Figure 6.1 - LP Profile Map_North.mxd

FIGURE 6.2

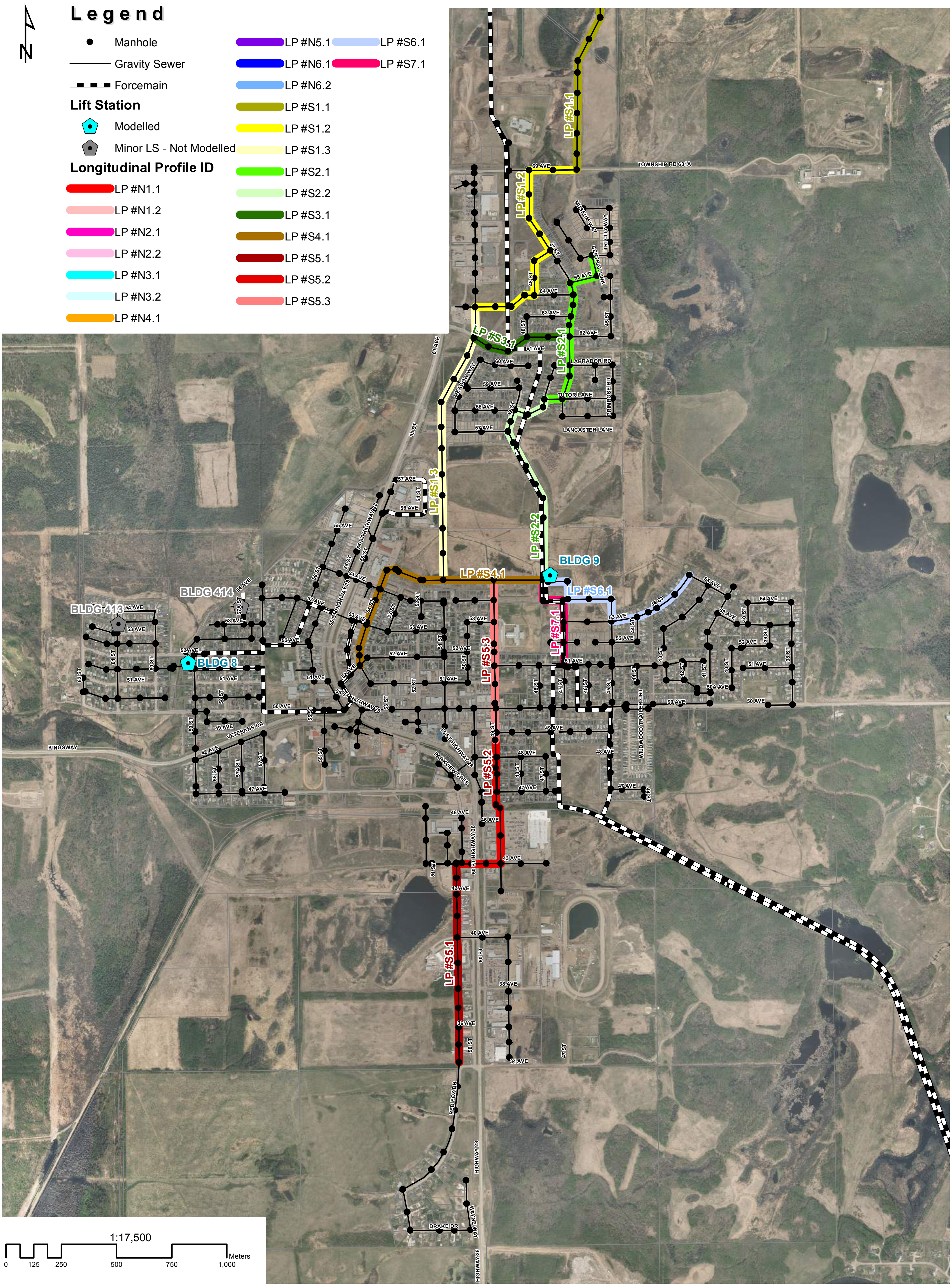

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FIGURE 6.3

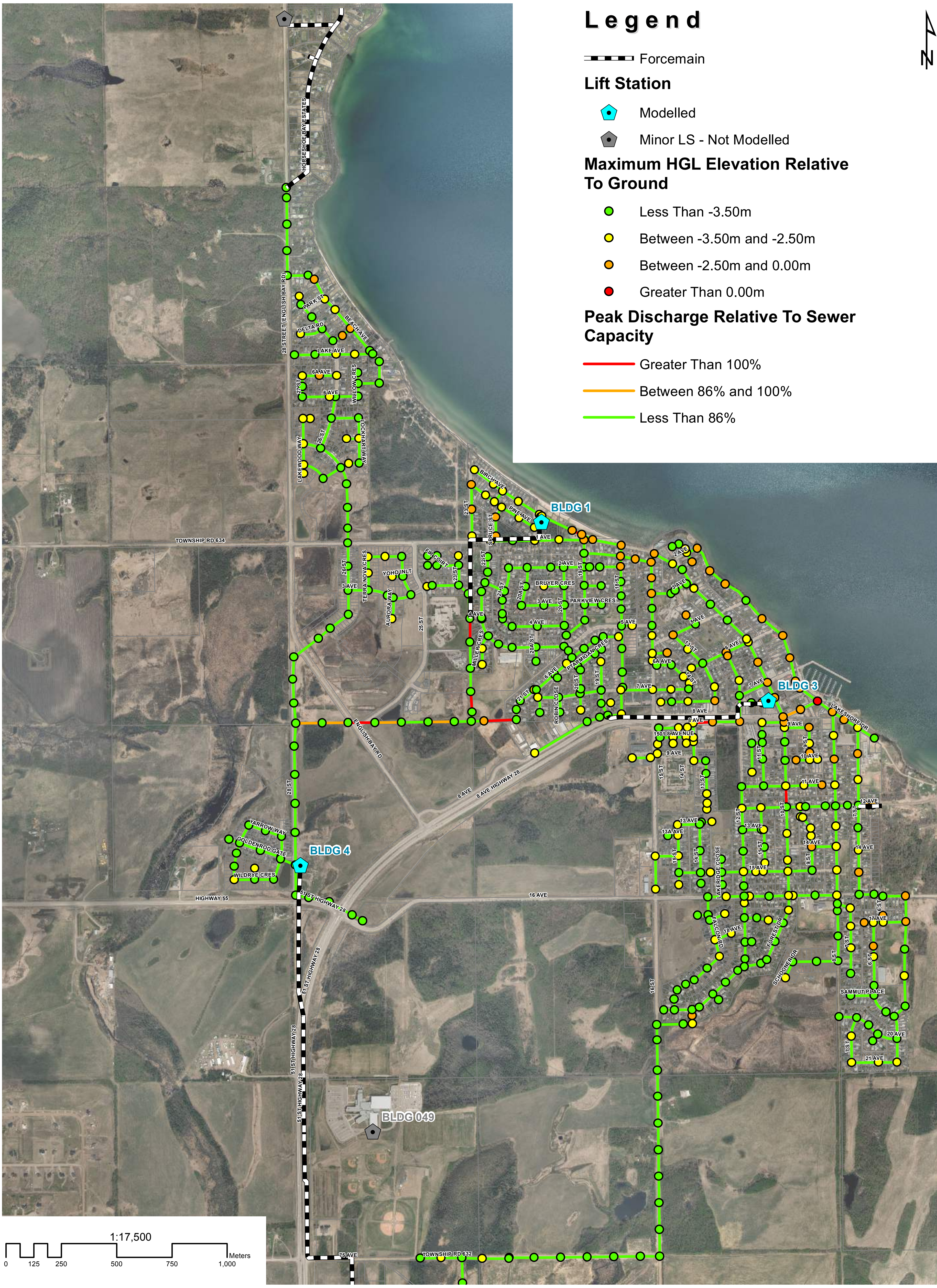

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FIGURE 6.4

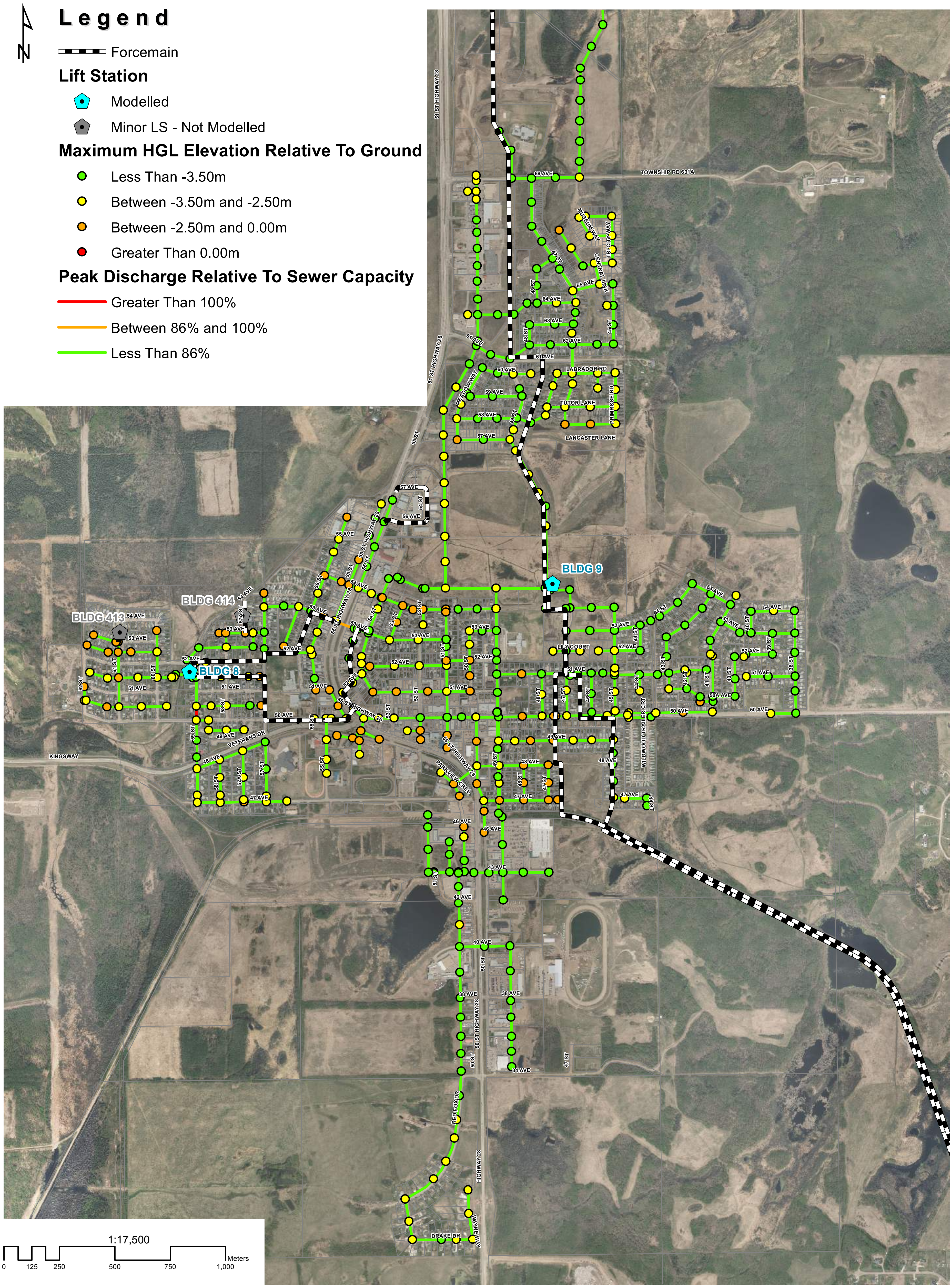

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FIGURE 6.5

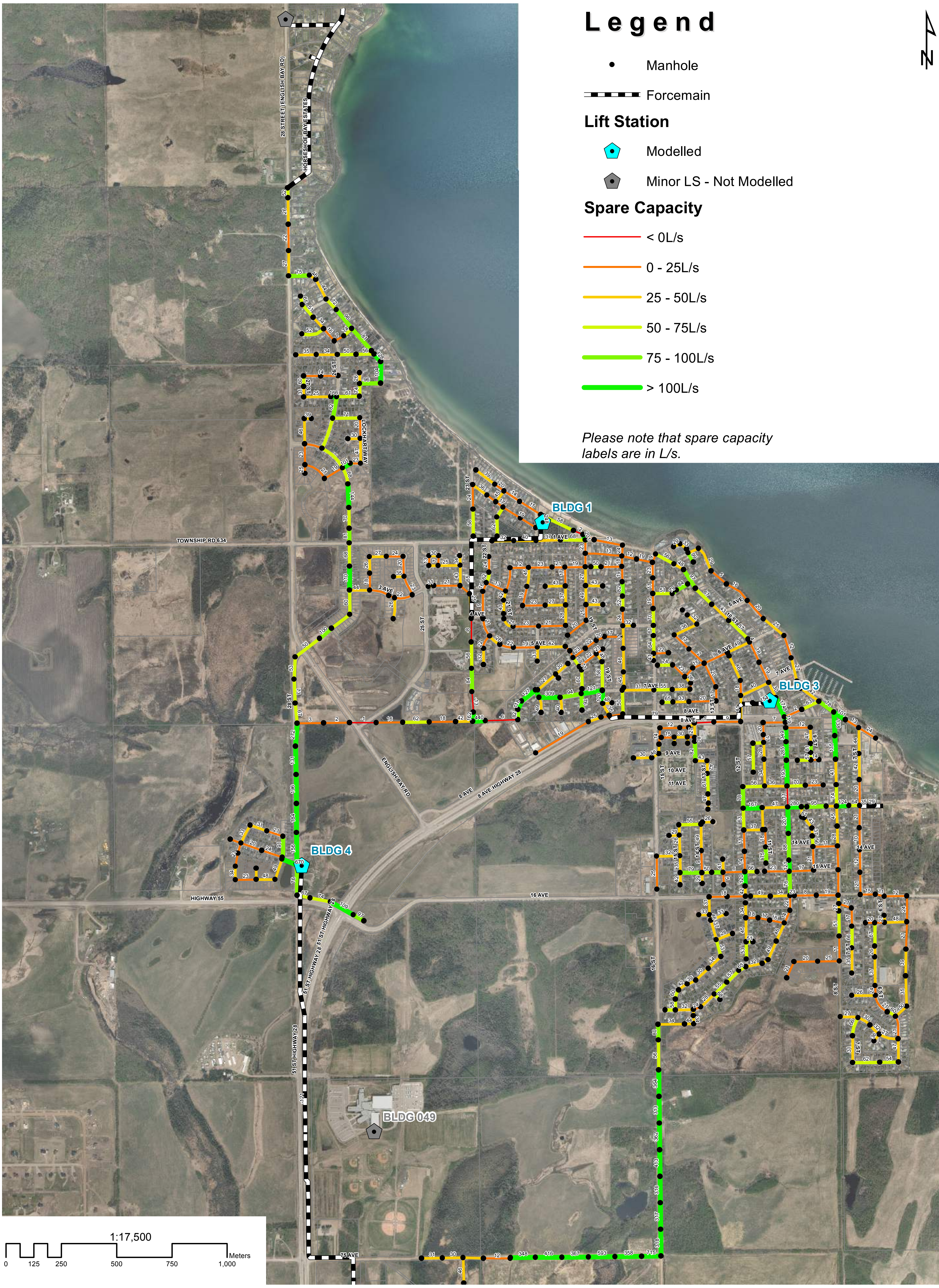

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FIGURE 6.6

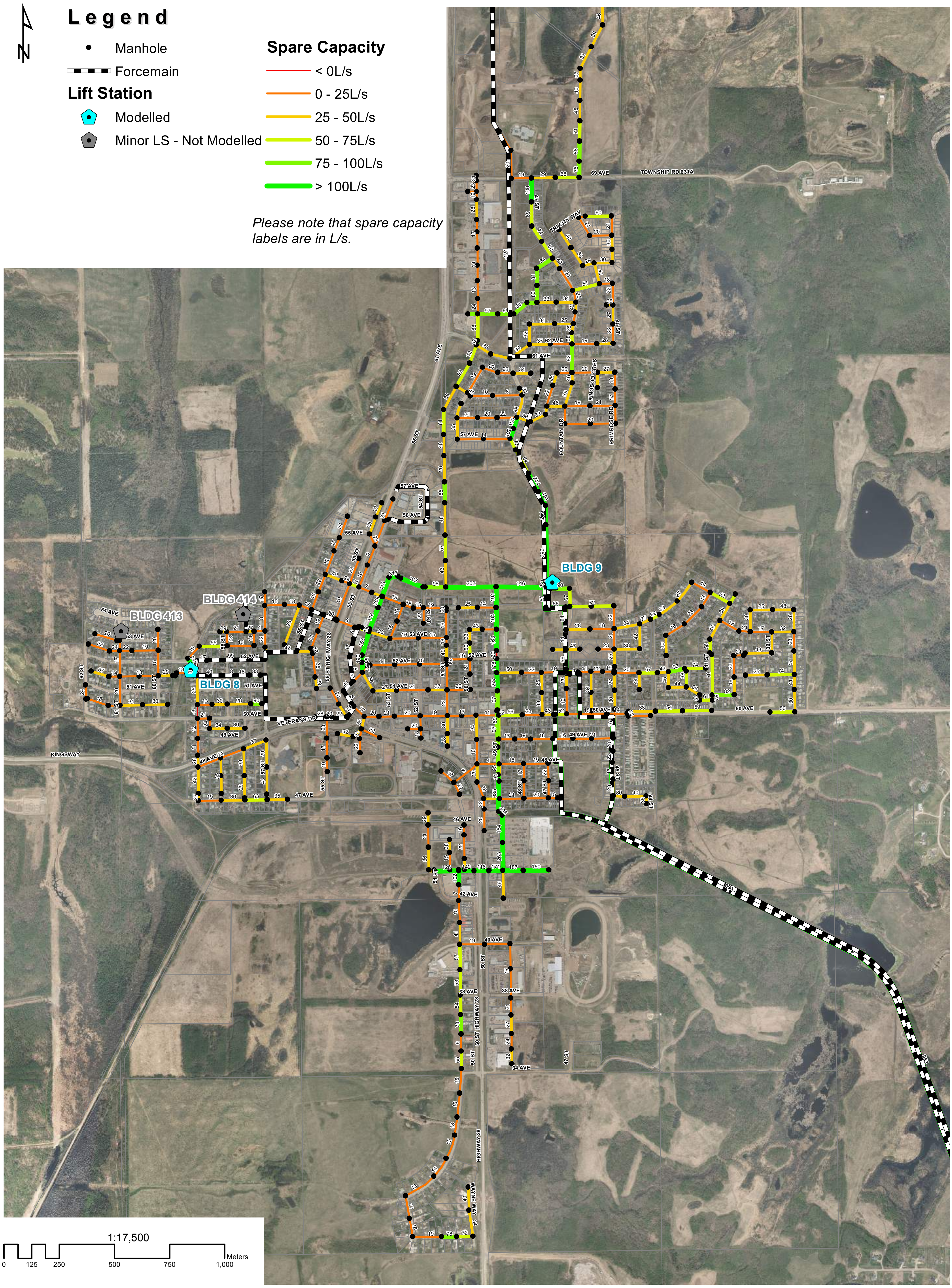

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FIGURE 6.7

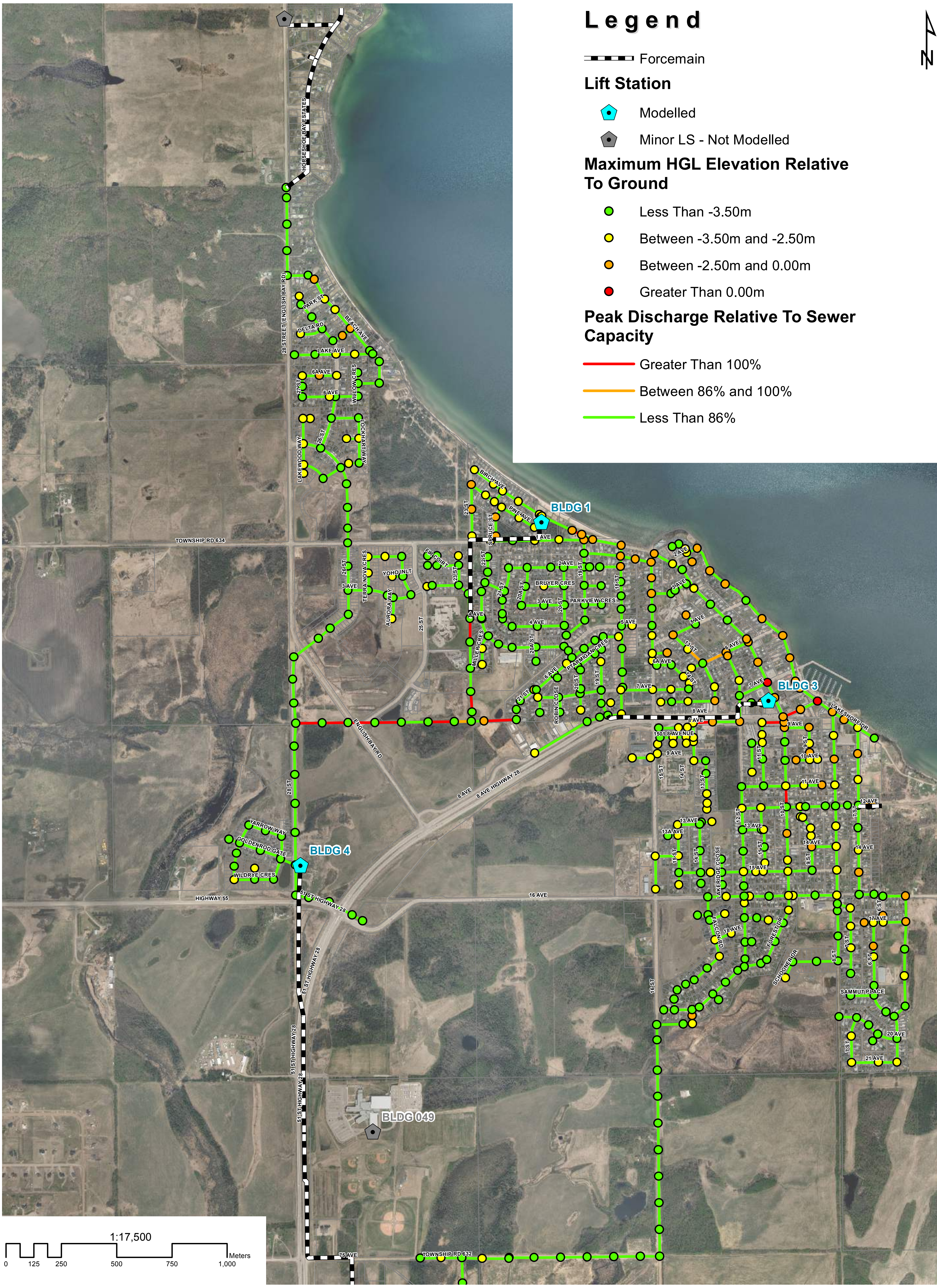

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FIGURE 6.8

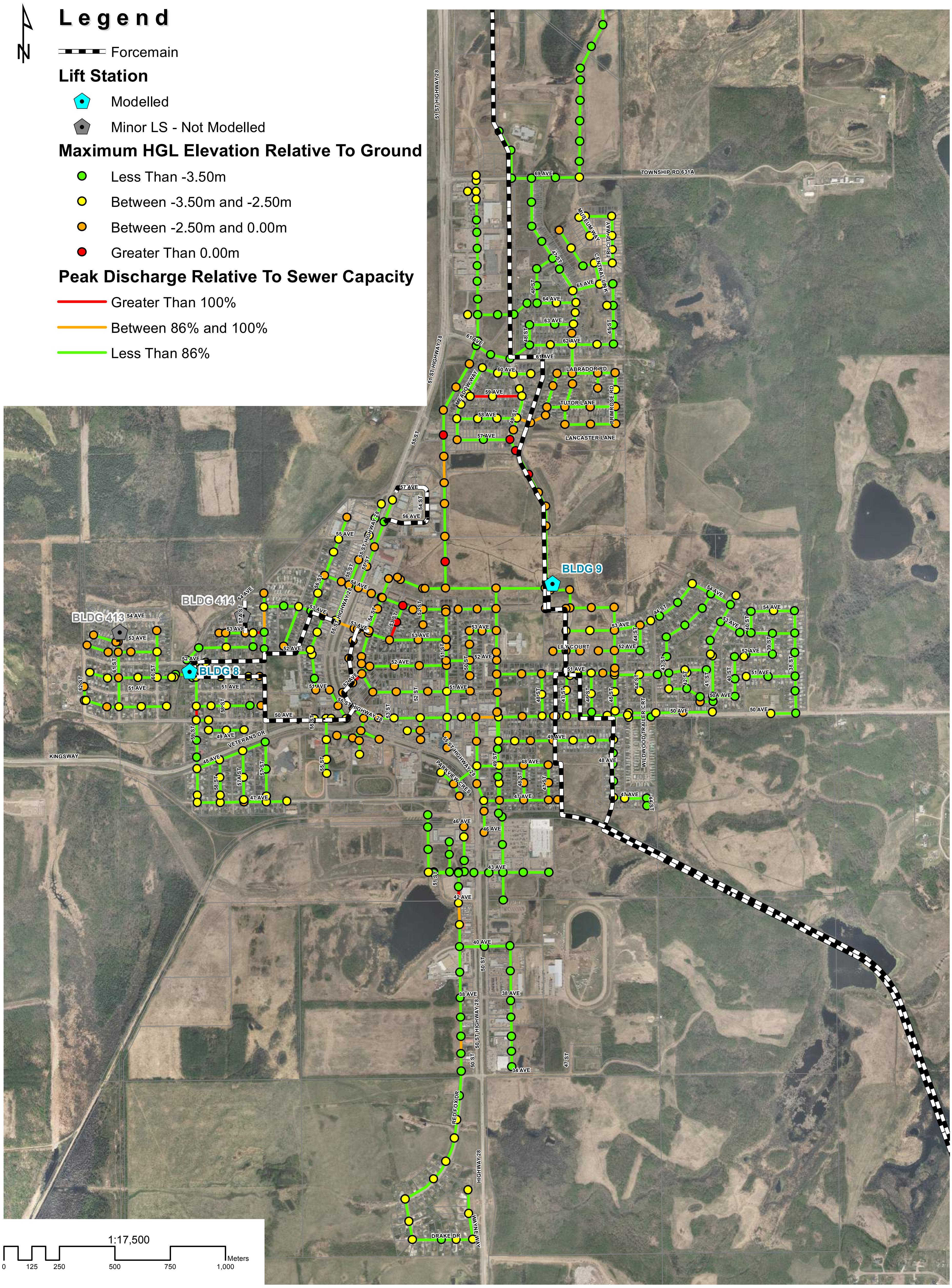

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FIGURE 6.9

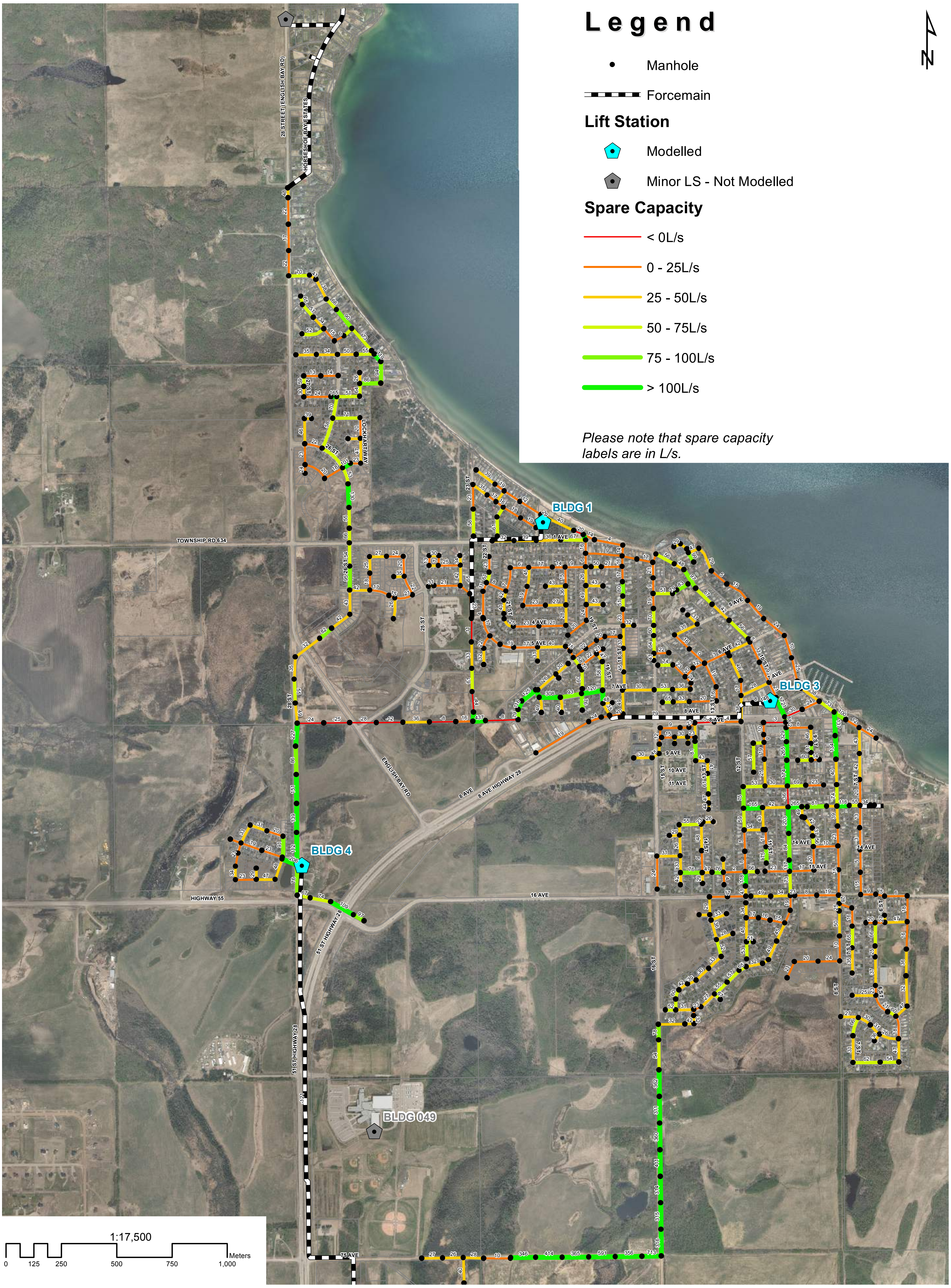

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FIGURE 6.10

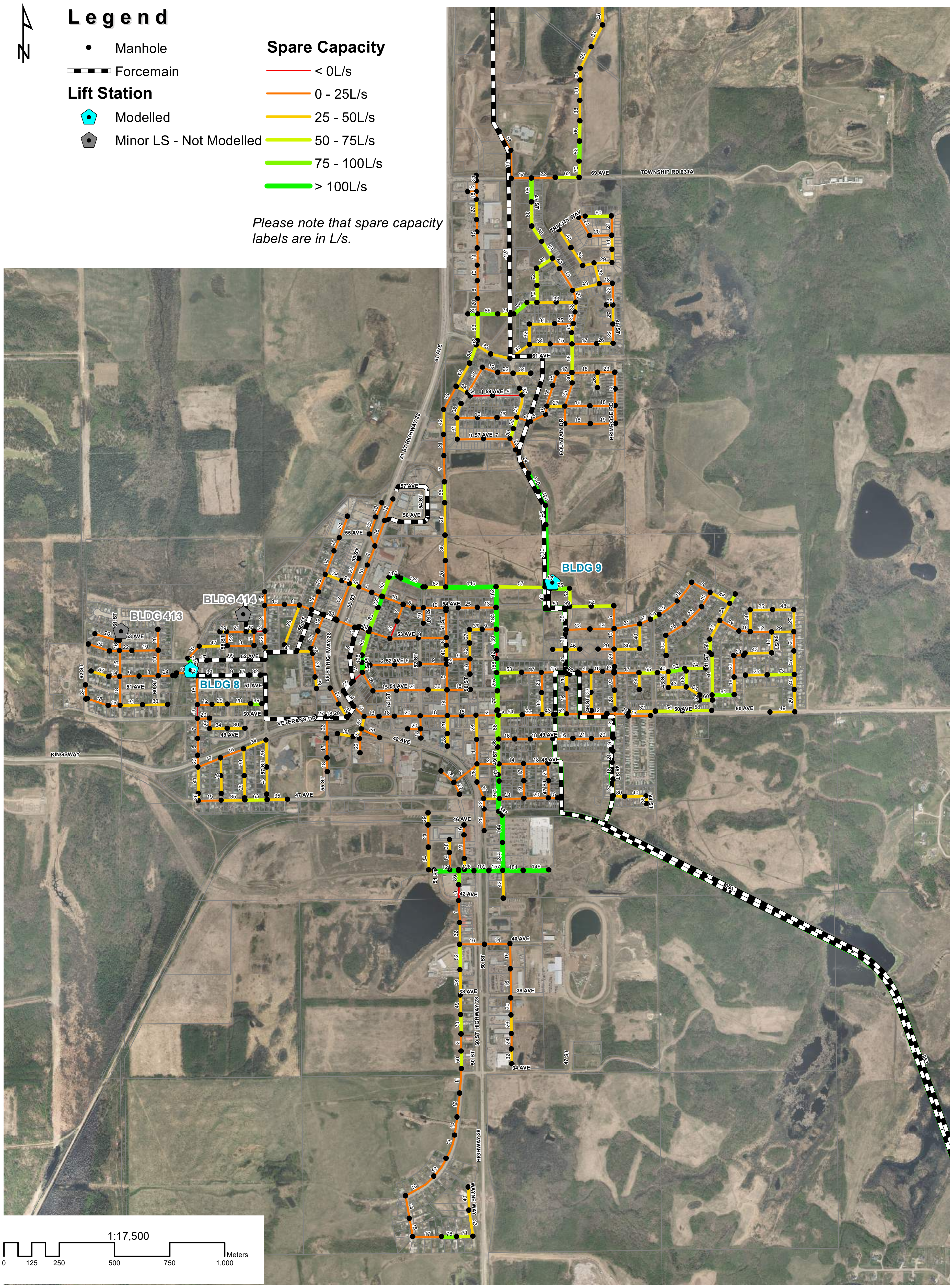

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FIGURE 6.11

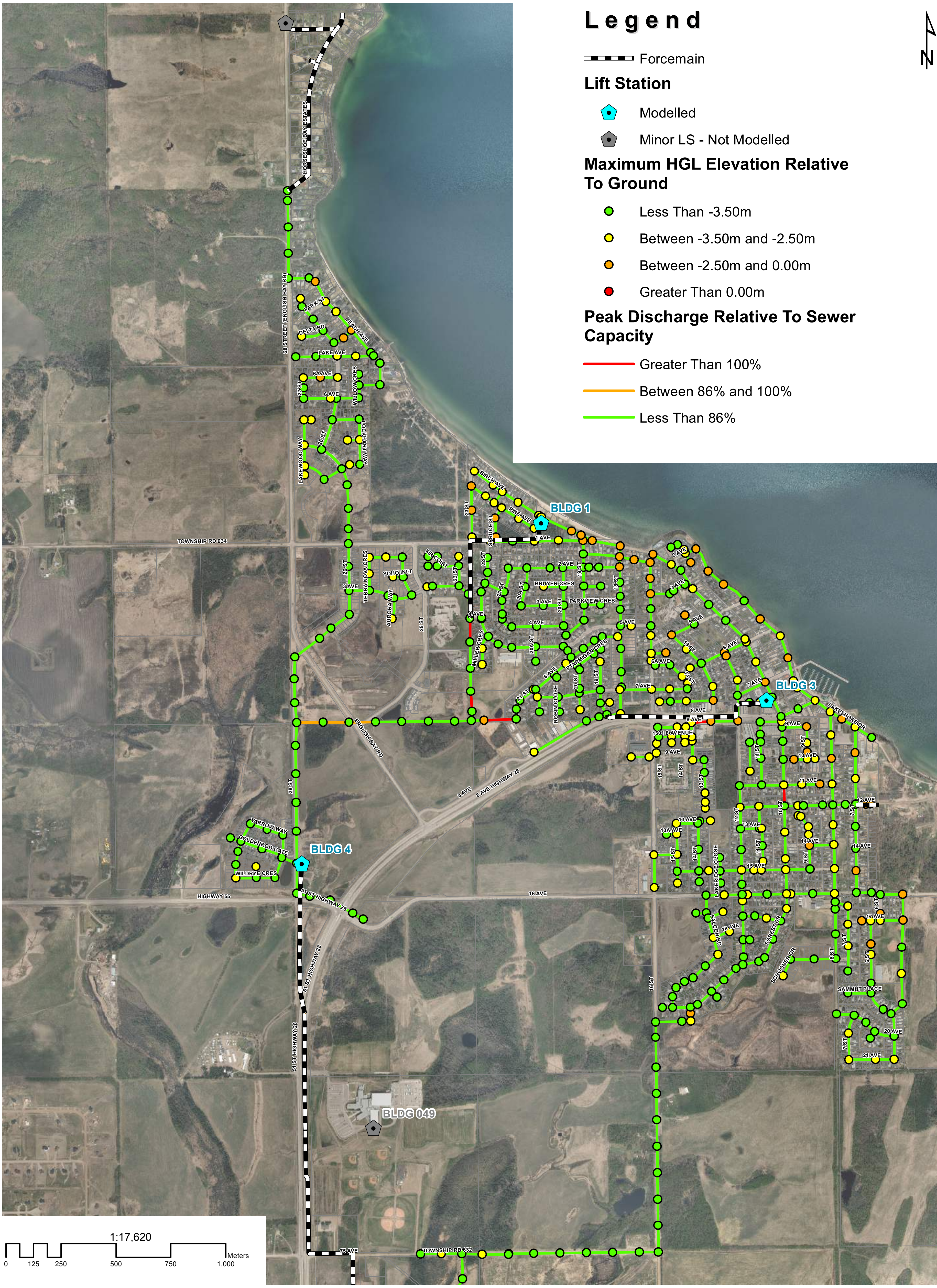

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FIGURE 6.12

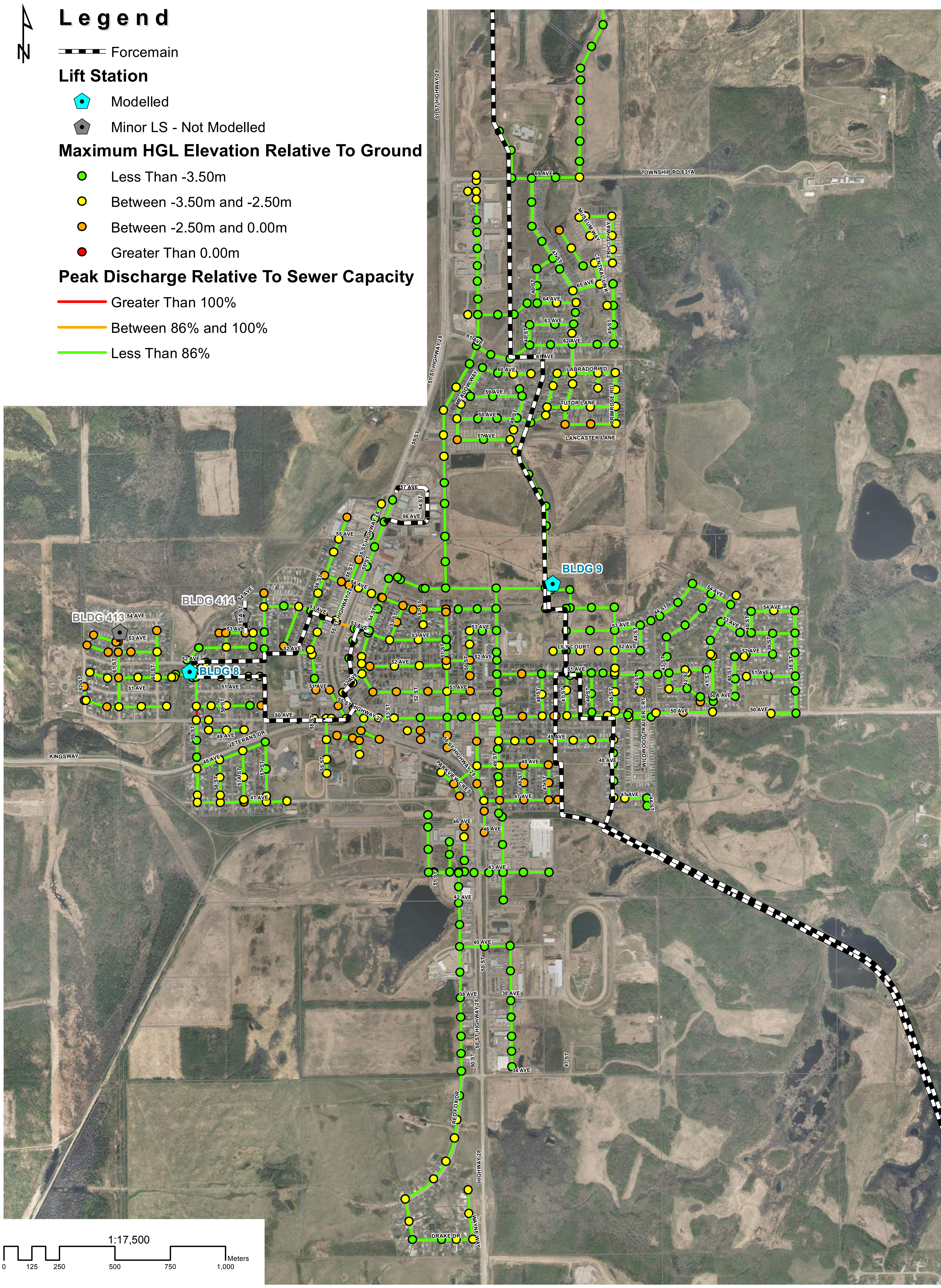

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FIGURE 6.13

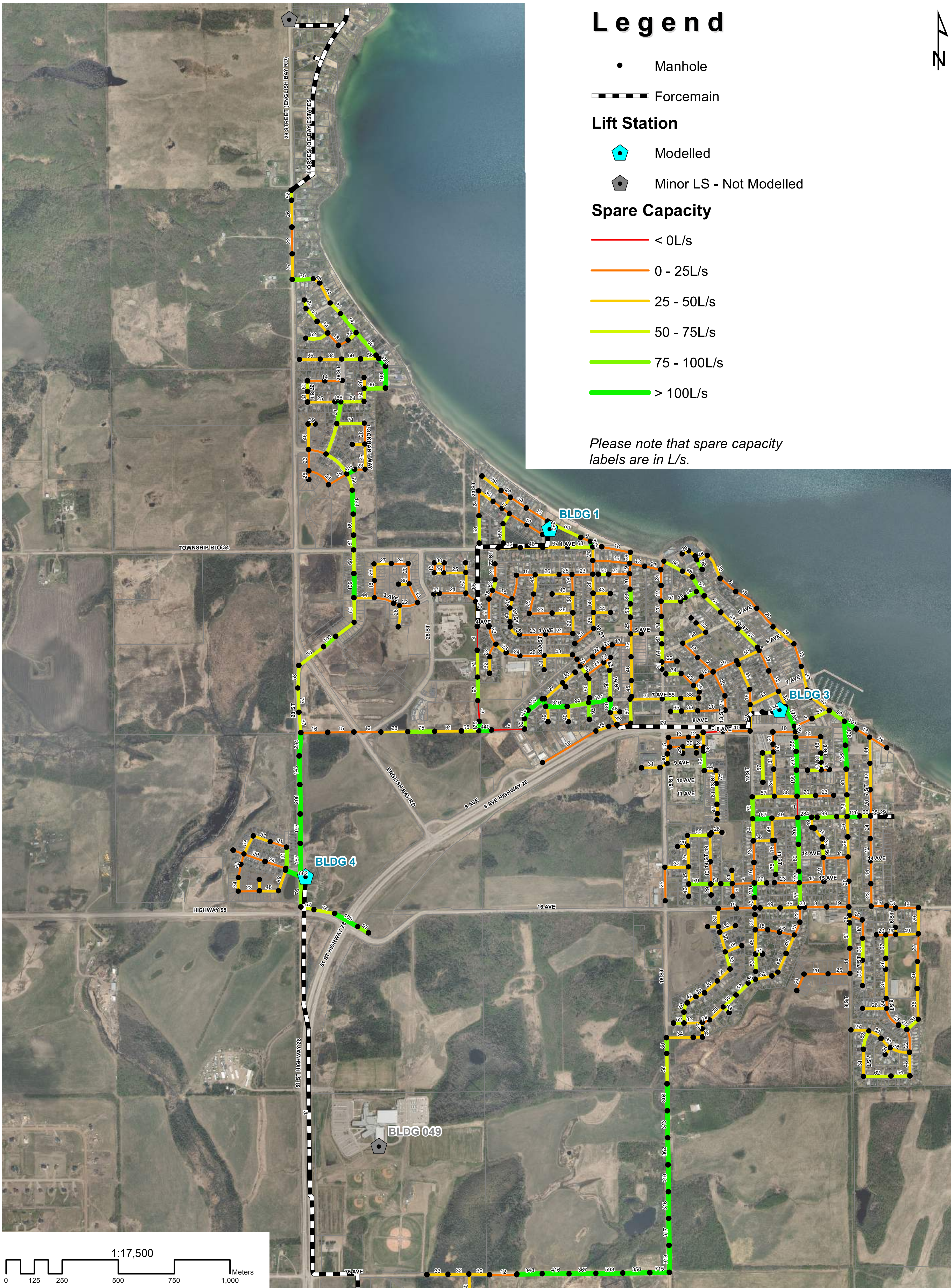

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FIGURE 6.14

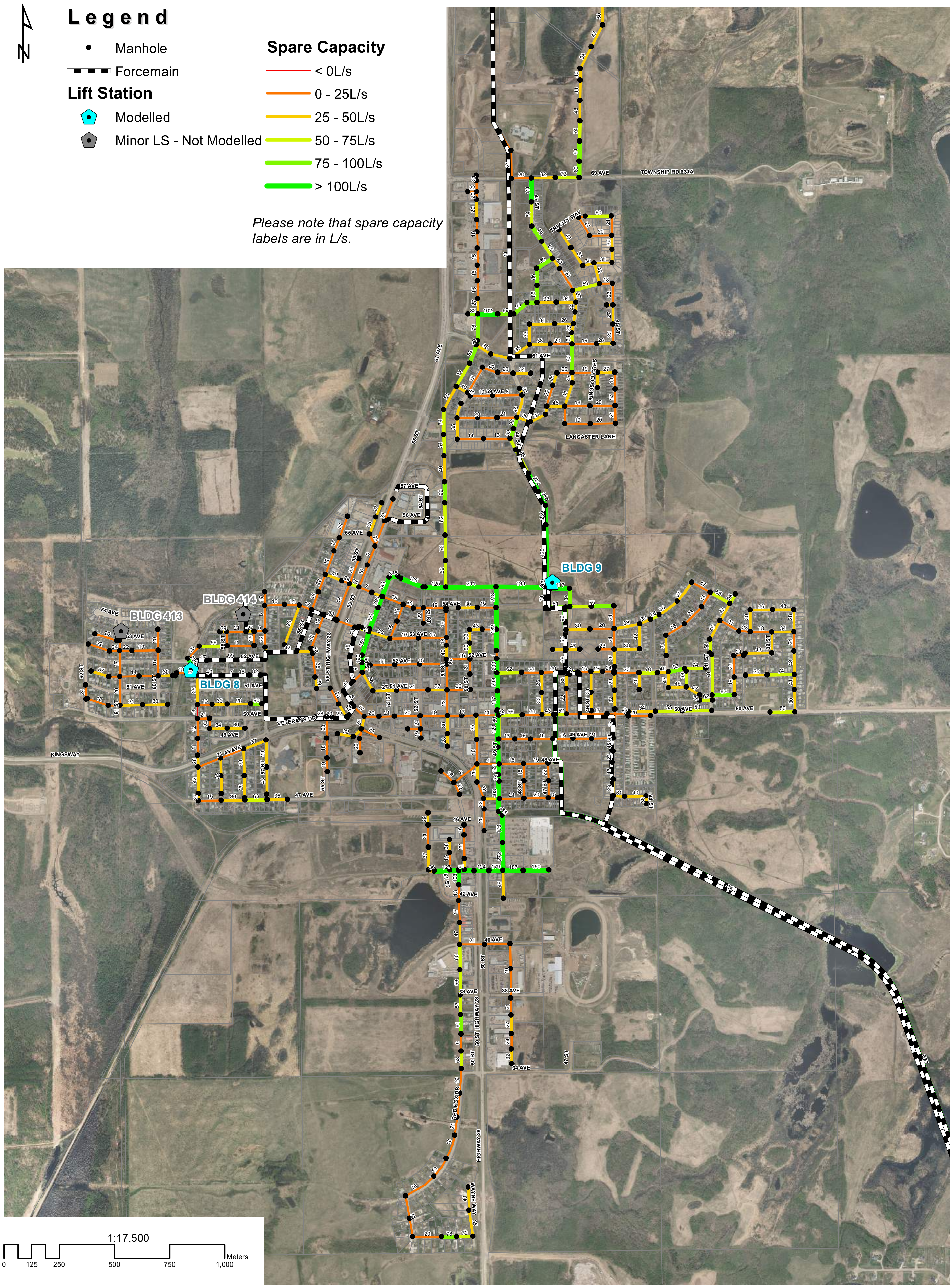

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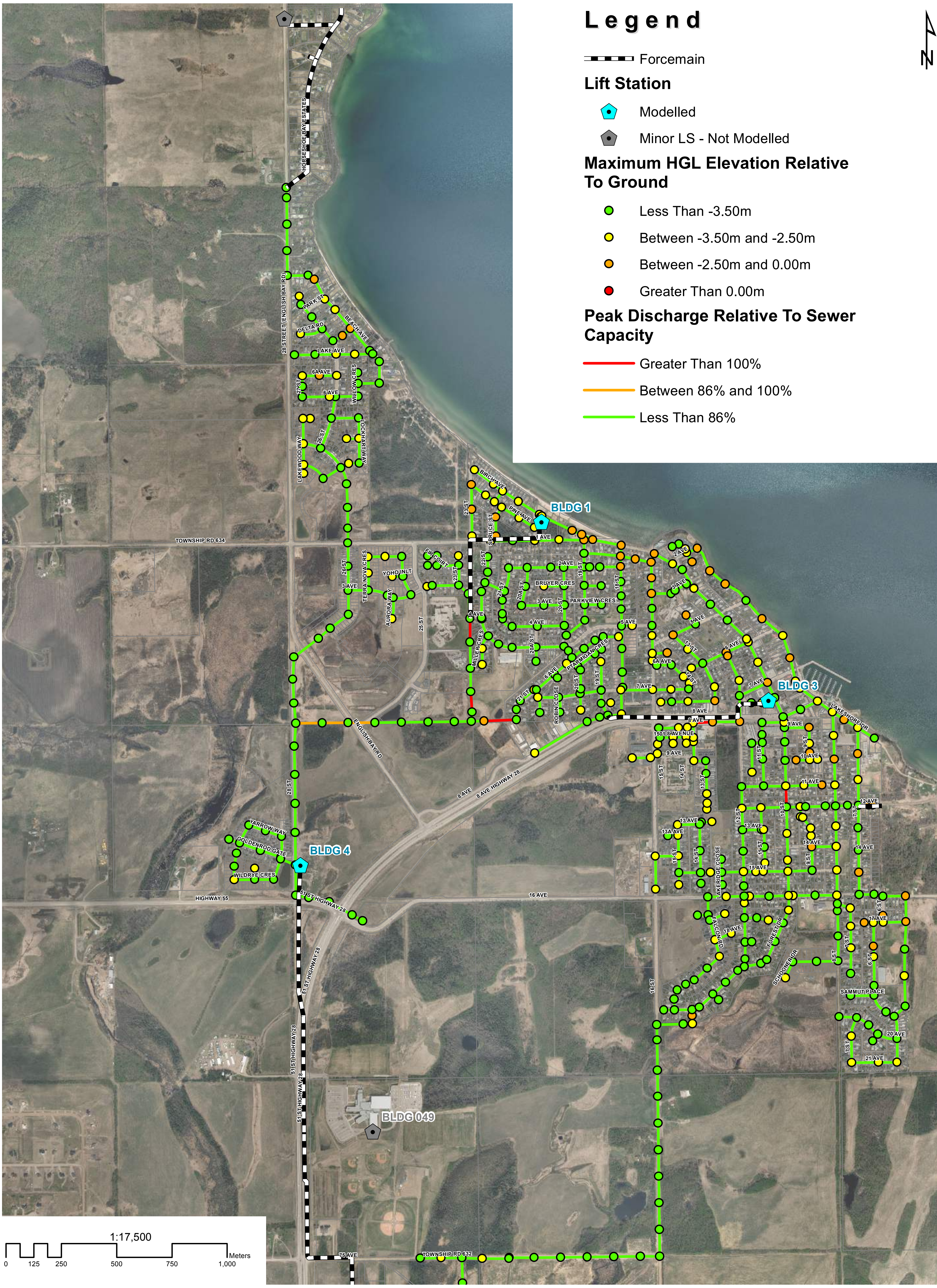
FIGURE 6.15



