

TOWN OF OKOTOKS

TOWN OF OKOTOKS WATER MASTER PLAN

FEBRUARY 28, 2020

CONFIDENTIAL





TOWN OF OKOTOKS WATER MASTER PLAN

TOWN OF OKOTOKS

FINAL REPORT
CONFIDENTIAL

PROJECT NO.: 19M-01217-00
DATE: FEBRUARY 2020

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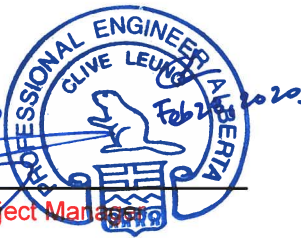
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EXECUTIVE SUMMARY

INTRODUCTION

The Town of Okotoks (Town) currently provides water to a population of over 29,000 and is approaching its previously denoted ‘build-out’ population of approximately 30,000 persons, including the supply, pumping, storage, and distribution of an average of 6.03 ML of metered water usage daily (approximately 8.55 ML per day when including non-revenue water). Where the Town has previously been built towards this 30,000-person population cap, the Town and its residents now envision a growing Okotoks, and therefore a new requisite to evaluate the future of its water network.

The Town presently requires an update to its Water Master Plan (WMP) which will provide a comprehensive plan for its utility to guide the Town in assessing its current water network, envision future water network requirements, and help to prioritize any current and future infrastructure upgrades to improve current levels of services and to support future growth and development in the Town. The capacity of the Town’s water system to provide service to accommodate future growth varies, depending on several factors such as the level of service required, location of the future growth, etc. This study aims to assist the Town in understanding the capacity of its current system and identify servicing opportunities and constraints such that future upgrades may be planned in an economic and efficient manner.

COMMUNITY GROWTH

The Town has seen significant population growth in recent years with the population of the Town approximately doubling between 2003 and 2018. The Town’s recent Municipal Development Plan (MDP) and Comprehensive Growth Strategy Report (CGSR) was used to develop population projections for each of the 5-, 10-, 25- and 50-year growth horizons of this water master plan. Through WSP’s work, Town staff have also provided input and suggestions for development phasing and for growth of up to a total population of 62,702 persons by the 50-year horizon, or 2069. This WMP has analyzed and assessed the infrastructure upgrades required to meet and maintain levels of service for these future populations, while also providing an indication of the needs and prioritization of these projects over the short-, medium-, and long-term assessment scenarios, accordingly.

WATER SUPPLY

The Town’s water system is provided raw groundwater that is pumped from thirteen (13) groundwater wells that are located in the East and West well fields of the Town. The water is treated at the Sheep River Water Treatment Plant (SRWTP), which has a current design capacity of 21.5 ML/day at peak production and an average daily production of 7.5 ML/day. The actual capacity of the SRWTP is to be confirmed through a separate capacity analysis. A detailed review of this existing water treatment plant is not included in the current scope of work of this project, aside from a review of the treated water capacity.

The Town’s existing maximum day demand (MDD) is approximately 148.4 L/s (12.8 ML per day) but could increase to 348 L/s (30.1 ML per day) under the future (2069) growth projections. The Town has expressed concerns regarding the supply capacity of the existing well fields in meeting future demands. Based on the Conceptual Water Servicing Review (CIMA, 2019), the Town plans to construct an alternative/redundant water source in 2024 to connect to the existing WTP. The hydraulic assessment completed within this report is based on the alternative/redundant water source connecting into the existing water treatment plant and/or clearwell, with no further consideration on the expansion of the water supply through additional groundwater wells. No hydraulic assessment of future potential direct connections between the new supply into the distribution network has been conducted as part of this

study. As well, the Capital Projects List does not include the alternative/redundant water source nor any interim raw water capacity improvement projects.

PUMP STATIONS

Based on WSP's understanding of the Town's current water distribution strategy, the Town's six (6) water pump stations are generally able to meet existing domestic servicing requirements, however there are some existing deficiencies due to undersized high flow pumps throughout the Town. Further, it is forecasted that a number of pump stations will have both domestic and emergency pumping capacity deficiencies by the 50-year (2069) horizon. Phased improvements to the SRWTP South Supply Pumps, as well as to the 3N, and Big Rock Pump Stations have been identified in this study.

PRESSURE REDUCING VALVES

It is estimated there are currently fifteen (15) pressure reducing valves in service within the Town. Confirmation on the size, location, operation, and pressure settings of these valves was not possible or provided by Town staff at the time of this study, with the best information available used as well as engineering judgment to fill in the data gaps. It is recommended that all of the Town's PRV stations should be field checked to improve the accuracy of the model, and to investigate the appropriate valve sizing (i.e. high velocity concerns). Naming conventions for the PRV stations are also needing consensus without one agreed established naming convention in place. The D9 PRV station, currently servicing the 1N Zone, has been flagged for immediate investigation based on its age and assumed condition, and critical supply, to determine if the station requires renewal in the short term.

WATER STORAGE

Water storage reservoirs store water for balancing peak water demands, for fire protection, and for emergency conditions in the water system. Analysis of the Town's reservoirs suggest that the reservoirs have enough capacity for current level of service requirements. However, two key reservoir projects were identified. Firstly, the rehabilitation of the existing 3N Reservoir to address existing operational issues. Secondly, the May 2019 West Okotoks Area Structure Plan (WOASP) included the provision of a new reservoir for South Okotoks to provide additional storage for the area. Although the storage capacity assessment has not indicated an immediate need for this additional storage, in discussion with Town staff, WSP has included this project in the Capital Projects List for future planning.

The construction of a new 3.66 ML reservoir and transmission main tying into the 1S Zone has been recommended for South Okotoks in order to provide storage volume for South Okotoks. The proposed reservoir location is west of Westland View at an approximate ground elevation of 1,093.5 m (limited by the local topography). The proposed timeframe for construction is by 2024.

DISTRIBUTION NETWORK

WSP has built, calibrated, and verified a hydraulic model of the Town's existing water distribution network to determine the existing level of service the Town is currently providing its residents. For future development parcels, for which there is currently no proposed watermain network layout, a standard grid main network was assumed, as directed by the Town, based on Section 3 of the City of Calgary's Design Guidelines for Subdivision Servicing (2014). WSP notes that while this current WMP attempts to maintain watermain size continuity between the existing system and future development, servicing levels (i.e. pressures and fire flows) and final watermain sizes may be dependent on the future watermain layout.

System pressures under average day and peak hour demand conditions as well as available fire flows coincident to maximum day demand were carefully reviewed under all existing and future scenarios, and the selection of water system improvements was optimized to first address existing deficiencies, while also being sized for future growth. In addition to capital projects, sizing, timing, and prioritization of

watermain renewals were taken into account based on the current age, material, and break history of watermain in the Town's water utility, allowing the team to incorporate a risk and criticality framework for renewal projects into the Capital Plan.

CAPITAL PROJECTS

The estimated total cost for all capital projects prioritized and recommended for the 10-year design horizon is \$8.3 M (including \$5.7 M associated with development or growth-related projects). The projects selected in this Water Master Plan will mitigate the majority of the supply, pumping, and distribution (pressure and fire flow) concerns for the proposed 10-year growth projection. System improvement projects for the 25-year and 50-year growth projections should be considered conceptual at this stage. It is recommended that the Town review individual development applications on a case-by-case basis to determine the impacts on the water utility using the latest hydraulic model.

Further, it is recommended that this Water Master Plan be updated by the Town every 5 years, as an industry best practice, to account for the variability and unknowns typically established under future planning assignments of similar nature.

AUXILIARY STUDIES

In addition to the Town's Water Master Plan, several auxiliary studies have been completed as a result of this assignment.

- **Water System GHG Emissions** – The Town's 2018 Environmental Master Plan outlined its plans and goals in order to minimize the generation of greenhouse gas emissions, while projecting that emissions could increase at a rate of 0.72% per year if no measures were taken. It was recommended that the Town actively look at the feasibility of upgrades to the existing infrastructure to improve efficiencies across the Town's water and wastewater sectors. This could range from addressing leakage via water system audits, increased water metering, leak detection and repair, and district metering areas, to the retrofitting or replacement of pumps.

Major recommendations include a complete water system audit in order to fully account for the non-revenue water within the system, feasibility studies on potential renewable energy sources for water facilities, and feasibility studies on building envelope retrofitting, to a higher energy efficient standard.

The state of GHG emissions in the Town is based on information available and recommendations for further studies are summarized in Section 7.1 of this report.

- **Chlorination System Review** – The Town's existing chlorination system is located at the Sheep River Water Treatment Plant. The water is dosed with chlorine following UV disinfection as the final stage of the treatment process. The free chlorine residual is then tested continuously at two points in the system, at Zone 3N and Zone 4N to test the primary disinfection rates. Looking ahead to future growth and considering the effects of climate change, the gradual decline and/or larger annual fluctuations in the free chlorine residual levels could likely be anticipated. In preparation of this, the consideration and planning for the installation of re-chlorination stations and/or chlorine analyzer stations/kiosks to consistently monitor residual levels throughout the water distribution network will be beneficial and also highly recommended. It is recommended that the Town could also eventually undertake a hydraulic modelling analysis of free chlorine in the distribution system in relation to population growth and climate change. The state of the chlorination system in the Town is based on information available and recommendations for further studies are summarized in Section 7.2 of this report.
- **Condition Assessment and Risk Evaluation** – The Town's reservoirs, pump stations, PRV stations, and watermain were assessed for their current age and assumed condition based on a desktop study

of available record data. WSP applied a standardized approach to evaluating the urgency with which major renewals of aged assets would have to be implemented. In the absence of detailed condition data, WSP followed an age-based approach to quantify the likely condition and likelihood of failure or need for intervention for each asset. The age based RSL can be further refined through subsequent studies using performance characteristics and historic asset life/survival data, as this information becomes available. The Condition and Risk Evaluation is summarized in Section 7.3 of this report.

These studies, with the exception of a few key findings from the condition assessment and risk evaluation, did not contribute to the Capital Projects List in this report, but its recommendations and findings if implemented further by the Town will ensure the continued long-term sustainable operation of the water utility.

1 INTRODUCTION

The Town of Okotoks (Town) retained WSP Canada Group Ltd. (WSP) to develop its Water Master Plan (WMP). The objective of the WMP is to provide a comprehensive plan that will guide the Town in prioritizing and phasing its required water infrastructure upgrades in a strategic and cost-effective manner to support future growth and development. The development and calibration of a hydraulic water model was carried out as a critical working tool to establish the improvement projects and servicing strategies identified in this report.

A technical assessment of the hydraulic infrastructure was undertaken by WSP to determine the capacity of the existing distribution network and recommend improvements. A 50-year improvement plan has been prepared to provide water service infrastructure projects to support the anticipated growth from the Town's planning department, and, in particular, to provide improved fire protection in the Town.

The hydraulic model developed provides a tool for the analysis of the Town's water system in order to:

- Assess the existing hydraulic performance and current operational settings for the Town's water network. Thus, determining the necessary short- -term capital improvements required in the system;
- Assess the existing system's capacity to service the Town's future projected water demands as envisioned by the Town's planning department through population growth and expansion of the Town's water service area to the outer boundaries of the municipality. Thus, determining the necessary medium- and long-term improvements and upgrade works necessary to serve the projected growth.

1.1 SCOPE OF WORK

The following summarizes the scope of work undertaken by WSP for the Water Master Plan:

- Gather and review all existing information relating to the water supply, such as studies, reports, drawings, operational data, etc. from the Town and EPCOR;
- Meet with Town staff to obtain and compile all relevant operational data;
- Construct the hydraulic model and verify critical modelling parameters which include pump curves, PRV pressure settings, confirmation of active elements and key boundary conditions under different demand scenarios;
- Obtain historical data on average day, peak day, and peak hour demands;
- Develop demand scenarios under short-, medium-, and long-term population projections for the 5-, 10-, 25-, and 50-year horizons and allocate demands spatially as required within the water model;
- Conduct a multi-pressure and c-factor hydrant flow test program for calibration purposes;
- Calibrate the hydraulic model based on field results;
- Establish design criteria for the review of the system's minimum and maximum service pressures, available fire flows, and capacities of the Town's pump stations and storage reservoirs;
- Identify system capacity issues under existing and future build-out scenarios to the design criteria established and propose recommendations for system improvements to address deficiencies under the 2019, 2024, 2029, 2034, and 2069 design horizons;
- Review the efficiency of the existing and proposed system related to energy use and greenhouse gas emissions;

- Summarize the current chlorine usage and confirm that the water within the Town’s system meets the current federal and provincial regulatory standards; and,
- Prepare cost estimates and prioritized schedule for the proposed system improvements.

1.2 RELEVANT TECHNICAL MEMORANDA

The following Technical Memoranda have been prepared over the course of this project. They include key information that have been updated, summarized, and included into this final report. They form part of the overall study and are included for reference.

- Technical Memorandum No. 1: Town of Okotoks Water Master Plan – Design Criteria (February 2020)
 - Technical Memorandum No. 2: Town of Okotoks Water Master Plan – Water Usage and Short-Term Water Availability Review (November 2019)
 - Technical Memorandum No. 3: Town of Okotoks Water Master Plan – Review of Water Conservation Measures (February 2020)
-

1.3 ABBREVIATIONS

ADD	Average Day Demand	FUS	Fire Underwriters Survey
MDD	Maximum Day Demand	GIS	Geographic Information System
PHD	Peak Hour Demand	HGL	Hydraulic Grade Line
ICI	Industrial/Commercial/Institutional	kPa	Kilopascal
ML	Million Litres	psi	Pounds per square inch
MLD	Million Litres per Day	PRV	Pressure Reducing Valve
Lcd	Litres per capita per day	PSV	Pressure Sustaining Valve
L/s	Litres per second	SRWTP	Sheep River Water Treatment Plant
WMP	Water Master Plan	CIRC	Canadian Infrastructure Report Card
MDP	Municipal Development Plan	CNAM	Canadian Network of Asset Managers
CGSR	Comprehensive Growth Strategy Report	ESL	Estimated Service Life
GHG	Greenhouse Gas Emissions	RSL	Remaining Service Life
CO ₂ e	Carbon-dioxide equivalent	% RSL	Percent Remaining Service Life
ENR	Engineering News Record	LoF	Likelihood of Failure
O&M	Operations and Maintenance	CoF	Consequence of Failure

2 POPULATION

2.1 EXISTING POPULATION

The majority of land within the Town consists of single-family residential parcels. Based on 2018 census data, the Town's residential population is approximately 29,000 people, and is approaching its previously denoted 'build-out' population of approximately 30,000. Parcel and land use information was provided by the Town in order for WSP to determine the existing occupancy and population, and spatial distribution throughout the Town.

2.2 FUTURE POPULATION

The Town has seen significant population growth in the recent years, with the population of the Town approximately doubling between 2003 and 2018. The following documents were used to estimate the future growth within the Town at the 5-, 10-, 25-, and 50-year growth horizons, and sequencing of the developments was further refined through discussion with Town staff:

- Okotoks Municipal Development Plan Draft (2019); and,
- Okotoks Comprehensive Growth Strategy Report (2019).

A key contributor of growth and water demands for the Town of Okotoks is identified to be single-family residential developments in the north and southwest areas, as well as industrial developments in the northeast and south east of the Town. The Town's vision sees vibrant neighbourhoods of mostly single-family housing centred around commercial hubs, which include both commercial usage and higher density housing. Defensive areas are tracts of land that have been identified as having high ecological value and are to be retained or enhanced for recreational use and environmental outcomes. With the exception of industrial lands in the southeast area of Zone 1S, growth projected under this WMP has not included densification of existing occupied parcels. It was agreed upon with Town staff that population growth for the purpose of this study consists of outward growth and development of new lands.

POPULATION DENSITY

The assumptions for all future residential and future commercial/mixed use areas, when applied to the all quarter sections to be developed within the next 50 years, were calculated to meet the Town's target density of 55 people per hectare. This is in line with the target density Okotoks Municipal Development Plan.

RESIDENTIAL

As agreed with the Town, except for the Wedderburn development, future residential parcels are assumed to be single-family housing. This consists of 24 houses per hectare with on average 2.2 people living in each single-family household.

The Wedderburn development in the N-1 quarter section has been subdivided and lots are available for purchase at the time of this study. Subdivision plans from this time give more detail around future land use for this particular area, digital files for layout and parcels have been made available and have been incorporated into the WMP, with completion and full occupancy of this development occurring in the next 5 years.

COMMERCIAL/MIXED USE

Future mixed commercial areas are assumed to be complexes of ground floor commercial usage and with three (3) storeys of multi-family units. The multi-family housing unit density is assumed to be 33 units per hectare, with the building footprint totalling 40% of the future mixed commercial area. On average, 2.2 people are assumed to live in each multi-family household.

PHASING OF DEVELOPMENT

The Town confirmed that an estimated 668 extra persons per year was to be the assumed population growth until 2041. From 2041 onwards, an estimated growth of 680 persons per year is the preferred growth scenario to be used in future planning. Over the course of the next 50 years, the population is projected to rise by 33,700 people, from 29,002 people to a total 2069 population of 62,702 persons. Table 2-1 summarizes the annual growth per year forecasted by the Town of Okotoks.

Table 2-1: Forecasted Annual Population Growth

PERIOD	POPULATION GROWTH PER YEAR
2018 – 2040	668
2041 – 2076	680

The timeline and phasing of development for the annexed quarter sections was also discussed and agreed upon with the Town. To accommodate the projected population growth per year, Town intends to permit development to occur in the N-1, N-2, N-3, S-2, S-3 and S-4 quarter sections concurrently. Development of quarter sections S-1, S-6, and N-4 will then be permitted preferentially and as needed afterwards, up to the projected population. It was also confirmed that existing industrial lands to the east of the Town that are not currently developed will be fully developed over the next 10 years. Development of quarter sections N-19 and N-15 will be permitted in the 10- to 25-year horizon, with N-20 and N-18 to follow in the 25- to 50-year horizon. Phasing of the future development areas illustrated in Figure 2-1 through Figure 2-4.



20% DEVELOPED IN
THE 5 YEAR HORIZON

N-8 N-10 N-12 N-20
N-5 N-6 N-9 N-11 N-18 N-19

N-2

N-3

N-4

N-7

N-17

N-15

N-16

N-1

N-14

N-13

S-6

50% DEVELOPED IN
THE 5 YEAR HORIZON

S-1

S-2

S-14

S-13

S-12

S-11

S-4

S-3

S-8

S-7

S-9

20% DEVELOPED IN
THE 5 YEAR HORIZON

20% DEVELOPED IN
THE 5 YEAR HORIZON

Legend

Horizon

5 year

Land Use

- Industrial
- Commercial
- Commercial / Mixed Use
- Residential
- Green space
- Defensive Area
- Existing Residential
- Existing Commercial / Mixed Use
- Existing Parcels

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Okotoks

**Figure 2-1
Future Land Use
5 Year Horizon**

Project No.:
19M-01217-00
Date:
January 2020
Scale: **1:45,000 @ Letter**
0 250 500 1,000 Meters



40% DEVELOPED IN
THE 10 YEAR HORIZON

N-8 N-10 N-12 N-20
N-5 N-6 N-9 N-11 N-18 N-19

N-2

N-3

N-4

N-7

N-17

N-15

N-16

N-1

N-14

N-13

100% DEVELOPED IN
THE 10 YEAR HORIZON

S-6

S-1

S-2

S-14

S-13

S-12

S-11

S-4

S-3

S-8

S-7

S-9

40% DEVELOPED IN
THE 10 YEAR HORIZON

40% DEVELOPED IN
THE 10 YEAR HORIZON

Legend

Horizon

10 year

Land Use

- Industrial
- Commercial
- Commercial / Mixed Use
- Residential
- Green space
- Defensive Area
- Existing Residential
- Existing Commercial / Mixed Use
- Existing Parcels



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Figure 2-2
Future Land Use
10 Year Horizon

Project No.:

19M-01217-00

Date:

January 2020

Scale: **1:45,000 @ Letter**

0 250 500 1,000 Meters




100% DEVELOPED IN
THE 25 YEAR HORIZON

100% DEVELOPED IN
THE 25 YEAR HORIZON

Legend

Horizon

 25 year

Land Use

-  Industrial
-  Commercial
-  Commercial / Mixed Use
-  Residential
-  Green space
-  Defensive Area
-  Existing Residential
-  Existing Commercial / Mixed Use
-  Existing Parcels

100% DEVELOPED IN
THE 25 YEAR HORIZON

Figure 2-3
Future Land Use
25 Year Horizon



Legend

Horizon

50 year

Outside 50 year horizon

Land Use

Industrial

Commercial

Commercial / Mixed Use

Residential

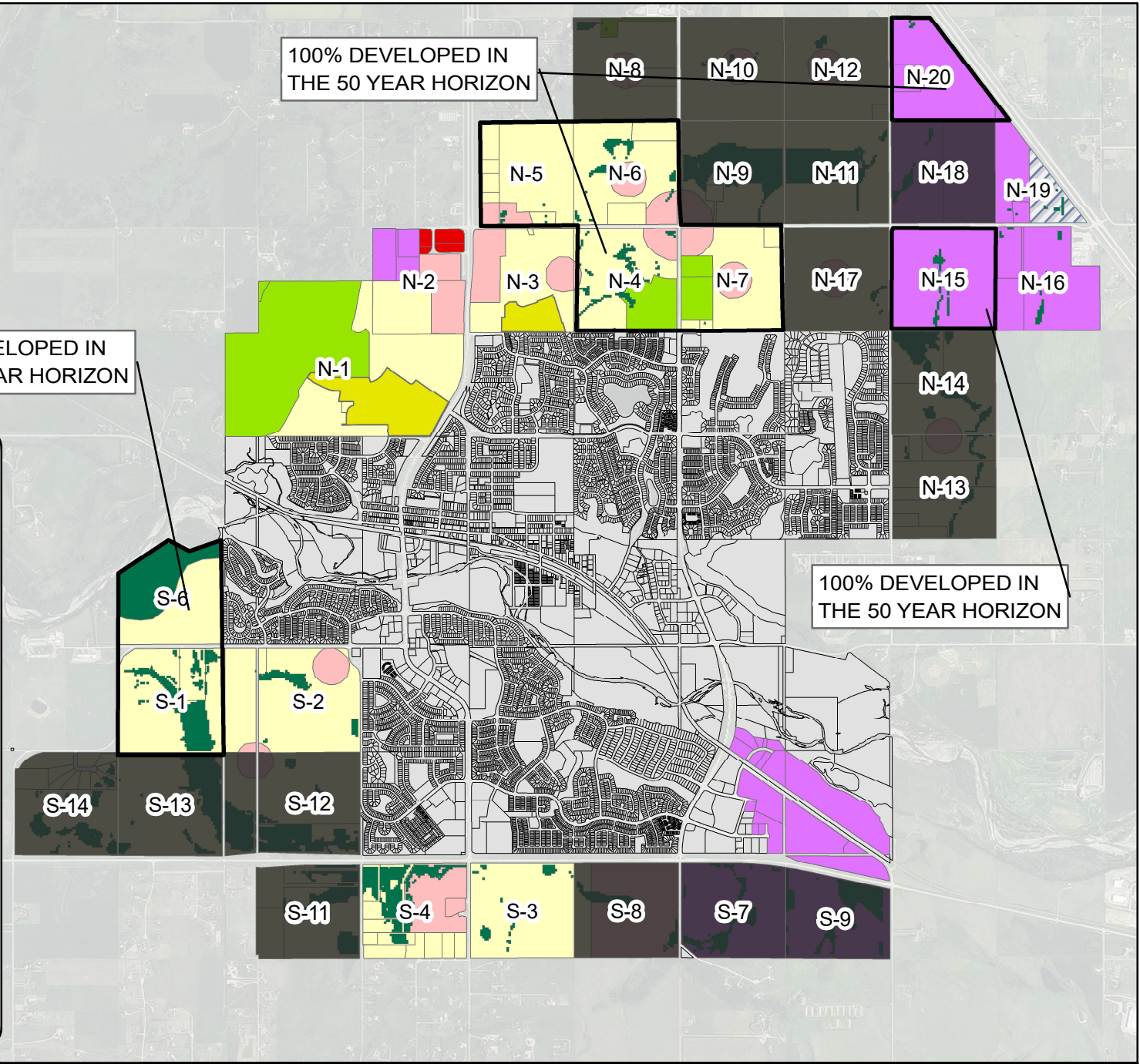
Green space

Defensive Area

Existing Residential

Existing Commercial / Mixed Use

Existing Parcels



The resulting populations calculated for each of the 5-, 10-, 25-, and 50-year growth horizons is shown in Table 2-2.

Table 2-2: Design Horizons – Total Population

YEAR	DESIGN HORIZON	INCREMENTAL DEVELOPED SECTIONS	TOTAL FORECASTED POPULATION
2019	Existing	-	29,002
2024	5 Year	N-1 (20% developed) N-2 (20% developed) N-3 (20% developed) S-2 (20% developed) S-3 (20% developed) S-4 (20% developed) Existing Industrial Parcels (50% Developed)	32,342
2029	10 Year	N-1 (40% developed) N-2 (40% developed) N-3 (40% developed) S-2 (40% developed) S-3 (40% developed) S-4 (40% developed) Existing Industrial Parcels (fully developed)	35,682
2044	25 Year	N-1 (fully developed) N-2 (fully developed) N-3 (fully developed) S-2 (fully developed) S-3 (fully developed) S-4 (fully developed) N-16 (fully developed) N-19 (fully developed)	45,702
2069	50 Year	N-4 (fully developed) N-5 (fully developed) N-6 (fully developed) N-7 (fully developed) N-15 (fully developed) N-20 (fully developed) S-1 (fully developed) S-6 (fully developed)	62,702

3 EXISTING WATER SYSTEM & MODEL DEVELOPMENT

The development of the hydraulic water model was based on creating a water model that is representative of the Town's current water system. The Town provided GIS shapefiles which were used to set the initial physical location and attributes of watermains, hydrants, pumping stations, storage reservoirs, and pressure reducing valve (PRV) stations. Excluding the reservoirs and pump stations, the location and attributes for watermains and PRVs were not reviewed against record drawings for accuracy prior to, and after, input into the model.

As agreed with the Town during the Project Start-up Meeting on August 8, 2019, the hydraulic water model was constructed using WaterGEMS. The following subsections discuss the components of the Town's water network and the assigned physical attributes and operational settings. Information was gathered from numerous sources and where conflicting data was present, these were presented to Town staff for confirmation.

EXISTING WATER SYSTEM OVERVIEW

The major components of the Town's water network as of November 2019 are summarized in Table 3-1. The physical locations of these components are illustrated in Figure 3-1.

Table 3-1: Water Network Components

COMPONENT	QUANTITY
Pressure Zones	8
Storage Reservoirs	3
Pump Stations	6
PRV Stations	15
Length of Watermains	Approx. 135 km

The development of the hydraulic model required a clear understanding of the connectivity of the components of the water network. For that reason, a water network schematic was created in which the hydraulic connectivity of the components is related in terms of their hydraulic grade line (HGL), as illustrated in Figure 3-1.

WATER SUPPLY SOURCES

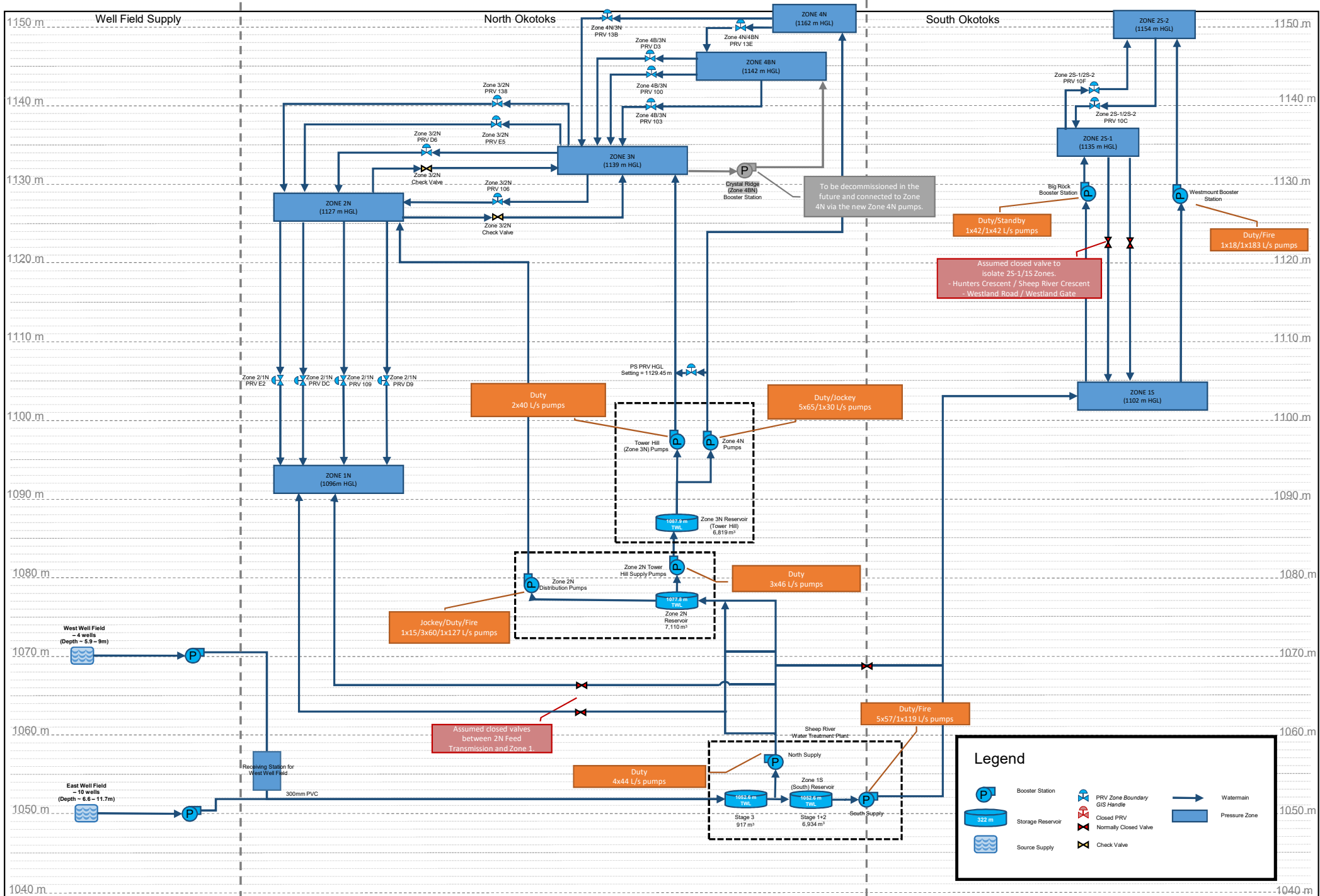
The Town's main source of potable water is via 13 groundwater wells. However, the current study does not include a technical review of the water supply wells, beyond comparing the Town's current water usage against the available water withdrawal limits, as per the Town's Water Allocation System. A detailed review of the Town's water usage is discussed in Technical Memorandum No. 2, attached in Appendix B.

Water from the supply wells is treated at the Town's Sheep River Water Treatment Plant (SRWTP) which has a current design capacity of 21.5 ML/day at peak production, and an average daily production of 7.5 ML/day. The actual capacity of the SRWTP is to be confirmed through a separate capacity analysis. A review of the existing water treatment plant is not included in the current scope of work, aside from a

review of the current treatment plant capacity. Review of, and recommendations for, the Town's water treatment facility are not included in the scope of this study.

STORAGE RESERVOIRS

There are three active storage reservoirs connected to the Town's water network. Table 3-2 summarizes the active storage reservoirs and the pressure zones which they supply.



Town of Okotoks Water Network Schematic - 2019

Project:		Scale:	
Drawn:		Approved:	
Map No:		Date:	
Revision:		Revision Date:	

Figure 3-1

Not to Scale

August 2019

Table 3-2: Storage Reservoirs

STORAGE RESERVOIR	PRESSURE ZONE(S) SUPPLIED	LOW WATER LEVEL (M)	TOP WATER LEVEL (M)	VOLUME (M ³)
Zone 1S (South) Reservoir	Zone 1S, Zone 2S-1, Zone 2S-2	1050.86	1,052.59	6,394
Zone 2N Reservoir	Zone 2N, Zone 1N	1073.55	1,077.83	7,110
Zone 3N (Tower Hill) Reservoir	Zone 3N, Zone 4N, Zone 4BN	1084.60	1,087.00	6,819

PUMP STATIONS

There are six pump stations in the Town of Okotoks. The number of pumps in each station are listed in Table 3-3 as well as the pressure zones to which they supply water to.

Table 3-3: Town of Okotoks Pump Stations

PUMP STATION	ELEVATION (M)	NO. OF PUMPS	PRESSURE ZONE SUPPLIED
Sheep River Water Treatment Plant	1,047	10	Zone 1S, Zone 2S-1 (via Big Rock Booster), Zone 2S-2 (via Westmount Booster)
2N Pump Station	1,074	8	Zone 2N, Zone 1N (via PRVs)
3N (Tower Hill) Pump Station	1,087	8	Zone 4N, Zone 4BN (via PRVs), Zone 3N
Crystal Ridge Booster Station	1,099	3	Zone 4BN
Big Rock Booster Station	1,072	3	Zone 2S-1
Westmount Booster Station	1,065	3	Zone 2S-2

Our understanding of these pump stations is based on past reports and is as follows:

- The SRWTP North Supply pumps supply water to the 2N reservoir (which services Zone 2N directly and Zone 1N via the E2, D9, and DC PRVs). The SRWTP South Supply Pumps services Zone 1S directly, as well as Zone 2S-1 and Zone 2S-2 via the Big Rock and Westmount Booster Stations, respectively;
- The 2N Pump Station supplies water to Zone 2N directly, Zone 1N via the E2, D9, and DC PRVs, as well as the Zone 3N (Tower Hill) reservoir;
- The 3N Pump Station supplies water to Zone 3N directly, Zone 2N via the 138, E5, and D6 PRVs, as well as Zone 4N through the Zone 4N pump header (the 4N pump header can also supply water to Zone 3N via PRV's);
- The Crystal Ridge Booster Station currently services Zone 4BN from Zone 3N, but is planned to be decommissioned in the near future with the Zone 4N pump header supplying Zone 4BN via PRVs;
- The Big Rock Booster Station supplies water to Zone 2S-1 from Zone 1S; and,
- The Westmount Booster Station supplies water to Zone 2S-2 from Zone 1S.

The supply pumps at the well heads have not been included in the hydraulic water model, as limited information has been provided for the groundwater wells and pumps, and for the further fact that these details do not impact the analysis of the water network downstream of the SRWTP. As such, the supply into the SRWTP was modelled as a fixed head open reservoir model component.

Data and network knowledge limitations have also been impacted by the fact that the Town had previously contracted EPCOR to operate and maintain its water system until November 2019, a

timeframe mid-way through the development of this WMP and also when the majority of the information would have been received and reviewed by, by the WSP team. WSP notes that according to Town staff, the pump stations are likely pressure controlled. As of the time of this study, pump and operation control narratives were not available. Therefore, as directed by Town staff, assumptions were made for the pump station settings. The model has assumed pump settings based on downstream demands and model calibration activities and are outlined in Table 3-4 through Table 3-7.

Table 3-4: Town of Okotoks Pump Station Settings – Operation during Average Day Demand

PUMP STATION	PUMP	STATUS
SRWTP	North Supply Duty Pump 6.401 ¹	Unknown
	North Supply Duty Pump 6.402 ¹	Unknown
	North Supply Duty Pump 6.403 ¹	Unknown
	North Supply Duty Pump 6.404 ¹	Unknown
	South Supply Duty Pump 6.301	ON
	South Supply Duty Pump 6.302	OFF
	South Supply Duty Pump 6.303	OFF
	South Supply Duty Pump 6.304	OFF
	South Supply Duty Pump 6.305	OFF
	South Supply High Flow Pump 6.310	OFF
2N Pump Station	3N (Tower Hill) Fill Pump P6 ¹	Unknown
	3N (Tower Hill) Fill Pump P7 ¹	Unknown
	3N (Tower Hill) Fill Pump P8 ¹	Unknown
	2N Distribution Pumps Duty P1	ON
	2N Distribution Pumps Duty P2	OFF
	2N Distribution Pumps Duty P3	OFF
	2N Distribution Pump Jockey P4	OFF
	2N High Flow Pump P5	OFF
3N Pump Station	4N Supply Jockey Pump P401	ON
	4N Supply Duty Pump 402	OFF
	4N Supply Duty Pump 403	OFF
	4N Supply Duty Pump 404	OFF
	4N Supply Duty Pump 405	OFF
	4N Supply Duty Pump 406	OFF
	3N Distribution Pump 301	ON
	3N Distribution Pump 302	OFF
Big Rock Booster Station	Big Rock Duty Pump P1	ON
	Big Rock Duty Pump P2	OFF
	Big Rock High Flow Pump	OFF
Westmount Booster Station	Westmount Duty Pump P1	ON
	Westmount Duty Pump P2	OFF
	Westmount High Flow Pump	OFF
Crystal Ridge Booster Station	Crystal Ridge Duty Pump P1	ON
	Crystal Ridge Duty Pump P2	OFF
	Crystal Ridge High Flow Pump	OFF

1. It is assumed that operational logic of the transfer / fill pumps is based on the level of the receiving tank. Pump control philosophies were not provided for this study. Sequencing of these pumps is unknown.

Table 3-5: Town of Okotoks Pump Station Settings – Operation during Maximum Day Demand

PUMP STATION	PUMP	STATUS
SRWTP	North Supply Duty Pump 6.401 ¹	Unknown
	North Supply Duty Pump 6.402 ¹	Unknown
	North Supply Duty Pump 6.403 ¹	Unknown
	North Supply Duty Pump 6.404 ¹	Unknown
	South Supply Duty Pump 6.301	ON
	South Supply Duty Pump 6.302	ON
	South Supply Duty Pump 6.303	OFF
	South Supply Duty Pump 6.304	OFF
	South Supply Duty Pump 6.305	OFF
	South Supply High Flow Pump 6.310	OFF
2N Pump Station	3N (Tower Hill) Fill Pump P6 ¹	Unknown
	3N (Tower Hill) Fill Pump P7 ¹	Unknown
	3N (Tower Hill) Fill Pump P8 ¹	Unknown
	2N Distribution Pumps Duty P1	ON
	2N Distribution Pumps Duty P2	OFF
	2N Distribution Pumps Duty P3	OFF
	2N Distribution Pump Jockey P4	OFF
	2N High Flow Pump P5	OFF
3N Pump Station	4N Supply Jockey Pump P401	ON
	4N Supply Duty Pump 402	OFF
	4N Supply Duty Pump 403	OFF
	4N Supply Duty Pump 404	OFF
	4N Supply Duty Pump 405	OFF
	4N Supply Duty Pump 406	OFF
	3N Distribution Pump 301	ON
	3N Distribution Pump 302	OFF
Big Rock Booster Station	Big Rock Duty Pump P1	ON
	Big Rock Duty Pump P2	OFF
	Big Rock High Flow Pump	OFF
Westmount Booster Station	Westmount Duty Pump P1	ON
	Westmount Duty Pump P2	OFF
	Westmount High Flow Pump	OFF
Crystal Ridge Booster Station	Crystal Ridge Duty Pump P1	ON
	Crystal Ridge Duty Pump P2	OFF
	Crystal Ridge High Flow Pump	OFF

1. It is assumed that operational logic of the transfer / fill pumps is based on the level of the receiving tank. Pump control philosophies were not provided for this study. Sequencing of these pumps is unknown.

Table 3-6: Town of Okotoks Pump Station Settings – Operation during Peak Hour Demand

PUMP STATION	PUMP	STATUS
SRWTP	North Supply Duty Pump 6.401 ¹	Unknown
	North Supply Duty Pump 6.402 ¹	Unknown
	North Supply Duty Pump 6.403 ¹	Unknown
	North Supply Duty Pump 6.404 ¹	Unknown
	South Supply Duty Pump 6.301	ON
	South Supply Duty Pump 6.302	ON
	South Supply Duty Pump 6.303	ON
	South Supply Duty Pump 6.304	OFF
	South Supply Duty Pump 6.305	OFF
	South Supply High Flow Pump 6.310	OFF
2N Pump Station	3N (Tower Hill) Fill Pump P6 ¹	Unknown
	3N (Tower Hill) Fill Pump P7 ¹	Unknown
	3N (Tower Hill) Fill Pump P8 ¹	Unknown
	2N Distribution Pumps Duty P1	ON
	2N Distribution Pumps Duty P2	ON
	2N Distribution Pumps Duty P3	OFF
	2N Distribution Pump Jockey P4	OFF
	2N High Flow Pump P5	OFF
3N Pump Station	4N Supply Jockey Pump P401	ON
	4N Supply Duty Pump 402	OFF
	4N Supply Duty Pump 403	OFF
	4N Supply Duty Pump 404	OFF
	4N Supply Duty Pump 405	OFF
	4N Supply Duty Pump 406	OFF
	3N Distribution Pump 301	ON
	3N Distribution Pump 302	OFF
Big Rock Booster Station	Big Rock Duty Pump P1	ON
	Big Rock Duty Pump P2	OFF
	Big Rock High Flow Pump	OFF
Westmount Booster Station	Westmount Duty Pump P1	ON
	Westmount Duty Pump P2	OFF
	Westmount High Flow Pump	OFF
Crystal Ridge Booster Station	Crystal Ridge Duty Pump P1	ON
	Crystal Ridge Duty Pump P2	OFF
	Crystal Ridge High Flow Pump	OFF

1. It is assumed that operational logic of the transfer / fill pumps is based on the level of the receiving tank. Pump control philosophies were not provided for this study. Sequencing of these pumps is unknown.

Table 3-7: Town of Okotoks Pump Station Settings – Operation during Fire Flows coincident to Maximum Day Demand

PUMP STATION	PUMP	STATUS
SRWTP	North Supply Duty Pump 6.401 ¹	Unknown
	North Supply Duty Pump 6.402 ¹	Unknown
	North Supply Duty Pump 6.403 ¹	Unknown
	North Supply Duty Pump 6.404 ¹	Unknown
	South Supply Duty Pump 6.301	OFF
	South Supply Duty Pump 6.302	OFF
	South Supply Duty Pump 6.303	OFF
	South Supply Duty Pump 6.304	OFF
	South Supply Duty Pump 6.305	OFF
	South Supply High Flow Pump 6.310	ON
2N Pump Station	3N (Tower Hill) Fill Pump P6 ¹	Unknown
	3N (Tower Hill) Fill Pump P7 ¹	Unknown
	3N (Tower Hill) Fill Pump P8 ¹	Unknown
	2N Distribution Pumps Duty P1	OFF
	2N Distribution Pumps Duty P2	OFF
	2N Distribution Pumps Duty P3	OFF
	2N Distribution Pump Jockey P4	OFF
	2N High Flow Pump P5	ON
3N Pump Station	4N Supply Jockey Pump P401	OFF
	4N Supply Duty Pump 402	ON
	4N Supply Duty Pump 403	ON
	4N Supply Duty Pump 404	ON
	4N Supply Duty Pump 405	OFF
	4N Supply Duty Pump 406	OFF
	3N Distribution Pump 301	ON
	3N Distribution Pump 302	OFF
Big Rock Booster Station	Big Rock Duty Pump P1	OFF
	Big Rock Duty Pump P2	OFF
	Big Rock High Flow Pump	ON
Westmount Booster Station	Westmount Duty Pump P1	OFF
	Westmount Duty Pump P2	OFF
	Westmount High Flow Pump	ON
Crystal Ridge Booster Station	Crystal Ridge Duty Pump P1	OFF
	Crystal Ridge Duty Pump P2	OFF
	Crystal Ridge High Flow Pump	ON

1. It is assumed that operational logic of the transfer / fill pumps is based on the level of the receiving tank. Pump control philosophies were not provided for this study. Sequencing of these pumps is unknown.

PRESSURE REDUCING STATIONS

There are currently fifteen (15) pressure reducing valves in service within the Town. The elevations and valve pressure settings are summarized in Table 3-8. **The valve diameters, elevations, and pressure settings should be field checked to improve the accuracy of the model and to investigate appropriate valve sizing (i.e. within maximum flow velocity limits) at each station. It is also unknown which PRV stations have lead/lag valve configuration, and this should also be confirmed in the future with the hydraulic water model updated accordingly.**

Table 3-8: Town of Okotoks Pressure Reducing Valves

PRV NAME	ELEVATION (M)	ZONE BOUNDARY	VALVE DIAMETER (MM)	ESTIMATED PRV SETTINGS ²		STATUS
13B ¹	1,097.75	4N / 3N	250	1,127 m	41.5 psi	Active
13E ¹	1,098.00	4N / 4BN	300	1,142 m	62.5 psi	Active
100	1,097.03	4BN / 3N	150	1,127 m	42.6 psi	Active
103	1,097.50	4BN / 3N	200	1,127 m	41.9 psi	Active
D3	1,096.00	4BN / 3N	300	1,127 m	44.0 psi	Active
138	1,081.50	3N / 2N	250	1,120 m	54.7 psi	Active
E5	1764.92	3N / 2N	250	1,121 m	52.5 psi	Active
D6	1,081.80	3N / 2N	300	1,122 m	57.1 psi	Active
106	1,084.22	3N / 2N	150	1,123 m	50.8 psi	Active
E2	1,061.34	2N / 1N	250	1,094 m	46.4 psi	Active
D9	1,071.04	2N / 1N	300	1,094 m	32.6 psi	Active
DC	1,056.55	2N / 1N	300	1,094 m	53.2 psi	Active
10C	1,067.88	2S-2 / 2S-1	300	1,130 m	88.2 psi	Active
10F	1,074.40	2S-1 / 2S-2	250	1,125 m	71.9 psi	Active
3N Pump Station	1,084.05	Within the 3N Pump Station, between the 4N and 3N distribution headers	250	56 psi	56.0 psi	Active

1. According to Town staff, these PRVs are capable of reversed flow. However, record drawing and/or field confirmation of these was not conducted as part of this assignment.
2. Pressure settings were not available from the Town. For the purposes of this water master plan, WSP has been requested to make estimates on the PRV settings without any available data.

DISTRIBUTION SYSTEM

The potable water system in the Town consists of over 135 kilometres of watermain supplying over 29,000 residents as well as ICI users. The distribution pipes generally range in diameter from 100 mm to 300 mm and were installed between 1952 and 2019.

The watermain shapefiles were provided by the Town were assumed to be ‘fit-for-purpose’ for the development of the Town’s hydraulic water model and were not reviewed against record drawings for accuracy prior to import into the hydraulic water model, unless they appeared incorrect based on our data review. To preserve the relationship of the hydraulic water model and the Town’s GIS shapefile, the

hydraulic model was not skeletonized, and the original asset IDs were used, as available, as the water model pipe labels.

FIRE HYDRANTS

Fire hydrants are not typically included in a water model, as nodes at road intersections of watermains are commonly used to simulate available hydrant flows during fire flow analysis. This method, however, is not ideally suited to represent fire flows at a hydrant which is located mid-block of a street. Therefore, to more accurately represent fire hydrants, nodes were created and modelled at the connection of hydrant leads to watermains. The Town's GIS shapefiles of watermains and hydrants were referenced to select nodes on watermains at the connection of the hydrants.

CHECK VALVES

The Town's GIS shapefiles did not include the locations of check valves. However, Town staff have noted three locations that potentially have check valve, as follows:

- Zone 2N to 3N (32 Street East and Milligan Drive)
- Zone 1N to 2N (Drake Landing Boulevard / Ranchers Boulevard and Milligan Drive)
- Between south transmission main and 1N distribution (Clarke Avenue and Patterson Road)

The check valve locations and diameters and should be field checked to improve the accuracy of the model.

NODE ELEVATIONS

The elevations of pump stations and storage reservoirs were referenced from record drawings, where available. The elevations of all PRV stations, hydrants, and other nodes (i.e. nodes at the intersections of watermains) were interpolated from the contour shapefile provided by the Town.

4 WATER DEMANDS AND SCENARIO DEVELOPMENT

4.1 EXISTING DEMANDS

2018 water meter data and land use information were provided by the Town for the purpose of estimating current water demands within the system. Existing demands within the Town are discussed in Technical Memorandum No. 1, attached in Appendix A.

4.2 FUTURE DEMANDS

The water demands developed in this section form an integral part of the model development process and form the 'background demand' loading of the hydraulic water model such that the existing and long-range planning infrastructure requirements for the water utility can be assessed.

PER CAPITA DEMANDS AND PEAKING FACTORS

The conclusions from the technical memorandum provides the following values for existing per capita demands and the relative peaking factors assigned to each demand use type. The residential usage of 242 L/c/d includes an estimated 29.5% for NRW and has been scaled to included 'unknown' consumption from meters where usage type could not be determined. Discounting the 29.5% for NRW, the residential demand is equivalent to 186 L/c/d.

Table 4-1: System-Wide per Capita Demands and Peaking Factors

LAND USE	ADD	MDD/ADD	PHD/ADD
Single Family	242 L/c/d	1.6	3.4
Multi-Family	242 L/c/d	1.3	2.3
Institutional	4,010 L/ha/d	1.1	1.5
Commercial	12,960 L/ha/d	1.1	1.5
Industrial	7,000 L/ha/d	1.1	1.5

FUTURE DEMANDS

It is assumed that the current demand totals and per capita rates will be representative of future usage within already developed areas of the Town, and that increases to the total system demand is solely due to future developed areas. No "infilling" of existing residential areas has been assumed as this would be a negligible increase on existing demand.

RESIDENTIAL

Residential demands were calculated by multiplying the future single family and multi-family population equivalents by the per capita demands. Per capita consumption is assumed to remain at 242 litres per person per day. Consumption patterns may change with time but given the Town's implementation of water conservation schemes it is difficult to quantify potential percent usage reduction. Further, under a

changing climate, it is difficult to predict if and how consumption may increase do to hotter and drier weather. Given these two factors oppose each other, it is assumed that the capita consumption remains unchanged through time.

INSTITUTIONAL, COMMERCIAL, AND INDUSTRIAL

No large institutional land use areas are outlined in the future land use, and as such no future institutional areas are explicitly included in the model. However, we note that institutional areas have a lower per hectare demand than commercial areas and have a similar fire flow demand. Thus, for planning purposes, future commercial areas can be viewed as either commercial or institutional land use. Like residential demands, the existing industrial, commercial and institutional water consumption per hectare usage rates are assumed to be representative of future usage.