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ASSESSMENT RESULTS - PEAK DISCHARGE RELATIVE TO SEWER CAPACITY
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EXISTING CONDITIONS PLUS 50YR 24HR Q3 HUFF STORM

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FIGURE 6.16

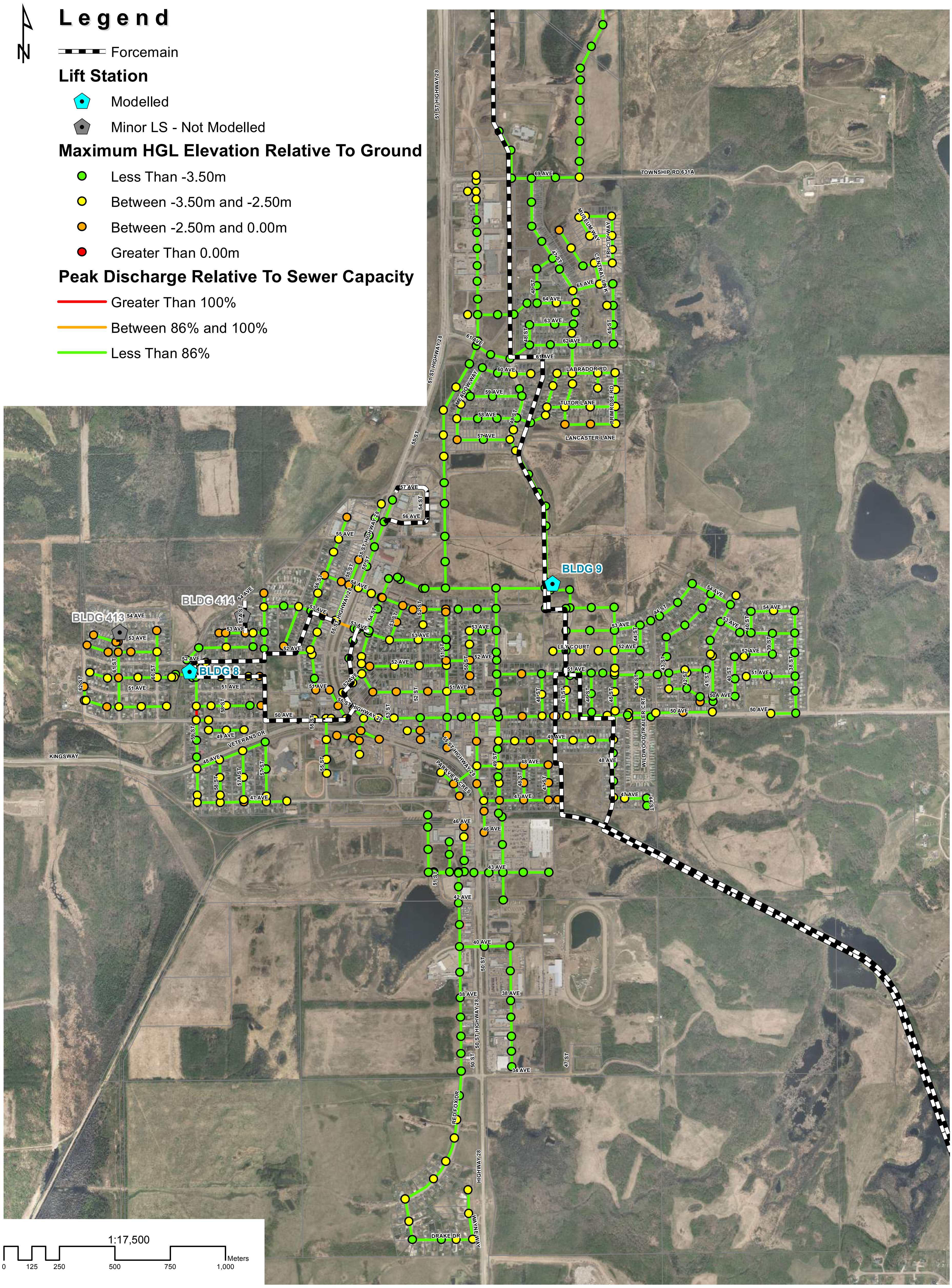

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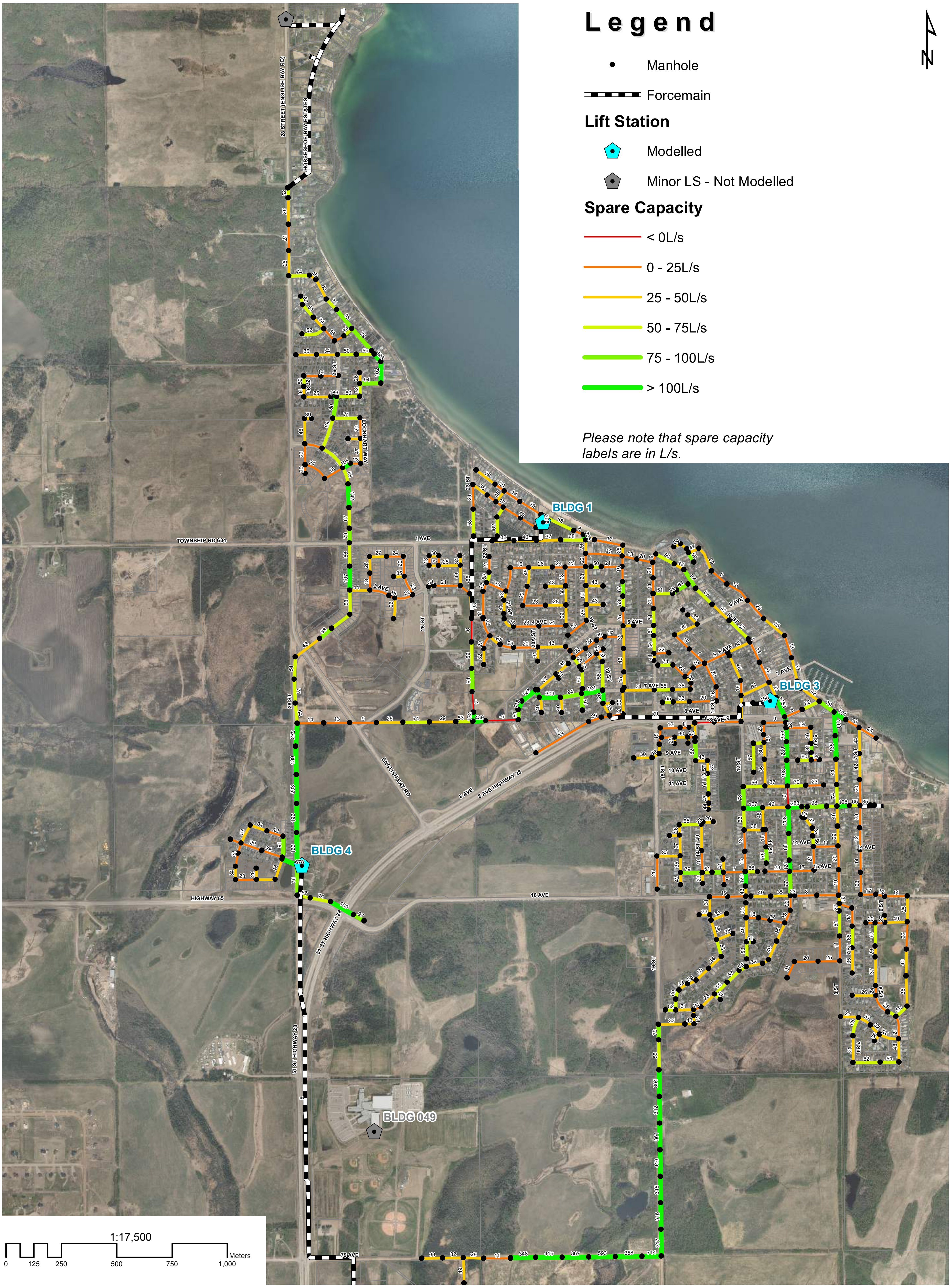
FIGURE 6.17



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EXISTING NETWORK - NORTH
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SPARE CAPACITY
EXISTING CONDITIONS PLUS 50YR 24HR Q3 HUFF STORM

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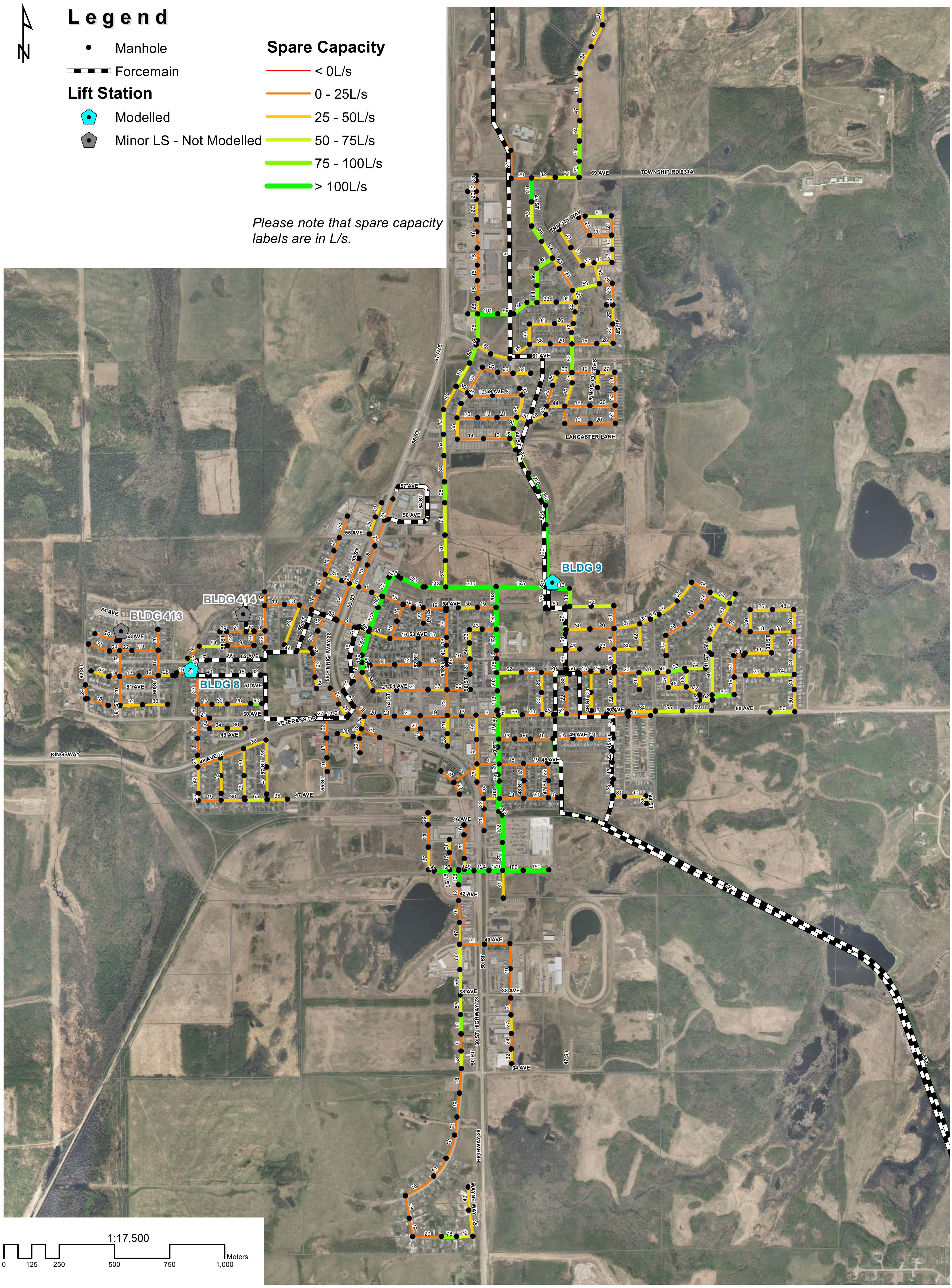
FIGURE 6.18



THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM

SANITARY COLLECTION SYSTEM
EXISTING NETWORK - SOUTH
ASSESSMENT RESULTS
SPARE CAPACITY
EXISTING CONDITIONS PLUS 50YR 24HR Q3 HUFF STORM

City of Cold Lake

ISL Engineering and Land Services

Date: 10/19/2017 Document: M:\26300\26367_Cold_Lake_I-I_Program\02_CADD\20_Drafting\01_GIS Figures\6.0 Existing System Assessment\Figure 6.18 - EX DWF Plus 50yr 24hr Huff_Spare Capacity_South.mxd

FIGURE 6.19

THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM

SANITARY COLLECTION SYSTEM
EXISTING NETWORK - NORTH
RECOMMENDED UPGRADES

City of Cold Lake

ISL Engineering and Land Services

7.0
Inflow-Infiltration Review

Based on the results found in Section 6.1, the City's system is perceived to be resilient as it largely successfully accommodated the ensuing wet weather flows as per the four simulated scenarios. The next step was to review inflow-infiltration in the system based on the observed flow monitoring data and design rainfall events of various return periods. This was done through use of the calibrated system model, flow monitoring data, and field investigation to help quantify it and find possible and apparent sources.

7.1 Inflow-Infiltration Overview

7.1.1 What is Inflow-Infiltration (I-I)?

Inflow and infiltration occurs when water that does not need to be treated enters the sanitary sewage system.

Inflow: stormwater that enters the sewer systems through improperly connected catchbasins, downspouts, sump pumps and foundation drains, or cross connections between the storm and sanitary sewers.

Infiltration: groundwater that seeps into sewers through damaged or deteriorated sewers and manholes.

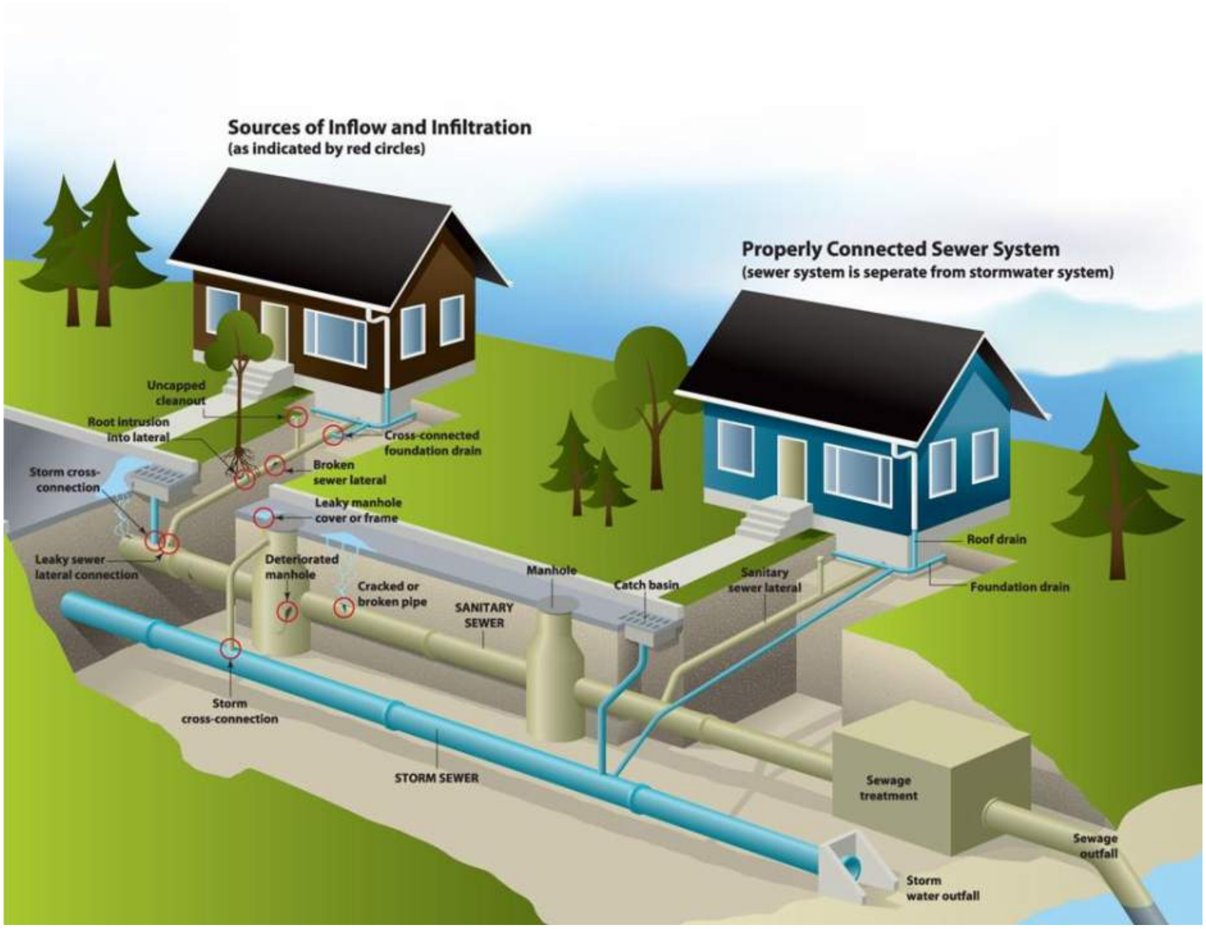
Rainfall Derived Inflow Infiltration (RDII): the increased water flow into the sanitary sewer system occurring during or shortly after a wet weather event.

Most I-I is caused by aging or improperly installed infrastructure that requires maintenance or replacement. Too much I-I undermines the sewer system and can lead to surcharged manholes, sewer backups, and even flooding in basements and streets.

7.1.2 Sources of Inflow-Infiltration

The main sources of I-I typically are:

- **Improperly connected infrastructure:** An improper connection lets water from sources other than sanitary fixtures and drains to enter the sanitary sewer system. That water does not need to be treated and should be entering the stormwater sewer system or allowed to soak into the ground without entering the sanitary sewer system.
    - A 200 mm sanitary sewer can adequately move the domestic sanitary sewage from up to 200 homes, but only eight sump pumps operating at full capacity or six homes with downspouts connected to the sanitary sewer will overload the capacity of the same eight inch sewer.
    - A single sump pump can contribute over 26,400 L of water to sanitary sewer systems in a 24 hour period, the equivalent of the average daily flow from 26 homes.
- **Aging infrastructure:** On average sanitary sewers are designed to last 30 to 50 years. As sewers age, cracks and leaks can form along the sewers and at connections. Groundwater can enter these cracks or leaks wherever sanitary sewer systems lie beneath water tables or the soil above the sewer systems becomes saturated.
- **Environmental Degradation**: The intrusion of roots into sanitary sewers not only damages the sewer structure, it also creates a physical barrier, effectively reducing flow capacity within the system.



Source: Image from the Regional Municipality of York

7.1.3 Consequences of Inflow-Infiltration

Any water entering the sanitary sewer system increases the operation and maintenance costs of sanitary infrastructure and exposes property owners to health risks, property and environmental damage. Increased volumes in the sanitary sewers can lead to:

- Increased cost of transporting and treating higher sewage volumes.
- More frequent maintenance on sanitary infrastructure.
- Reduced capacity in the system which can lead to expensive upgrades, growth restrictions, and increased utility costs for residents.
- Increased risk of sewer backups into basements and streets creating potential health concerns, and property damage.
- Increased risk of contamination of groundwater and surface water.

Keeping stormwater out of the separate sanitary system is critical for the protection of properties, neighborhoods and the environment.

7.1.4 Pinpointing Inflow-Infiltration Problem Areas

A number of field tests and inspections can be conducted to help the City identify the sources of I-I.

Visual Inspections: Interior and exterior visual inspections of manholes are a quick and inexpensive way to identify obvious defects and assess the condition of joints, seals and other possible I-I sources.

Smoke Tests: Non-toxic, odorless 'smoke' is injected into sanitary manholes. The locations of exiting smoke can indicate where I-I might enter the sanitary sewer system. Smoke will typically appear from roof drains, catchbasins or yard drains connected to the sewer system. The smoke may also appear from cracks in the pavement above the sewer, around homes with foundation drains connected to the sewer or in basements through sump pumps, floor drains or other direct openings to the sanitary system.

Dye Tests: A non-toxic dye is added to a stormwater source upstream of suspected I-I locations. The stormwater can then be traced through the system to confirm locations where stormwater is entering the sanitary sewer system.

Targeted Closed Captioned TV (CCTV) Inspections: A video camera is sent through sections of the sanitary sewer system recording the condition of the sewers. The video footage can help identify I-I problem areas such as cracks, root intrusions, leaks and stormwater cross-connections.

7.1.5 Mitigation Measures

Once I-I sources have been identified, a municipality should consider a number of mitigation options and establish an I-I Reduction Program. Depending on the location and severity of issues, there are a number of different mitigation strategies ranging from full sanitary replacement and upgrades to less invasive options such as installing sewer and manhole liners, and disconnecting known inflow sources such as sump pumps, roof drains or downspouts.

7.2 Rainfall Statistics

As part of the 2015 and 2016 flow monitoring programs, two rain gauges – one in Cold Lake North and one in Cold Lake South – were installed in order to record the amount of precipitation accumulated during rainfall events. The main purpose of these rain gauges was to determine wet weather periods, and to correlate the observed rainfall with the peak wet weather flows recorded at each of the selected flow monitoring locations. In addition to this, the recorded rainfall data allowed for an assessment of each rainfall event in order to determine their return periods. As some of the analysis below is based on simulating a design storm with a specific return period (either the 25 year or 50 year 24 hour Q3 Huff Storms) using a calibrated model, this information becomes useful when comparing the assessment results to the observed results.

For that purpose, the rainfall data for both 2015 and 2016 was analyzed to establish the total rainfall depths and the return period of each major recorded rainfall event. The total rainfall depths observed during the 2015 and 2016 flow monitoring periods are presented in Figures 7.1 and 7.2, respectively.

Tables 7.1 and 7.2 summarize the major recorded rainfall events along with their determined return periods for the 2015 and 2016 flow monitoring periods, respectively, while Figures 7.3 and 7.4 illustrate these results graphically. It is noted that due to the spatial variance between the two rain gauges, many major rainfall events were recorded in one portion of the City and not the other, resulting in many storms only having one set of results. Table 7.3 below summarizes the comparative analysis findings.

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Table 7.1: 2015 Rainfall Statistics for the Period of May 8th to September 22nd

Event	Rainfall Statistics of RG 1						Rainfall Statistics of RG 2					
	Date	Duration (hr)	Maximum (mm)	Average (mm/hr)	Total (mm)	Return Period	Date	Duration (hr)	Maximum (mm)	Average (mm/hr)	Total (mm)	Return Period
2015 RE 1	5/13/2015 7:15	7.25	7.366	5.080	36.83	25 Year	5/13/2015 7:15	6.08	5.334	5.932	36.068	25 Year
2015 RE 2	6/11/2015 17:10	5.33	3.048	3.145	16.764	< 2 Year	6/11/2015 17:05	5.92	2.032	3.132	18.542	< 2 Year
2015 RE 3	6/12/2015 22:40	7.92	1.016	1.187	9.398	< 2 Year	6/12/2015 21:55	8.75	0.508	1.539	13.462	< 2 Year
2015 RE 4	6/22/2015 13:10	5.42	2.032	1.593	8.636	< 2 Year	6/22/2015 14:55	1.58	1.016	6.430	10.16	< 2 Year
2015 RE 5	7/3/2015 0:25	1.58	1.016	4.019	6.35	< 2 Year	7/2/2015 23:00	3.92	0.508	2.138	8.382	< 2 Year
2015 RE 6	7/13/2015 19:50	7.58	4.826	2.480	18.796	< 2 Year	7/13/2015 20:20	7.58	4.826	3.217	24.384	2 Year
2015 RE 7	7/16/2015 19:25	11.92	2.032	2.088	24.892	< 2 Year	7/16/2015 17:00	27.08	1.524	1.060	28.702	< 2 Year
2015 RE 8	*No Significant Rainfall Event for RG 1*						8/4/2015 20:25	8.25	0.508	1.108	9.144	< 2 Year
2015 RE 9	8/5/2015 14:55	11.92	1.524	1.193	14.224	< 2 Year	8/5/2015 23:10	3.58	2.032	4.754	17.018	< 2 Year
2015 RE 10	8/15/2015 11:05	6.42	0.254	1.226	7.874	< 2 Year	8/15/2015 11:35	6.25	0.508	1.585	9.906	< 2 Year
2015 RE 11	9/2/2015 19:25	3.08	8.636	6.350	19.558	2 Year	9/2/2015 19:25	3	2.286	4.233	12.7	< 2 Year
2015 RE 12	9/6/2015 3:10	8.42	0.254	2.655	22.352	< 2 Year	9/6/2015 3:15	7.42	0.508	3.423	25.4	< 2 Year

Table 7.2: 2016 Rainfall Statistics for the Period of April 30th to October 11th

Event	Rainfall Statistics of RG 1						Rainfall Statistics of RG 2					
	Date	Duration (hr)	Maximum (mm)	Average (mm/hr)	Total (mm)	Return Period	Date	Duration (hr)	Maximum (mm)	Average (mm/hr)	Total (mm)	Return Period
2016 RE 1	4/29/2016 10:15	1.917	4.064	16.168	30.99	5 Year	4/29/2016 10:15	4.667	0.254	6.586	30.73	2 Year
2016 RE 1[1]	4/29/2016 11:35	0.500	4.064	54.356	27.18	10 Year	4/29/2016 14:20	0.500	4.064	53.848	26.92	10 Year
2016 RE 2	*No Significant Rainfall Event for RG 1*						5/22/2016 1:50	2.167	0.762	2.931	6.35	< 2 Year
2016 RE 3	6/3/2016 1:35	1.750	0.508	2.322	4.06	< 2 Year	6/3/2016 1:35	1.750	0.508	2.322	4.06	< 2 Year
2016 RE 4	6/8/2016 20:50	7.083	0.508	1.542	10.92	< 2 Year	*No Significant Rainfall Event for RG 2*					
2016 RE 5[1]	6/22/2016 18:05	16.000	0.508	1.683	26.92	< 2 Year	6/22/2016 18:00	0.083333	5.08	73.152	6.10	2 Year
2016 RE 6	*No Significant Rainfall Event for RG 1*						7/3/2016 17:25	2.500	1.016	3.454	8.64	< 2 Year
2016 RE 7	*No Significant Rainfall Event for RG 1*						7/8/2016 14:25	7.583	3.302	1.574	11.94	< 2 Year
2016 RE 7[1]	*No Significant Rainfall Event for RG 1*						7/8/2016 14:30	0.083	3.302	79.248	6.60	2 Year
2016 RE 8	7/18/2016 14:20	0.083	2.032	33.528	2.79	< 2 Year	*No Significant Rainfall Event for RG 2*					
2016 RE 9	*No Significant Rainfall Event for RG 1*						7/19/2016 10:05	4.250	4.572	7.112	30.23	2 Year
2016 RE 9[1]	*No Significant Rainfall Event for RG 1*						7/19/2016 10:10	0.500	4.572	50.800	25.40	10 Year
2016 RE 10	*No Significant Rainfall Event for RG 1*						7/21/2016 16:15	0.583	1.016	3.048	1.78	<2 Year
2016 RE 11	7/22/2016 22:40	1.167	1.016	2.177	2.54	< 2 Year	7/22/2016 22:40	1.083	3.556	6.096	6.60	<2 Year
2016 RE 12	7/24/2016 19:00	3.167	3.302	3.770	11.94	< 2 Year	*No Significant Rainfall Event for RG 2*					
2016 RE 13	*No Significant Rainfall Event for RG 1*						8/1/2016 18:20	0.667	0.762	3.429	2.29	<2 Year
2016 RE 14	8/9/2016 19:35	4.500	1.27	3.161	14.22	< 2 Year	8/9/2016 19:45	8.667	2.032	1.788	15.49	<2 Year
2016 RE 15	8/11/2016 18:00	1.667	1.524	1.981	3.30	< 2 Year	*No Significant Rainfall Event for RG 2*					
2016 RE 16	8/18/2016 18:35	0.250	1.778	21.336	5.33	< 2 Year	8/18/2016 17:10	2.000	1.524	1.524	3.05	<2 Year
2016 RE 17	8/22/2016 17:45	11.667	3.81	1.524	17.78	< 2 Year	8/22/2016 17:30	0.333	1.27	11.430	3.81	<2 Year
2016 RE 18	*No Significant Rainfall Event for RG 1*						8/23/2016 0:50	4.000	1.524	1.842	7.37	<2 Year
2016 RE 19	9/6/2016 6:55	3.583	0.762	1.630	5.84	< 2 Year	9/6/2016 6:50	3.500	0.508	1.742	6.10	<2 Year

* *Represents a portion of a major rainfall event that would result in a larger return period than the overall major rainfall event if a shorter duration was considered.*

Table 7.3: Comparison of 2015 and 2016 Rainfall Data

Item	2015		2016	
	Rain Gauge 1	Rain Gauge 2	Rain Gauge 1	Rain Gauge 2
Monitoring Period	May 8th to September 22nd		April 30th to October 11th	
Total Rainfall Depth (mm)	270.76	287.27	310.13	299.21
Number of Major Rainfall Events	11	12	11	14
Number of Major Rainfall Subevents[1]	0	0	2	4
Rainfall Events < 2 Year Return Period	9	10	11	12
Rainfall Events ≥ 2 Year Return Period	1	1	0	4
Rainfall Events ≥ 5 year Return Period	0	0	1	0
Rainfall Events ≥ 10 Year Return Period	0	0	1	2
Rainfall Events ≥ 25 Year Return Period	1	1	0	0

[1] *Represents a portion of a major rainfall event that would result in a larger return period than the overall major rainfall event if a shorter duration was considered.*

It is apparent that the observed total rainfall depths varied a fair degree between the two monitoring periods. From Table 7.3 above, it is evident that the total rainfall depths were greater in 2016 than in 2015 at both rain gauge locations. There was more of a drastic increase from 2015 to 2016 at Rain Gauge 1 (increase of roughly 39 mm) than at Rain Gauge 2 (increase of roughly 12 mm). Having said that, a higher intensity storm was observed in 2015, with the rainfall event being classified as greater than a 25-year return period. Though this was the case, there were a greater number of major rainfall events, including the number of total rainfall events classified as above a 2-year return period during the 2016 flow monitoring period.

As such, it was deemed acceptable to utilize the 2016 data during the wet weather flow calibration process summarized in Section 4.3 above. Further to this, the 2015 rainfall event classified as greater than a 25-year return period occurred on May 13th. At that point the rain gauges were installed and operational, however some of the flow monitoring sites were in the process of being installed by SFE Global. Consequently, a portion of the flow monitoring data was not available therefore calibration based on that storm would not have been feasible. As well, the flow monitors that were already recording data during the rainfall event did not exhibit major responses during that time frame, thus would be unsuitable for calibration purposes.

7.3 Runoff Rate Review

To test the potential runoff rates generated in the system, a combination of flow monitoring data review, as well as checking modelled runoff rates generated by the Huff scenarios was undertaken. Table 7.4 summarizes rates observed through flow monitoring, while Table 7.5 summarizes the simulated rates established based on the calibrated model. A rate comparison is presented in Figure 7.5. The observed I-I rates represent the measured peak WWF minus the measured peak DWF divided by the corresponding total upstream catchment area. Similarly, the modelled I-I rates represent the sum of discharge from the upstream catchments divided by the corresponding total upstream catchment area.

Table 7.4: Observed Inflow-Infiltration Rates based on 2015 and 2016 Flow Monitoring Data

FM Site	Dry Weather Peak Flow [1]	Wet Weather Peak Flow [1]	Difference	WWF/DWF Ratio	Upstream Area	2016 I-I Rate	2015 I-I Rate
	L/s				ha	L/s/ha	L/s/ha
FM #1[2]	11.32	56.83	45.51	5.02	106.01	0.429	0.419
FM #2	23.82	26.32	2.50	1.10	57.73	0.043	0.229
FM #3	16.44	24.01	7.57	1.46	58.36	0.130	0.243
FM #4	7.40	9.83	2.43	1.33	41.19	0.059	0.078
FM #5[2]	21.18	32.92	11.74	1.55	79.17	0.148	0.230
FM #6	5.91	15.06	9.15	2.55	18.45	0.496	0.243
FM #7A	4.52	7.62	3.10	1.69	32.51	0.095	0.098
FM #7B	5.34	7.44	2.10	1.39	41.78	0.050	0.063
FM #8 2015	8.58	12.01	3.43	1.40	33.20	N/A	0.103
FM #8 2016	3.15	6.47	3.32	2.05	20.17	0.165	N/A

[1] *Dry weather and wet weather peak flows stipulated above are based on the 2016 flow monitoring data for all sites with the exception of FM #8 2015, where the flows are based on the 2015 flow monitoring data.*

[2] *It is noted that Sites 1 and 5 were calibrated using a rainfall event that was less than the peak wet weather flow mentioned above, due to the suitability of the wet weather flow periods.*

Table 7.5: Modelled Inflow-Infiltration Rates based on Simulated Design Huff Storms

FM Site	Number of Catchments	Catchment Area	25yr 24hr Huff Q3 Storm	50yr 24hr Huff Q3 Storm
			I-I Rate	
		ha	L/s/ha	
Site 1	1,014	100.04	0.202	0.230
Site 2	605	57.73	0.161	0.182
Site 3	543	58.36	0.308	0.353
Site 4	143	35.64	0.075	0.085
Site 5	476	79.29	0.146	0.165
Site 6	102	18.45	0.839	1.111
Site 7A	324	32.51	0.190	0.217
Site 7B	436	41.78	0.072	0.083
Site 8	208	19.22	0.338	0.448
Unmonitored[1]	1,866	257.41	0.338	0.448

[1] *The unmonitored catchments were assigned Site 8 calibrated hydrologic parameters based on similar hydrologic characteristics.*

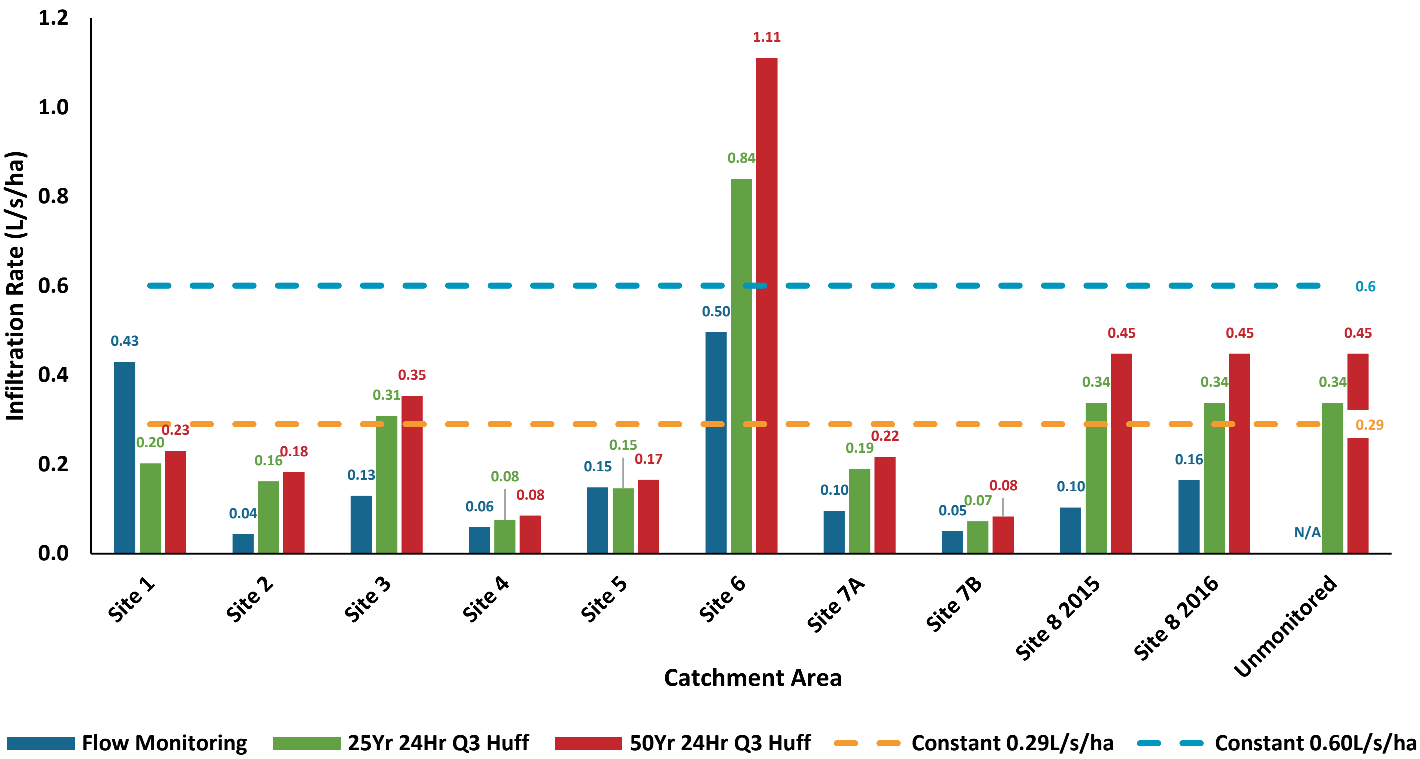

Figure 7.5: Comparison of Infiltration Rates for Each Catchment Area

As anticipated, given the fact that each rainfall event observed in 2016 was determined to have a return period of less than 1 in 25 years, the corresponding I-I rates from the flow monitoring period yielded values between 0.043 to 0.496 L/s/ha. The values are below those of the 25 year and 50 year 24 hour third quartile Huff design storms, with the exception of Sites 1 and 5, as expected. It is noted that Sites 1 and 5 were calibrated using a rainfall event that produced a lower peak wet weather flow than that mentioned above in Table 7.4, due to the suitability of the wet weather flow periods. This is because the observed instantaneous peak flows used in Table 7.4 for both sites were determined to be very sharp of extreme short duration. For this reason, the I-I rates observed through modelling results are less than those calculated for the flow monitoring period. As no rainfall events above or equal to a 1 in 25 year storm were observed in either 2015 or 2016, theoretically the modelled I-I rates should all be greater than the flow monitoring results. This is not the case with Sites 1 and 5 due to the lesser rainfall event that was used for WWF calibration.

The 25 year 24 hour Q3 Huff design storm produced projected I-I rates ranging from 0.072 to 0.839 L/s/ha with a weighted average of 0.260 L/s/ha while the 50 year 24 hour Q3 Huff design storm produced projected I-I rates ranging from 0.083 to 1.111 L/s/ha with a weighted average of 0.327 L/s/ha. This indicates that a number of areas such as Site 1, Site 3, Site 6, and Site 8 would experience a considerable amount of inflow-infiltration under these theoretical design storms. Site 6 produced the highest I-I rates which is an interesting fact given that this site encompasses a relatively new area. One can only stipulate the reason as to why a new area has such high projected I-I rates are illegal connections to the sanitary system in the form of weeping tiles or poor installation of the sewer resulting in misalignments at the sewer joints or manholes. Nonetheless, as stated above the assessment scenarios indicate that even the elevated I-I flows did not result in system-wide surcharging, suggesting a rather resilient network. Having said that, to reduce the extraneous flows the City should focus on investigating the sources of I-I in the system further and implement appropriate remediative measures.

7.4 Smoke Testing

The purpose of smoke testing is to see locations where non-toxic smoke, concentrated in the sewer system will escape. The logic here is to identify locations where water can get into the system (i.e. if smoke can get out, water can get in).

SFE Global was retained to undertake smoke testing. Results of the smoke testing are shown on Figures 7.6 and 7.7, with a detailed report attached in Appendix F. Roughly 52 km (~61% of all sanitary sewers in Cold Lake) of sewers were selected to be a part of the 2016/2017 smoke testing program based on the approved City's budget. Of these sewers, approximately 34 km (64% of program) were tested in 2016, and 18 km (36% of program) in 2017.

Broadly depicted, the 2016 and 2017 smoke testing programs each found 77 incidents for a total of 154 incidents, as shown in Figures 7.6 and 7.7. This included manhole covers that are not sealed or are open, as well as service connections and cleanout caps that exhibited smoke release. Twelve incidents were identified as a high level of smoke intensity as summarized in Table 7.6 below.

In addition to the incidents flagged as having a high level of smoke intensity, there is one location where the smoke intensity was identified as 'none'. This is because the manhole is located in a swamp, completely submerged, so no smoke was able to actually escape. This incident, Incident 72, has been flagged as having very high inflows and should be remediated as soon as possible. Incident 72 has also been included in Table 7.6 below.

Table 7.6: High Level of Smoke Intensity Incidents

Incident ID	Year Tested	Location	Incident Comments	Leak Source
5	2016	1 Ave. at 19 St.	Smoke from two (2) low elevated, grated manhole lids in Waterpark. Tamperproof, could not investigate.	Main Sewer
21	2016	Behind 1801 5 Ave.	Low lying manhole, very poor seals, infiltration around entire manhole.	Main Sewer
25	2016	616 20 St.	Cleanout cap missing on lawn.	Service Connection
26	2016	615 20 St.	Cleanout cap missing on lawn.	Service Connection
37	2016	1204 13 St.	Missing cleanout cap on driveway.	Service Connection
38	2016	1206 13 St.	Missing cleanout cap on driveway.	Service Connection
40	2016	920 7 St.	St. Dominic Elementary School had smoke come up from drain. Fire department called.	Service Connection
67	2016	616 21 Ave.	Leaking cleanout cap.	Service Connection
72[1]	2016	Behind arena on 6 St.	Manhole located in swamp/sewer, very high inflow.	Main Sewer
74	2016	Imperial Park 75 Ave.	Unidentified leaking manhole collar/low lying manhole east of Imperial Park Entrance. Manhole not part of project, but the incident was very obvious. Manhole directly north of MH 919.	Main Sewer
122	2017	5418 56 St.	Smoke in home. Suspected faulty plumbing connection.	Service Connection
124	2017	5204 - 57 St.	Smoke in home. Suspected faulty plumbing connection - main floor bath tub.	Service Connection
144	2017	East end of 43 Ave	Manhole open. Riser broken.	Main Sewer

[1] *Incident flagged as having zero smoke intensity as it is located in a swamp completely submerged. Very high inflows have been recorded.*

7.5 Possible Inflow-Infiltration Reduction Measures

It is highly recommended that the identified incidents are addressed as soon as possible in order to greatly reduce the amount of unnecessary additional flows into the sanitary system. It is warranted that the City complete smoke testing along with other field investigative measures for the remaining ~39% of the sewers throughout the city. In the meantime, the City could do a visual inspection of any sewers not smoke tested by traversing the sewer paths for any obvious indications of sources of inflow such as manholes located in sags or depressions that are susceptible to water ponding on the surface.

Based on the smoke testing, a number of possible recommendations pertaining to inflow-infiltration reduction can be considered by the City. These include the following:

- Smoke test the remaining sewers not included in the 2016/2017 smoke testing program (roughly 33 km (39%) remaining).
- Consider micro flow monitoring to pin-point the sources of inflow in areas with determined high I-I rates.
- Ensure all sanitary manholes in the city that are experiencing a high level of smoke intensity, especially in low lying areas are sealed. When doing so, it is crucial to ensure that appropriate exhaust and ventilation systems are incorporated throughout the system to ensure that the potential for H_2S gas build-up is mitigated. This could have a moderate impact on sewer inflows. Sanitary manholes that are proposed to be sealed are shown in Figures 7.8 and 7.9.
- Conduct CCTV testing on sewers in the city exhibiting large amounts of inflow-infiltration, but may not have shown much of a concern during smoke testing. This task could be carried out as part of an over-arching Asset Management Condition Assessment Framework.
- Consider a sewer relining program where sewers are found to be degraded, but not sagged. Sewers with sags would need replacement. Please note that a CCTV inspection would be required to determine if a sewer is a good candidate for relining.
- Due to the difficulty in managing I-I on private lots, consider a resident education campaign, encouraging residents to ensure that within their lots that:
    - Sump pumps do not discharge to the sanitary system
    - Roof leaders discharge to the ground surface
    - Positive drainage is maintained away from homes in case weeping tiles could be connected to the sanitary system.

A program like this could have a reasonable positive impact on the overall inflow-infiltration in the city.

7.6 Areas for Further Review

Site 6 Flow Monitoring Location

Given the extreme observed runoff rates at Site 6, coupled with the calibrated model exceeding these rates, this is a likely primary candidate for further review. Given that the majority of the sewers upstream of the Site 6 flow monitor were installed between 2005 and 2015, with a few being installed between 2000 and 2005, one would expect that this area's runoff rates would be below the City's minimum allowance design criteria of 0.29 L/s/ha. In this case it is likely that the cause of such significant runoff rates observed at Site 6 would be one or more instances of poor sewer installation in the upstream reaches or a potential cross connection to a stormwater sewer. Looking at the hydrograph, as shown in Figure 4.32, the flow monitoring data suggests that there is a sharp response to rainfall at Site 6, consistent with an inflow problem. During the chosen wet weather flow calibration period, it is noted that sewage flows went from roughly 4 L/s to a peak 9 L/s resulting in a 225% increase.

Site 6 falls within an area that was smoke tested in the summer of 2017. The smoke testing program indicated that there are numerous locations upstream of Site 6 where inflow could be occurring. Though many of these incidents were found to have a low or moderate smoke intensity, the sheer number of incidents found upstream of Site 6 (25 incidents) would be enough to cause large volumes of inflow. It is recommended that the City remedy all incidents that were flagged and subsequently monitors areas upstream of Site 6 further through micro flow monitoring. If future flow monitoring is to occur, observed runoff rates can be calculated to determine if the issues have been resolved or if they still exist.

It is noted that there is a critical flow split at the corner of 62nd Avenue and 47th Street, where sewage can either flow south on 47th Street or west on 62nd Avenue. Due its critical location, field survey was conducted on this manhole to ensure that the model had proper invert elevations, which in turn it was determined that both outlet sewers (west and south) had identical invert elevations. As a result, an educated guess of the upstream catchment areas was made. It is as well possible that there is a greater catchment area than originally assumed going to the Site 6 flow monitor as opposed to the Site 5 flow monitor, thus potentially decreasing the observed runoff rates at Site 6 and increasing the runoff rates at Site 5.

Site 1 Flow Monitoring Location

Though not as extreme as the observed runoff rates at Site 6, Site 1 also exhibited rates higher than the minimum allowance design criteria of 0.29 L/s/ha under the flow monitoring scenario. This is not unexpected, as the sewers in this area were installed up to 60 years ago thus could be showing signs of degradation such as sewer cracks, poor seals, and invasive tree roots, amongst others. These sewer abrasions could be potential sources of I-I. Looking at the hydrographs from the flow monitoring data suggests that there are some sharp responses to rainfall at Site 1 attributed to inflow, but also many indications of slow rainfall response which would be caused by infiltration. During the chosen wet weather flow calibration period, it is noted that sewage flows increase from roughly 10 L/s to 20 L/s, doubling in intensity. It is also noted that the rainfall response takes a few days to dissipate, due to increased infiltration into the sewer network.

Site 1 was included in the smoke testing program that was conducted in 2016. From this program thirty incidents were highlighted, with one being a high smoke intensity, thirteen having a moderate smoke intensity, and the remainder having a low smoke intensity. Of these incidents, the main causes revolved around missing, broken, or buried cleanout caps. Additionally, as mentioned above, Incident 72 was determined to be the cause of very high inflows into the sanitary system due to the fact that the manhole is located in a swamp resulting in the manhole being completely submerged. It is recommended that these incidents be remediated, and that this site be monitored afterwards to ensure the causes of high inflow/infiltration have been resolved. If upon further investigation this site still exhibits high I-I issues, it is recommended that a CCTV program is undertaken to determine the condition of the sewers.

7.7 July 21st, 2017 Rainfall Event

Following the completion of the modelling assessment stage of the project, Cold Lake experienced a rainfall event on July 21st, 2017. This event resulted in significant sewer back-up issues throughout the city. Sewer back-ups were recorded in roughly twelve locations in Cold Lake North and eleven locations in Cold Lake South. The City requested that ISL investigate the cause of these back-ups, which led to an extensive memorandum on the subject, which has been included in Appendix G

The objective of the memorandum was to demonstrate that the high intensity and short duration thunderstorm experienced on July 21st, 2017 resulted in unprecedented I-I rates which lead to the above noted sewer back-ups. This is despite the fact that the City's sanitary collection system was found to have adequate capacity under both the theoretical conservative inflow-infiltration rates (i.e. 0.29 L/s/ha and 0.60 L/s/ha) and those ensuing from the design rainfall events applied to the calibrated model, as discussed in Section 6.0.

A number of aspects that might have contributed to the observed system surcharge were investigated, including the following:

- Rainfall Analysis
    - A rainfall analysis of the July 21st, 2017 event based on the rain gauge data supplied by SFE Global, and a comparison to the previous events utilized for calibration of the sanitary model.
    - A rainfall analysis of the July 21st, 2017 event based on the historical weather radar imagery obtained from Environment Canada's website to estimate the maximum return period for the thunderstorm and investigate the potential for spatial variability throughout the city.
- Sanitary Collection System Analysis
    - A comparison of the projected I-I rates for the theoretical design storms with the return period of 25-, 50-, 100-, and 200-Year, against those modelled based on the July 21st 2017 thunderstorm.
    - A sanitary system response, based on the calibrated hydrodynamic model using the 2015-2016 flow monitoring and rain gauge data, under the July 21st 2017 thunderstorm, in addition to the 100-Year and 200-Year 24 Hour Huff Design Storms.
- Flow Monitoring Analysis
    - A comparison of I-I rates for the observed July 21st, 2017 rainfall event, based on the flow monitoring data supplied by SFE Global, with the previously determined rates.
- Smoke Testing/Field Investigation Observations
    - An analysis of the 2016/2017 smoke testing and how the results likely influenced the surcharged state of the sanitary system on July 21st, 2017.

The findings of these investigations are fully described in the appended memorandum. At the time this investigation was conducted, raw flow monitoring data obtained from SFE Global's online portal was used, as the 2017 flow monitoring program was still in progress and final data not available. Following completion of the program, a portion of the flow monitoring data was adjusted by SFE Global. Data was adjusted whenever the weirs were surcharged by taking the velocity and multiplying by the cross-sectional area of the pipe. Due to the severity of the July 21st event, the data from a number of flow monitoring sites was adjusted. Though this presents some concerns with the overall validity of the flow monitoring data, the overarching findings of the memorandum remain true. The City's sanitary system is quite robust, but is being undermined by the sheer volume of inflow and infiltration. The incidents flagged during the 2017 smoke testing program should be monitored and remediated wherever possible, and a smoke testing program should be extended to the remaining 33 km (39%) of sewers that have not been tested to date.

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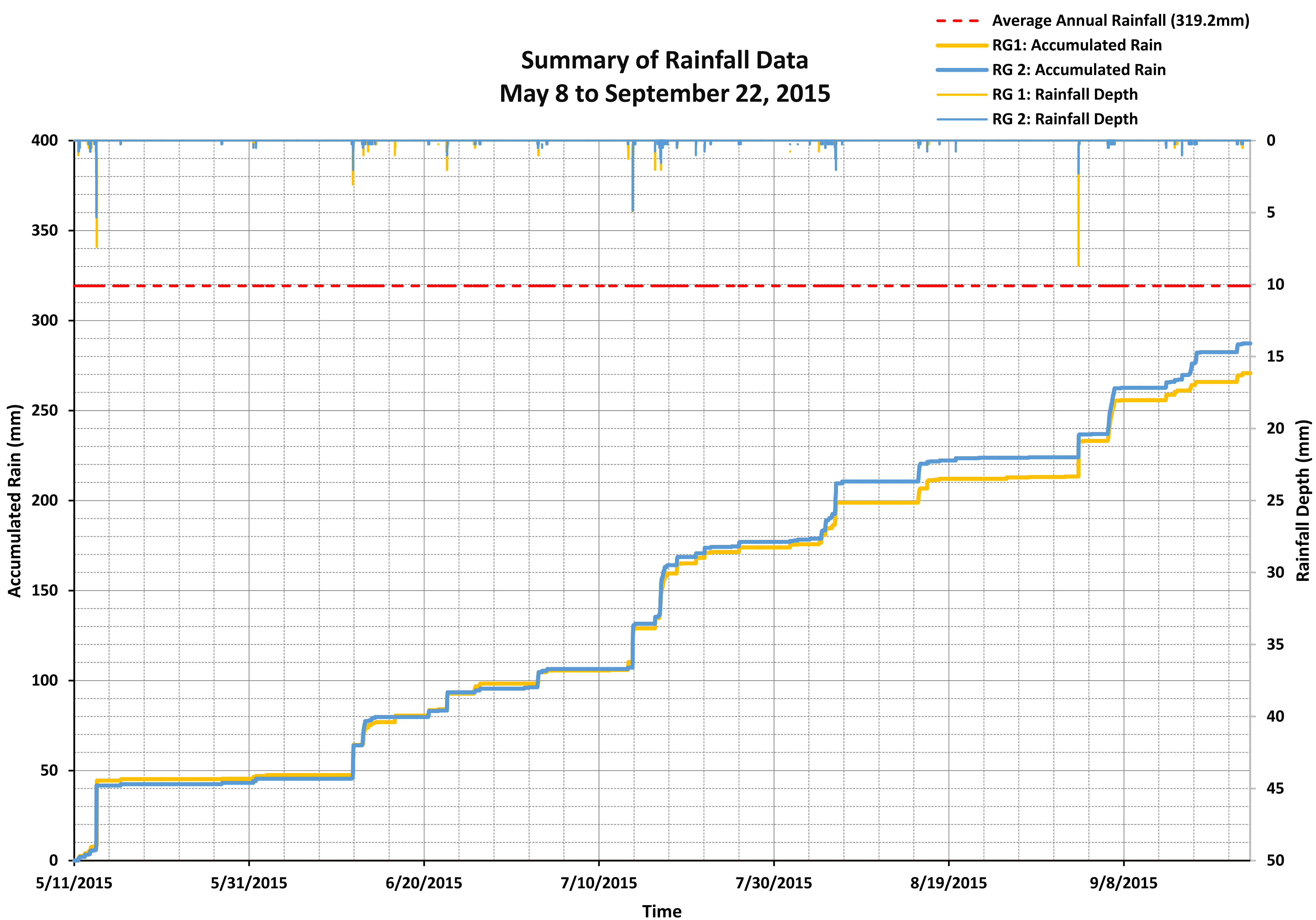
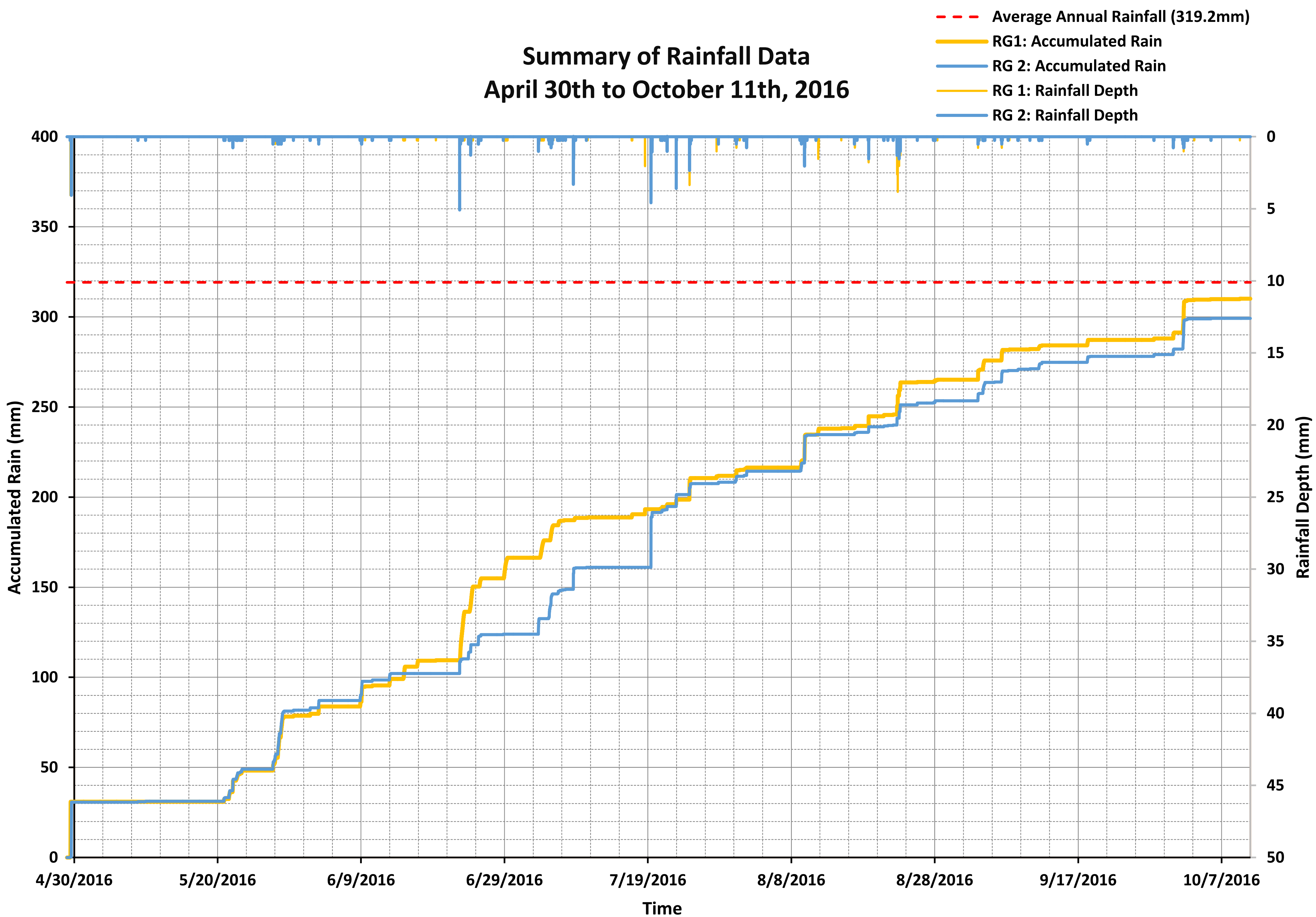


THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM

INFLOW-INFILTRATION REVIEW
2015 RAINFALL DATA

FIGURE 7.2



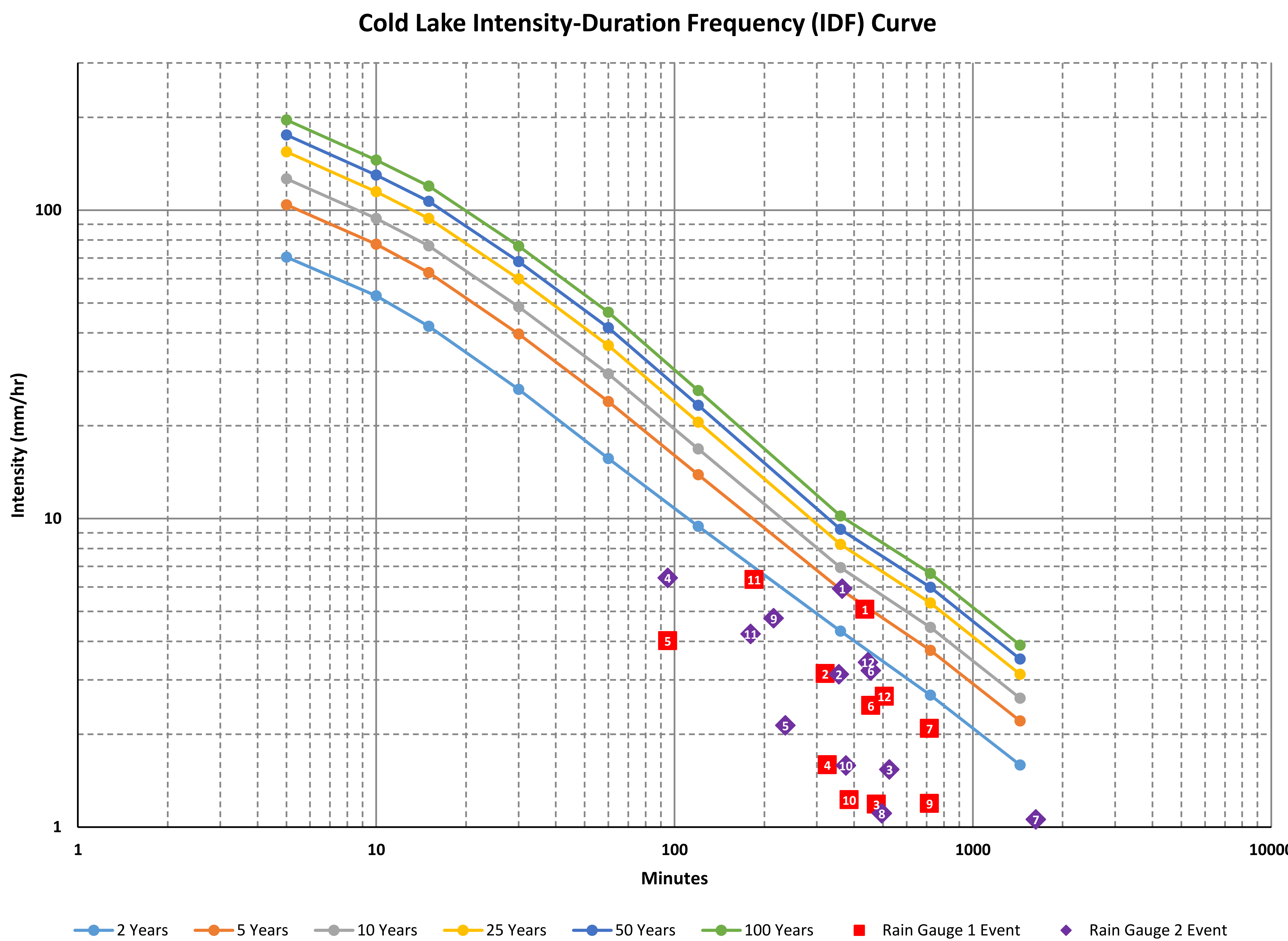
City of Cold Lake

THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM

INFLOW-INFILTRATION REVIEW
2016 RAINFALL DATA

ISL Engineering and Land Services

FIGURE 7.3



THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM

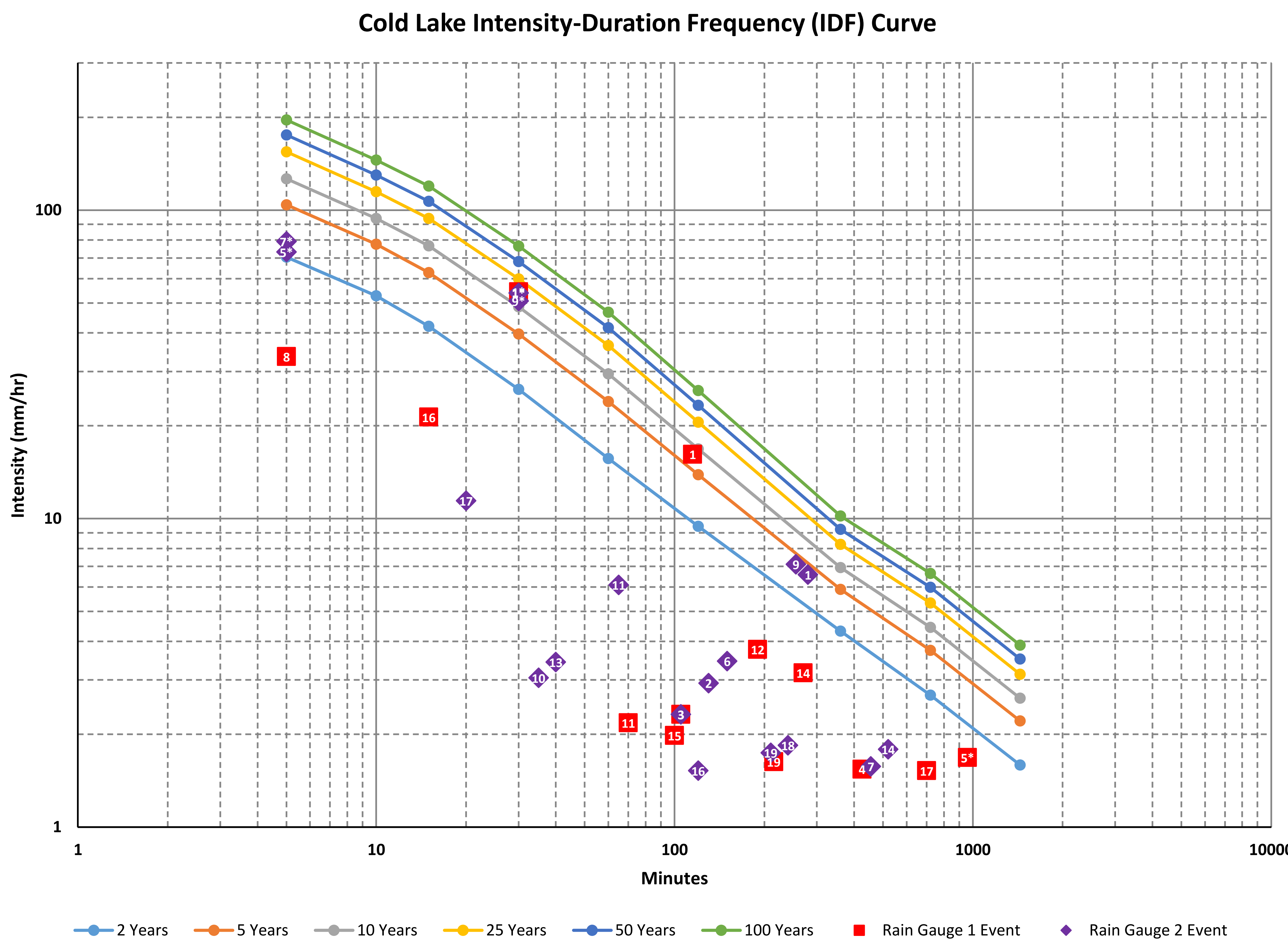
INFLOW-INFILTRATION REVIEW
COLD LAKE IDF CURVE
WITH 2015 RAINFALL EVENT
RETURN PERIODS SUPERIMPOSED

City of Cold Lake

ISL Engineering and Land Services

Date: 10/19/2017 Document: M:\26300\26367_Cold_Lake_I-I_Program\02_CADD\20_Drafting\201_GIS Figures\7.0 Inflow-Infiltration Review\Figure 7.3 - 2015 IDF Curve.mxd

FIGURE 7.4



City of Cold Lake

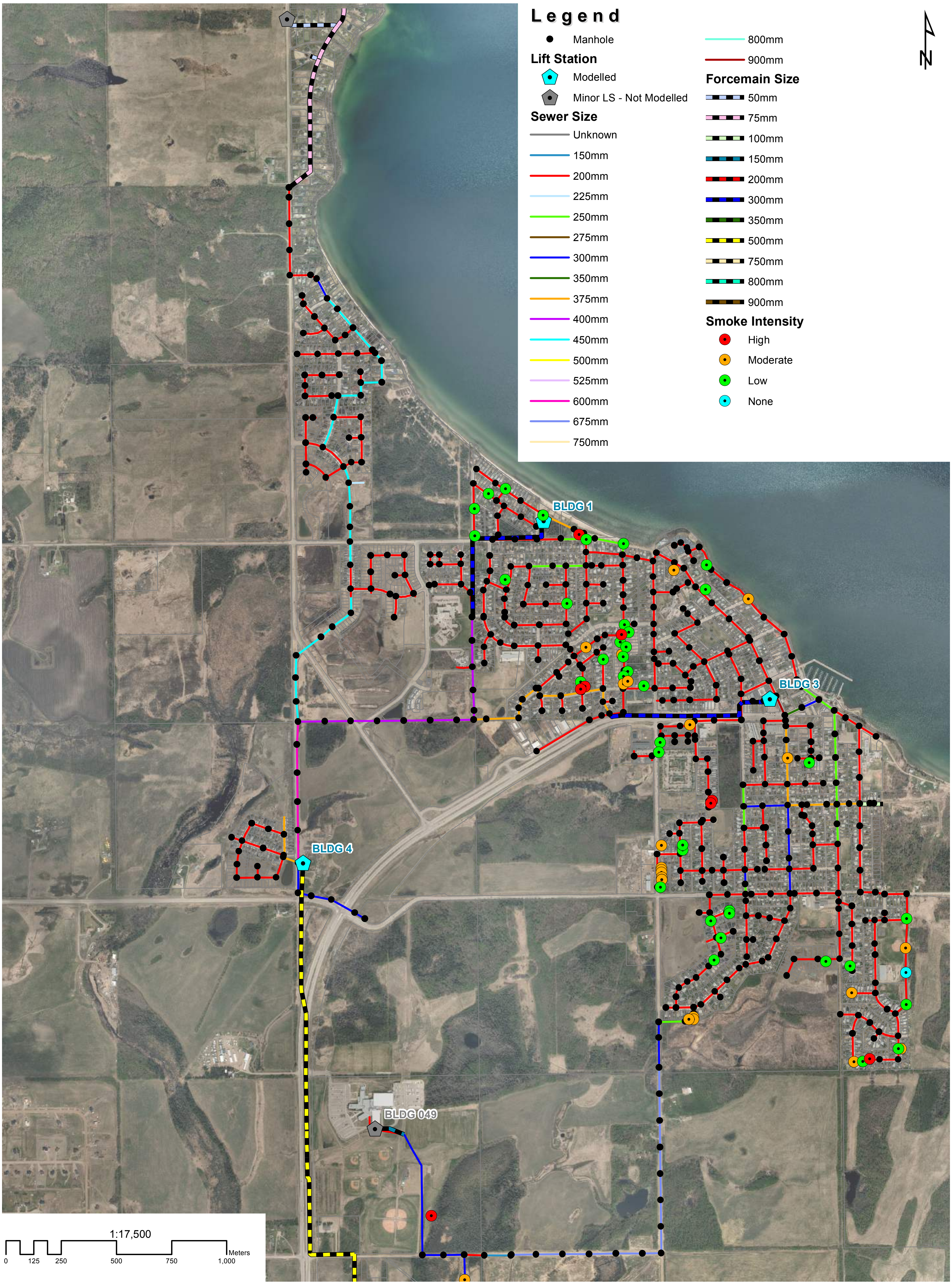
THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM

INFLOW-INFILTRATION REVIEW
COLD LAKE IDF CURVE
WITH 2016 RAINFALL EVENT
RETURN PERIODS SUPERIMPOSED

ISL Engineering and Land Services

Date: 10/19/2017 Document: M:\26300\26367_Cold_Lake_I-I_Program\02_CADD\20_Drafting\201_GIS Figures\7.0 Inflow-Infiltration Review\Figure 7.4 - 2016 IDF Curve.mxd

FIGURE 7.6



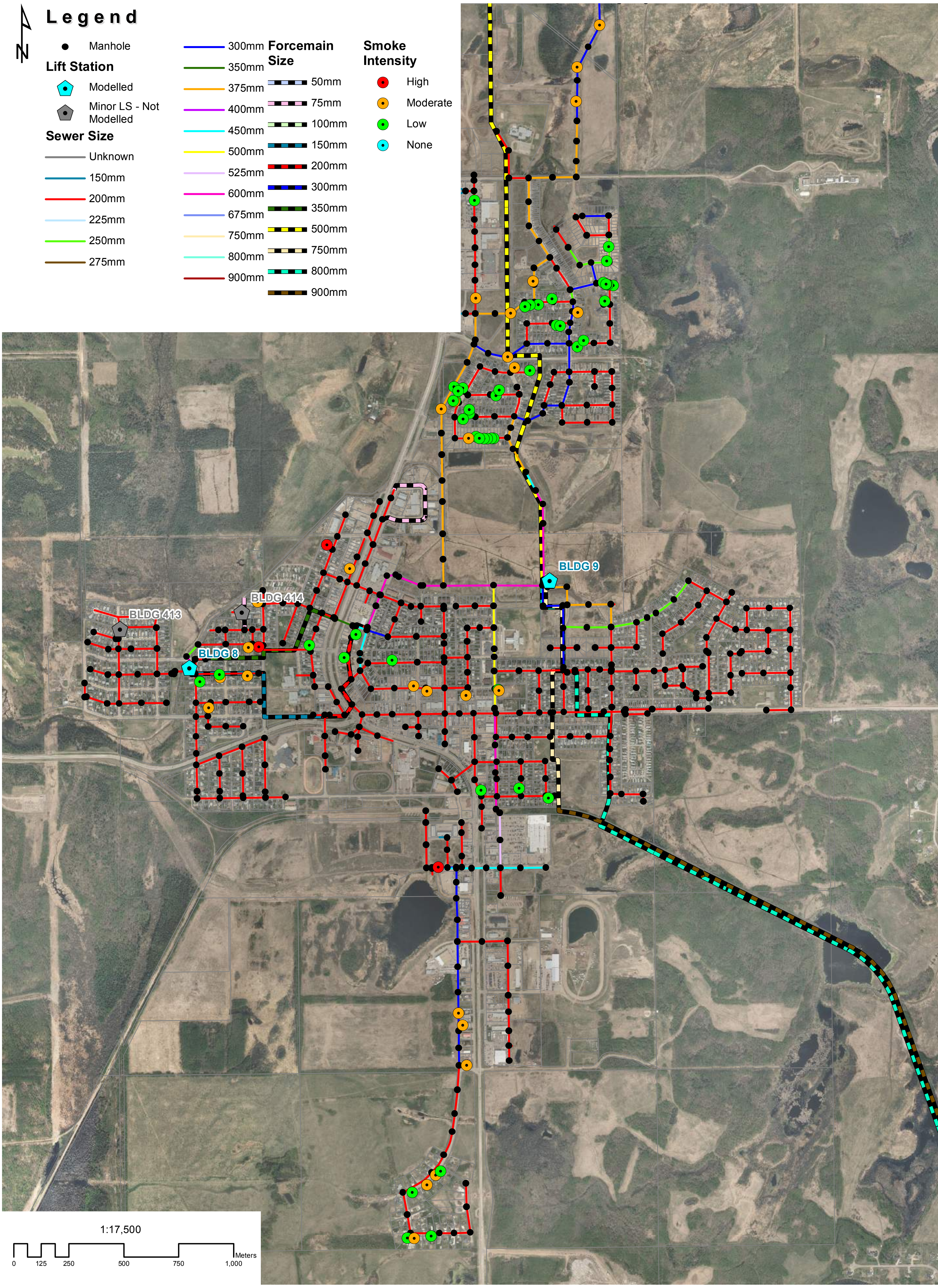
City of Cold Lake

THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM

SANITARY COLLECTION SYSTEM
EXISTING NETWORK - NORTH
SMOKE TESTING INCIDENTS

ISL Engineering and Land Services

Date: 10/19/2017 Document: M:\26300\26367_Cold_Lake_I-I_Program\02_CADD\20_Drafting\201_GIS Figures\7.0 Inflow-Infiltration Review\Figure 7.6 - Smoke Testing Locations_North.mxd



City of Cold Lake

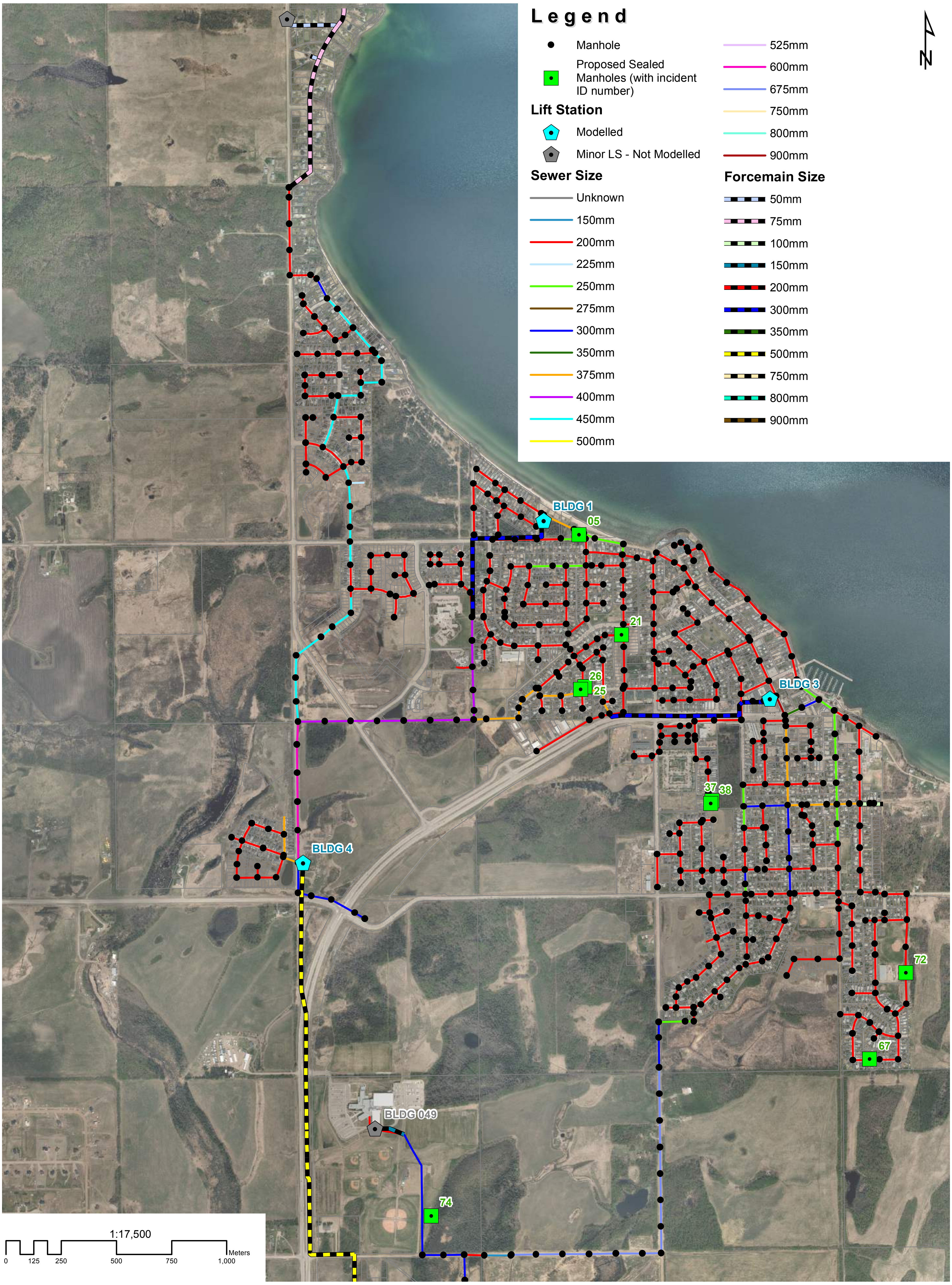
THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM

SANITARY COLLECTION SYSTEM
EXISTING NETWORK - SOUTH
SMOKE TESTING INCIDENTS

ISL Engineering and Land Services

Date: 10/19/2017 Document: M:\26300\26367_Cold_Lake_I-I_Program\02_CADD\20_Drafting\201_GIS Figures\7.0 Inflow-Infiltration Review\Figure 7.7 - Smoke Testing Locations_South.mxd

FIGURE 7.8



City of Cold Lake

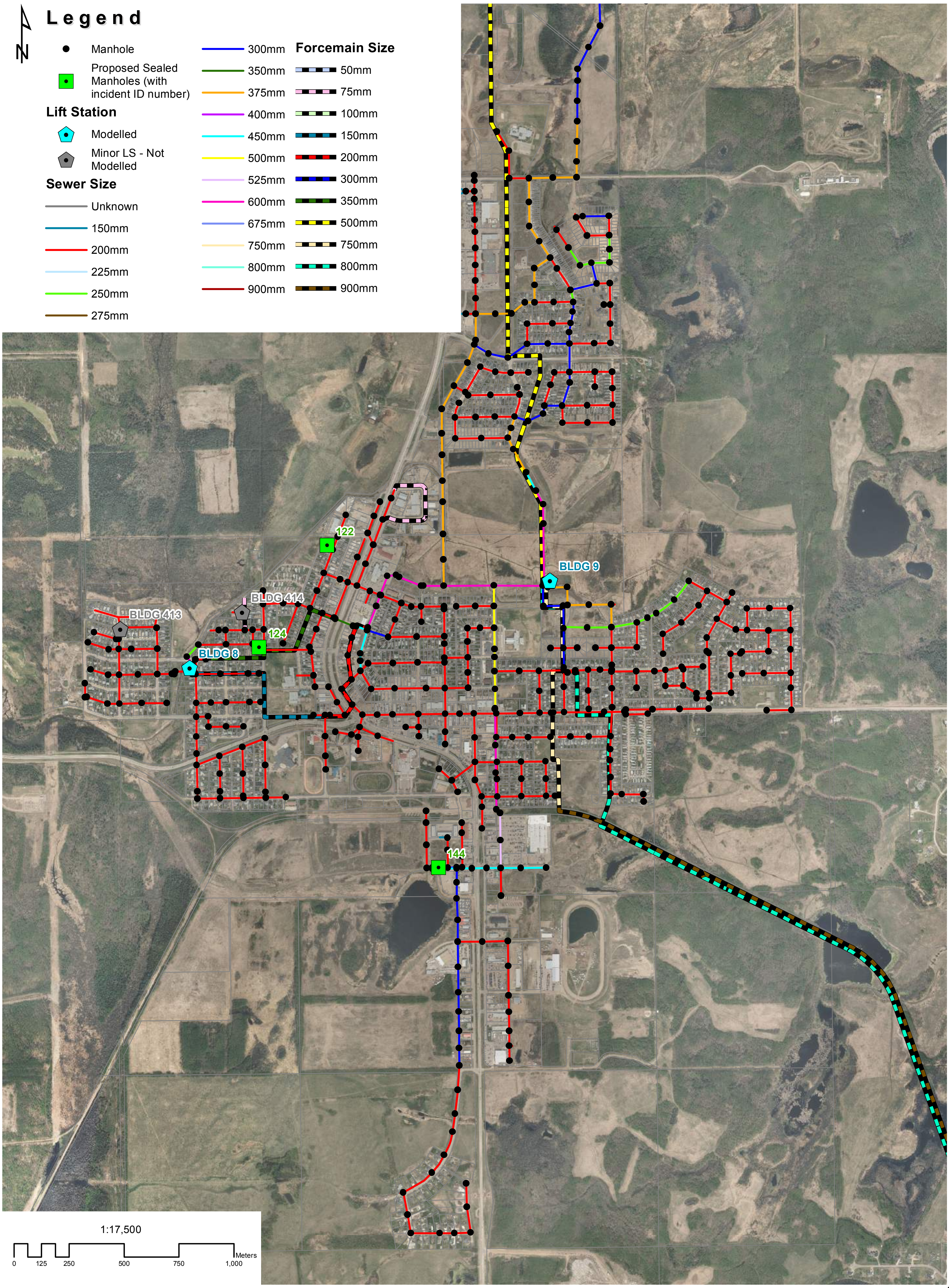
THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM

SANITARY COLLECTION SYSTEM
EXISTING NETWORK - NORTH
MANHOLES PROPOSED TO BE SEALED

ISL Engineering and Land Services

Date: 10/19/2017 Document: M:\26300\26367_Cold_Lake_I-I_Program\02_CADD\20_Drafting\201_GIS Figures\7.0 Inflow-Infiltration Review\Figure 7.8 - Manholes to Seal_North.mxd

FIGURE 7.9



THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM

SANITARY COLLECTION SYSTEM
EXISTING NETWORK - SOUTH
MANHOLES PROPOSED TO BE SEALED

City of Cold Lake

ISL Engineering and Land Services

Date: 10/19/2017 Document: M:\26300\26367_Cold_Lake_I-I_Program\02_CADD\20_Drafting\201_GIS Figures\7.0 Inflow-Infiltration Review\Figure 7.9 - Manholes to Seal_South.mxd

8.0
Future Sanitary Servicing Concepts

8.1 Future Growth Scenarios

As previously mentioned, four growth horizons were considered as part of the Inflow-Infiltration Program study as shown in Figures 8.1 and 8.2, including:

- Stage 1 – Build-out of Existing System Upgrading Concept
- Stage 2 – Build-out to Current City Boundary Upgrading Concept
- Stage 3 – Build-out of Annexation Areas Upgrading Concept
- Stage 3+ – Build-out of Annexation Areas with Additional Three Quarter Sections Upgrading Concept

Catchments required for the four future scenarios were delineated using three key shapefiles, four reports, one presentation, and input from the City, stated below:

1. City Boundary shapefile (provided by the City)
2. Parcels shapefile (provided by the City)
3. Proposed Annexation Boundaries shapefile (provided by the City)
4. Sanitary Master Plan (SMP) Update (2015) (completed by AECOM, and provided by the City)
5. Municipal Development Plan (2007) (obtained from the City's website)
6. Intermunicipal Development Plan (2009) (obtained from the City's website)
7. Cold Lake Annexation Proposal: Public Open House Presentation (2014) (obtained from the City's website)
8. Forest Heights Sanitary Sewer Trunk Preliminary Design Report (2012) (completed by MMM Group, and provided by the City)
9. Input from the City regarding potential additions in the north to the City's annexation areas

In addition to these eight critical files and the City's input, a number of area structure plans (ASPs) and outline plans were obtained from the City's website and utilized throughout the delineation process, as well as to derive future populations.

The first step of delineating the catchments was to separate all of the existing catchments that were already in the MIKE URBAN model from the areas which were considered as future development areas. Doing so ensured that there were no overlaps between the existing and future scenarios, and that parcels of land were not being accounted for more than once. From there, the remaining parcels were divided in terms of land use, by referring to the reports and ASPs mentioned above. The catchments were then further divided to account for topographical differences within each catchment area. Subsequently, areas, X- and Y-coordinates, number of lots, and populations were determined for each catchment.

The following assumptions were made when determining catchment land uses:

1. ASPs and outline plans took precedence over the other four reference reports.
   - Each ASP/outline plan has a Land Use Concept Map, so these maps were transferred into Autodesk's Civil 3D in order to digitize the exact borders of the different land uses.
2. Where ASPs were unavailable, land uses were assumed from Figure 2.3 of the SMP Update report.
   - Figure 2.3 has a number of blank catchments without assigned land uses, in this case land uses were assumed from the MDP.
   - When cross referencing the land uses between the SMP Update and the MDP, there were a few discrepancies. The land uses defined in the SMP Update were assumed to be correct, provided that this report was the more recently administered document.

- Figure 2.3 states that the quarter section at the very south end of the City is considered a future residential area. When comparing to the IMDP, this area has been dedicated as a landfill site. For the purposes of this study, this quarter section has been considered undevelopable, as it is currently classified as a landfill, and the landfill will additionally require a 300 m buffer zone as per the required offsets stipulated by the Provincial Guidelines.

3. The annexation area land uses were assigned in conjunction with the land uses provided in the Post-Annexation Preliminary Aggregated Land Supply Map from the City's Annexation Open House Presentation.
   - A similar process to the ASP outline maps was undertaken, in which the map was transferred into Civil 3D, and land use divisions were digitized and then transferred into a GIS format.
   - The map illustrates a number of undevelopable features in the annexation lands, including Palm Creek, African Lake, and Fontaine Lake. It was assumed that areas falling within these waterbodies will remain undevelopable, therefore were excluded from the developable catchment areas and were not modelled.
   - A number of quarter sections in the east that are not within the City's Proposed Annexation Boundaries shapefile were included as catchment areas. This was done to align with the catchments stipulated for growth in the Forest Heights Sanitary Sewer Trunk Preliminary Design Report, and was confirmed with the City.
4. In addition to the original annexation area (Stage 3), another scenario (Stage 3+) was considered in which three additional quarter sections in the north, to the west of Horseshoe Bay Estates, were included. This was requested by the City, as these quarter sections are being considered for annexation.

The following assumptions were made when determining catchment populations:

1. ASPs and outline plans took precedence over all other documentation.
   - Many of the ASPs and outline plans stated specific information pertaining to residential developments. Each ASP had its own criteria, and varied in terms of the amount of information provided. Data that was provided including the following, and was available depending on the age of the ASP and the thoroughness of the document:
     i. Developable Areas
     ii. Type of residential areas (low, medium, or high density residential, multifamily, mobile home, etc.)
     iii. Unit per hectare density
     iv. Persons per unit density
     v. Number of lots
     vi. Populations
   - This information was utilized for each specific ASP in order to determine the population values.
   - In ASPs where development has been already partially completed (i.e. some catchments already included in the existing system scenarios), these populations, lots, and/or areas (depending on the type of information obtained in the ASP) were deducted from the totals to obtain a net increase value.
2. If population information was not provided in the ASP, and for all remaining catchment areas including those in the annexation lands and beyond (Stage 3+), a constant persons per hectare density was assumed.
   - A density of 37 persons per gross residential hectare value was applied for this purpose, which is consistent with the method used in the SMP Update, and was the residential density for new neighbourhoods value stipulated in the MDP.

Please refer to Figures 8.3 and 8.4 for depictions of the proposed land uses and Figures 8.5 and 8.6 for depictions of the projected populations under the four growth scenarios. Table 8.1 below summarizes the total catchment areas and populations that were applied as part of the I-I Program. Note that in the following table, the multiple types of residential land uses (i.e. low-, medium-, high-density residential, mixed use, mobile home, etc.) were grouped together for a single 'residential' category.

Table 8.1: Future Catchment and Population Summary

Land Use Type	Stage 1		Stage 2		Stage 3		Stage 3+	
	Total Population	Total Area	Total Population	Total Area	Total Population	Total Area	Total Population	Total Area
		ha		ha		ha		ha
Residential	438	36	42,701	886	28,618	973	5,043	136
Commercial	N/A	3	N/A	82	N/A	177	N/A	0
Industrial	N/A	3	N/A	70	N/A	187	N/A	0
Institutional	N/A	0	N/A	18	N/A	74	N/A	0
Total	**438**	**43**	**42,701**	**1,056**	**28,618**	**1,410**	**5,043**	**136**

8.2 Future Servicing Concept

8.2.1 Future Sanitary Servicing Concept Development Principles

The proposed sanitary servicing plan for all developable lands based on the four growth projections was sized using a spreadsheet approach. This approach was based on the dry-weather residential and ICI generation rates, peaking factors, and the I-I allowance rate outlined in the assessment criteria section above (Section 5.2).

The specified sewer sizes are the smallest possible determined based on the required minimum design slope to provide a self-cleansing full-sewer velocity of greater than 0.60 m/s, under the derived peak wet weather flows, based on a roughness coefficient (n) of 0.013 as per the City's Sanitary Design Standards as presented in Table 8.2.

Table 8.2: Minimum Design Slopes for Sewers

Nominal Sewer Size	Minimum Design Slope		Full Sewer Velocity	Full Sewer Capacity
mm	%	m/m	m/s	L/s
200	0.40	0.0040	0.66	20.7
250	0.28	0.0028	0.64	31.5
300	0.22	0.0022	0.64	45.4
375	0.15	0.0015	0.61	67.9
450	0.12	0.0012	0.62	98.8
525	0.10	0.0010	0.63	136.0
600 or Greater	0.08	0.0008	0.61	173.7

If flatter slopes are preferred or required at the detailed design stages, this can be reviewed, though it would have negative repercussions. If this was acceptable, the determined sewer sizes would need to be increased to meet the specified design flows.

With regards to pumped flows, a new forcemain/siphon is typically designed to operate between 1.1 m/s to 2.0 m/s with a preferred velocity of 1.5 m/s. This approach was utilized to size new forcemains for the purpose of developing future servicing options to minimize the resulting head losses which in turn would yield savings on the energy consumption front in terms of forcemains. Ensuring that forcemains/siphons are sized for a minimum velocity of 1.1 m/s helps to keep materials suspended, thus decreasing sediment build-up in the sewer. Each future forcemain/siphon was specified as a twin sewer to provide a degree of redundancy, as well as staging of flows (as opposed to one larger forcemain).

The servicing schemes are a conceptual concept of the proposed sanitary system. 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. A developer may also choose to connect services directly to the future sanitary trunks if found beneficial, provided the designed system does not result in any negative impacts on the directly connected developments. Specifically, surcharge conditions within the system resulting in basement back-ups is of concern.

8.2.2 Future Sanitary Servicing Concept

Stage 1 – Build-out of Existing System Upgrading Concept

As this growth scenario consists of developments intended to grow within the existing sanitary system, all catchments have a nearby tie-in connection to the existing system. Subsequently, under this scenario it is assumed that all catchments tie into the existing system thus a servicing strategy is not required.

Stage 2 – Build-out to Current City Boundary Upgrading Concept

Under the Stage 2 growth scenario, many of the future development areas have sufficient grade to directly tie back into the existing system, using the minimum slopes stipulated above in Table 8.2. In these cases, it is assumed that the developer will be responsible for the servicing designs. Catchments within Stage 2 that fall under this category are cross-hatched in Figures 8.1 and 8.2.

The servicing concept for Cold Lake North under Stage 2 is shown in Figure 8.7. Essentially, flows from the development that occur in Cold Lake North are routed through either a completely gravity or gravity/pumped system back into the existing trunk network. For the developments to the east, flows are conveyed to the north through a series of gravity sewers collecting flows from each catchment area's lowest point, ultimately to a proposed lift station. From there, flows are pumped to the southwest where the proposed twinned forcemain ties into the existing Forest Heights Trunk. Additionally, the development in quarter section NE 14-63-2-4 flows to a low point in the northwest corner of the quarter section, then is pumped via a lift station to Phase 2 of the Forest Heights Trunk. Please note that at this point it is assumed that Phase 2 of the Forest Heights Trunk is operational, as discussed below in Section 9.0. The development in the middle of Cold Lake North discharges flows from the north to the south towards 16th Avenue via a series of gravity sewers. These trunks ultimately converge and convey flows west to the intersection with the future gravity line conveying flows from Building 3 to Building 4 Lift Station, which is discussed further in Section 9.0.

The servicing concept for Cold Lake South under Stage 2 is shown in Figure 8.8. The developments in Cold Lake South that do not directly tie back to the existing system remain completely independent of the current sanitary network. To this regard, another major lift station and forcemain will be required to pump the flows from these catchment areas southbound to the City's sanitary lagoon. Flows produced from the developments in the west will be collected at the catchment area's lowest points and conveyed southwest along the existing City boundary. From there, the sewer turns east to an intermediary proposed lift station with twinned forcemains that will pump sewage east to the major lagoon lift station. Due to further topographical constraints, an additional lift station will be needed in the east in order to allow three quarter sections in the north portion of Cold Lake South to go online. This lift station's proposed twinned forcemains convey sewage to the southwest to a high point, at which point the system changes to gravity sewers ultimately to the proposed major lagoon lift station in the south.

In all, this growth scenario consists of:

- Five additional lift stations (two in Cold Lake North and three in Cold Lake South)
- Five additional twinned forcemains varying from 100 mm to 300 mm in size
- Gravity sewers varying from 200 mm to 600 mm in size

A detailed breakdown of sanitary sewage flows and sewer size determination for Stage 2 is provided in Appendix H.

Stage 3 – Build-out of Annexation Areas Upgrading Concept

For all development occurring within Stage 3, it was assumed that no catchments would be able to tie into the existing system due to the longer distances to potential tie-in locations and significant topographical differences, which would both result in inverts being too low to match existing elevations. As a result, a servicing concept was required to cover all of the annexation areas.

The servicing concept for Cold Lake North under Stage 3 is shown in Figure 8.9. The developments on the east side of Cold Lake North are conveyed southbound to a low point east of African Lake. From this point, a proposed lift station pumps the sewage through twinned forcemains ultimately to a manhole along the Forest Heights Trunk. Once again, it is assumed that Phase 2 of the Forest Heights Trunk is in operation, as discussed in the subsequent section. On the west side of Cold Lake North, a network of gravity sewers and siphons conveys flows to the south. There are four siphons (of which two are in Cold Lake South) that cross Palm Creek. Though it was deemed possible to have a secondary gravity sewer running on the east side of the creek, it was determined that having multiple siphon crossings would be more cost beneficial versus installing a significant length of sewer which would result in doubling the required gravity sewer length. It is noted that if the City would desire fewer siphons and instead have a greater length of sewer, this option exists as well however is not stipulated further in this report. Additional analysis would in that case be required to determine the exact sewer layout and sizing.