DEMAND BY ZONE

Table 4-2 provides a summary of the ADD in each pressure zone for existing and future design horizons.

Table 4-2: Average Day Demands by Pressure Zone

PRESSURE ZONE	FUTURE (2024) ADD (L/S)	FUTURE (2029) ADD (L/S)	FUTURE (2044) ADD (L/S)	FUTURE (2069) ADD (L/S)
Zone 1N	10.3	10.3	10.3	10.3
Zone 2N	21.1	21.1	21.1	21.1
Zone 3N	22.2	23.9	28.5	28.5
Zone 4N	5.3	8.8	28.3	73.2
Zone 4BN	4.1	4.1	4.1	4.1
Zone 1S	32.2	35.6	35.6	35.6
Zone 2S-1	12.0	13.9	19.5	33.5
Zone 2S-2	9.1	12.1	21.6	21.6
Total	116.37	129.9	168.9	227.8

4.3 DISTRIBUTION SYSTEM

For future development parcels, for which there is currently no proposed watermain network layout, a standard grid main network was assumed, based on Section 3 of the City of Calgary's Design Guidelines for Subdivision Servicing (2014), as requested by the Town of Okotoks. Where digital information on approved layouts have been provided, these have been incorporated into the future modelling. WSP notes that while the current WMP study attempts to maintain watermain size continuity between the existing system and future development, servicing levels (i.e. pressures and fire flows) and final watermain sizes may be dependent on the future watermain layout. Additional fire flow review should be conducted as detailed network information and design parameters become available.

4.4 FIRE FLOW MODEL DEVELOPMENT

Details on the development of fire flow requirements to be applied in this WMP are discussed in Technical Memorandum No. 1, attached in Appendix A. The minimum fire flow requirements are summarized in Table 4-3.

Table 4-3: Minimum Fire Flow Requirements

LAND USE	MINIMUM FIRE FLOW REQUIRED (L/S)	MINIMUM FIRE FLOW DURATION (HRS)
Single Family	60	1.5
Multi-Family	110	2.0
Commercial / Mixed Use	150	2.0
Institutional	180	2.5
Industrial	225	3.0

Fire flow demands for existing developed areas were assigned to model nodes near existing hydrants by spatially relating nodes to adjacent parcels which had site specific recommended fire flow requirements based on land use (i.e. single family, multi-family, and ICI land use parcels). Where multiple land use designations were assigned to a model node, the maximum fire flow requirement was taken (i.e. if a node is assigned both a single family and institutional land usage, the higher institutional fire flow requirement was assigned to that node. It is assumed land use designations within existing developed areas will not change under future conditions, and future fire flow requirements were not recalculated.

For future development parcels, fire flow requirements were assigned based on proposed land usage, as discussed in Section 2.2. As there are no existing hydrants in these areas, fire flow requirements were assigned along demand nodes of proposed subdivision watermain grid described in Section 4.3.

For new developments, FUS fire flows calculations ought to be carried out on a case-by-case basis to determine site-specific fire flow requirements in accordance with the Town's latest bylaw requirements or the most current version of "Water Supply for Public Fire Protection - A Guide to Recommended Practice", published by the Fire Underwriters Survey (FUS).

4.5 WATER DEMAND ALLOCATION

EXISTING DEMANDS

Water demands were allocated based on assigned demands from each parcel using a 'closest watermain' methodology. This assigns the calculated water demands for a parcel to the the closest watermain in the model which, presumably, would service the parcel. The Town's GIS information was used to determine the watermain to connect to parcels. The required inputs for this allocation method are:

- Watermain shapefile from Town of Okotoks, imported into WaterGEMs – provides pipe label and location;
- Junction shapefile created in WaterGEMs – assigned Start Node and Stop Node labels for each watermain, to which to assign demands; and,
- Parcel Shapefile – provides the land and demands to be allocated to the watermain and nodes.

The demands are then proportionally assigned to model nodes upstream and downstream of the watermain based on distance.

5 MODEL CALIBRATION

“Water-distribution-model calibration consists of comparing model results with field measurements, making adjustments to a model, and reviewing field data to improve agreement between the two. The calibration process should result in a more accurate model as well as a better understanding of the strengths and weakness of the model – and in many cases a better understanding of the distribution system itself”.

(Committee Report: Defining Model Calibration, AWWA, 2013)

A water model is a decision-support tool. Although a water model can be calibrated to accurately perform an analysis of fire flows, water quality, and/or energy requirements, a model that is calibrated for one of these analyses may not be well calibrated for another. It is how the water model will be used as a decision support tool that will dictate the type and extent of model calibration.

The hydraulic calibration of a water model for fire flow analysis provides a model that is well suited to assess other demands on the system such as ADD, MDD, and PHD and how these demands impact the sizing of reservoirs, sizing of transmission and distribution watermains, pumping capacity, PRV settings, etc. The calibration of the hydraulic water model for a fire flow analysis therefore provides the Town with a tool to develop a cost-effective strategy to manage and upgrade its potable water infrastructure to meet the demands of the current population as well as anticipated growth.

5.1 CALIBRATION METHODOLOGY

Calibration of a water model is an iterative review process encompassing the details of each component of the water system including: the length, diameter, material, and roughness factors of the watermains; node demands and elevations; and pump configurations and operational settings. The calibration process allows for confirmation and, where appropriate, revisions to the assumptions and/or estimates made in the development of the model.

Calibration requires confirmation of the model predictions by comparison to field measurements. Therefore, a hydrant flow testing program was developed such that static and residual pressures with the actual water network could be recorded during a simulation of fire flows, as well as any special operational changes to the system (such as main closures, valve closures, etc.) from the days of hydrant flow testing are also collected. The recorded field results are then compared to the computer water model predicted results through the calibration process.

A program for multi-pressure and C-factor hydrant flow testing was developed for the purpose of collecting field data from which to calibrate the constructed hydraulic water model. For the multi-pressure tests, a total of three sets of hydrant flow tests were conducted in three of the Town’s pressure zones. The three sets of hydrant flow tests are listed in Table 5-1 and presented in detail in Appendix D. The hydrant flow testing program was conducted from October 3, 2019 to October 4, 2019.

Table 5-1: Hydrant Flow Test Sets and pressure Zones

FLOW TEST SET	PRESSURE ZONE
Set 1	Zone 1S
Set 2	Zone 1N
Set 3	Zone 3N

Twelve C-Factor tests were conducted across the Town's six pressure zones and are presented in detail in Appendix D.

5.1.1 HYDRANT FLOW TEST PROGRAM

A multi-pressure hydrant flow testing program includes fully opening a pre-determined hydrant and measuring flow from it, while simultaneously recording residual pressures at four other hydrants in the surrounding area, within the same pressure zone. A C-factor hydrant flow testing program includes isolating supply to and fully opening a pre-determined hydrant and measuring flow from it, while simultaneously recording residual pressures at the flow hydrant and at an adjacent hydrant upstream. The procedure used to collect data for model calibration is outlined as follows:

- For multi-pressure hydrant flow testing, four high resolutions pressure loggers ($\pm 0.2\%$ of full scale) were installed on predetermined hydrants within the test zone and one was installed on the hydrant adjacent to the flow hydrant. For C-factor hydrant flow testing, two pressure loggers were installed on the hydrants immediately upstream of the flow hydrant;
- One 2.5-inch turbine flow meter (accuracy 0.5%) was installed on a predetermined flow hydrant port to achieve full hydrant flow, this was repeated two more times within each test set;
- SFE field crews monitored flow and supervised drainage and dechlorination;
- Flow rates were recorded from an analog readout meter. This flow is later used to simulate flow in the water model to calibrate the modelled system pressure changes to those recorded by the pressure loggers; and,
- Pressure loggers were removed, stopped, and downloaded into a computer program. From this recorded data, static and residual pressures were later retrieved.

The following were considered in the selection of the multi-pressure hydrant flow and pressure locations to obtain representative coverage of the zone:

- All hydrants are in the same pressure zone;
- General location and populated areas; and,
- Land use.

The following were considered in the selection of the C-factor hydrant flow test and pressure locations to obtain representative coverage of the system's watermains:

- All hydrants are in the same pressure zone;
- Range of pipe diameters; and,
- Range of pipe materials.

5.1.2 CALIBRATION PARAMETERS

Recorded system demands were provided by EPCOR operations staff to determine the actual water usage during the days the hydrant flow tests were carried out. Table 5-2 summarizes the recorded demands for the calibration scenario and compares the values to the calculated average day demands,

Table 5-2: Recorded Daily Demands during Hydrant Flow Testing

FLOW TEST DATE	MODEL ADD (L/S)	CALIBRATION DEMAND (L/S)	RATIO TO MODELED ADD
October 3, 2019	98 L/s	93 L/s	95%

Based on discussions with Town staff, the Town's pump stations are pressure controlled, but control philosophies for the pump stations were not available at the time of this study. Therefore, records of reservoir levels were not available or used to estimate background levels during testing. Confirmation of PRV settings throughout the Town was not available during model calibration and was assumed and refined during the calibration process.

5.2 RESULTS AND DISCUSSION

5.2.1 C-FACTOR FIELD CALIBRATION RESULTS

Watermain materials and years of installation were based on the GIS information provided by the Town. Results of the C-factor hydrant testing and calibrated values are summarized in Table 5-3.

Table 5-3: C-Factor Calibration Results

FLOW TEST NO.	FLOW HYDRANT	RESIDUAL HYDRANT	FIELD RECORDED HEADLOSS (M)	PIPE MATERIAL	PIPE DIAMETER (MM)	PIPE INSTALL YEAR	CALIBRATION C-FACTOR	CALIBRATION CALCULATED HEADLOSS (M)
1	NW-55	H	4.16	PVC	250	2008	55	4.25
2	NE-76	NE-77	5.33	PVC	200	2003	43	5.20
3	NW-48	NW-48A	11.11	PVC	200	2016/2017	137	11.41
4	SW-29	SW-30	9.76	PVC PVC	200 300	1980 1980	75 90	9.76
5	SW-58	SW-55	15.51	PVC PVC	150 200	2008 2008	165 165	15.15
6	NE-134	NE-137	15.24	PVC	200	2003	112	15.14
7	NE-210	NE-208	8.10	PVC	200	2001	120	8.34
8	NE-171	NE-172	9.42	PVC PVC	200 250	2008 2008	65 80	9.68
9	NE-234	NE-235	7.38	PVC PVC	200 250	2014/2016 2014/2016	132 132	7.30
10	NE-73	NE-72	14.13	PVC	200	1978	112	14.49
11	NE-184	NE-182	5.83	PVC	300	2009	70	5.91
12	SE-96	SE-93	5.62	PVC	300	2016	220	5.87

C-factor verification was completed using the Hazen-Williams equation, by calculating the C-factor value that provides the closest calculated headloss in comparison to field recorded results. Where some values fell within expected values for C-factor, these have been used and included as updated values into the Town's hydraulic water model. Where values did not fall within expected values, WSP did not include the c-factors into the water model. Poor correlation is due to suspected field measurement errors or other unknown sources of errors such as valve configurations in the field which were not fully closed as envisioned, or unknown connections. Table 5-3 summarizes the updated C-factors used in the hydraulic model.

Table 5-4: Watermain C-Factor Values

MATERIAL	YEAR INSTALL	YEAR INSTALL	> 300 MM DIAMETER
	1970 – 1990	1990 - 2019	
Ductile Iron	105	120	+ 20
HDPE / PEX	110	130	-
PVC	100	120	+ 20
Steel	130	140	+ 10

5.2.2 MULTI-PRESSURE FIELD CALIBRATION RESULTS

The results of the calibration process indicate generally a good correlation between the field pressure measurements and computer predicted results, based on assumed HGL settings at PRV stations between pressure zones. The complete calibration and validation results are provided in Appendix D.

Field investigation by Town staff is recommended to confirm PRV settings, and to confirm if throttled or closed valves occur near hydrants which are not well calibrated, which are summarized below:

- Hydrant Flow Test No. 1, Set 1 – Set 1 hydrants appear to be hydraulically disconnected under static conditions. Additionally, several residual pressure readings did not show to have a reduction in pressure in comparison with recorded static pressures. This test set has been removed from the calibration comparisons.
- Hydrant Flow Test Set 1 – Field measured static pressures for Hydrant SE-78 were approximately 15 m higher than the pressures of the other static hydrants, which all showed similar pressures. However, the computer simulated residual pressures of these hydrants appeared to generally be within 10% of field recorded residual pressures. Equipment error is suspected for this location, and field recorded pressures were not compared against model-predicted results for this hydrant.
- Hydrant Flow Test No. 2, Set 2 – The field recorded pressure of the residual hydrant was significantly lower than the computer simulated residual pressure for this test. However, for all other tests in the set, the residual the computer simulated static and residual pressures were within 10% of the field recorded data.
- Hydrant Flow Test Set 3 – One of the selected static hydrants, NE-101, is noted to be close to the 3N pump station. The computer simulated residual pressures for this hydrant were higher than the recorded field pressures across all four tests within the set.

The acceptable tolerance between field and computer predicted results are within 10% for pressures. Based on the calibration activities and the system information available at this time, WSP considers the hydraulic water model to be sufficiently calibrated to assess the capacity of the existing water system. Results of the hydrant testing and calibrated values of the water model are summarized in Appendix D.

5.2.3 CALIBRATION SUMMARY

94% (98/104) of the hydrant tests were successfully calibrated, showing less than 10% differences between field-recorded and model predicted values. WSP notes that PRV and pump station settings were not available at the time of this study and, as directed by Town staff, assumptions were made for these settings. Model calibration error is approximately within 5 psi, with flows approximately within 5 L/s of actual. While the model appears to be sufficiently calibrated for the current system modelling analysis, elevations, and pressure settings should be field checked to improve the accuracy of and confidence in the model.

6 HYDRAULIC ANALYSIS

This section of the report covers the hydraulic analysis of the existing water system under the current and future demand conditions. The objective of this analysis is to assess the system's compliance with the level of service criteria discussed and agreed upon with Town staff, as detailed in Technical Memorandum No. 1 attached in Appendix A.

Existing and future deficiencies are highlighted in order to determine appropriate upgrade options for the short-, medium-, and long-term design horizons. Analysis in this section includes a review of the storage capacities, pumping capacities, a review and operation of the existing PRVs, and available system pressures and fire flows in the distribution system. A review of the source supply of water to the Town is not included in this study.

6.1 STORAGE RESERVOIRS

EXISTING RESERVOIR CONTRIBUTIONS

Existing storage reservoirs and volumes are summarized in Table 6-1. While reservoirs are designed to meet the demands of the pressure zone it serves, reservoir volumes may cascade into lower pressure zones or be pumped into high pressure zones to meet storage volume deficiencies during fire flow demand, as appropriate.

STORAGE CAPACITY ASSESSMENT

As detailed in Technical Memorandum No. 1, the fire storage component is based on the FUS recommended duration for the required fire flows. For all system reservoirs under consideration, the fire flow requirement was based on the land use with the highest fire flow requirement under the pressure zones which are serviced by each reservoir.

Table 6-1: Storage Capacity Analysis

RESERVOIR	A – FIRE STORAGE (ML)	B – EQUALIZATION STORAGE (ML)	C – EMERGENCY STORAGE (ML)	A + B + C REQUIRED STORAGE (ML)	AVAILABLE STORAGE	EXCESS	DEFICIENT?
Existing, 2019 (9.05 MLD)							
South Storage	1.62	0.97	0.58	3.17	6.39	3.23	No
2N Reservoir	2.43	0.68	0.41	3.52	7.11	3.59	No
3N Reservoir	1.62	0.47	0.28	2.37	6.82	4.45	No
Future, 2024 (11.3 MLD)							
South Storage	2.43	1.15	0.69	4.27	6.39	2.12	No
2N Reservoir	2.43	0.68	0.41	3.52	7.11	3.59	No
3N Reservoir	2.43	0.68	0.41	3.52	6.82	3.29	No
Future, 2029 (11.8 MLD)							
South Storage	2.43	1.33	0.80	4.56	6.39	1.83	No

RESERVOIR	A – FIRE STORAGE (ML)	B – EQUALIZATION STORAGE (ML)	C – EMERGENCY STORAGE (ML)	A + B + C REQUIRED STORAGE (ML)	AVAILABLE STORAGE	EXCESS	DEFICIENT?
2N Reservoir	2.43	0.68	0.41	3.52	7.11	3.59	No
3N Reservoir	2.43	0.80	0.41	3.70	6.82	3.12	No
Future, 2044 (13.1 MLD)							
South Storage	2.43	1.66	0.99	5.08	6.39	1.32	No
2N Reservoir	2.43	0.68	0.41	3.52	7.11	3.59	No
3N Reservoir	2.43	1.31	0.79	4.53	6.82	2.29	No
Future, 2069 (15.2 MLD)							
South Storage	2.43	1.96	1.17	5.56	6.39	0.83	No
2N Reservoir	2.43	0.68	0.41	3.52	7.11	3.59	No
3N Reservoir	2.43	2.28	1.37	6.09	6.82	0.73	No

The above analysis shows that there are no forecasted storage volume deficiencies within the Town up to the 2069 design horizon. However, in discussion with Town staff and through review of background reports and analyses, two key projects have been identified as detailed in the following subsections.

STORAGE RESERVOIR RECOMMENDATIONS

Improvement Project R-01 – Construct a new 3.66 ML Reservoir in South Okotoks (2024)

The May 2019 West Okotoks Area Structure Plan (WOASP) included the provision of a new reservoir for South Okotoks to provide additional storage for the area. Although the storage capacity assessment has not indicated an immediate need for this additional storage, in discussion with Town staff, WSP has included this project in the Capital Projects List for future planning. However, it should be noted that this project is still at the conceptual stage and therefore the design is to be confirmed in the future through future siting work and review. Considerations which should be taken to determine the optimal location of reservoir storage in the distribution system may include:

- Long-term operation of the network (from an operational and asset management point of view);
- Balancing storage across the network;
- Proximity to roads and existing residents;
- Property ownership and proposed land use;
- Appropriate topography for construction and tie-in to existing service areas;
- Maintaining / providing fire flows; and,
- Influence on system hydraulics.

For the hydraulic modelling assessment, WSP has tied in the new reservoir to the 1S Zone at an approximate ground elevation of 1,093.5 m with a buried depth of 5 m for a TWL of 1092.7, based on the topographic constraints of the proposed site location in the WOASP. The new reservoir has been tentatively sized at 3.66 ML as it ties into the 1S Zone and could potentially feed the zone by gravity, therefore the storage volume applied is based on the storage volume required for the 1S Zone under the ultimate 2069 horizon. Pre-design studies should be carried out to determine the optimal pressure zone(s) through which to connect and supply the reservoir, and the subsequent optimal siting of reservoir

locations. In addition, the corresponding pumping and transmission upgrades recommended in this study should be reviewed.

It is also recommended that the Town review its overall reservoir and storage philosophy to optimize the current system while planning for future growth and resiliency.

Improvement Project R-02 – Rehabilitation works for the Existing 3N Reservoir (2019)

Although no storage volume deficiencies were identified with the existing 3N Reservoir, Town staff did indicate that the existing reservoir requires rehabilitation works to address ongoing issues. Town staff has indicated that the total amount for these rehabilitation works is approximately \$500,000 which has been included in the Capital Projects List. An investigation into the 3N Reservoir's current condition is recommended to assess the scope and timeframe for any rehabilitative works.

6.2 PUMP STATIONS

EXISTING PUMP CAPACITY

Design flows for all pumps were estimated based on the provided pump curves and design reports available. Table 6-2 summarizes the firm capacity at each of the Town's pump stations

Table 6-2: Existing Pump Capacities

PUMP STATION	PUMP	RATED CAPACITY (L/S)	FIRM CAPACITY (L/S)
SRWTP	North Supply Duty Pump 6.401	44	132
	North Supply Duty Pump 6.402	44	
	North Supply Duty Pump 6.403	44	
	North Supply Duty Pump 6.404	44	
	South Supply Duty Pump 6.301	57	285
	South Supply Duty Pump 6.302	57	
	South Supply Duty Pump 6.303	57	
	South Supply Duty Pump 6.304	57	
	South Supply Duty Pump 6.305	57	
	South High Flow Pump	119	
2N Pump Station	3N (Tower Hill) Fill Pump P6	46	92
	3N (Tower Hill) Fill Pump P7	46	
	3N (Tower Hill) Fill Pump P8	46	
	2N Distribution Pumps Duty P1	60	195
	2N Distribution Pumps Duty P2	60	
	2N Distribution Pumps Duty P3	60	
	2N Distribution Pump Jockey P4	15	
	2N High Flow Pump	127	

PUMP STATION	PUMP	RATED CAPACITY	
		(L/S)	FIRM CAPACITY (L/S)
3N Pump Station	4N Supply Jockey Pump P401	30	370 (3N Zone) 290 (4N Zone)
	4N Supply Duty Pump 402	65	
	4N Supply Duty Pump 403	65	
	4N Supply Duty Pump 404	65	
	4N Supply Duty Pump 405	65	
	4N Supply Duty Pump 406	65	
	3N Distribution Pump 301	40	
	3N Distribution Pump 302	40	
Big Rock Booster Station	Big Rock Duty Pump P1	42	84
	Big Rock Duty Pump P2	42	
	Big Rock High Flow Pump	47	
Westmount Booster Station	Westmount Duty Pump P1	18	36 (183 L/s for fire flows)
	Westmount Duty Pump P2	18	
	Westmount High Flow Pump	183	

As agreed upon with Town Staff, for the purposes of this assessment, the firm capacity of a pump station is based on its capability in meeting the highest demand of all its service areas with the largest pump in the station (e.g. the high flow pump) out of service. Furthermore, while the Town's pump stations should also be designed to meet the domestic PHD of all its service areas, the governing condition for the majority of the pump stations was determined to be during supply of fire flows coincident to maximum day demand, as illustrated in Table 6-3, as there are no reservoirs in the system capable of supplying balancing flows to their downstream service areas by gravity. WSP notes the following exceptions:

- The North Supply pumps at the SRWTP and the Tower Hill (3N) pumps at the 2N Pump Station do not directly service domestic demands. Therefore, the capacity required of these pump station headers is based on providing the MDD demands of the reservoir downstream (i.e. North Supply pumps to provide MDD of the 2N Pump Station, 3N Fill Pumps to provide MDD of the 3N Pump Station);
- The control philosophy for the 3N Pump Station (CIMA, 2019) suggests that the 4N distribution header within the pump station is to support the 3N zone only during emergency conditions, via a PRV between the distribution headers. However, based on discussions with as noted by Town staff, the 4N header should also be assessed to supply the 3N zone with backup supply as needed, during PHD conditions. Under this operational philosophy, the capacity assessment of the 3N Pump Station will be based on the 4N distribution header providing back up support to the 3N zone, but the 3N pumps (two 40 L/s pumps) are not configured to support the higher 4N zone;
- Further, the Town has indicated that the 3N/4N pump station shall be considered as one overall pump station. This means that the largest pump out of service will be one of the 4N duty pumps, and the 3N and 4N pumps would be assessed together to meet the network's (3N and 4N pressure zone) PHD requirements; and,
- The Crystal Ridge pump station is currently in place as a backup to the 3N/4N pump station and has not been assessed in the following capacity analyses;
- Fire flow servicing for the areas serviced by the Westmount pump station will not be assessed with the largest pump out of service, as the high flow pump is uniquely designed at this station for fire flow servicing and is also much larger than the station's duty pumps; and,
- The Town has indicated that the proposed industrial land users to the northeast of the Town, in sections N-15 to N-20, shall be assessed to be provide domestic demands (up to PHD). Therefore, the system's capacity to provide industrial fire flows to these parcels has not been assessed in this study.

Fire protection is tentatively planned for the industrial land users in N-2, and is reflected in the pumping capacity assessment required by the 3N Pump Station (4N distribution header).

Table 6-3: Pump Station Capacity Assessment

PUMP STATION	PUMPS	SERVICE AREA	CRITICAL DESIGN CONDITION	CAPACITY REQUIRED (L/S)	FIRM CAPACITY (L/S)	EXCESS CAPACITY (L/S)	DEFICIENT
EXISTING, 2019							
SRWTP	North Supply	Zone 1N Zone 2N Zone 3N Zone 4N Zone 4BN	MDD MDD MDD MDD MDD	81	132	51	No
	South Distribution	Zone 1S Zone 2S-1 Zone 2S-2	PHD PHD PHD	135	285	150	No
	South Fire Protection	Zone 1S Zone 2S-1 Zone 2S-2	MDD + Maximum FF of the serviced areas	247	285	38	No
2N Pump Station	3N Fill	Zone 3N Zone 4N Zone 4BN	MDD MDD MDD	36	92	56	No
	2N Distribution	Zone 1N Zone 2N	PHD PHD	89	195	106	No
	2N Fire Protection	Zone 1N Zone 2N	MDD + Maximum FF of the serviced areas	271	195	-76	Yes
3N Pump Station	3N Distribution	Zone 3N Zone 4BN	PHD PHD	70	370	300	No
	4N Distribution	Zone 4N	PHD	1	290	103	No
	3N/4N Fire Protection	Zone 3N Zone 4N Zone 4BN	Zone 4N MDD plus maximum FF of serviced areas	187			
Big Rock Booster Station	2S-1 Distribution	Zone 2S-1	PHD	33	84	51	No
	2S-1 Fire Protection	Zone 2S-1	MDD+FF	166	84	-82	Yes
Westmount Booster Station	2S-2 Distribution	Zone 2S-2	PHD	17	36	19	No
	2S-1 Fire Protection	Zone 2S-2	MDD+FF	189	36	-153	Yes

PUMP STATION	PUMPS	SERVICE AREA	CRITICAL DESIGN CONDITION	CAPACITY REQUIRED (L/S)	FIRM CAPACITY (L/S)	EXCESS (L/S)	DEFICIENT
FUTURE, 2024							
SRWTP	North Supply	Zone 1N Zone 2N Zone 3N Zone 4N Zone 4BN	MDD MDD MDD MDD MDD	93	132	39	No
	South Distribution	Zone 1S Zone 2S-1 Zone 2S-2	PHD PHD PHD	155	285	130	No
	South Fire Protection	Zone 1S Zone 2S-1 Zone 2S-2	MDD + Maximum FF of the serviced areas	303	285	-18	Yes
2N Pump Station	3N Fill	Zone 3N Zone 4N Zone 4BN	MDD MDD MDD	48	92	44	No
	2N Distribution	Zone 1N Zone 2N	PHD PHD	89	195	106	No
	2N Fire Protection	Zone 1N Zone 2N	MDD + Maximum FF of the serviced areas	271	195	-76	Yes
3N Pump Station	3N Distribution	Zone 3N Zone 4BN	PHD PHD	83	370	287	No
	4N Distribution	Zone 4N	PHD	14	290	52	No
	3N/4N Fire Protection	Zone 3N Zone 4N Zone 4BN	Zone 4N MDD plus maximum FF of serviced areas	238			
Big Rock Booster Station	2S-1 Distribution	Zone 2S-1	PHD	39	84	45	No
	2S-1 Fire Protection	Zone 2S-1	MDD+FF	169	84	-85	Yes
Westmount Booster Station	2S-2 Distribution	Zone 2S-2	PHD	29	36	9	No
	2S-1 Fire Protection	Zone 2S-2	MDD+FF	193	36	-157	Yes

PUMP STATION	PUMPS	SERVICE AREA	CRITICAL DESIGN CONDITION	CAPACITY REQUIRED (L/S)	FIRM CAPACITY (L/S)	EXCESS (L/S)	DEFICIENT
FUTURE, 2029							
SRWTP	North Supply	Zone 1N Zone 2N Zone 3N Zone 4N Zone 4BN	MDD MDD MDD MDD MDD	101	132	31	No
	South Distribution	Zone 1S Zone 2S-1 Zone 2S-2	PHD PHD PHD	175	285	110	No
	South Fire Protection	Zone 1S Zone 2S-1 Zone 2S-2	MDD + Maximum FF of the serviced areas	315	285	-30	Yes
2N Pump Station	3N Fill	Zone 3N Zone 4N Zone 4BN	MDD MDD MDD	55	92	37	No
	2N Distribution	Zone 1N Zone 2N	PHD PHD	89	195	106	No
	2N Fire Protection	Zone 1N Zone 2N	MDD + Maximum FF of the serviced areas	271	195	-76	Yes
3N Pump Station	3N Distribution	Zone 3N Zone 4BN	PHD PHD	88	370	282	No
	4N Distribution	Zone 4N	PHD	24	290	46	No
	3N/4N Fire Protection	Zone 3N Zone 4N Zone 4BN	Zone 4N MDD plus maximum FF of serviced areas	244			
Big Rock Booster Station	2S-1 Distribution	Zone 2S-1	PHD	45	84	39	No
	2S-1 Fire Protection	Zone 2S-1	MDD+FF	171	84	-87	Yes
Westmount Booster Station	2S-2 Distribution	Zone 2S-2	PHD	36	36	0	Yes
	2S-1 Fire Protection	Zone 2S-2	MDD+FF	198	36	-162	Yes

PUMP STATION	PUMPS	SERVICE AREA	CRITICAL DESIGN CONDITION	CAPACITY REQUIRED (L/S)	FIRM CAPACITY (L/S)	EXCESS (L/S)	DEFICIENT
FUTURE, 2044							
SRWTP	North Supply	Zone 1N Zone 2N Zone 3N Zone 4N Zone 4BN	MDD MDD MDD MDD MDD	132	132	0	No
	South Distribution	Zone 1S Zone 2S-1 Zone 2S-2	PHD PHD PHD	222	285	63	No
	South Fire Protection	Zone 1S Zone 2S-1 Zone 2S-2	MDD + Maximum FF of the serviced areas	337	285	-52	Yes
2N Pump Station	3N Fill	Zone 3N Zone 4N Zone 4BN	MDD MDD MDD	87	92	5	No
	2N Distribution	Zone 1N Zone 2N	PHD PHD	89	195	106	No
	2N Fire Protection	Zone 1N Zone 2N	MDD + Maximum FF of the serviced areas	271	195	-76	Yes
3N Pump Station	3N Distribution	Zone 3N Zone 4BN	PHD PHD	104	370	266	No
	4N Distribution	Zone 4N	PHD	66	290	22	No
	3N/4N Fire Protection	Zone 3N Zone 4N Zone 4BN	Zone 4N MDD plus maximum FF of serviced areas	268			
Big Rock Booster Station	2S-1 Distribution	Zone 2S-1	PHD	63	84	21	No
	2S-1 Fire Protection	Zone 2S-1	MDD+FF	180	84	-96	Yes
Westmount Booster Station	2S-2 Distribution	Zone 2S-2	PHD	65	36	-29	Yes
	2S-1 Fire Protection	Zone 2S-2	MDD+FF	212	36	-176	Yes

PUMP STATION	PUMPS	SERVICE AREA	CRITICAL DESIGN CONDITION	CAPACITY REQUIRED (L/S)	FIRM CAPACITY (L/S)	EXCESS (L/S)	DEFICIENT
FUTURE, 2069							
SRWTP	North Supply	Zone 1N Zone 2N Zone 3N Zone 4N Zone 4BN	MDD MDD MDD MDD MDD	132	132	0	No
	South Distribution	Zone 1S Zone 2S-1 Zone 2S-2	PHD PHD PHD	270	285	15	No
	South Fire Protection	Zone 1S Zone 2S-1 Zone 2S-2	MDD + Maximum FF of the serviced areas	337	285	-52	Yes
2N Pump Station	3N Fill	Zone 3N Zone 4N Zone 4BN	MDD MDD MDD	87	92	5	No
	2N Distribution	Zone 1N Zone 2N	PHD PHD	89	195	106	No
	2N Fire Protection	Zone 1N Zone 2N	MDD + Maximum FF of the serviced areas	271	195	-76	Yes
3N Pump Station	3N Distribution	Zone 3N Zone 4BN	PHD PHD	104	370	266	No
	4N Distribution	Zone 4N	PHD	190	290	22	No
	3N/4N Fire Protection	Zone 3N Zone 4N Zone 4BN	Zone 4N MDD plus maximum FF of serviced areas	268			
Big Rock Booster Station	2S-1 Distribution	Zone 2S-1	PHD	110	84	-26	Yes
	2S-1 Fire Protection	Zone 2S-1	MDD+FF	180	84	-96	Yes
Westmount Booster Station	2S-2 Distribution	Zone 2S-2	PHD	65	36	-29	Yes
	2S-1 Fire Protection	Zone 2S-2	MDD+FF	212	36	-176	Yes

The above analysis indicates that there are pumping capacity deficiencies up to the ultimate 2069 design horizon at the SRWTP, 2N, Big Rock, Westmount, and Crystal Ridge Pump Stations. In the short term, there are pump capacity deficiencies for the most part due to fire flow provision deficiencies, while in the future, deficiencies are identified primarily due to or exasperated by future growth and high fire flow requirements.

The hydraulic water model results indicate that the deficiencies in the 2S-2 zone downstream of the Westmount Pump Station can be mitigated through the backup supply from the 2S-1 Zone via PRVs. Similarly, the fire flow deficiencies downstream of the 2N Pump Station can be mitigated through backup

supplies from the 3N zone via PRVs. Therefore, WSP has not assessed pumping improvements for the Westmount and 2N Pump Stations, though the reliability and operability of the Town's PRV stations should be field-investigated and confirmed.

As well, WSP has taken into account the Town's plans to decommission the Crystal Ridge Pump Station and service the 4BN zone from the 4N zone via PRVs, so the pump station has been excluded from further analysis.

The remaining pump stations with identified deficiencies have been targeted for improvements. In addition, WSP has identified through hydraulic modelling the need for pumping improvements to the 4N Pump Station to meet industrial fire flow demands in the N-2 service area under the ultimate 2069 design horizon. The town has indicated that these improvements would only be required if the N-2 service area becomes industrial in the future (for which it is tentatively slated for), which is reflected in the Capital Projects List. The proposed improvement (of replacing the 4N Header jockey pump with a larger pump) yields available fire flows in the N-2 service area which are within 5 L/s of the desired 225 L/s for industrial users under the ultimate 2069 design horizon. In order to meet and/or exceed the desired 225 L/s fire flow requirement in the N-2 area, upgrades would be required to the existing 4N Header distribution pumps.

PUMP STATION RECOMMENDATIONS

A summary of the pumping upgrades as recommended by WSP are listed below:

- By 2024, replace the SRWTP south supply pumps with 6 x 100 HP pump (5 duty, 1 standby) to meet ultimate domestic and fire flow needs (individual pump capacity of 67.4 L/s @ 95 m);
- By 2044, replace the Big Rock pumps with 3 x 60 HP pumps (2 duty, 1 standby) to meet ultimate domestic and fire flow needs (individual pump capacity of 90 L/s @ 42 m); and,
- By 2069, replace the 4N Header jockey pump with the same type of pump as the 100 HP duty pumps (for a 5 duty, 1 standby arrangement) to meet ultimate industrial fire flow needs in the N-2 service area (individual pump capacity of 65 L/s @ 77 m).

The above recommended pump station improvements are required to address pumping capacity deficiencies up to the ultimate 2069 design horizon. As such, WSP has listed the ultimate capacity suggested for the above-mentioned pumps, and recommends the improvements include VFDs to meet flows at interim conditions (i.e. existing, 5-, 10-, and 25-year horizons). Pre-design studies should be carried out to determine the optimal pump sizing and staging for each station, taking into account the existing infrastructure and the pumping needs at existing, interim, and ultimate conditions.

6.3 DISTRIBUTION SYSTEM

This section assesses the capacity of the Town's water distribution mains with respect to their ability to convey adequate flows to meet service pressure requirements and fire flows throughout the water distribution system under existing, interim, and ultimate demand conditions. The Town's hydraulic water model developed and calibrated as part of this study was specifically used to carry out this analysis.

MAXIMUM SERVICE PRESSURES – AVERAGE DAY DEMAND

As discussed in Technical Memorandum No. 1, the normal operating range for water distribution systems is 350 kPa to 550 kPa (50 psi to 90 psi). Water distribution systems should be designed to handle this range under PHD conditions, and pressures above 550 kPa (90 psi) should be reviewed against the

Canadian plumbing code to determine specific building and household requirements to avoid damage to internal building and household piping.

The maximum service pressure within each zone occurs at the properties at the lowest elevation compared to the HGL of the zone set either by a reservoir, PRV, or pump, and typically occurs under low demand conditions. Figures 6-1 to 6-5 illustrate the maximum service pressures assessed under the worst-case condition (in this case, under ADD conditions) for each horizon.

While improvements to address service pressures exceeding the normal operating range have not been included in this study, the figures will provide Town staff with a basis for investigating buildings and households in areas of potential risk due to high service pressures.

MINIMUM SERVICE PRESSURES – PEAK HOUR DEMAND

As discussed in Technical Memorandum No. 1, the minimum service pressure under PHD conditions applied for this study is 40 psi, which is in line with the previous Infrastructure Study and consistent with standards from other municipalities and governing agencies in Alberta.

The minimum pressures within each zone occur at the properties at the highest elevation compared to the HGL of the zone set by either by a reservoir, PRV or pump, and typically occurs under high demand conditions. Figures 6-6 to 6-10 illustrate the minimum service pressures assessed under PHD conditions for each horizon.

As illustrated in the figures, there are some critical locations where the Town should improve its water system in order to meet minimum service pressures under PHD conditions. The proposed pump station and reservoir improvements summarized in previous sections play a critical role in improving available minimum service pressures. As well, service pressures are improved through watermain upgrades recommended to primarily address fire flow deficiencies detailed further in this report.

FIRE FLOWS COINCIDENT TO MAXIMUM DAY DEMAND

The results from the fire flow analysis are summarized in Figures 6-11 to 6-15 which illustrate the various ranges of fire flow requirements and availabilities throughout the system and identifies where deficiencies occur under each horizon.

As requested by the Town, it should be noted that the future N-15 and N-20 service areas were only assessed for servicing static demands. As such, the available fire flow in these areas have been illustrated purely for information, and they were not assessed for any fire flow deficiencies.

While some deficiencies can be ignored as there are adjacent nodes with sufficient fire flow within the nearby service area, there are some critical locations where the Town should improve its water system in order to be able to provide the fire flows. Model nodes with significant fire flow deficiencies have been prioritized over locations with minor deficiencies (i.e. where available fire flows are within 5 L/s of desired levels of service). The proposed pump station and reservoir improvements summarized in previous sections play a critical role in improving available fire flows. Where pump station and reservoir upgrades left unresolved fire flow deficiencies, watermain improvements have been identified to improve available fire flows to desired levels and are summarized in the following section.

DISTRIBUTION SYSTEM UPGRADES

The recommendations presented in this section are limited to the main distribution system and generally do not directly address dead end watermains where no hydrants are connected. Improvements for fire flow servicing to dead ends should be addressed on a case-by-case basis, especially as there are

opportunities in the future to have required watermain upgrades borne by developers wishing to connect to the existing water system in the future.

Table 6-4 summarizes the recommended upgrade works to overcome existing and future distribution system deficiencies.

Table 6-4: Distribution System Upgrade Recommendations

PROJECT	TRIGGER SCENARIO	IMPROVEMENT TYPE	ULTIMATE SIZE	DESCRIPTION	DEFICIENCY RESOLVED
WM-01	2019	Upsizing	300	Along North Railway Street between McRae Street and Poplar Avenue	Fire Flows
WM-02	2019	Upsizing	200	Along McRae Street and Maple Street between North Railway Street and Poplar Avenue, and along Lineham Avenue between North Railway Street and McRae Street	Fire Flows
WM-03	2019	Upsizing	300	Along North Railway Street between Stockton Avenue and Fisher Gate, and along Stockton Avenue east of Stockton Point.	Fire Flows
WM-04	2019	Upsizing	200	Along Elm Place North of North Railway Street	Fire Flows
WM-05	2019	Upsizing	250	Along Fisher Gate South of North Railway Street	Fire Flows
WM-06	2019	Upsizing	200	Along Elma Street East between Veterans Way and Clark Ave	Fire Flows
WM-07 (i)	2019	New Loop	200	Along Riverside Way to the West of Northridge Drive	Fire Flows
WM-07 (ii)	2019	Upsizing	200	Along Northridge Drive between Riverside Drive and Riverside Way	Fire Flows
WM-08	2019	Upsizing	200	At the intersection of Milligan Drive and Downey Road	Fire Flows
WM-09 (i)	2024	New Loop / Zone Transfer	200	At the intersection of Crystal Ridge Drive and Milligan Drive	Fire Flows / Transmission Pressures
WM-09 (ii)	2024	Valve Closure / Zone Transfer	-	At the intersection of Crystal Ridge Drive and Crystal Ridge Crescent	Fire Flows / Transmission Pressures
WM-10	2024	Upsizing	300	Along Crystal Shores Heights West of 32 Street East	Fire Flows
WM-11	2024	New Reservoir Transmission Main	200	Along Big Rock Trail and parallel to Westland Street to the Reservoir tie-in point near Westland View.	Storage
PRV-01	2024	New PRV	300	At the eastern boundary of Hessel Park to supply flows from Zone 4N to Zone 4BN (assumed setpoint = 1,142 m)	Fire Flow / Transmission Pressures

The distribution network improvements noted in Table 6-4 have been chosen and designed to address the majority of the fire flow deficiencies in the Town's current water distribution network while providing the best cost-benefit for their construction to the ultimate design horizon of 2069.

The resulting fire flow deficiencies decrease dramatically under the ultimate 2069 scenario due to distribution main upgrades as well as pumping station, PRV station, and reservoir improvement projects.

Figures 6-16 and 6-17 illustrate the resulting service pressures and fire flows in the Town's water system under the ultimate 2069 horizon with all the network improvements completed (including pump station and reservoir upgrades).

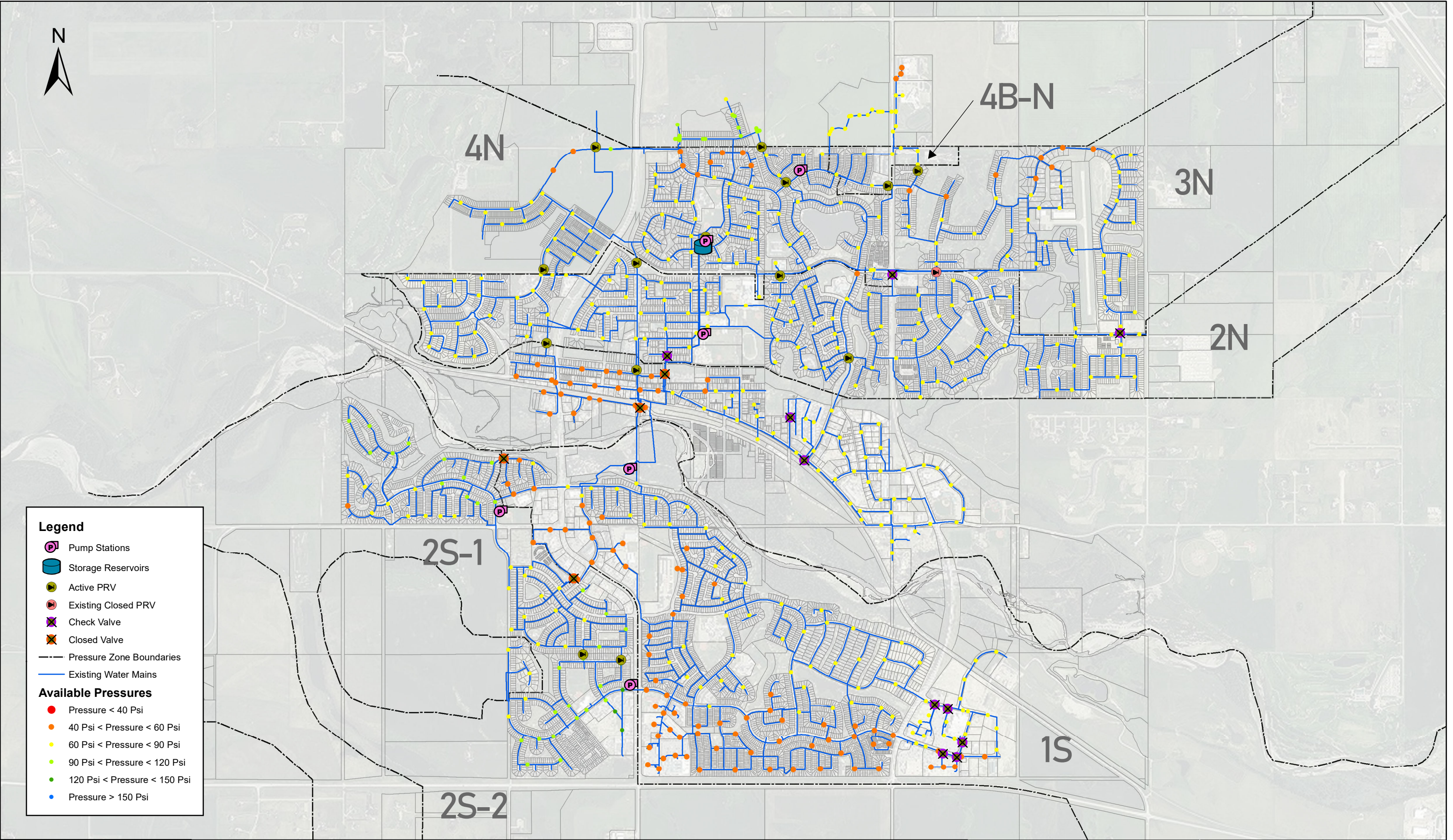
A detailed figure of the proposed network improvements accompanies the Capital Projects List in Section 8.

HYDRANT COVERAGE ANALYSIS

A mapping of the Town's existing fire hydrants was carried out to determine the area of influence and coverage of existing hydrants. Based on available record data, the Town currently operates 506 hydrants. Figure 6-18 illustrates the existing hydrant coverage mapping. Coverage for hydrants is illustrated in two circles as required for each hydrant, a smaller circle representing a 150 metres diameter coverage (which indicates the multi-family and ICI servicing distance), and a larger circle representing a 300 metres diameter coverage (which indicates the single-family residential servicing distance).

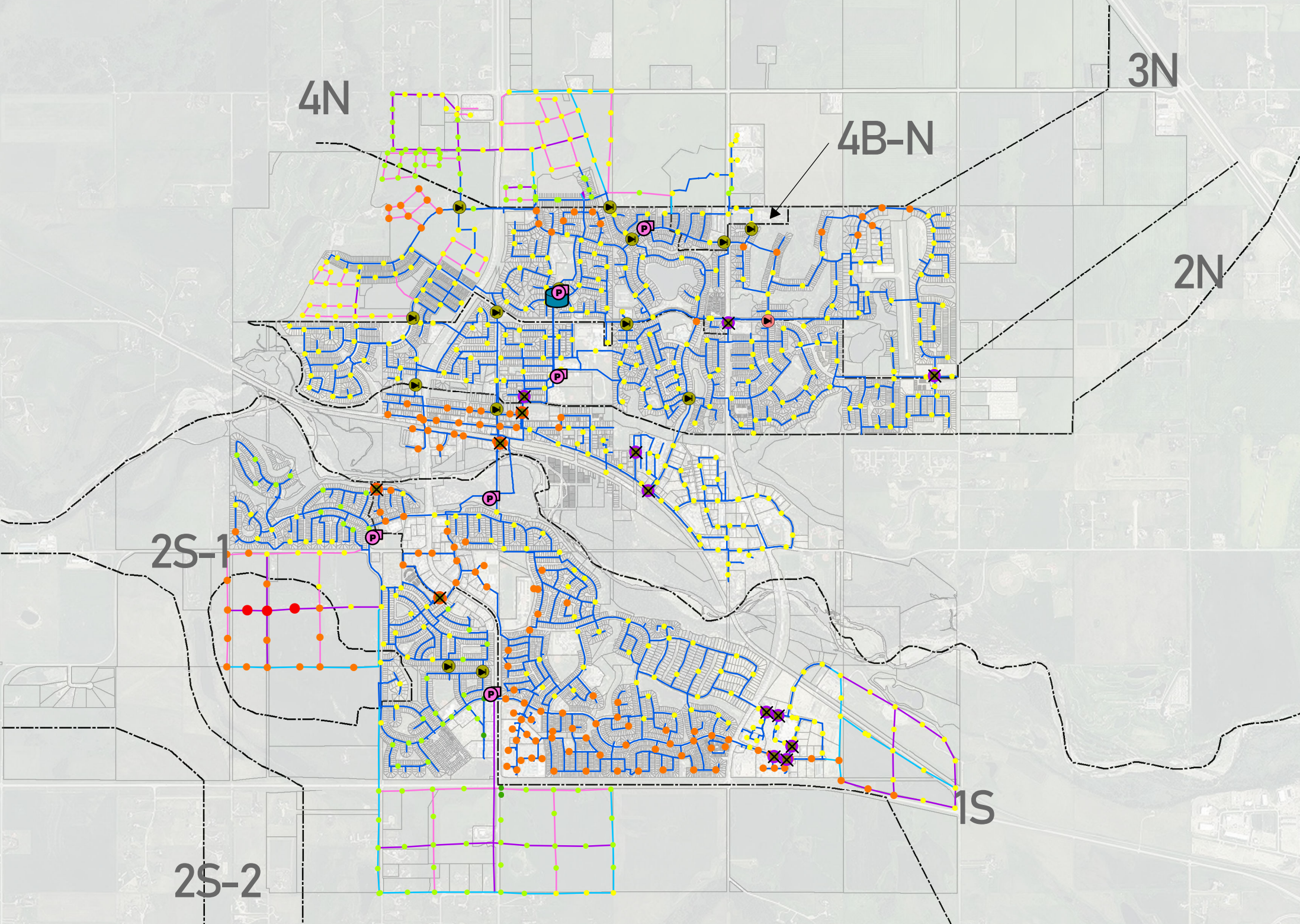
An analysis for future hydrant coverage requirements was not carried out for the purposes of this report. Future hydrant servicing requirements should be made on a case-by-case basis in the course of the construction approval processes for new developments as they occur in the Town.

Hydrant coverage in the Town's distribution system has been deemed adequate and no additional fire hydrants are recommended for the water system at this time.