The servicing concept for Cold Lake South under Stage 3 is shown in Figure 8.10. In Cold Lake South, annexed areas in the northeast are conveyed via a network of gravity sewers to Phase 2 of the Forest Heights Trunk. The exact tie-in location may vary, as detailed design of the exact manhole locations along Phase 2 has not begun. For the purposes of modelling these catchment areas, the catchment connection point was at the most upstream end of Phase 2. This was deemed the most conservative approach for modelling. The remainder of the annexed areas on the east side are conveyed by gravity to a proposed local lift station, which pumps sewage through a twinned forcemain that ultimately ties into the lowest point of the most northern Stage 2 development. Sewage is then conveyed through the servicing concept proposed in Stage 2. In the west, flows from the annexed areas continue from Cold Lake North towards the south, with an additional local siphon crossing Palm Creek. At the south end of the annexed areas, the gravity sewer turns east under Palm Creek through a more major siphon crossing. A proposed lift station and twinned forcemain conveys sewage south through the City, and ties into the upstream end of the proposed Stage 2 west servicing concept. Please note that sewer sizes are incremental between figures, with the ultimate sewer sizes shown in the Stage 3+ servicing concept.

It is noted that under this scenario, three of the Stage 2 forcemains in Cold Lake South are utilized to convey flows from Stage 3. As mentioned, sizing of these twinned forcemains is incremental between figures. From a practicality point of view, instead of reinstalling and upsizing twinned forcemains between stages the City could consider installing forcemains under the first stage that would serve under the ultimate scenario. In this case, it is assumed that there would be one smaller forcemain to convey flows from Stage 2 under DWF and WWF conditions, then a larger forcemain that would convey the remaining flows from Stages 3 and 3+. That said, the following forcemain sizes would be recommended, being sufficient for Stages 2, 3, and 3+:

- FUT STG 2 FM_1: 300 mm and 800 mm forcemains
- FUT STG 2 FM_2: 150 mm and 300 mm forcemains
- FUT STG 2 FM_Lagoon: 450 mm and 900 mm forcemains

In terms of redundancy, if there was a failure in the larger forcemains under the ultimate scenario, the smaller forcemains would not have sufficient capacity to convey sewage under peak wet weather flow conditions; this should be contemplated by the City, as in the event of a failure, sewage would need to be hauled until a repair was completed. That said, it is noted that the probability of the two events coinciding is very unlikely, and it is ultimately up to the City what the degree of resiliency in their sanitary system is. However, for presentation purposes of the recommended servicing option on provided figures, twinned forcemains of the same size were utilized.

In all, this growth scenario consists of:

- Three additional lift stations (one in Cold Lake North and two in Cold Lake South)
- Three additional twinned forcemains varying from 200 mm to 600 mm in size
- Four siphons (two in Cold Lake North and two in Cold Lake South)
- Gravity sewers varying from 200 mm to 1050 mm in size

A detailed breakdown of sanitary sewage flows, and sewer size determination for Stage 3 is provided in Appendix H.

Stage 3+ – Build-out of Annexation Areas with Additional Three Quarter Sections Upgrading Concept

The servicing concept for both Cold Lake North and Cold Lake South under Stage 3+ is shown in Figures 8.11 and 8.12. Stage 3+ consists of three quarter sections, divided into five catchment areas due to specific topographic constraints. The majority of the low points of these catchment areas are along the east side of the quarter sections, thus a gravity sewer has been implemented along the east, running from north to south. There is a large ridge in the southernmost quarter section that divides the catchment in two, with one of the low points being located on the west side of the quarter section. In order to connect this low point to either the proposed Stage 3+ servicing concept or to the proposed Stage 3 servicing concept, a local lift station will be needed. To this extent, it was determined that this lift station would tie into the proposed Stage 3+ servicing concept, in order to minimize the length of the required twinned forcemains. The twinned forcemains convey flows to the east, to a high point on the ridge. After this point, a gravity sewer continues to convey flows to the east, until the sewer converges with the north-south sewer along the east side of the three quarter sections. The sewer continues south on 28th Street, ultimately reaching a low point east of the 28th Street and 1st Avenue intersection. A proposed local lift station then pumps the sewage westwards, where it ties into the upstream reaches of the proposed Stage 3 servicing concept. Please note that the sewer sizes under this growth scenario are the ultimate sewer sizes.

In all, this growth scenario consists of:

- Two additional lift stations (two in Cold Lake North)
- Two additional twinned forcemains varying from 100 mm to 675 mm in size
- Gravity varying from 200 mm to 1050 mm in size

A detailed breakdown of sanitary sewage flows and sewer size determination for Stage 3+ is provided in Appendix H.

8.3 Cost Estimates – Future Sanitary Servicing Concept

The summary of Class D cost estimates for the preferred servicing option is summarized in Table 8.3 below. For a detailed cost breakdown, please refer to Appendix I. The following assumptions were applied when determining the cost estimates:

1. No costs have been calculated for Stage 1, as all the proposed developments under this stage tie into the existing network and have been assumed to be detailed by the developers.
2. The opinion of probable costs herein refers to the total costs required to provide servicing to accommodate growth including the preceding stages e.g. Stage 3+ would include infrastructure required for Stages 1 through 3 in addition to Stage 3+. Hence,
   - Costs of the lift stations are not incremental. That said, costs of lift stations have not been carried over from previous stages, therefore the total flow allowances have been accounted for in each growth horizon. Realistically, lift stations from prior growth horizons would already be built, meaning that only the wet well sizing and additional pumps would be required thus reducing the overall capital costs.
   - Costs of the gravity sewers are not incremental. If a sewer must be upsized between scenarios, the entire cost of the new sewer is accounted for at that grown horizon. It is up to the City how they would like to stage the gravity sewers, if they would prefer to upsize the sewers as needed, install the proper sewer size initially, or potentially twin the lines in a manner that satisfies the required flows. This is done as timing of growth is unknown – for instance, if say, Stage 3 happened 20 years after Stage 2, replacement might be preferred due to the age of the infrastructure.
   - Costs of the forcemains are not incremental. In the cost estimates, it is assumed that each stage is independent of the next. The City may however wish to implement a staged approach to forcemain implementation as described above.
3. Siphons will be installed using a trenchless method, thus the cost of launch pits has been included.

Table 8.3: Class D Cost Estimates for the Recommended Future Sanitary Servicing System

Item	Growth Horizon			
	Stage 1	Stage 2	Stage 3	Stage 3+
Trunk Sewers	N/A	$6,465,000	$28,900,000	$34,130,000
Forcemains		$19,575,000	$40,755,000	$44,530,000
Siphons		$0	$1,225,000	$1,225,000
Lift Stations		$11,745,000	$42,195,000	$47,670,000
Cost per Growth Horizon[1]	**N/A**	**$37,785,000**	**$113,075,000**	**$127,555,000**

[1] *Costs have been rounded to the nearest $5,000*

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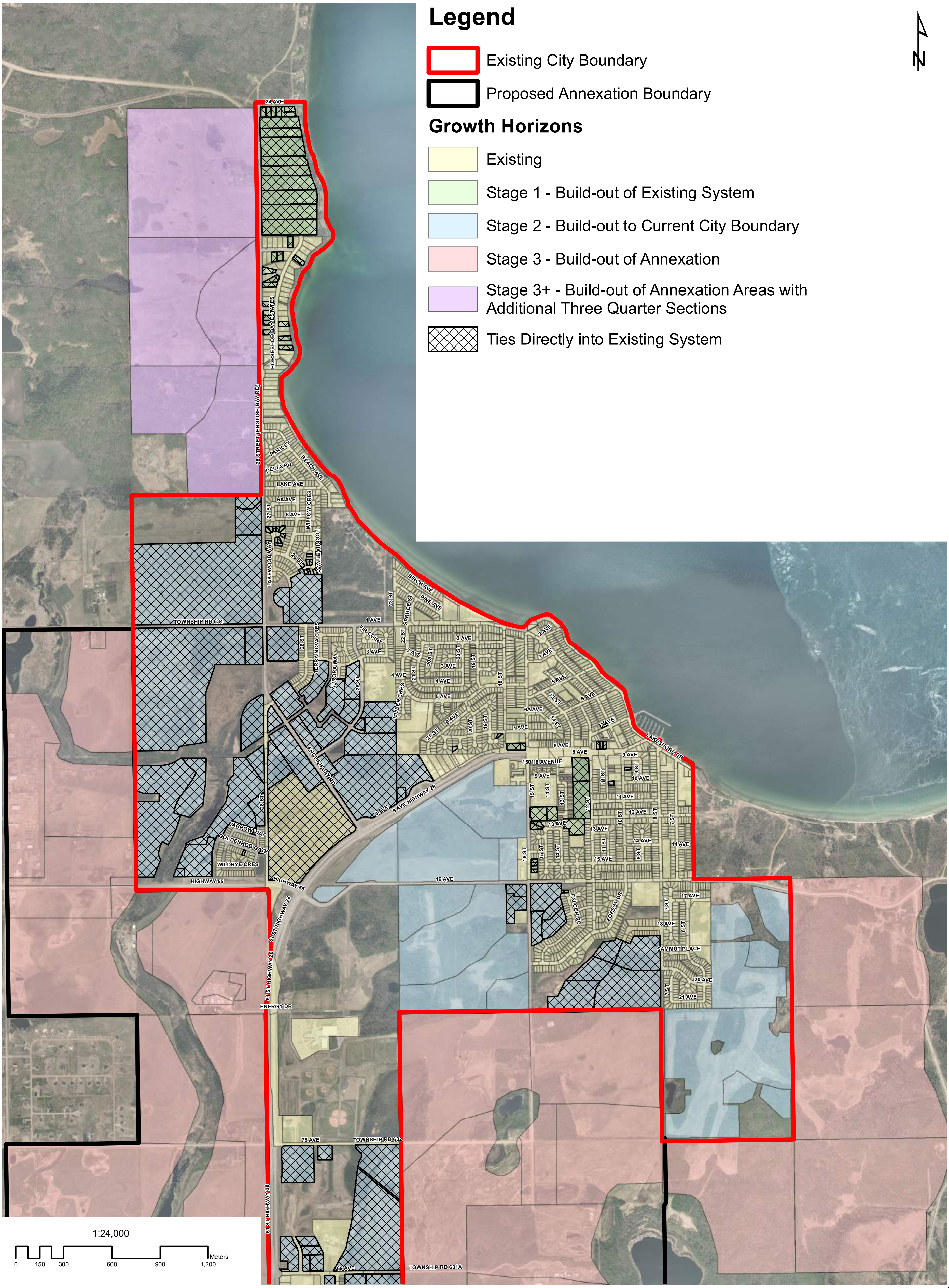
FIGURE 8.1

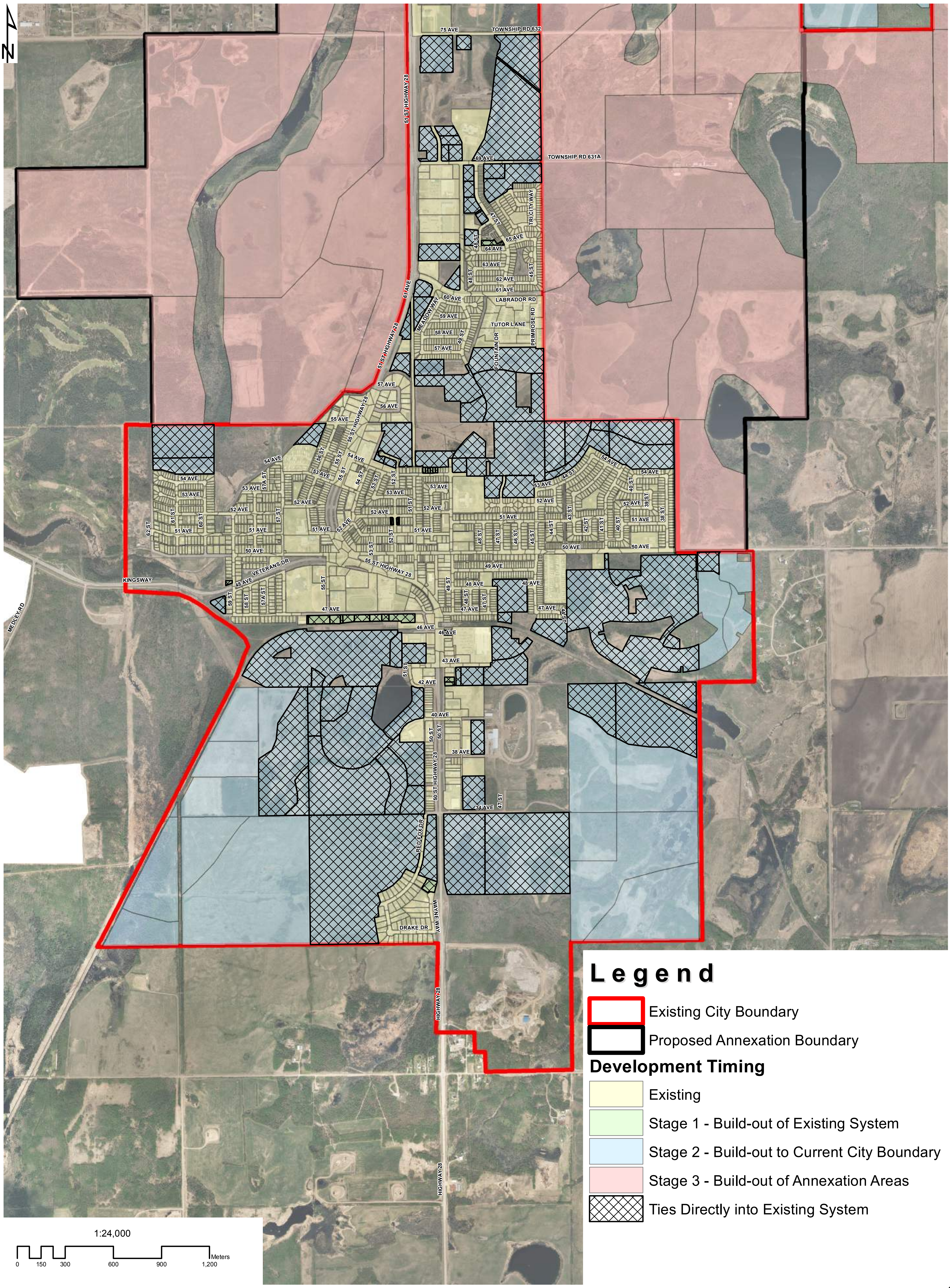


City of Cold Lake

THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM

PROPOSED CATCHMENT AREAS - NORTH
GROWTH HORIZONS

ISL Engineering and Land Services



City of Cold Lake

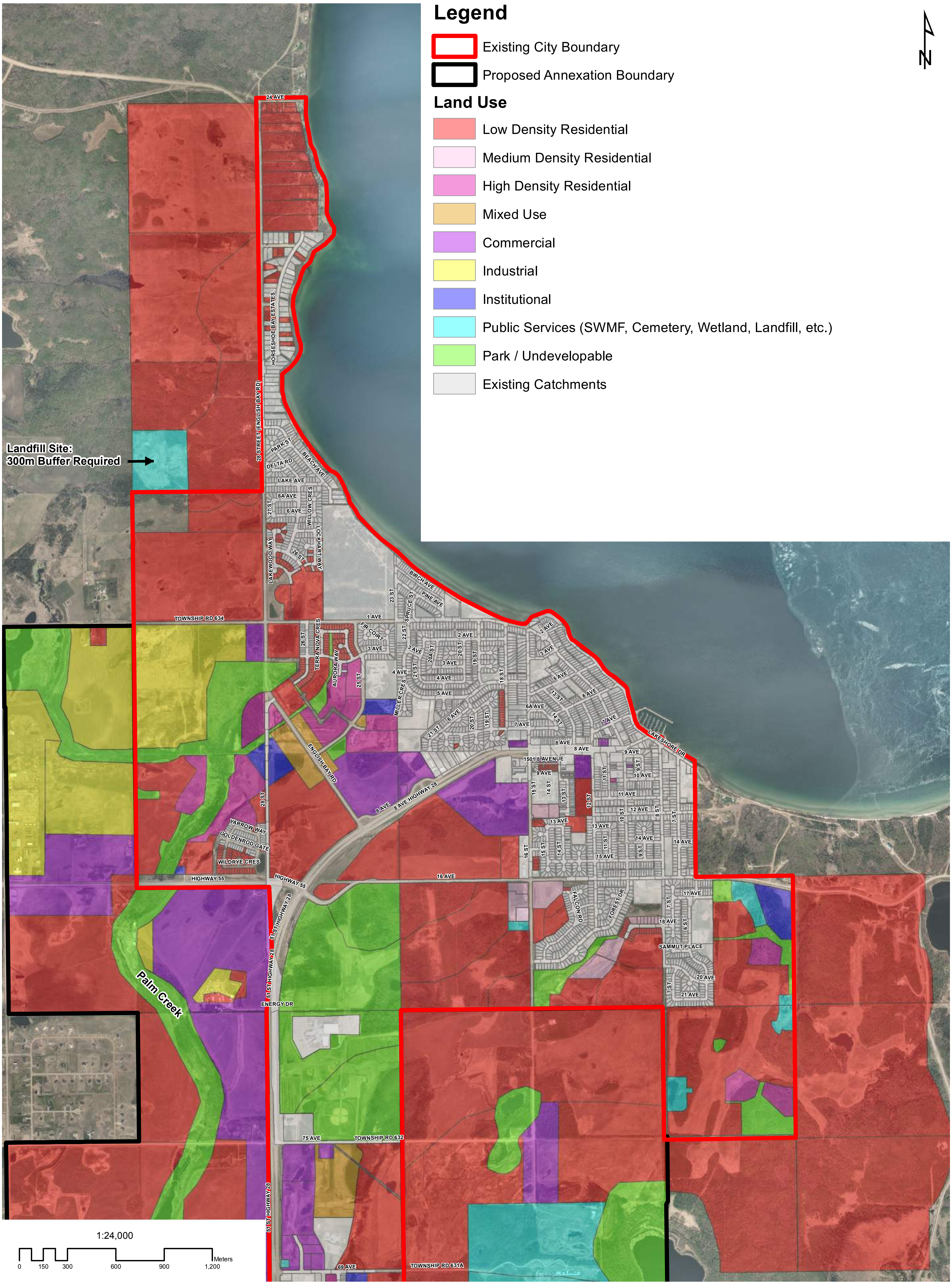
THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM

PROPOSED CATCHMENT AREAS - SOUTH
GROWTH HORIZONS

ISL Engineering and Land Services

Date: 10/19/2017 Document: M:\26300\26367_Cold_Lake_I-I_Program\02_CADD\20_Drafting\201_GIS Figures\8.0 Future Servicing Concepts\Figure 8.2 - Growth Horizons_South.mxd

FIGURE 8.3



City of Cold Lake

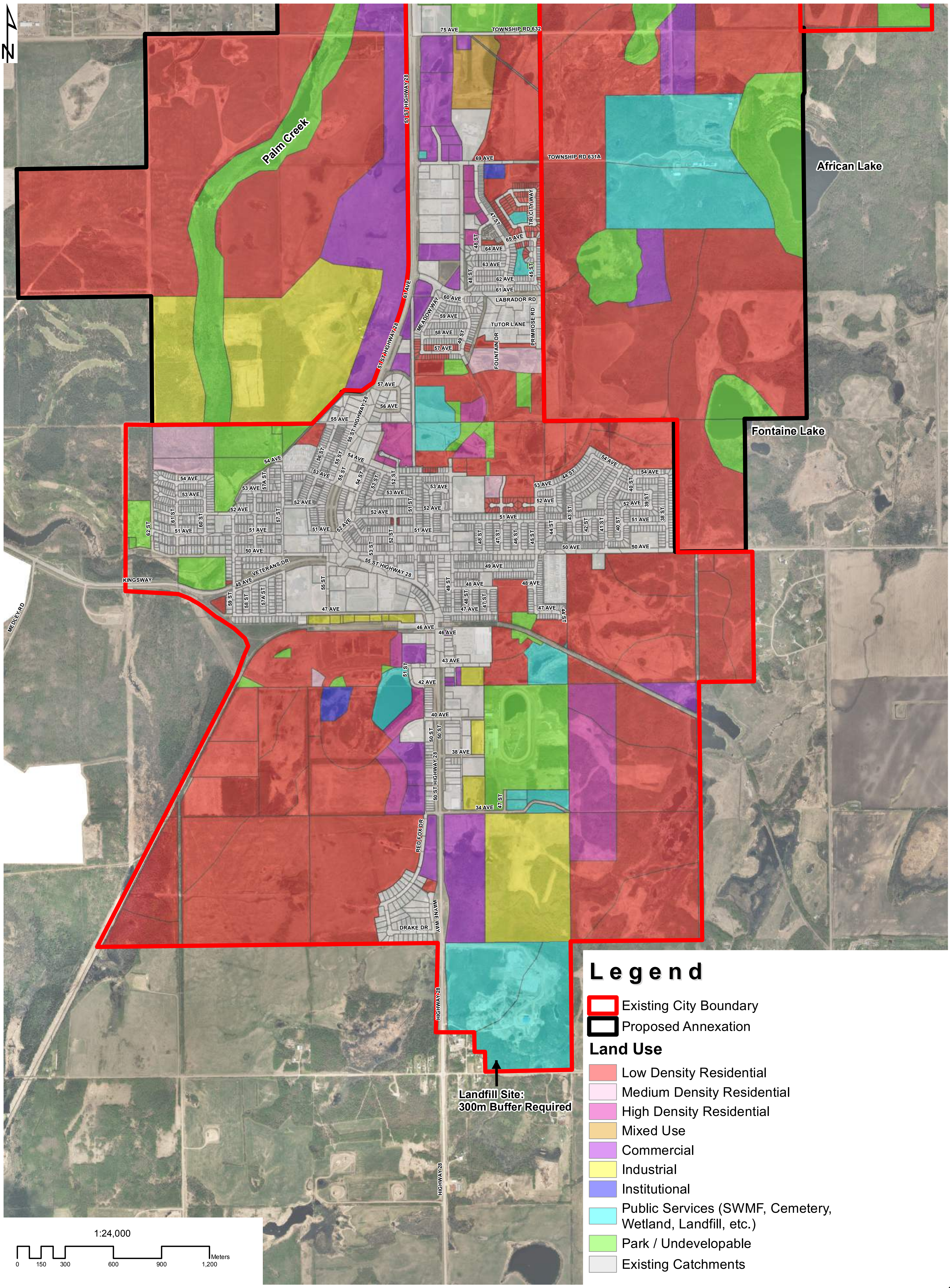
THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM

PROPOSED CATCHMENT AREAS - NORTH
DEVELOPMENT LAND USES

ISL Engineering and Land Services

Date: 10/19/2017 Document: M:\26300\26367_Cold_Lake_I-I_Program\02_CADD\20_Drafting\201_GIS Figures\8.0 Future Servicing Concepts\Figure 8.3 - Proposed Land Uses_North.mxd

FIGURE 8.4



City of Cold Lake

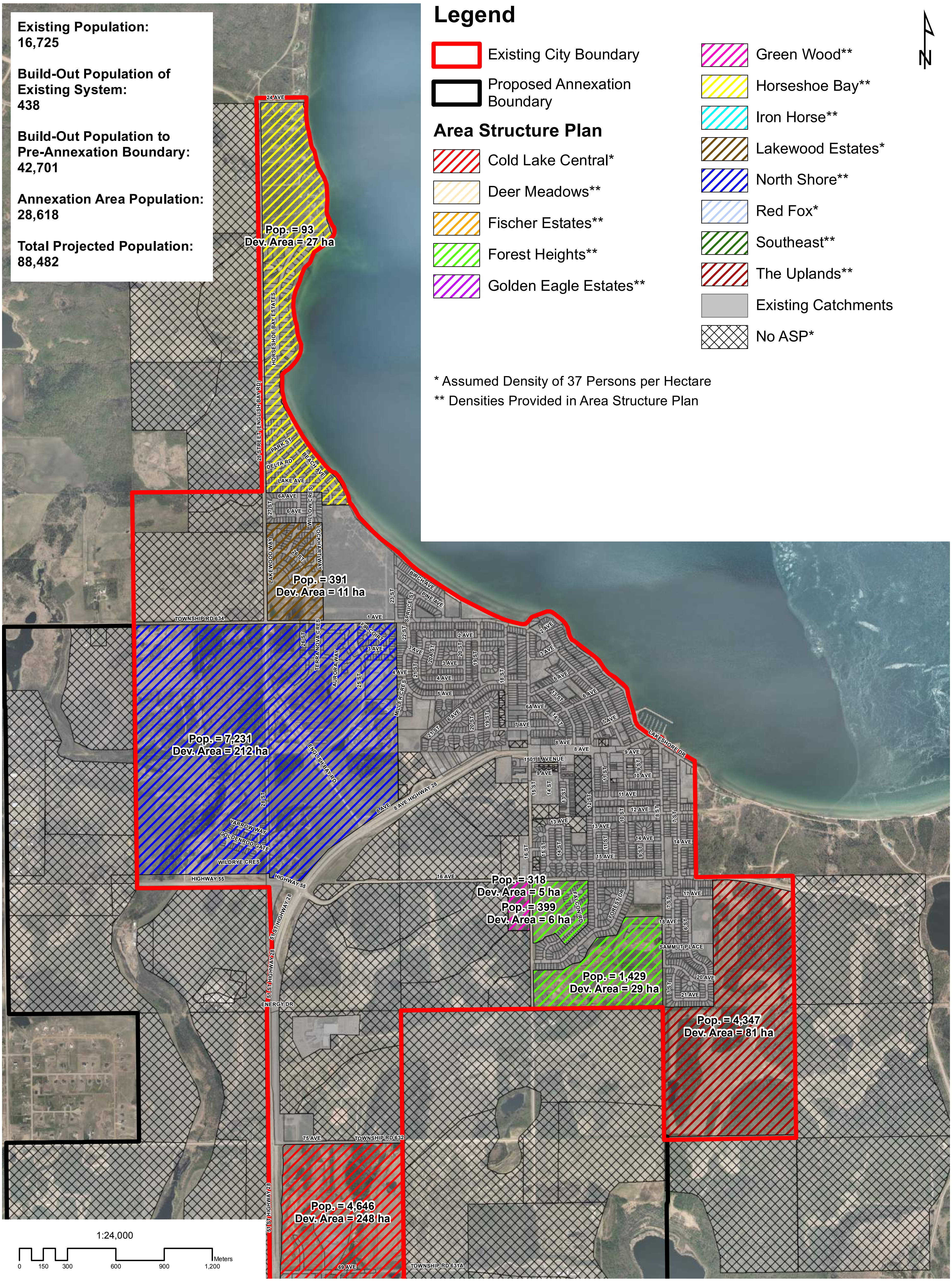
THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM

PROPOSED CATCHMENT AREAS - SOUTH
DEVELOPMENT LAND USES

ISL Engineering and Land Services

Date: 10/19/2017 Document: M:\26300\26367_Cold_Lake_I-I_Program\02_CADD\20_Drafting\201_GIS Figures\8.0 Future Servicing Concepts\Figure 8.4 - Proposed Land Uses_South.mxd

FIGURE 8.5



Date: 10/19/2017 Document: M:\26300\26367_Cold_Lake_I-I_Program\02_CADD\20_Drafting\201_GIS Figures\8.0 Future Servicing Concepts\Figure 8.5 - Projected Populations_North.mxd

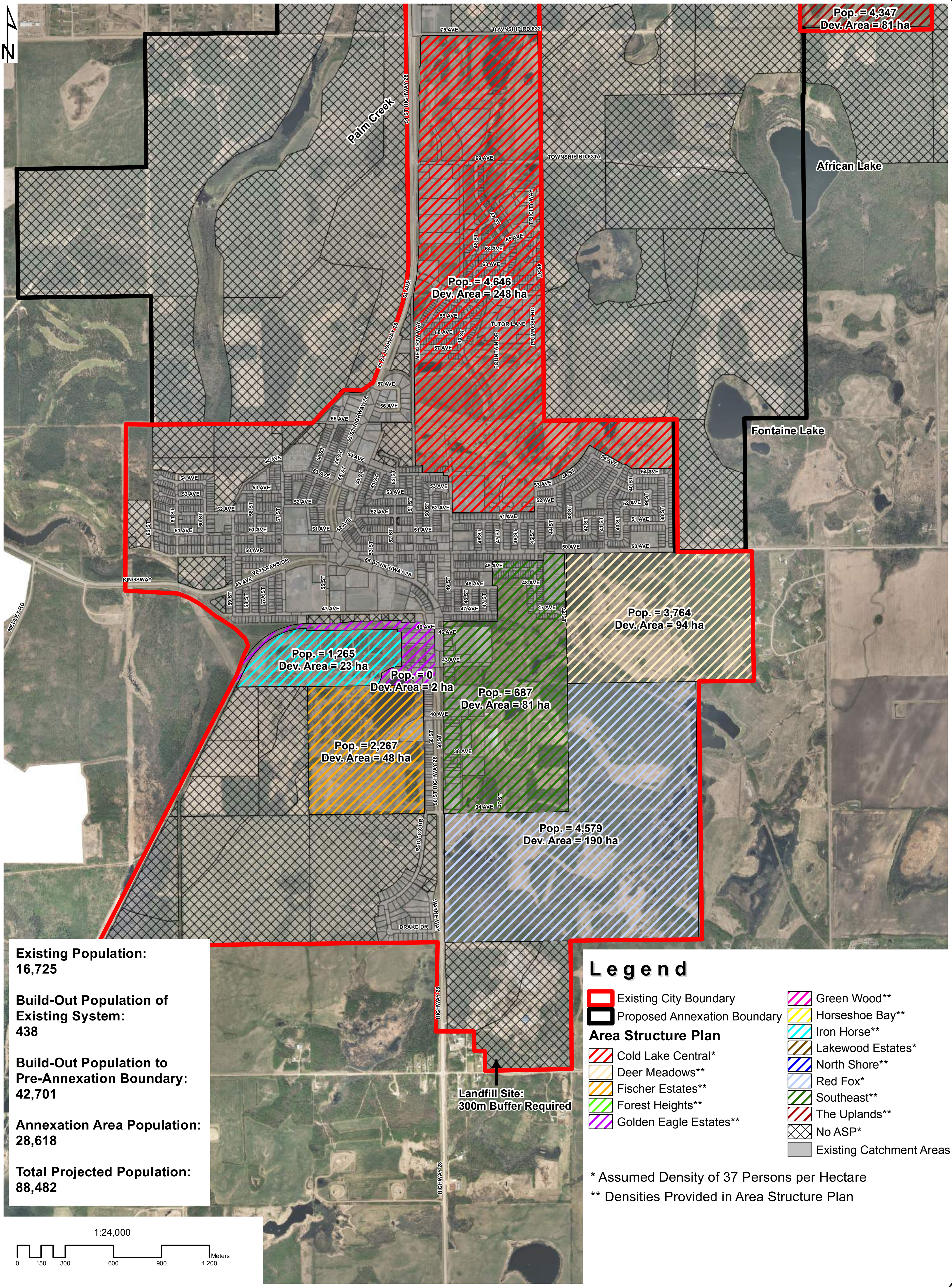
City of Cold Lake

THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM

PROPOSED CATCHMENT AREAS - NORTH
DERIVED POPULATIONS

ISL Engineering and Land Services

FIGURE 8.6

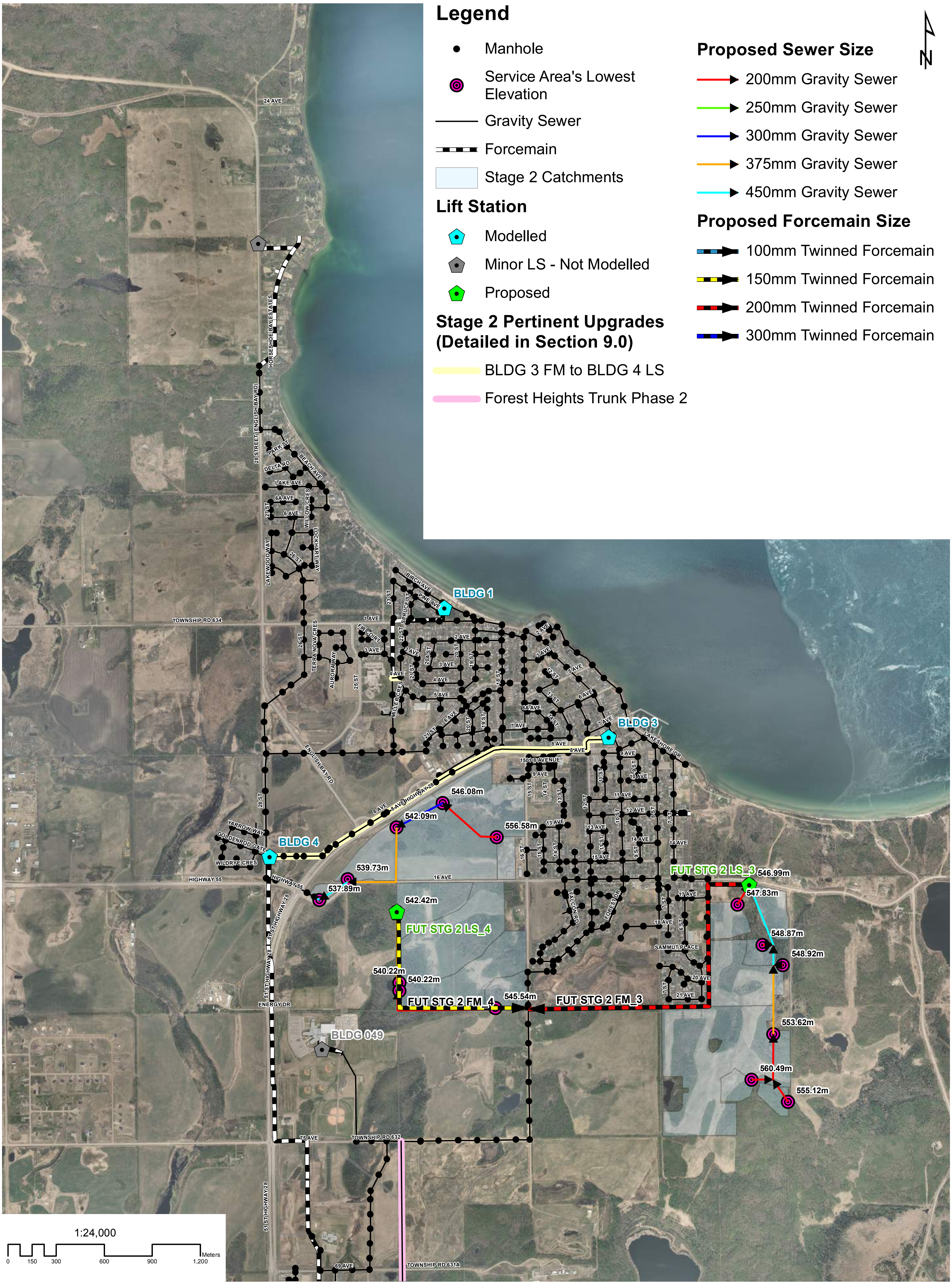


City of Cold Lake

THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM

PROPOSED CATCHMENT AREAS - SOUTH
DERIVED POPULATIONS

ISL Engineering and Land Services

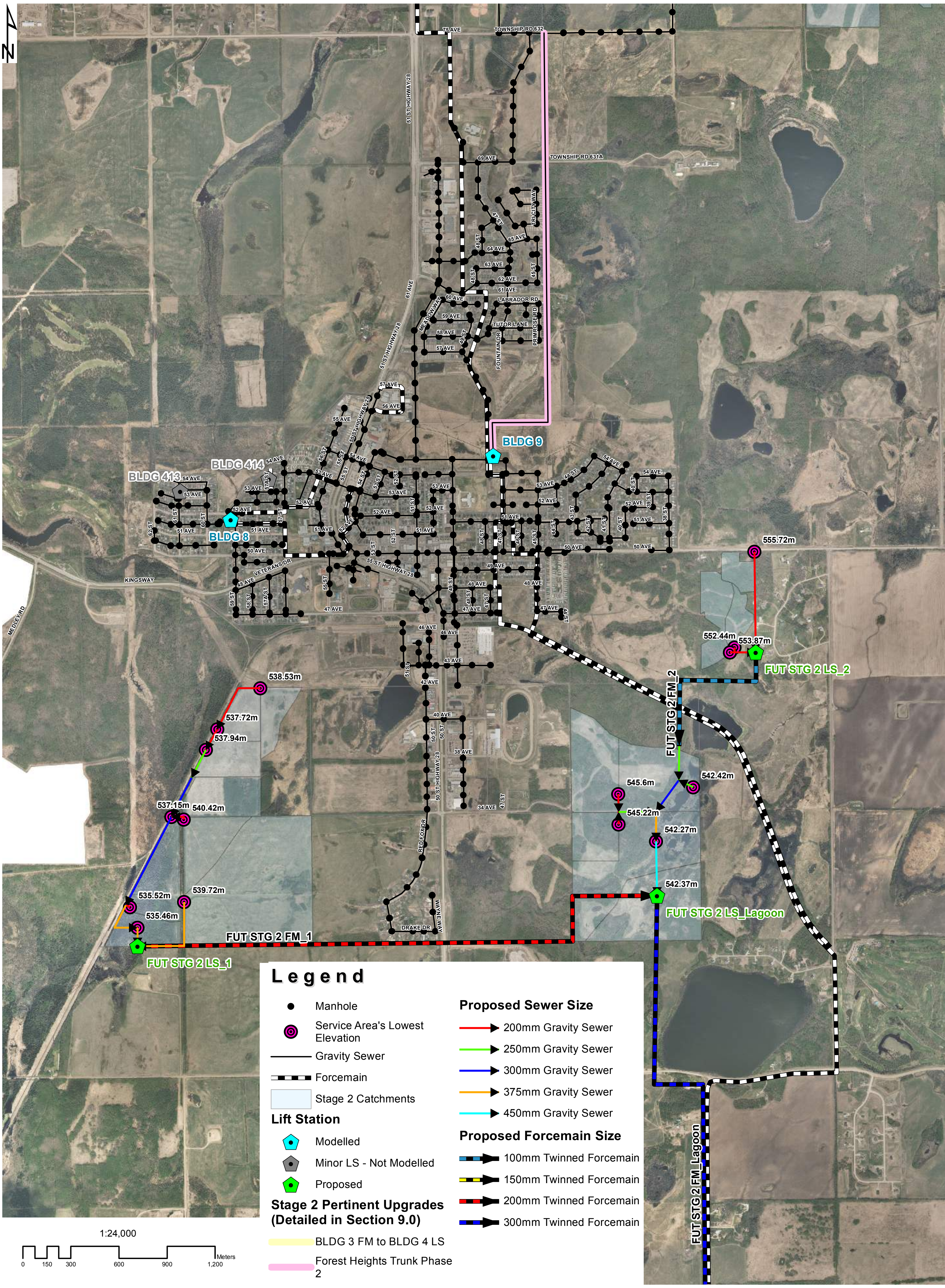


THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM
SANITARY COLLECTION SYSTEM
PROPOSED NETWORK - NORTH
STAGE 2 - BUILD-OUT TO CURRENT CITY BOUNDARY
PROPOSED SERVICING CONCEPT

City of Cold Lake

ISL Engineering and Land Services

Date: 10/20/2017 Document: M:\26300\26367_Cold_Lake_I-I_Program\02_CADD\20_Drafting\201_GIS Figures\8.0 Future Servicing Concepts\Figure 8.7 - Servicing Stage 2_North.mxd



City of Cold Lake

THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM
SANITARY COLLECTION SYSTEM
PROPOSED NETWORK - SOUTH
STAGE 2 - BUILD-OUT TO CURRENT CITY BOUNDARY
PROPOSED SERVICING CONCEPT

ISL Engineering and Land Services

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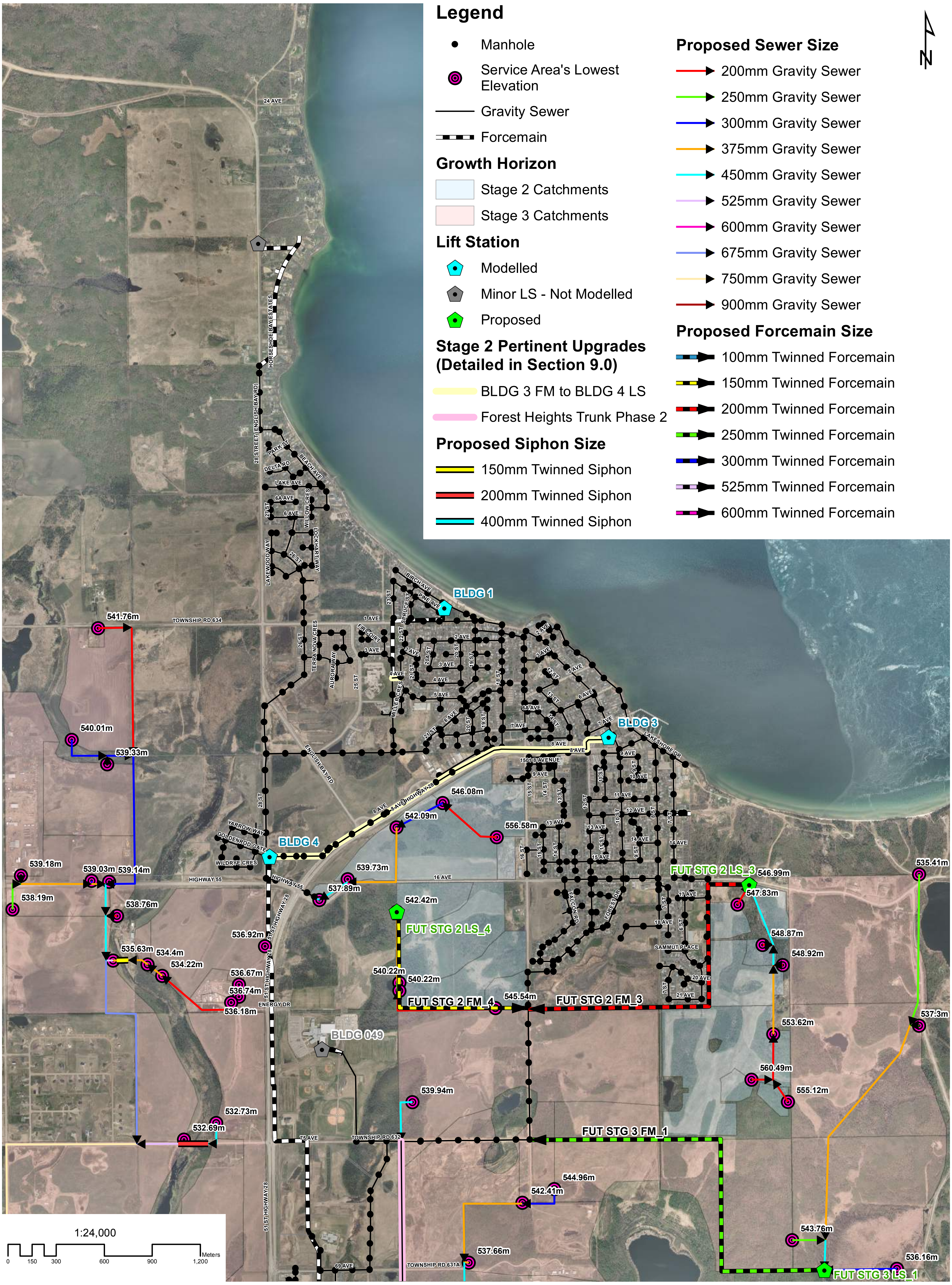
FIGURE 8.9



THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM
SANITARY COLLECTION SYSTEM
PROPOSED NETWORK - NORTH
STAGE 3 - BUILD-OUT OF ANNEXATION AREAS
PROPOSED SERVICING CONCEPT

City of Cold Lake

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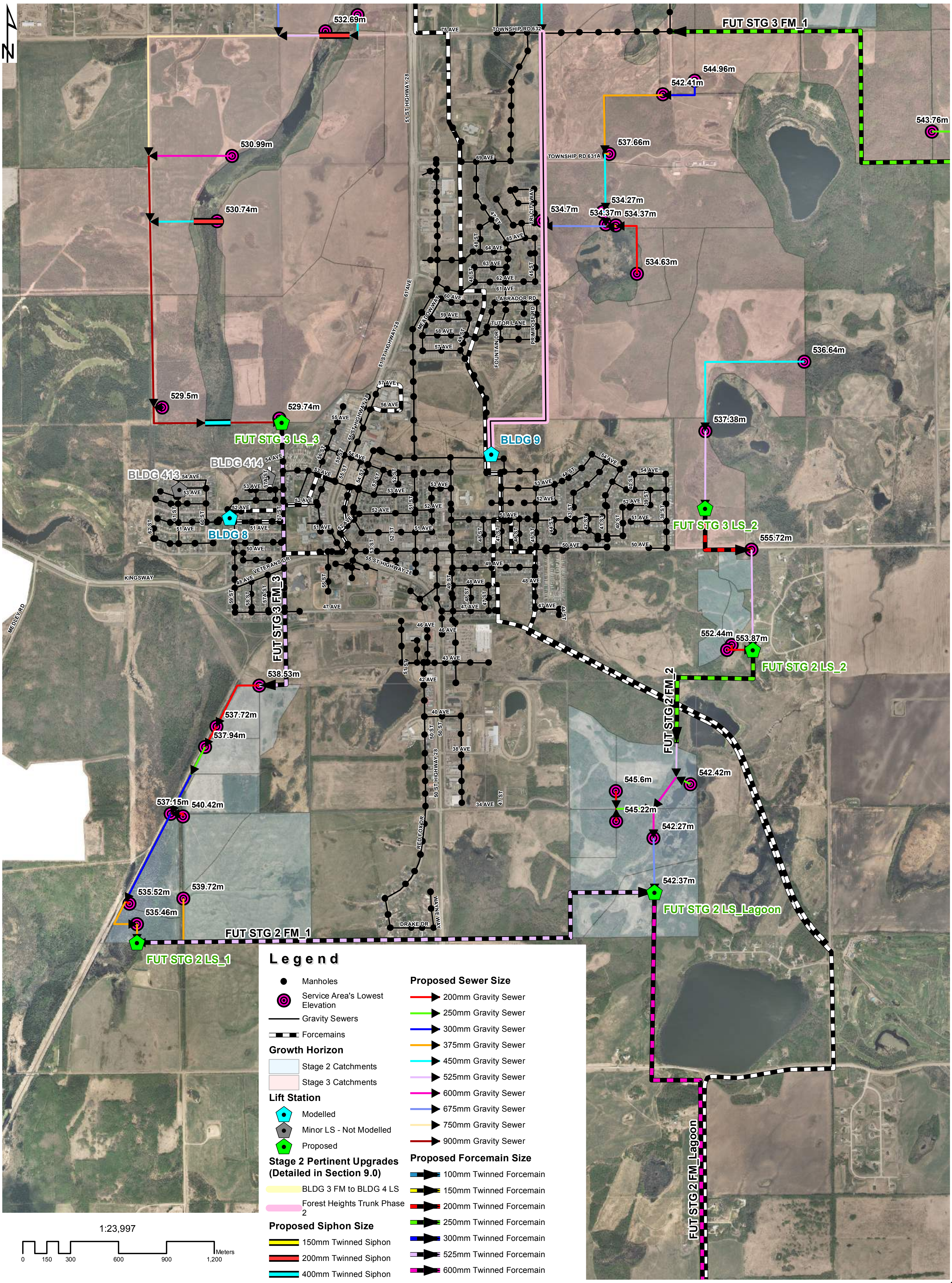
Date: 10/20/2017 Document: M:\26300\26367_Cold_Lake_I-I_Program\02_CADD\20_Drafting\201_GIS Figures\8.0 Future Servicing Concepts\Figure 8.9 - Servicing Stage 3_North.mxd

FIGURE 8.10



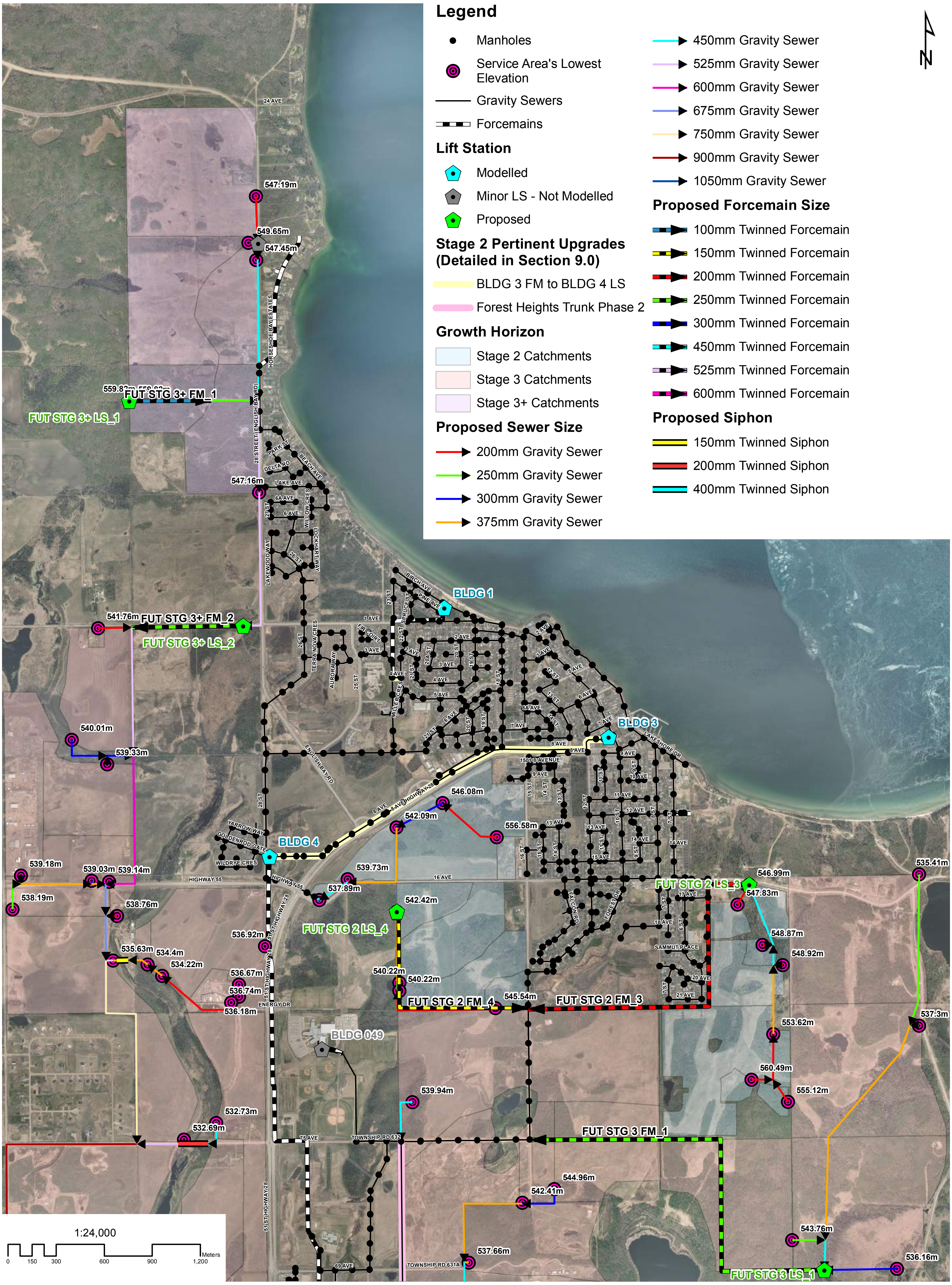
City of Cold Lake

THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM
SANITARY COLLECTION SYSTEM
PROPOSED NETWORK - SOUTH
STAGE 3 - BUILD-OUT OF ANNEXATION AREAS
PROPOSED SERVICING CONCEPT