Note: Future system deficiencies are based on an approximation of future watermain network layouts and future demand allocations based on the City of Calgary grid system and future land use shapefile and population estimates, as suggested by WSP and agreed upon by the Town of Okotoks. Where digital files of known future network layouts were provided, the grid layouts were modified accordingly.



Legend

- Pump Stations
- Storage Reservoirs
- Active PRV
- Existing Closed PRV
- Check Valve
- Closed Valve
- Pressure Zone Boundaries
- Existing Water Mains

Available Pressures

- Pressure < 40 Psi
- 40 Psi < Pressure < 60 Psi
- 60 Psi < Pressure < 90 Psi
- 90 Psi < Pressure < 120 Psi
- 120 Psi < Pressure < 150 Psi
- Pressure > 150 Psi

Future Water Mains

- 200 mm
- 250 mm
- 300 mm



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Town of Okotoks
Available Pressures during Average Day Demand
2024

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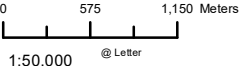


Figure 6-2



Note: Future system deficiencies are based on an approximation of future watermain network layouts and future demand allocations based on the City of Calgary grid system and future land use shapefile and population estimates, as suggested by WSP and agreed upon by the Town of Okotoks. Where digital files of known future network layouts were provided, the grid layouts were modified accordingly.

Legend

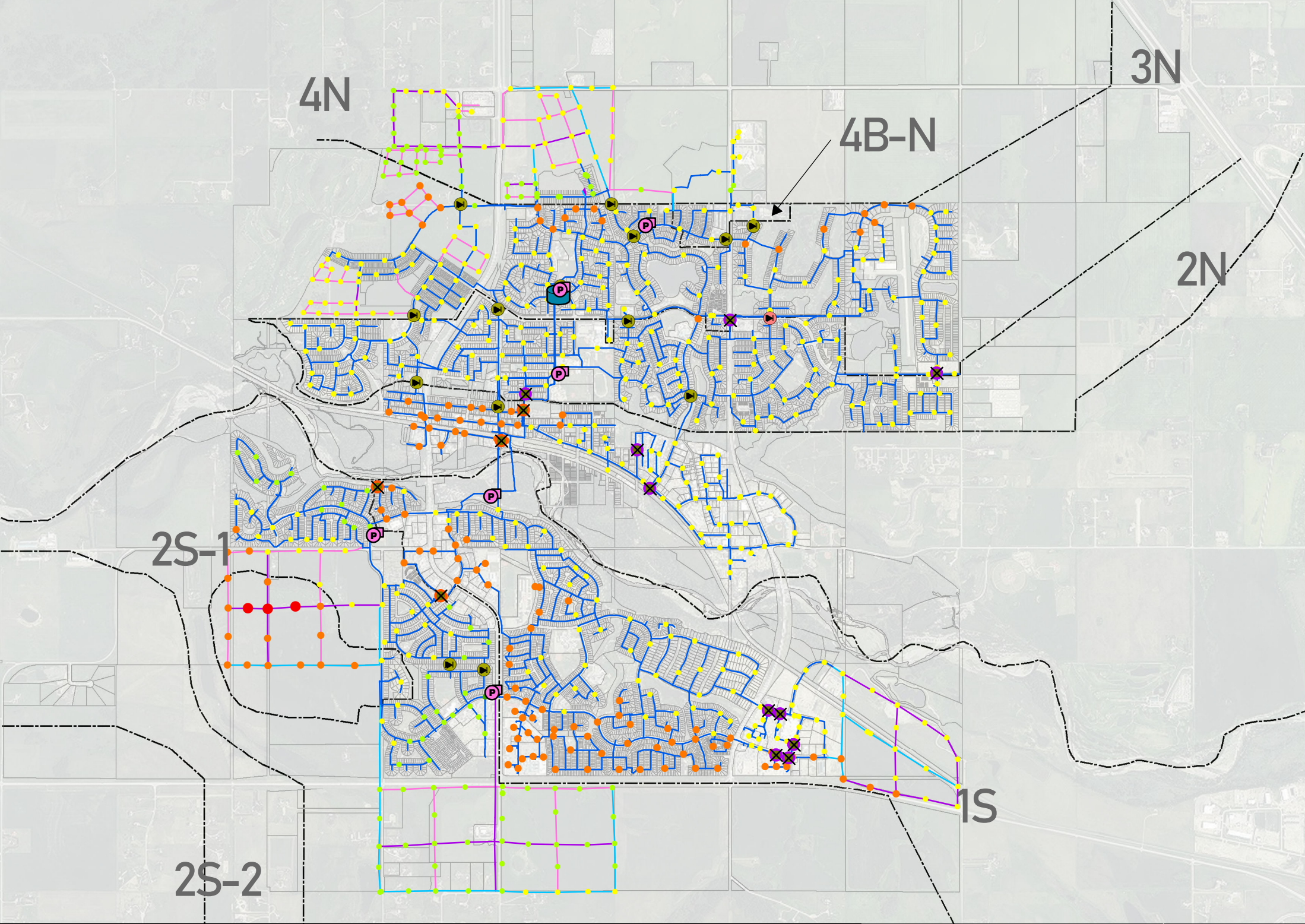
- Pump Stations
- Storage Reservoirs
- Active PRV
- Existing Closed PRV
- Check Valve
- Closed Valve
- Pressure Zone Boundaries
- Existing Water Mains

Available Pressures

- Pressure < 40 Psi
- 40 Psi < Pressure < 60 Psi
- 60 Psi < Pressure < 90 Psi
- 90 Psi < Pressure < 120 Psi
- 120 Psi < Pressure < 150 Psi
- Pressure > 150 Psi

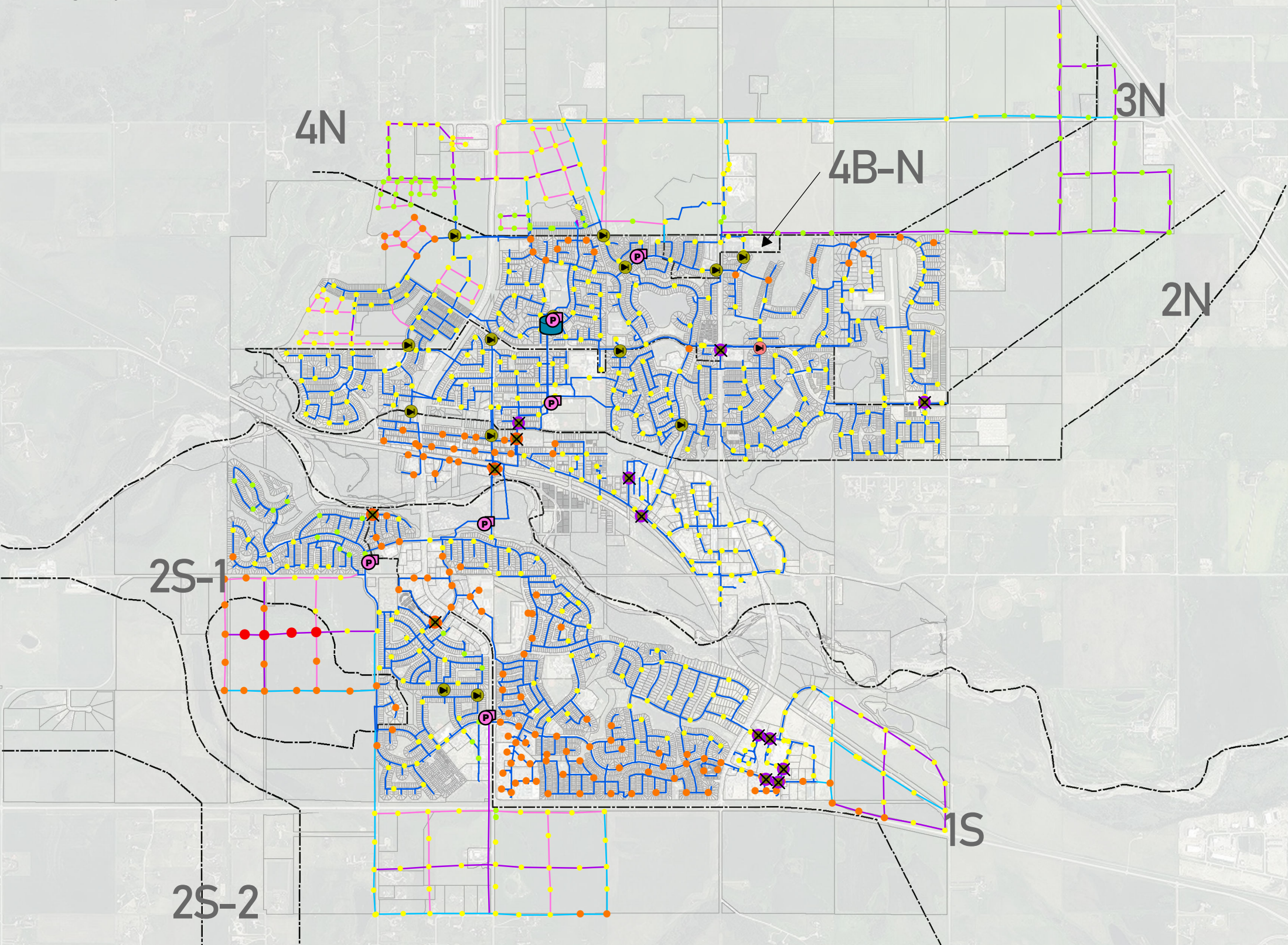
Future Water Mains

- 200 mm
- 250 mm
- 300 mm





Note: Future system deficiencies are based on an approximation of future watermain network layouts and future demand allocations based on the City of Calgary grid system and future land use shapefile and population estimates, as suggested by WSP and agreed upon by the Town of Okotoks. Where digital files of known future network layouts were provided, the grid layouts were modified accordingly.



Legend

- Pump Stations
- Storage Reservoirs
- Active PRV
- Existing Closed PRV
- Check Valve
- Closed Valve
- Pressure Zone Boundaries
- Existing Water Mains

Available Pressures

- Pressure < 40 Psi
- 40 Psi < Pressure < 60 Psi
- 60 Psi < Pressure < 90 Psi
- 90 Psi < Pressure < 120 Psi
- 120 Psi < Pressure < 150 Psi
- Pressure > 150 Psi

Future Water Mains

- 200 mm
- 250 mm
- 300 mm



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Town of Okotoks
Available Pressures during Average Day Demand
2044

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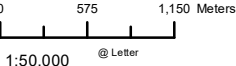
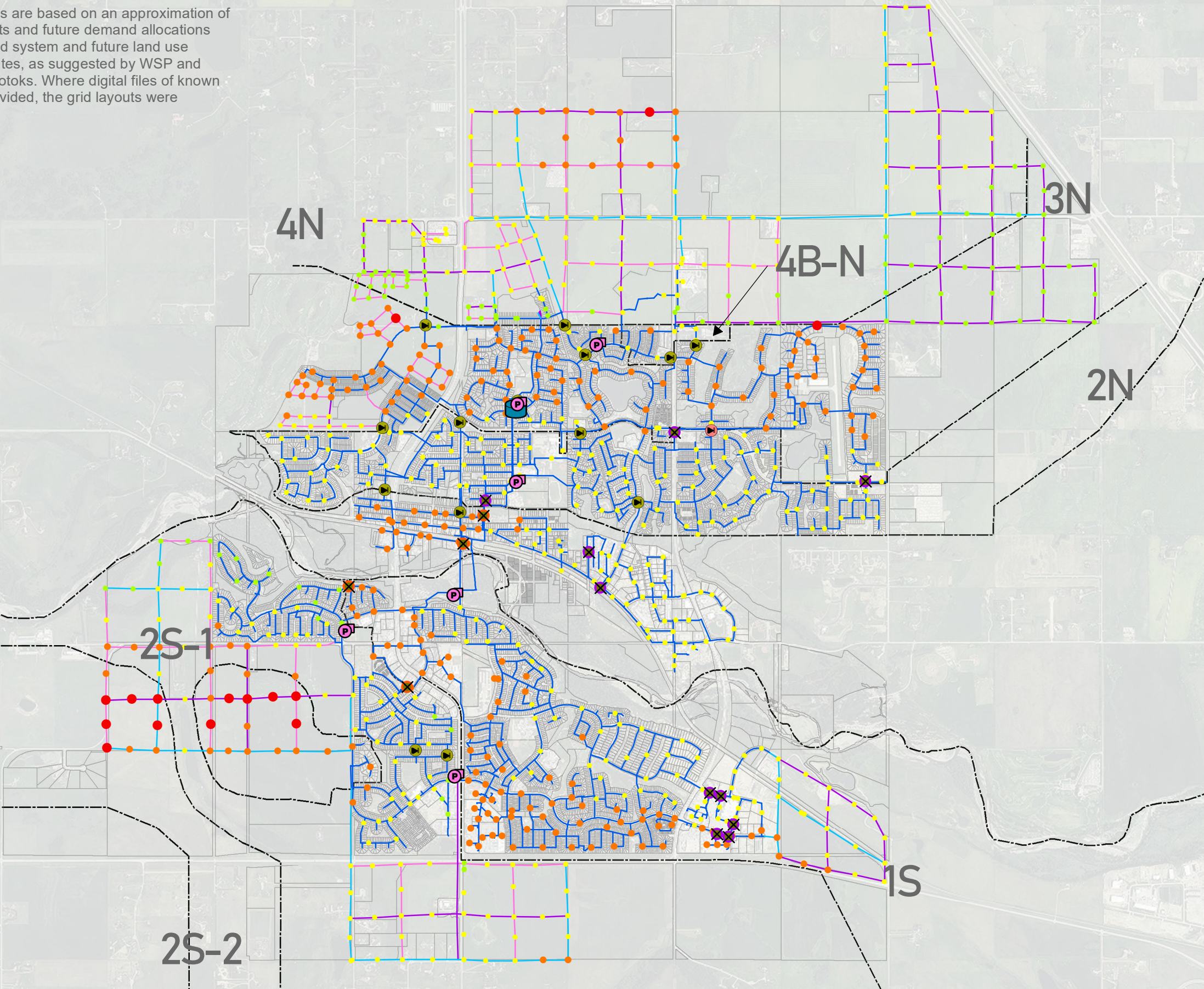


Figure 6-4



Note: Future system deficiencies are based on an approximation of future watermain network layouts and future demand allocations based on the City of Calgary grid system and future land use shapefile and population estimates, as suggested by WSP and agreed upon by the Town of Okotoks. Where digital files of known future network layouts were provided, the grid layouts were modified accordingly.



Legend

- Pump Stations
- Storage Reservoirs
- Active PRV
- Existing Closed PRV
- Check Valve
- Closed Valve
- Pressure Zone Boundaries
- Existing Water Mains

Available Pressures n

- Pressure < 40 Psi
- 40 Psi < Pressure < 60 Psi
- 60 Psi < Pressure < 90 Psi
- 90 Psi < Pressure < 120 Psi
- 120 Psi < Pressure < 150 Psi
- Pressure > 150 Psi

Future Water Mains

- 200 mm
- 250 mm
- 300 mm



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Town of Okotoks
Available Pressures during Average Day Demand
2069

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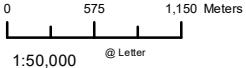
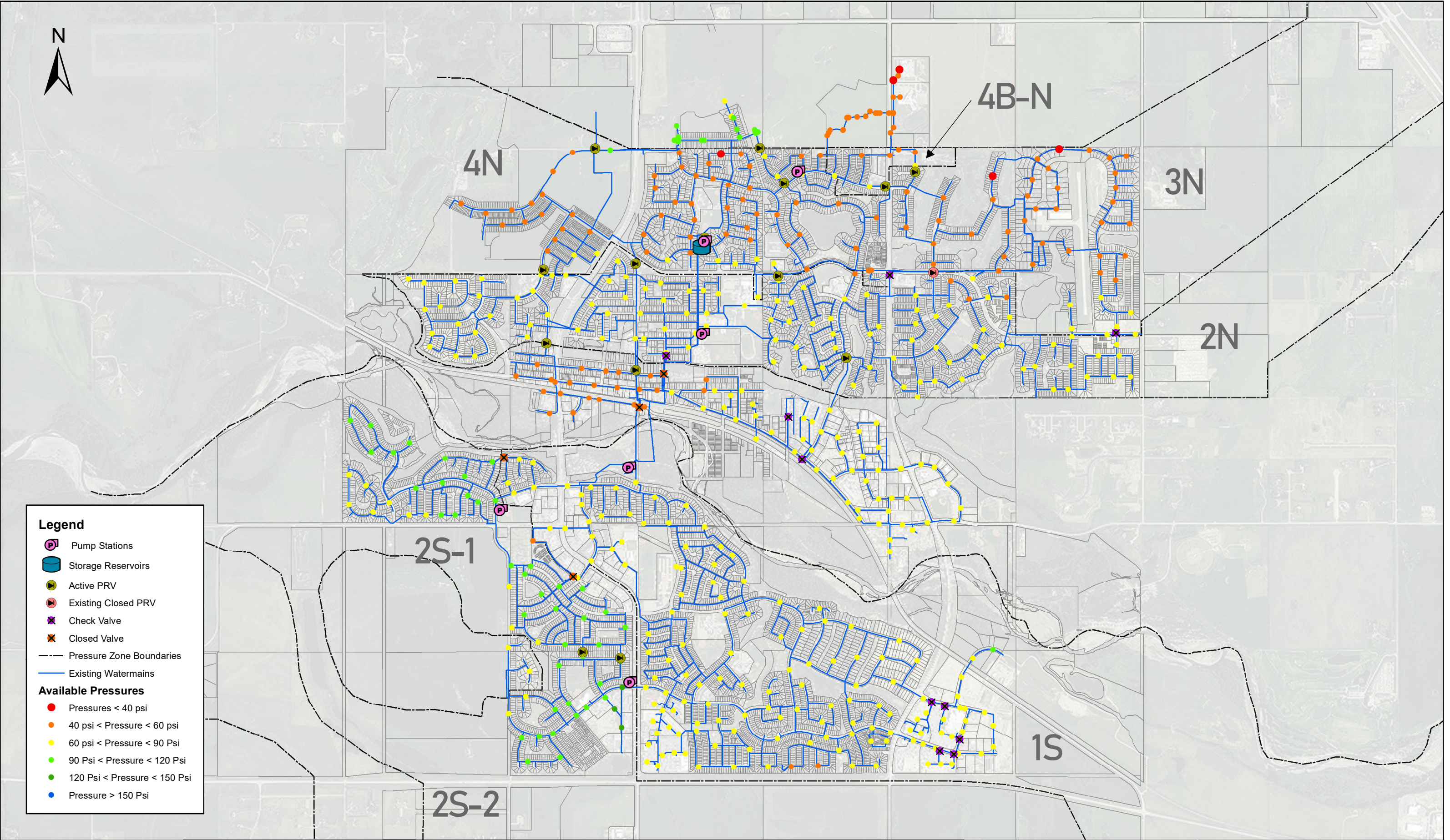


Figure 6-5



Town of Okotoks
Available Pressures during Peak Hour Demand
2019

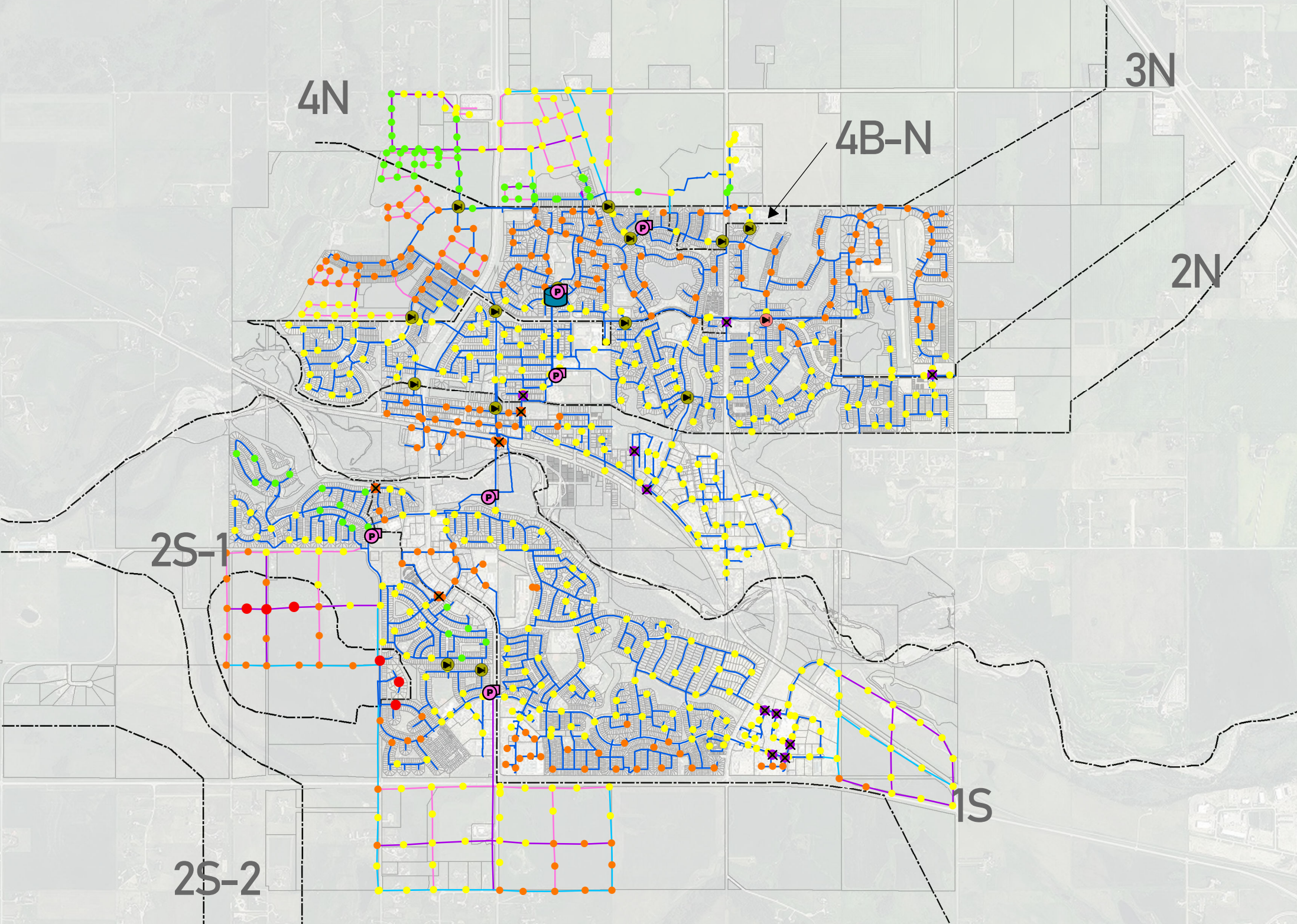
The information used to create this product is based on the most current data available on the date of issue, and is considered reliable only at the scale at which the data was created and the scale at which the map was published. This map is prepared solely for the contractual customer of WSP and WSP

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0 420 840 Meters
1:35,000 @ Letter
Figure 6-6



Note: Future system deficiencies are based on an approximation of future watermain network layouts and future demand allocations based on the City of Calgary grid system and future land use shapefile and population estimates, as suggested by WSP and agreed upon by the Town of Okotoks. Where digital files of known future network layouts were provided, the grid layouts were modified accordingly.



Legend

- Pump Stations
- Storage Reservoirs
- Active PRV
- Existing Closed PRV
- Check Valve
- Closed Valve
- Pressure Zone Boundaries
- Existing Watermains

Available Pressures

- Pressures < 40 psi
- 40 psi < Pressure < 60 psi
- 60 psi < Pressure < 90 Psi
- 90 Psi < Pressure < 120 Psi
- 120 Psi < Pressure < 150 Psi
- Pressure > 150 Psi

Future Water Mains

- 200 mm
- 250 mm
- 300 mm



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Town of Okotoks
Available Pressures during Peak Hour Demand
2024

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0 580 1,160 Meters
1:50,000 @ Letter
Figure 6-7



Note: Future system deficiencies are based on an approximation of future watermain network layouts and future demand allocations based on the City of Calgary grid system and future land use shapefile and population estimates, as suggested by WSP and agreed upon by the Town of Okotoks. Where digital files of known future network layouts were provided, the grid layouts were modified accordingly.

Legend

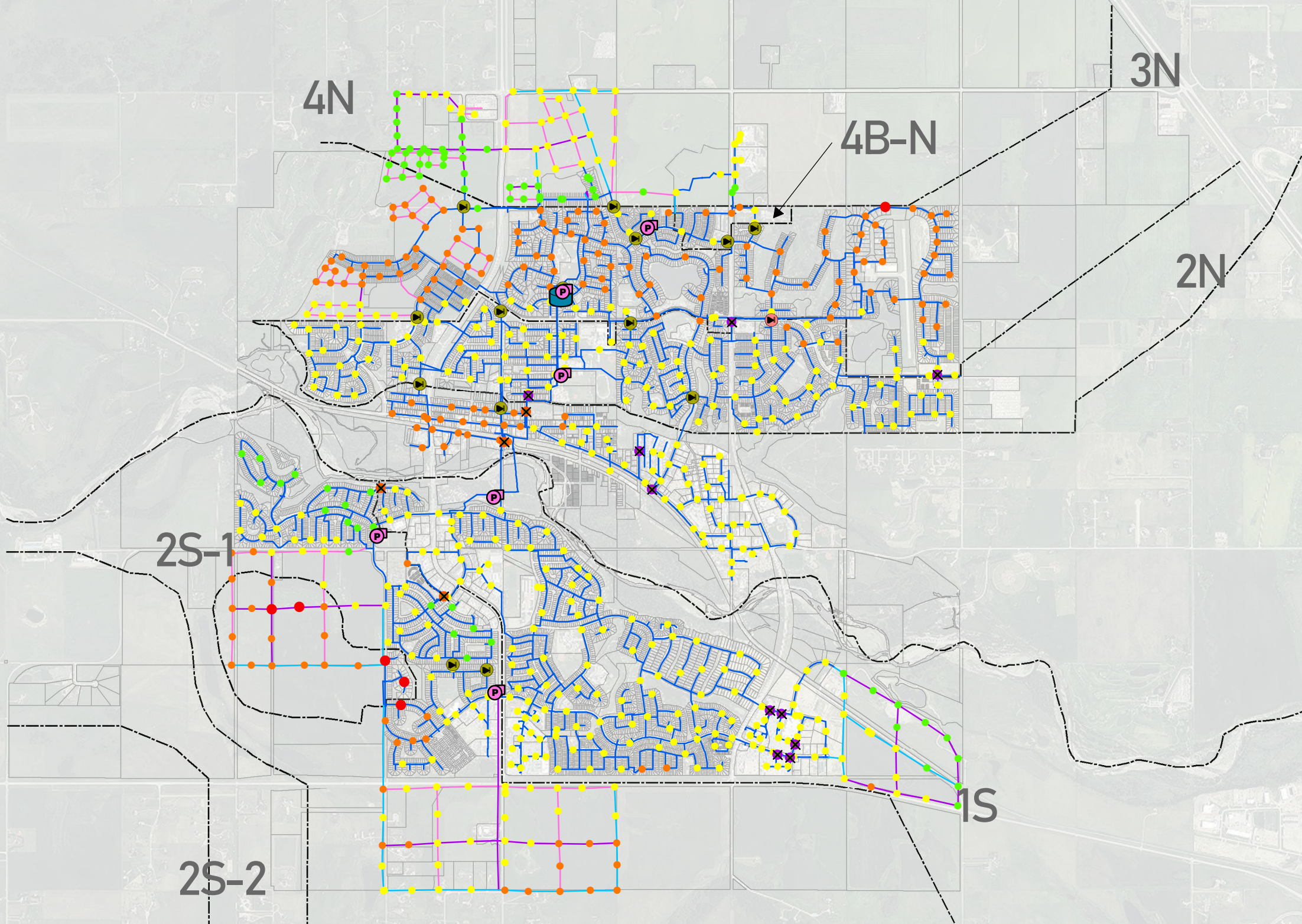
- Pump Stations
- Storage Reservoirs
- Active PRV
- Existing Closed PRV
- Check Valve
- Closed Valve
- Pressure Zone Boundaries
- Existing Watermains

Available Pressures

- Pressures < 40 psi
- 40 psi < Pressure < 60 psi
- 60 psi < Pressure < 90 Psi
- 90 Psi < Pressure < 120 Psi
- 120 Psi < Pressure < 150 Psi
- Pressure > 150 Psi

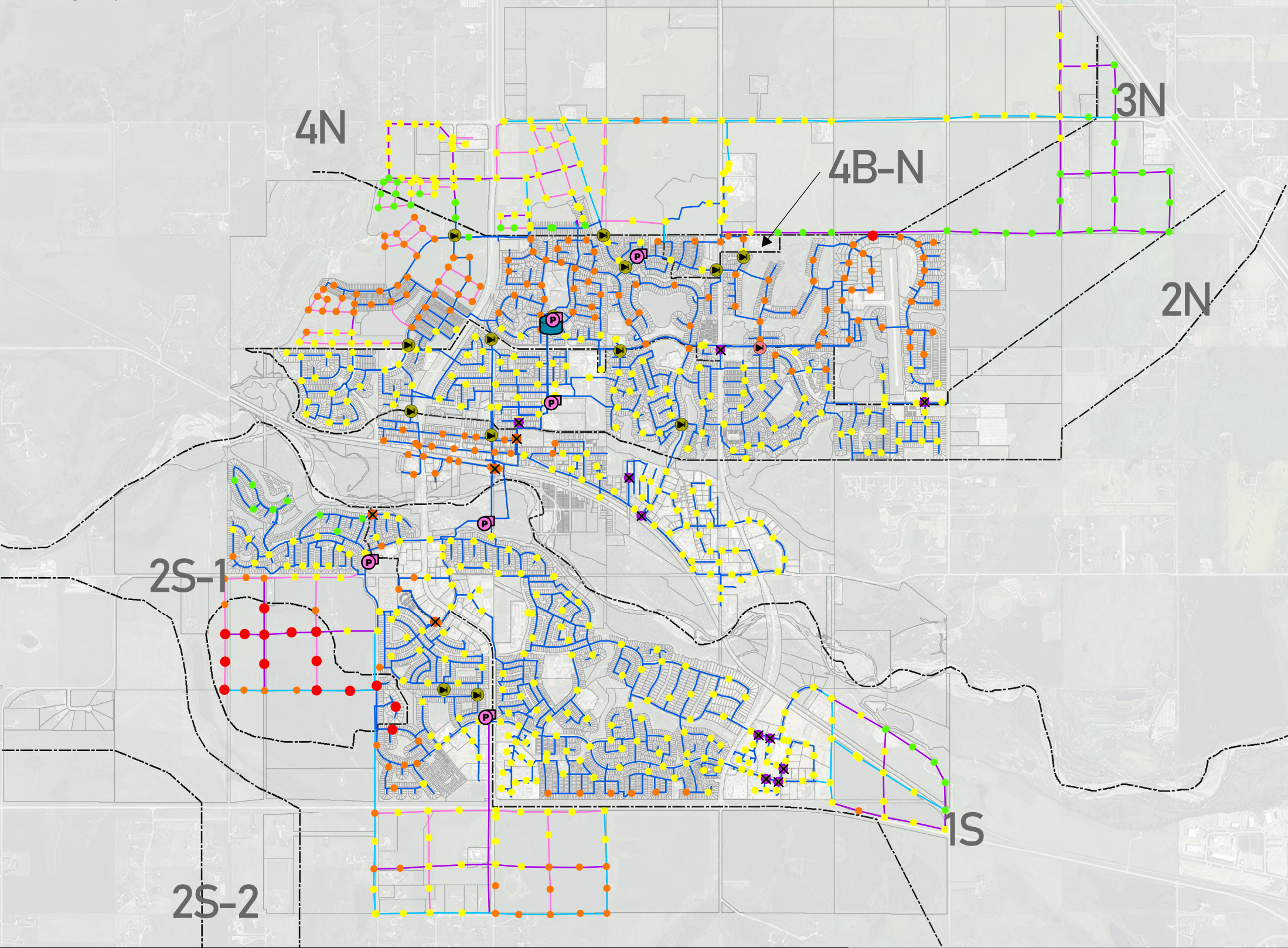
Future Water Mains

- 200 mm
- 250 mm
- 300 mm





Note: Future system deficiencies are based on an approximation of future watermain network layouts and future demand allocations based on the City of Calgary grid system and future land use shapefile and population estimates, as suggested by WSP and agreed upon by the Town of Okotoks. Where digital files of known future network layouts were provided, the grid layouts were modified accordingly.



Legend

- Pump Stations
- Storage Reservoirs
- Active PRV
- Existing Closed PRV
- Check Valve
- Closed Valve
- Pressure Zone Boundaries
- Existing Watermains

Available Pressures

- Pressures < 40 psi
- 40 psi < Pressure < 60 psi
- 60 psi < Pressure < 90 Psi
- 90 Psi < Pressure < 120 Psi
- 120 Psi < Pressure < 150 Psi
- Pressure > 150 Psi

Future Water Mains

- 200 mm
- 250 mm
- 300 mm



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Town of Okotoks
Available Pressures during Peak Hour Demand
2044

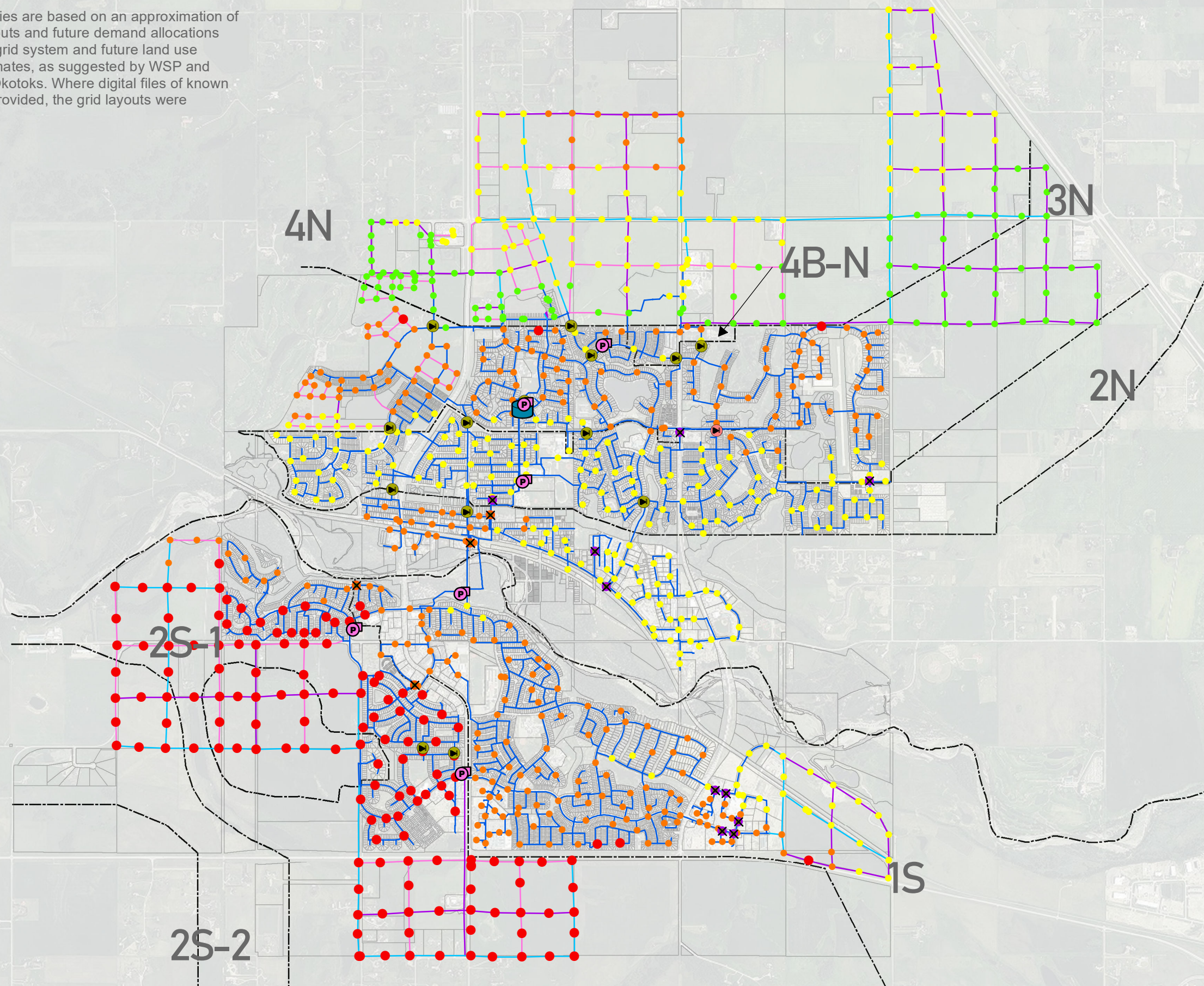
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Date: FEB 2020
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Approved: ML

0 580 1,160 Meters
1:50,000 @ Letter
Figure 6-9



Note: Future system deficiencies are based on an approximation of future watermain network layouts and future demand allocations based on the City of Calgary grid system and future land use shapefile and population estimates, as suggested by WSP and agreed upon by the Town of Okotoks. Where digital files of known future network layouts were provided, the grid layouts were modified accordingly.



Legend

- Pump Stations
- Storage Reservoirs
- Active PRV
- Existing Closed PRV
- Check Valve
- Closed Valve
- Pressure Zone Boundaries
- Existing Watermains

Available Pressures

- Pressures < 40 psi
- 40 psi < Pressure < 60 psi
- 60 psi < Pressure < 90 Psi
- 90 Psi < Pressure < 120 Psi
- 120 Psi < Pressure < 150 Psi
- Pressure > 150 Psi

Future Water Mains

- 200 mm
- 250 mm
- 300 mm



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Town of Okotoks Available Pressures during Peak Hour Demand 2069

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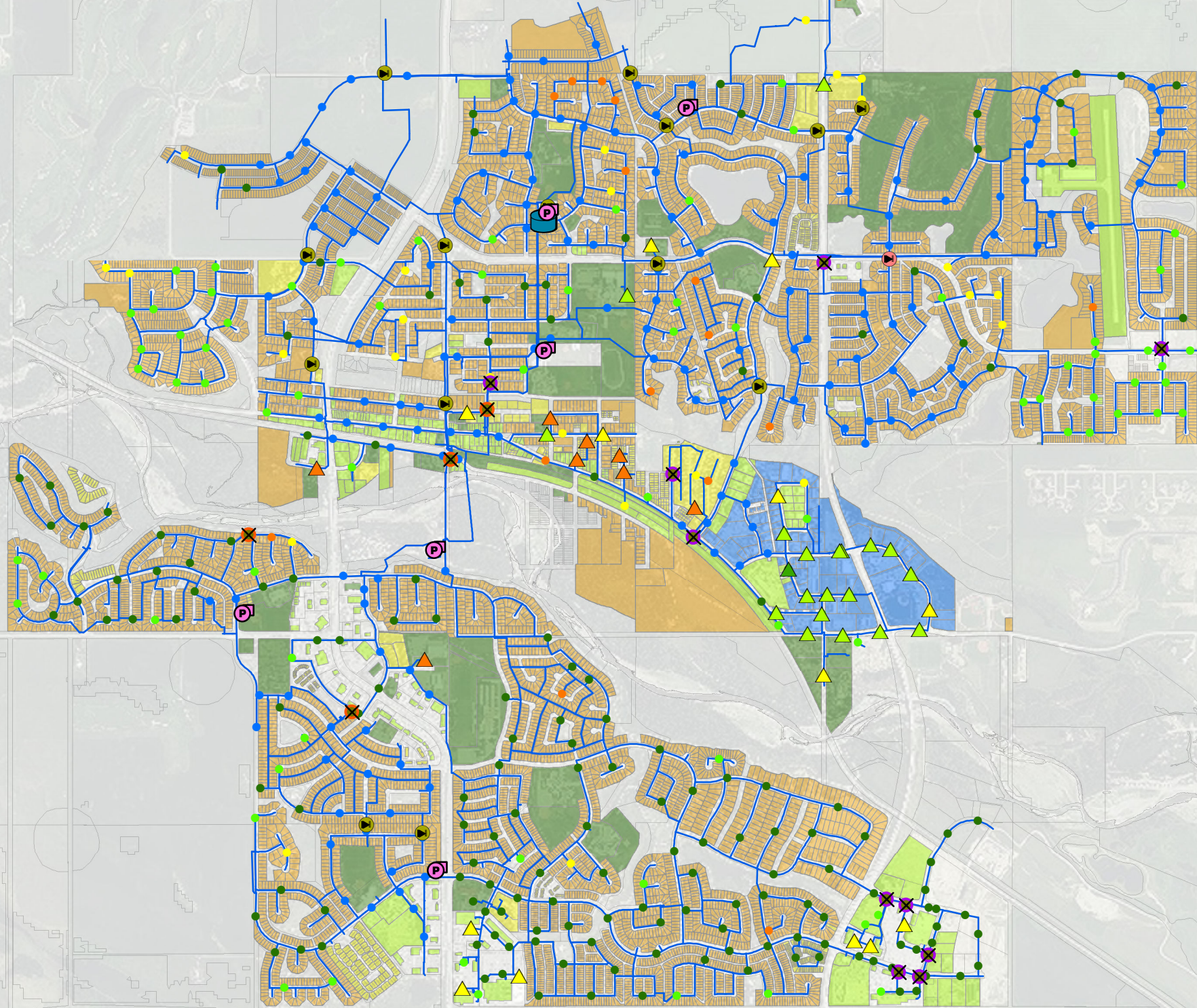
Date: FEB 2020

Drawn: VP/KD

Approved: ML

0 580 1,160 Meters
1:50,000 @ Letter

Figure 6-10



Legend

- Pump Stations
- Storage Reservoirs
- Active PRV
- Existing Closed PRV
- Check Valve
- Closed Valve
- Existing Water Mains

Fire Flow Deficiencies

- Fire Flows < 60 L/s
- 60 L/s < Fire Flows < 110 L/s
- 110 L/s < Fire Flows < 150 L/s
- 150 L/s < Fire Flows < 180 L/s
- 180 L/s < Fire Flows < 225 L/s
- Fire Flows > 225 L/s

Available Fire Flow

- Fire Flows < 60L/s
- 60 L/s < Fire Flows < 110 L/s
- 110 L/s < Fire Flows < 150 L/s
- 150 L/s < Fire Flows < 180 L/s
- 180 L/s < Fire Flows < 225 L/s
- Fire Flows > 225 L/s

Fire Flow Requirements

- Residential (min Fire Flow = 60 L/s)
- Multi-Family (min Fire Flow = 110 L/s)
- Commercial (min Fire Flow = 150 L/s)
- Institutional (min Fire Flow = 180 L/s)
- Industrial (min Fire Flow = 225L/s)



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Town of Okotoks
Available Fire Flows Coincident to Maximum Day Demand
2019

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Date: FEB 2020

Drawn: VP/KD

Approved: ML

0 410 820 Meters
1:35,000 @ Letter

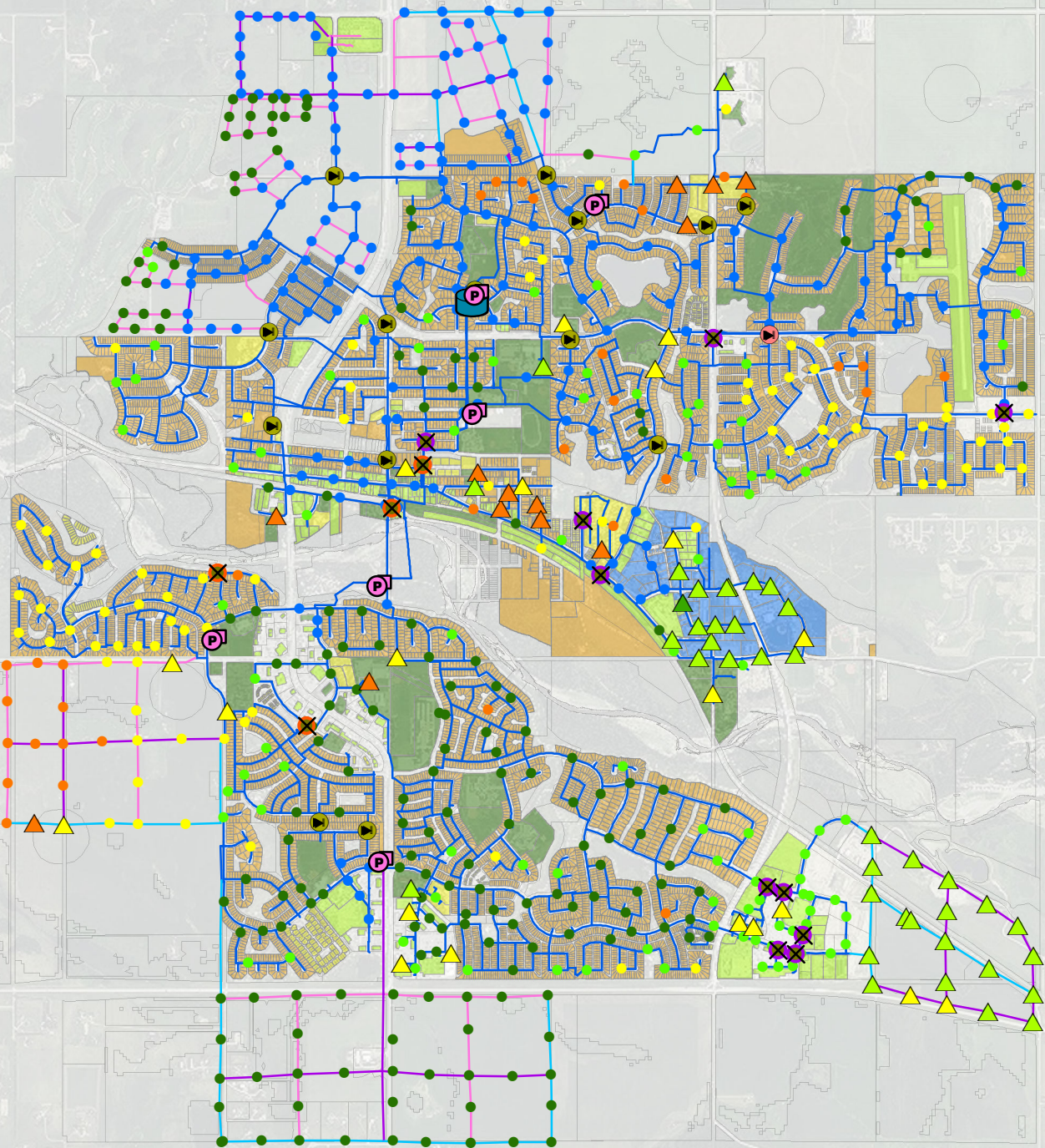
Figure 6-11



Note: Future system deficiencies are based on an approximation of future watermain network layouts and future demand allocations based on the City of Calgary grid system and future land use shapefile and population estimates, as suggested by WSP and agreed upon by the Town of Okotoks. Where digital files of known future network layouts were provided, the grid layouts were modified accordingly.

Legend

- Pump Stations
- Storage Reservoirs
- Active PRV
- Existing Closed PRV
- Check Valve
- Closed Valve
- Existing Water Mains
- Fire Flow Deficiencies**
 - Fire Flows < 60 L/s
 - 60 L/s < Fire Flows < 110 L/s
 - 110 L/s < Fire Flows < 150 L/s
 - 150 L/s < Fire Flows < 180 L/s
 - 180 L/s < Fire Flows < 225 L/s
 - Fire Flows > 225 L/s
- Available Fire Flow**
 - Fire Flows < 60L/s
 - 60 L/s < Fire Flows < 110 L/s
 - 110 L/s < Fire Flows < 150 L/s
 - 150 L/s < Fire Flows < 180 L/s
 - 180 L/s < Fire Flows < 225 L/s
 - Fire Flows > 225 L/s
- Future Water Mains**
 - 200 mm
 - 250 mm
 - 300 mm
- Fire Flow Requirements**
 - Residential (min Fire Flow = 60 L/s)
 - Multi-Family (min Fire Flow = 110 L/s)
 - Commercial (min Fire Flow = 150 L/s)
 - Institutional (min Fire Flow = 180 L/s)
 - Industrial (min Fire Flow = 225L/s)



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Town of Okotoks
Available Fire Flows Coincident to Maximum Day Demand
2024

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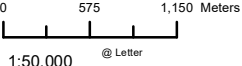


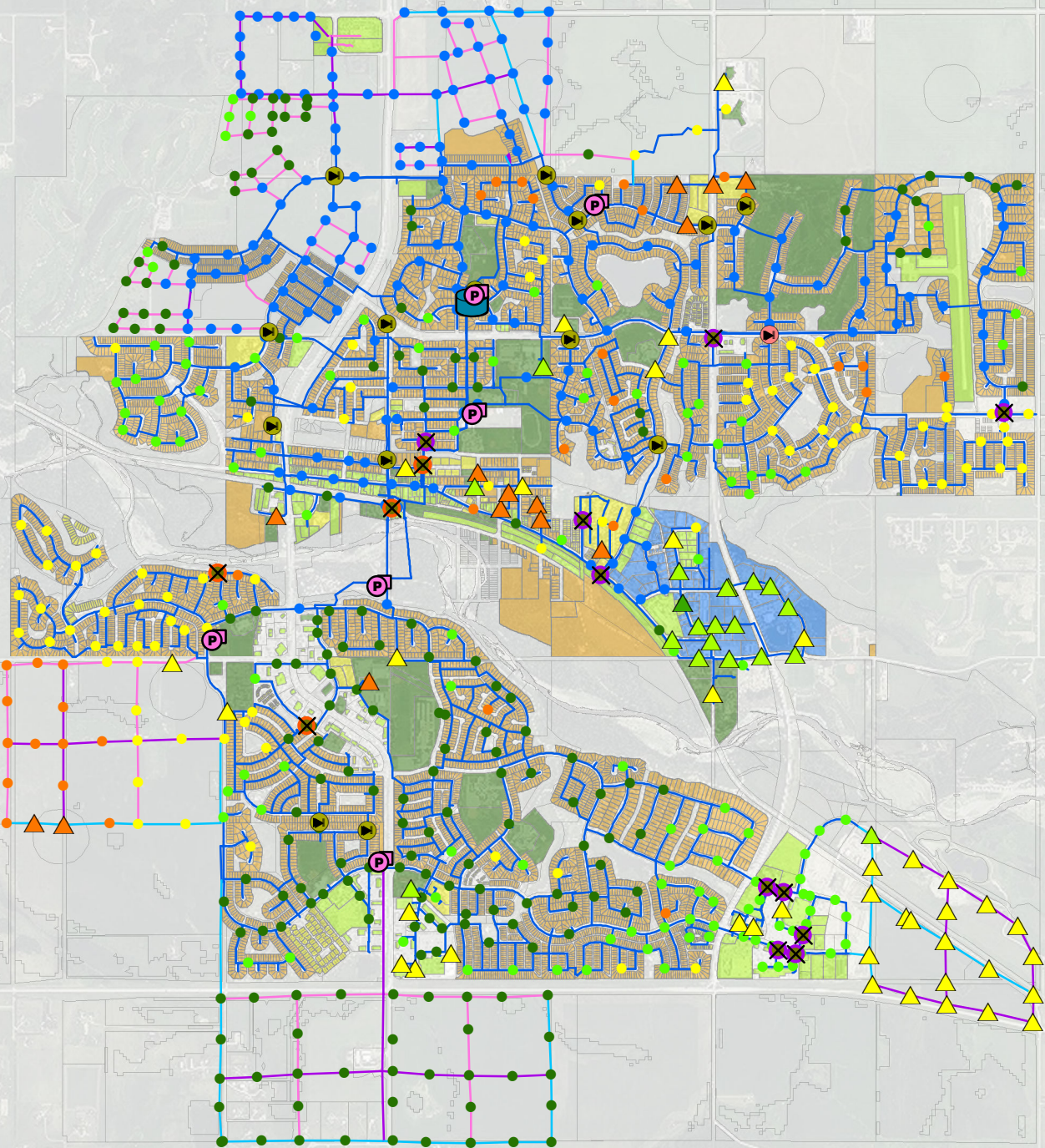
Figure 6-12



Note: Future system deficiencies are based on an approximation of future watermain network layouts and future demand allocations based on the City of Calgary grid system and future land use shapefile and population estimates, as suggested by WSP and agreed upon by the Town of Okotoks. Where digital files of known future network layouts were provided, the grid layouts were modified accordingly.

Legend

- Pump Stations
- Storage Reservoirs
- Active PRV
- Existing Closed PRV
- Check Valve
- Closed Valve
- Existing Water Mains
- Fire Flow Deficiencies**
 - Fire Flows < 60 L/s
 - 60 L/s < Fire Flows < 110 L/s
 - 110 L/s < Fire Flows < 150 L/s
 - 150 L/s < Fire Flows < 180 L/s
 - 180 L/s < Fire Flows < 225 L/s
 - Fire Flows > 225 L/s
- Available Fire Flow**
 - Fire Flows < 60L/s
 - 60 L/s < Fire Flows < 110 L/s
 - 110 L/s < Fire Flows < 150 L/s
 - 150 L/s < Fire Flows < 180 L/s
 - 180 L/s < Fire Flows < 225 L/s
 - Fire Flows > 225 L/s
- Future Water Mains**
 - 200 mm
 - 250 mm
 - 300 mm
- Fire Flow Requirements**
 - Residential (min Fire Flow = 60 L/s)
 - Multi-Family (min Fire Flow = 110 L/s)
 - Commercial (min Fire Flow = 150 L/s)
 - Institutional (min Fire Flow = 180 L/s)
 - Industrial (min Fire Flow = 225L/s)



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Town of Okotoks
Available Fire Flows Coincident to Maximum Day Demand
2029

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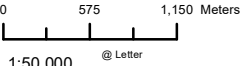


Figure 6-13



Note: Future system deficiencies are based on an approximation of future watermain network layouts and future demand allocations based on the City of Calgary grid system and future land use shapefile and population estimates, as suggested by WSP and agreed upon by the Town of Okotoks. Where digital files of known future network layouts were provided, the grid layouts were modified accordingly.

Legend

- Pump Stations
- Storage Reservoirs
- Active PRV
- Existing Closed PRV
- Check Valve
- Closed Valve
- Existing Water Mains

Fire Flow Deficiencies

- Fire Flows < 60 L/s
- 60 L/s < Fire Flows < 110 L/s
- 110 L/s < Fire Flows < 150 L/s
- 150 L/s < Fire Flows < 180 L/s
- 180 L/s < Fire Flows < 225 L/s
- Fire Flows > 225 L/s

Available Fire Flow

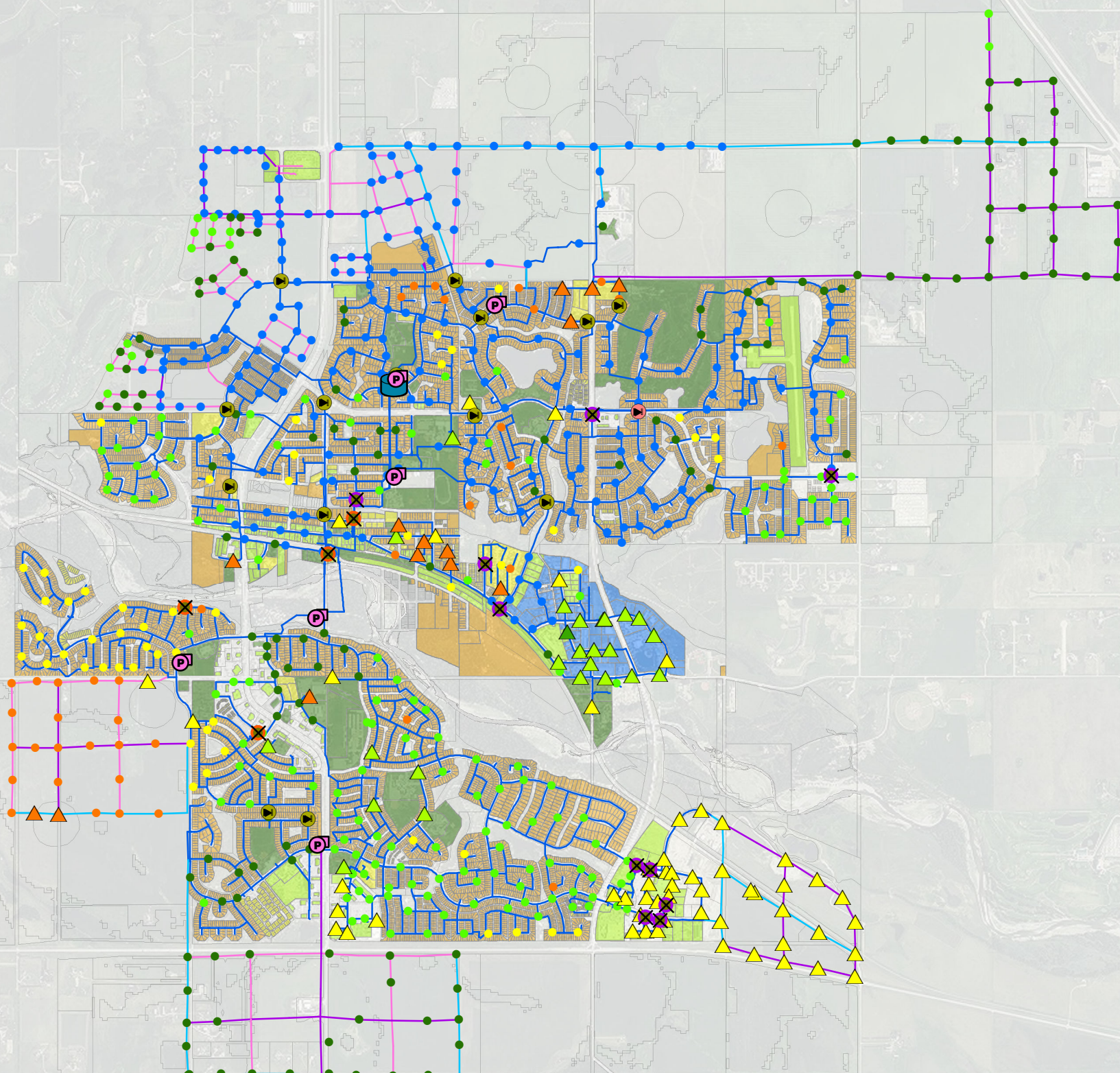
- Fire Flows < 60L/s
- 60 L/s < Fire Flows < 110 L/s
- 110 L/s < Fire Flows < 150 L/s
- 150 L/s < Fire Flows < 180 L/s
- 180 L/s < Fire Flows < 225 L/s
- Fire Flows > 225 L/s

Future Water Mains

- 200 mm
- 250 mm
- 300 mm

Fire Flow Requirements

- Residential (min Fire Flow = 60 L/s)
- Multi-Family (min Fire Flow = 110 L/s)
- Commercial (min Fire Flow = 150 L/s)
- Institutional (min Fire Flow = 180 L/s)
- Industrial (min Fire Flow = 225L/s)



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Town of Okotoks Available Fire Flows Coincident to Maximum Day Demand 2044

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Project No: 19M-01217-00

Date: FEB 2020

Drawn: VP/KD

Approved: ML

0 575 1,150 Meters
1:50,000 @ Letter

Figure 6-14



Note: Future system deficiencies are based on an approximation of future watermain network layouts and future demand allocations based on the City of Calgary grid system and future land use shapefile and population estimates, as suggested by WSP and agreed upon by the Town of Okotoks. Where digital files of known future network layouts were provided, the grid layouts were modified accordingly.

Legend

- Pump Stations
- Storage Reservoirs
- Active PRV
- Existing Closed PRV
- Check Valve
- Closed Valve
- Existing Water Mains

Fire Flow Deficiencies

- Fire Flows < 60 L/s
- 60 L/s < Fire Flows < 110 L/s
- 110 L/s < Fire Flows < 150 L/s
- 150 L/s < Fire Flows < 180 L/s
- 180 L/s < Fire Flows < 225 L/s
- Fire Flows > 225 L/s

Available Fire Flow

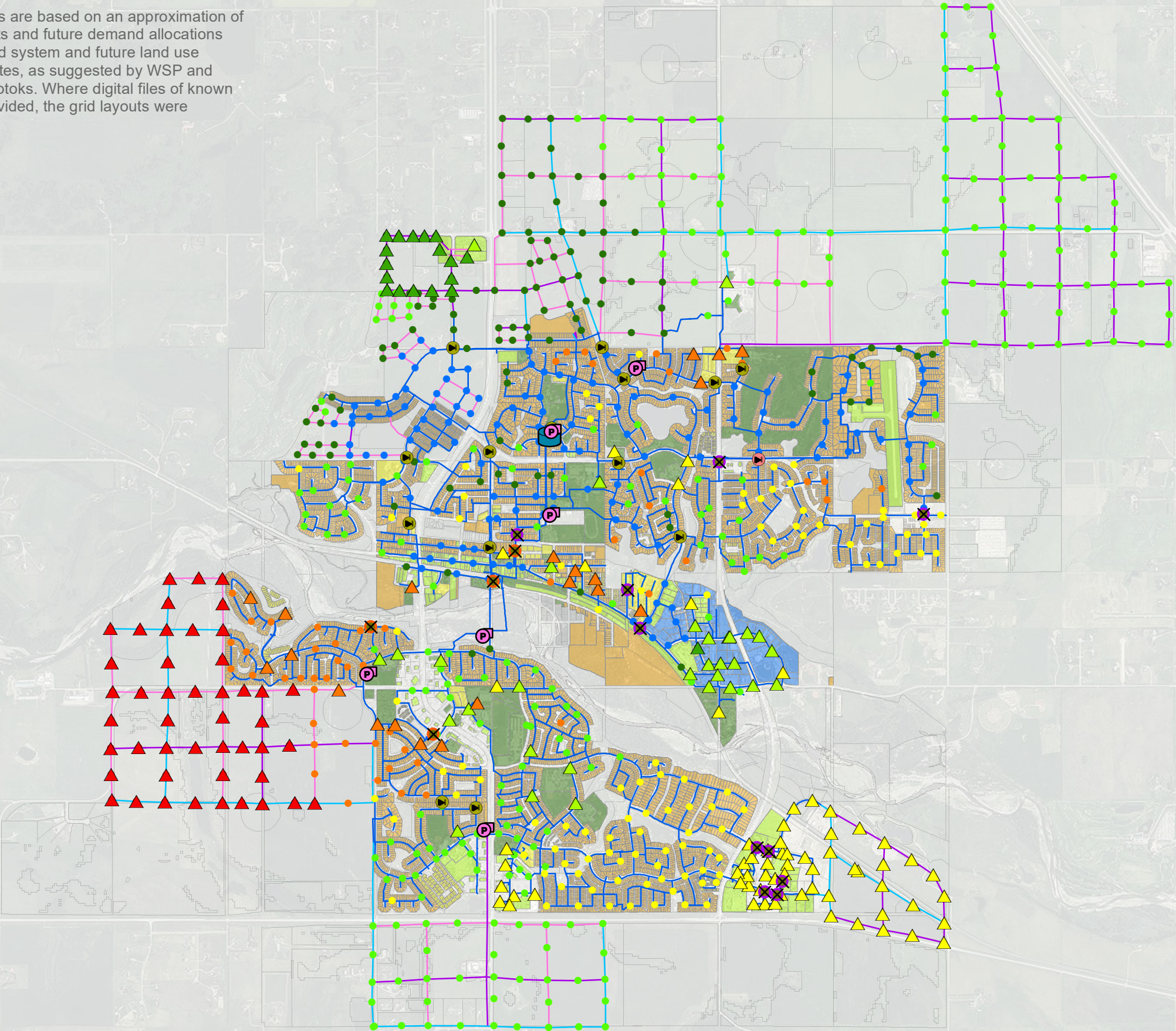
- Fire Flows < 60L/s
- 60 L/s < Fire Flows < 110 L/s
- 110 L/s < Fire Flows < 150 L/s
- 150 L/s < Fire Flows < 180 L/s
- 180 L/s < Fire Flows < 225 L/s
- Fire Flows > 225 L/s

Future Water Mains

- 200 mm
- 250 mm
- 300 mm

Fire Flow Requirements

- Residential (min Fire Flow = 60 L/s)
- Multi-Family (min Fire Flow = 110 L/s)
- Commercial (min Fire Flow = 150 L/s)
- Institutional (min Fire Flow = 180 L/s)
- Industrial (min Fire Flow = 225L/s)



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Town of Okotoks
Available Fire Flows Coincident to Maximum Day Demand
2069

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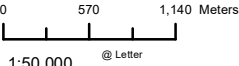


Figure 6-15



Note: Future watermain network layouts and future demand allocations based on the City of Calgary grid system and future land use shapefile and population estimates, as suggested by WSP and agreed upon by the Town of Okotoks. Where digital files of known future network layouts were provided, the grid layouts were modified accordingly.

Legend

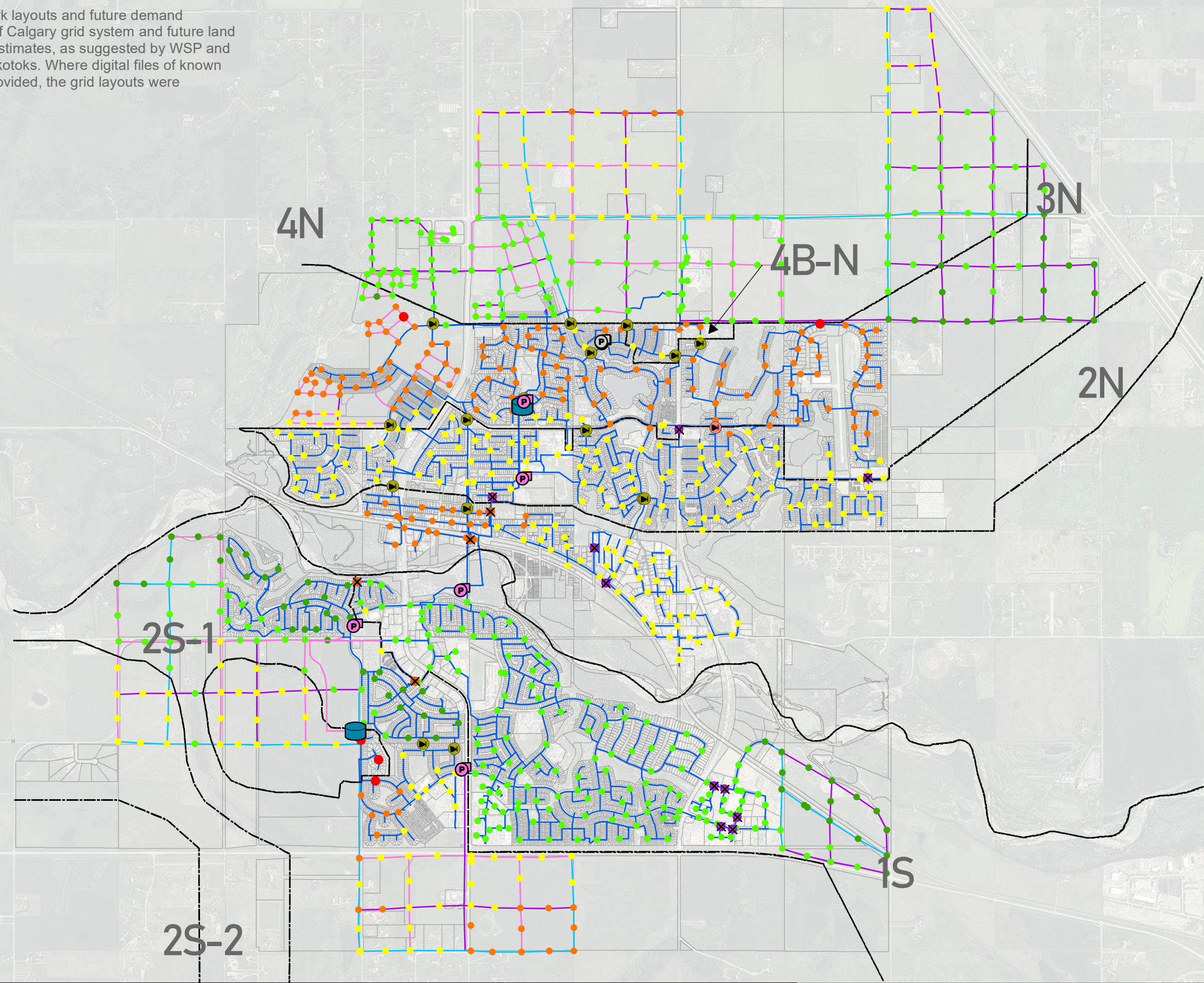
- Decommissioned Crystal Ridge PS
- Pump Stations
- Storage Reservoirs
- Active PRV
- Existing Closed PRV
- Check Valve
- Closed Valve
- Pressure Zone Boundaries
- Existing Watermains

Future Water Mains

- 200 mm
- 250 mm
- 300 mm

Available Pressures

- Pressures < 40 psi
- 40 psi < Pressure < 60 psi
- 60 psi < Pressure < 90 Psi
- 90 Psi < Pressure < 120 Psi
- 120 Psi < Pressure < 150 Psi
- Pressure > 150 Psi



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Town of Okotoks

Available Pressures during Peak Hour Demand with Improvements

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Date:	FEB 2020
Drawn:	VP/KD
Approved:	ML

Figure 6-16



Note: Future watermain network layouts and future demand allocations based on the City of Calgary grid system and future land use shapefile and population estimates, as suggested by WSP and agreed upon by the Town of Okotoks. Where digital files of known future network layouts were provided, the grid layouts were modified accordingly.

Legend

- Decommissioned Crystal Ridge PS
- Pump Stations
- Storage Reservoirs
- Active PRV
- Existing Closed PRV
- Check Valve
- Closed Valve

Fire Flow Requirements

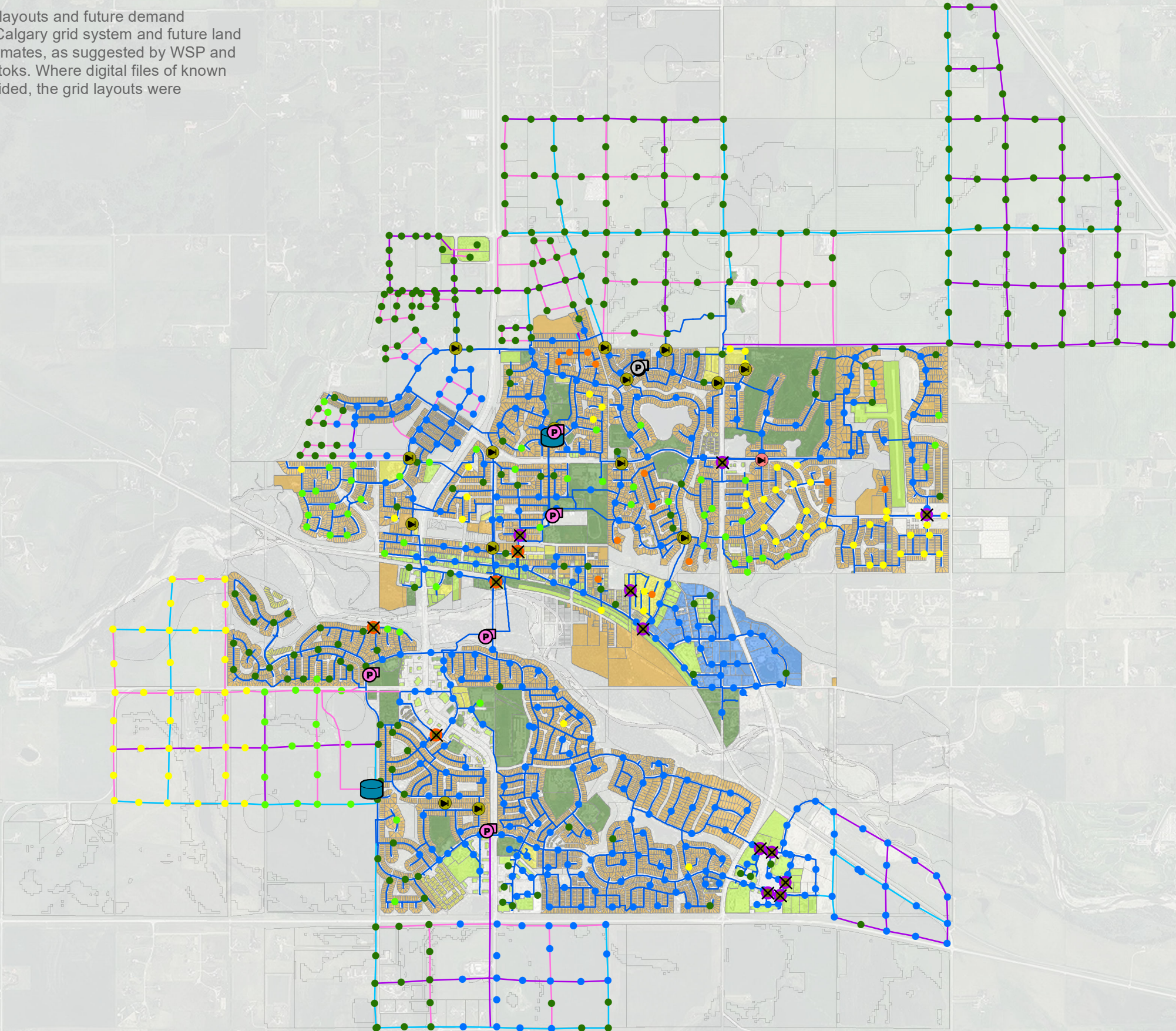
- Residential (min Fire Flow = 60 L/s)
- Multi-Family (min Fire Flow = 110 L/s)
- Commercial (min Fire Flow = 150 L/s)
- Institutional (min Fire Flow = 180 L/s)
- Industrial (min Fire Flow = 225L/s)
- Existing Water Mains

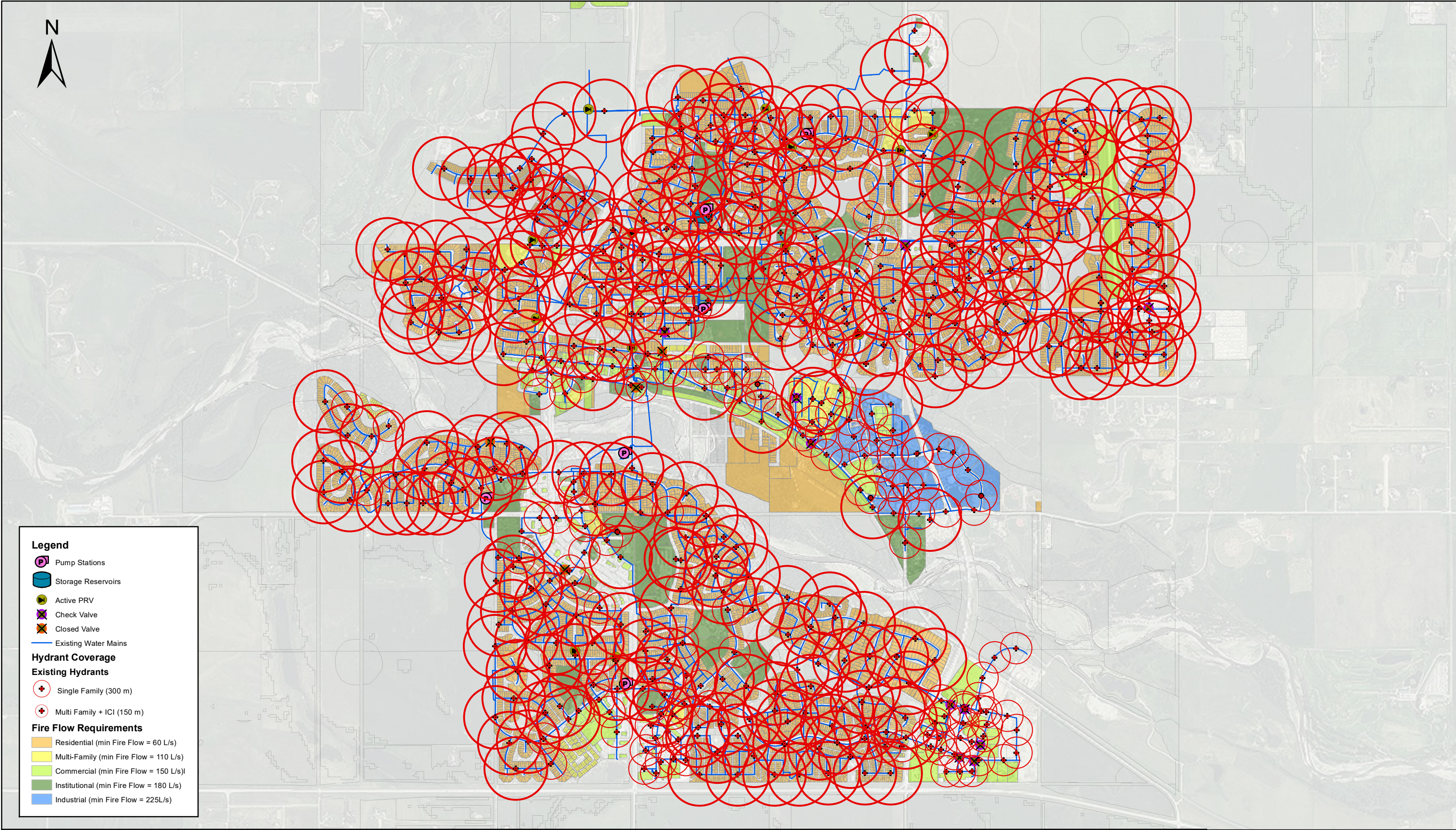
Future Water Mains

- 200 mm
- 250 mm
- 300 mm

Available Fire Flows

- Fire Flows < 60L/s
- 60 L/s < Fire Flows < 110 L/s
- 110 L/s < Fire Flows < 150 L/s
- 150 L/s < Fire Flows < 180 L/s
- 180 L/s < Fire Flows < 225 L/s
- Fire Flows > 225 L/s





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**Town of Okotoks
Hydrant Coverage Analysis**

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Drawn: VP/KD
Approved: ML

0 390 780 Meters
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Figure 6-18

7 AUXILIARY STUDIES

This section details the auxiliary studies completed within the Water Master Plan for the Town of Okotoks to provide further review of the Town's overall network and future opportunities.

7.1 WATER SYSTEM GHG EMISSIONS

In 2018, the Town of Okotoks published its Environmental Master Plan which outlined its plans and goals in order to minimize the generation of greenhouse gas emissions (GHG) and air pollutants from all sources. This document sets the Town's target to achieve carbon neutrality by 2050, to achieve 100% renewable energy generation by 2050 and to meet or beat Alberta's Ambient Air Quality Objectives. The goal of achieving carbon neutrality by 2050 aligns with the Canadian Government's recent announcement to achieve net-zero emissions by 2050.

This report outlines the following eleven key strategies to reduce GHG emissions and air pollutants;

- 1 Develop and implement a comprehensive Renewable Energy Strategy to encourage, support and implement new forms of renewable energy generation,
 - 2 Work with partners to identify appropriate alternative space heating fuels and technologies,
 - 3 Improve access to energy and emissions performance of existing buildings,
 - 4 Require higher levels of energy performance in new building construction,
 - 5 Assist and incentivize the building industry and homeowners in meeting higher energy performance levels in new and existing buildings,
 - 6 Foster the use of non-automotive, active modes of transportation,
 - 7 Improve access to public transit options, both within Okotoks and between neighboring municipalities,
 - 8 Support the uptake of low-emissions vehicles,
 - 9 Support car and ride sharing,
 - 10 Create pedestrian-friendly, emission-free environments,
 - 11 Develop and implement measures to improve indoor and outdoor air quality.
-

7.1.1 EXISTING ENERGY USE AND GHG EMISSIONS

In 2019, the Town of Okotoks published its Greenhouse Gas Inventory which outlines 2018 as a baseline against which progress towards carbon neutrality will be measured. The baseline year of 2018 shows a corporate inventory of 24,335 metric tons of carbon-dioxide equivalent (tonnes CO₂e) and a community inventory of 379,747 tonnes CO₂e.

The Water and Wastewater sector of the Town is documented to produce approximately 5,315 tonnes CO₂e which makes up about 1.3% of the Town's total GHG Emissions and 21.8% of the Corporate Inventory GHG Emissions. The Water and Wastewater sector is the third largest emitter within the Corporate Inventory sector. The majority of the Water and Wastewater sector's GHG emissions come from electricity, 87.8%, while the remaining emissions come from Natural Gas. This indicates that moving towards renewable electricity generation would significantly reduce or eliminate GHG emissions within the Water and Wastewater sector.

The inventory baseline report further outlines the top emitters within the sector. The wastewater treatment plant, the water treatment plant, the west well field pump station, the Zone 2 North reservoir and Zone 3 reservoir make up 93% of GHG emissions within the sector. This indicates that the sector may benefit

from retrofitting the existing buildings to increase energy efficiency or the requirement of higher levels of energy performance in new building construction.

It is also noted in Technical Memorandum No.3 - Review of Water Conservation Measures of this WMP, that non-revenue water currently accounts for 27.4% of the Town's gross volume of water extracted in 2018. Non-revenue water is defined as the difference between gross water extracted from wells and billed water. It can be used as a metric to measure the water system efficiency as it can be used as an indicator of leakage within a system. While the Town has made progress by reducing water treatment plant process losses from 8% to 4% from 2010 to 2019 it still has some ways to go to further increase its water system efficiency. Accounting for water treatment plant process losses, the unaccounted non-revenue water in 2018 was 23.4%. The reduction of this value means targeting leakage and finding unaccounted for water. A reduction in the NRW value is likely to lead to an improvement on water system efficiencies thus leading to a reduction on associated GHG emissions from the water treatment process.

As climate change progresses and global temperatures increase, a greater variance in reservoir levels are expected and water resource management and planning will become even more critical.

7.1.2 GHG EMISSION PROJECTIONS

As the population of the Town of Okotoks is projected to grow from its current 29,002 residents to 54,474 residents in the next 30 years, the forecast shows that the business-as-usual approach will lead to a continual increase in corporate and community emission levels.

We have carried out a projection of emissions within the sector based on the three reference case scenarios as outlined in the "Greenhouse gas and air pollutant emissions projections: 2019" document published by the Government of Canada.

The 2015 Reference Case (BR2) is the worst-case scenario for GHG under the Greenhouse gas and air pollutant emissions projections. It includes actions proposed by the Canadian Government in the biennial report on climate change, prior to the establishment of the Pan-Canadian Framework on Clean Growth and Climate change. The 2019 Reference Case (BR4) scenario includes government actions, consumer actions, and business actions put in place by September 2019. This projection assumes governments take no further climate action from September 2019 on. It is considered a mid level project between the worst-case scenario and most optimistic projections. The 2019 Additional Measures Case (BR4) is the most optimistic scenario for GHG under the Greenhouse gas and air pollutant emissions projections. This scenario additionally considers actions taken by federal, provincial and territorial governments, as well as actions not fully implemented but that have been announced by September 2019. An example of such a measure would be the Clean Fuel Standard, which is being developed but is not yet implemented. The current estimates do not yet fully account for future reductions from green infrastructure, clean technology and innovation. Environment and Climate Change Canada expects that GHG projections will continue to decline towards the 2030 target.

The Water and Wastewater sector in the Town was reviewed together in order to maintain consistency with the Town's Greenhouse Gas Inventory Baseline Report. In the analysis below, data obtained from the emissions projection document was used to develop graphs that will reflect the projected annual change in GHG Emissions from 2018 to 2030 in the Town's Water and Wastewater sector. A baseline year of 2018 was used for the analysis, using the data provided in the Greenhouse Gas Inventory Report, which equates to a starting point of 5,315 tonnes CO₂e as outlined in the Town's Greenhouse Gas Inventory.

Figure 7-1 shows the Town's Water and Wastewater sector GHG emission projections while Table 7-1 outlines the Town's GHG Emission projections in the years 2025 and 2030 under the three scenarios.

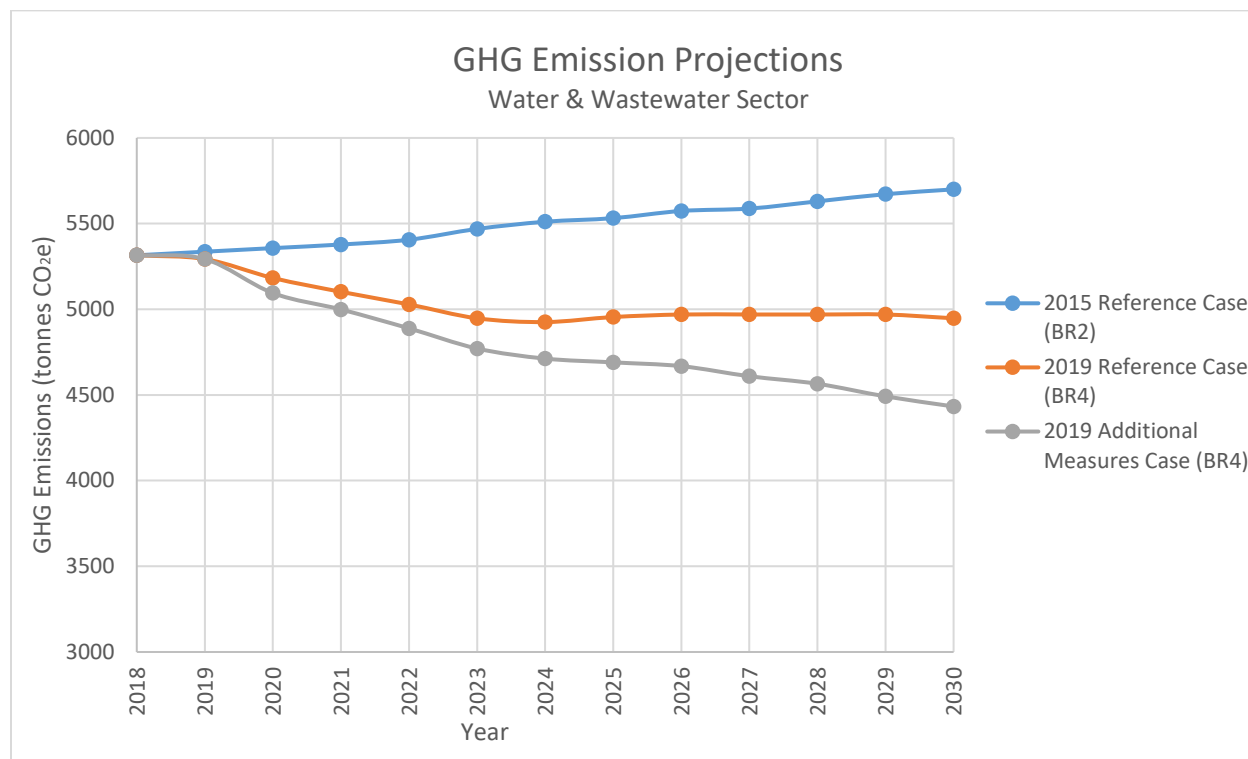


Figure 7-1: Water and Wastewater GHG Projections

Table 7-1: Water and Wastewater GHG Projections

SCENARIO	2025 GHG EMISSIONS	2030 GHG EMISSIONS
The 2015 Reference Case (BR2)	5,532 tonnes CO ₂ e	5,700 tonnes CO ₂ e
The 2019 Reference Case (BR4)	4,955 tonnes CO ₂ e	4,947 tonnes CO ₂ e
The 2019 Additional Measures Case (BR4)	4,690 tonnes CO ₂ e	4,433 tonnes CO ₂ e

The data shows an approximately linear increase in GHG emissions for the Town's Water and Wastewater sector under the 2015 reference case, which translates to a 0.72% increase in GHG emissions per year. Under the 2019 Additional Measures case, the Town could see a reduction in GHG emissions at a rate of approximately 1.65% per year.

7.1.3 RECOMMENDATIONS ON FURTHER STUDIES

It is noted that the Town has already made progress in outlining their goals and strategies via the Environmental Master Plan published in 2018. While this is a strong starting point, the Town should actively implement these goals and strategies to reduce GHG emissions.

To support sustainable growth and development of the Town's water system it is recommended that the Town actively look at the feasibility of upgrades to the existing infrastructure to improve efficiencies across the Town's Water and Wastewater sectors. This may range from repair of leakages via water system audits, increased water metering, leak detection and repair, district metering areas to the

retrofitting or replacement of pumps. As noted, the Town may would also benefit from investigating the retrofitting of existing buildings within this sector and renewable electricity sources as this would significantly reduce or eliminate GHG emissions within the sector.

Details on recommended further studies for reducing GHG emissions are listed below:

- A complete water system audit in order to fully account for the non-revenue water within the system. Any water that is unaccounted for or lost via leakage is water that is treated and pumped within the system leading to inefficiencies causing increased GHG emissions. It is likely that a decrease in non-revenue water will lead to a decrease in emissions within the sector.
- Feasibility studies on potential renewable energy sources, this would have a positive impact on GHG emissions within the sector as well as on the Town as a whole. While the Town has made progress on this via the Drake Landing Solar Community which began operation in 2007 further investigations into the use of renewables should be considered. The emissions in the sector are made up entirely from Electricity and Natural Gas, therefore the use of renewables such as Solar, Wind or Hydro would directly reduce emissions by directly offsetting the use of carbon heavy fuels for generation.
- Feasibility studies on building envelope retrofitting, for items like renewable energy sources, would have a positive impact on GHG emissions within the sector as well as on the Town as a whole. Improvements in treatment plant efficiency may be possible through the retrofitting of building components such as building envelopes. Any newly constructed buildings within the sector should also be constructed to a higher energy efficient standard. Producing bylaws and regulations to require higher levels of energy performance in new building construction would assist this across the Town. Further initiatives such as an investigation into available retrofitting grants may be beneficial.

7.2 CHLORINATION SYSTEM REVIEW

The Town's existing chlorination system is located at the Sheep River Water Treatment Plant. The water is dosed with chlorine following UV disinfection as the final stage of the treatment process. The free chlorine residual is then tested continuously at two points in the system, at Zone 3N and Zone 4N to test the primary disinfection rates.

WSP obtained data from the Town and EPCOR from a document entitled "Annual Summary of the Distribution Chlorine Residual" for 2015 to 2018. The data received showed that testing was taken at the South Reservoir and the Zone 2N Reservoir to test the primary disinfection rates during this time. Grab samples were taken daily at two random locations across the water distribution system to test the secondary disinfection rate.

Our assessment of the data concluded that water quality at the respective test locations adequately met the free chlorine residual limit of ≥ 0.2 mg/L for primary disinfection locations and ≥ 0.1 mg/L for secondary disinfection locations. These are the minimum chlorine residual level standards as set out by the Canadian Drinking Water Quality Guideline and the Alberta Municipal Water Works Standard. The World Health Organization suggests using no more than 5 mg/L as most people will smell or taste the chlorine at higher concentrations. The average chlorine residual level over the period in the primary disinfection of the system was 1.22 mg/L at the South Reservoir testing location and 1.20 mg/L at the Zone 2N Reservoir testing location. The minimum chlorine residual across the system tested was 0.35 mg/L, at the random test location #2 during the month of June in 2018. The chlorine residual level data over the period is summarized in Table 7-2 below.

Table 7-2: Chlorine Residual Levels by Location (2015-2018)

LOCATION	WATER QUALITY PARAMETER	APPROVAL LIMIT	MINIMUM CHLORINE RESIDUAL	MAXIMUM CHLORINE RESIDUAL	AVERAGE CHLORINE RESIDUAL
Southern Reservoir	Primary Disinfection	≥0.2mg/L	1.57 mg/L	1.6 mg/L	1.22 mg/L
Zone 2N Reservoir	Primary Disinfection	≥0.2mg/L	1.57 mg/L	1.48 mg/L	1.20 mg/L
Random Test Location 1	Secondary Disinfection	≥0.1mg/L	0.53 mg/L	0.75 mg/L	1.02 mg/L
Random Test Location 2	Secondary Disinfection	≥0.1mg/L	0.35 mg/L	0.81 mg/L	1.02 mg/L

While the residual levels fluctuate throughout the year, it is noted that the annual minimum has been recorded in April and May in both the primary and secondary disinfection in all instances except in the secondary disinfection in 2016 where the minimum residual was recorded in August. This can be seen in Figures 7-2 and 7-3 below.

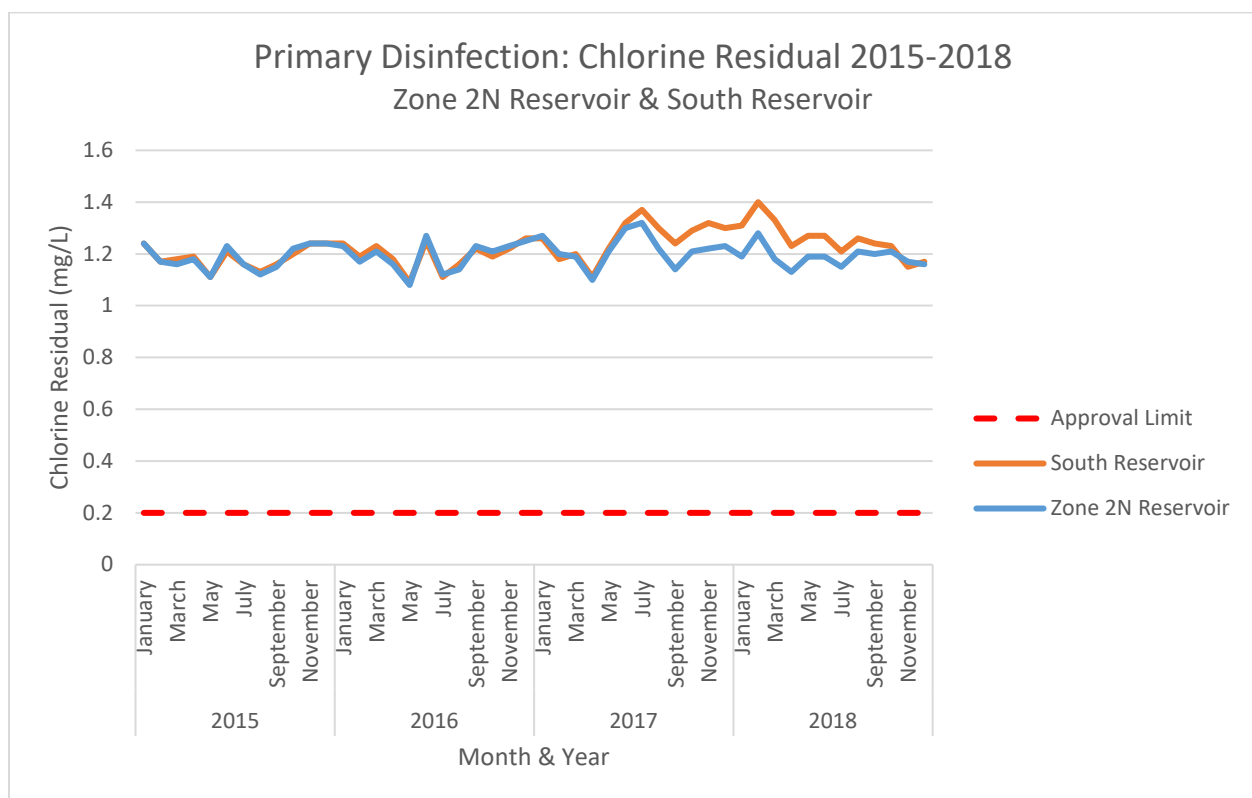


Figure 7-2: Primary Disinfection Residual Levels

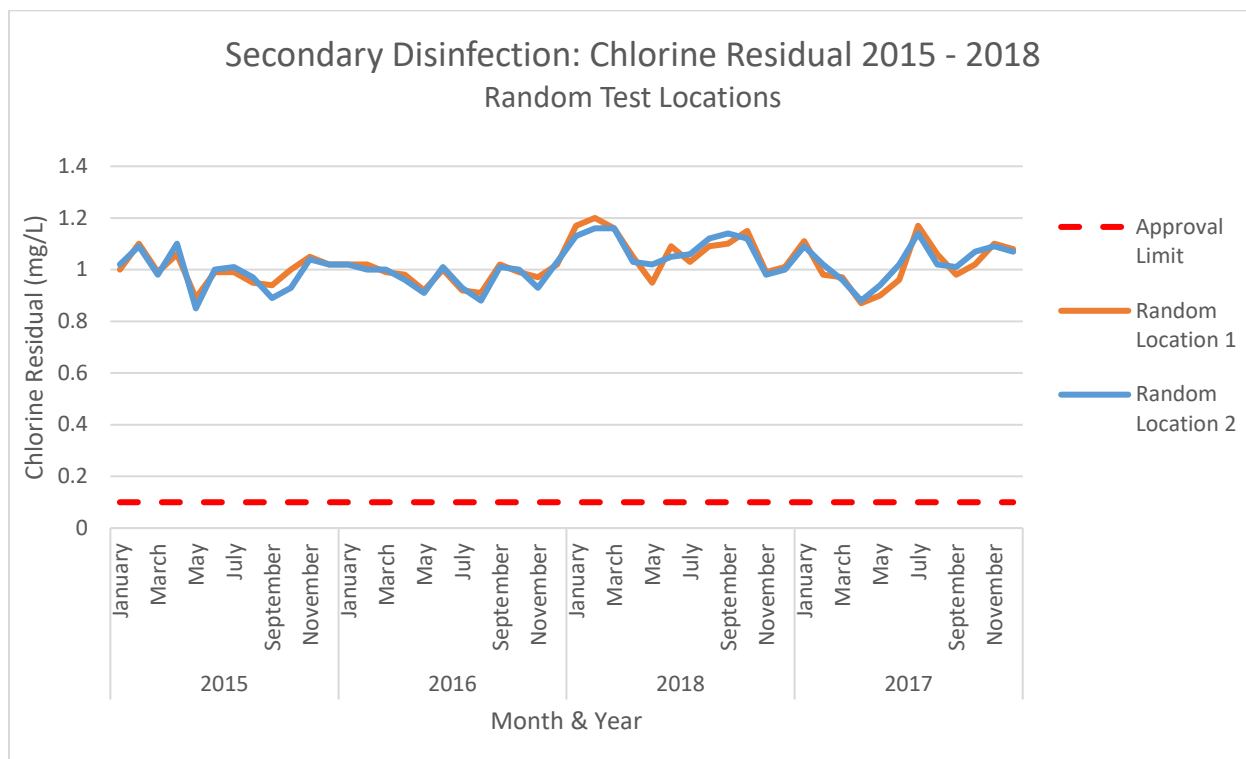


Figure 7-3: Secondary Disinfection Residual Levels

There are a number of factors that may cause the decrease of chlorine residual levels in the water system such as;

- Higher ambient temperatures;
- Organic matter in the source water;
- Longer retention times; and,
- Low flow/stagnant areas within the distribution system.

While a decrease is noted in the chlorine residual in the summer months, the existing chlorination system at Sheep River Water Treatment Plant is providing the Town with adequate chlorine residual levels and no immediate system improvements to the system is required.

Looking ahead to future growth and considering the effects of climate change, the gradual decline and/or larger annual fluctuations in the free chlorine residual levels may occur due to the expected higher ambient temperatures in the summer. In preparation of this, consideration and planning for the installation of re-chlorination stations and/or chlorine analyzer stations to consistently monitor residual levels throughout the water distribution network will be beneficial. It will also allow the town to gain a better understanding of their chlorination throughout the water distribution system.

If the town is to increase of free chlorine residual levels in the system to combat the potential drops from climate change, closer monitoring of water odour and taste will be required. Currently there is no upper limit on the approval limits for the addition of chlorine to drinking water in the Canadian Drinking Water Quality Guideline or the Alberta Municipal Water Works Standard, as a guideline value is not necessary due to the low toxicity at concentrations found in drinking water. The World Health Organization suggests using no more than 5 mg/L. Typically, free chlorine concentrations in most Canadian drinking water distribution systems range from 0.04 to 2.0 mg/L, the Town comfortably fell within this range

during the 2015 to 2018 period. With adequate placement of chlorine booster stations, a balance between residual chlorine levels, taste and odor issues can be achieved, and preservation of water quality throughout the system allowing for future growth is possible, it will also allow the Town to further understand the chlorination within their system.