ISL Engineering and Land Services

Date: 10/20/2017 Document: M:\26300\26367_Cold_Lake_I-I_Program\02_CADD\20_Drafting\201_GIS Figures\8.0 Future Servicing Concepts\Figure 8.10 - Servicing Stage 3_South.mxd

FIGURE 8.11



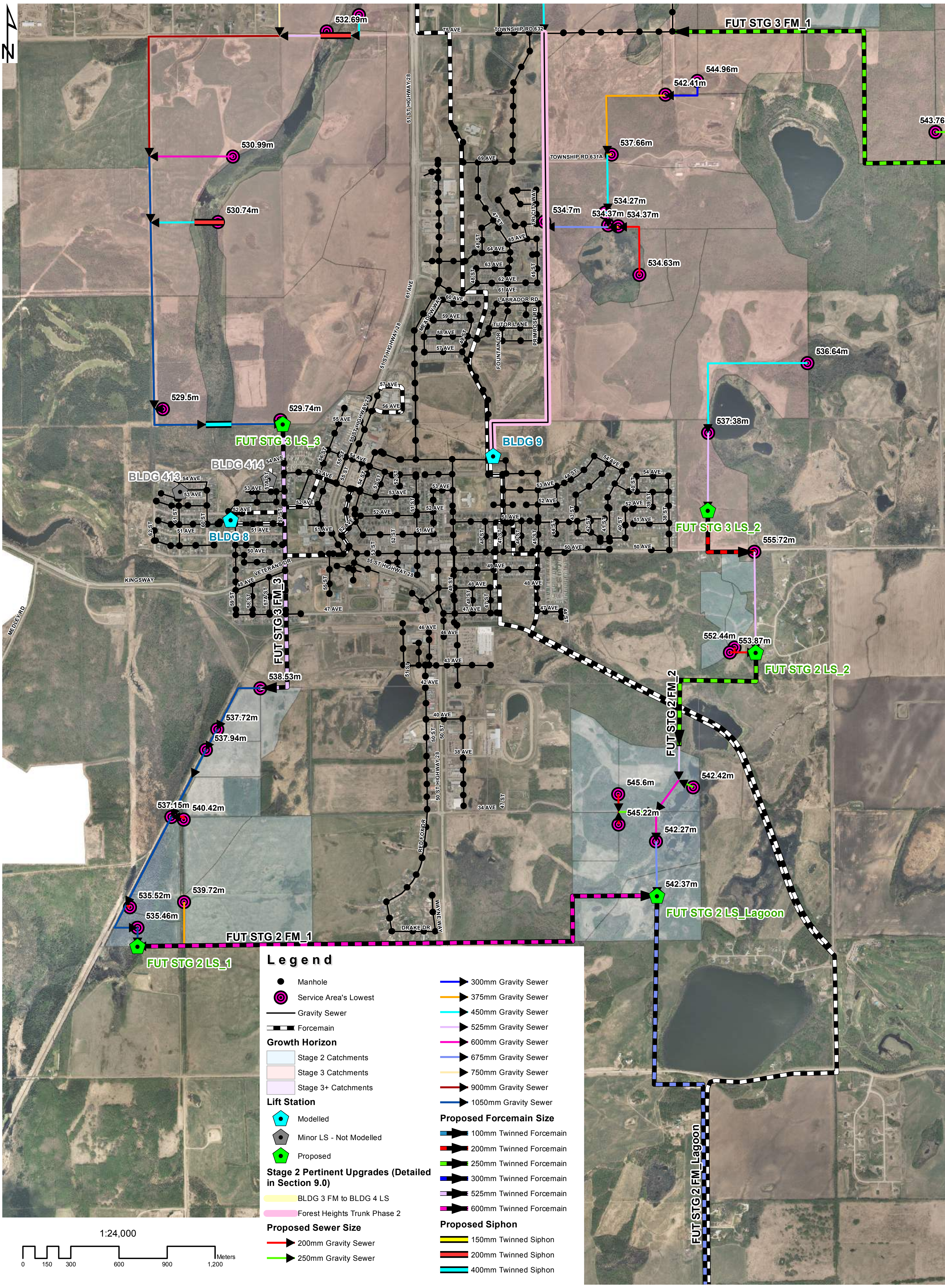
Date: 10/20/2017 Document: M:\26300\26367_Cold_Lake_I-I_Program\02_CADD\20_Drafting\201_GIS Figures\8.0 Future Servicing Concepts\Figure 8.11 - Servicing Stage 3+_North.mxd

City of Cold Lake

THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM
SANITARY COLLECTION SYSTEM
PROPOSED NETWORK - NORTH
STAGE 3+ - BUILD-OUT OF ANNEXATION AREAS
WITH ADDITIONAL THREE NORTH QUARTER SECTIONS
PROPOSED SERVICING CONCEPT

ISL Engineering and Land Services

FIGURE 8.12



City of Cold Lake

THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM
SANITARY COLLECTION SYSTEM
PROPOSED NETWORK - SOUTH
STAGE 3+ - BUILD-OUT OF ANNEXATION AREAS
WITH ADDITIONAL THREE NORTH QUARTER SECTIONS
PROPOSED SERVICING CONCEPT

ISL Engineering and Land Services

Date: 10/20/2017 Document: M:\26300\26307_Cold_Lake_I-I_Program\02_CADD\20_Drafting\201_GIS Figures\8.0 Future Servicing Concepts\Figure 8.12 - Servicing Stage 3+_South.mxd

9.0 Future System Assessment and Upgrades

The performance of the existing system under future population and area growth scenarios for the Stage 1, Stage 2 and Stage 3 horizons were assessed using the criteria discussed in Section 5.0. As a result, the calibrated existing system model was run under the following design storms under future conditions:

- Inflow-Infiltration Allowance of 0.29 L/s/ha
- 1 in 25-year 24-hour 3rd Quartile Huff Storm
- 1 in 50-year 24-hour 3rd Quartile Huff Storm

It is noted that Stage 3+ was not modelled, as there are no catchments that tie back into the existing system. Each of the servicing options detailed in Section 8.2 (omitting Stage 3+) were run in order to assess the HGL relative to the surface, the discharge relative to sewer capacity, and the spare capacity of the sewers. The future system assessment figures for the Stage 1, Stage 2, and Stage 3 growth horizons are shown in Figures 9.1 to 9.12, Figures 9.13 to 9.24, and Figures 9.25 to 9.36, respectively. The corresponding maximum HGL longitudinal profiles are provided in Appendices J through to L. It is assumed that any upgrades to the existing system necessary for each growth horizon have been already implemented prior to the following stage, thus have been carried over into the subsequent modelling scenarios.

It is again noted that typically, constant I-I rate scenarios are not used to test the performance of lift stations and forcemains, as the ensuing indefinite inflow rate is likely to always inundate each pumping facility.

9.1 Stage 1 – Build-out of Existing System Assessment Results and Required Upgrades

A description of the general areas of concern with respect to the gravity system are provided in Table 9.1.

Table 9.1: Affected Sewer Sections under the Stage 1 Growth Horizon

Section ID	Sewer Section	Associated Longitudinal Profile(s)	Location	Affected Sizes	Section Length
				mm	m
STG 1.1	GSAN_640 to GSAN_366	LP #N3.1, LP #N4, N/A	North	200, 250, 300, 350, 375, 900	780
STG 1.2	GSAN_374 to GSAN_514	LP #N4.1, N/A	North	200, 250	150
STG 1.3	GSAN_370 to GSAN_721	N/A	North	200	280
STG 1.4	GSAN_361 to GSAN_362	N/A	North	200	110

Peak modelled wet weather inflows into each lift station under all three design storms are detailed in Table 9.2 below.

Upon investigation of the longitudinal profiles from the affected sewer sections mentioned above (STG 1.1 to STG 1.4) and review of the lift station inflows and water levels, it is evident that the surcharging under all of these sections is attributed to the Building 3 Lift Station backing up. This was further confirmed by testing a 'free outfall condition' at Building 3 Lift Station, to verify that it is indeed the lift station that is lacking capacity and not an issue in the upstream gravity reach. As a result, the only required upgrade under the Stage 1 growth horizon is an increase in capacity at the Building 3 Lift Station in the order of 5 L/s, to a total lift station capacity of 81 L/s (this assumes that the lift station has already been upgraded by 15 L/s under existing conditions to reach the required pumping capacity of 76 L/s for the existing scenario). It is noted that a pressure gauge at this lift station would be valuable, in order to determine if it is the pumps or forcemain that requires upgrading. This required upgrade is illustrated in Figure 9.37.

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Table 9.2: Lift Station Wet Weather Flow Results under the Stage 1 Growth Horizon

Lift Station	Max. Pumping Capacity	Forcemain Size	Forcemain Capacity[1]	Incoming Pipe Diameter	Lift Station Inflow			Lift Station Platform Elevation	Lift Station Water Level		
					0.29 L/s/ha	25yr 24hr Q3 Huff	50yr 24hr Q3 Huff		0.29 L/s/ha	25yr 24hr Q3 Huff	50yr 24hr Q3 Huff
	L/s	mm	L/s	mm	L/s			m			
Building 1	125.91	300	141	300	44	32	33	531.800	531.072	531.087	531.069
Building 3	76.26 [2]	300	141	375	81	70	75	537.600	536.231	531.111	531.148
				200	4	1	1				
Building 4	282.49	500	393	675	179	157	168	537.956	529.496	529.492	529.481
Building 8	218.94	350	192	600	14	13	15	524.000	523.205	523.211	523.21
				200	26	27	32				
Building 9	295.09	900	1,272	750	488	316	444	526.425	528.988	524.513	526.822
		800	1,005								

[1] Forcemain capacity determined based on the velocity of 2.0 m/s

[2] Assumes previous lift station capacity upgrades have been implemented

9.2 Stage 2 – Build-out to Current City Boundary Assessment Results and Required Upgrades

A description of the general areas of concern with respect to the gravity system are provided below in Table 9.3.

Table 9.3: Affected Sewer Sections under the Stage 2 Growth Horizon

Section ID	Sewer Section	Associated Longitudinal Profile(s)	Location	Affected Sizes (mm)	Section Length (m)
STG 2.1	GSAN_47 to GSAN_359	LP #N2.1, LP #N2.2, N/A	North	200, 400, 600, 675	1,875
STG 2.2	GSAN_177 to GSAN_182	LP #N1.2	North	450	615
STG 2.3	GSAN_640 to GSAN_368	LP #N3.1, LP #N4.1, N/A	North	200, 250, 300, 350, 375, 900	965
STG 2.4	Multiple Sections	LP #S1.3, LP #S2.1, LP #S2.2, LP #S3.1, LP #S4.1, LP #S5.2, LP #S5.3, LP #S6.1, LP #S7.1	South	250, 300, 375, 450, 500, 525, 600, 750	7,995
STG 2.5	GSAN_260 to GSAN_60	N/A	South	200	475
STG 2.6	GSAN_52 to GSAN_210	LP #S5	South	300	335
STG 2.7	GSAN_247 to GSAN_868	LP #S5	South	500, 525, 600	1,390

Peak modelled wet weather inflows into each lift station under all three design storms are detailed in Table 9.4 below.

In summary, there are a number of issues contributing to the affected sewer sections mentioned in Table 9.3, including:

1. Once again, there is a lack of capacity at the Building 3 Lift Station, which was confirmed by simulating a 'free outfall condition' at this lift station.
   - Upgrades to this lift station, in the order of an additional 5 L/s under Stage 2 equaling a total increase of 25 L/s (15 L/s required under existing conditions, 5 L/s required under Stage 1, and 5 L/s required under Stage 2) to 86 L/s, are required in order to mitigate the backups occurring upstream of the lift station.
2. Under this scenario, there is a lack of capacity at the Building 4 Lift Station, which was confirmed from the results of Table 9.4.
   - Upgrades to this lift station, up to 100 L/s are required to accommodate the additional developments in the north.
   - It is noted that when a 'free outfall condition' simulation was performed at this lift station, a number of sewers upstream of the lift station remained in surcharged conditions. This triggered the local improvements that had been requested by the City, including:
     i. Diversion of flows from 22nd Street to 23rd Street (4th Avenue Interconnection)
     ii. Reconnection of the Building 3 Forcemain directly to the Building 4 Lift Station

   Following completion of the Draft Final copy of this report, the City verified that the 4th Avenue interconnection local improvement sewer (200 mm) has been constructed. At this point, the sewer connecting to the north is not plugged, however works as an overflow, thus the portion of this upgrade to plug the north sewer remains valid.

   The required pumping capacity at Building 3 Lift Station will need to be determined to ensure that the system can overcome additional system losses due to the FM extension to ensure that the new pumps can provide the required total dynamic head based on the new forcemain configuration. An additional study should be undertaken to confirm this.

3. As this stage consists of many additional developments coming online in the east, the most logical connection point was the Forest Heights Trunk. In order to accommodate the additional flows, and as some of the connection points are further south than Phase 1 of the Forest Heights Trunk, Phase 2 was triggered.
   - It is noted that the recommendations of the Forest Heights Sanitary Sewer Trunk Preliminary Design Report were incorporated when addressing these upgrades. That said, the design of this trunk has not been altered in any way for the purposes of this report.
   - For modelling purposes, this trunk was assumed as a 900 mm sewer running directly from Phase 1 down to the Building 9 Lift Station. Please note that the Forest Heights Preliminary Design Report stipulates a section of 900 mm and 1050 mm trunk sewer for Phase 2, however for the purposes of this I-I Program only the more conservative 900 mm was assumed.
   - If the City chooses to reconnect Building 4 Lift Station to the Forest Heights Trunk, which was an option presented in the Forest Heights Preliminary Design Report, the size of the Phase 2 trunks increase to 1050 mm and 1200 mm. Note that in order to do a proper assessment of this Building 4 Lift Station to Forest Heights Trunk reconnection, further information pertaining to Building 4 is necessary. This would include all available background reports and forcemain drawings.
4. Due to the large increase in flows from the additional developments tying into the existing system, there becomes a lack of capacity at the Building 9 Lift Station. This was further confirmed from the results of Table 9.4, as well as by completing a 'free outfall condition' simulation at this lift station.
   - Upgrades to this lift station, in the order of an additional 650 L/s resulting in a total pumping capacity of 950 L/s are required to accommodate the additional flows.
   - 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. Realistically, 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 is assuming the City would be fine with having a stand-by pump operational to accommodate the estimated peak wet weather flow. Given that Building 9 constitutes a critical piece of infrastructure, 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.
5. The 475 m length of sewer in the south (GSAN_260 to GSAN_60), along 47th Street between 51st Avenue and 50th Avenue, then along 50th Avenue between 47th Street and 44th Street was flagged as being under capacity. This is attributed to the additional developments being implemented upstream.
   - It is recommended that this section of sewer be upsized from 200 mm to 300 mm, in order to mitigate the surcharging and effectively accommodate the added flows.
6. It is noted that even though sewer sections GSAN_52 to GSAN_210 and GSAN_247 to GSAN_868 have been flagged along 49th Street, surcharging in these sewers is relatively minimal, with the maximum HGLs remaining below the 3 m threshold. For this reason no upgrades are recommended at this point in time, however these sections should be monitored by the City and the proper courses of action should be followed if any issues arise.

The upgrades that have been proposed as part of Stage 2 are illustrated in Figures 9.38 and 9.39 for Cold Lake North and Cold Lake South, respectively.

Table 9.4: Lift Station Wet Weather Flow Results under the Stage 2 Growth Horizon

Lift Station	Max. Pumping Capacity	Forcemain Size	Forcemain Capacity[1]	Incoming Pipe Diameter	Lift Station Inflow			Lift Station Platform Elevation	Lift Station Water Level		
					0.29 L/s/ha	25yr 24hr Q3 Huff	50yr 24hr Q3 Huff		0.29 L/s/ha	25yr 24hr Q3 Huff	50yr 24hr Q3 Huff
	L/s	mm	L/s	mm	L/s			m			
Building 1	125.91	300	141	300	44	32	33	531.8	531.071	531.073	531.074
Building 3	81.26 [2]	300	141	375	84	76	81	537.6	536.234	531.096	531.103
				200	5	1	1				
Building 4	282.49	500	393	675	362	316	356	537.956	532.612	530.463	531.04
Building 4 Free Outfall					365	316	359		527.045	527.025	527.042
Building 8	218.94	350	192	600	23	21	24	524	523.205	523.212	523.207
				200	27	27	32				
Building 9	295.09	900	1,272	750	722	668	726	526.425	532.784	532.13	532.156
		800	1,005	900	112	198	228				
Building 9 Free Outfall		900	738	750	741	685	746		522.077	522.065	522.08
		800	471	900	112	105	119				

[1] Forcemain capacity determined based on the velocity of 2.0 m/s

[2] Assumes previous lift station capacity upgrades have been implemented

9.3 Stage 3 – Build-out of Annexation Areas Assessment Results and Required Upgrades

A description of the general areas of concern with respect to the gravity system are provided below in Table 9.5.

Table 9.5: Affected Sewer Sections under the Stage 3 Growth Horizon

Section ID	Sewer Section	Associated Longitudinal Profile(s)	Location	Affected Sizes	Section Length
				mm	m
STG 3.1	Multiple Sections	LP #S1, LP #S2, LP #S3, LP #S4, LP #S5, LP #S6, LP #S7	South	250, 300, 375, 450, 500, 525, 600, 750	7,995
STG 3.2	GSAN_52 to GSAN_210	LP #S5	South	300	335
STG 3.3	GSAN_247 to GSAN_868	LP #S5	South	500, 525, 600	1,390

Peak modelled wet weather inflows into each lift station under all three design storms are detailed in Table 9.6 below.

It is evident from both the results from Table 9.6 above as well as a simulated 'free outfall condition' at Building 9 Lift Station that there is a lack of capacity due to the additional annexation areas coming online and tying into the Forest Heights Trunk. For that reason, it is proposed that the capacity of Building 9 Lift Station be upgraded by an additional 400 L/s to 1,350 L/s (note that this assumes that the lift station has already been upgraded by 650 L/s under Stage 2). Again, 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. Realistically, 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. Noted above, 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.

Alternatively, 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. In order to temporarily store sewage discharging to the Building 9 Lift Station, approximately 50,000 m^3 would be required. This would offset the total additional pumping capacity of 1,050 L/s required at buildout of Stage 3 (includes an additional 650 L/s under Stage 2 and 400 L/s under Stage 3). Assuming a depth of 5 m, the offline storage would require a footprint of one hectare and would cost up to $1,500,000, not including any piping costs or land costs, which could be substantial considering the sterilization footprint. Based on this the option is not ideal, due to the extensive amount of storage space that would be required to accommodate 50,000 m^3 and related costs. The dry weather flows observed under Stage 3 (i.e. flows generated from residential and non-residential developments without the presence of any rainfall events) range from roughly 200 L/s to 675 L/s depending on the diurnal peaking factor. This means that the pumps in their current configuration would not be sufficient under DWF conditions in many hours of the day, further supporting the option to increase pumping capacity as opposed to implementing offline storage.

It is once again noted that though sewer sections GSAN_52 to GSAN_210 and GSAN_247 to GSAN_868 have been flagged, surcharging in these sewers is relatively minimal, with the maximum HGLs remaining below the 3 m threshold. For this reason no upgrades are recommended at this point in time, however these sections should be monitored by the City and the proper courses of action should be followed if any issues arise.

The upgrades that have been proposed as part of Stage 3 are illustrated in Figure 9.40 for Cold Lake South.

The following table (Table 9.7) provides a summary of all upgrades that have been proposed through the three modelled growth horizons.

Table 9.7: Recommended Upgrades to the Future Sanitary System

Stage	Map ID	Triggered Design Storm	Location	Upgrade
1	FUT Upgrade 1[2]	• Constant I-I of 0.29 L/s/ha	10th Street between 7th Avenue and 8th Avenue	• Upgrade the capacity[1] of the Building 3 Lift Station by 5 L/s, for a total capacity of 81 L/s.
2	FUT Upgrade 2[2]	• Constant I-I of 0.29 L/s/ha	10th Street between 7th Avenue and 8th Avenue	• Upgrade the capacity[1] of the Building 3 Lift Station by an additional 5 L/s, for a total capacity of 86 L/s.
	FUT Upgrade 3[3]	• Constant I-I of 0.29 L/s/ha • 25yr 24hr Q3 Huff Storm • 50yr 24hr Q3 Huff Storm	English Bay Road and Goldenrod Gate	• Upgrade the capacity of the Building 4 Lift Station of up to 100 L/s, for a total capacity of 382 L/s.
	FUT Upgrade 4	• Constant I-I of 0.29 L/s/ha • 25yr 24hr Q3 Huff Storm • 50yr 24hr Q3 Huff Storm	22nd Street to 23rd Street along 4th Avenue	• Diversion of flows from 22nd Street to 23rd Street[4].
	FUT Upgrade 5	• Constant I-I of 0.29 L/s/ha • 25yr 24hr Q3 Huff Storm • 50yr 24hr Q3 Huff Storm	Along 8th Avenue from 19th Street to Highway 55	• Reconnection of the Building 3 Forcemain directly to the Building 4 Lift Station[5].
	FUT Upgrade 6	• Constant I-I of 0.29 L/s/ha • 25yr 24hr Q3 Huff Storm • 50yr 24hr Q3 Huff Storm	From 75th Avenue to north of 54th Avenue on 49th Street	• Completion of the Forest Heights Phase 2 900 mm to 1050 mm Trunk[2].
	FUT Upgrade 7[3]	• Constant I-I of 0.29 L/s/ha • 25yr 24hr Q3 Huff Storm • 50yr 24hr Q3 Huff Storm	North of 54th Avenue on 49th Street	• Upgrade the capacity of the Building 9 Lift Station by 650 L/s, for a total capacity of 950 L/s. • As there are additional upgrades required to this lift station as part of Stage 3, the City may wish to implement all the upgrades at once. As a result, the ultimate capacity required would be 1,350 L/s (additional 1,050 L/s).
	FUT Upgrade 8	• Constant I-I of 0.29 L/s/ha • 25yr 24hr Q3 Huff Storm • 50yr 24hr Q3 Huff Storm	47th Street between 51st Avenue and 50th Avenue, then 50th Avenue between 47th Street and 44th Street	• Upsize the section of sewer from 200 mm to 300 mm.
3	FUT Upgrade 9	• Constant I-I of 0.29 L/s/ha • 50yr 24hr Q3 Huff Storm	North of 54th Avenue on 49th Street	• Upgrade the capacity of the Building 9 Lift Station by 400 L/s, for a total capacity of 1,350 L/s.

[1] *It is noted that without a pressure gauge installed at this lift station, it is not possible to say whether the pumps or the forcemain requires an increase in capacity. This should be reviewed once again in the near future, once a pressure gauge has been installed.*

[2] *It is noted that depending on the staging approach the City chooses, this upgrade may have been completed as part of the existing upgrades, following installation of the pressure gauges and additional analysis on the pumps and forcemain.*

[3] *As the required upgrades are quite substantial, the City could choose to construct another lift station adjacent to the existing lift station if it is determined the schematics of the existing system (i.e. wet well storage requirements and room for additional pumps) would not allow for such major upgrades.*

[4] *Following completion of the Draft Final version of this report, it was noted that a 200 mm sewer has been constructed along 4th Avenue, however the north sewer remains unplugged.*

[5] *Trunk could be upsized to 1050 mm to 1200 mm sewers if the City chooses to connect Building 4 Lift Station to the upstream end (subject to further analysis).*

Table 9.6: Lift Station Wet Weather Flow Results under the Stage 3 Growth Horizon

Lift Station	Max. Pumping Capacity	Forcemain Size	Forcemain Capacity[1]	Incoming Pipe Diameter	Lift Station Inflow			Lift Station Platform Elevation	Lift Station Water Level		
					0.29 L/s/ha	25yr 24hr Q3 Huff	50yr 24hr Q3 Huff		0.29 L/s/ha	25yr 24hr Q3 Huff	50yr 24hr Q3 Huff
	L/s	mm	L/s	mm	L/s			m			
Building 1	125.91	300	141	300	37	28	29	531.8	531.063	531.072	531.057
Building 3	86.26 [2]	300	141	375	91	76	81	537.6	532.324	531.101	531.103
				200	2	1	1				
Building 4	382.49 [2]	500	393	675	282	240	276	537.956	529.542	529.51	529.521
				750	86	78	84				
Building 8	218.94	350	192	600	22	21	24	524	523.206	523.205	523.206
				200	27	27	32				
Building 9	945.09 [2]	900	1,272	750	826	761	817	526.425	530.088	526.193	527.866
		800	1,005	900	687	687	682				
Building 9 Free Outfall		900	738	750	838	766	840		522.159	522.144	522.171
		800	471	900	485	485	559				

[1] Forcemain capacity determined based on the velocity of 2.0 m/s

[2] Assumes previous lift station capacity upgrades have been implemented

9.4 Phasing Plan Recommendations

The phasing of the recommended sanitary servicing network to meet the ultimate Stage 3+ growth horizon should occur in the following sequence, in conjunction with the City's development staging plan.

1. Complete upgrades at the Building 3 Lift Station to properly service the existing system, as well as roughly 220 people and 2.50 ha in Stage 1 and 525 people under Stage 2. Please note that this assumes that all upgrades to the Building 3 Lift Station are completed at once to reduce capital expenditure related costs.
2. Reconnect the Building 3 Forcemain to the Building 4 Lift Station to alleviate some of the flows upstream of the Building 4 Lift Station from 23rd Street to 28th Street north of Highway 28.
3. Complete upgrades at the Building 4 Lift Station to service the additional lands in the north, equalling an additional residential populations of roughly 380 and 10,900 and non-residential areas of 2.50 ha and 80 ha for Stage 1 and Stage 2, respectively.
4. Implement Phase 2 of the Forest Heights Trunk in order to open up development in the northeast and central north areas.
5. Complete upgrades at the Building 9 Lift Station in the form of either additional pumping capacity (as the offline storage option was found to not be cost effective or practical) to service the additional lands in the north, equalling an additional population of 380 in Stage 1, 18,895 in Stage 2, and 15,570 in Stage 3 as well as additional non-residential areas of 2.5 ha, 85 ha, and 95 ha, for Stages 1, 2, and 3 respectively. Please note that this assumes that all upgrades to Building 9 Lift Station are completed at once to reduce capital expenditure related costs.
6. Construct the future south lift station (*FUT STG 2 LS_Lagoon*) in quarter section 10-26-62-4 and the associated twinned forcemains to the City's lagoons (*FUT STG 2 FM_Lagoon*). This allows the genesis of the east and west trunks. Staging of the new lift station's pumping system and most importantly the associated forcemains will be critical to ensure proper system performance while a portion of the lands under Stages 2 and 3, and all of Stage 3+ are being developed. The proposed concept recommends implementing a twinned 675 mm forcemain to the City's lagoons under the ultimate growth horizon (Stage 3+). Please note that at the detailed design stage, a designer perhaps could consider constructing a smaller forcemain at early growth stages such that the preferred minimum velocity of 1.5 m/s can be realized as the anticipated flows will be below the ultimate design flows.
7. Begin construction of the east and west trunks subject to development pressures/locations.

9.5 Cost Estimates – Required Upgrades to Accommodate Each Servicing Option

In total, there are nine upgrades to the existing system that are required to accommodate the growth from Stages 1, 2, and 3. A summary of the costs associated with the recommended future system upgrades are detailed below in Table 9.8. A full breakdown of the costs has been provided in Appendix M.

Table 9.8: Class D Cost Estimates for Recommended Upgrades to the Existing Sanitary System under Future Conditions

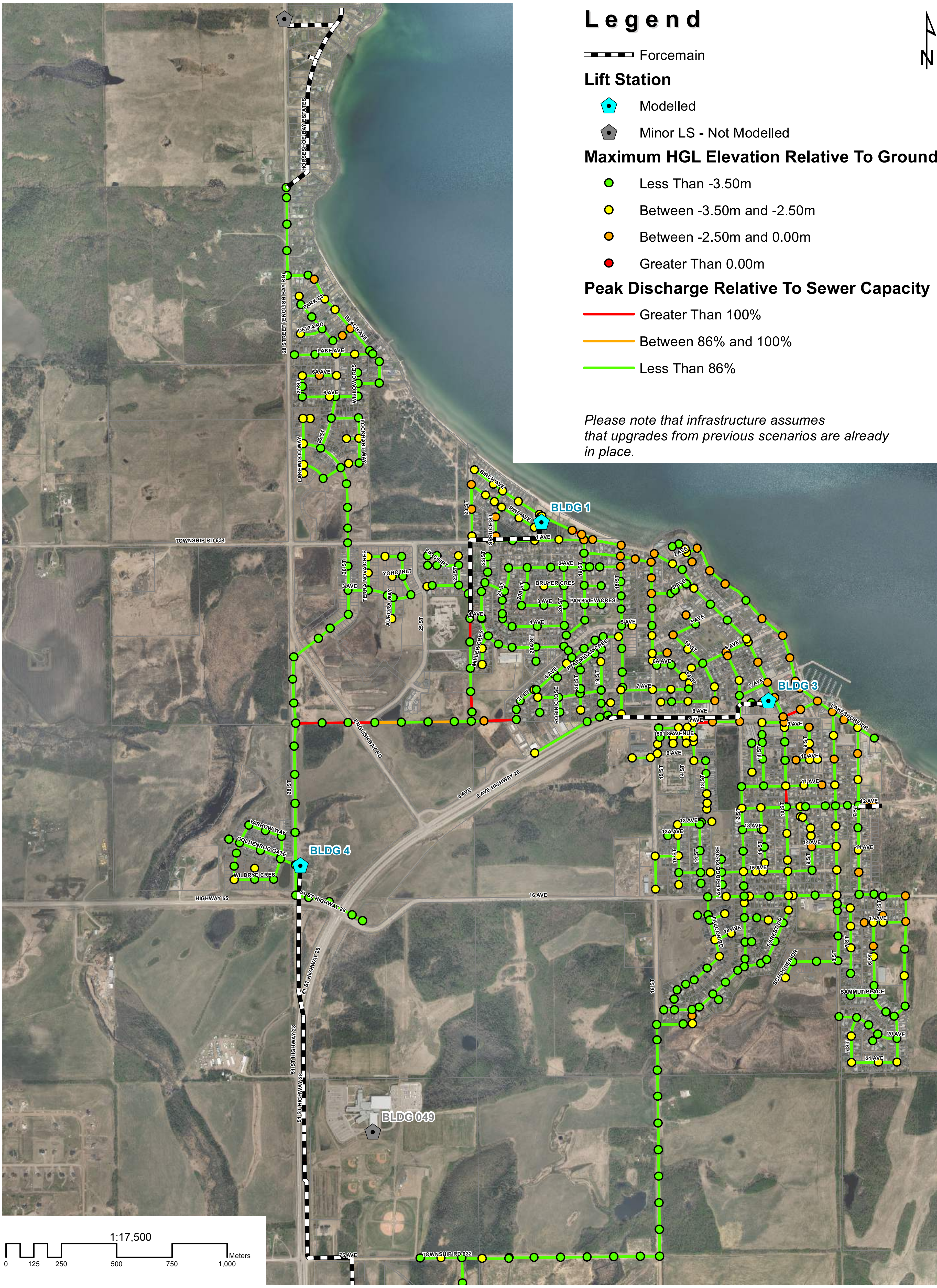
Stage	Item Number	Upgrade	Total Cost
1	**FUT Upgrade 1**	BLDG 3 Lift Station Upgrade – 81 L/s from 76 L/s (Additional 5 L/s)	$75,000 [1]
	FUT Upgrade 2	BLDG 3 Lift Station Upgrade – 86 L/s from 81 L/s (Additional 5 L/s)	$75,000 [1]
	FUT Upgrade 3	BLDG 4 Lift Station Upgrade – 382 L/s from 282 L/s (Additional 100 L/s)	$1,450,000
	FUT Upgrade 4	Diversion of flows from 22nd Street to 23rd Street	$105,000 [2]
2	**FUT Upgrade 5**	Reconnection of the Building 3 Forcemain directly to the Building 4 Lift Station	$3,455,000
	FUT Upgrade 6	Completion of the Forest Heights Phase 2 900 mm to 1050 mm Trunk	$8,335,000
	FUT Upgrade 7	BLDG 9 Lift Station Upgrade – 950 L/s from 300 L/s (Additional 650 L/s)	$9,425,000 [3]
	FUT Upgrade 8	Upsize section of sewer from 200 mm to 300 mm	$930,000
3	**FUT Upgrade 9**	BLDG 9 Lift Station Upgrade – 1,350 L/s from 950 L/s (Additional 400 L/s)	$5,800,000 [3]
		Total	**$29,650,000**

[1] *The stipulated costs at the Building 3 Lift Station constitutes an incremental cost to upgrade the pumping capacity from the previous stages to the current stage. The total cost to upgrade the pumping capacity at the Building 3 Lift Station is $362,500 when build-out of all stages have been accounted for.* That said, as mentioned in Section 6.0, the cost of upgrading this lift station under the existing conditions exclusively is $217,500.

[3] *Following completion of the Draft Final version of this report, it was noted that a 200 mm sewer has been constructed along 4th Avenue, however the north sewer remains unplugged. It would therefore cost roughly $1,000 to complete the upgrade.*

[2] *The stipulated costs at the Building 9 Lift Station constitutes an incremental cost to upgrade the pumping capacity from the previous stage to the current stage. The total cost to upgrade the pumping capacity at the Building 9 Lift Station at full build-out is $15.225M.*

FIGURE 9.1



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PROPOSED NETWORK - NORTH
STAGE 1 - BUILD-OUT OF EXISTING SYSTEM
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FUTURE CONDITIONS PLUS CONSTANT I-I RATE OF 0.29L/s/ha