7.2.1 RECOMMENDATIONS ON FURTHER ANALYSIS

Currently the existing chlorination system at Sheep River Water Treatment Plant is providing the Town with adequate chlorine residual levels and no immediate system improvements to the system are required.

Looking ahead to future growth and considering the effects of climate change, the gradual decline and/or larger annual fluctuations in the free chlorine residual levels could likely be anticipated. In preparation of this, the consideration and planning for the installation of re-chlorination stations and/or chlorine analyzer stations/kiosks to consistently monitor residual levels throughout the water distribution network will be beneficial and also highly recommended.

It is recommended that the Town could also eventually undertake a hydraulic modelling analysis of free chlorine in the distribution system in relation to population growth and climate change. This will provide insight into the Town's need for chlorine booster stations and chlorine residual analyzers over the growth horizons as population increases, water demands increase, and global temperatures rise. This will provide information on the optimal placement of chlorine booster stations within the Town's distribution network and provide insight into long term infrastructure planning.

7.3 CONDITION ASSESSMENT AND RISK EVALUATION

The purpose of the condition assessment and risk evaluation was to conduct a review of the Town's linear and non-linear water utility assets based on an initial review of existing available record data from the Town. The subsequent task was to develop a standardized approach to evaluating the urgency with which major renewals of aged assets would have to be implemented. Risk in the context of reinvestment planning is a measure of the consequence of the asset's failure combined with its probability of failure.

WSP calculated Estimated Service Lives (ESL) and Remaining Service Lives (RSL) for each of the Town's reservoirs, pump stations, PRV stations, and watermains. ESL's for each asset were based on industry-standard service lives for major municipal utility components. A critical aspect to estimating RSL is asset age and condition. In the absence of detailed condition data, WSP followed an age-based approach to quantify the likely condition and likelihood of failure or need for intervention for each asset. The age-based RSL can be further refined through subsequent studies using performance characteristics and historic asset life/survival data, as this information becomes available.

7.3.1 NON-LINEAR ASSETS (RESERVOIRS, PUMP STATIONS, PRV STATIONS)

For the Town's non-linear assets, WSP applied condition scores to each asset based on the Percent Remaining Service Life (% RSL) which follows the standardized qualitative rating schema defined in the 2016 Canadian Infrastructure Report Card (CIRC) and the Canadian Network of Asset Managers (CNAM) Asset Management 101 booklet. As indicated by CNAM and in the 2016 CIRC, using Percent RSL is a good approximation of physical condition in the absence of field-recorded condition data and performance-based deterioration curves.

Table 7-3 illustrates the condition grading system laid out in the 2016 CIRC and the CNAM Asset Management 101 booklet which was used to rate the Town's non-linear assets.

Table 7-3: Non-Linear Asset Condition Ranking Criteria based on CIRC

CONDITION DESCRIPTION	CONDITION SCORE	DESCRIPTION	% REMAINING SERVICE LIFE
Very Good	1	Fit for the future. Well maintained, good condition, new or recently rehabilitated.	80% - 100%
Good	2	Adequate for now. Acceptable, generally approaching mid stage of expected service life.	60% - 80%
Fair	3	Requires attention. Signs of deterioration, some elements exhibit deficiencies.	40% - 60%
Poor	4	At risk of affecting service. Approaching end of service life, condition below standard, large portion of system exhibits significant deterioration.	20% - 40%
Very Poor	5	Unfit for sustained service. Near or beyond expected service life, widespread signs of advanced deterioration, some assets may be unusable.	< 20%

Once condition ratings were determined for each non-linear asset, WSP determined consequence of failure ratings for each asset on a scale of 1 to 5. The consequence of failure rating was based on the size of the downstream service area for each asset and criticality of the asset in delivering services (e.g. considering primary versus secondary supplies, backup supplies, etc.). Once the condition/likelihood of failure and the consequence of failure scores were tabulated, each asset was assigned a risk rating based on the scoring matrix summarized in Table 7-4.

Table 7-4: Risk Scoring Matrix for Non-Linear Assets

		Consequence of Failure				
		1	2	3	4	5
Condition Rating (Likelihood of Failure)		Very Low	Low	Medium	High	Very High
1	Very Good	1 (good)	2 (good)	3 (good)	4 (good)	5 (good)
2	Good	2 (good)	4 (good)	6 (accept)	8 (accept)	10 (accept)
3	Fair	3 (good)	6 (accept)	9 (accept)	12 (monitor)	15 (monitor)
4	Poor	4 (good)	8 (accept)	12 (monitor)	16 (Mitigate)	20 (mitigate)
5	Very Poor	5 (good)	10 (accept)	15 (monitor)	20 (mitigate)	25 (mitigate)

The subsections below summarize the risk ratings for each non-linear asset and the rationale and scoring for each item.

RESERVOIR RISK RATINGS

As each of the Town's three reservoirs are part of either a larger reservoir and pump station site or part of the Sheep River WTP, the reservoirs were evaluated only on their structural component as this is the most critical subcomponent for a reservoir asset. Ratings for mechanical and electrical subcomponents were considered as part of the associated pump stations.

Table 7-5 summarizes the scoring for each existing reservoir as well as provides details on the rationale for scoring.

Table 7-5: Reservoir Risk Rating

RESERVOIR	INSTALL YEAR	% RSL ¹	CONDITION RATING	COF RATING	RISK SCORE	NOTES
South	1995	75%	2	5	10 (accept)	CoF scores of 5 since outage cannot be tolerated due to critical infrastructure.
2N	2003	83%	1	5	5 (good)	
3N	1979	59%	3	5	15 (monitor)	

1. Assumed ESL of 100 years for reservoir structures, assuming regular inspections, repairs, and O&M.

As indicated in the table above, the Town's reservoirs have a low risk rating score with the exception of the 3N reservoir which has a risk score of 15 (monitor). The 3N Reservoir should be monitored and considered a priority for detailed condition assessment in the near future. The Town has indicated the 3N Reservoir requires rehabilitation works, therefore the actual condition score may be higher (closer to 4 or 5). Therefore, the 3N Reservoir has been targeted for improvement works in the Capital Plan, however it is recommended to conduct field investigations into the asset's actual condition prior to any upgrades or renewals.

PUMP STATION RISK RATINGS

A number of the Town's pump stations were identified for distribution and fire suppression capacity-related improvements. These improvements are phased over the life of the pump stations and could involve significant mechanical and electrical subcomponent improvements. As such, the mechanical and electrical subcomponents have not been evaluated for this risk-based assessment as most are covered under the capacity analysis. Therefore, the risk assessment for existing pump stations focuses solely on the life of the pump station structures.

Table 7-6 summarizes the scoring for each existing pump station as well as provides details on the rationale for scoring.

Table 7-6: Pump Station Risk Rating

PUMP STATION	INSTALL YEAR	% RSL ¹	CONDITION RATING	COF RATING	RISK SCORE	NOTES
SRWTP – North Supply	1995	50%	3	5	15 (monitor)	CoF of 5 since outage cannot be tolerated due to critical infrastructure.
SRWTP – South Supply	2004	68%	2	5	10 (accept)	
2N Pump Station	2003	66%	2	4	8 (accept)	CoF of 4 since service area could be supplied by Zone 3N Reservoir and Pump Station for limited time in case of outage.
3N Pump Station	2018	96%	1	5	5 (good)	CoF of 5 since outage cannot be tolerated due to critical infrastructure.
Big Rock Booster Station	1990	40%	4	3	12 (monitor)	CoF of 3 since service area could be serviced by Westmount Booster Station in case of outage.
Westmount Booster Station	2004	68%	2	2	4 (good)	CoF of 2 since service area is small, could be serviced by Big Rock Booster Station in case of outage.

PUMP STATION	INSTALL YEAR	% RSL ¹	CONDITION RATING	COF RATING	RISK SCORE	NOTES
Crystal Ridge Booster Station	2003	66%	2	1	2 (good)	To be decommissioned in the near future, 4BN Zone can be supplied by 4N Zone via PRVs.

1. Assumed ESL of 50 years for pump station structures, assuming regular inspections, repairs, and O&M.

As indicated in the table above, the Town's pump stations have a low risk rating score with the exception of the North Supply pumps and the Big Rock booster station. Based on the scoring methodology, the Big Rock booster station will not trigger a higher risk rating as the asset ages, therefore the station should be monitored for condition and performance. The North Supply pumps will reach a condition score of 4 which will trigger a higher risk rating requiring possible major intervention by 2024. It is recommended to conduct field investigations into the asset's existing condition to determine the actual level of risk for the pump station.

PRV STATION RISK RATINGS

With regular maintenance, repairs, and teardowns, PRV station mechanical subcomponent ESLs can be extended to the ESL of the PRV station structure. Renewal cost associated with electrical subcomponents are considered minimal compared to the mechanical and structural subcomponents. Therefore, the risk assessment for existing PRV stations focuses solely on the life of the PRV station structures.

Table 7-6 summarizes the scoring for each existing PRV station as well as provides details on the rationale for scoring.

Table 7-7: PRV Station Risk Rating

PRV STATION	INSTALL YEAR	% RSL ¹	CONDITION RATING	COF RATING	RISK SCORE	NOTES
10C	2005	70%	2	2	4 (good)	CoF of 2 due to low domestic flows and available back up supply
10F	2005	70%	2	5	10 (accept)	CoF of 5 due to significant fire flow deficiencies due to outage
13B	2018	96%	1	3	3 (good)	CoF of 3 due to medium domestic flows and available back up supply
13E	2018	96%	1	4	4 (good)	CoF of 4 due to medium domestic flows and primary supply once Crystal Ridge Pump Station is decommissioned.
100	2004	68%	2	3	6 (accept)	CoF of 3 due to medium domestic flows and available back up supply
103	2005	70%	2	3	6 (accept)	CoF of 3 due to medium domestic flows and available back up supply
106	2006	72%	2	2	4 (good)	CoF of 2 due to low domestic flows and available back up supply
138	2017	94%	1	2	2 (good)	CoF of 2 due to low domestic flows and available back up supply
D3	2002	64%	2	3	6 (accept)	CoF of 3 due to medium domestic flows and available back up supply

PRV STATION	INSTALL YEAR	% RSL ¹	CONDITION RATING	COF RATING	RISK SCORE	NOTES
D6	1979	18%	5	3	15 (monitor)	CoF of 3 due to medium domestic flows and available back up supply
D9	1979	18%	5	5	25 (mitigate)	CoF of 5 due to significant fire flow deficiencies due to outage
DC	2013	86%	1	3	3 (good)	CoF of 3 due to medium domestic flows and available back up supply
E2	2003	66%	2	2	4 (good)	CoF of 2 due to low domestic flows and available back up supply
E5	2013	86%	1	2	2 (good)	CoF of 2 due to low domestic flows and available back up supply
PRV-461	2018	96%	1	3	3 (good)	CoF of 3 due to medium domestic flows and available back up supply

1. Assumed ESL of 50 years for PRV station structures, assuming regular inspections, repairs, and O&M.

As indicated in the table above, the Town's PRV stations have a low risk rating score with the exception of the D6 PRV station supplying the 2N Zone and the D9 PRV station supplying the 1N Zone. Based on the scoring methodology, the D6 PRV station will not trigger a higher risk rating as the asset ages, therefore the station should be monitored for condition and performance. The D9 PRV station is currently rated as a high-risk asset requiring possible major intervention in the near term. It is highly recommended to conduct field investigations into the asset's existing condition to determine the actual level of risk for the D9 PRV station. The replacement of the D9 PRV station has been included in the Capital Projects List detailed in Section 8.

7.3.2 LINEAR ASSETS (WATERMAINS)

For the Town's linear assets, WSP considered the age, material, and historic watermain break history to determine a renewal schedule for the Town's watermains. Figures 7-4 and 7-5 illustrate the distribution of watermain breaks in the Town between 2006 and 2017 based on available records.

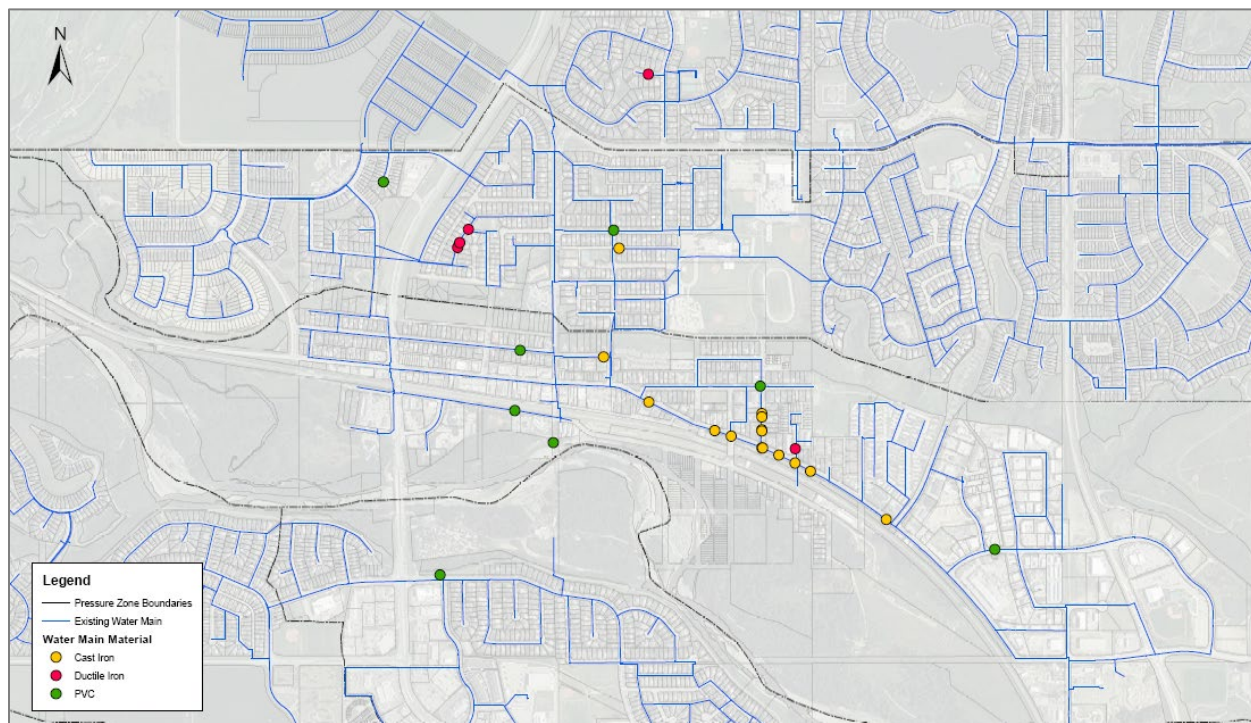


Figure 7-4: Watermain Breaks in the Town of Okotoks by Location (2006 – 2017)

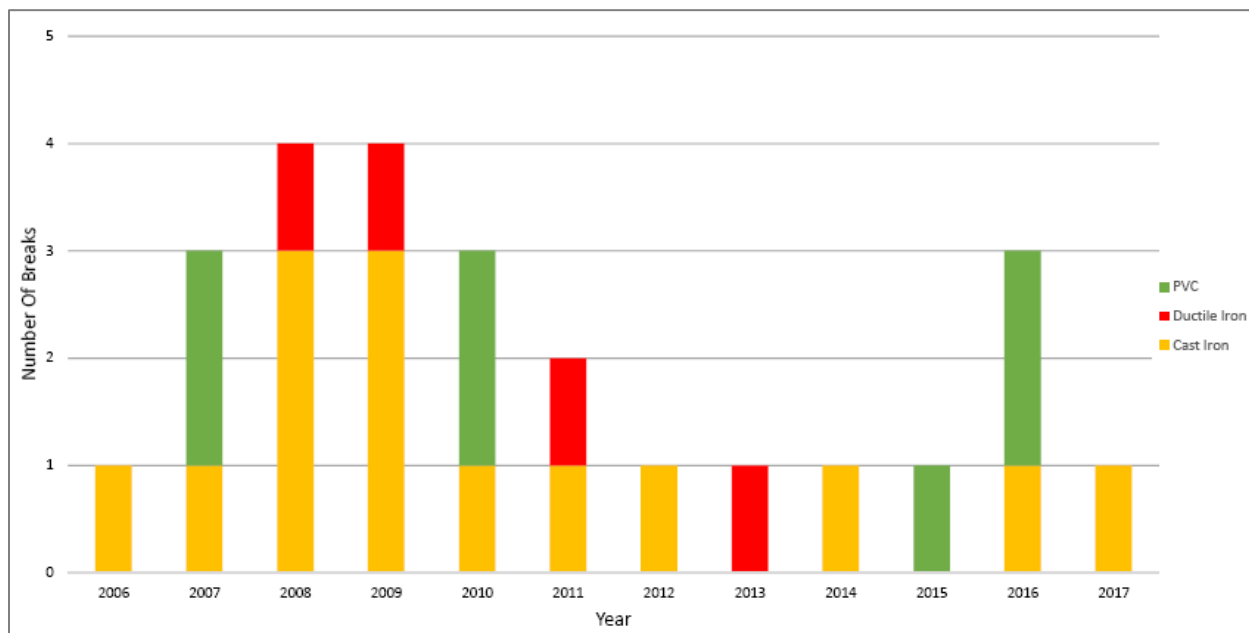


Figure 7-5: Watermain Breaks in the Town of Okotoks by Material (2006 – 2017)

As illustrated in the figures above, the majority of watermain breaks in recent history have occurred on cast iron mains, concentrated along the 150 mm watermain on North Railway Street east of McRae Street which was originally constructed in 1952 (this section has been targeted for capital upgrades as part of Capital Project WM-01 as detailed in the Capital Projects List, though a portion of it was recently upgraded by the Town). There have also been some breaks observed on PVC and Ductile Iron mains.

Based on the Town's watermain break history and typical estimated service lives, WSP developed a table of estimated service lives for watermain based on type of material, as detailed in Table 7-8 below. As the Town moves forward with any detailed Asset Management Program for its water utility in the future, these service lives can be updated as required for the specific purposes of asset management.

Table 7-8: Watermain Estimated Service Lives

MATERIAL	ESTIMATE SERVICE LIFE (YEARS)
Steel	80
Asbestos Cement	80
PVC	80
HDPE	80
Ductile Iron	80
Copper	80
PEX	80
Cast Iron	60

Figure 7-6 illustrates the long-range renewal forecast for the Town based on the current age of watermain and the expected service lives for each asset. As indicated in the figure, the majority of the Town's watermain were recently constructed so the renewal forecast is light in the short term and heaviest on the back end.

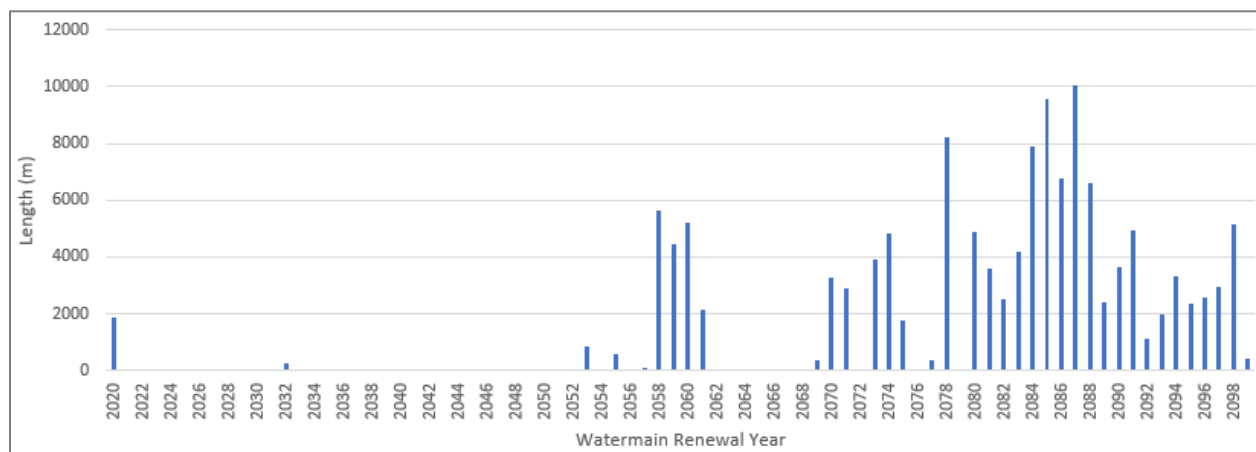
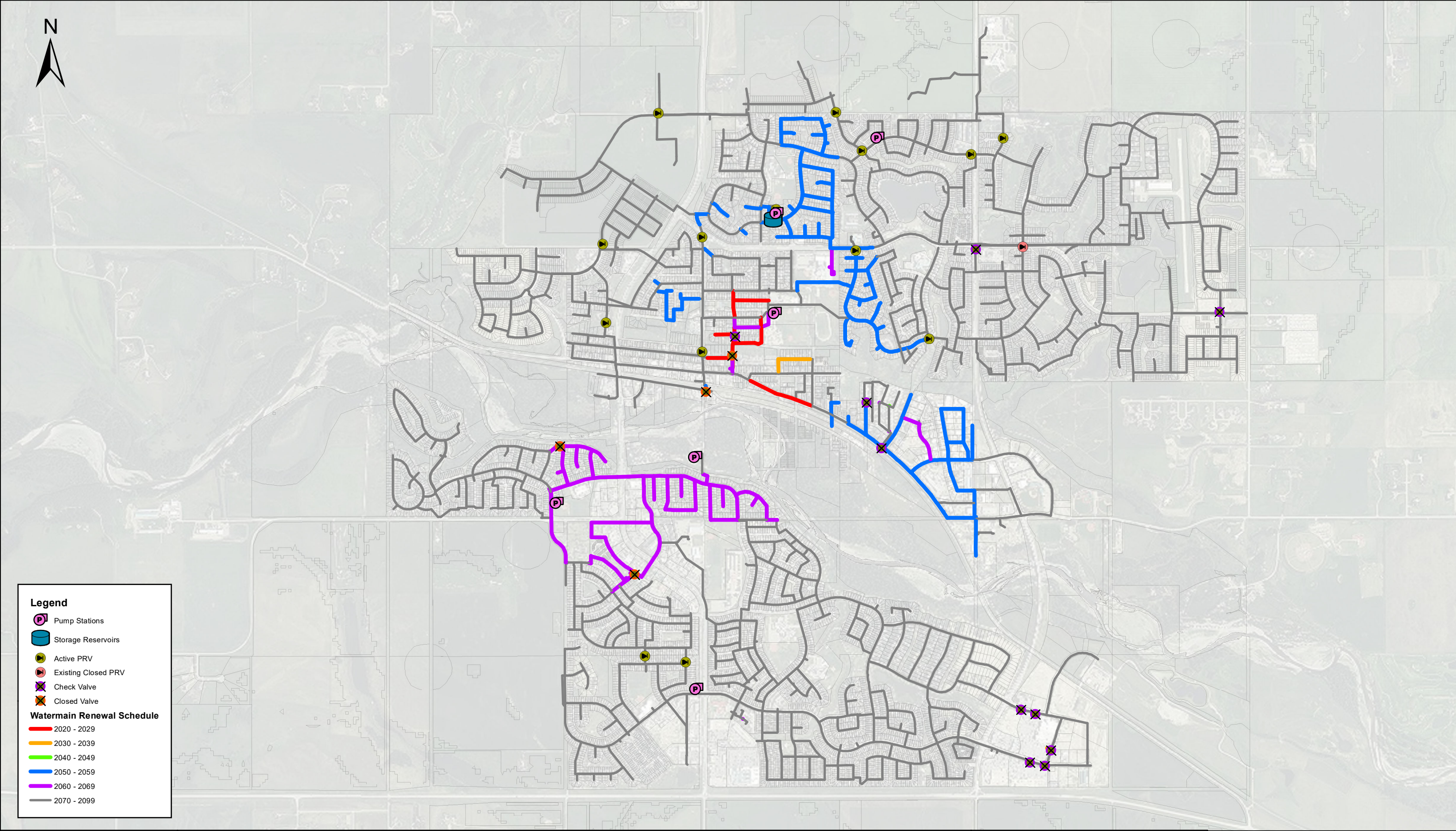








Figure 7-6: Long Range Watermain Renewal Forecast.

Figure 7-7 illustrates the location of watermain renewals, broken down in five-year periods up to the ultimate 2069 study horizon. Estimated renewal costs have been included in the Capital Projects List in Section 8.



Legend

-  Pump Stations
-  Storage Reservoirs
-  Active PRV
-  Existing Closed PRV
-  Check Valve
-  Closed Valve

Watermain Renewal Schedule

-  2020 - 2029
-  2030 - 2039
-  2040 - 2049
-  2050 - 2059
-  2060 - 2069
-  2070 - 2099



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**Town of Okotoks
Watermain Renewal Schedule**

The information used to create this product is based on the most current data available on the date of issue, and is considered reliable only at the scale at which the data was created and the scale at which the map was published. This map is prepared solely for the contractual customer of WSP and WSP

Project No: 19M-01217-00
Date: FEB 2020
Drawn: KD
Approved: ML

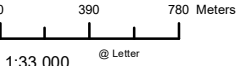


Figure 7-7

8 CAPITAL PROJECTS SUMMARY

This section details the cost estimating approach for infrastructure requirements and a capital projects list for the water distribution system for the Town of Okotoks to accommodate anticipated growth.

8.1 COST ESTIMATE BASIS

WSP maintains an in-house database for costs for a variety of water distribution projects which is indexed to the Engineering News Record (ENR) Construction Cost Index. The database has extensive records of unit costs for pipe supply and installation compiled from previous projects completed by WSP, adjusted to 2020 dollars.

Table 8-1 summarizes the Class “D” order-of-magnitude unit cost rates used to estimate the capital improvement works.

Table 8-1: Water Distribution Network Unit Costs

ASSET TYPE	SIZE	UNIT COST	UNIT
Watermains	100	\$250	Lineal Metre
	150	\$425	Lineal Metre
	200	\$500	Lineal Metre
	250	\$550	Lineal Metre
	300	\$625	Lineal Metre
	350	\$675	Lineal Metre
	400	\$725	Lineal Metre
	500	\$800	Lineal Metre
	600	\$900	Lineal Metre
Reservoir Construction ¹	-	\$1,000	Cubic Metre
Reservoir Rehabilitation		\$500,000	Lump Sum
Pump Upgrades ²	-	\$1,600	Total Horsepower
PRV Station	-	\$200,000	Lump Sum

1. Estimated unit cost for reservoir construction only, exclusive of any tie-in works, building expansion, or land acquisition required.

2. Estimated unit cost for pump replacement, exclusive of any structural works required, building expansions, electrical upgrades, provisions for (additional) back up power/gensets, and programming and commissioning.

The unit rates above include allowances of 40% for engineering fees and contingency.

Capital costs for individual projects have been broken down into Account 1) New Capital Projects; Account 2) Rehabilitation, and Account 3) Off-Site Levy/Growth-Related Projects. These distinctions can be useful to Town staff for delineating expenditures for financial planning within the utility with regards to calculating funding requirements under each project expenditure class, and for determining whether existing capital reserves are sufficient for the proposed projects or if alternative funding methods such as increased utility fees or grant applications are required.

The Capital Projects List does not include

Projects which are required to meet existing conditions, but which have been upsized to accommodate additional demands due to growth are proportionally split between Account 1 and Account 3 based on the required upsizing or increase in demands.

While cost-sharing of growth-related projects with developers is envisioned, capital costs under Account 3 have been included in the summation of total capital costs and reflected in the forecasted remaining capital budget in a given timeframe so that the Town has a complete view of the required expenditures for water utility upgrades.

It is recommended that the Town review individual development applications on a case-by-case basis to determine impacts on the water utility using the latest hydraulic model.

8.2 CAPITAL PROJECTS PRIORITIZATION

A detailed 10-year infrastructure upgrade plan with a forecast of improvement works to the 2069 horizon for the Town of Okotoks has been developed to lay out an implementation schedule for all the identified upgrade projects required in the area. The Capital Projects List, which details the phasing of prioritized infrastructure improvement projects recommended as part of this study, is broken down by five-year intervals up to the ultimate 2069 horizon year.

Capital projects are grouped by types of infrastructure upgrades (i.e. reservoirs, pump stations, PRV stations, watermains, etc.) and broken down by the type of improvement and timeframe, with priority towards projects addressing existing system deficiencies over future growth-related improvements. Distribution system renewal costs from the watermain renewal analysis are broken down in five-year periods. Any overlap with distribution system upgrades based on addressing service pressure and fire flow deficiencies capacity have been flagged, with capital upgrades taking priority. Cost savings from overlap with renewals have been incorporated into the Capital Projects List.

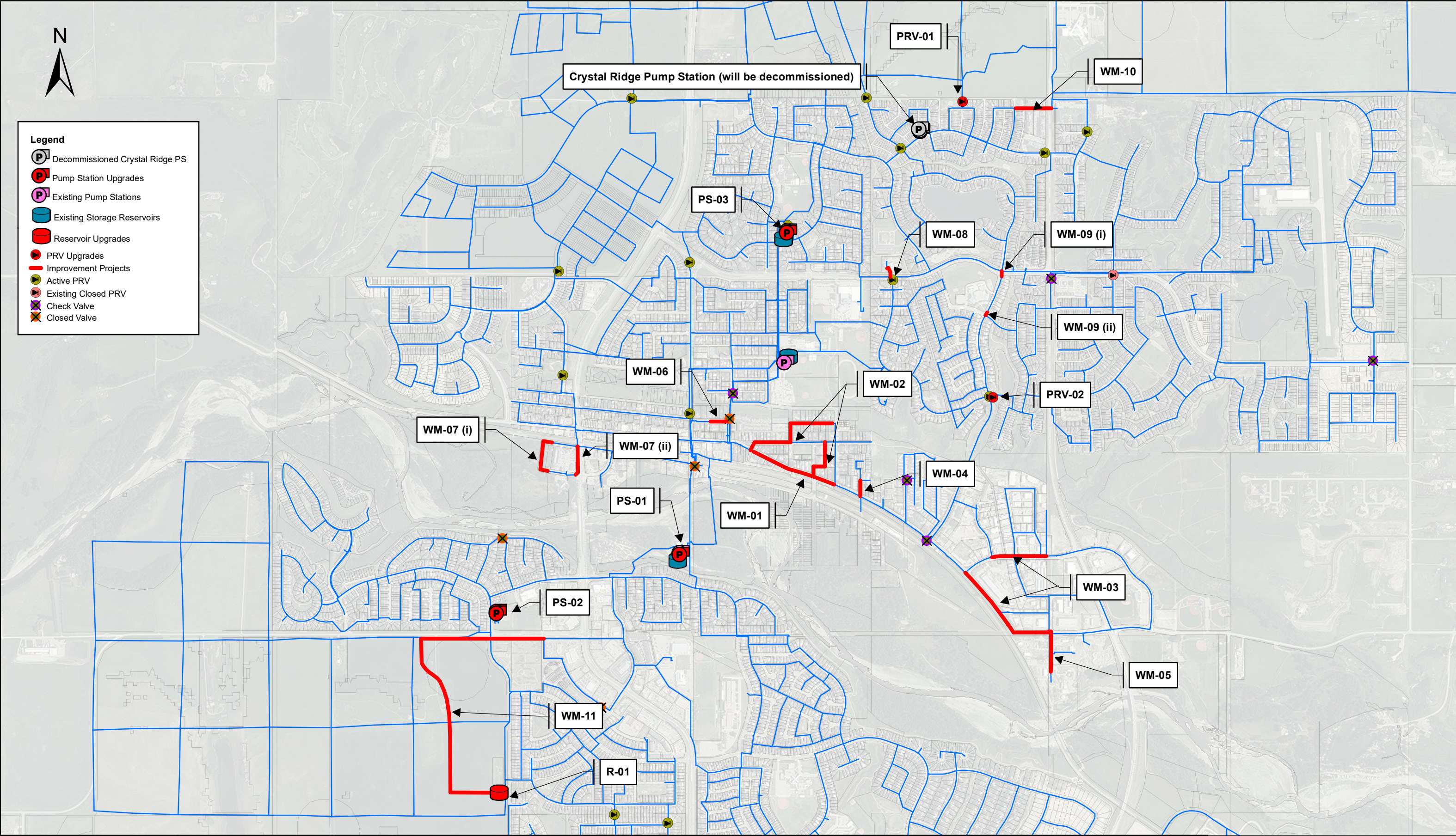
8.3 OTHER MASTER PLAN RECOMMENDATIONS

Additional recommendations of this WMP are as follows:

- Following completion of the WMP, consolidate maps and recommendations of all master plans (sanitary sewer, transportation, etc.) and municipal development plans for consistency;
- The Town should review its overall reservoir and storage philosophy to optimize the current system while planning for future growth and resiliency;
- Confirm settings and control philosophies for pumps at each and every pump station, in particular, pump on/off setpoints, and pump curves, with the hydraulic water model updated accordingly;
- Consider establishing a naming convention for PRVs and other valves for ease of future reference;
- Confirmation of the locations, sizes, operational logic, and pressure settings of all pump stations PRVs within the existing system;
- It is also unknown which PRV stations have lead/lag valve configuration, and this should also be confirmed in the future with the hydraulic water model updated accordingly;
- The check valve locations and diameters and should be field checked to improve the accuracy of the model;
- Update the hydraulic model and watermain renewal schedule for any recent updates recently captured in the Town's GIS but not yet part of the WMP;

- Conduct any updated water system modelling as required following the completion of the Off-Site Levy (OSL) memorandum (February 2020) which is to contain confirmation on population densities;
- Review of the minimum fire flow requirements for different land uses, and confirm alignment with the design and operational philosophies of the pump stations;
- Use a combination of increased water metering, water system audits, leak detection and repair programmes, and district metered areas to improve water conservation measures within the municipality;
- Feasibility studies on potential renewable energy sources in the water sector, this would have a positive impact on GHG emissions within the sector as well as on the Town as a whole;
- Feasibility studies on building envelope retrofitting, for items like renewable energy sources;
- Producing bylaws and regulations to require higher levels of energy performance in new building construction;
- Further initiatives such as an investigation into available retrofitting grants;
- Consideration and planning for the installation of re-chlorination stations and/or chlorine analyzer stations/kiosks to consistently monitor residual levels throughout the water distribution network; and,
- Eventually undertake a hydraulic modelling analysis of free chlorine in the distribution system in relation to population growth and climate change.

Town of Okotoks 2020 Water Master Plan Table 8-2: Capital Projects List				* 2020 Dollars												
				Account 1 (New Capital) Account 2 (Rehabilitation) Account 3 (Development/ Growth Related)		2020-2024	2025-2029	2030-2034	2035-2039	2040-2044	2045-2049	2050-2054	2055-2059	2060-2064	2065-2069	
					Account 1	\$ 1,703,478	\$ 1,437,878	\$ -	\$ -	\$ -	\$ 265,600	\$ -	\$ -	\$ -	\$ -	\$ -
					Account 2	\$ 10,613,959	\$ 950,676	\$ 200,000	\$ -	\$ -	\$ -	\$ 308,059	\$ 4,982,903	\$ 3,952,851	\$ 219,470	
					Account 3	\$ 5,876,250	\$ 5,693,850	\$ -	\$ -	\$ -	\$ 22,400	\$ -	\$ -	\$ -	\$ -	\$ 160,000
Total from Accounts	\$ 18,193,687	\$ 8,082,404	\$ 200,000	\$ -	\$ -	\$ -	\$ 288,000	\$ -	\$ 308,059	\$ 4,982,903	\$ 3,952,851	\$ 379,470				
	Year	Trigger		OSL's or Developer Contribution	Cost	2020-2024	2025-2029	2030-2034	2035-2039	2040-2044	2045-2049	2050-2054	2055-2059	2060-2064	2065-2069	
Reservoir Improvements (addressing storage requirements)																
R-01 - Construct a new 3.66 ML reservoir in South Okotoks	2020-2024	Future	Account 3	100%	\$ 3,660,000	\$ 3,660,000										
R-02 - Conduct rehabilitation works on the existing 3N Reservoir	2020-2024	Existing	Account 2		\$ 500,000	\$ 500,000										
Subtotal					\$ 4,160,000	\$ 4,160,000	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Pump Station Improvements (addressing capacity requirements)																
PS-01 - Replace the SRWTP south supply pumps with 6 x 100 HP pump (5 duty, 1 standby) to meet ultimate domestic and fire flow needs (individual pump capacity of 67.4 L/s @ 95 m, VFD incl.)	2020-2024	Future	Account 3		\$ 960,000	\$ 960,000										
PS-02 - Replace the Big Rock pumps with 3 x 60 HP pumps (2 duty, 1 standby) to meet ultimate domestic and fire flow needs (individual pump capacity of 90 L/s @ 42 m, VFD incl.)	2040-2044	Existing/Future	Account 1	92%	\$ 265,600					\$ 265,600						
- (see above)	2040-2044	Existing/Future	Account 3	8%	\$ 22,400					\$ 22,400						
PS-03 - Replace the 4N Header jockey pump with the same type of pump as the 100 HP duty pumps (for a 5 duty, 1 standby arrangement) to meet ultimate industrial fire flow needs in the N-2 service area (individual pump capacity of 65 L/s @ 77 m, VFD incl.). Note: this project is only required if the N-2 Service Area becomes industrial in the future	2065-2069	Future	Account 3	100%	\$ 160,000										\$ 160,000	
Subtotal					\$ 1,408,000	\$ 960,000	\$ -	\$ -	\$ -	\$ 288,000	\$ -	\$ -	\$ -	\$ -	\$ 160,000	
PRV Station Improvements (to address fire flow deficiencies and risk-based condition assessment concerns)																
PRV-01 - Construct a new PRV Station with a 300 mm PRV at the eastern boundary of Hessel Park to supply flows from Zone 4N to Zone 4BN (assumed setpoint = 1,142 m)	2020 - 2024	Future	Account 3	100%	\$ 200,000	\$ 200,000										
PRV-02 - Investigate and replace the D9 PRV station (currently servicing the 1N Zone)	2020 - 2024	Existing	Account 2		\$ 200,000		\$ 200,000									
Subtotal					\$ 400,000	\$ 200,000	\$ 200,000	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Watermain Improvements (to address service pressures and fire flow deficiencies)																
WM-01 - Upsize 395 m of watermain to 300 mm along North Railway Street between McRae Street and Poplar Avenue	2020-2024	Existing	Account 1		\$ 247,063	\$ 247,063										
WM-02 - Upsize 688 m of watermain to 200 mm along McRae Street and Maple Street between North Railway Street and Poplar Avenue, and along Lineham Avenue between North Railway Street and McRae Street	2020-2024	Existing	Account 1		\$ 343,910	\$ 343,910										
WM-03 - Upsize 763 m of watermain to 300 mm along North Railway Street between Stockton Avenue and Fisher Gate, and along Stockton Avenue east of Stockton Point	2020-2024	Existing	Account 1		\$ 476,781	\$ 476,781										
WM-04 - Upsize 72 m of watermain to 200 mm along Elm Place North of North Railway Street	2020-2024	Existing	Account 1		\$ 35,910	\$ 35,910										
WM-05 - Upsize 191 m of watermain to 250 mm along Fisher Gate South of North Railway Street	2020-2024	Existing	Account 1		\$ 105,094	\$ 105,094										
WM-06 - Upsize 72 m of watermain to 200 mm along Elma Street East between Veterans Way and Clark Ave	2020-2024	Existing	Account 1		\$ 36,065	\$ 36,065										
WM-07 (i) - Construct 204 m of 200 mm watermain along Riverside Way to the West of Northridge Drive	2020-2024	Existing	Account 1		\$ 101,920	\$ 101,920										
WM-07 (ii) - Upsize 134 m of watermain to 200 mm along Northridge Drive between Riverside Drive and Riverside Way	2020-2024	Existing	Account 1		\$ 67,040	\$ 67,040										
WM-08 - Upsize 48 m of watermain to 200 mm at the intersection of Milligan Drive and Downey Road	2020-2024	Existing	Account 1		\$ 24,095	\$ 24,095										
WM-09 - Construct 24 m of 200 mm watermain at the intersection of Crystal Ridge Drive and Milligan Drive. Close a valve at the intersection of Crystal Ridge Drive and Crystal Ridge Crescent to transfer Dr. Morris Gibson School from the top of Zone 2N to the bottom of Zone 3N	2020-2024	Future	Account 3	100%	\$ 12,050	\$ 12,050										
WM-10 - Upsize 164 m of watermain to 300 mm along Crystal Shores Heights West of 32 Street East	2020-2024	Future	Account 3	100%	\$ 102,800	\$ 102,800										
WM-11 - Construct 1518 m of 200 mm watermain along Big Rock Trail and parallel to Westland Street to the new South Reservoir tie-in point near Westland View, to tie into the 2S-2 Zone	2020-2024	Future	Account 3	100%	\$ 759,000	\$ 759,000										
Subtotal					\$ 2,311,728	\$ 2,311,728	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Watermain Renewals (from age-based renewal schedule)																
Watermain Renewals	2020-2069	Existing/Future	Account 2		\$ 9,913,959	\$ 450,676	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 308,059	\$ 4,982,903	\$ 3,952,851	\$ 219,470	
Subtotal					\$ 9,913,959	\$ 450,676	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 308,059	\$ 4,982,903	\$ 3,952,851	\$ 219,470	
Total					\$ 18,193,687	\$ 8,082,404	\$ 200,000	\$ -	\$ -	\$ 288,000	\$ -	\$ 308,059	\$ 4,982,903	\$ 3,952,851	\$ 379,470	



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**Town of Okotoks
Proposed Improvements**

The information used to create this product is based on the most current data available on the date of issue, and is considered reliable only at the scale at which the data was created and the scale at which the map was published. This map is prepared solely for the contractual customer of WSP and WSP

Project No: 19M-01217-00	0 125 250 500 Meters
Date: FEB 2020	1:25,000 @ Tabloid
Drawn: KD	
Approved: ML	
Figure 8-1	

APPENDIX

A TECHNICAL MEMORANDUM NO. 1 – DESIGN CRITERIA



TECHNICAL MEMORANDUM NO. 1

TO: Rob Dickinson, P.Eng.
FROM: Clive Leung, P.Eng., Ana Kovacevic, Designer
SUBJECT: Okotoks Water Master Plan – Design Criteria
DATE: February 18, 2020
FILE: 19M-01217-00

1. INTRODUCTION

In August 2019, WSP Canada Group Limited (WSP) were retained by the Town of Okotoks (Town) to deliver a Water Master Plan (the Plan). As a general overview, the Plan is to provide:

- A comprehensive inventory and hydraulic assessment of the existing water system
- Recommendations for upgrades and maintenance of the existing water system
- Expansion concepts, including associated costs, to serve future development areas, incorporating projections of future population and estimated water consumption at the 5, 10, 25, and 50 year horizons.

This Technical Memorandum details the design criteria that will be established for the Plan, which will inform assumptions and inputs for the work to be undertaken and provides the main water network design parameters through which the WaterCAD water distribution model will be assessed against.

The Plan will involve modelling at the 5, 10, 25, and 50 year horizons assuming four different demand scenarios:

- Average Daily Demand (ADD)
- Maximum Daily Demand (MDD)
- Maximum Day Demand and Fire Flows (MDD + FF)
- Peak Hour Demand (PHD)

And through each of the above demand scenarios, network demands will be categorized through five (5) different land use categories:

- Single Family
- Multi-family
- Industrial
- Commercial
- Institutional

This technical memorandum will set the design criteria for each of these demand scenarios.

BACKGROUND

Many studies have been completed in the past to inform the Town's sustainable growth. As part of this Plan, the Town has supplied previous reports detailing studies of projected population growth, housing and job demand; reports on the sustainability of the Sheep River water source and ultimate capacity of the shallow well fields; reports on the future servicing of housing developments and reports detailing water production, loss and consumption.

In formulating design criteria for the current Plan, WSP has conducted a review of the following reports, made available by the Town, detailing previous work done:

- Town of Okotoks, Draft Infrastructure Study 2005 (Urban Systems, 2006)
- Town of Okotoks Comprehensive Growth Strategy Report 20190730 (O2 Planning + Design, 2019)
- Okotoks Draft Municipal Development Plan (MDP, June 2019)
- The Town of Okotoks Policy for Water Allocation System for Planning Approvals (revised August 2013)

Each of the above reports detail the objectives of the Town in attaining equitable and viable growth, with population projections, anticipated growth areas and designated land uses, and the intention for developing new vibrant, livable neighbourhoods with localised commercial hubs.

To provide context and comparison to the design criteria being suggested for use in the Town's Water Master Plan and as reviewed in this technical memorandum, WSP also reviewed the water distribution systems chapters of the following design sources in order of significance:

- Town of Okotoks Engineering Services, General Design and Construction Specifications (2013)
- City of Calgary Standards and Specifications, specifically;
 - i. Standard Specifications for Waterworks Construction (2018)
 - ii. Design Guidelines for Development Site Servicing Plans (2018)
 - iii. Potable Water Feedermain Design Guidelines and Specifications (2019)
 - iv. Design Guidelines for Subdivision (2014)
- Alberta's provincial Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems (2006)
- Airdrie Utility Master Plan 2016 (2016, ISL Engineering and Land Services)
- Town of Canmore Utilities Master Plan 2016 (2107, CIMA)
- Town of Chestermere Utilities Master Plan 2008 (Stantec, 2010)
- Leduc County Design Guidelines and Construction Standards for Developments (2007)
- City of Prince Albert Design Standards (2015)
- EPCOR Design and Construction Standards, Vol 4 Water (2013)

Review of the **Okotoks Engineering Services, General Design & Construction Specifications** found detailed guidance regarding construction (such as bedding instructions and minimum pressure classes for pipes of various material), and less focus on broader design criteria (such as operating pressures or storage requirements) for the distribution system.

The Okotoks Engineering Services, General Design & Construction Specifications directly reference the **City of Calgary Standard Specifications for Waterworks Construction (2018)** for further information. Similarly, these standards, and others listed above published by the City of Calgary are heavily detailed regarding construction and light on guidance regarding criteria to evaluate the network as a whole.

Where applicable guidance from the Town and City of Calgary specifications has been given precedence. Where not applicable, guidance from the other sources listed above has been evaluated and applied as appropriate, to develop design criteria to evaluate system performance of the Town's distribution network as represented in the WaterCAD model.

The **Leduc County Design Guidelines** and the **City of Prince Albert Design Standards** offer perspectives from other small regional municipalities and their approach to similar design goals and constraints. The **Airdrie Utility Master Plan (UMP)**, **Canmore UMP** and **Chestermere UMP** are examples of design criteria applied for similar studies of water networks in similar size jurisdictions near to Calgary.

The **Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems** published by the province of Alberta in 2006 is the design standard that a large public waterworks system must meet as a minimum, in accordance with the Potable Water Regulation Act (277/2003).

EPCOR's Design and Construction Standards are presented as a comparison that is regionally significant. EPCOR also has managed the Okotoks water system on behalf on the Town for approximately the last 10 years.

DATA SOURCES

The Town has supplied WSP with multiple spreadsheets with meter data, billing information and well production volumes. The following list of sources outlines in further detail the content of each data source.

Table 1: Data Sources

DATA SOURCE ⁽¹⁾	ORIGINATOR	DESCRIPTION OF DATA
2010-2019 Production and Consumption summaries.xlsx	Town	A spreadsheet which has annual totals of gross water produced and billed from 2010 to 2018, allowing for an estimation of non-revenue water, and maximum day demand factor
consumption_report 2018 per accounts Sensus.xls	Town	A spreadsheet with Sensus meter data which gives annual consumption in 2018 for each account (or meter) ID.
WaterCon2016.shp	Town	A GIS shapefile which contains account ID per parcel, allowing for meter usage to be linked to land use and parcel area. 2015 occupied units and population data per parcel is also included.
2019 09 20 Water Licence Summary - WSP.xlsx	Town	A spreadsheet which compiles all relevant source supply licenses.

(1) The data received was reviewed and checked by the WSP project team.

2. DESIGN CRITERIA

The following subsections outline the proposed design criteria to be applied in the development of the Plan, and in the development and eventual assessment of the Town's new WaterCAD water distribution model.

DEMAND

The approach to estimate water usage per simplified land use category assumes that the 2018 production and consumption summaries and the 2018 meter data supplied is representative of current system water usage. The 2018 data is the basis for the completed analysis as this is the most recent dataset with a full year of data. Meter IDs and Account IDs supplied in the spreadsheet were matched with the Account IDs in the WaterCon2016.shp and as such were geospatially located.

2015 occupancy and population information for each Account ID were also supplied by the Town in the WaterCon2016.shp, and was used to estimate litres per capita demand.

Total consumption from the metered data for the "Residential" (i.e. single family), "Multi-family," "Industrial," "Commercial," and "Institutional" were used to calculate average daily consumption in litres per second, as per Table 2 below.

Table 2 – Average daily metered consumption and factored daily consumption

LAND USE	METERED ⁽²⁾ ADD (l/s)	FACTORED FOR NRW ⁽³⁾ ADD (l/s)
Single Family	50.4	71.5
Multi-Family	6.9	9.8
Industrial	1.2	1.7
Commercial	8.5	12.0
Institutional	2.8	4.0
TOTAL	69.8	99.0

(2) The consumption in Table 2 was scaled to include the "Unknown" consumption from Account IDs that did not match with the any in the WaterCon2016.shp shapefile.

(3) Non-revenue water (NRW) is defined as the difference between gross water extracted from wells and metered water, calculated to be 29.5% based on the metered consumption total of 2,199,778 cubic metres and the reported total production volume of 3,120,603 cubic metres in 2018.

The above usage is summarised in more readily accessible units of litres per capita per day and litres per hectare per day:

- Residential – 242 l/c/d
- Multi-Family – 242 l/c/d
- Industrial – 7,000 l/ha/d
- Commercial – 12,960 l/ha/d
- Institutional – 4010 l/ha/d

WSP notes that the 2018 meter data together with the 2015 population per occupied unit as supplied in the WaterCon2016.shp shapefile incidentally gives the same Single Family and Multi-Family consumption. The average density for Single Family homes is approximately 3 people per

home, and for Multi-Family approximately 2 people per unit, such that the usage per household is greater in the Single Family category. The peaking factors for Single Family and Multi-Family are different and reflect the greater Single Family maximum and peak hour demand.

Commercial usage calculated may be higher than the Town's understanding of commercial demand and could potentially be due to changing parcel areas as represented in the WaterCon2016.shp. However, the WaterCAD model is predicated on actual metered usage (inflated for NRW) per parcel where this information is available and rates of demand per hectare will not affect model calibration.

The overall maximum daily peaking factor was calculated by taking the maximum day production volume in 2018 and dividing it by the average daily production in the same year. The overall peak hour demand factor was assumed to be 3, following the EPCOR Design and Construction Standards. Table 3 shows ADD and peaking factors from other nearby studies, and provides some context for the calculated ADD and peaking factors chosen in this Plan.

Table 3– ADD and peaking factors from other sources

	ADD (LPCD)	MDD/ADD	PHD/ADD
Infrastructure Study 2005	318	1.75	3.5
Airdrie UMP	315	2	4
Chestermere UMP	323	2	4
Canmore UMP	420	2	4
Leduc County	340	2	3
EPCOR	250	1.7	3
Alberta Provincial	To be estimated from past usage	1.8 - 2	2 - 5

Typical peaking factors for Commercial, Industrial and Institutional use categories (1.1 for MDD and 1.5 for PHD) were assumed. Multi-family peaking factors were assumed (1.3 for MDD and 2.6 for PHD) which gives in the calculated Single Family peaking factors as per Table 4.

Table 4 – Average daily, maximum day and peak hour demands and associated peaking factors

LAND USE	ADD (l/s)	MDD (l/s)	PHD (l/s)	MDD/ADD	PHD/ADD
Single Family	71.5	116.3	244.9	1.63	3.43
Multi-Family	9.8	12.7	25.4	1.3	2.6
Commercial	1.7	1.8	2.5	1.1	1.5
Industrial	12.0	13.2	18.0	1.1	1.5
Institutional	4.0	4.4	6.0	1.1	1.5
Total	99.0	148.4	296.9	1.5	3

SERVICE PRESSURES

Minimum service pressures are required to ensure an adequate flow and pressure of water to all serviced properties in the Town. There are, in most cases, two conditions in which systems should be designed for minimum service pressures:

- a) the maximum day demand plus fire flow condition, and

- b)** the peak hour demand condition.

Maximum service pressures in the system also need to be regulated to prevent over-pressurizing of the system and subsequent breaks or increased leakage. Maximum pressures are normally reviewed under the average day demand scenario.

Table 5 below is a summary of service pressures suggested by the previous Okotoks Infrastructure Study of 2005, previous UMPs in the region, the EPCOR guidelines and the Leduc County and Alberta Provincial guidelines. All sources, bar the Alberta Provincial Guidelines, have adopted very similar service pressures. We note that the Alberta Provincial Guidelines for minimum pressure are in some cases higher, but these are only guidelines. The service pressures adopted in the previous Infrastructure Study are still relevant and will be applied again in this Plan.

Table 5 Service Pressures from other sources

	MINIMUM PRESSURE: MAX. DAY + FIRE FLOW	MINIMUM PRESSURE: PEAK HOUR	NORMAL OPERATING RANGE
Infrastructure Study 2005	140 kPa (20.3 psi)	275 kPa (39.9 psi)	-
Airdrie UMP	140 kPa (20.3 psi)	275 kPa (39.9 psi)	350-550 kPa (50.8 - 79.8 psi)
Chestermere UMP	140 kPa (20.3 psi)	275 kPa (39.9 psi)	280-550 kPa (40.6 - 79.8 psi)
Canmore UMP	138 kPa (20 psi)	275 kPa ⁽⁴⁾ (39.9 psi)	350-620 kPa (50.8 - 89.9 psi)
Leduc County	150 kPa (21.8 psi)	280 kPa (40.6 psi)	-
EPCOR	140 kPa (20.3 psi)	280 kPa (40.6 psi)	350-550 kPa (50.8 - 79.8 psi)
Alberta Provincial	150 kPa (21.8 psi)	350 kPa (50.8 psi)	350-550 kPa (50.8 - 79.8 psi)

(4) From the Canmore Engineering Design and Construction Guidelines, available at:

<https://canmore.ca/documents/engineering/engineering-design-and-construction-guidelines-2010/506-part-2-3-edcg-final-draft-water/file>

FIRE FLOWS

Water distribution systems must be able to deliver large volumes of water for fire protection in addition to normal water demands. Fire protection assumptions/considerations are:

- a)** only one fire will be fought;
- b)** a minimum residual pressure on the street main is required during fires to ensure pumper trucks obtain adequate water supply from hydrants, and
- c)** fire flow is coincident with maximum day demand.

Table 6 details minimum fire flow requirements as suggested by the previous Okotoks Infrastructure Study of 2005, the previous UMPs in the region, the EPCOR guidelines and the Leduc County, Prince Albert City and Alberta Provincial guidelines. WSP note that the EPCOR guidelines appear to be conservative, particularly for non-residential land uses, and are not the standard the Town's water network has been designed to.

The Infrastructure Study 2005 gives fire flow requirements that were based on values developed for the Town prior to the study, done by Fire Underwriters Survey staff in accordance with the Water Supply for Public Fire Protection - A Guide to Recommended Practice.

Table 6 Minimum fire flows from other sources

	RESIDENTIAL (SF)	RESIDENTIAL (MF)	COMMERCIAL	INSTITUTIONAL	INDUSTRIAL
Infrastructure Study 2005	75 l/s	113 l/s	189 l/s	151 l/s	227 l/s
Leduc County	60 l/s	90 l/s	90 l/s	90 l/s	-
Prince Albert	60 l/s	120 l/s	120 l/s	-	180 l/s
Airdrie UMP	76 l/s	114 -227 l/s	265 l/s	114 -227 l/s	227 l/s
Chestermere UMP	83 l/s	-	200 l/s	-	200 l/s
Canmore UMP	85 l/s	120 – 200 l/s	200 l/s	200 l/s	200 l/s
EPCOR	100 l/s	180 l/s	300 l/s	300 l/s	300 l/s
Alberta Provincial Guidelines	References “the most current Water Supply for Public Fire Protection - A Guide to Recommended Practice, published by the Fire Underwriters Survey.”				

Review of fire flows in Table 6 suggest that the 2005 Infrastructure Study recommendations are still generally applicable, especially across the residential and industrial categories. For commercial and institutional properties, NFPA calculations were carried out for actual commercial (i.e. bakery, Tim Hortons) and institutional (i.e. municipal hall) sites within the City. Based on these tests, WSP suggest that the commercial fire flow be revised to 150 l/s and the institutional fire flow be revised to 180 l/s.

The Town revised the residential (single family) fire flow to 60 l/s. Table 7 summarises the fire flows to be adopted in this Plan.

Table 7 Fire flows to be applied in this study

	RESIDENTIAL (SF)	RESIDENTIAL (MF)	COMMERCIAL	INSTITUTIONAL	INDUSTRIAL
Minimum Fire Flows	60 l/s	110 l/s	150 l/s	180 l/s	225 l/s

WSP reiterate that the fire flows in Table 7 are suggested as a minimum for each use category to be applied in this study, and that for new developments fire flows are to be recalculated in accordance with the most current Water Supply for Public Fire Protection - A Guide to Recommended Practice, published by the Fire Underwriters Survey.

As a point of reference WSP has calculated the equivalent footprint of a representative building for the fire flow rates noted above in Table 7, for buildings in each use category following NFPA (Annex G) guidelines. For these calculations WSP have made assumptions as to building footprint using ArcGIS aerial imagery, and the number of storeys and the type of construction using google street view. These calculations are presented in Table 8.

Table 8 Fire flows for buildings in each land use category calculated following NFPA (Annex G) guidelines

	ADDRESS	FOOT PRINT (m ²)	CONSTRUCTION TYPE	FIRE FLOW (l/s)
Residential	301 Woodside Place	195	Wood framed, 2 storeys	59
Multi-Family	1-11 Tucker Circuit	380	Wood framed, multi story	100
Commercial	206-220 - 100 Southbank Boulevard	2300	Normal construction	152
Institutional	11 Cimarron Common	3340	Normal construction	183
Industrial	220 Stockton Ave	2050	Normal construction	238

Hydrant Spacing

WSP will follow the City of Calgary's Design Guidelines for Subdivision for hydrant spacing to perform a spatial analysis for hydrants adjacent to residential and industrial, commercial and institutional properties.

For single family low density residential housing:

- i. The maximum allowable spacing between fire hydrants shall be 300 m and they shall be separated by a line valve.
- ii. Spacing of all hydrants shall be determined such that all lots are within coverage of two hydrants. The maximum allowable distance from the first (primary) hydrant to all property lines of a lot shall be 150 m. The maximum allowable distance from the second (backup) hydrant to all property lines of a lot shall be 300 m.

For institutional, commercial, industrial and multi-family higher density residential housing:

- iii. The maximum allowable spacing between fire hydrants shall be 150 m and they shall be separated by a line valve.
- iv. Spacing of all hydrants shall be determined such that all lots are within coverage of two hydrants. The maximum allowable distance from the first (primary) hydrant to all property lines of a lot shall be 75 m. The maximum allowable distance from the second (backup) hydrant to all property lines of a lot shall be 150 m.

For all land use types the backup hydrant shall not be supplied from the same dead end main as the primary hydrant. These criteria will be applied for hydrant spacing evaluation in this Plan.

STORAGE

Water storage reservoirs are located at specific elevations to establish pressure zones within the distribution system. Typically design pressures within a pressure zone varies from a minimum of about 300 kPa (43.5 psi) to a maximum in the order of 800 kPa (116 psi). During a fire event, minimum pressures are usually allowed to drop.

Water storage is used to balance and optimize supply and delivery of water. If properly sized, reservoirs will store water during low demand periods and supplement the source supply during peak hour demand.

Typically, reservoirs are designed to refill every day and to have adequate storage capacity to provide for balancing storage, fire storage and emergency storage. Following Alberta's Provincial Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems, storage volumes requirements will be estimated based on the following formula:

$$S = A + B + \max(C, D)$$

Where;

A = Fire storage, m³

B = Equalization storage (25% of projected average daily design flow), m³

C = Emergency storage (15% of projected average daily design flow), m³

D = Disinfection contact time storage

Note that it is assumed that the disinfection contact time storage is less than the emergency storage volume. This criteria approach will be applied for storage evaluation in this Plan.

MAXIMUM VELOCITY

The recommended maximum acceptable velocity of 3.0 m/s for flows in the water transmission system mains, a common industry wide assumption, as per the Airdrie, Canmore and Chestermere UMPs. This criteria approach will be applied for velocity review in this Plan. However, WSP notes that during fire flows, which are an intermittent occurrence, that these maximum velocities may be exceeded for a short period of time, as per normal practice in utilities. WSP will highlight this discrepancy as part of the Plan where relevant.

HAZEN-WILLIAMS COEFFICIENT

The Hazen-Williams coefficient is a measure of pipe smoothness, used in calculating friction losses. Limiting this coefficient sets a minimum loss to be expected and usually represents the long-term condition and roughness of a system.

WSP will calibrate Hazen-Williams coefficients for pipe material, pipe diameter, and pipe age through the hydrant flow testing and model calibration exercise as part of the Plan. This approach taken via a combination of c-factor and multi-hydrant pressure tests will enable WSP to provide a material specific representation of c-factors for all network water mains.

3. SUMMARY

The demands and other design criteria summarised here in this Technical Memorandum will be used to assess the water distribution system's ability to service the Town's existing and future residents.

4. CLOSURE

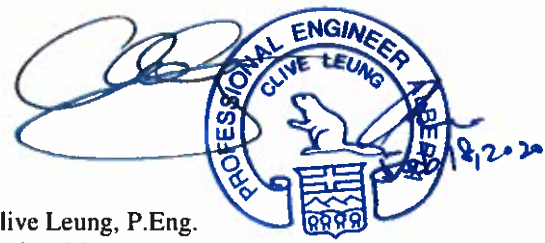
We trust you will find the foregoing Technical Memorandum suitable. Please do not hesitate to contact the undersigned should you have any questions.

Prepared by:



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APPENDIX

B TECHNICAL MEMORANDUM NO. 2 – WATER USAGE AND SHORT-TERM WATER AVAILABILITY



TECHNICAL MEMORANDUM NO. 2

TO: Rob Dickinson, P.Eng.
FROM: Clive Leung, P.Eng., Ana Kovacevic, Designer
SUBJECT: Town of Okotoks – Water Usage and Short-Term Water Availability Review
DATE: November 26, 2019
FILE: 19M-01217-00

EXECUTIVE SUMMARY

As a thriving regional hub, the Town of Okotoks (Town) has seen significant population growth in recent years, with the population of the Town doubling between the years of 2003 and 2018. However, a limiting factor to the Town's ongoing sustainable growth is a secure potable water supply for its existing population in addition to new housing developments.

As of 2019, the Town is approaching its previously denoted 'build-out' population of approximately 30,000. This population estimate was based on previous license withdrawal limits from the Sheep River that the Town could secure, as well as the capacity of the Town's water treatment plant, based on established average and peak day water usage per capita rates estimated at the time of last evaluation (circa 2010).

Since the year 2010, in an effort to keep water usage in check and to provide best practice management of its water usage and supply, the Town has embarked on a series of intensive demand and supply side water conservation initiatives. In addition, the Town has also begun work to secure additional water supply, reviewing several potential source options including expansion of the treatment plant and increased withdrawal limits from the Sheep River. On November 25, 2013 Okotoks Town Council decided to pursue the development of a regional water system via a connection to the City of Calgary to meet future growth needs.

Since the development of a regional water pipeline is a multi-year process, the Town has been working on and has been successful with interim water solutions such as the above noted water conservation strategies and water license transfers and has continued in this regard.

The purpose of this Technical Memorandum No. 2 is to provide an updated Water Usage and Short-Term Water Availability Review to provide an anticipated remaining volume of water available for current approved and short-term 'to be approved' new developments, and to update the 'build-out' population based on more recent data, including lower per unit water usage rates.

Pertinent assessment details and findings are as follows:

- WSP has focused on 2018 data unless otherwise noted. 2018 is the last full year of data available;
- WSP has confirmed updated maximum annual water license diversion totals;
- WSP has reviewed current metered usage information as reported from the Town’s system water meters and customer meters to determine current per land use unit water usage; Water usage has been summarized in 8 different land use type categories (e.g. R1, R1N, R1S, R2, R3 etc.), used to determine the per unit water usage rates (and used to determine allowable equivalent ‘buildout’ per land use type expressed in the conclusions of this report);
- WSP has reviewed and confirmed reported Non-Revenue Water rates for the utility;
- WSP has reviewed and confirmed, based on 2018 data, the latest full year of available data, the resultant “remaining availability” of water usage for allocation in the Town in terms of average water usage. Although risky to base availability on one year of data, 2016 and 2017 annual values are noted to be comparable;
- Based on the “remaining availability” of water, WSP has identified a surplus of 463,333 cubic meters (375.6 ac-ft) of water (based on 2018 water usage patterns);
- WSP notes that approved developments such as D’Arcy Ranch Phase 1, Phase 2, Wedderburn, and Wind Walk Phase 1 are not included in terms of current water usage, and their approved amounts will need to be subtracted from the surplus value above;

Without accounting for the approved developments as noted above, we estimate a total annual surplus of 463,333 cubic meters (375.6 ac-ft). This surplus will be able to accommodate an additional equivalent of the following properties

- 2110 R1 properties; or,
- 2160 R1N properties; or,
- 2560 R1S properties; or,
- 3050 R2 properties; or,
- 3830 R3 properties; or,
- A combination therefore of the above properties.

The average annual water usage was reviewed in comparison to the annual water withdrawal licenses limits. WSP was not instructed to review peak day water usage at this time. Therefore, there is potential that the water shortages during summer periods like those experienced in 2017 in the Town could still occur in dry summers in the short term before the City of Calgary connection is provided. Watering restrictions would likely become more frequent and also more restrictive, potentially negatively impacting residents. However, assuming a peaking factor of 1.5 applied to all the metered usage in 2018 and the surplus, the resultant daily peak demand would be less than 18 million litres per day, which is the anecdotal capacity of Town’s water treatment plant as reported by Town staff.

This technical memorandum outlines the approach undertaken by WSP, the assumptions and data sources used, leading to the final conclusions of the analysis.

DATA SOURCES

In undertaking this analysis, the Town has supplied WSP with multiple spreadsheets with meter data, billing information and well production volumes. The following list of sources outlines in further detail the content of each data source.

Table 1: Data Sources

DATA SOURCE ⁽¹⁾	ORIGINATOR	DESCRIPTION OF DATA
2010-2019 Production and Consumption Summaries.xlsx	Town	A spreadsheet which has annual totals of gross water produced and billed from 2010 to 2018, allowing for an estimation of non-revenue water, and maximum day demand factor
Consumption Report 2018 per accounts Sensus.xls	Town	A spreadsheet with Sensus meter data which gives annual consumption in 2018 for each account (or meter) ID.
WaterCon2016.shp	Town	A GIS shapefile which contains account id per parcel, allowing for meter usage to be linked to land use and parcel area. Also has 2015 occupied units and population data per parcel.
2019 09 20 Water Licence Summary - WSP.xlsx	Town	A spreadsheet which compiles all relevant source supply licenses.

- (1) The data received was reviewed and checked by the WSP project team. Any data discrepancies were reviewed and clarified with Town staff, however, some discrepancies have not been clarified at the time of production of this memo. As a result, WSP has provided the necessary assumptions to complete our analysis. Assumptions taken, and limitations noted have been summarized at the end of this report.

DATA ASSESSMENT AND REVIEW

In order to establish the “remaining availability” of licensed water supply for the Town of Okotoks, an assessment and comparison of current water supply (licensed volume) versus the estimated demand (water usage and non-revenue water) is required.

The following sections outline the assumptions for estimating the available water supply and non-revenue water, and the approach to estimate usage, including the approach for estimation of usage for each land use type.

SOURCE SUPPLY LICENSING

The Town has licenses to extract raw water from the Sheep River via shallow well fields and have provided WSP with a summary of the current water licenses. A summary of the licenses and extraction limits is provided below:

Table 2: Source Licences for Okotoks

LICENSE IDENTIFIER	TRANSFER YEAR	WELL NUMBER	AEP APPROVAL ID	DIVERSION VOLUME (m ³ /YEAR)	SEASONAL DIVERSION VOLUME (m ³ /YEAR)
79-12-10-01	-	Well #1	35105	790,909.1	-
79-12-01-02	-	Well #2			
79-12-01-03	-	Well #3			
85-01-22-03	-	Well #4	35112	660,910	-
85-01-22-07	-	Well #6			
52-12-31-02	-	Well #5	35110	250,455	-
92-06-10-10	-	Well #7	202472	62,908	-
			35104	91,313	-
92-06-10-11	-	Well #8	72884	11,101	-
			74820	444,056	-
PW-9	-	Well #9	191251	454,372	-
CanEra	2010	-	268353	216,476	-
Irving	2011	-	268349	-	28,864
MacMillan	2011	-	283404	-	36,634
Willumsen	2013	-	327785	-	45,516
Lauder	2013	-	342912	-	85,037
Wolosuk	2013	-	336563	-	15,231
Sirocco	2014	-	348644	-	99,912
River Bend Hutterian	2015	-	353780	-	9,770
Hutterian Brethren of Bow City	2015	-	368797	-	36,908
Gertzen	2017	-	379986	4,341	-
Gertzen	2017	-	379987	14,476	-
Ellis Ranching	2017	-	390822	22,536	-
Burnswest	2017	-	391311	88,810	-
				9,868	-
Bow River Irrigation District	2017	-	385019	244,229	-
Total ⁽²⁾				3,366,759	357,872

(2) Two Nexen water wells (total diversion volume of 49,340 m³/year) are licensed for non-potable water supply. They are not connected to the WTP and used for an irrigation purpose. The water source is aquifer, so restrictions related to Sheep River do not apply.

From the above provided information, the Town has confirmed that the maximum annual total diversion volume licensed is a summation of the two values above, which provides a total diversion volume of 3,724,631 cubic meters.

QUANTIFICATION OF NON-REVENUE WATER

Non-revenue water (NRW) is defined as the difference between gross water extracted from wells and billed water. It includes losses from the water treatment process, and water lost through leakage in the distribution network. An analysis of the gross water extracted and the billed water in the years from 2015 and 2018 suggests that on average NRW accounts for approximately 28.5% of the gross volume of water extracted, as per Table 3.

Table 3: Estimated Non-Revenue Water

YEAR	GROSS WATER PRODUCED (m ³)	BILLED WATER ⁽³⁾ (m ³)	NRW – GROSS LESS BILLED (m ³)	NRW – GROSS LESS BILLED (%)
2015	3,018,328	2,105,167	913,161	30.3%
2016	3,009,091	2,099,179	909,912	30.2%
2017	2,988,044	2,207,163	780,881	26.1%
2018	3,120,603	2,266,199	854,404	27.4%
AVERAGE				28.5%

- (3) Annual volumes of billed water come from the 2010-2019 Production and Consumption summaries.xlsx spreadsheet supplied by the Town. There is a 3% discrepancy between this total and the 2018 metered total, considered to be acceptably within flow meter error.

DETERMINATION OF WATER USAGE

The approach to estimate usage per land use type assumes that the 2018 meter data supplied is representative of future usage in the next 2-5 years. 2018 metered data is the basis for analysis as this is the most recent dataset with a full year of data. Meter IDs were matched with parcel IDs supplied by the Town, such that parcel area and land use type for each metered parcel could be inferred. Detailed land uses were simplified to broader land uses for each metered parcel as per Table 4. Occupancy and population information for each meter ID were also supplied by the Town.

Table 4: Proposed Simplification of Land Use Types

LAND USE	DESCRIPTION	SIMPLIFIED LAND USE
R1	Residential Single Detached	R1
R1N	Residential Narrow Lot Single Detached	R1N
R1S	Residential Small Lot Single Detached	R1S
R2	Residential Low Density Multi-Unit	R2
R3	Residential Medium Density Multi-Unit	R3
CCB	Central Business Commercial District	Commercial
CGATE	Gateway Commercial District	
CHWY	Highway Commercial District	
CSC	Shopping Centre Commercial District	
CSD	Special Development Commercial District	
I1	Business Industrial District	Industrial
I1S	South Business Industrial District	
I2	General Industrial District	

LAND USE	DESCRIPTION	SIMPLIFIED LAND USE
I3	Industrial District	
PS	Public Service District	Institutional

Combining the metered consumption per parcel with land use and population information per parcel allowed WSP to estimate the per occupied unit use of the simplified residential R1, R2 and R3 land uses, as per Table 5. The daily per capita consumption for each the simplified residential land use, presented in Table 6. Note that Table 5 includes a usage per occupied unit with a 10% buffer applied, which accounts for estimated further leakage in extending the distribution system.

Table 5: Residential per Property Consumption Totals.

LAND USE	METERED USAGE ⁽⁴⁾ (2018, m³)	NO. OCCUPIED UNITS (2015)	USAGE PER OCCUPIED UNIT (m³)	USAGE PER OCCUPIED UNIT + 10% (m³)
R1	989,573	4953	199.8	219.8
R1N	211,294	1083	195.1	214.6
R1S	105,803	644	164.3	180.7
R2	37,868	274	138.2	152.0
R3	126,141	1147	110.0	121.0

(4) Note that metered usage less than zero has been excluded

Table 6: Residential per Person Consumption Totals

LAND USE	METERED USAGE (2018, m³)	POPULATION (2015)	ANNUAL USAGE PER PERSON (m³)	AVERAGE DAILY PER CAPITA CONSUMP. (l/c/d)
R1	989,573	15,719	63.0	172
R1N	211,294	3,637	58.1	159
R1S	105,803	1,967	53.8	147
R2	37,868	572	66.2	181
R3	126,141	2,128	59.3	162

The per hectare usage for simplified commercial, industrial and institutional land uses as summarized as per Table 7.

Table 7: Commercial, Industrial and Institutional Average Daily Consumption Per Hectare.

LAND USE	METERED USAGE		SIMP. LAND USE	AGGR. USAGE		CONSUMP. PER AREA (m ³ / Ha)
	(2018, m ³)	AREA (m ²)		(2018, m ³)	AREA (Ha)	
CCB	54,141	67,133	Comm.	196,526	51	3,869
CGATE	66,854	297,806				
CHWY	26,231	63,835				
CSC	47,918	73,761				
CSD	1,381	5,456				
I1	4,479	22,034	Ind.	51,928	30	1,747
I1S	12,180	58,647				
I2	15,901	120,502				
I3	19,369	95,976				
PS	80,390	581,603	Inst.	80,390	58	1,382

HISTORY OF WATER CONSERVATION

From a supply and demand point-of-view, a combination of water license transfers and water conservation strategies have impacted the overall water supply and demand profile for the Town since the year 2010. The Town's strategy is outlined in the Water Conservation Efficiency Productivity Plan and some of these initiatives are summarized as follows in Table 8.

Table 8: Summary of Water Conservation Measures

TOOL	MEASURE	DESCRIPTION	YEAR IMPLEMENTED	ANTICIPATED BENEFITS
Educational and Outreach Programs	Conservation Educators (Public Education)	Conservation Educators visit many households in Okotoks, educating the community on water and energy conservation and waste management.	2002 - 2019	Sharing information on best practices in water conservation. Reduced per capita water use.
	Conservation Educators (School Education)	Conservation Educators attend all summer community events and provide conservation presentations to children at schools and summer day camps.	2002 - 2019	Sharing information on best practices in water conservation to students.
	Town Website	Improvements to the website to provide easily accessible information to residents and promote the community's Sustainable Okotoks vision.	2010 - 2019	Sharing information on best practices in water conservation. Reduced per capita water use.
	Water Wagon	A Water Wagon that supplies clean drinking water is present at events throughout the summer.	2015 - 2019	Increased public awareness towards tap water quality and decreased use of plastic bottles.
	Learning Centre	The EPCOR Environmental Centre offers a visual exploration of Okotoks' water system and provides insight into people's interdependency with this essential life-giving resource.	2017 - 2019	Sharing information on how the town interacts with water.
Infrastructure Improvements	Universal Meter Upgrades	Upgrade meters to make sure that they are recording information accurately.	2016 - 2019	Improved measurements and ability to manage water demand. Reduced leakage rates.
	Water Main Upgrades	Upgrade waterworks distribution system to reduce water losses.	2005 - 2019	More efficient water use.
	Water Treatment Plant	Air scour improvement projects.	2005 - 2019	Reduced water treatment plant process losses from 8% to 4%.
Operations	Water Reuse	Okotoks utilizes reclaimed water for: <ul style="list-style-type: none"> — Spraying down process scum at the Wastewater Treatment Plant — Watering of boulevard trees and planting beds on Town land — Town maintenance projects that can use non-potable water. 	Unknown	Reduced extraction from water bodies.

TOOL	MEASURE	DESCRIPTION	YEAR IMPLEMENTED	ANTICIPATED BENEFITS
	Raw Water	Okotoks utilizes raw water for: <ul style="list-style-type: none"> — Watering of boulevard trees and planting beds on Town land — Street cleaning — Irrigation of fields and parks 	Unknown	Reduced water use associated with treatment.
	Water Meter Program	An online water meter portal allows residents to actively monitor their individual daily water consumption. Residents can set up high water consumption alerts, which can help to catch leakage before utility bills become costly.	2019	Reduced per capita water use and potential domestic leakage detection.
	Free Lawn and Yard Assessment	A limited amount of free "Lawn and Yard Assessments" to residential and commercial utility customers. The goal is to help them understand exactly how much water their lawn needs in order to help them save water and money.	2019	Reduced outdoor per capita water use.
Regulatory Tools	Outdoor Watering Schedule	The outdoor watering schedule helps balance the high demand for water during the peak watering season. <ul style="list-style-type: none"> — Odd numbered addresses may water lawns on Sundays & Thursdays, and even numbered addresses may water lawns on Wednesdays & Saturdays — Watering may occur from 6:00 AM - 9:00 AM or 7:00 PM - 10:00 PM — Households with programmable water irrigation systems can water their lawns from 2:00 AM - 5:00 AM 	2010 - 2019	Reduced per capita peak hour water use. Reduced outdoor per capita water use.
	Water Exemption Permits	Residents are required to apply for a water exemption permit if they are installing new sod or seed on their property. This permit allows additional watering days to ensure root growth establishment of new turf.	2017 - 2019	Reduced outdoor per capita water use.
	Residential Grading (Bylaw 15-12)	Minimum top soil depth requirement (12" average uniform depth) in landscape areas for new residential property construction. Measure promotes water conservation through increased soil water retention and reduced water run-off.	Unknown	Reduced outdoor per capita water use.

TOOL	MEASURE	DESCRIPTION	YEAR IMPLEMENTED	ANTICIPATED BENEFITS
	Indoor Water Conserving Measures (Bylaw 24-18)	In all new or renovation/retrofit applications, water conservation measures (including water conserving fixtures) are to be used, including flow capped faucets, showerheads and toilets.	Unknown	Reduced indoor per capita water use.
	Water Conservation Requirements	In all landscaping projects, the seven principles of xeriscaping are to be considered and applied: planning, top soil, vegetation selection, mulch, turf areas, water, and maintenance.	2010 - 2019	Reduced outdoor per capita water use.
Financial Tools	Residential Water Conservation Rebate Program	A water conservation rebate program is in place to incentivize and reward residents for their efforts towards water conservation. The rebate program includes or has included in the past items such as: <ul style="list-style-type: none"> — Low-flow toilets (WaterSense® certified) — Clothes washers (EnergyStar® certified) — Dishwashers (EnergyStar® certified) — Rain Barrels — Organic and Inorganic Mulch — Rain Sensors or Irrigation Controllers (WaterSense® certified) — Drought Tolerant Ground Cover or Turf — Xeriscaping — Water Timer 	2008 - 2019	Reduced per capita water use.
	LEED Building Incentive Program	A rebate program is in place to incentive the construction of environmentally sustainable commercial and institutional buildings. A recent example is the Spray Park which is a closed loop system, treating and recycling water. Other examples of conservation strategies: <ul style="list-style-type: none"> — Rainwater Reuse — Greywater Reuse — Ultra-low Flush / Dual Flush Toilets — Low Flow Faucets and Showerheads — Waterless Urinals 	2009 - 2019	Reduced per capita water use.



TOOL	MEASURE	DESCRIPTION	YEAR IMPLEMENTED	ANTICIPATED BENEFITS
	Utility Rate Structure	"The more you use, the more you pay" approach to water utility rates. 2019 water consumption rates broken down into tiers: <ul style="list-style-type: none">• Tier 1 (0 - 23 m³) - \$1.55/m³• Tier 2 (24 - 68 m³) - \$1.90/m³• Tier 3 (68+ m³) - \$2.65/m³	2014 - 2019	Reduced per capita water use.

WATER USAGE TRENDS

In order to understand the efficacy of the Town's conservation strategies, gross water produced per capita per day was estimated for the years of 2010 to 2019. Figure 1 shows consumption through time.

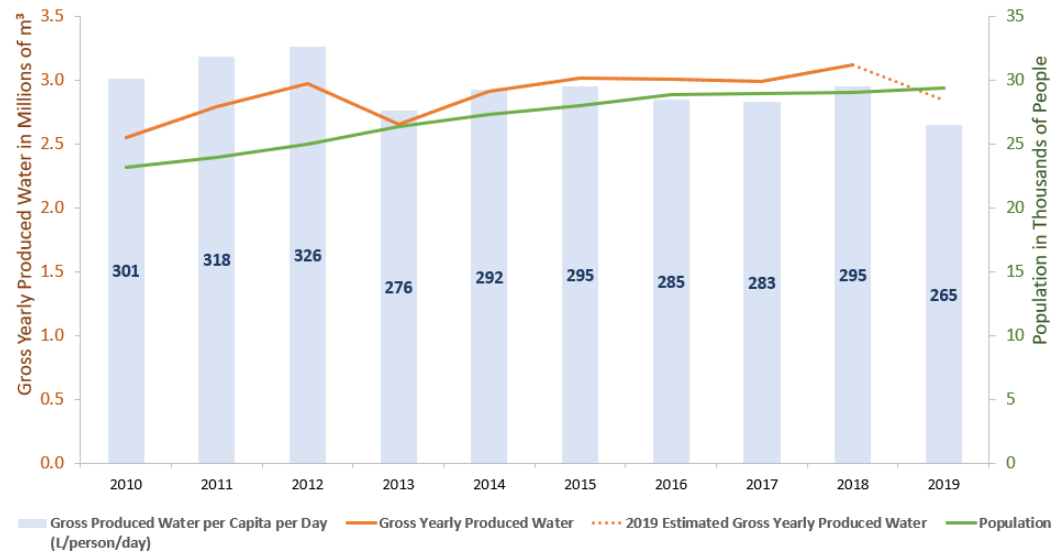


Figure 1: Water Usage Trending

Population has increased from 23,201 in 2010 to 29,002 in 2018 though the produced water has remained constant or decreased with time, suggesting overall conservation measures are working to slightly reduce per capita usage. Gross capita usage before 2013 was above 300 L/c/d. Since 2013, gross capita usage has decreased to below 300 l/c/d, with the Water Conservation, Efficiency and Productivity Plan officially introduced in 2014.

Figure 1 contains incomplete data for 2019, and WSP has linearly extrapolated the usage to date to project a total 2019 value for water production. This value is currently tracking lower than previous years, perhaps impacted by a wet summer, or as the Town suggest, an effective start in 2019 of a more aggressive leak identification and repair program.

SUMMARY AND CONCLUSIONS

CONCLUSIONS

WSP has assessed the supply available against the current residential, commercial, industrial and institutional usage, allowing for 28.5% losses of gross water produced through leakage and the treatment process, as summarized in Table 9.

Table 9: Estimated Annual Water Balance and Surplus for Development

LICENSED ANNUAL SUPPLY VOLUME	MEASURED 2018 ANNUAL USAGE	ESTIMATED ANNUAL LOSSES (NON-REVENUE WATER)	APPROXIMATE ANNUAL SURPLUS
3,724,631 m ³	2,199,778 m ³	1,061,520 m ³	463,333 m ³
	59.1%	28.5%	12.4%

There is an estimated 463,333 cubic metres of water available annually for development in the interim. Without accounting for already approved developments, the total annual surplus will be able to accommodate an additional equivalent of the following properties in the short term on annual average water usage:

- 2110 R1 properties; or,
- 2160 R1N properties; or,
- 2560 R1S properties; or,
- 3050 R2 properties; or,
- 3830 R3 properties; or,
- A combination therefore of the above properties

LIMITATIONS AND ASSUMPTIONS

WSP has reviewed the files pertaining to past and current water usage and has made assumptions to evaluate the remaining water supply licensed volume that the Town can sustain in the short term. Agreement from the Town is required on the key assumptions pertaining to license volume and simplification of land use types.

The key assumptions are as follows:

- 1 2018 meter data supplied by the Town is representative of future usage in the short term
- 2 Population and occupation densities per land use category have been provided by Town staff for 2015, and have been applied in this analysis in the absence of any updated (2018) data.
- 3 The five residential land use categories analysed are a subset of all residential land uses. However, as suggested by Town staff, this subset covers approximately 90% of the residential population and is representative.

A limitation of this document is the absence of analysis for the maximum day demand condition. This is an important scenario to consider as the water treatment plant (and the distribution system) should be demonstrably robust enough to maintain treated potable water to the network if there are several consecutive high demand days. However, assuming a peaking factor of 1.5 applied to all the metered usage in 2018 and the surplus, the resultant daily peak demand would be less than 18 million litres per day, which is the anecdotal capacity of Town's water treatment plant as reported by Town staff.

The key limitations are as follows:

- 1 As agreed with the Town, an assessment of maximum day demand is not part of the scope of this work.
- 2 Many data discrepancies and outstanding questions for clarification have not yet been answered by Town staff at time of writing this memorandum. WSP has emailed Town staff for confirmation about spreadsheet values where values were presented vaguely, but in some cases have not received any feedback from the Town as to the data accuracy. However, Town staff have confirmed the maximum annual licensed total amount of 3,724,631 cubic meters, which was an important value to confirm.



CLOSURE

We trust you will find the foregoing Technical Memorandum suitable. Please do not hesitate to contact the undersigned should you have any questions.

Prepared by:

Ana Kovacevic, Designer
Project Engineer

Approved by:

Clive Leung, P.Eng.
Project Manager

Reviewed by:

Frank Colosimo, P.Eng.
Senior Technical Reviewer



Nov. 26, 2019

ak/cl/jl/ab

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APPENDIX

C TECHNICAL MEMORANDUM NO. 3 – REVIEW OF WATER CONSERVATION MEASURES



TECHNICAL MEMORANDUM NO. 3

TO: Rob Dickinson, P.Eng.
FROM: Clive Leung, P.Eng., Cian Gallagher, Designer.
SUBJECT: Town of Okotoks – Review of Water Conservation Measures
DATE: February 18, 2020
FILE: 19M-01217-00

INTRODUCTION

As a thriving regional hub, the Town of Okotoks (Town) has seen significant population growth in recent years, with the population of the Town doubling between 2018 to a total of 29,002. However, a limiting factor to the Town's ongoing sustainable growth is a secure potable water supply for its existing population in addition to new housing developments.

As of 2019, the Town is approaching its previously denoted 'build-out' population of approximately 30,000. This population estimate was based on previous license withdrawal limits from the Sheep River that the Town could secure, as well as the capacity of the Town's water treatment plant, based on established average and peak day water usage per capita rates estimated at the time of last evaluation (circa 2010).

Since the year 2010, in an effort to keep water usage in check and to provide best practice management of its water usage and supply, the Town has embarked on a series of intensive demand and supply side water conservation initiatives. In addition, the Town has also begun work to secure additional water supply, reviewing several potential source options including expansion of its water treatment plant and increased withdrawal limits from the Sheep River. On November 25, 2013, Okotoks Town Council decided to pursue the development of a regional water system via a connection to the City of Calgary to meet future growth needs. In 2014, the Town released its Water Conservation, Efficiency and Productivity (CEP) Plan, which established the tools by which the Town would to continue to be a leader in water conservation, with a 2014 goal to maintain community water consumption at less than 285 litres per capita per day (lpcd) and achieve a target of 275 lpcd or less by 2017.

Since the development of a regional water pipeline is a multi-year process, the Town has been working on and has been successful with interim water solutions such as the above noted water conservation strategies and water license transfers.

The purpose of this Technical Memorandum No. 3 is to provide a review of the current status of water conservation initiatives being led in the Town, and to review and recommend any further programs based on new research and any other industry initiatives not yet implemented by the Town.

Pertinent assessment details and findings are as follows:

- WSP has focused on 2018 data unless otherwise noted. 2018 is the last full year of data available;
- Non-revenue water accounted for 27.4% of gross water produced in 2018. Accounting for water treatment plant process losses at 4.0%, it can be said that the unaccounted non-revenue water in 2018 was 23.4%.
- The Town has achieved an average day community water consumption at less than 285 lpcd in a number of years; 2013, 2016 and 2017.
- In 2017, the Town achieved gross capita usage of 283 lpcd which is the lowest year average to date, however, has not met the goals of the 2014 CEP.
- At the time of production of this report, the estimated gross capita rate for 2019 was 265 lpcd, however, pending analysis of the full years' of data by the Town.
- The Town's MDP set a baseline of 174 lpcd for 2018, with a target to maintain the lowest per capita residential potable water consumption rates in Canada. Measured values as summarized in this memo provides the Town's residential water consumption rate at approximately 147 – 181 lpcd.

This technical memorandum outlines the approach undertaken by WSP, the assumptions and data sources used, leading to the final conclusions of the analysis.

All data in this technical memorandum are taken from sources listed in Technical Memorandum No. 2 - Water Usage and Short-Term Water Availability Review.

CURRENT WATER USAGE

The Town has licenses to extract raw water from the Sheep River via shallow well fields and has provided WSP with a summary of the current water licenses. The Town has confirmed that the maximum annual total diversion volume licensed is a summation of the two values above, which provides a total diversion volume of 3,724,631 cubic meters. As per Technical Memorandum No. 2 - Water Usage and Short-Term Water Availability Review, the daily per capita consumption for each the simplified residential land use, presented in Table 1.

Table 1: Residential per Person Consumption Totals

LAND USE	METERED USAGE (2018, m ³)	POPULATION (2015)	ANNUAL USAGE PER PERSON (m ³)	AVERAGE DAILY PER CAPITA CONSUMP. (l/c/d)
R1	989,573	15,719	63.0	172
R1N	211,294	3,637	58.1	159
R1S	105,803	1,967	53.8	147
R2	37,868	572	66.2	181
R3	126,141	2,128	59.3	162

NON-REVENUE WATER

Non-revenue water (NRW) is defined as the difference between gross water extracted from wells and billed water. It includes unbilled authorized consumption, apparent losses and real losses which are discussed further below. An analysis of the gross water extracted and the billed water in the years from 2015 and 2018 is provided in Table 2.

Table 2: Estimated Non-Revenue Water

YEAR	GROSS WATER PRODUCED (m ³)	BILLED WATER ⁽³⁾ (m ³)	NRW – GROSS LESS BILLED (m ³)	NRW – GROSS LESS BILLED (%)
2015	3,018,328	2,105,167	913,161	30.3%
2016	3,009,091	2,099,179	909,912	30.2%
2017	2,988,044	2,207,163	780,881	26.1%
2018	3,120,603	2,266,199	854,404	27.4%
AVERAGE				28.5%

(3) Annual volumes of billed water come from the 2010-2019 Production and Consumption summaries.xlsx spreadsheet supplied by the Town. There is a 3% discrepancy between this total and the 2018 metered total, considered to be acceptably within flow meter error.

While NRW has reduced to below 30% in 2017 and 2018 it is still an issue facing the Town. As mentioned above NRW includes unbilled authorized consumption, apparent losses and real losses. It should be noted that the Town reduced water treatment plant process losses from 8% to 4% from 2010 to 2019. Non-revenue water accounted for 27.4% of gross water produced in 2018. Accounting for water treatment plant process losses, it can be said that the unaccounted non-revenue water in 2018 was 23.4%.

Unbilled authorized consumption are losses in revenue water through consumption of treated water in authorized ways for which no revenue is gained.

Apparent losses are those found in metering data, through under-reading meters, billing inaccuracies or illegal bypasses of meters. These losses are a discrepancy between potential and actual revenues, as water is delivered to and consumed by customers, but is not paid for. Apparent losses are the non-physical, paper or commercial losses.

Real losses include annual water volume lost through leaks/breaks on mains and service connections up to the point of the customer meter, hydrant flushing and reservoir overflows. Real losses are treated water placed into the distribution system, but never consumed by users.

Table 3 below summarizes the components of revenue and non-revenue water.

Table 3: Standard Water Balance

System Input Volume (corrected for known errors)	Authorized Consumption	Billed Authorized Consumption	Billed Metered Consumption	Revenue Water
			Billed Unmetered Consumption	
		Unbilled Authorized Consumption	Unbilled Metered Consumption	Non-Revenue Water
			Unbilled Unmetered Consumption	
	Water Losses	Apparent Losses	Unauthorized Consumption	
			Customer Metering Inaccuracies	
			Systematic Data Handling Errors	
		Real Losses	Leakage on Transmission and Distribution Mains	
			Leakage and overflows at Utilities' Storage Tanks	
			Leakage on Service Connections up to point of Customer Metering	

WATER CONSERVATION TARGETS

In 2014 the Town of Okotoks published their Water Conservation, Efficiency and Productivity (CEP) Plan. Within this document the Town defined the tools to achieve their overarching goals of maintaining community water consumption at less than 285 litres per capita per day (lpcd) and achieve a target of 275 lpcd or less by 2017.

The CEP plan also outlined further short-term water conservation targets of;

- Develop a residential per capita per day consumption target for 2015,
- Strive to continuously reduce our gross water consumption rate while increasing in population,
- Provide Council with an annual update of the progress of the Plan's implementation strategies,
- Achieve a waterworks leak rate of 5% or less.

More recently, the Town of Okotoks has published their Municipal Development Plan (MDP) which further defined their objectives to reduce water consumption.

The MDP outlined the following targets specifically in relation to water conservation;

- Continue to strengthen water conservation standards and embed these into design guidelines, zoning, and Bylaws for new developments.
- Continue to apply drought-tolerant landscaping standards in all new community public spaces.
- Continue to design for non-irrigated landscapes and convert irrigated spaces to non-irrigated over time. Alternatively, move to water re-use for irrigation of Town owned public spaces.

CURRENT WATER CONSERVATION MEASURES

The Town's strategy is outlined in the Water Conservation Efficiency Productivity Plan and these initiatives are summarized as follows in Table 4. This information has been taken from the CEP Plan and information gained from the Town.

Table 4: Current Water Conservation Measures

TOOL	MEASURE	DESCRIPTION	YEAR IMPLEMENTED	ANTICIPATED BENEFITS
Educational and Outreach Programs	Conservation Educators (Public Education)	Conservation Educators visit many households in Okotoks, educating the community on water and energy conservation and waste management.	2002 – Current	Sharing information on best practices in water conservation. Reduced per capita water use.
	Conservation Educators (School Education)	Conservation Educators attend all summer community events and provide conservation presentations to children at schools and summer day camps.	2002 – Current	Sharing information on best practices in water conservation to students.
	Town Website	Improvements to the website to provide easily accessible information to residents and promote the community's Sustainable Okotoks vision.	2010 – Current	Sharing information on best practices in water conservation. Reduced per capita water use.
	Water Wagon	A Water Wagon that supplies clean drinking water is present at events throughout the summer.	2015 – Current	Increased public awareness towards tap water quality and decreased use of plastic bottles.
	Learning Centre	The EPCOR Environmental Centre offers a visual exploration of Okotoks' water system and provides insight into people's interdependency with this essential life-giving resource.	2017 – Current	Sharing information on how the Town interacts with water.
Infrastructure Improvements	Universal Meter Upgrades	Upgrade meters to make sure that they are recording information accurately.	2016 – Current	Improved measurements and ability to manage water demand. Reduced leakage rates.
	Water Main Upgrades	Upgrade waterworks distribution system to reduce water losses.	2005 – Current	More efficient water use.
	Water Treatment Plant	Air scour improvement projects.	2005 – Current	Reduced water treatment plant process losses from 8% to 4%.

TOOL	MEASURE	DESCRIPTION	YEAR IMPLEMENTED	ANTICIPATED BENEFITS
Operations	Water Reuse	Okotoks utilizes reclaimed water for: <ul style="list-style-type: none"> — Spraying down process scum at the Wastewater Treatment Plant — Watering of boulevard trees and planting beds on Town land — Town maintenance projects that can use non-potable water. 	Unknown	Reduced extraction from water bodies.
	Raw Water	Okotoks utilizes raw water for: <ul style="list-style-type: none"> — Watering of boulevard trees and planting beds on Town land — Street cleaning — Irrigation of fields and parks 	Unknown	Reduced water use associated with treatment.
	Water Meter Program	An online water meter portal allows residents to actively monitor their individual daily water consumption. Residents can set up high water consumption alerts, which can help to catch leakage before utility bills become costly.	2019 – Current	Reduced per capita water use and potential domestic leakage detection.
	Free Lawn and Yard Assessment	A limited amount of free "Lawn and Yard Assessments" to residential and commercial utility customers. The goal is to help them understand exactly how much water their lawn needs to help them save water and money.	2019 – Current	Reduced outdoor per capita water use.
Regulatory Tools	Outdoor Watering Schedule	The outdoor watering schedule helps balance the high demand for water during the peak watering season. <ul style="list-style-type: none"> — Odd numbered addresses may water lawns on Sundays & Thursdays, and even numbered addresses may water lawns on Wednesdays & Saturdays — Watering may occur from 6:00 AM - 9:00 AM or 7:00 PM - 10:00 PM — Households with programmable water irrigation systems can water their lawns from 2:00 AM - 5:00 AM 	2010 – Current	Reduced per capita peak hour water use. Reduced outdoor per capita water use.

TOOL	MEASURE	DESCRIPTION	YEAR IMPLEMENTED	ANTICIPATED BENEFITS
	Water Exemption Permits	Residents are required to apply for a water exemption permit if they are installing new sod or seed on their property. This permit allows additional watering days to ensure root growth establishment of new turf.	2017 – Current	Reduced outdoor per capita water use.
	Residential Grading (Bylaw 15-12)	Minimum top soil depth requirement (12” average uniform depth) in landscape areas for new residential property construction. Measure promotes water conservation through increased soil water retention and reduced water run-off.	Unknown	Reduced outdoor per capita water use.
	Indoor Water Conserving Measures (Bylaw 24-18)	In all new or renovation/retrofit applications, water conservation measures (including water conserving fixtures) are to be used, including flow capped faucets, showerheads and toilets.	Unknown	Reduced indoor per capita water use.
	Water Conservation Requirements	In all landscaping projects, the seven principles of xeriscaping are to be considered and applied: planning, top soil, vegetation selection, mulch, turf areas, water, and maintenance.	2010 – Current	Reduced outdoor per capita water use.
Financial Tools	Residential Water Conservation Rebate Program	<p>A water conservation rebate program is in place to incentivize and reward residents for their efforts towards water conservation. The rebate program includes or has included in the past items such as:</p> <ul style="list-style-type: none"> — Low-flow toilets (WaterSense® certified) — Clothes washers (EnergyStar® certified) — Dishwashers (EnergyStar® certified) — Rain Barrels — Organic and Inorganic Mulch — Rain Sensors or Irrigation Controllers (WaterSense® certified) — Drought Tolerant Ground Cover or Turf — Xeriscaping — Water Timer 	2008 – Current	Reduced per capita water use.

TOOL	MEASURE	DESCRIPTION	YEAR IMPLEMENTED	ANTICIPATED BENEFITS
	LEED Building Incentive Program	<p>A rebate program is in place to incentive the construction of environmentally sustainable commercial and institutional buildings. A recent example is the Spray Park which is a closed loop system, treating and recycling water. Other examples of conservation strategies:</p> <ul style="list-style-type: none"> — Rainwater Reuse — Greywater Reuse — Ultra-low Flush / Dual Flush Toilets — Low Flow Faucets and Showerheads — Waterless Urinals 	2009 – Current	Reduced per capita water use.
	Utility Rate Structure	<p>"The more you use, the more you pay" approach to water utility rates. 2019 water consumption rates broken down into tiers:</p> <ul style="list-style-type: none"> • Tier 1 (0 - 23 m³) - \$1.55/m³ • Tier 2 (24 - 68 m³) - \$1.90/m³ • Tier 3 (68+ m³) - \$2.65/m³ 	2014 – Current	Reduced per capita water use.