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FIGURE 9.2

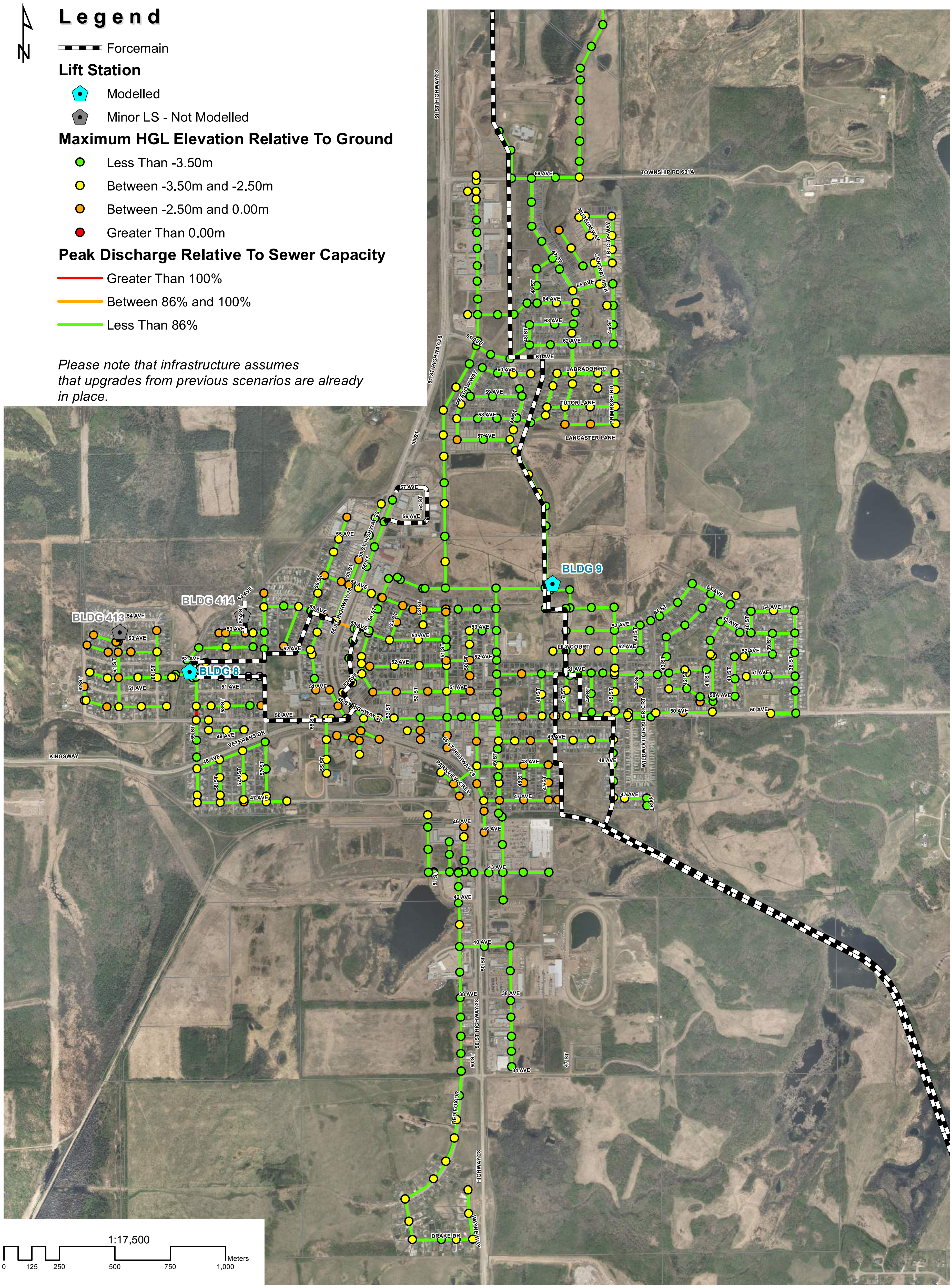

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FIGURE 9.3

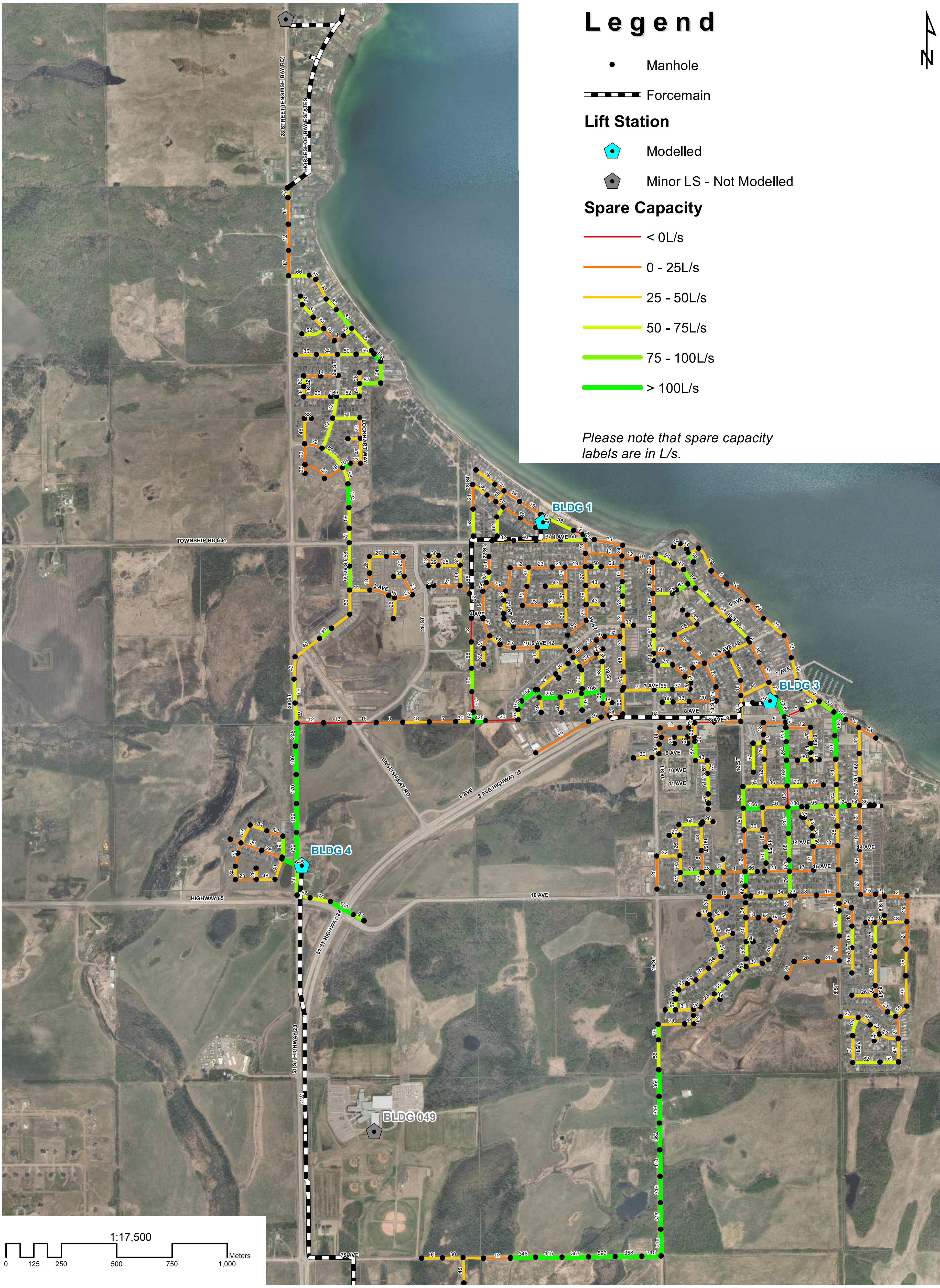

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FIGURE 9.4

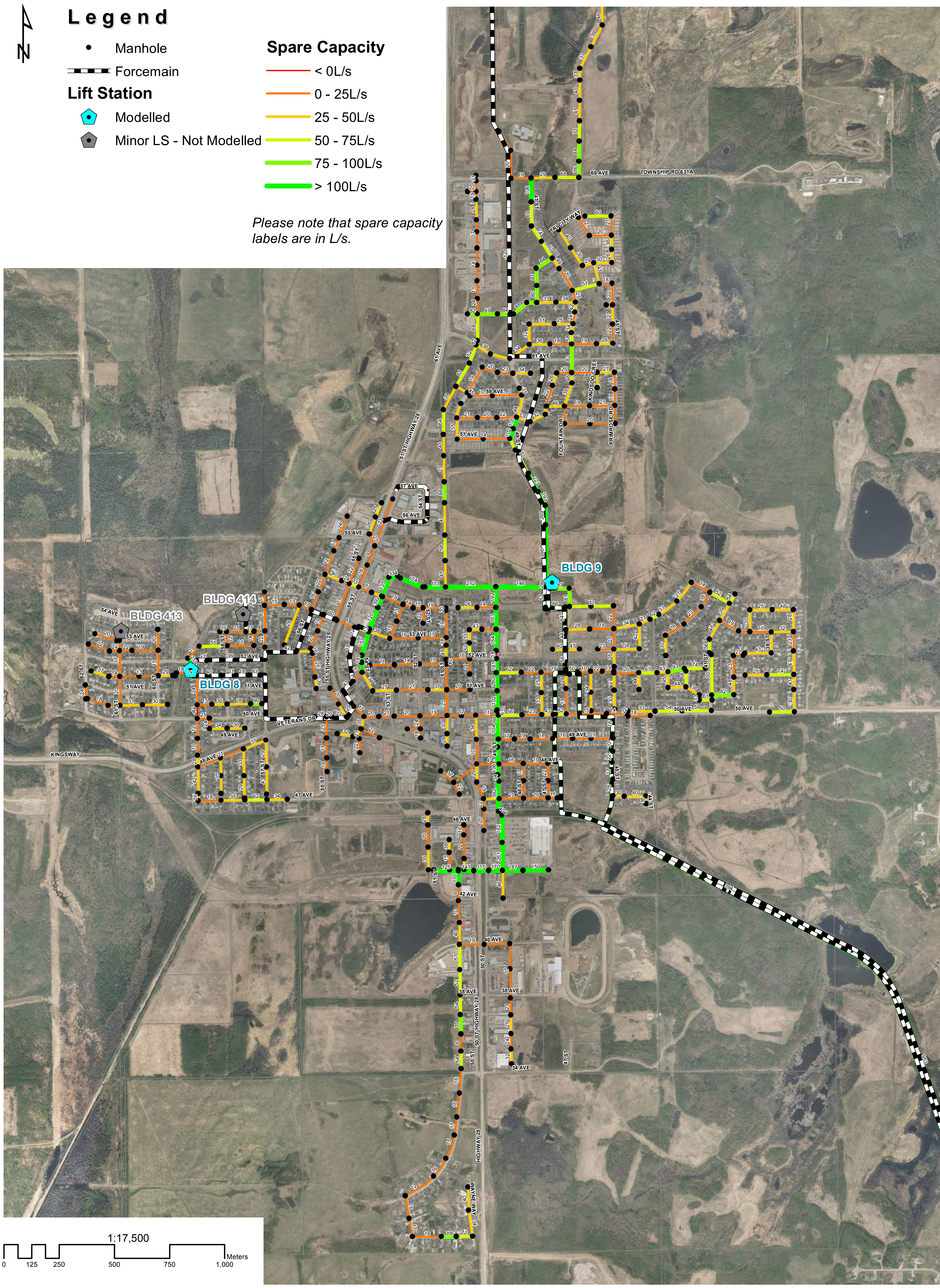

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FIGURE 9.5

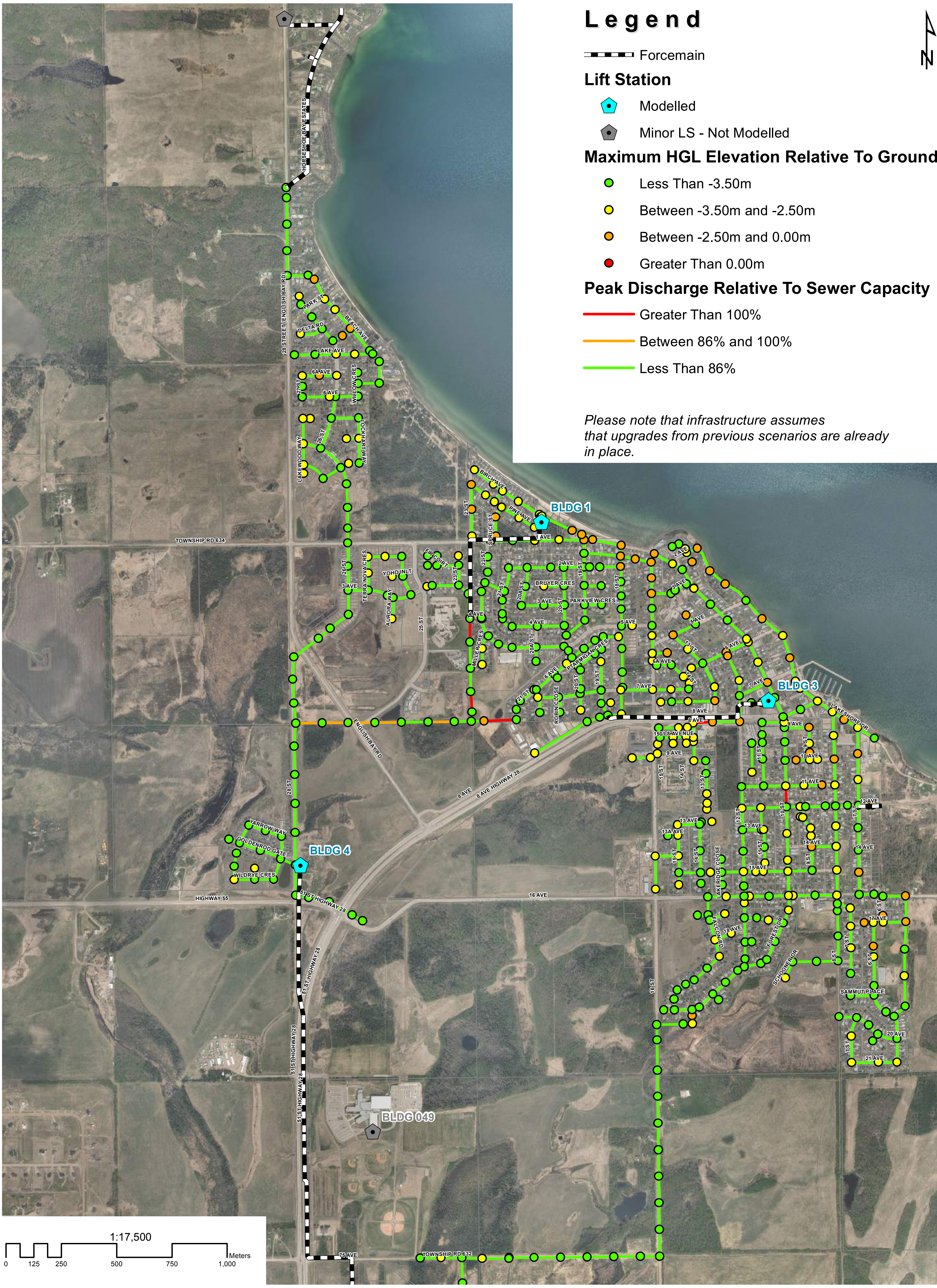

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FIGURE 9.6

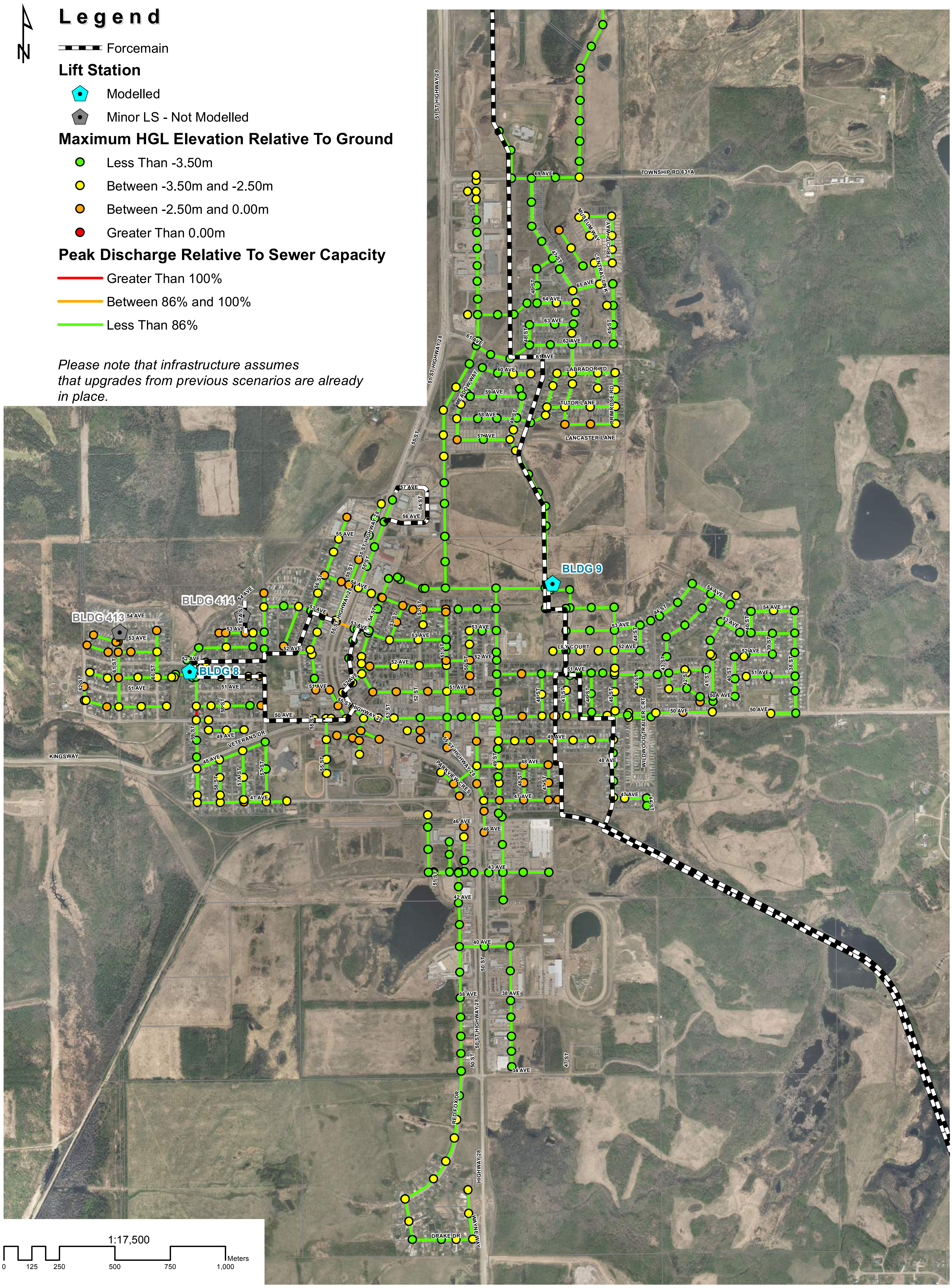

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FIGURE 9.7

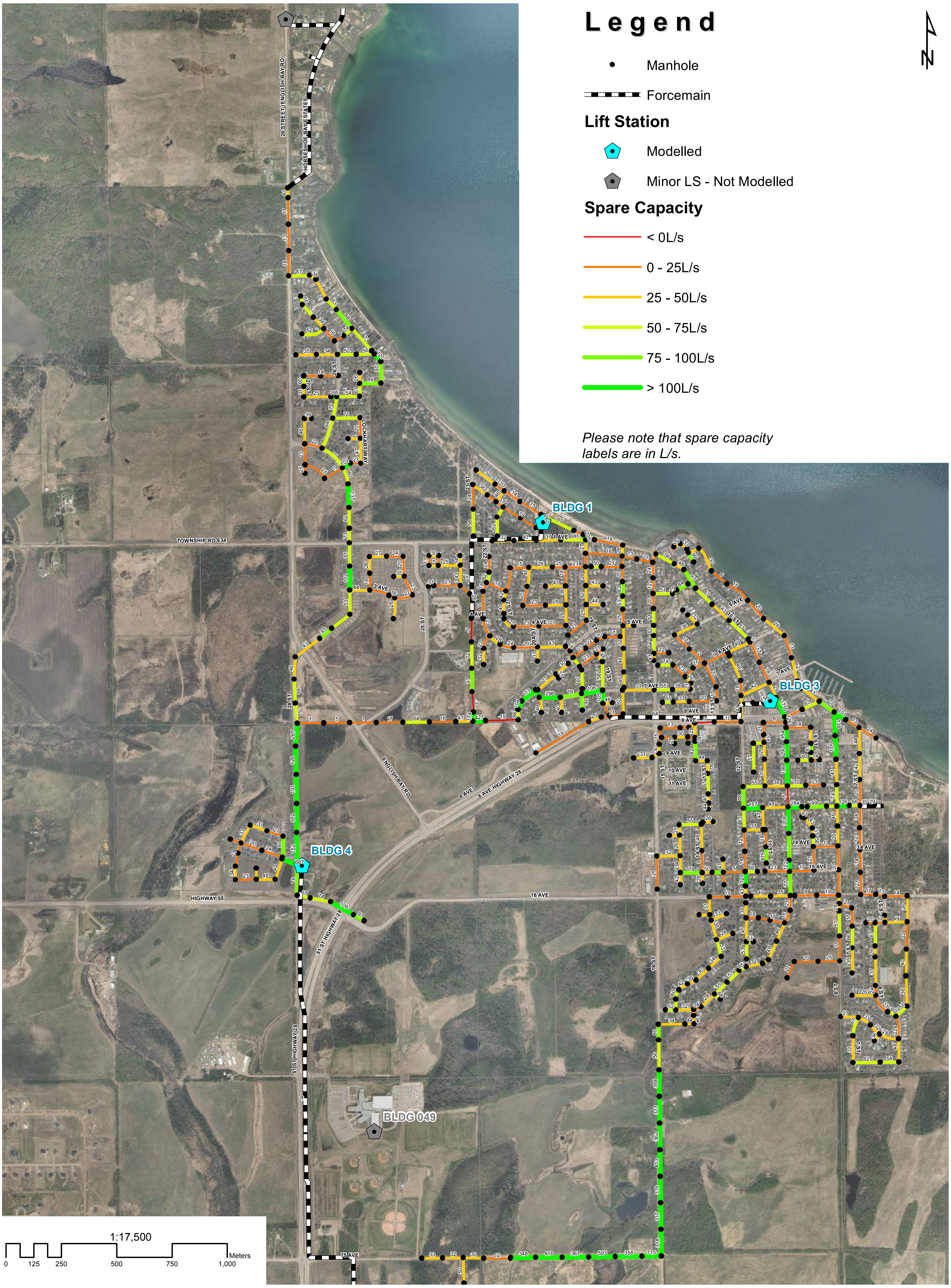

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FIGURE 9.8

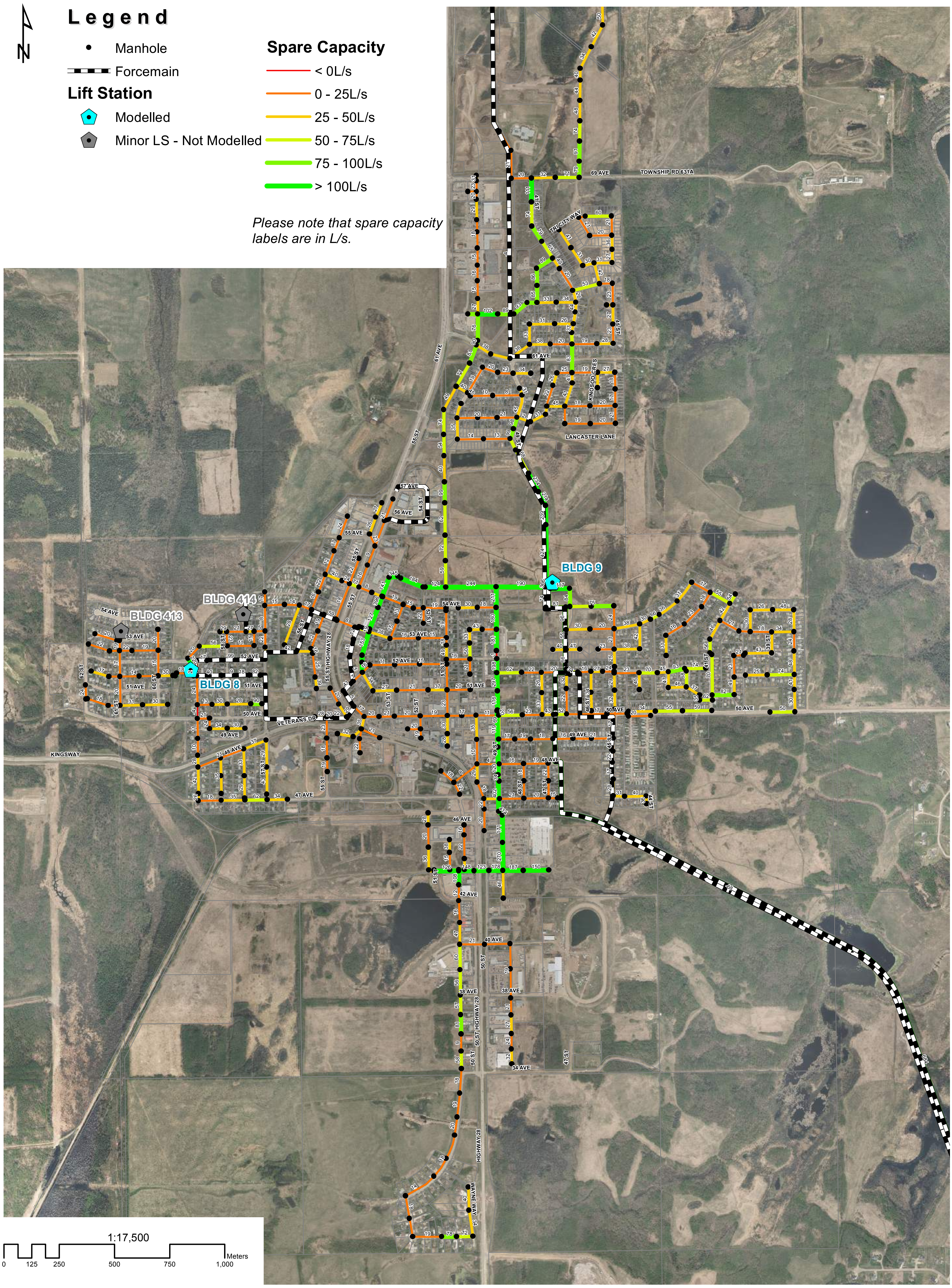

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FIGURE 9.9

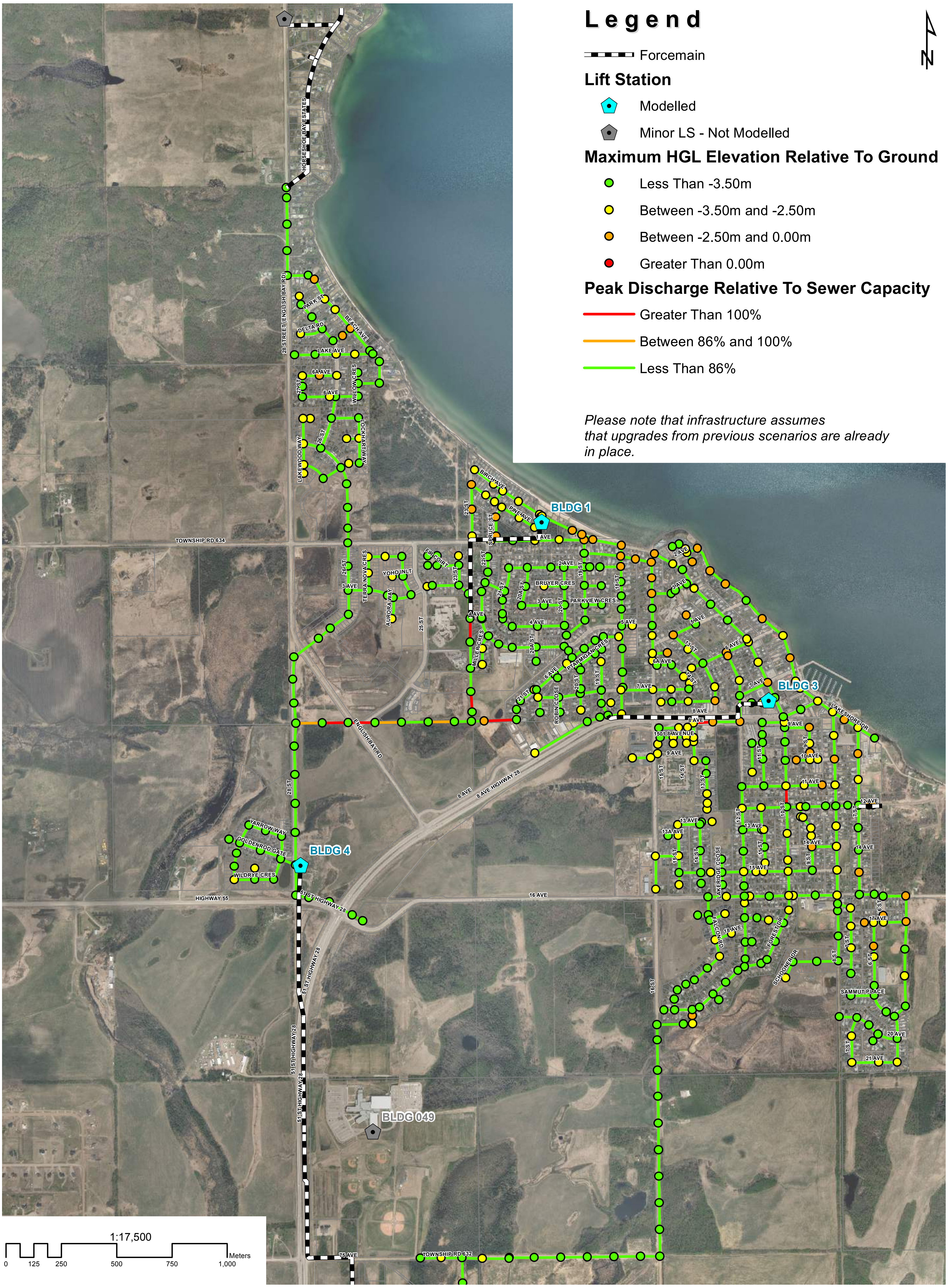

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FIGURE 9.10

Legend

- Forcemain

Lift Station

- Modelled
- Minor LS - Not Modelled

Maximum HGL Elevation Relative To Ground

- Less Than -3.50m
- Between -3.50m and -2.50m
- Between -2.50m and 0.00m
- Greater Than 0.00m

Peak Discharge Relative To Sewer Capacity

- Greater Than 100%
- Between 86% and 100%
- Less Than 86%

Please note that infrastructure assumes that upgrades from previous scenarios are already in place.

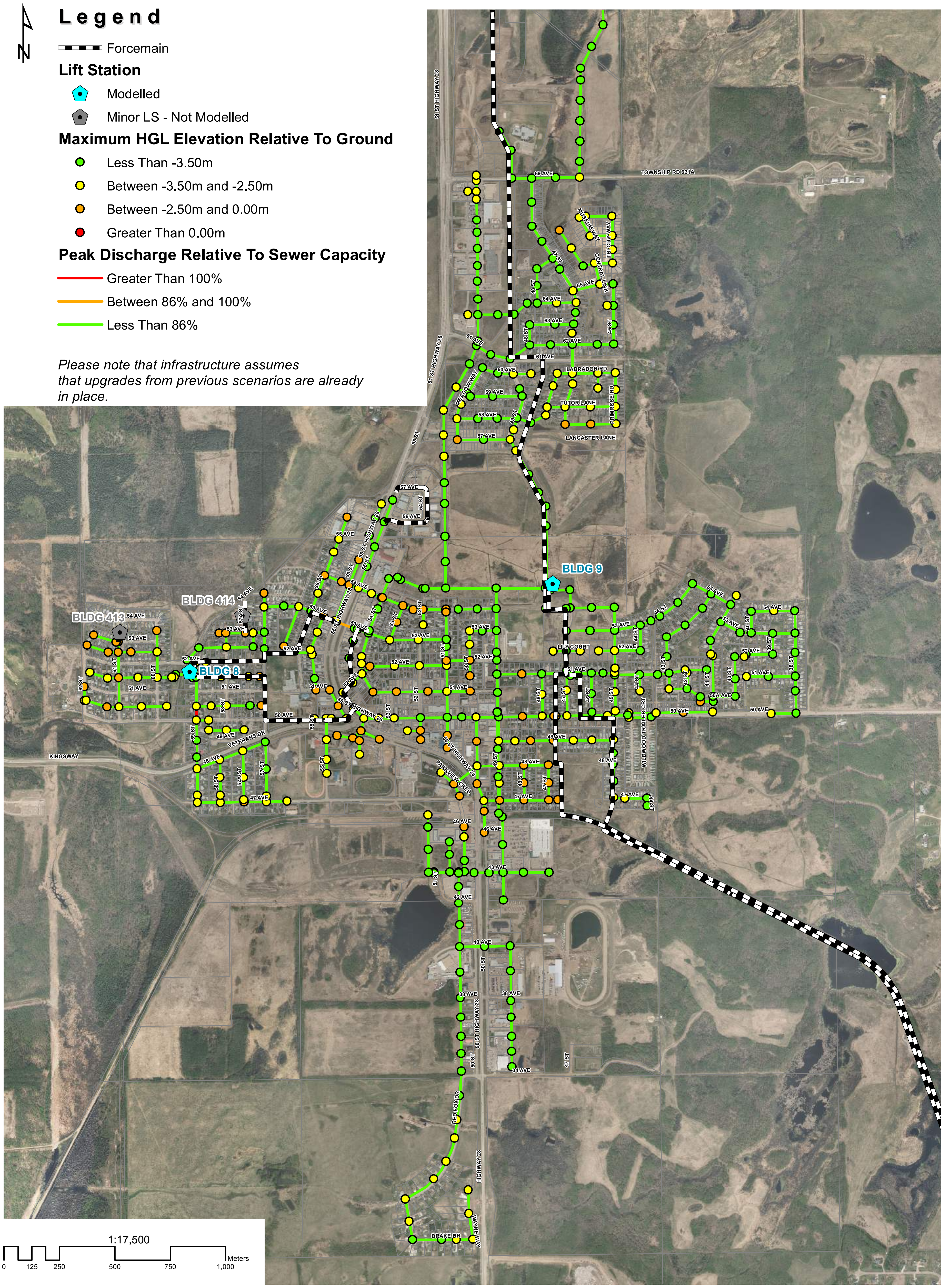

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FIGURE 9.11

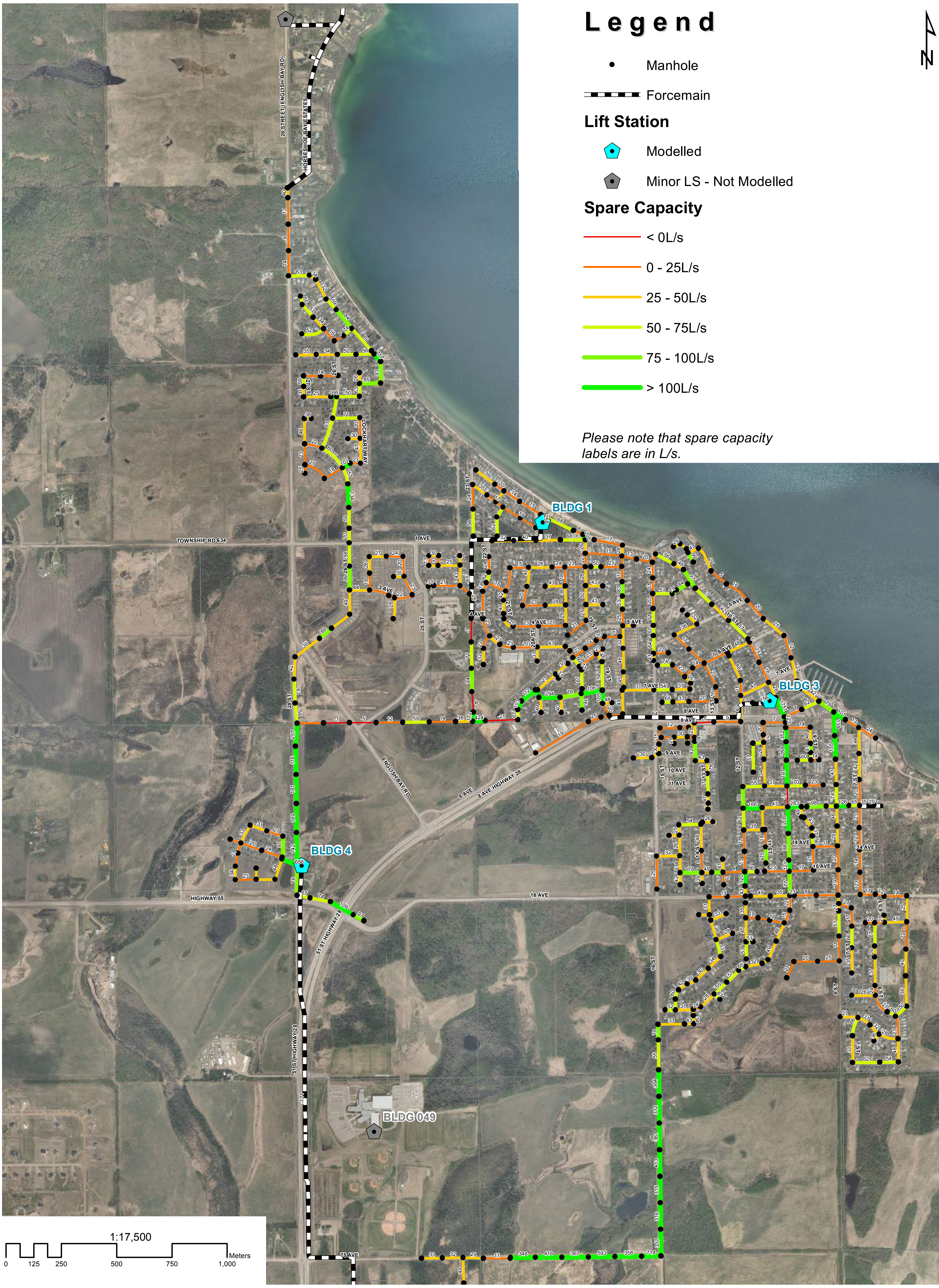

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FIGURE 9.12

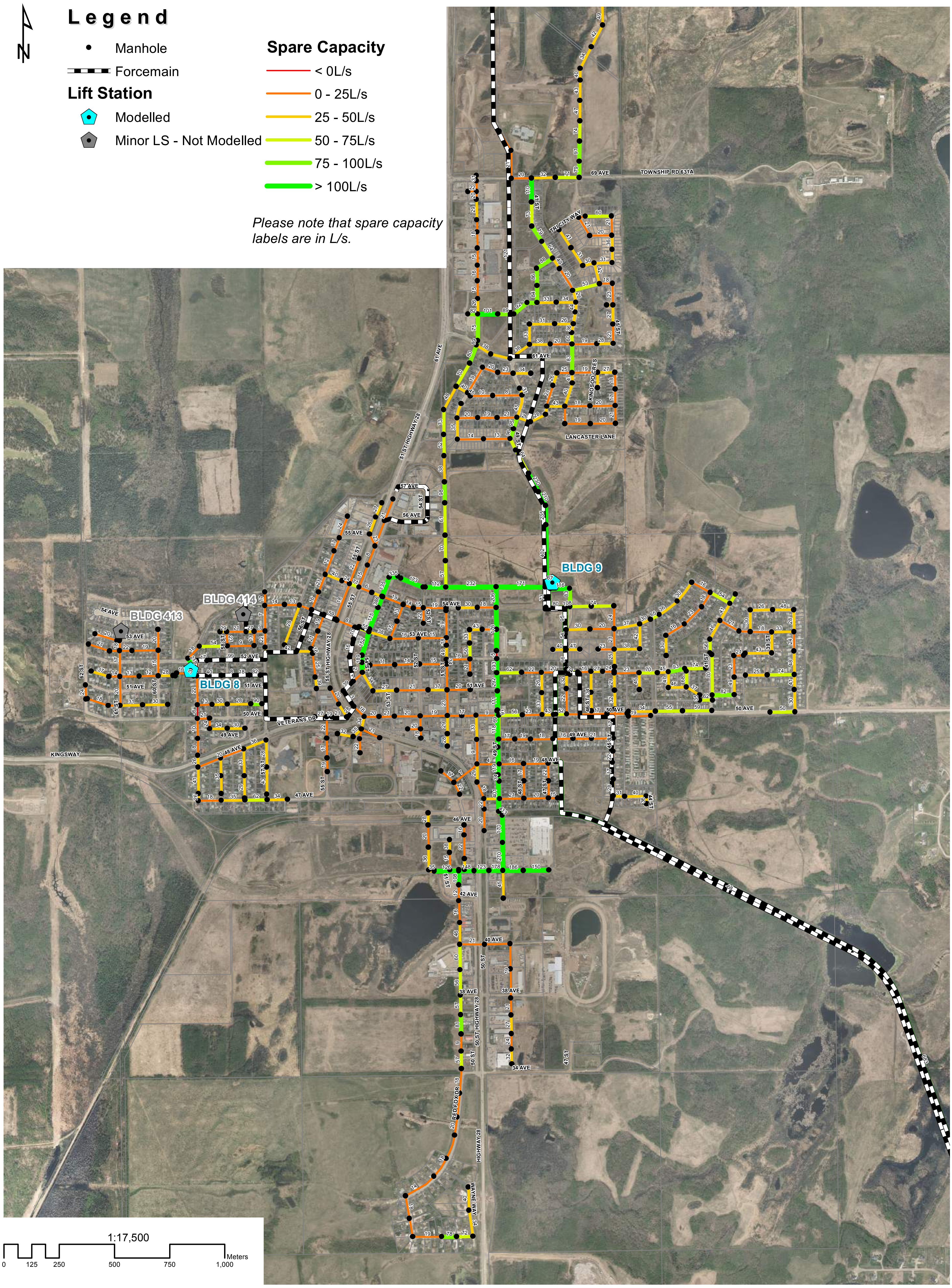

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FIGURE 9.13

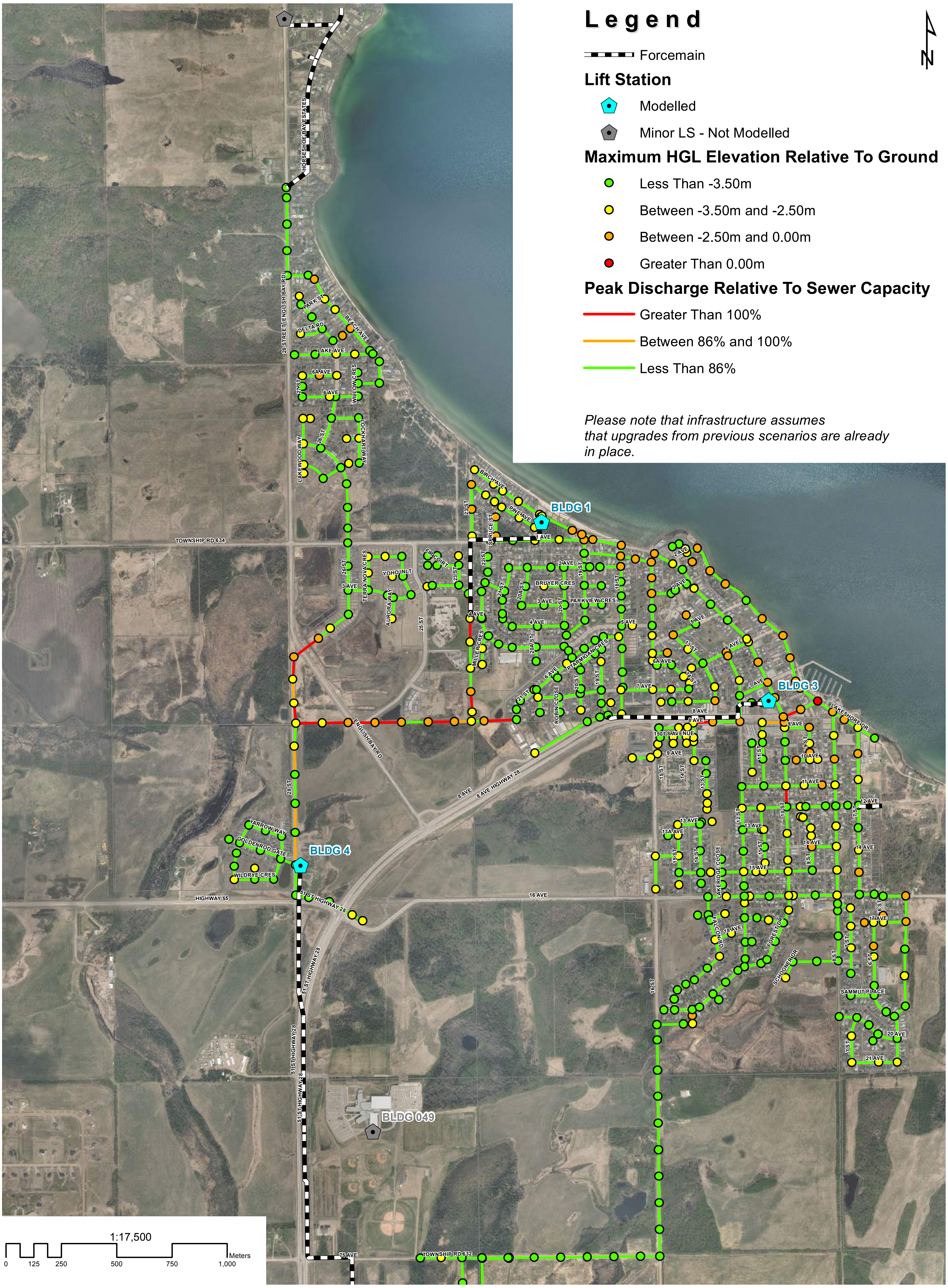

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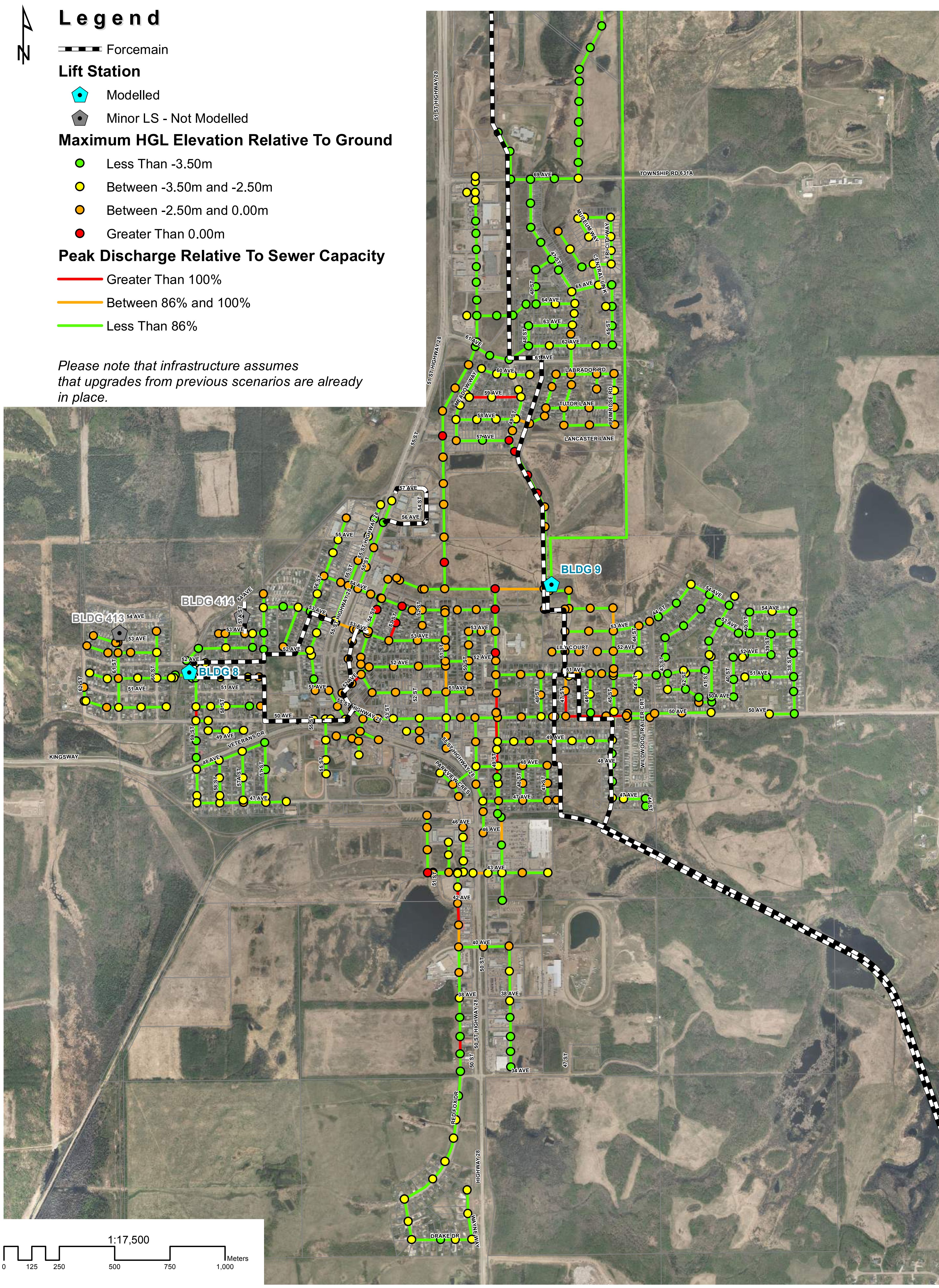
FIGURE 9.14



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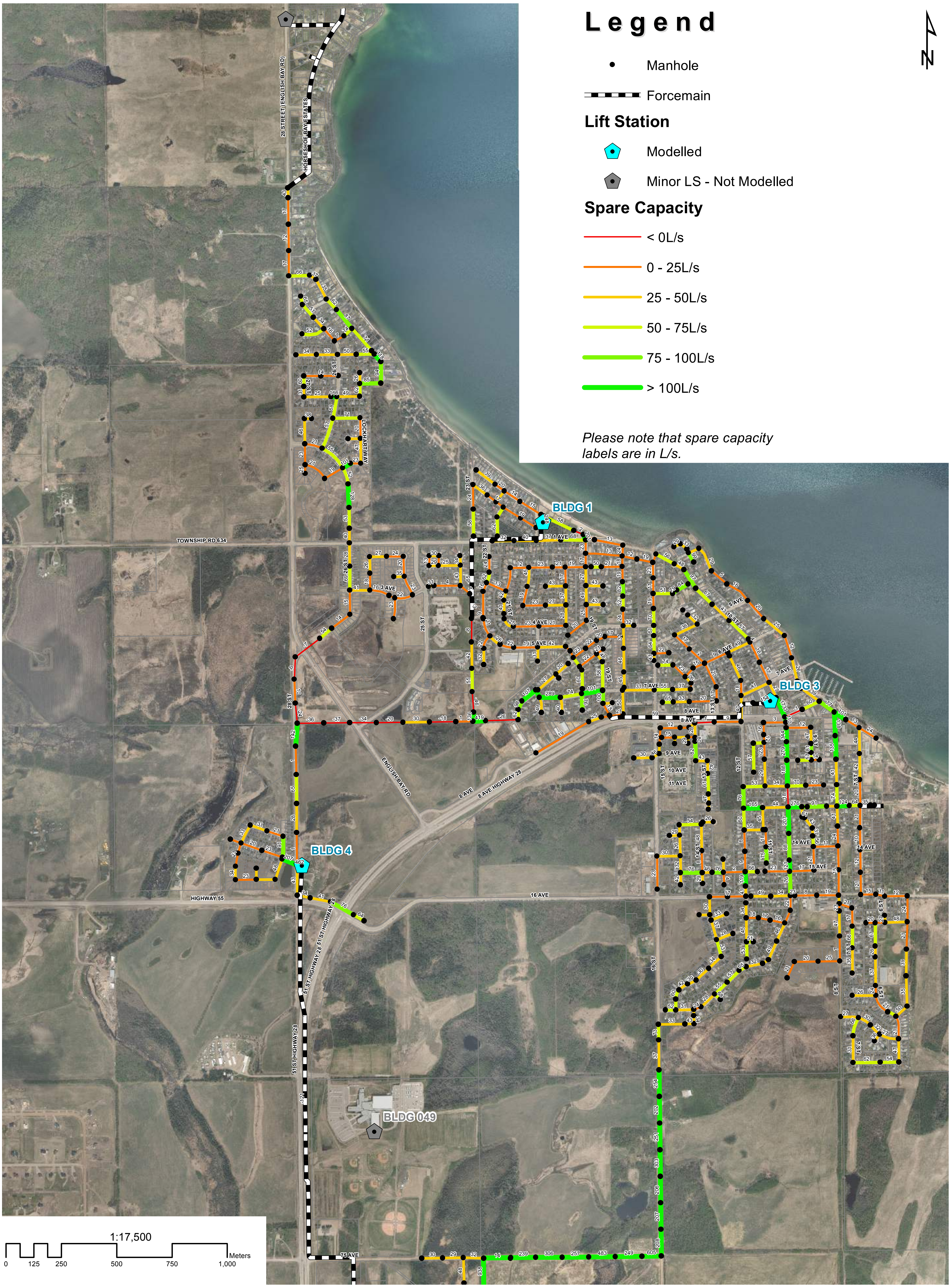

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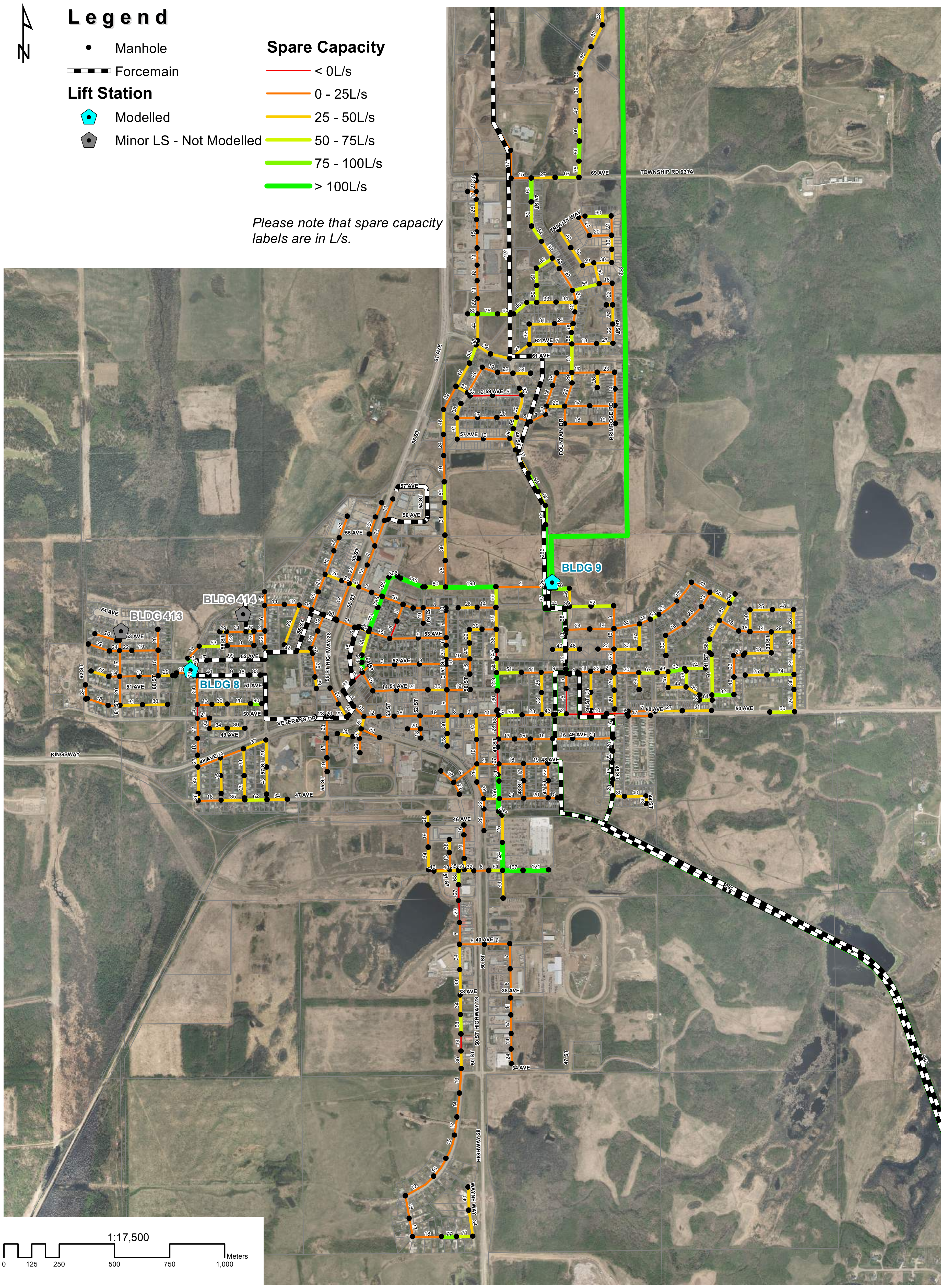
FIGURE 9.16



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ASSESSMENT RESULTS - SPARE CAPACITY
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FIGURE 9.17

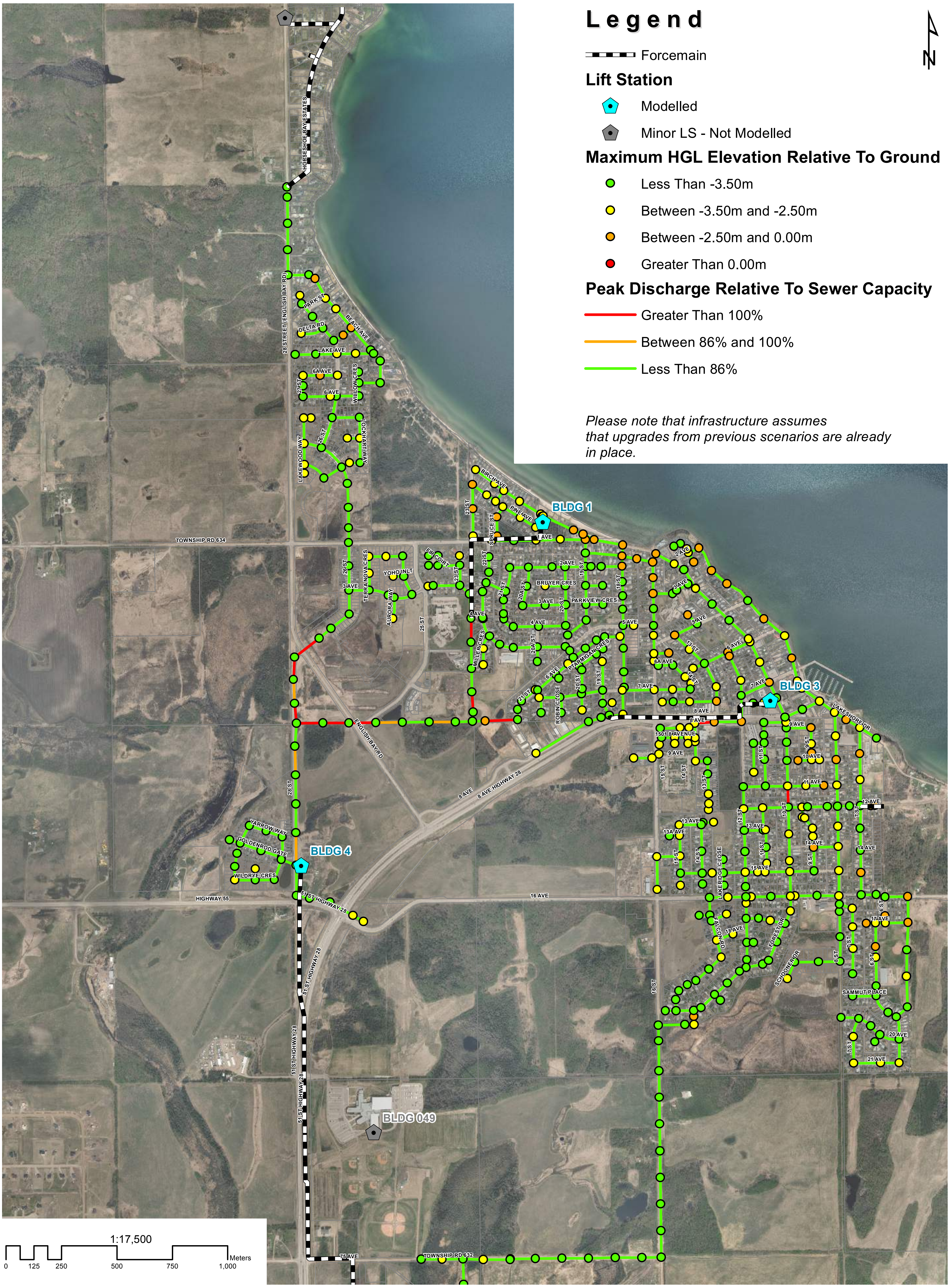

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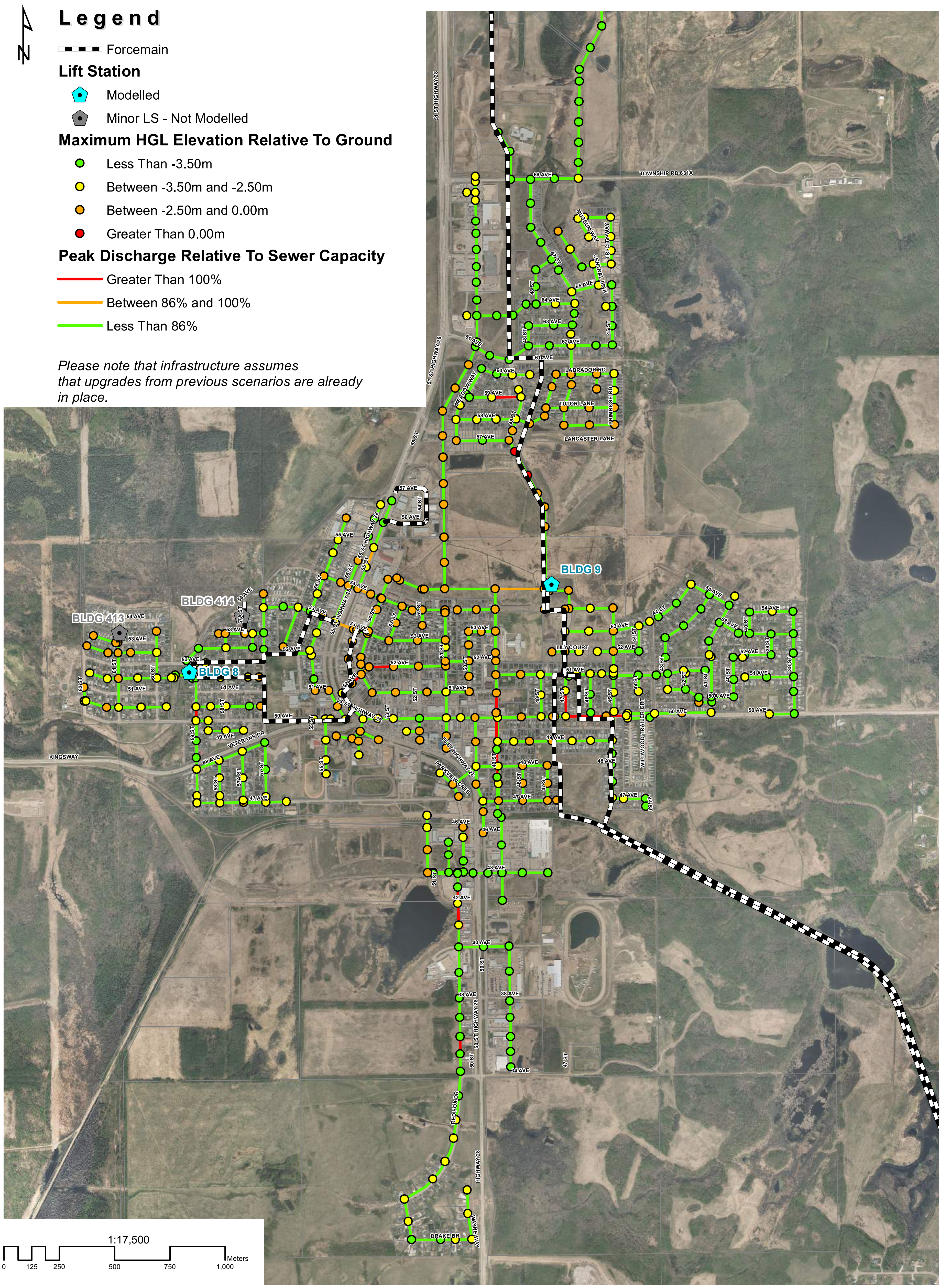
FIGURE 9.18



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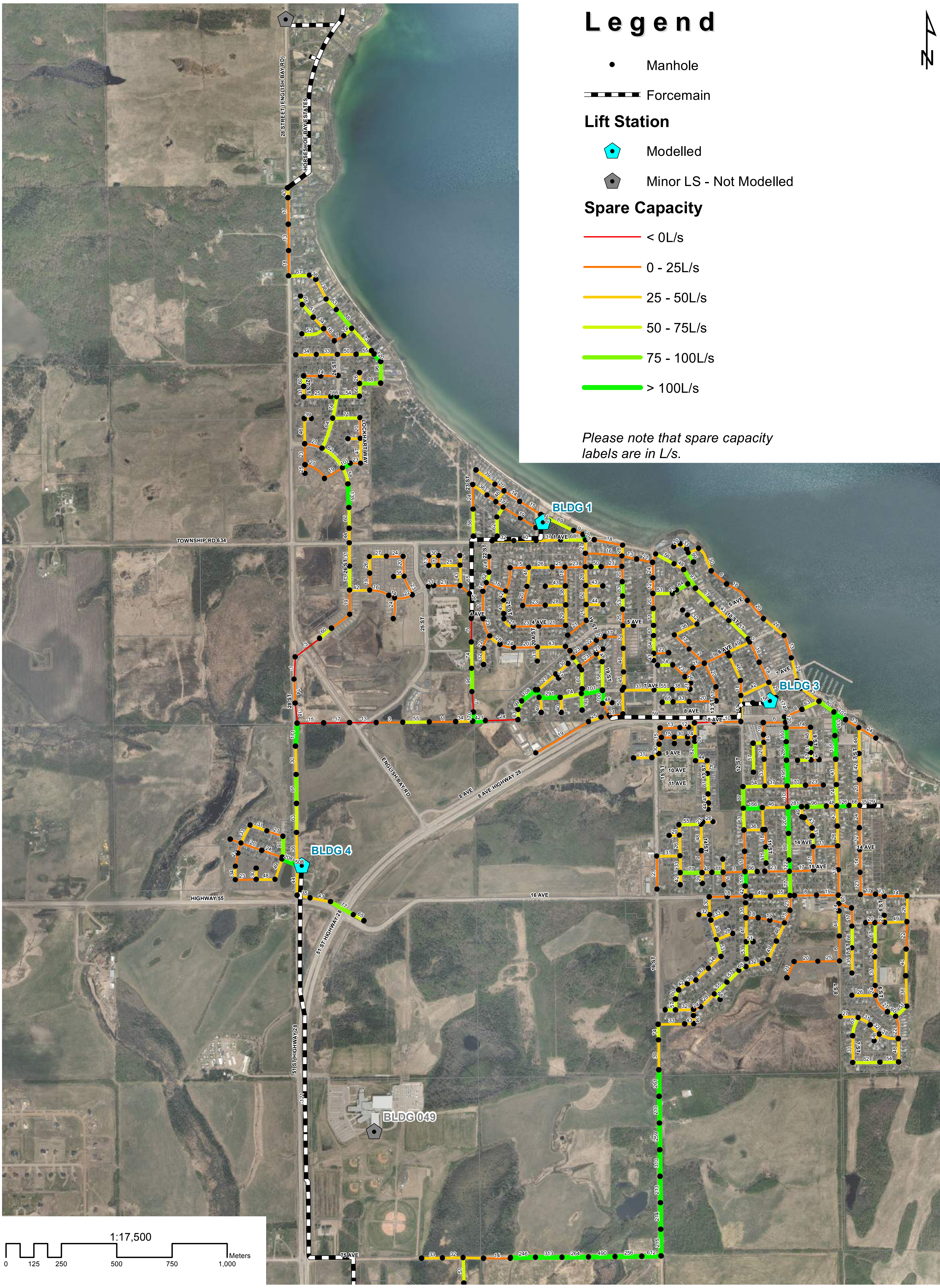
Date: 10/19/2017 Document: M:\26300\26367_Cold_Lake_I-I_Program\02_CADD\20_Drafting\201_GIS Figures\9.0 Future System Assessment\Figure 9.18 - FUT Stg. 2 DWF Plus 25yr 24hr Huff_South.mxd

FIGURE 9.19



THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM

SANITARY COLLECTION SYSTEM
PROPOSED NETWORK - NORTH
STAGE 2 - BUILD-OUT TO CURRENT CITY BOUNDARY
ASSESSMENT RESULTS - SPARE CAPACITY
FUTURE CONDITIONS PLUS 25YR 24HR Q3 HUFF STORM

City of Cold Lake

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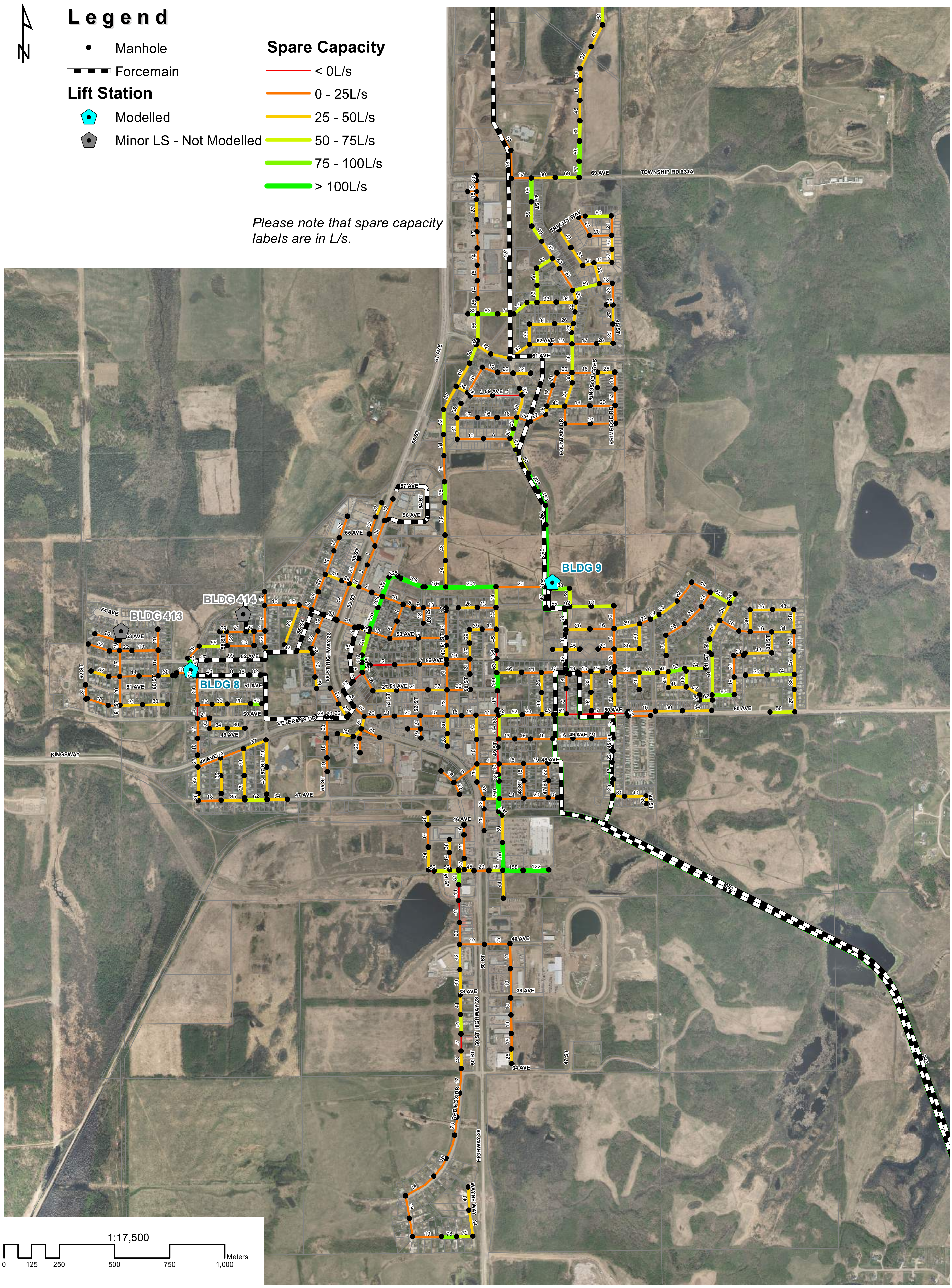
FIGURE 9.20



City of Cold Lake

THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM

SANITARY COLLECTION SYSTEM
PROPOSED NETWORK - SOUTH
STAGE 2 - BUILD-OUT TO CURRENT CITY BOUNDARY
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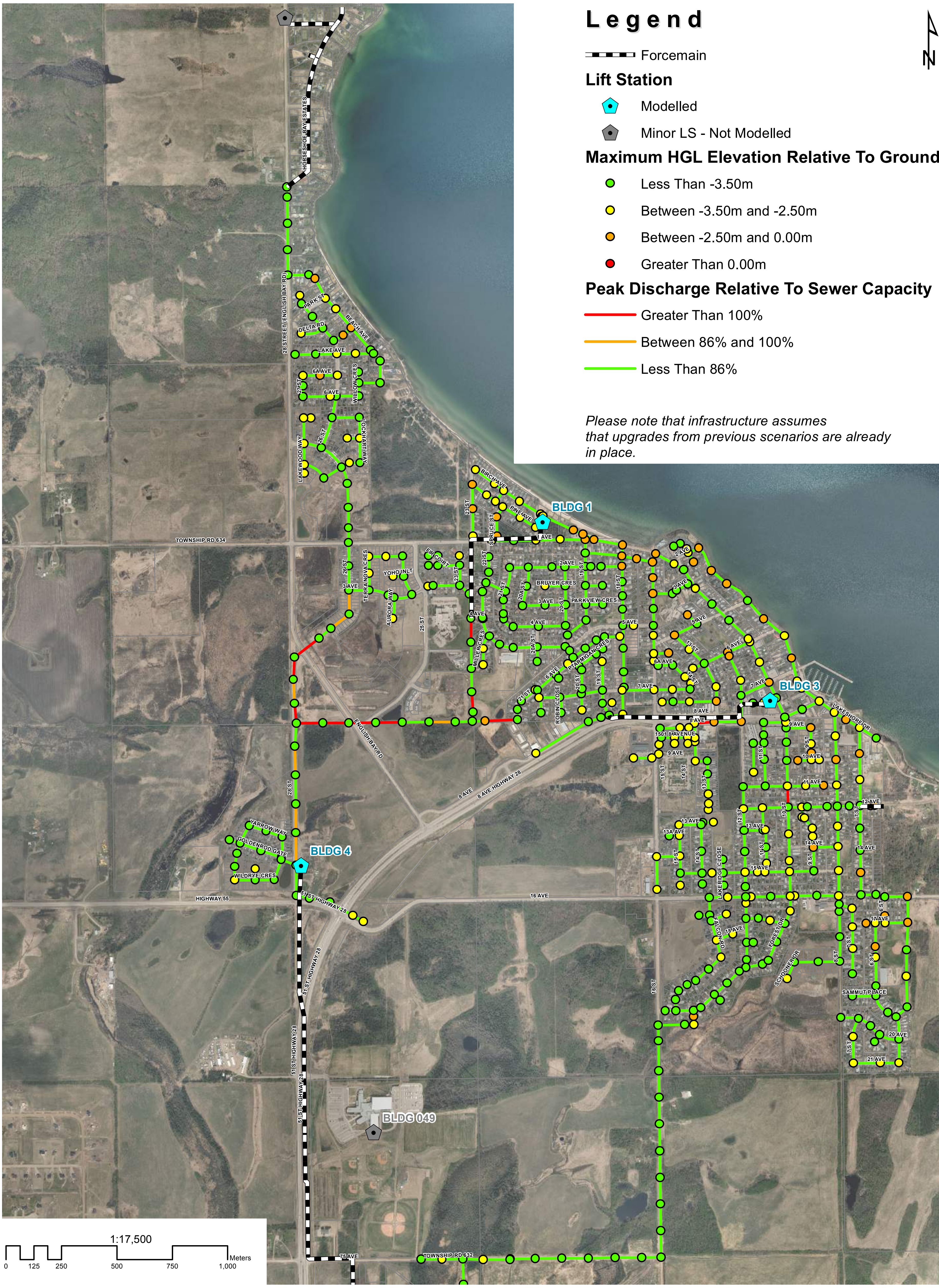
FIGURE 9.21



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THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM
SANITARY COLLECTION SYSTEM
PROPOSED NETWORK - NORTH
STAGE 2 - BUILD-OUT TO CURRENT CITY BOUNDARY
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AND MAXIMUM HGL ELEVATION RELATIVE TO GROUND
FUTURE CONDITIONS PLUS 50YR 24HR Q3 HUFF STORM

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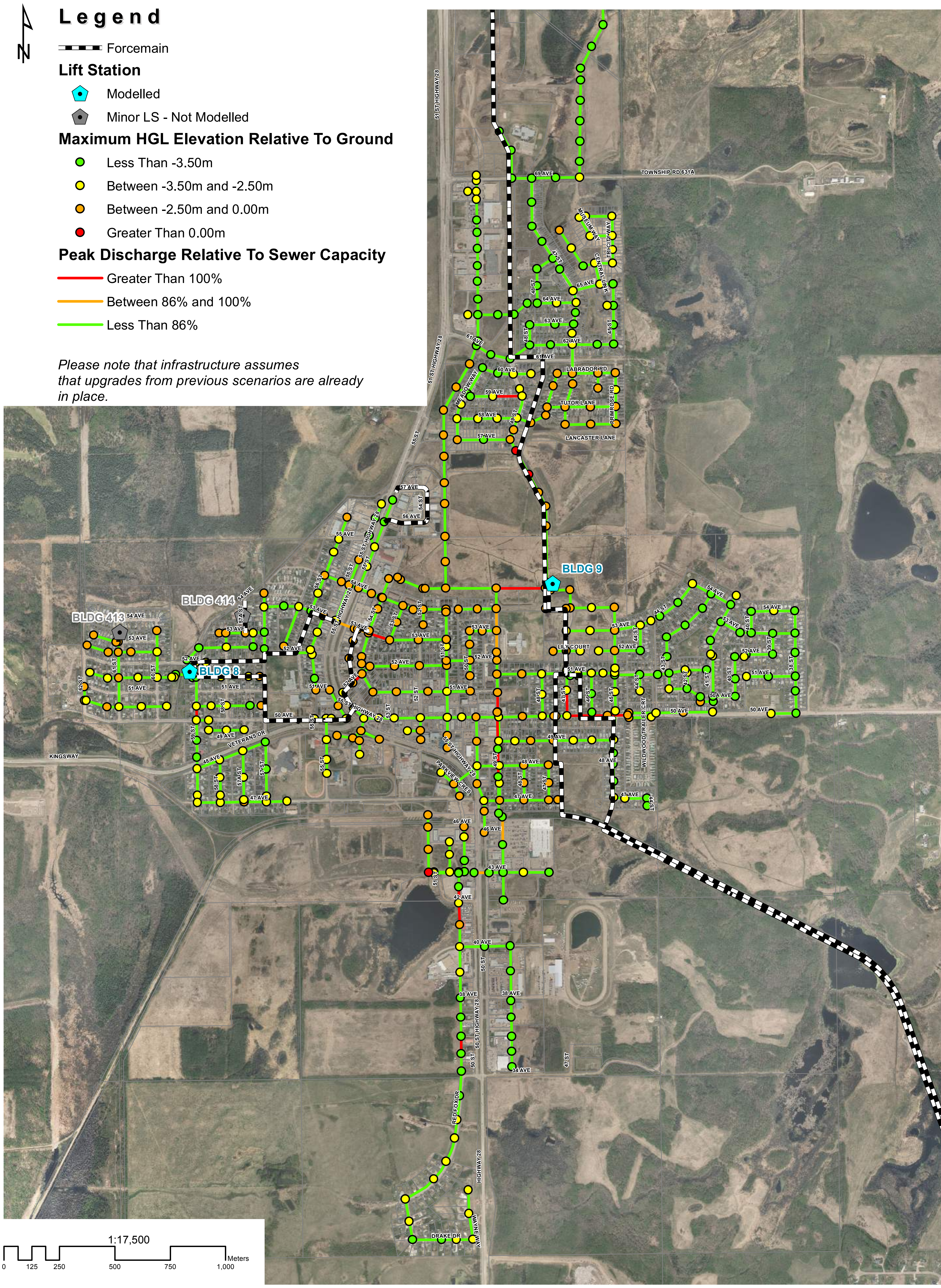
FIGURE 9.22



THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM

SANITARY COLLECTION SYSTEM
PROPOSED NETWORK - SOUTH
STAGE 2 - BUILD-OUT TO CURRENT CITY BOUNDARY
ASSESSMENT RESULTS - PEAK DISCHARGE RELATIVE TO SEWER CAPACITY
AND MAXIMUM HGL ELEVATION RELATIVE TO GROUND
FUTURE CONDITIONS PLUS 50YR 24HR Q3 HUFF STORM

City of Cold Lake

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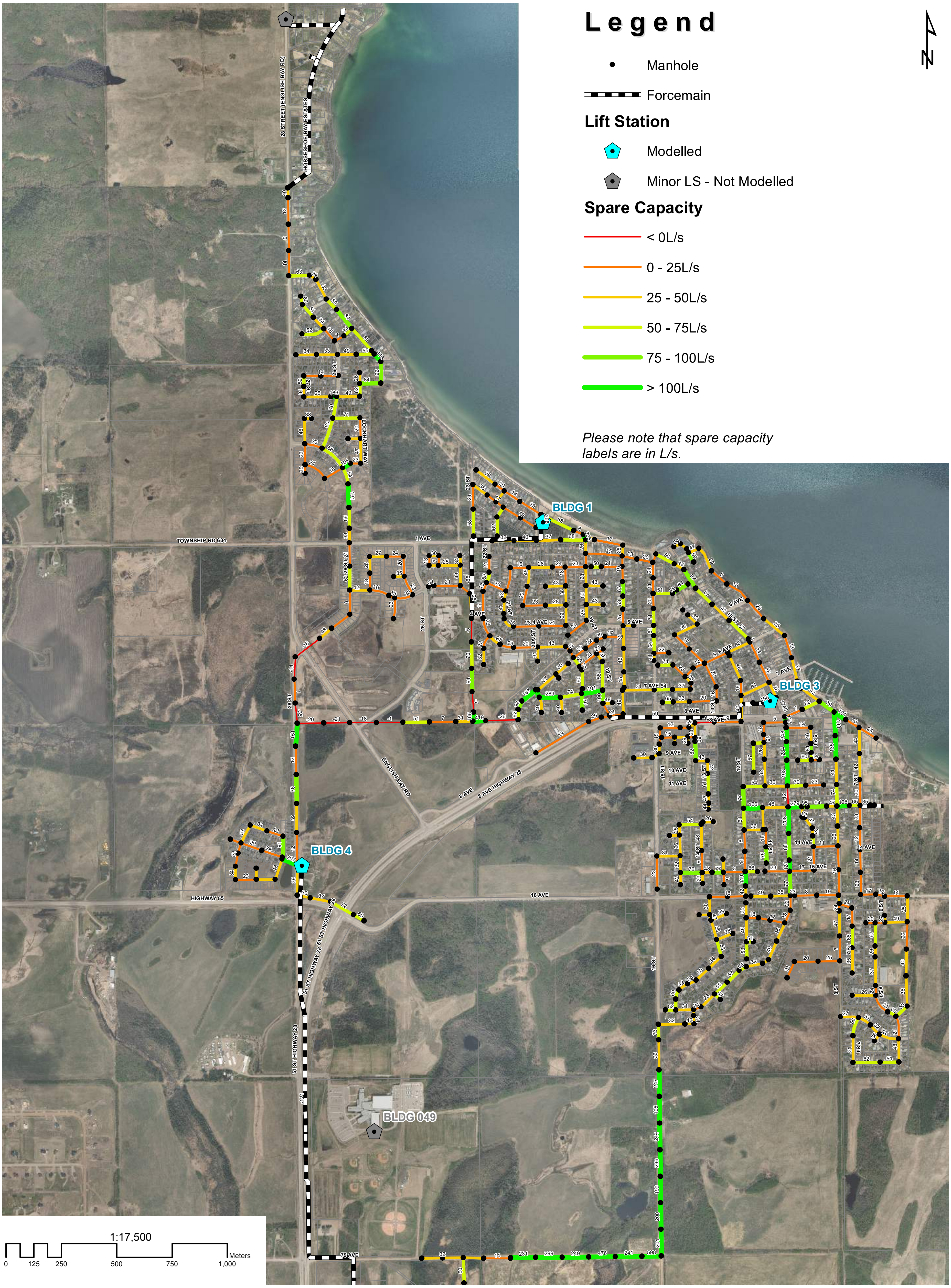
FIGURE 9.23



THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM

SANITARY COLLECTION SYSTEM
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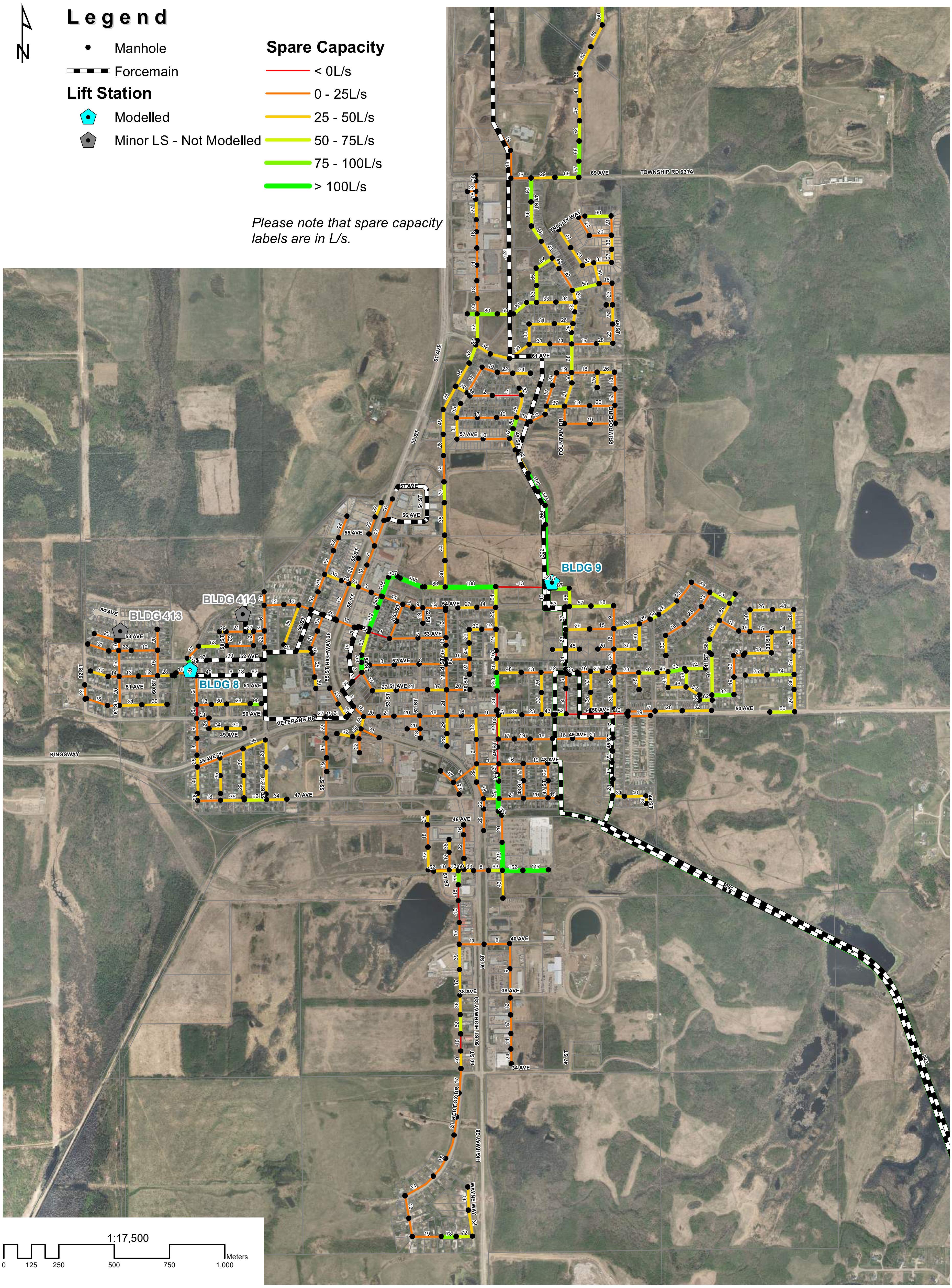
FIGURE 9.24



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ASSESSMENT RESULTS - SPARE CAPACITY
FUTURE CONDITIONS PLUS 50YR 24HR Q3 HUFF STORM

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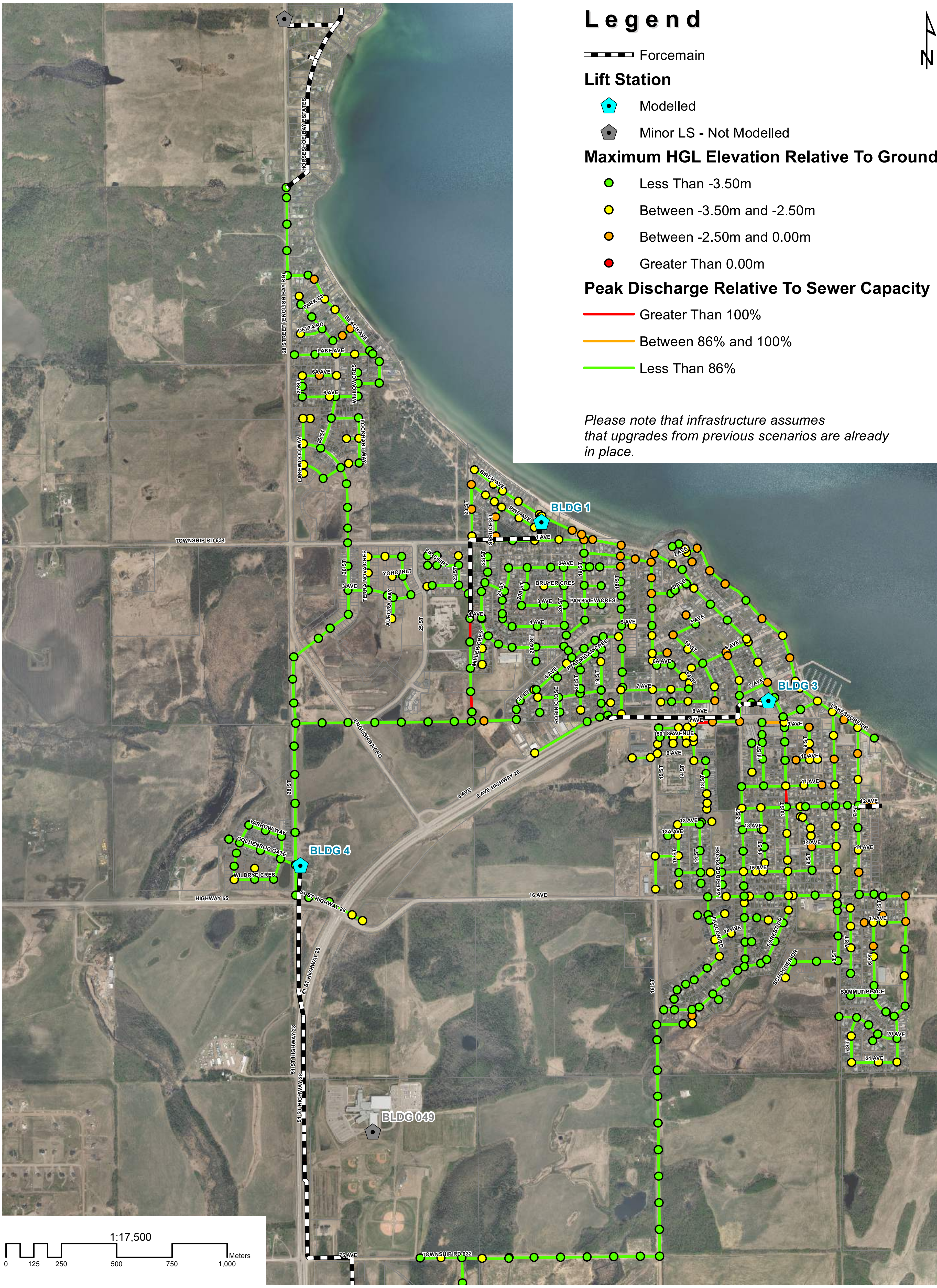
FIGURE 9.25



THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM

SANITARY COLLECTION SYSTEM
PROPOSED NETWORK - NORTH
STAGE 3 - BUILD-OUT OF ANNEXATION AREAS
ASSESSMENT RESULTS - PEAK DISCHARGE RELATIVE TO SEWER CAPACITY
AND MAXIMUM HGL ELEVATION RELATIVE TO GROUND
FUTURE CONDITIONS PLUS CONSTANT I-I RATE OF 0.29L/s/ha

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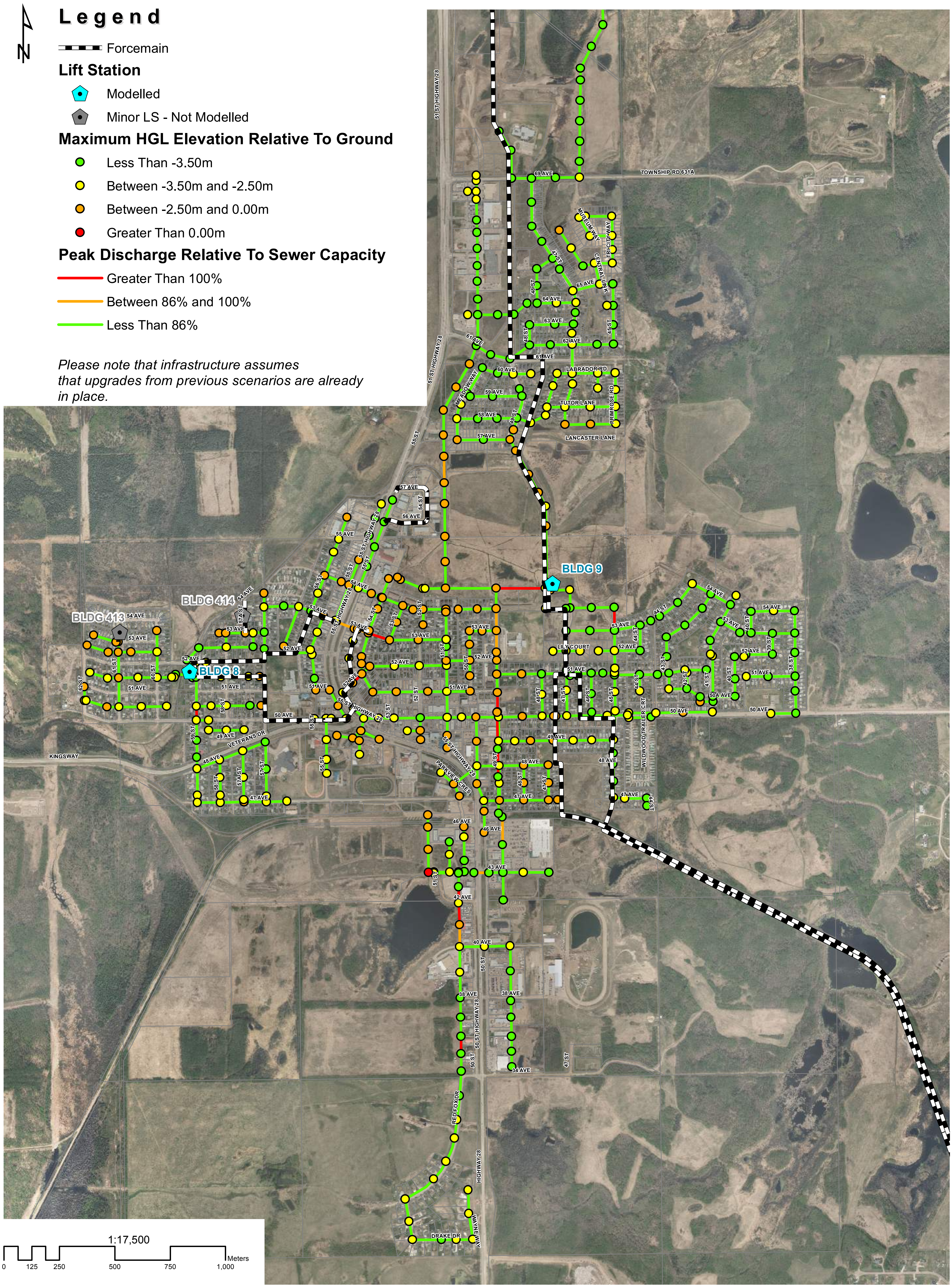
FIGURE 9.26



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THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM

SANITARY COLLECTION SYSTEM
PROPOSED NETWORK - SOUTH
STAGE 3 - BUILD-OUT OF ANNEXATION AREAS
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FUTURE CONDITIONS PLUS CONSTANT I-I RATE OF 0.29L/s/ha

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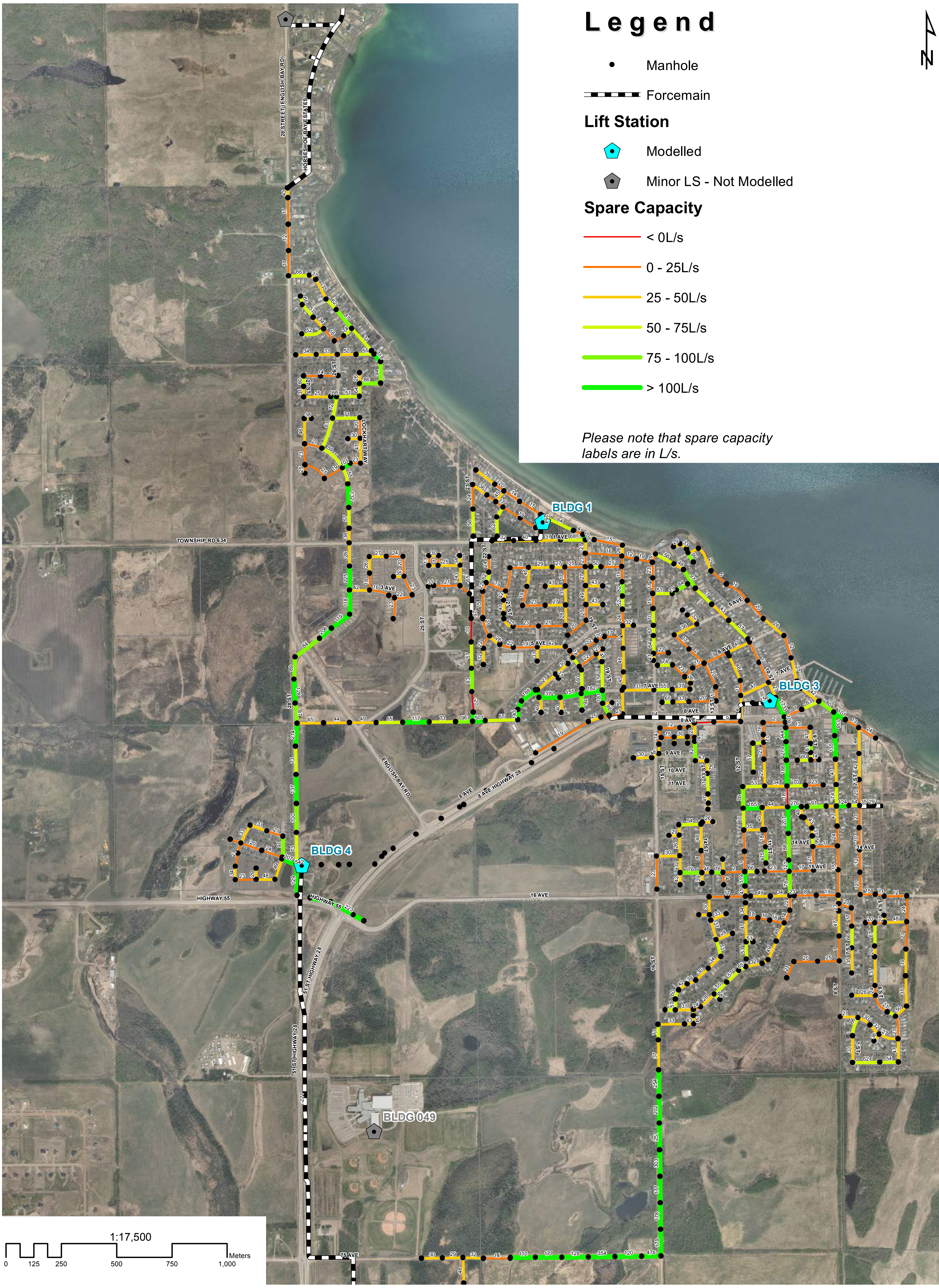
FIGURE 9.27



THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM

SANITARY COLLECTION SYSTEM
PROPOSED NETWORK - NORTH
STAGE 3 - BUILD-OUT OF ANNEXATION AREAS
ASSESSMENT RESULTS - SPARE CAPACITY
FUTURE CONDITIONS PLUS CONSTANT I-I RATE OF 0.29L/s/ha

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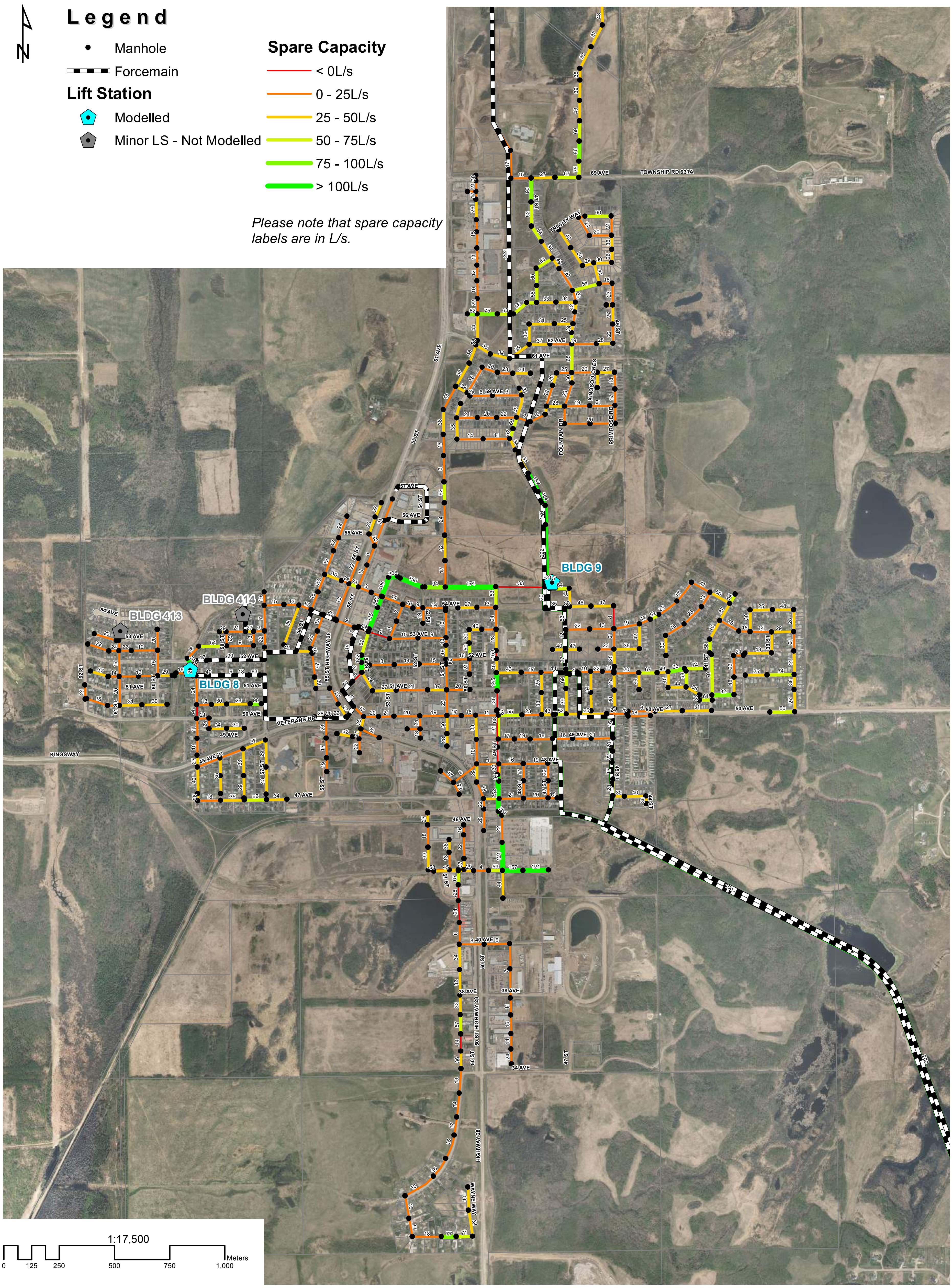
FIGURE 9.28



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INFLOW - INFILTRATION PROGRAM

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ASSESSMENT RESULTS - SPARE CAPACITY
FUTURE CONDITIONS PLUS CONSTANT I-I RATE OF 0.29L/s/ha

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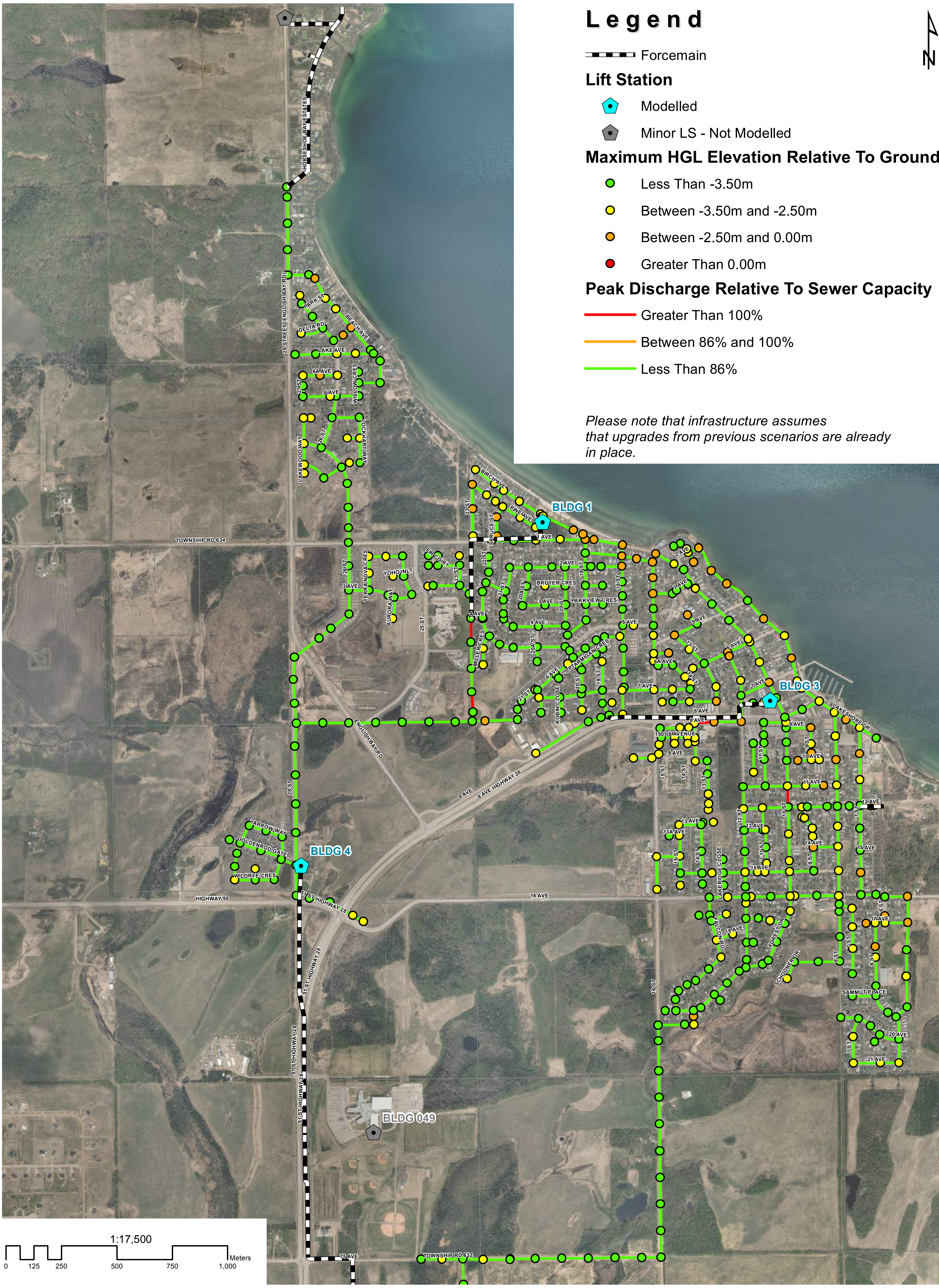
FIGURE 9.29



THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM
SANITARY COLLECTION SYSTEM
PROPOSED NETWORK - NORTH
STAGE 3 - BUILD-OUT OF ANNEXATION AREAS
ASSESSMENT RESULTS - PEAK DISCHARGE RELATIVE TO SEWER CAPACITY
AND MAXIMUM HGL ELEVATION RELATIVE TO GROUND
FUTURE CONDITIONS PLUS 25YR 24HR Q3 HUFF STORM

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FIGURE 9.30

Legend

Forcemain

Lift Station

- Modelled
- Minor LS - Not Modelled

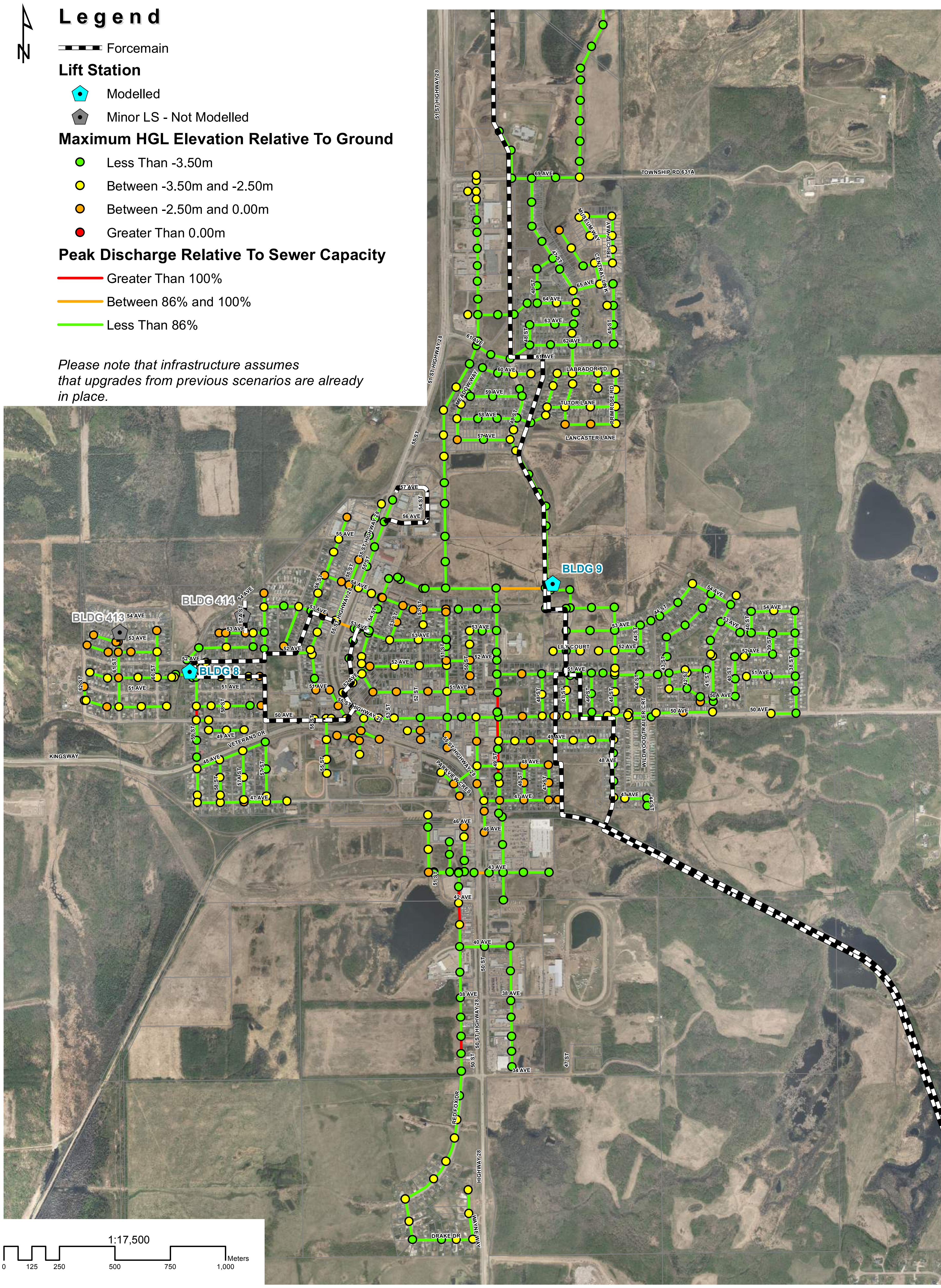
Maximum HGL Elevation Relative To Ground

- Less Than -3.50m
- Between -3.50m and -2.50m
- Between -2.50m and 0.00m
- Greater Than 0.00m

Peak Discharge Relative To Sewer Capacity

- Greater Than 100%
- Between 86% and 100%
- Less Than 86%

Please note that infrastructure assumes that upgrades from previous scenarios are already in place.



THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM

SANITARY COLLECTION SYSTEM
PROPOSED NETWORK - SOUTH
STAGE 3 - BUILD-OUT OF ANNEXATION AREAS
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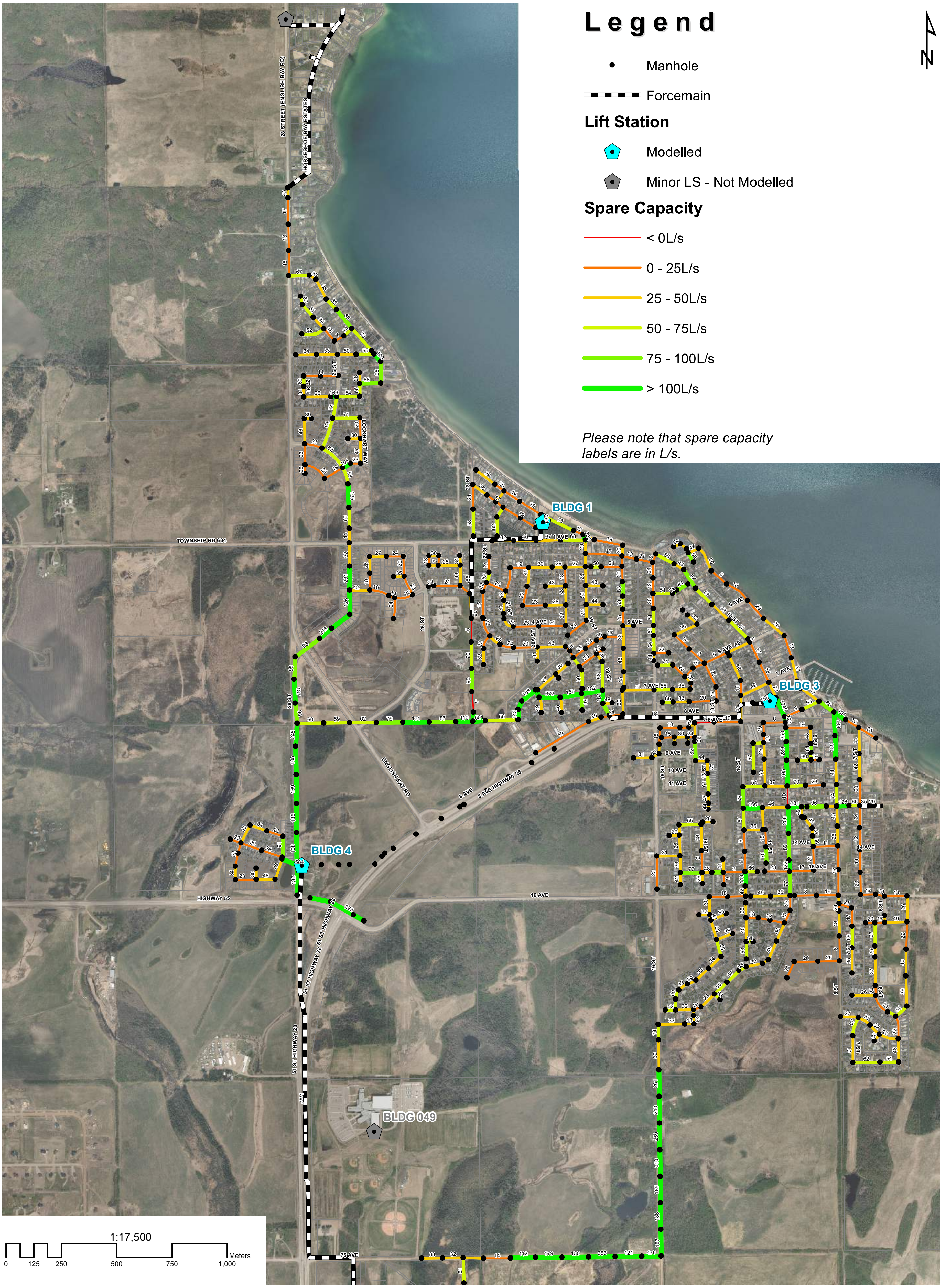
FIGURE 9.31



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THE CITY OF COLD LAKE
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SANITARY COLLECTION SYSTEM
PROPOSED NETWORK - NORTH
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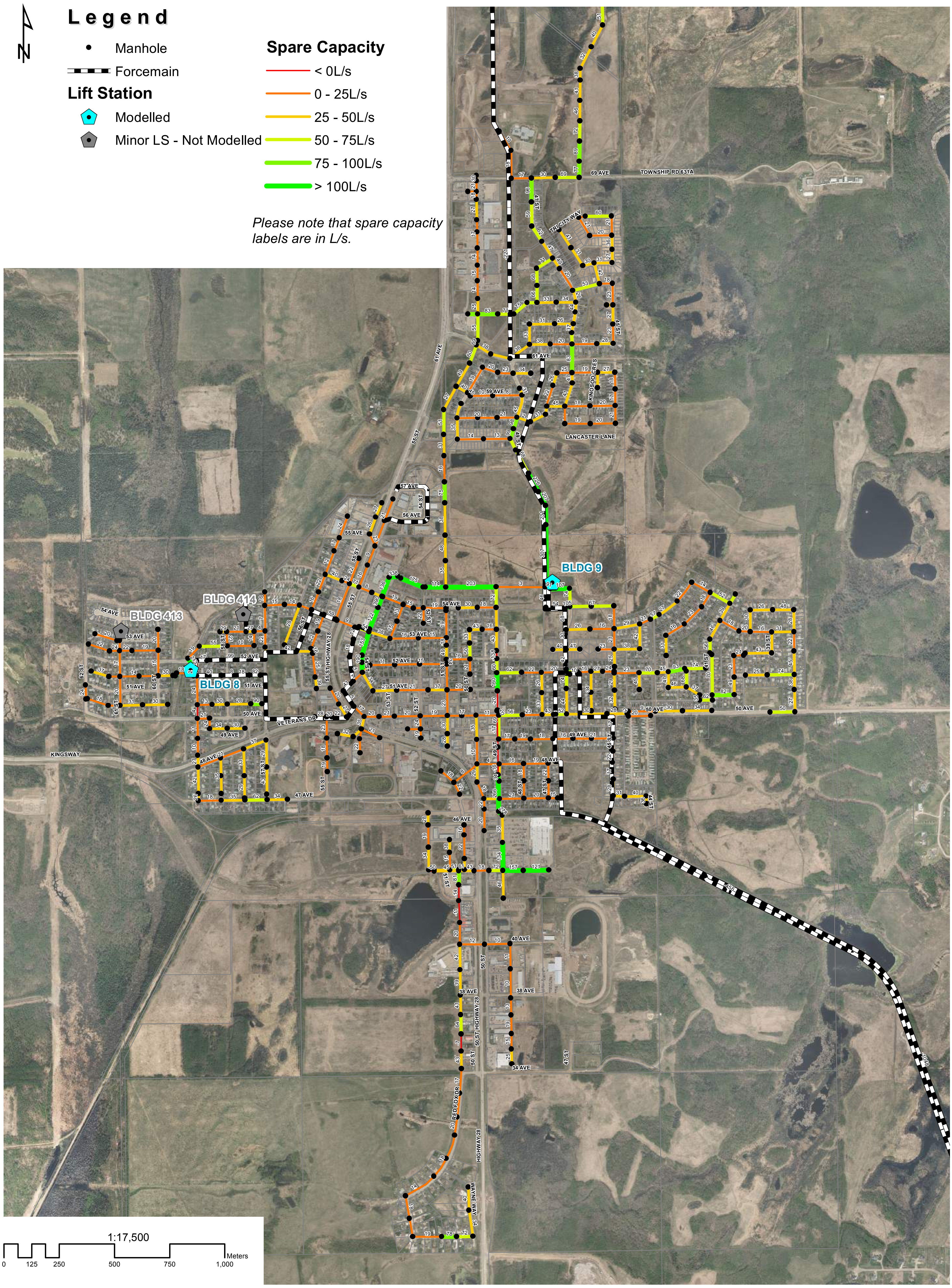
FIGURE 9.32



THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM

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PROPOSED NETWORK - SOUTH
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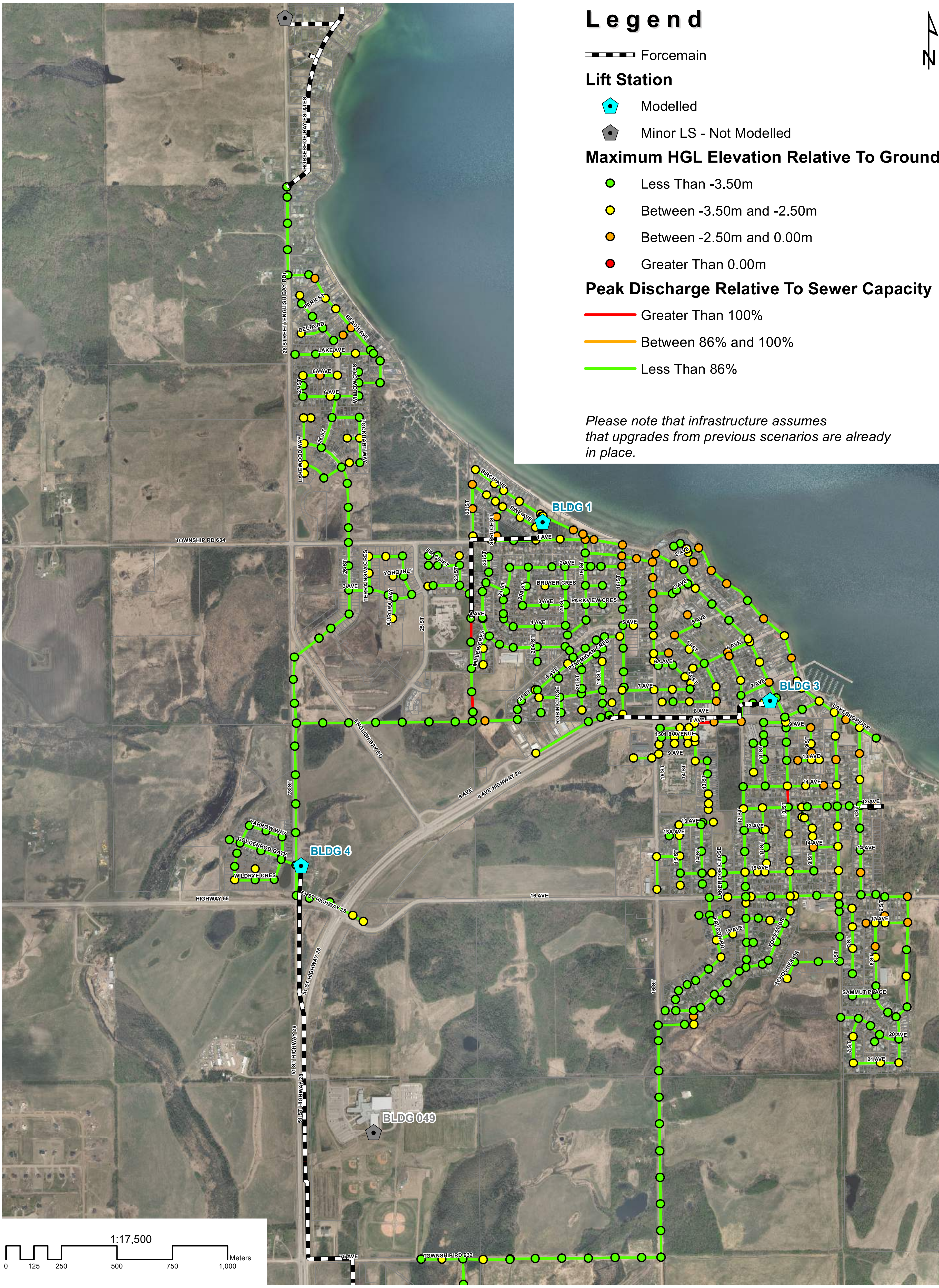
FIGURE 9.33



THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM

SANITARY COLLECTION SYSTEM
PROPOSED NETWORK - NORTH
STAGE 3 - BUILD-OUT OF ANNEXATION AREAS
ASSESSMENT RESULTS - PEAK DISCHARGE RELATIVE TO SEWER CAPACITY
AND MAXIMUM HGL ELEVATION RELATIVE TO GROUND
FUTURE CONDITIONS PLUS 50YR 24HR Q3 HUFF STORM

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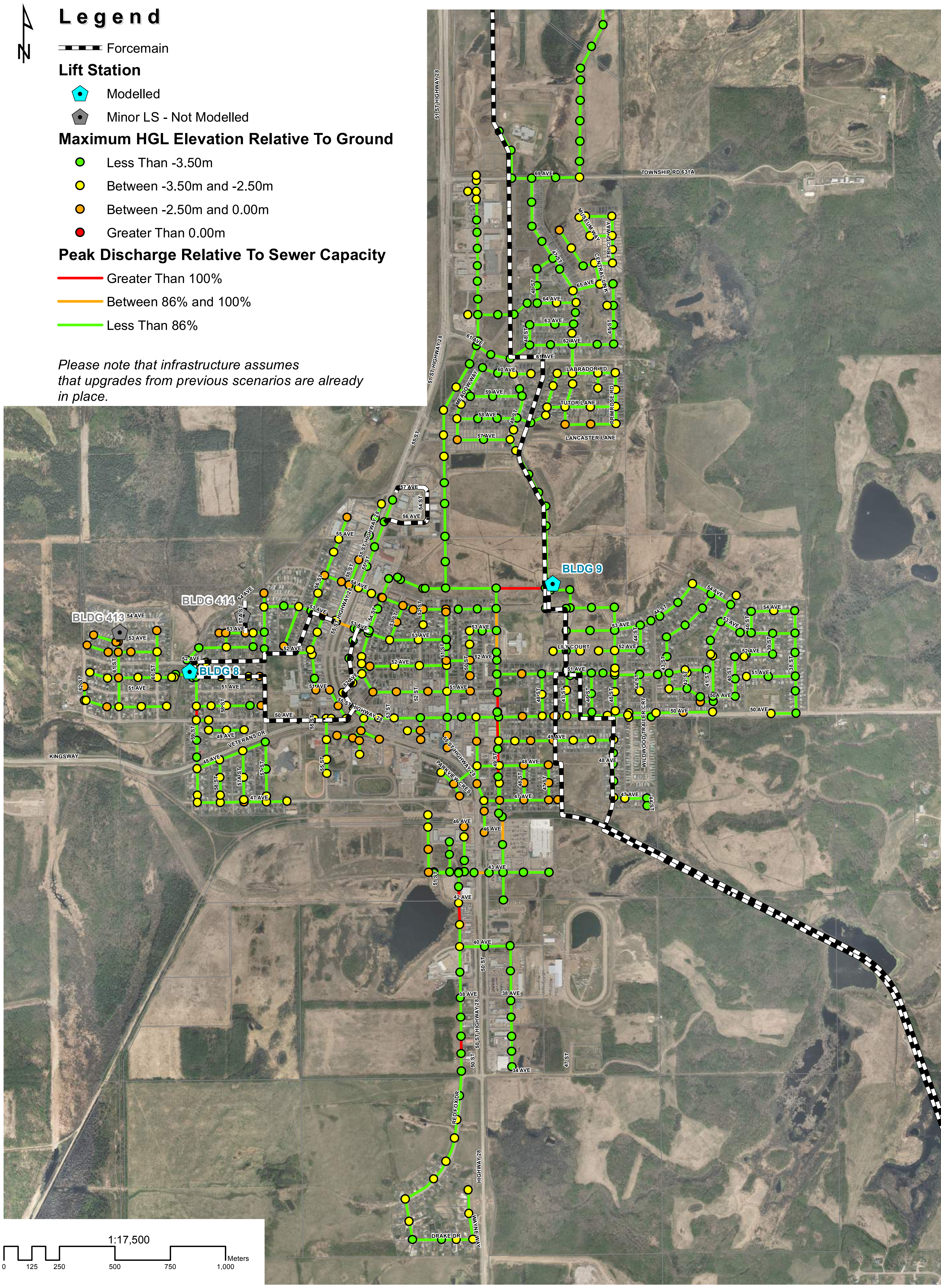
Date: 10/19/2017 Document: M:\26300\26367_Cold_Lake_I-I_Program\02_CADD\20_Drafting\201_GIS Figures\9.0 Future System Assessment\Figure 9.33 - FUT Stg. 3 DWF Plus 50yr 24hr Huff_North.mxd

FIGURE 9.34



THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM
SANITARY COLLECTION SYSTEM
PROPOSED NETWORK - SOUTH
STAGE 3 - BUILD-OUT OF ANNEXATION AREAS
ASSESSMENT RESULTS - PEAK DISCHARGE RELATIVE TO SEWER CAPACITY
AND MAXIMUM HGL ELEVATION RELATIVE TO GROUND
FUTURE CONDITIONS PLUS 50YR 24HR Q3 HUFF STORM

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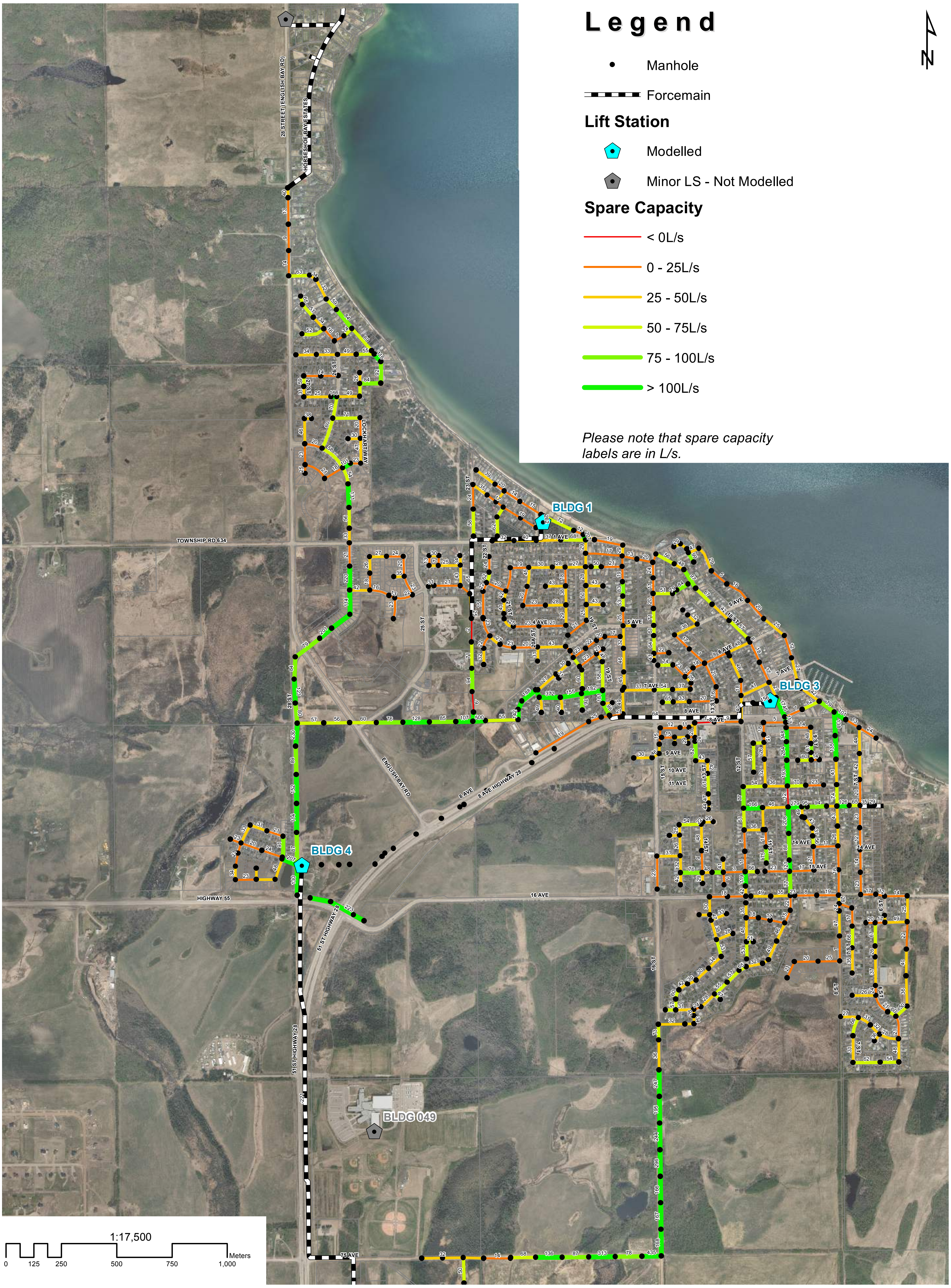
Date: 10/19/2017 Document: M:\26300\26367_Cold_Lake_I-I_Program\02_CADD\20_Drafting\201_GIS Figures\9.0 Future System Assessment\Figure 9.34 - FUT Stg. 3 DWF Plus 50yr 24hr Huff_South.mxd



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THE CITY OF COLD LAKE
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PROPOSED NETWORK - NORTH
STAGE 3 - BUILD-OUT OF ANNEXATION AREAS
ASSESSMENT RESULTS - SPARE CAPACITY
FUTURE CONDITIONS PLUS 50YR 24HR Q3 HUFF STORM

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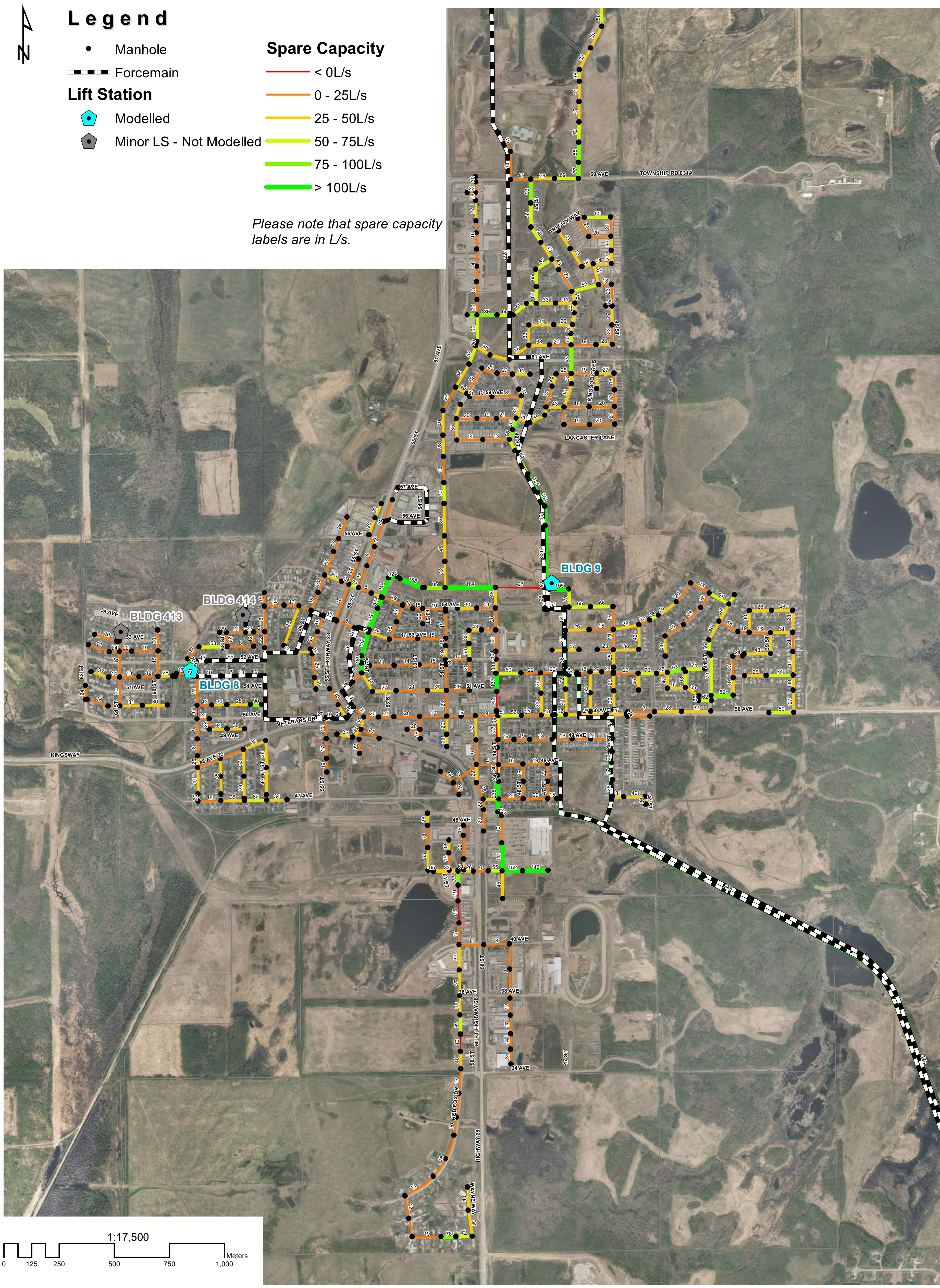
FIGURE 9.36



THE CITY OF COLD LAKE
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Date: 10/19/2017 Document: M:\26300\26367_Cold_Lake_I-I_Program\02_CADD\20_Drafting\201_GIS Figures\9.0 Future System Assessment\Figure 9.36 - FUT Stg. 3 DWF Plus 50yr 24hr Huff_Spare Capacity_South.mxd

FIGURE 9.37

Date: 10/19/2017 Document: M:\26300\26367_Cold_Lake_I-I_Program\02_CADD\20_Drafting\201_GIS Figures\9.0 Future System Assessment\Figure 9.37 - Stage 1 Upgrades_North.mxd

City of Cold Lake

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SANITARY COLLECTION SYSTEM
PROPOSED NETWORK - NORTH
STAGE 1 - BUILD-OUT OF EXISTING SYSTEM
RECOMMENDED UPGRADES

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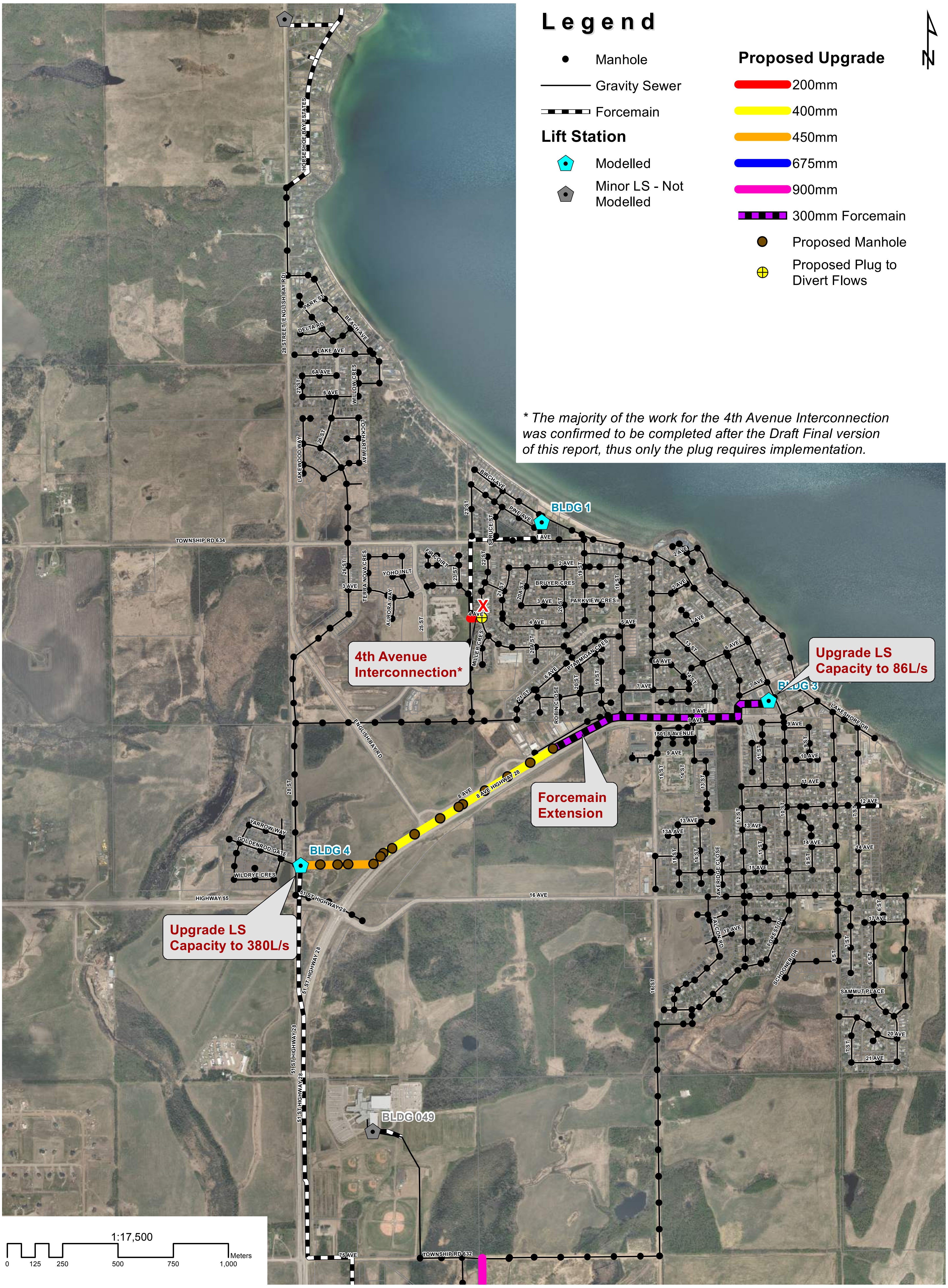
FIGURE 9.38



THE CITY OF COLD LAKE
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SANITARY COLLECTION SYSTEM
PROPOSED NETWORK - NORTH
STAGE 2 - BUILD-OUT TO CURRENT CITY BOUNDARY
RECOMMENDED UPGRADES

City of Cold Lake

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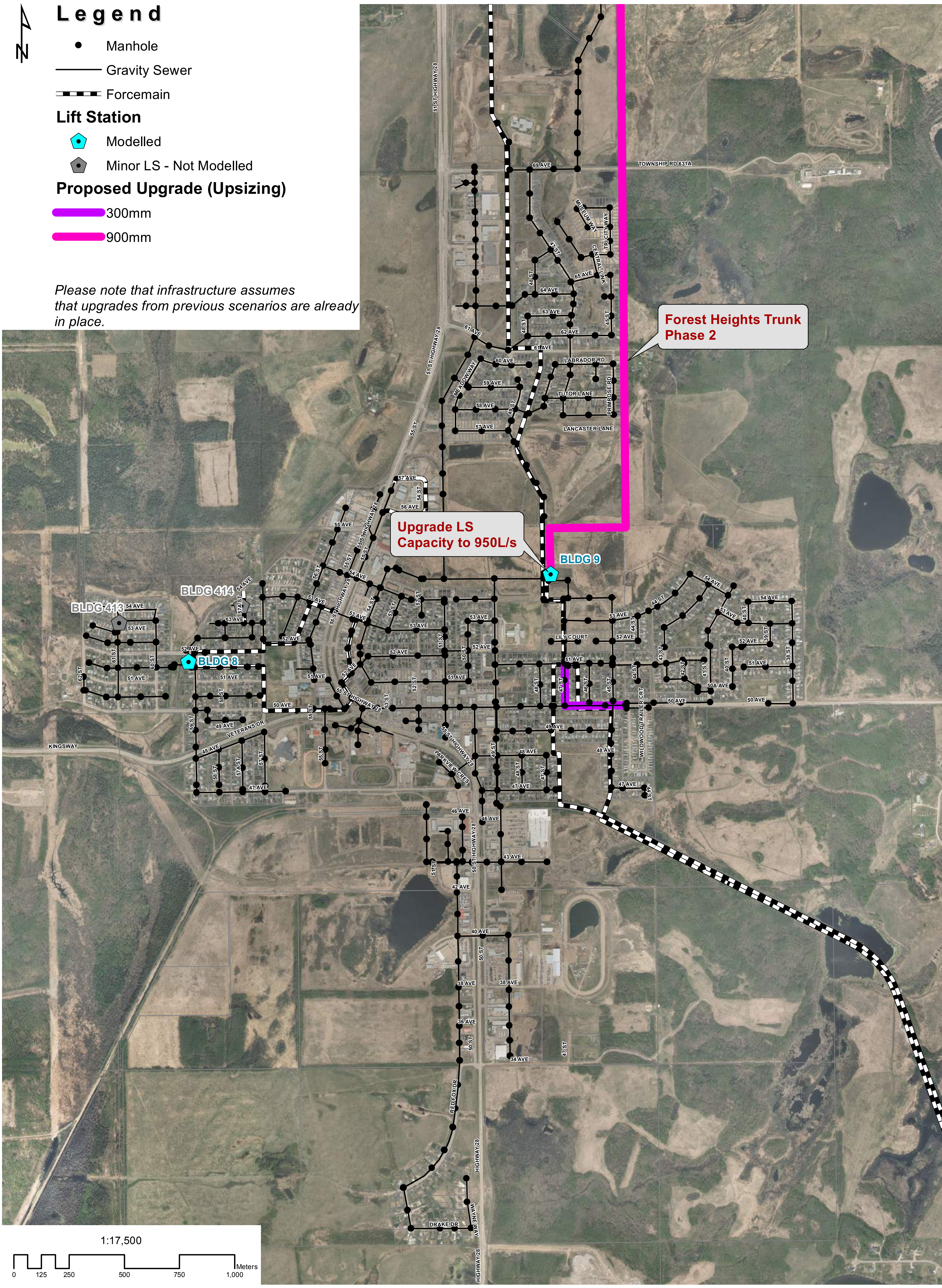
Date: 1/29/2018 Document: M:\26300\26367_Cold_Lake_I-I_Program\02_CADD\20_Drafting\201_GIS Figures\9.0 Future System Assessment\Figure 9.38 - Stage 2 Upgrades_North.mxd

FIGURE 9.39



Date: 10/19/2017 Document: M:\26300\26367_Cold_Lake_I-I_Program\02_CADD\20_Drafting\201_GIS Figures\9.0 Future System Assessment\Figure 9.39 - Stage 2 Upgrades_South.mxd

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PROPOSED NETWORK - SOUTH
STAGE 2 - BUILD-OUT TO CURRENT CITY BOUNDARY
RECOMMENDED UPGRADES

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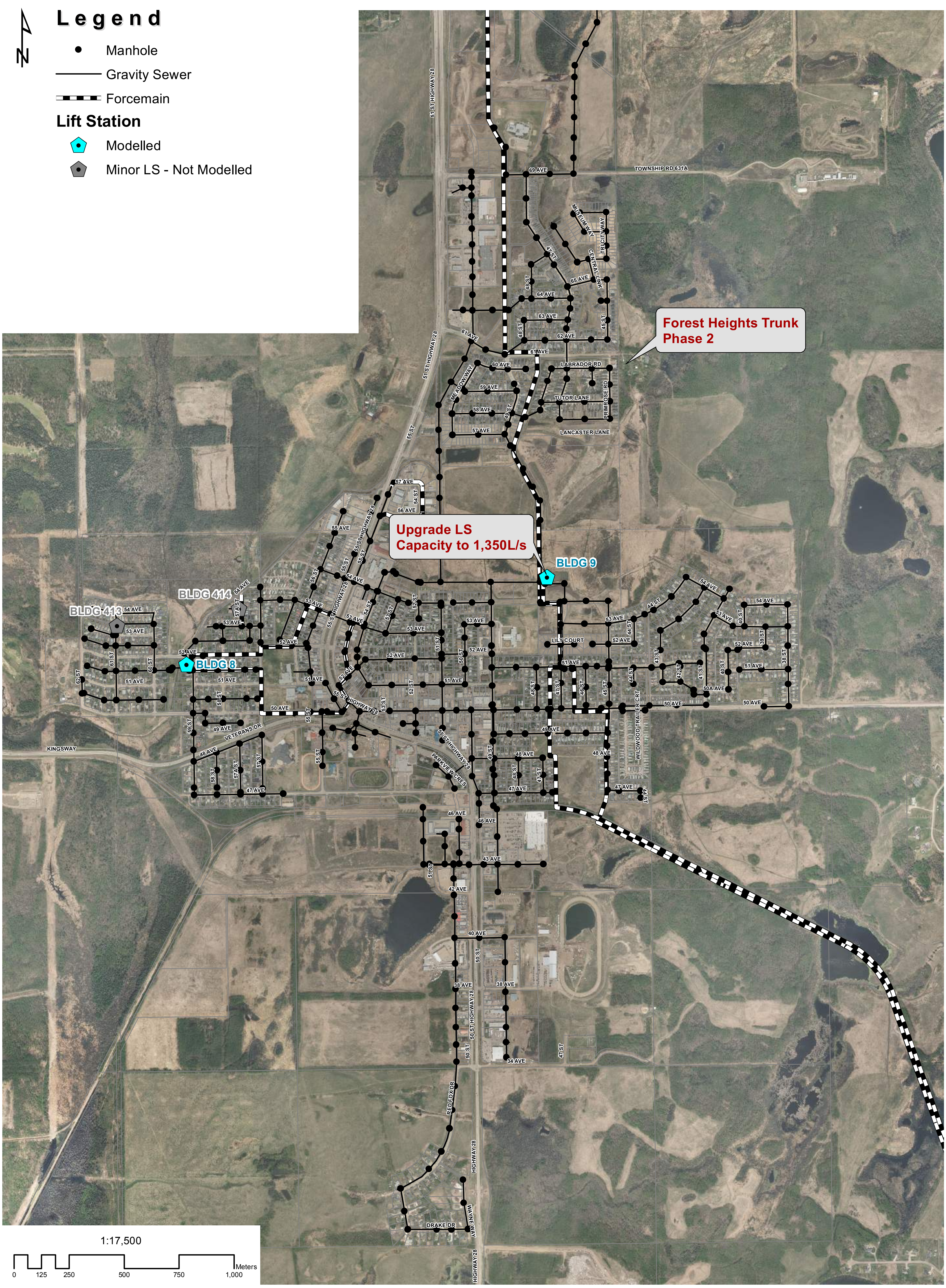
FIGURE 9.40



THE CITY OF COLD LAKE
INFLOW - INFILTRATION PROGRAM

SANITARY COLLECTION SYSTEM
PROPOSED NETWORK - SOUTH
STAGE 3 - BUILD-OUT OF ANNEXATION AREAS
RECOMMENDED UPGRADES

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Date: 10/19/2017 Document: M:\26300\26367_Cold_Lake_I-I_Program\02_CADD\20_Drafting\201_GIS Figures\9.0 Future System Assessment\Figure 9.40 - Stage 3 Upgrades_South.mxd

10.0 Conclusions and Recommendations

The Inflow-Infiltration Program was prepared to achieve the following objectives:

- To develop a hydrodynamic MIKE URBAN model of the City's existing sanitary collection system and calibrate it to realistically replicate and estimate future flows under dry and wet weather flow conditions.
- To use the calibrated model to conduct a capacity assessment of the existing sanitary servicing system and determine its ability to perform under existing and growth conditions.
- To determine what, if any, upgrades for existing City infrastructure are required
- To review existing inflow-infiltration rates observed under wet weather conditions and compare against the projected I-I rates under various design storms based on the calibrated model using the 2015 and 2016 flow monitoring and rainfall data.
- To review possible sources of inflow-infiltration and recommend remedial measures.
- To develop a future sanitary servicing system within the current and future City boundaries under 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)
- To determine what upgrades to the City's existing infrastructure are required to meet servicing objectives under the aforementioned growth horizons.
- To provide a framework for future sanitary capital planning.
- To provide costs related to infrastructure requirements.
- To comment on possible staging of infrastructure and/or growth areas, where applicable.

The completed Cold Lake Inflow-Infiltration Program will provide a guiding document for future development of the study area that can be used for infrastructure implementation planning purposes and to inform development of the subject area.

10.1.1 Conclusions

Conclusions for the I-I Program are as follows:

1. The performance of the existing system was assessed under the following four scenarios:
    - Constant I-I allowance of 0.29 L/s/ha
    - Constant I-I allowance of 0.60 L/s/ha – used only for illustration and comparison purposes under the existing conditions
    - 1 in 25 year, 24 hour, 3rd quartile Huff Storm
    - 1 in 50 year, 24 hour, 3rd quartile Huff Storm
2. The City's existing sanitary collection system performs generally adequately under the 1 in 25 year, 24 hour, 3rd quartile Huff storm as well as the 1 in 50 year, 24 hour, 3rd quartile Huff storm.
3. Under the City's design standard of 0.29 L/s/ha, simulation results suggest that Building 3 Lift Station is under capacity causing significant backups upstream. It is recommended that the City performs a detailed review of the performance of both the lift station and forcemain to determine if this hydraulic system can be optimized to reduce the stipulated upgrades.
4. Under a constant I-I rate of 0.60 L/s/ha, the sanitary conveyance system was found to perform quite adequately as no critical surcharge conditions were observed. In terms of the pumping capacity at the

major lift stations, constraints were found to exist at the Building 3 and Building 9 Lift Stations. This was transpired in the form of significant backups in the upstream sewer reaches. It is noted that this scenario was deemed to be excessively conservative and thus inappropriate to assess the performance of the lift stations, hence was simulated for illustration purposes only. It is not recommended that this scenario be used to determine any necessary upgrades at the lift stations.

5. The major constraint in the City's sanitary collection system was found to be at the Building 3 Lift Station under a conservative constant I-I rate of 0.29 L/s/ha scenario. As mentioned above, further analysis would be required to determine if the performance of the hydraulic system (pumps and forcemains) can be optimized to reduce the stipulated upgrades. It should also be noted that the proposed extension of the associated forcemain will result in a higher TDH required to convey the estimated future peak wet weather flows due to an increase in frictional and minor losses.
6. Inflow-Infiltration rates in the City's system can be summarized as follows:
   - Site 6 – Extreme observed and projected I-I rates that are very unusual
   - Site 1 – Elevated observed I-I rates typical for an older system
   - Sites 3, 8 (2015) and 8 (2016) – Elevated projected I-I rates exceeding the City's design standard of 0.29 L/s/ha
   - Remaining Sites – Below the City's design standard of 0.29 L/s/ha
7. The smoke testing program found 154 incidents as indicated in Figures 7.6 and 7.7, including manhole covers that are not sealed, as well as service connections and cleanout caps that showed smoke release. The results indicated that there were 12 incidents that were identified as a high level of smoke intensity and one incident with very high inflows, as shown in Table 7.6.
8. Servicing concepts were determined for Stages 2, 3 and 3+. It is noted that all of the development areas anticipated for growth in Stage 1 are expected to tie directly into the existing system, thus no servicing concept was required.
9. Performance of the existing system under future population and area growth scenarios for Stages 1, 2, and 3 were assessed under the following design storms:
   - Constant I-I allowance of 0.29 L/s/ha
   - 1 in 25 year, 24 hour, 3rd quartile Huff Storm
   - 1 in 50 year, 24 hour, 3rd quartile Huff Storm

   It is noted that Stage 3+ was not modelled, as there are no catchments that tie back into the existing system.
10. Nine upgrades to the existing system under future conditions were identified through the assessment process; one under Stage 1, seven under Stage 2 and one under Stage 3. The majority of these upgrades involve increasing the capacities at lift stations, including Building 3, Building 4, and Building 9 Lift Stations.

10.1.2 Recommendations

Recommendations for the I-I Program are as follows:

1. The following upgrades under existing conditions are recommended. These upgrades are shown in Figure 6.19 in Section 6.0 above.
   - Install pressure gauges at all headers at both the Building 1 and Building 3 Lift Stations. It is noted that since the completion of the Draft Final version of this report, pressure gauges have been installed at both lift stations.
   - Upgrade the capacity of Building 3 Lift Station by 15 L/s, for a total capacity of 76 L/s. Alternatively, as additional upgrades to this lift station are required in multiple growth horizons, it may be beneficial for the City to complete all the upgrades at once. That said, the total required capacity at the Building 3 Lift Station under the ultimate conditions is 86 L/s, which correlates to a 25 L/s increase.
     i. It is recommended that the City performs a detailed review of the performance of both the lift station and forcemain to determine if this hydraulic system can be optimized to reduce the stipulated upgrades.
     ii. It should also be noted that the proposed extension of the associated forcemain will result in a higher TDH required to convey the estimated future peak wet weather flows due to an increase in frictional and minor losses
   - The total cost of completing the upgrades noted above (assuming that the capacity of Building 3 Lift Station increases to the interim 76 L/s) is approximately $232,000.
   - Monitor the performance of the City's five major lift stations, and consider a forcemain hydraulics assessment to determine if any forcemains are candidates for pigging.
2. To reduce inflow-infiltration in the City, the following are recommended:
   - Smoke test the remaining sewers not included in the 2016/2017 smoke testing program (roughly 33 km (39%) remaining).
   - Consider micro flow monitoring to pin-point the sources of inflow in areas with identified high I-I rates.
   - Ensure all manholes experiencing high levels of smoke intensity are sealed (i.e. seal lid, plug holes), as shown in Figures 7.8 and 7.9, while ensuring that appropriate exhaust and ventilation systems are implemented
   - Conduct CCTV testing on sewers exhibiting large amounts of inflow-infiltration which could be carried out as part of an over-arching Asset Management Condition Assessment Framework.
   - Consider a sewer relining program for older sewers where replacement is not required
   - Develop an education program to encourage residents to:
     i. Disconnect sump pumps from the sanitary system
     ii. Direct roof leaders onto the ground surface
     iii. Ensure positive drainage away from their homes to reduce flows to weeping tiles
3. It is advised to resolve the incidents highlighted during the smoke testing program in order to reduce the sources of inflow-infiltration.
   - After this point in time, it is recommended that the City undertakes additional flow monitoring in the following years to determine if issues upstream of Sites 1 and 6 have been resolved, or to pinpoint the sources of inflow-infiltration.
4. The servicing concepts outlined in Section 8.2, and depicted in Figures 8.7 to 8.12 are recommended to accommodate the growth in Stages 2, 3, and 3+.
   - The total cost of implementing the aforementioned infrastructure are as follows:
     i. Stage 2 – Total Cost of $37.8M
     ii. Stage 3 – Total Cost of $113.1M
     iii. Stage 3+ - Total Cost of $127.6M

5. The following upgrades to the existing system in order to accommodate future growth under Stages 1, 2, and 3 are recommended. These upgrades are illustrated in Figures 9.37, 9.38, 9.39 and 9.40 in Section 9.0.
   - Stage 1 – Total Cost of $75,000
     i. Upgrade the capacity of the Building 3 Lift Station to a capacity of 81 L/s. It is noted that depending on how the City chooses to stage this upgrade, this might have been completed as part of the existing system upgrades noted above.
   - Stage 2 – Total Cost of $23.8M
     i. Upgrade the capacity of the Building 3 Lift Station to an ultimate capacity of 86 L/s. It is noted that depending on how the City chooses to stage this upgrade, this might have been completed as part of the existing system upgrades noted above.
     ii. Upgrade the capacity of the Building 4 Lift Station by 100 L/s, for a total capacity of 382 L/s.
     iii. Divert flows from 22^{nd} Street to 23^{rd} Street. The majority of the work for this upgrade was confirmed to be completed after the Draft Final version of this report, thus only the plug requires implementation.
     iv. Reconnect Building 3 Forcemain directly to the Building 4 Lift Station.
     v. Complete the Forest Heights Phase 2 900 mm to 1050 mm Trunk.
     vi. Upgrade the capacity of the Building 9 Lift Station to a capacity of 950 L/s. This may be done in stages (upgrade by 650 L/s initially (Stage 2) and an additional 400 L/s (Stage 3) afterwards) or all at once, for an ultimate capacity of 1,350 L/s.
     vii. Upsize the section of sewer running from 47^{th} Street between 51^{st} Avenue and 50^{th} Avenue, then 50^{th} Avenue between 47^{th} Street and 44^{th} Street from 200 mm to 300 mm.
   - Stage 3 – Total Cost of $5.8M
     i. Upgrade the capacity of the Building 9 Lift Station by 400 L/s, for an ultimate capacity of 1,350 L/s. It is noted that depending on how the City chooses to stage this upgrade, this might have been completed as part of the Stage 2 upgrades noted above.
6. This document should 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.

11.0 References

AECOM. December, 2009. City of Cold Lake Wastewater System Modelling and Assessment.

AECOM. February, 2015. City of Cold Lake Sanitary Master Plan Update.

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

Armin A. Preiksaitis & Associates Ltd in association with Associated Engineering Ltd. February, 2009. Intermunicipal Development Plan.

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. July, 2011. Lakeshore Area Redevelopment Plan.

City of Cold Lake. November, 2011. Northshore Area Structure Plan.

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

Durrance Projects Ltd. and Ross W. Sharp & Associates Ltd. October, 2014. Red Fox Commercial Outline Plan.

MMM Group. November, 2012. City of Cold Lake Forest Heights Sanitary Sewer Trunk Preliminary Design Report (FINAL).

planningAlliance Area Consulting Inc. October, 2014. Deer Meadows Area Structure Plan.

Scheffer Andrew Ltd. December, 2002. Golden Eagle Estates Area Structure Plan.

Scheffer Andrew Ltd. March, 2003. Fischer Estates Area Structure Plan.

Scheffer Andrew Ltd. July, 2009. The Uplands Area Structure Plan.

Scheffer Andrew Ltd. September, 2012. Green Wood Outline Plan.

SE Design and Consulting Inc. July, 2005. Iron Horse Subdivision Area Structure Plan.

SE Design and Consulting Inc. June, 2007. Forest Heights Area Structure Plan.

Town of Grand Centre. 1989. Southeast Area Structure Plan.

UMA & AECOM. April, 2007. Central Cold Lake Area Structure Plan.

Wastewater Planning Users Group. 2002. Code of Practice for the Hydraulic Modelling of Sewer Systems.