SUCCESS OF CURRENT WATER CONSERVATION MEASURES

To understand the success of the Town's conservation strategies, gross water produced per capita per day was estimated for the years of 2010 to 2019. Figure 1 shows consumption through time.

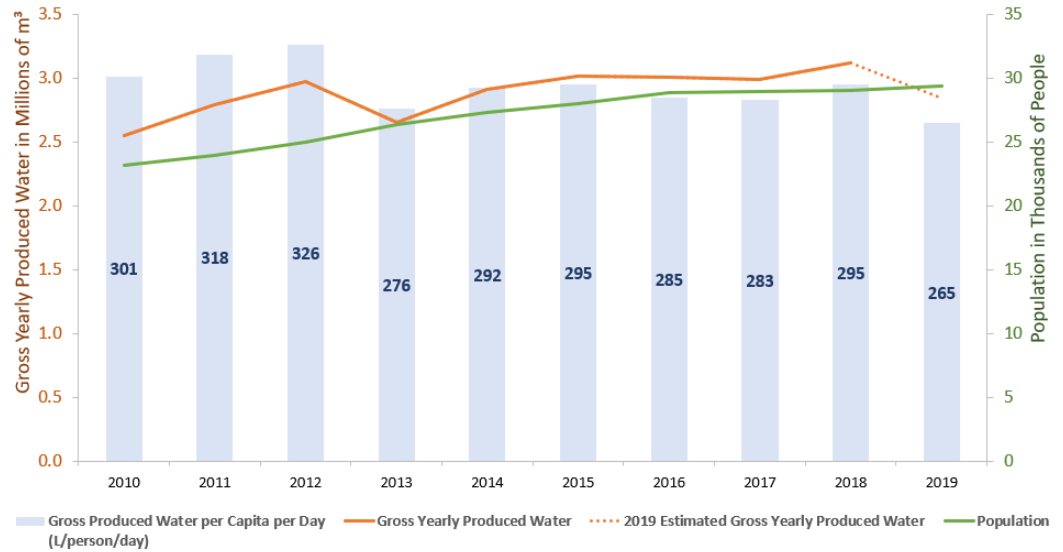


Figure 1: Water Production and Population

While population has increased from 23,201 in 2010 to 29,002 in 2018 the produced water has remained constant or even has slightly decreased with time, suggesting overall conservation measures are working to promote a general reduction in per capita usage. Gross capita usage before 2013 was above 300 L/c/d. Since 2013, gross capita usage has decreased to below 300 L/c/d, with the CEP Plan officially introduced in 2014.

Figure 1 contains incomplete data for 2019, as available at the time of the analysis completed for this memo, and WSP has linearly extrapolated the usage to date to project a total 2019 value for water production. This value is currently tracking lower than previous years, perhaps impacted by a wetter summer, or, as suggested by the Town, an effective start in 2019 to a more aggressive leak identification and repair program. Regardless, the Town is encouraged to keep its trending up-to-date and monitor water usage moving forwards.

Table 5 below summarizes the Town's results in relation to their water conservation targets outlined in the 2014 CEP Plan.

Table 5: Targets and Results of Water Conservation Measures

TARGET	RESULTS
Maintain community water consumption at less than 285 lpcd	The Town has achieved community water consumption at less than 285 lpcd in a number of years; 2013, 2016 and 2017. However, it was not maintained in 2018 (295 lpcd) which potentially indicates that annual seasonal variability (i.e. hot summers) may still be a challenge for the Town.
Community wide gross water consumption target of 275 lpcd or less by 2017	In 2017, the Town achieved gross capita usage of 283 lpcd which is the lowest year average to date. WSP has linearly extrapolated 2019 values for water production from available date, suggesting that the Town may achieve gross capita usage of 265 lpcd. Future trending and continued water conservation efforts are still encouraged.
Develop a residential per capita per day consumption target for 2015	The Town's MDP set a baseline of 174 lpcd for 2018 with a target to maintain the lowest per capita residential potable water consumption rates in Canada.
Strive to continuously reduce our gross water consumption rate while increasing population	Population has continuously increased from 23,201 in 2010 to 29,002 in 2018. However, the gross water consumption rate has not continuously reduced over the same period suggesting the gross water consumption rates have continued to reduce.
Provide Council with an annual update of the progress of the Plan's implementation strategies	Unknown at time of this reporting.
Achieve a waterworks leak rate of 5% or less	Non-revenue water accounted for 27.4% of gross water produced in 2018. Accounting for 4% of this as losses in the water treatment plant process it can be said that the waterworks leak rate may be as high as 23.4%. The Town still has a large opportunity for water loss reduction through leak reduction activities.

FURTHER WATER CONSERVATION MEASURES

The Town has in its history, implemented an wide array of water conservation measures focusing on educational programmes, improved infrastructure, operations, regulatory tools and financial tools. These measures have lead to measured successes for the community as shown in Table 5, however the percentage of annual NRW appears to continue to be a large opportunity for the Town to focus on for water loss reduction.

A number of further water conservation measures aimed at reducing consumption through targeting water loss reduction as recommended by our current review are outlined below.

WATER SYSTEM AUDITS

A water audit is a process to measure consumption and losses in a system. A water audit enables the Town to determine the water supplied, consumed, and lost in the distribution system.

Water audits improve the utility's knowledge of the water supply infrastructure which can lead to significant reductions in demand by enabling the identification of leaks and allow the utility to monitor the efficacy of other water conservation programs. Beyond the initial costs of putting the required metering infrastructure in the network, costs for carrying out audits are generally low.

By reducing real losses, there is a direct conservation benefit. Any amount of reduced leakage is the same amount of water that does not need to be supplied by the source. A base level of information about the system is required to carry out a water audit. This may require installation of flow meters and other infrastructure to generate more meaningful results.

The original scope of the water master plan project from which this Technical Memorandum is based, included a Water Audit review in the scope. However, during the course of the project, the Town has advised that a Water Audit has recently been completed by others. WSP has not been able to obtain this information from the Town, nor has the Town been successful in obtaining the water audit, so our team can not comment on the validity of the water audits previously conducted at this point. However, understanding the significant opportunity for water loss reduction through the known large NRW values, WSP reiterates that a Water Audit should be completed for the Town.

INCREASED WATER METERING

A comparison of the 2018 consumption report and the 2016 Parcel Shapefile indicated that 92.3% of lots in the Town of Okotoks are currently metered. By increasing the metering to include all lots this may reduce the NRW by reducing unauthorized consumption. This includes residential and ICI customers. This may also give greater certainty to the water auditing process by reducing unbilled unmetered consumption by converting it to unbilled consumption. Universal metering is instrumental to the success of other conservation programs such as volumetric pricing, system water audits and leak detection programs. A program to bring the Town to 100% universal metering is strongly recommended.

A further major recommendation and measure for water metering is also the addition of meters on irrigation sprinklers for commercial properties. This would allow the Town to gain a greater level of understanding of the current outdoor water usage with ICI customers and add further certainty to the water system auditing.

LEAK DETECTION AND REPAIR PROGRAM

A leak detection and repair program should be considered by the Town to reduce the volume of NRW related to system losses. Initial steps are to review leak, break, and maintenance data to identify areas of historical pipe problems and review reservoir overflow levels. They also include metering or estimating municipal uses such as main flushing, street washing, and firefighting. Information from a water audit is also a key input at this stage.

Leak detection equipment could also be utilized at this point. Acoustic leak-detection technologies use sound waves to help locate leaks in distribution systems and prioritize leak repair by identifying the largest leaks. Leaks create a distinctive noise as water leaves the pipe, with smaller leaks producing a higher-frequency sound and larger leaks typically having a lower-frequency sound.

Noise loggers are a specific type of acoustic leak-detection technology that includes a listening head and digital recorder in a single sensor. They can be attached magnetically along the distribution system (e.g., key junctions, main valves, or hydrants) and left in place for extended periods or moved as needed to record noise levels and detect leaks.

Acoustic leak-detection noise loggers work well for long-term recording because they eliminate the need for an operator during the recording. However, analyzing the data requires experience or specialized software to characterize and differentiate leak sounds from those of normal water flow through the distribution system, pumps and any other background noises such as construction or traffic.

Acoustic leak-detection noise loggers work best on cast iron, ductile iron, steel, concrete, and transit pipes. They will work on PVC pipes though longer data collection periods may be necessary.

PRESSURE MANAGEMENT

This conservation strategy is designed to reduce the amount of leakage and water lost in the distribution system based on internal watermain pressures. During low consumption periods (i.e.: night-time flows or even in the winter) the distribution system is subjected to higher pressures than during the daytime (or the summer). A pressure management strategy will use pressure reduction valve (PRV) stations linked to the SCADA network to remotely sense and reduce pressures in the system during periods of low demand. Lower internal watermain pressures reduce the amount of background leakage. Reduced pressures may also have the added benefit of extending the life of the Town's existing water system infrastructure.

Implementing a pressure management system is most cost-effective where pressure zones are only supplied by PRVs and the elevation change across a pressure zone is relatively minor. This strategy can be investigated for the Town of Okotoks. Typically reducing pressure in can result in gross water use reductions of approximately 10 to 15%. (Mueller Company, 2018)

DISTRICT METERED AREAS

A District Metered Area (DMA) is a methodology where the Town is divided into sections, and the flow of water that enters the area is checked against a theoretical flow of water. These sections are usually created by closing boundary valves so that it remains flexible to changing demands. When a significant difference occurs between flow and theoretical flow, targeted leak detection programmes are undertaken to find the leaks that may be causing the difference. The leaks can then be repaired to decrease water losses in the system.

DMA's can offer increased operational control, additional information on both short- and long-term consumption patterns, which can facilitate system hydraulic analysis and identify required upgrades and quantification of minimum night-time flows which allows targeting of high leakage areas.

SUMMARY AND CONCLUSIONS

WSP previously assessed the supply available against the current residential, commercial, industrial and institutional usage, allowing for 27.4% losses of gross water produced in 2018 the various mechanisms causing NRW, as summarized in Table 6.

Table 6: 2018 Estimated Annual Water Balance

GROSS WATER PRODUCED	MEASURED 2018 ANNUAL USAGE	ESTIMATED ANNUAL LOSSES (NON-REVENUE WATER)
3,120,603 m ³	2,266,199 m ³	854,404 m ³
	72.6 %	27.4%

Since 2010, the Town has implemented an array of water conservation measures to date focusing on educational programmes, improved infrastructure, operations, regulatory tools and financial tools. The Town has had relative success in relation to the goals it set in the 2014 CEP document and has set further goals in the Town's 2019 MDP.

Non-revenue water for the Town in 2018 accounted on average for 27.4% of gross water produced. Accounting for 4% of this as losses in the water treatment plant process it can be said that the water distribution system leak rate may be as high as 23.4%. Any water further conservation measures should focus on the reduction of NRW within the Town.

The Town can use a combination of increased water metering, water system audits, leak detection and repair programmes, and district metered areas to improve water conservation measures within the municipality. The Town should initially focus on increased water metering to achieve universal metering within the municipality to reduce the NRW and to gain a complete understanding of the water system. Following this DMAs can be set up to localise areas of leakage and to inform a targeted leak detection programme. This combined with a repair program will greatly assist the Town in reducing water leaks and thereby reducing NRW. Following the implementation of the above a water system audit can be carried out to measure consumption and residual losses in the system.

Pressure management should not be considered by the Town at this time, as the Town has a relatively flat topography and therefore has small pressure zones. It is also serviced by a reservoir and has multiple PRV's currently installed.

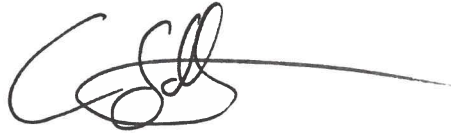
REFERENCES

Mueller Company. (2018). *Examining Pressure Management Methods in Water Distribution Systems*. Chattanooga, TN.

CLOSURE

We trust you will find the foregoing Technical Memorandum suitable. Please do not hesitate to contact the undersigned should you have any questions.

Prepared by:



Cian Gallagher, MIEI
Designer
WSP Canada Group Ltd.

Approved by:



Clive Leung, P.Eng.
Project Manager
WSP Canada Group Ltd.

CG/CL

This document has been prepared by WSP Canada Group Ltd. ("WSP") for the exclusive use and benefit of the client to whom it is addressed. The information and data contained herein represent WSP's best professional judgement in light of the knowledge and information available to WSP at the time of preparation and using skills consistent with those exercised by members of the engineering profession currently practicing under similar conditions. Except as required by law, this document and the information and data contained herein are to be treated as confidential and may be used and relied upon only by the client. WSP denies any liability whatsoever to other parties who may obtain access to this document for any injury, loss or damage suffered by such parties arising from their use of, or reliance upon, this document or any of its contents without the express written consent of WSP and the client. Information in this document is to be

APPENDIX

D HYDRANT FLOW TESTING REPORTS AND CALIBRATION RESULTS

Final Report for
WSP

Attn: **Kate Huston, E.I.T.**

Okotoks, Alberta
Fire Hydrant Flow Testing
October, 2019



Prepared and submitted by:

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January 6, 2020, 2019

Kate Houston, E.I.T.

WSP

237 4th Avenue SW, Suite 3300
Fifth Avenue Place
Calgary, Alberta
T2P 4K3

FINAL REPORT: 2019 Fire Hydrant Flow Testing - Okotoks, Alberta

Dear Ms. Houston;

Please find enclosed SFE's Final Report for the above mentioned project. If you have any questions, comments or concerns, please do not hesitate to contact us at your earliest convenience.

Thank you for having SFE conduct this work on your behalf. We are appreciative of the opportunity to work with you and your team on this project. We look forward to working together again in the near future.

Sincerely,
SFE Global

Kevin McMillan
Vice President
(780) 461-0171
Kevin.McMillan@sfeglobal.com
www.sfeglobal.com

1. Executive Summary

This report provides details of the hydrant fire flow testing conducted in Okotoks, Alberta. SFE Global was retained by WSP, under the direction of Ms. Kate Houston, E.I.T.. Kevin McMillan represented SFE Global as Project Manager during this project.

As requested, SFE conducted twelve C-Factor fire hydrant fire flow tests and twelve Multi-Pressure fire hydrant flow tests. Testing was performed on October 3rd and 4th, 2019. The flow hydrants and test hydrants were indicated to SFE by maps supplied by the client. The fire flow tests were conducted according to National Fire Protection Association (NFPA) 291 standards.

2. Summary of Testing

SFE Technicians met representatives of the Town of Okotoks and WSP on-site to perform testing. The testing plan was discussed and location maps reviewed by all participants.

Testing Equipment

Testing was performed on flow hydrants utilizing a Hydro Flow Products 4-inch Hose Monster system with integral de-chlorinator. These are fixed pitot devices to measure flow, de-chlorinate and diffuse in one process. The benefit of this system is the ability to provide repeatable results and manage discharge water conditions.

The configuration for the Hose Monster System consisted of one four-inch hose monster on the Flow hydrant pumper port. To digitally log pressure on the residual and multi-pressure hydrants SFE Technicians installed Telog HPR hydrant pressure loggers. These devices were set to ten second logging intervals and one second sampling intervals. Each interval logs the minimum, maximum and average pressure for that ten second time period.

Testing Procedure

The client selected all flow and residual hydrants for each test. SFE Technicians installed flow testing equipment on each flow hydrant and residual pressure measurement equipment on the residual and static pressure hydrants.

For C-Factor testing, Town Personnel closed appropriate mainline vales to direct flow to the flow hydrant. Pressure loggers were installed on two upstream residual pressure hydrants to measure pressure drop between these points. The tests were performed by recording system static pressure then flowing the four-inch port on the flow hydrant. Once fire pumps activated and the pressure and flow stabilized all flow and residual pressures were recorded. Total flow and extrapolated flow to 20 psi residual pressure are calculated from this test on the flow testing summary sheets.

For Multi-Pressure testing, SFE Technicians installed static pressure loggers on four hydrants in the study area, chosen by the client. Flow tests were then performed on four, flow and residual hydrant pairs within the study area. Once fire pumps activated, and the pressure and flow stabilized all flow and residual pressures were recorded. Static pressure hydrant values were included on the report sheets for each test. Total flow and extrapolated flow to 20 psi residual pressure are calculated from this test on the flow testing summary sheets.

- Flow testing summary sheets are included in Appendix I.
- Flow testing map is included in Appendix II.

3. Data

The testing reports included in Appendix I contain all test results and photos. All pressure readings are in psi and all flow values are reported in IGPM. All hydrants were returned to as found condition upon completion of testing.

4. Safety

A pre-job safety inspection and meeting was conducted by SFE personnel, and the following potential hazards were identified:

- Need for Personal Protective Equipment
- Working with water under pressure
- Pedestrian and vehicular traffic conditions
- Safe operation and shut down of fire hydrants

This project was conducted in accordance with the WCB and OSHA safety standards as documented in SFE's Safety Procedures Manual. The SFE crew reviewed the work to be completed and safety requirements at a tail-gate safety meeting held prior to commencing work.

Report End
January 2020

SFE Global
Project A19-056

Appendix I

Test Results

C-Factor Tests



Fire Flow Test Report

Client Name:	WSP Engineering	Flow Hyd Port Size	Four Inch	Flow Hyd	NW-55
Project Location:	Town of Okotoks	Pito Type	Four Inch HM	Res Hyd 1	NW-59
SFE Project #:	A19-056	Test Procedure	NFPA 291	Res Hyd 2	h
SFE Technicians:	KM/NS			Fire Pump Status (circle one)	Auto
					Force On

Test ID: S1 Test: 1 of 12 Date: 3-Oct-19

		Flow Hydrant		Residual Hydrant 1		Residual Hydrant 2		Flow Summary (igpm)	
Start Time	End Time	Pito Pressure psi	Hydrant Pressure psi	Static Pressure psi	Residual Pressure psi	Static Pressure psi	Static Pressure psi	Pressure psi	Static Pressure psi
10:01	10:06	7.5	26	69	33	69	69	31	69
		Static Pressure Before Test		62			62		
Notes:									



Flow Hydrant

GPS | 50.7367 -113.9836



Residual Hydrant 1

GPS | 50.7358 -113.9862



Residual Hydrant 2

GPS | 50.73629 -113.9846



Fire Flow Test Report

Client Name:	WSP Engineering	Flow Hyd Port Size	Four Inch	Flow Hyd	NW-48
Project Location:	Town of Okotoks	Pito Type	Four Inch HM	Res Hyd 1	NW-46
SFE Project #:	A19-056	Test Procedure	NFPA 291	Res Hyd 2	NW-48A
SFE Technicians:	KM/NS			Fire Pump Status (circle one)	Auto
					Force On

Test ID: S3 Test: 2 of 12 Date: 3-Oct-19

		Flow Hydrant		Residual Hydrant 1		Residual Hydrant 2		Flow Summary (igpm)	
Start Time	End Time	Pito Pressure psi	Hydrant Pressure psi	Static Pressure psi	Residual Pressure psi	Static Pressure psi	Static Pressure psi	Pressure psi	Static Pressure psi
10:30	10:34	13	38	82	58	81	82	48	81
		Static Pressure Before Test		70			67		
Notes:									



Flow Hydrant

GPS | 50.7275 -113.9913



Residual Hydrant 1

GPS | 50.7285 -113.9895



Residual Hydrant 2

GPS | 50.7274 -113.9897



Fire Flow Test Report

Client Name:	WSP Engineering	Flow Hyd Port Size	Four Inch	Flow Hyd	NE-134
Project Location:	Town of Okotoks	Pito Type	Four Inch HM	Res Hyd 1	NE-136
SFE Project #:	A19-056	Test Procedure	NFPA 291	Res Hyd 2	NE-137
SFE Technicians:	KM/NS			Fire Pump Status (circle one)	Auto
					Force On

Test ID: S6 Test: 3 of 12 Date: 3-Oct-19

		Flow Hydrant		Residual Hydrant 1		Residual Hydrant 2		Flow Summary (igpm)	
Start Time	End Time	Pito Pressure psi	Hydrant Pressure psi	Static Pressure psi	Residual Pressure psi	Static Pressure psi	Static Pressure psi	Pressure psi	Static Pressure psi
11:30	11:35	11.5	36	77	52	77	73	42	73
		Static Pressure Before Test		68			65		
Notes:									



Flow Hydrant

GPS 50.7389 -113.9599



Residual Hydrant 1

GPS 50.7378 -113.9601



Residual Hydrant 2

GPS 50.7377 -113.9622



Fire Flow Test Report

Client Name:	WSP Engineering	Flow Hyd Port Size	Four Inch	Flow Hyd	NE-210
Project Location:	Town of Okotoks	Pito Type	Four Inch HM	Res Hyd 1	NE-206
SFE Project #:	A19-056	Test Procedure	NFPA 291	Res Hyd 2	NE-208
SFE Technicians:	KM/NS			Fire Pump Status (circle one)	Auto
					Force On

Test ID: S7 Test: 4 of 12 Date: 3-Oct-19

		Flow Hydrant		Residual Hydrant 1		Residual Hydrant 2		Flow Summary (igpm)	
Start Time	End Time	Pito Pressure psi	Hydrant Pressure psi	Static Pressure psi	Residual Pressure psi	Static Pressure psi	Static Pressure psi	Pressure psi	Static Pressure psi
11:56	11:58	8	25	70	44	70	66	38	66
		Static Pressure Before Test		64			60		
Notes:									



Flow Hydrant

GPS | 50.7385 -113.9374



Residual Hydrant 1

GPS | 50.7357 -113.9364



Residual Hydrant 2

GPS | 50.7369 -113.9361



Fire Flow Test Report

Client Name:	WSP Engineering	Flow Hyd Port Size	Four Inch	Flow Hyd	NE-171
Project Location:	Town of Okotoks	Pito Type	Four Inch HM	Res Hyd 1	NE-175
SFE Project #:	A19-056	Test Procedure	NFPA 291	Res Hyd 2	NE-172
SFE Technicians:	KM/NS			Fire Pump Status (circle one)	Auto
					Force On

Test ID: S8 Test: 5 of 12 Date: 3-Oct-19

		Flow Hydrant		Residual Hydrant 1		Residual Hydrant 2		Flow Summary (igpm)	
Start Time	End Time	Pito Pressure psi	Hydrant Pressure psi	Static Pressure psi	Residual Pressure psi	Static Pressure psi	Static Pressure psi	Pressure psi	Static Pressure psi
13:19	13:24	11	36	82	56	82	78	49	78
		Static Pressure Before Test		71			67		
Notes:									



Flow Hydrant

GPS 50.7279 -113.9413



Residual Hydrant 1

GPS 50.7271 -113.9433



Residual Hydrant 2

GPS 50.7274 -113.9451



Fire Flow Test Report

Client Name:	WSP Engineering	Flow Hyd Port Size	Four Inch	Flow Hyd	NE-234
Project Location:	Town of Okotoks	Pito Type	Four Inch HM	Res Hyd 1	NE-236
SFE Project #:	A19-056	Test Procedure	NFPA 291	Res Hyd 2	NE-235
SFE Technicians:	KM/NS			Fire Pump Status (circle one)	Auto
					Force On

Test ID: S9 Test: 6 of 12 Date: 3-Oct-19

		Flow Hydrant		Residual Hydrant 1			Residual Hydrant 2			Flow Summary (igpm)	
Start Time	End Time	Pito Pressure psi	Hydrant Pressure psi	Static Pressure psi	Residual Pressure psi	Static Pressure psi	Static Pressure psi	Pressure psi	Static Pressure psi	Hydrant Flow	
13:50	13:57	9.5	36	80	48	80	80	48	80	983	
										Res 1 flow @ 20psi	1380
										Res 2 flow @ 20psi	1380
Static Pressure Before Test				71			71				
Notes: Flow extra three minutes due to water turning brown mid test.											



Flow Hydrant

GPS | 50.7274 -113.9326



Residual Hydrant 1

GPS | 50.7261 -113.9314



Residual Hydrant 2

GPS | 50.7262 -113.9337



Fire Flow Test Report

Client Name:	WSP Engineering	Flow Hyd Port Size	Four Inch	Flow Hyd	NE-73
Project Location:	Town of Okotoks	Pito Type	Four Inch HM	Res Hyd 1	NE-68
SFE Project #:	A19-056	Test Procedure	NFPA 291	Res Hyd 2	NE-72
SFE Technicians:	KM/NS			Fire Pump Status (circle one)	Auto
					Force On

Test ID: S10 Test: 7 of 12 Date: 3-Oct-19

		Flow Hydrant		Residual Hydrant 1		Residual Hydrant 2		Flow Summary (igpm)	
Start Time	End Time	Pito Pressure psi	Hydrant Pressure psi	Static Pressure psi	Residual Pressure psi	Static Pressure psi	Static Pressure psi	Pressure psi	Static Pressure psi
14:27	14:31	12	39	117	60	117	117	53	117
		Static Pressure Before Test		63			63		
Notes:									



Flow Hydrant

GPS 50.7235 -113.9530



Residual Hydrant 1

GPS 50.7213 -113.9541



Residual Hydrant 2

GPS 50.7229 -113.9543



Fire Flow Test Report

Client Name:	WSP Engineering	Flow Hyd Port Size	Four Inch	Flow Hyd	NE-184
Project Location:	Town of Okotoks	Pito Type	Four Inch HM	Res Hyd 1	NE-181
SFE Project #:	A19-056	Test Procedure	NFPA 291	Res Hyd 2	NE-182
SFE Technicians:	KM/NS			Fire Pump Status (circle one)	Auto
					Force On

Test ID: **S11** Test: **8** of **12** Date: **3-Oct-19**

		Flow Hydrant		Residual Hydrant 1		Residual Hydrant 2		Flow Summary (igpm)	
Start Time	End Time	Pito Pressure psi	Hydrant Pressure psi	Static Pressure psi	Residual Pressure psi	Static Pressure psi	Static Pressure psi	Pressure psi	Static Pressure psi
14:55	15:00	15	48	112	56	112	113	56	113
		Static Pressure Before Test		55			55		
Notes: Residual hydrants changed from original plan due to valve issues.									



Flow Hydrant

GPS | 50.7199 -113.9464



Residual Hydrant 1

GPS | 50.7209 -113.9486



Residual Hydrant 2

GPS | 50.7209 -113.9476



Fire Flow Test Report

Client Name:	WSP Engineering	Flow Hyd Port Size	Four Inch	Flow Hyd	SW-29
Project Location:	Town of Okotoks	Pito Type	Four Inch HM	Res Hyd 1	SW-26
SFE Project #:	A19-056	Test Procedure	NFPA 291	Res Hyd 2	SW-30
SFE Technicians:	KM/NS			Fire Pump Status (circle one)	Auto
					Force On

Test ID: S4 Test: 9 of 12 Date: 4-Oct-19

		Flow Hydrant		Residual Hydrant 1		Residual Hydrant 2		Flow Summary (igpm)	
Start Time	End Time	Pito Pressure psi	Hydrant Pressure psi	Static Pressure psi	Residual Pressure psi	Static Pressure psi	Static Pressure psi	Pressure psi	Static Pressure psi
9:35	9:40	12	37	63	52	63	56	48	56
		Static Pressure Before Test		56			52		
Notes:									



Flow Hydrant

GPS 50.7200 -113.9866



Residual Hydrant 1

GPS 50.7195 -113.9841



Residual Hydrant 2

GPS 50.7193 -113.9858



Fire Flow Test Report

Client Name:	WSP Engineering	Flow Hyd Port Size	Four Inch	Flow Hyd	SW-58
Project Location:	Town of Okotoks	Pito Type	Four Inch HM	Res Hyd 1	SW-50
SFE Project #:	A19-056	Test Procedure	NFPA 291	Res Hyd 2	SW-55
SFE Technicians:	KM/NS			Fire Pump Status (circle one)	Auto
					Force On

Test ID: S5 Test: 10 of 12 Date: 4-Oct-19

		Flow Hydrant		Residual Hydrant 1		Residual Hydrant 2		Flow Summary (igpm)	
Start Time	End Time	Pito Pressure psi	Hydrant Pressure psi	Static Pressure psi	Residual Pressure psi	Static Pressure psi	Static Pressure psi	Pressure psi	Static Pressure psi
10:07	10:12	8	25	89	66	89	83	48	83
		Static Pressure Before Test		76			69		
Notes:									



Flow Hydrant

GPS | 50.7117 -113.9864



Residual Hydrant 1

GPS | 50.7124 -113.9850



Residual Hydrant 2

GPS | 50.7127 -113.9824



Fire Flow Test Report

Client Name:	WSP Engineering	Flow Hyd Port Size	Four Inch	Flow Hyd	NE-76
Project Location:	Town of Okotoks	Pito Type	Four Inch HM	Res Hyd 1	NE-87
SFE Project #:	A19-056	Test Procedure	NFPA 291	Res Hyd 2	NE-77
SFE Technicians:	KM/NS			Fire Pump Status (circle one)	Auto
					Force On

Test ID: S2 Test: 11 of 12 Date: 4-Oct-19

		Flow Hydrant		Residual Hydrant 1		Residual Hydrant 2		Flow Summary (igpm)	
Start Time	End Time	Pito Pressure psi	Hydrant Pressure psi	Static Pressure psi	Residual Pressure psi	Static Pressure psi	Static Pressure psi	Pressure psi	Static Pressure psi
10:56	11:01	14	43	70	46	70	73	47	73
		Static Pressure Before Test		58			61		
Notes:									



Flow Hydrant
GPS 50.7287 -113.9538

Residual Hydrant 1
GPS 50.7309 -113.9538

Residual Hydrant 2
GPS 50.7291 -113.9530



Fire Flow Test Report

Client Name:	WSP Engineering	Flow Hyd Port Size	Four Inch	Flow Hyd	SE-96
Project Location:	Town of Okotoks	Pito Type	Four Inch HM	Res Hyd 1	
SFE Project #:	A19-056	Test Procedure	NFPA 291	Res Hyd 2	SE-93
SFE Technicians:	KM/NS			Fire Pump Status (circle one)	Auto
					Force On

Test ID: S12 Test: 12 of 12 Date: 4-Oct-19

		Flow Hydrant		Residual Hydrant 1			Residual Hydrant 2			Flow Summary (igpm)	
Start Time	End Time	Pito Pressure psi	Hydrant Pressure psi	Static Pressure psi	Residual Pressure psi	Static Pressure psi	Static Pressure psi	Pressure psi	Static Pressure psi	Hydrant Flow	
16:46	16:50	15	45				74	51	74	Res 1 flow @ 20psi	N/A
										Res 2 flow @ 20psi	1923
		Static Pressure Before Test					65				
Notes: Fire flow only, isolation valves not available.											



Flow Hydrant

GPS | 50.7062 -113.9448

Residual Hydrant 1

GPS | _____



Residual Hydrant 2

GPS | 50.7055 -113.9452

Appendix I

Test Results

Multi-Pressure Tests



Fire Flow Test Report

Client Name:	WSP Engineering	Flow Hyd Port Size	Four Inch	Flow Hydrant	SE-37
Project Location:	Town of Okotoks	Pito Type	Four Inch HM	Residual Hydrant	SE-36
SFE Project #:	A19-056	Test Procedure	NFPA 291		
SFE Technicians:	KM/NS			Fire Pump Status (circle one)	Auto
					Force On

Test ID: S1Q4 Test: 1 of 4 Date: 4-Oct-19

		Flow Hydrant					Residual Hydrant			Flow Summary (igpm)	
Start Time	End Time	Pito Pressure psi	Hydrant Pressure psi				Static Pressure psi	Pressure psi	Static Pressure psi	Hydrant Flow	
12:09	12:14	12	39				69	50	69	1085	
		Static Pressure Hydrants		Pre Test Static Pressure			58			Flow @ 20psi	1810
S1PS1	SE-55						52	43	63		
S1PS2	SE-40						58	48	69		
S1PS3	SE-61						54	45	65		
S1PS4	SE-78						43	35	55		
Notes:											



Flow Hydrant

GPS 50.7066 -113.9649



Residual Hydrant

GPS 50.7072 -113.9686



Fire Flow Test Report

Client Name:	WSP Engineering	Flow Hyd Port Size	Four Inch	Flow Hydrant	SE-57
Project Location:	Town of Okotoks	Pito Type	Four Inch HM	Residual Hydrant	SE-58
SFE Project #:	A19-056	Test Procedure	NFPA 291		
SFE Technicians:	KM/NS			Fire Pump Status (circle one)	Auto
					Force On

Test ID: S1Q2 Test: 2 of 4 Date: 4-Oct-19

		Flow Hydrant					Residual Hydrant			Flow Summary (igpm)	
Start Time	End Time	Pito Pressure psi	Hydrant Pressure psi				Static Pressure psi	Pressure psi	Static Pressure psi	Hydrant Flow	
12:26	12:31	11.5	35				67	45	67	1062	
		Static Pressure Hydrants		Pre Test Static Pressure			56			Flow @ 20psi	1600
S1PS1	SE-55						53	42	63		
S1PS2	SE-40						59	48	69		
S1PS3	SE-61						55	43	65		
S1PS4	SE-78						45	34	55		
Notes:											



Flow Hydrant

GPS | 50.7048 -113.9654



Residual Hydrant

GPS | 50.7055 -113.9660



Fire Flow Test Report

Client Name:	WSP Engineering	Flow Hyd Port Size	Four Inch	Flow Hydrant	SE-59
Project Location:	Town of Okotoks	Pito Type	Four Inch HM	Residual Hydrant	SE-64
SFE Project #:	A19-056	Test Procedure	NFPA 291		
SFE Technicians:	KM/NS			Fire Pump Status (circle one)	Auto
					Force On

Test ID: S1Q1 Test: 3 of 4 Date: 4-Oct-19

		Flow Hydrant					Residual Hydrant			Flow Summary (igpm)	
Start Time	End Time	Pito Pressure psi	Hydrant Pressure psi				Static Pressure psi	Pressure psi	Static Pressure psi	Hydrant Flow	
12:41	12:45	10.5	31				57	41	57	1024	
		Static Pressure Hydrants		Pre Test Static Pressure			48			Flow @ 20psi	1610
S1PS1	SE-55						52	44	60		
S1PS2	SE-40						57	50	66		
S1PS3	SE-61						53	46	62		
S1PS4	SE-78						44	36	52		
Notes:											



Flow Hydrant

GPS | 50.7034 -113.9659



Residual Hydrant

GPS | 50.7037 -113.9690



Fire Flow Test Report

Client Name:	WSP Engineering	Flow Hyd Port Size	Four Inch	Flow Hydrant	SE-50
Project Location:	Town of Okotoks	Pito Type	Four Inch HM	Residual Hydrant	SE-53
SFE Project #:	A19-056	Test Procedure	NFPA 291		
SFE Technicians:	KM/NS			Fire Pump Status (circle one)	Auto
					Force On

Test ID: S1Q3 Test: 4 of 4 Date: 4-Oct-19

		Flow Hydrant					Residual Hydrant			Flow Summary (igpm)	
Start Time	End Time	Pito Pressure psi	Hydrant Pressure psi				Static Pressure psi	Pressure psi	Static Pressure psi	Hydrant Flow	
13:01	13:05	14	43				69	47	69	1172	
		Static Pressure Hydrants		Pre Test Static Pressure			57			Flow @ 20psi	1806
S1PS1	SE-55						52	44	65		
S1PS2	SE-40						58	48	70		
S1PS3	SE-61						54	46	66		
S1PS4	SE-78						44	36	57		
Notes:											



Flow Hydrant

GPS 50.7082 -113.9601



Residual Hydrant

GPS 50.7062 -113.9582



Fire Flow Test Report

Client Name:	WSP Engineering	Flow Hyd Port Size	Four Inch	Flow Hydrant	NW-4A
Project Location:	Town of Okotoks	Pito Type	Four Inch HM	Residual Hydrant	NW-4
SFE Project #:	A19-056	Test Procedure	NFPA 291		
SFE Technicians:	KM/NS			Fire Pump Status (circle one)	Auto
					Force On

Test ID: S2Q4 Test: 1 of 4 Date: 4-Oct-19

		Flow Hydrant					Residual Hydrant			Flow Summary (igpm)	
Start	End	Pito	Hydrant				Static		Static	Hydrant Flow	1172
Time	Time	Pressure	Pressure				Pressure	Pressure	Pressure	Flow @ 20psi	1555
		psi	psi				psi	psi	psi		
15:03	15:07	14	42				96	51	96		
		Static Pressure Hydrants		Pre Test Static Pressure			60				
S2PS1	NW-5						60	53	96		
S2PS2	NW-22						59	52	95		
S2PS3	NW-34						58	51	94		
S2PS4	NE-4						61	55	97		
Notes:											



Flow Hydrant

GPS | 50.7266 -113.9778



Residual Hydrant

GPS | 50.7270 -113.9843



Fire Flow Test Report

Client Name:	WSP Engineering	Flow Hyd Port Size	Four Inch	Flow Hydrant	NE-3
Project Location:	Town of Okotoks	Pito Type	Four Inch HM	Residual Hydrant	NE-2
SFE Project #:	A19-056	Test Procedure	NFPA 291		
SFE Technicians:	KM/NS			Fire Pump Status (circle one)	Auto
					Force On

Test ID: S2Q3 Test: 2 of 4 Date: 4-Oct-19

		Flow Hydrant					Residual Hydrant			Flow Summary (igpm)	
Start Time	End Time	Pito Pressure psi	Hydrant Pressure psi				Static Pressure psi	Pressure psi	Static Pressure psi	Hydrant Flow	1129
15:19	15:21	13	44				101	55	101	Flow @ 20psi	1532
		Static Pressure Hydrants		Pre Test Static Pressure			62				
S2PS1	NW-5						60	53	99		
S2PS2	NW-22						59	52	98		
S2PS3	NW-34						58	52	97		
S2PS4	NE-4						61	54	100		
Notes: Test run for shorter duration due to being in central downtown.											



Flow Hydrant

GPS 50.7253 -113.9730



Residual Hydrant

GPS 50.7255 -113.9745



Fire Flow Test Report

Client Name:	WSP Engineering	Flow Hyd Port Size	Four Inch	Flow Hydrant	NW-7
Project Location:	Town of Okotoks	Pito Type	Four Inch HM	Residual Hydrant	NW-2
SFE Project #:	A19-056	Test Procedure	NFPA 291		
SFE Technicians:	KM/NS			Fire Pump Status (circle one)	Auto
					Force On

Test ID: S2Q2 Test: 3 of 4 Date: 4-Oct-19

		Flow Hydrant					Residual Hydrant			Flow Summary (igpm)	
Start Time	End Time	Pito Pressure psi	Hydrant Pressure psi				Static Pressure psi	Pressure psi	Static Pressure psi	Hydrant Flow	
15:42	15:45	12	36				101	46	101	1085	
		Static Pressure Hydrants		Pre Test Static Pressure			46			Flow @ 20psi	1337
S2PS1	NW-5						54	54	100		
S2PS2	NW-22						53	53	99		
S2PS3	NW-34						52	51	98		
S2PS4	NE-4						56	55	101		
Notes: Test run for shorter duration due to being in central downtown.											



Flow Hydrant

GPS 50.7249 -113.9791



Residual Hydrant

GPS 50.7252 -113.9789



Fire Flow Test Report

Client Name:	WSP Engineering	Flow Hyd Port Size	Four Inch	Flow Hydrant	NW-23
Project Location:	Town of Okotoks	Pito Type	Four Inch HM	Residual Hydrant	NW-12
SFE Project #:	A19-056	Test Procedure	NFPA 291		
SFE Technicians:	KM/NS			Fire Pump Status (circle one)	Auto
					Force On

Test ID: S2Q1 Test: 4 of 4 Date: 4-Oct-19

		Flow Hydrant					Residual Hydrant			Flow Summary (igpm)	
Start Time	End Time	Pito Pressure psi	Hydrant Pressure psi				Static Pressure psi	Pressure psi	Static Pressure psi	Hydrant Flow	
15:56	16:01	12.5	38				99	51	99	1107	
		Static Pressure Hydrants		Pre Test Static Pressure			59			Flow @ 20psi	1449
S2PS1	NW-5						60	54	99		
S2PS2	NW-22						59	52	98		
S2PS3	NW-34						58	52	98		
S2PS4	NE-4						62	55	101		
Notes:											



Flow Hydrant

GPS 50.7261 -113.9859



Residual Hydrant

GPS 50.7261 -113.9825



Fire Flow Test Report

Client Name:	WSP Engineering	Flow Hyd Port Size	Four Inch	Flow Hydrant	NE-117
Project Location:	Town of Okotoks	Pito Type	Four Inch HM	Residual Hydrant	NE-116
SFE Project #:	A19-056	Test Procedure	NFPA 291		
SFE Technicians:	KM/NS			Fire Pump Status (circle one)	Auto
					Force On

Test ID: S3Q3 Test: 1 of 4 Date: 3-Oct-19

		Flow Hydrant					Residual Hydrant			Flow Summary (igpm)	
Start	End	Pito	Hydrant				Static		Static	Hydrant Flow	902
Time	Time	Pressure	Pressure				Pressure	Pressure	Pressure	Flow @ 20psi	1350
		psi	psi				psi	psi	psi		
16:14	16:17	8	26				58	40	58		
		Static Pressure Hydrants		Pre Test Static Pressure			56				
S3PS1	NE-101						64	54	67		
S3PS2	NE-113						55	44	59		
S3PS3	NE-120						60	48	63		
S3PS4	NE-97						67	57	70		
Notes:											



Flow Hydrant

GPS | 50.7388 -113.9672



Residual Hydrant

GPS | 50.7384 -113.9683



Fire Flow Test Report

Client Name:	WSP Engineering	Flow Hyd Port Size	Four Inch	Flow Hydrant	NE-110
Project Location:	Town of Okotoks	Pito Type	Four Inch HM	Residual Hydrant	NE-109
SFE Project #:	A19-056	Test Procedure	NFPA 291		
SFE Technicians:	KM/NS			Fire Pump Status (circle one)	Auto
					Force On

Test ID: S3Q4 Test: 2 of 4 Date: 3-Oct-19

		Flow Hydrant					Residual Hydrant			Flow Summary (igpm)	
Start Time	End Time	Pito Pressure psi	Hydrant Pressure psi				Static Pressure psi	Pressure psi	Static Pressure psi	Hydrant Flow	
16:36	16:41	11.5	37				62	47	62	1062	
		Static Pressure Hydrants		Pre Test Static Pressure			61			Flow @ 20psi	1852
S3PS1	NE-101						63	52	66		
S3PS2	NE-113						55	42	58		
S3PS3	NE-120						59	47	62		
S3PS4	NE-97						67	56	69		
Notes:											



Flow Hydrant

GPS 50.7370 -113.9733



Residual Hydrant

GPS 50.7363 -113.9712



Fire Flow Test Report

Client Name:	WSP Engineering	Flow Hyd Port Size	Four Inch	Flow Hydrant	NE-104
Project Location:	Town of Okotoks	Pito Type	Four Inch HM	Residual Hydrant	NE-103
SFE Project #:	A19-056	Test Procedure	NFPA 291		
SFE Technicians:	KM/NS			Fire Pump Status (circle one)	Auto
					Force On

Test ID: S3Q1 Test: 3 of 4 Date: 3-Oct-19

		Flow Hydrant					Residual Hydrant			Flow Summary (igpm)	
Start Time	End Time	Pito Pressure psi	Hydrant Pressure psi				Static Pressure psi	Pressure psi	Static Pressure psi	Hydrant Flow	1192
16:52	16:56	14.5	45				75	56	75	Flow @ 20psi	2116
		Static Pressure Hydrants		Pre Test Static Pressure			71				
S3PS1	NE-101						63	52	67		
S3PS2	NE-113						54	42	58		
S3PS3	NE-120						58	47	61		
S3PS4	NE-97						66	55	70		
Notes:											



Flow Hydrant

GPS 50.7330 -113.9737



Residual Hydrant

GPS 50.7328 -113.9721



Fire Flow Test Report

Client Name:	WSP Engineering	Flow Hyd Port Size	Four Inch	Flow Hydrant	NE-98
Project Location:	Town of Okotoks	Pito Type	Four Inch HM	Residual Hydrant	NE-99
SFE Project #:	A19-056	Test Procedure	NFPA 291		
SFE Technicians:	KM/NS			Fire Pump Status (circle one)	Auto
					Force On

Test ID: S3Q2 Test: 4 of 4 Date: 3-Oct-19

		Flow Hydrant					Residual Hydrant			Flow Summary (igpm)	
Start Time	End Time	Pito Pressure psi	Hydrant Pressure psi				Static Pressure psi	Pressure psi	Static Pressure psi	Hydrant Flow	1271
17:08	17:11	16.5	50				74	60	74	Flow @ 20psi	2635
		Static Pressure Hydrants		Pre Test Static Pressure			73				
S3PS1	NE-101						63	51	64		
S3PS2	NE-113						55	41	55		
S3PS3	NE-120						59	46	60		
S3PS4	NE-97						66	53	66		
Notes:											



Flow Hydrant

GPS 50.7326 -113.9658

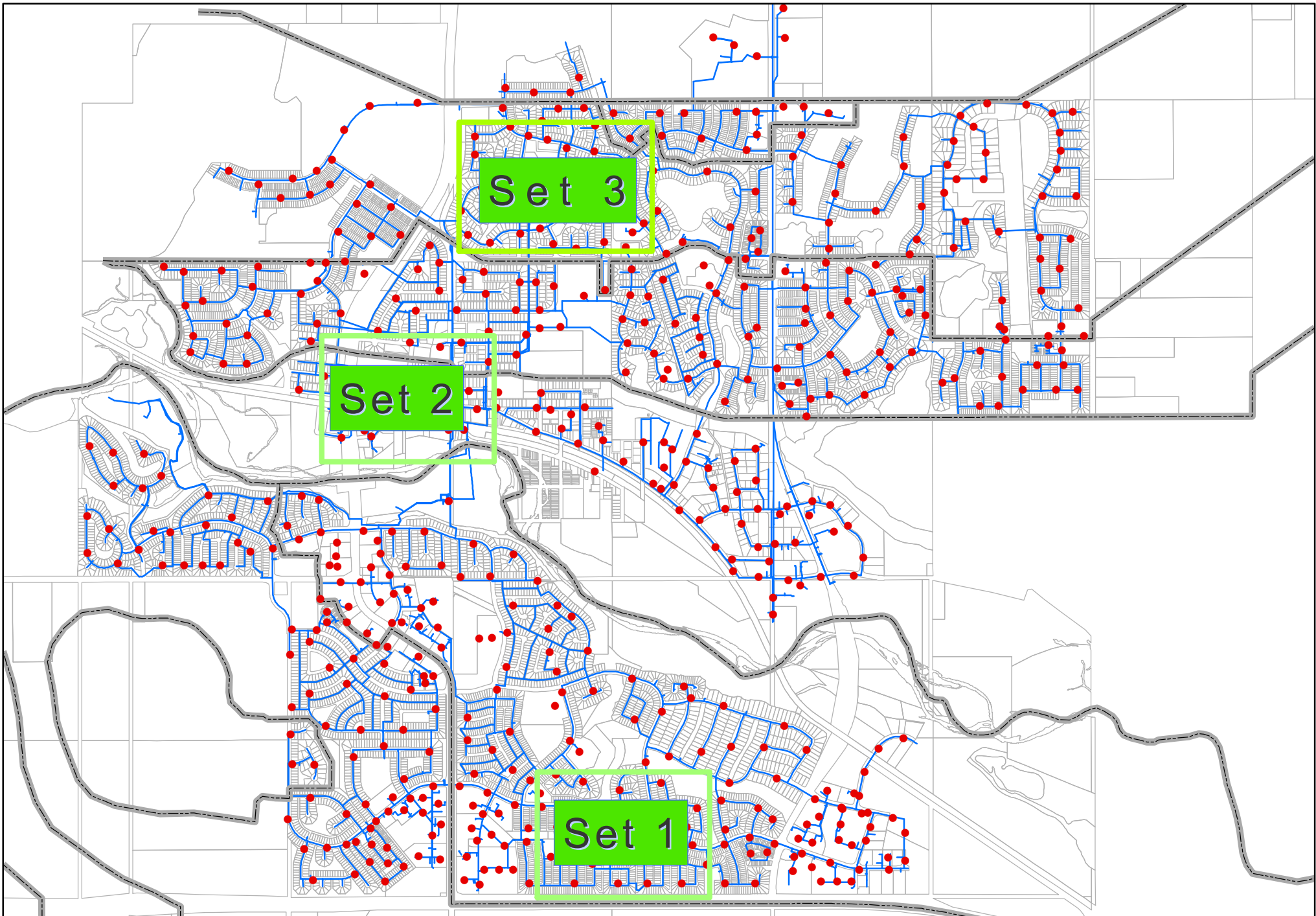


Residual Hydrant

GPS 50.7327 -113.9677

Appendix II

Test Maps



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TOWN OF OKOTOKS WATER MASTER PLAN MULTI-PRESSURE HYDRANT FLOW TEST OVERVIEW

Project No: 19M-01217-00

Drawn By: Approved By:

VP

CL

Note:

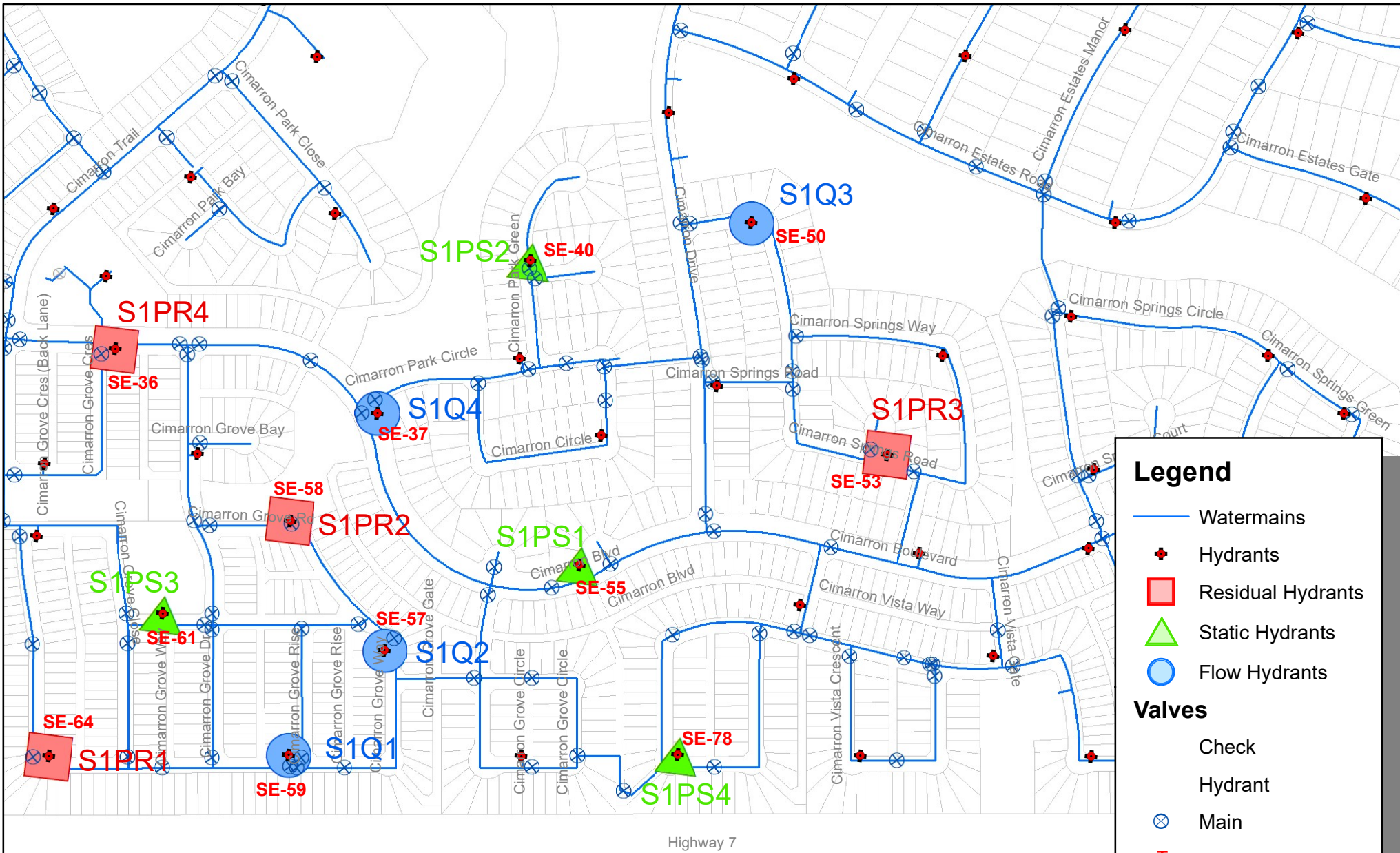
Scale
0 125 250 Meters

1:25,000 @ Letter

Map No. 00

Sept 2019

Revision

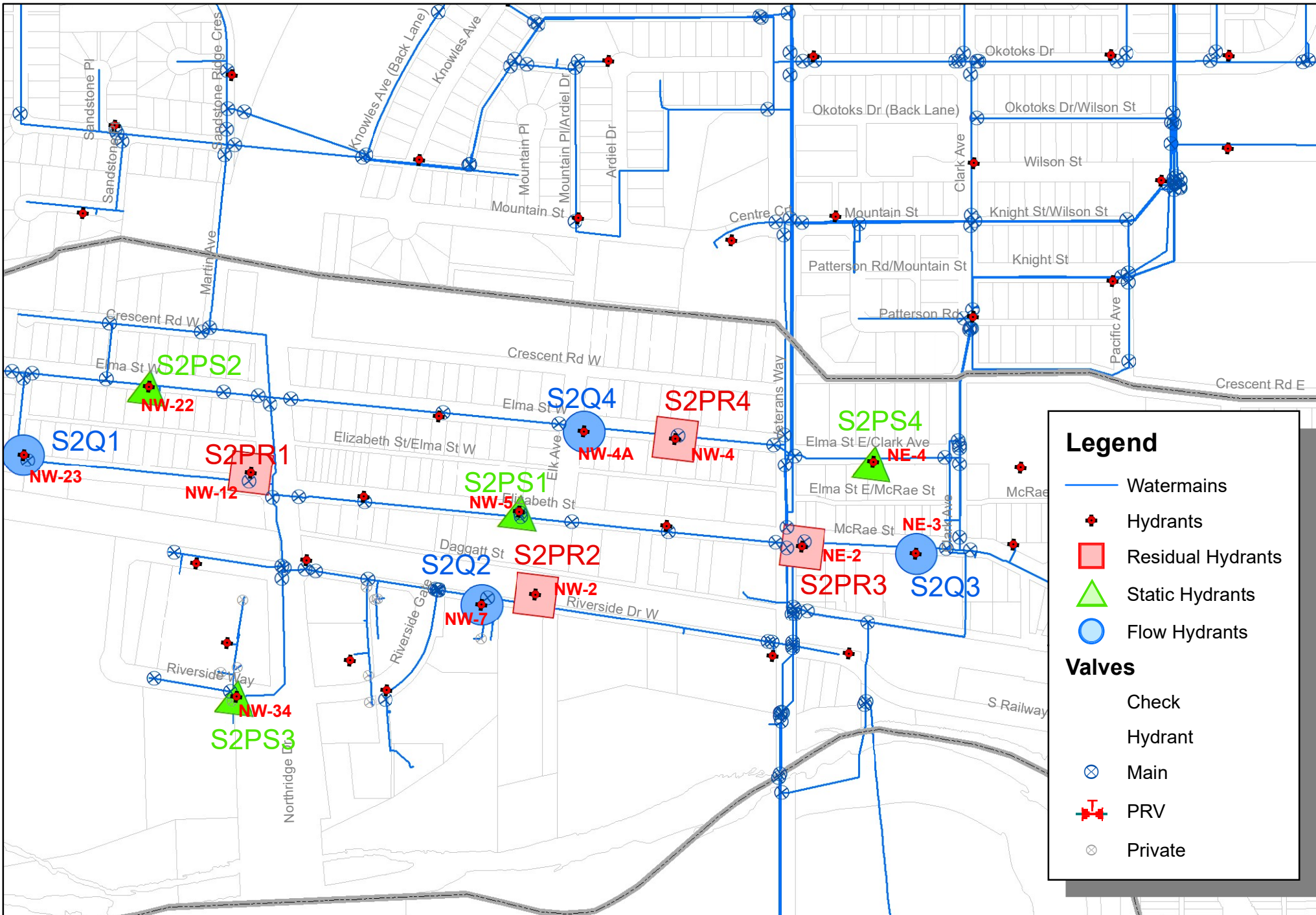


Legend

- Watermains
- Hydrants
- Residual Hydrants
- Static Hydrants
- Flow Hydrants

Valves

- Check
- Hydrant
- Main
- PRV
- Private

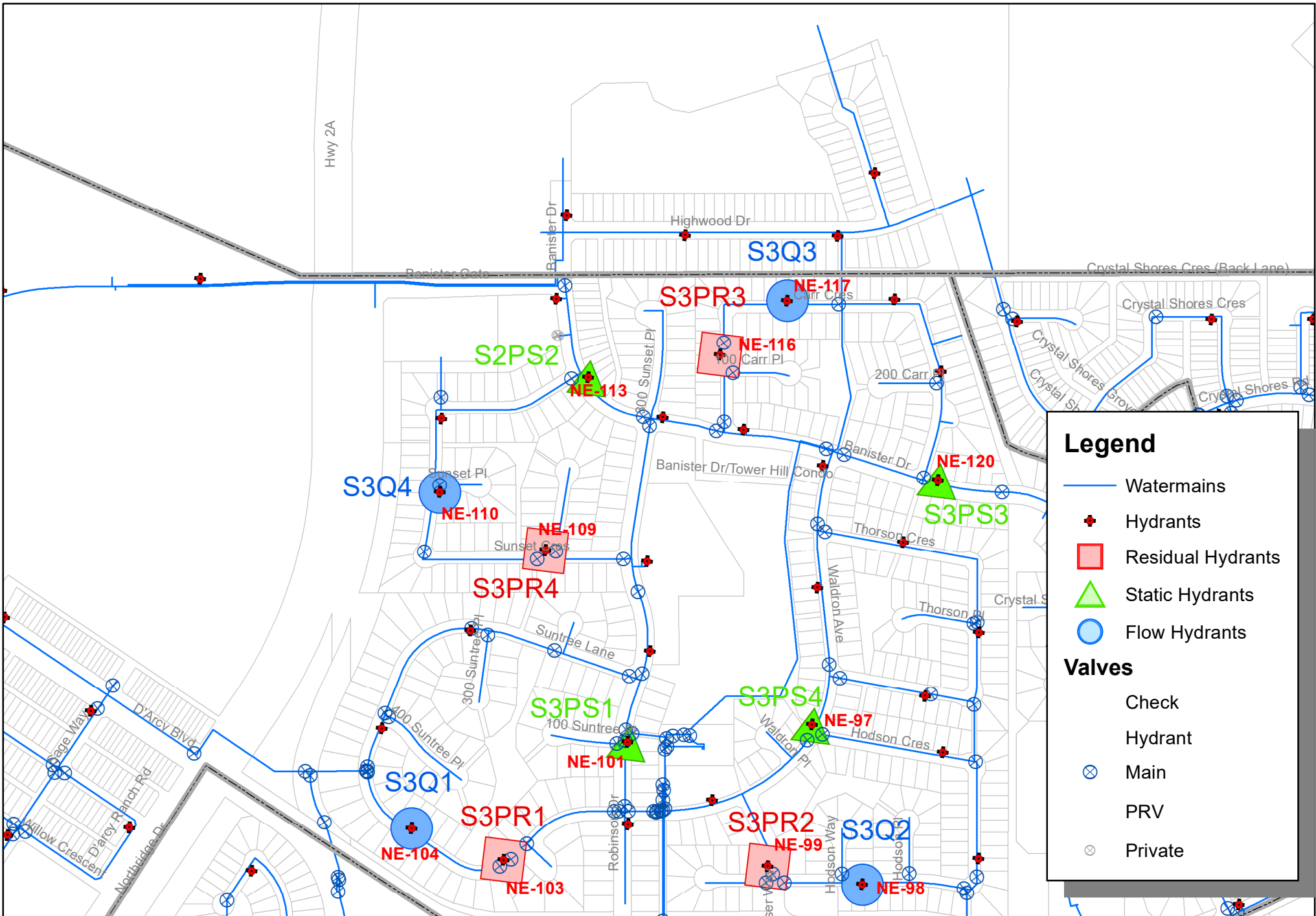


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TOWN OF OKOTOKS WATER MASTER PLAN HYDRANT TEST SET # 2

Project No: 19M-01217-00	Scale	0	45	90 Meters
Drawn By: Approved By:				
VP	CL			1:5,000 @ Letter
Note:		Map No. 01	Sept 2019	
		Revision		

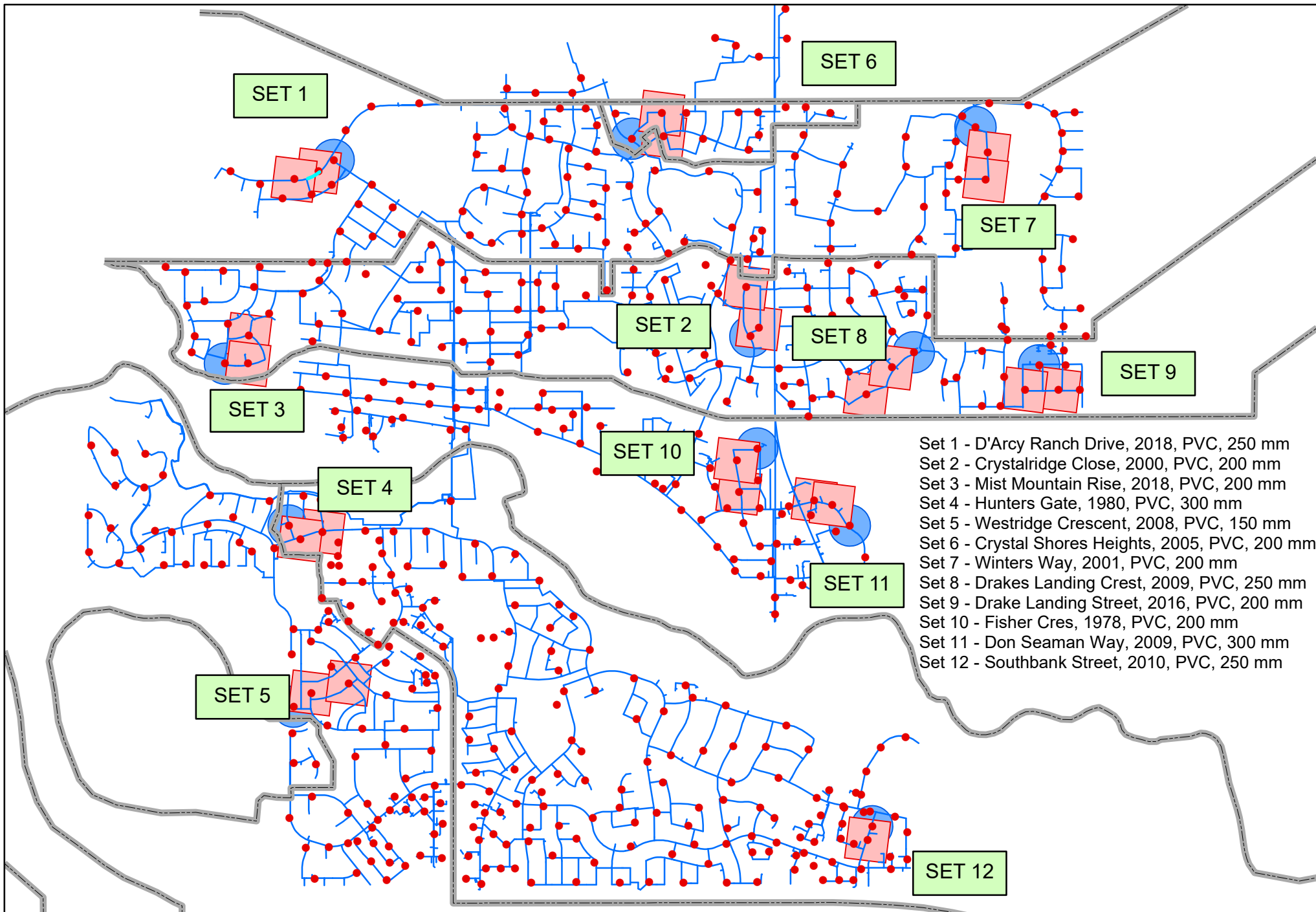


Legend

- Watermains
- Hydrants
- Residual Hydrants
- Static Hydrants
- Flow Hydrants

Valves

- Check
- Hydrant
- Main
- PRV
- Private



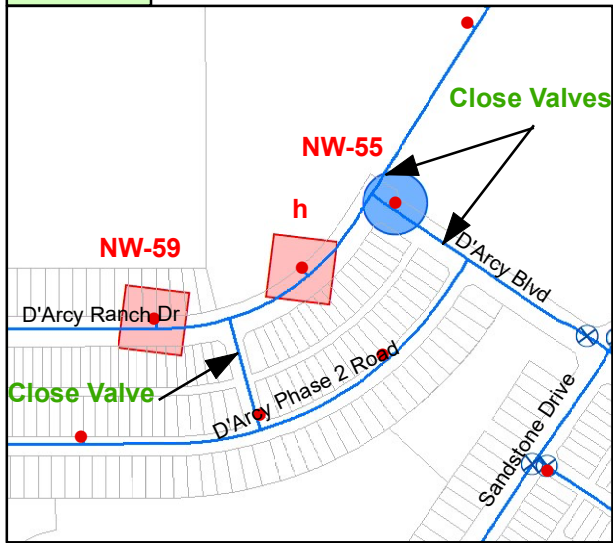
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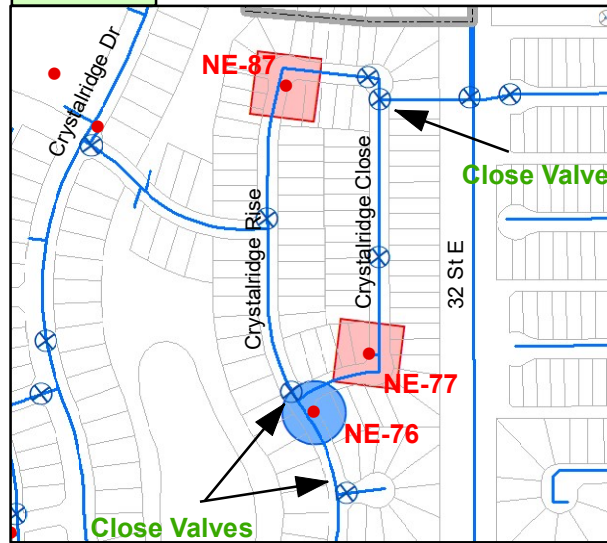
TOWN OF OKOTOKS WATER MASTER PLAN C-FACTOR TEST OVERVIEW

Project No: 19M-01217-00		Scale 0 125 250 Meters	
Drawn By: Approved By:			
VP	CL	1:25,000 @ Letter	
Note:		Map No. 04	Sept 2019
		Revision	

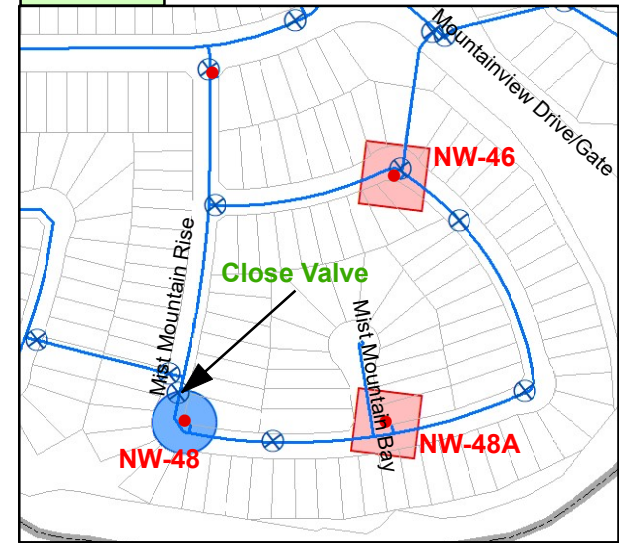
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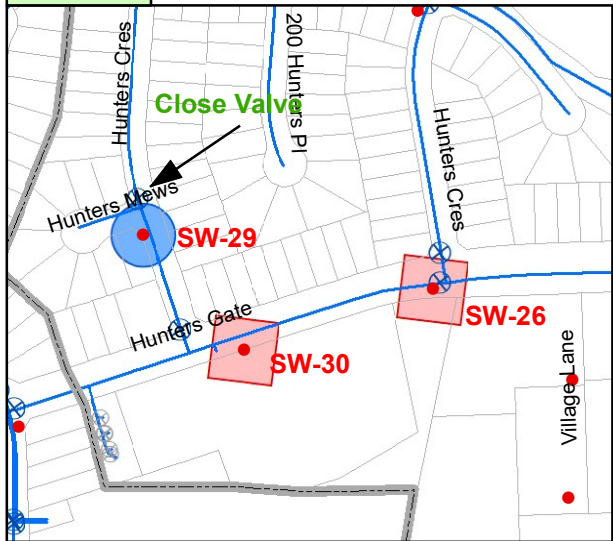
SET 2



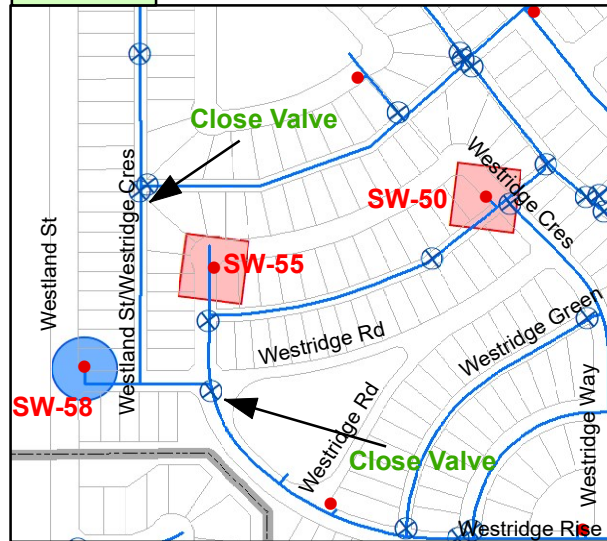
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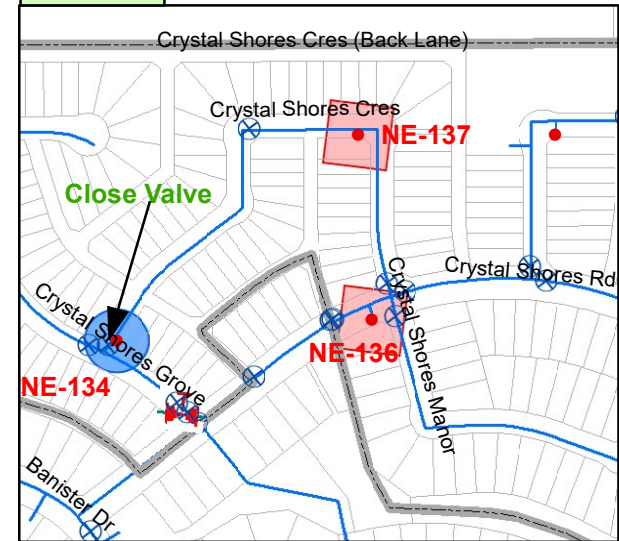
SET 4



SET 5



SET 6



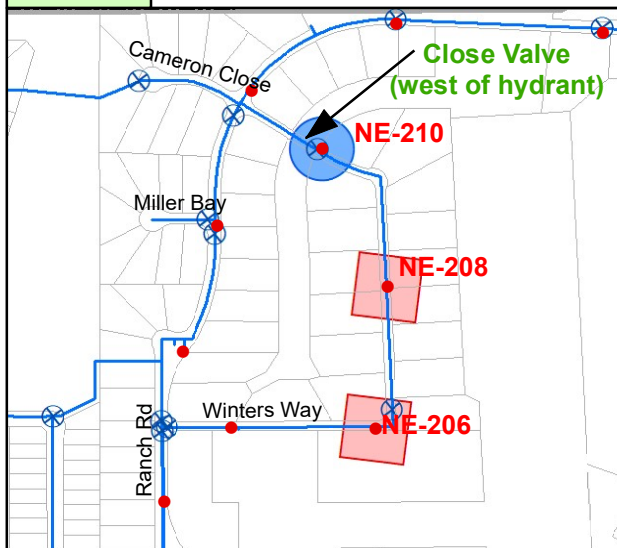
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TOWN OF OKOTOKS WATER MASTER PLAN C-FACTOR TEST OVERVIEW

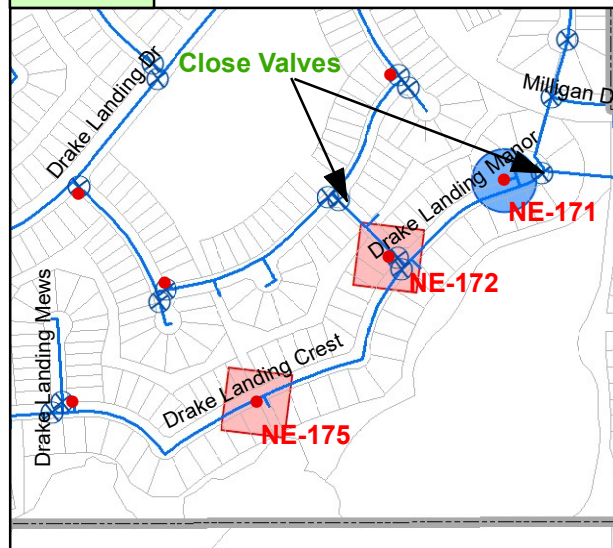
Project No: 19M-01217-00	Scale	0	60	120 Meters
Drawn By: Approved By:				
VP	CL			1:6,323 @ Letter
Note:				Map No. 04 Sept 2019
				Revision

Path: \\c:\nvr-win01\nc_gen_glopus_dk\consultants - contractors\A03 Opus Stewart Weir\proj\19M-01217-00 - Town of Okotoks WMP-400 Tech\GIS\Hydrant Testing\04_1_Hydrant Test C-Factor

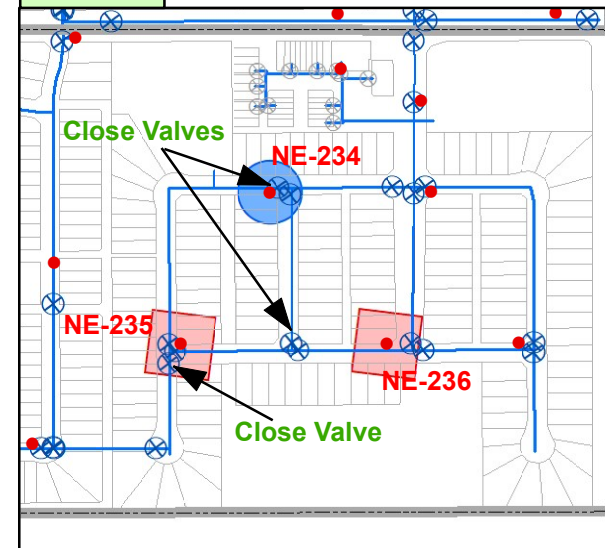
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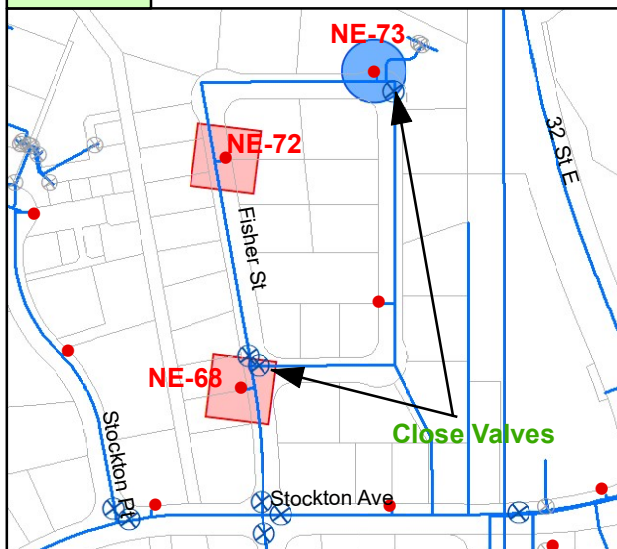
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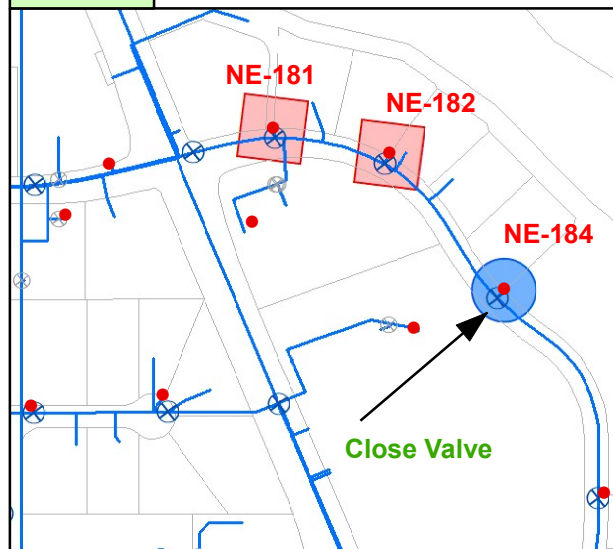
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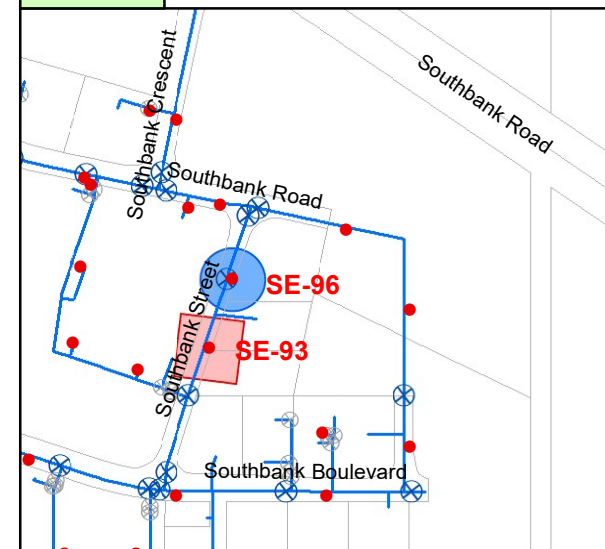
SET 10



SET 11



SET 12



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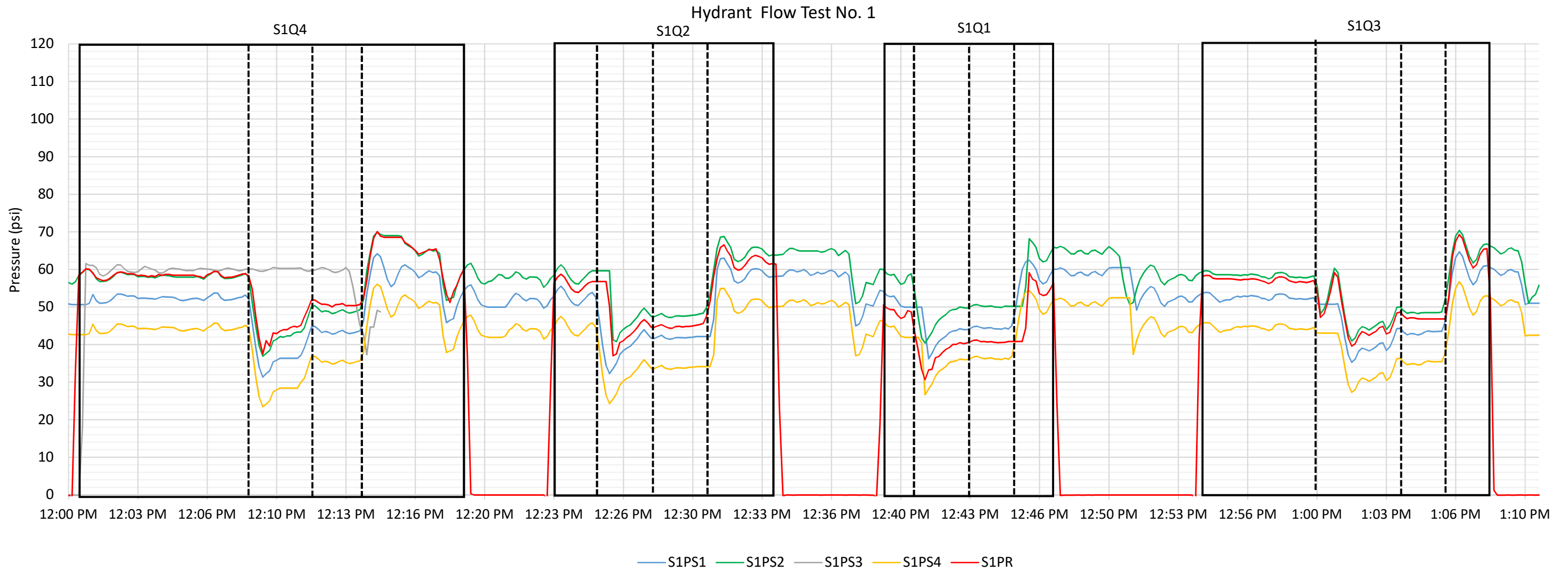
TOWN OF OKOTOKS WATER MASTER PLAN C-FACTOR TEST OVERVIEW

Project No: 19M-01217-00	Scale	0	62.5	125 Meters
Drawn By: VP	Approved By: CL	1:7,235 @ Letter		
Note:		Map No. 04	Sept 2019	
		Revision		

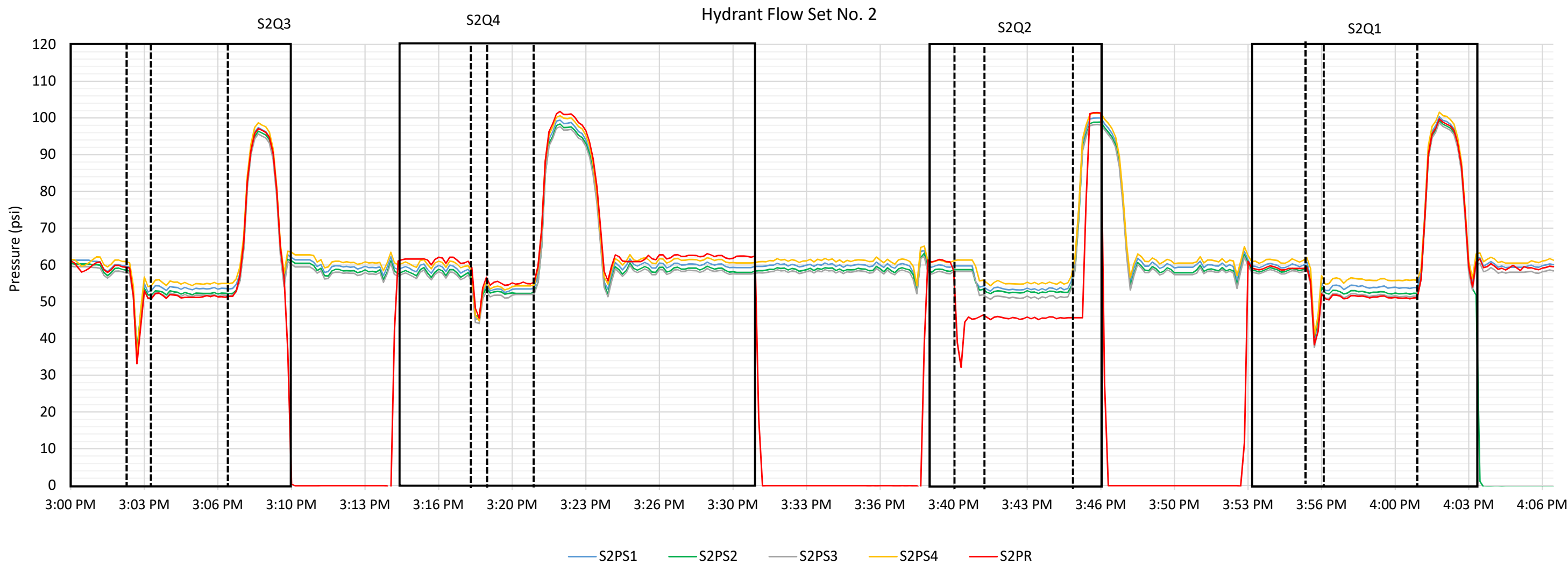
C Factor Calibration

Set	Start Node	Stop Node	Year	Material	D (mm)	igpm	Q (L/s)	C	L (m)	HL	% Diff	
Q1	J-1194	J-391	2018	PVC	250	873	66.15	55	118.94	4.25		
										4.25	Total Headloss (m)	
										4.16	Recorded Headloss (m)	2%
Q3	J-3105	J-556	2016/2017	PVC	200	1129	85.54	137	122.82	3.87		
	J-556	J-1208	2016/2017	PVC	200	1129	85.54	137	239.49	7.54		
										11.41	Total Headloss (m)	
										11.11	Recorded Headloss (m)	3%
Q6	J-1128	J-801	2003	PVC	200	1062	80.47	112	238.09	9.72		
	J-801	J-828	2003	PVC	200	1062	80.47	112	132.54	5.41		
										15.14	Total Headloss (m)	
										15.24	Recorded Headloss (m)	-1%
Q7	J-684	J-1488	2001	PVC	200	902	68.34	120	147.74	3.92		
	J-1488	J-1417	2001	PVC	200	902	68.34	120	166.06	4.41		
										8.34	Total Headloss (m)	
										8.10	Recorded Headloss (m)	3%
Q8	J-870	J-5069	2008	PVC	200	1039	78.72	65	9.25	0.99		
	J-5069	J-3953	2008	PVC	250	1039	78.72	80	138.92	3.43		
	J-3953	J-2793	2008	PVC	250	1039	78.72	80	213.08	5.26		
										9.68	Total Headloss (m)	
										9.42	Recorded Headloss (m)	3%
Q9	J-1543	J-558	2014/2016	PVC	200	983	74.48	132	217.98	5.69		
	J-482	J-1543	2014/2016	PVC	250	983	74.48	132	182.59	1.61		
										7.30	Total Headloss (m)	
										7.38	Recorded Headloss (m)	-1%
Q10	J-2263	J-2166	1978	PVC	200	1085	82.21	112	179.69	7.64		
	J-2166	J-2551	1978	PVC	200	1085	82.21	112	161.42	6.86		
										14.49	Total Headloss (m)	
										14.13	Recorded Headloss (m)	3%
Q11	J-891	J-1142	2009	PVC	300	1213	91.91	70	179.69	3.11		
	J-1142	J-1238	2009	PVC	300	1213	91.91	70	161.42	2.79		
										5.91	Total Headloss (m)	
										5.86	Recorded Headloss (m)	1%
Q4	J-432	J-5593	1980	PVC	200	1085	82.21	75	73.47	6.56		
	J-5593	J-690	1980	PVC	300	1085	82.21	90	150.47	1.33		
	J-690	J-1495	1980	PVC	300	1085	82.21	90	211.85	1.87		
										9.76	Total Headloss (m)	
										9.76	Recorded Headloss (m)	0%
Q5	J-3566	J-2546	2008	PVC	200	902	68.34	165	131.39	1.94		
	J-2546	J-3778	2008	PVC	150	902	68.34	165	158.11	9.45		
	J-3778	J-3813	2008	PVC	150	902	68.34	165	62.88	3.76		
										15.15	Total Headloss (m)	
										15.51	Recorded Headloss (m)	-2%
Q2	J-828	J-1128	2003	PVC	200	1172	88.80	220	370.63	5.20		
										5.20	Total Headloss (m)	
										5.33	Recorded Headloss (m)	-2%
Q12	J-765	J-534	2016	PVC	300	1213	91.91	43	137.48	5.87		
										5.87	Total Headloss (m)	
										5.62	Recorded Headloss (m)	4%

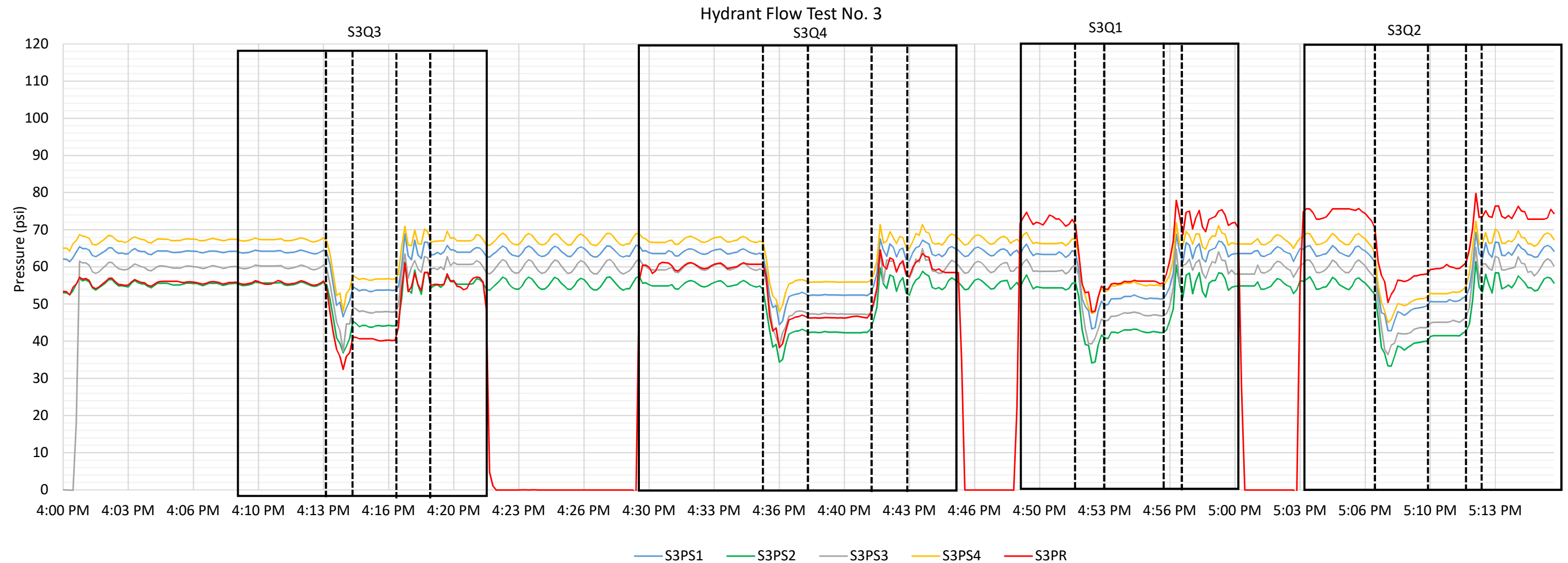
MULTI PRESSURE FIELD RESULTS VS. COMPUTER PREDICTED RESULTS																											
Date	Flow set no.	Pressure Zone	Location	Hydrant Test No. & Time	Flow (GPM)	Flow (L/s)	Test ID	WaterGEMS Node	Hydrant	Hydrant Elev. (m)	Field Result					Computer Result				Static Pressure Diff (psi)	% diff Static Pressure	Residual Pressure Diff (psi)	% diff Residual Pressure	Demand Boundary Conditions	Comments		
											Static (psi)	Residual (psi)	Static HGL (m)	Residual HGL (m)	Pressure Drop (psi)	Static (psi)	Residual (psi)	Static HGL (m)	Residual HGL (m)								
4-Oct-19	1	1S		Q1 Start			S1Q1	J-721	SE-59	1067.1														0.92 ADD	Static pressure tests show that this set appears to be hydraulically disconnected from the system - potentially a closed valve. Removed this test set from comparisons.		
				12:42:00 PM	1024	77.59	S1PR1	J-1167	SE-58	1061.7	33.6	40.6	1085.4	1090.2	-6.9	57.4	50.0	1102.1	1096.9	-	-	-	-				
							S1PS1	J-2283	SE-55	1064.1	51.3	45.7	1100.1	1096.1	5.7	53.9	47.1	1101.9	1097.2	-	-	-	-				
							S1PS2	J-1184	SE-40	1060.5	42.4	50.0	1090.3	1095.7	-7.6	59.2	52.5	1102.2	1097.4	-	-	-	-				
				End			S1PS3	J-1334	SE-61	1063.0	47.3	47.4	1096.3	1096.3	-0.1	55.7	48.3	1102.2	1096.9	-	-	-	-				
				12:45:00 PM			S1PS4	J-797	SE-78	1069.6	55.9	37.6	1108.9	1096.0	18.3	46.0	39.2	1101.9	1097.2	-	-	-	-				
				Q2 Start			S1Q2	J-452	SE-57	1063.4																	PS4 (Hydrant SE-78) not compared due to suspected equipment error.
				12:27:00 PM	1062	80.47	S1PR2	J-1167	SE-58	1061.7	55.9	45.0	1101.0	1093.3	10.9	57.4	49.5	1102.1	1096.5	1.5	3%	4.5	10%				
							S1PS1	J-2283	SE-55	1064.1	49.2	42.1	1098.6	1093.6	7.1	53.9	46.7	1101.9	1096.9	4.7	10%	4.6	11%				
							S1PS2	J-1184	SE-40	1060.5	55.4	47.8	1099.5	1094.1	7.6	59.2	52.1	1102.2	1097.1	3.8	7%	4.2	9%				
				End			S1PS3	J-1334	SE-61	1063.0	60.0	43.7	1105.2	1093.8	16.2	55.7	48.0	1102.2	1096.8	-4.3	-7%	4.3	10%				
				12:30:00 PM			S1PS4	J-797	SE-78	1069.6	67.3	34.0	1116.9	1093.5	33.3	46.0	38.8	1101.9	1096.8	-	-	-	-				
				Q3 Start			S1Q3	J-447	SE-54	1059.0																PS4 (Hydrant SE-78) not compared due to suspected equipment error.	
				1:03:00 PM	1172	88.80	S1PR3	J-110	SE-53	1061.1	57.3	47.1	1101.3	1094.2	10.2	58.5	50.3	1102.2	1096.4	1.2	2%	3.2	7%				
							S1PS1	J-2283	SE-55	1064.1	52.6	43.5	1101.0	1094.6	9.1	53.9	45.8	1101.9	1096.3	1.3	2%	2.3	5%				
							S1PS2	J-1184	SE-40	1060.5	50.2	48.9	1095.8	1094.9	1.2	59.2	51.1	1102.2	1096.4	9.0	18%	2.2	4%				
				End			S1PS3	J-1334	SE-61	1063.0	54.7	46.0	1101.5	1095.4	8.7	55.7	48.2	1102.2	1096.9	1.0	2%	2.1	5%				
				1:06:00 PM			S1PS4	J-797	SE-78	1069.6	62.4	35.5	1113.5	1094.5	27.0	46.0	38.0	1101.9	1096.3	-	-	-	-				
				Q4 Start			S1Q4	J-768	SE-37	1061.1																PS4 (Hydrant SE-78) not compared due to suspected equipment error.	
				12:12:00 PM	1085	82.21	S1PR4	J-562	SE-36	1060.0	58.5	50.5	1101.1	1095.5	8.0	59.9	53.2	1102.2	1097.4	1.4	2%	2.6	5%				
							S1PS1	J-2283	SE-55	1064.1	52.5	43.2	1100.9	1094.5	9.2	53.9	46.8	1101.9	1096.9	1.4	3%	3.5	8%				
							S1PS2	J-1184	SE-40	1060.5	55.4	48.7	1099.4	1094.8	6.6	59.2	52.0	1102.2	1097.0	3.8	7%	3.2	7%				
				End			S1PS3	J-1334	SE-61	1063.0	60.0	45.6	1105.2	1095.1	14.3	55.7	48.8	1102.2	1097.3	-4.3	-7%	3.2	7%				
				12:14:00 PM			S1PS4	J-797	SE-78	1069.6	67.3	35.3	1116.9	1094.4	32.0	46.0	39.0	1101.9	1097.0	-	-	-	-				
Date	Flow set no.	Pressure Zone	Location	Hydrant Test No. & Time	Flow (GPM)	Flow (L/s)	Test ID	WaterGEMS Node	WaterGEMS Node / Hydrant	Hydrant Elev. (m)	Static (psi)	Residual (psi)	Static HGL (m)	Residual HGL (m)	Pressure Drop (psi)	Static (psi)	Residual (psi)	Static HGL (m)	Residual HGL (m)	Static Pressure Diff (psi)	% diff Static Pressure	Residual Pressure Diff (psi)	% diff Residual Pressure	Demand Boundary Conditions	Comments		
4-Oct-19	2	1N		Q1 Start			S2Q1	J-1838	NW-23	1055.7														0.92 ADD	PRV Fed Zone		
				3:03:00 PM	1107	83.88	S2PR1	J-2274	NW-12	1054.8	59.1	51.3	1096.3	1090.8	7.8	56.1	54.0	1094.2	1092.8	-3.0	-5%	2.8	5%				
							S2PS1	J-232	NW-5	1054.1	59.8	54.0	1096.1	1092.0	5.9	56.6	56.0	1093.9	1093.4	-3.2	-5%	2.0	4%				
							S2PS2	J-2067	NW-22	1055.0	58.7	52.5	1096.3	1091.9	6.2	55.4	54.8	1093.9	1093.6	-3.3	-6%	2.3	4%				
				End			S2PS3	J-1342	NW-34	1054.2	58.1	51.7	1095.1	1090.6	6.5	56.5	55.5	1094.0	1093.2	-1.6	-3%	3.8	7%				
				3:07:00 PM			S2PS4	J-1881	NE-4	1053.7	61.1	56.0	1096.7	1093.1	5.1	57.2	57.0	1093.9	1093.8	-3.9	-6%	1.0	2%				
				Q2 Start			S2Q2	J-1643	NW-2	1053.4																	PRV Fed Zone
				3:19:00 PM	1085	82.21	S2PR2	J-2274	NW-12	1054.8	60.7	45.6	1097.4	1086.8	15.1	56.1	55.4	1094.2	1093.7	-4.6	-8%	9.8	21%				
							S2PS1	J-232	NW-5	1054.1	59.7	56.2	1096.0	1093.5	3.5	56.6	55.9	1093.9	1093.4	-3.1	-5%	-0.2	0%				
							S2PS2	J-2067	NW-22	1055.0	58.5	55.2	1096.2	1093.8	3.3	55.4	55.1	1093.9	1093.8	-3.2	-5%	-0.1	0%				
				End			S2PS3	J-1342	NW-34	1054.2	57.9	54.1	1094.9	1092.2	3.8	56.5	54.9	1094.0	1092.8	-1.4	-2%	0.8	2%				
				3:21:00 PM			S2PS4	J-1881	NE-4	1053.7	61.0	57.8	1096.6	1094.3	3.2	57.2	56.8	1093.9	1093.7	-3.8	-6%	-0.9	-2%				
				Q3 Start			S2Q3	J-445	NE-3	1052.1																	PRV Fed Zone
				3:40:00 PM	1129	85.54	S2PR3	J-2274	NW-12	1054.8	61.3	55.0	1097.8	1093.4	6.3	56.1	55.6	1094.2	1093.9	-5.2	-8%	0.7	1%				
							S2PS1	J-232	NW-5	1054.1	58.9	53.3	1095.5	1091.5	5.6	56.6	56.0	1093.9	1093.4	-2.3	-4%	2.7	5%				
							S2PS2	J-2067	NW-22	1055.0	57.9	53.3	1095.7	1092.5	4.6	55.4	55.2	1093.9	1093.8	-2.5	-4%	1.9	4%				
				End			S2PS3	J-1342	NW-34	1054.2	57.2	51.7	1094.4	1090.6	5.4	56.5	56.0	1094.0	1093.6	-0.6	-1%	4.3	8%				
				3:45:00 PM			S2PS4	J-1881	NE-4	1053.7	60.2	54.0	1096.0	1091.7	6.1	57.2	56.1	1093.9	1093.2	-3.0	-5%	2.0	4%				
				Q4 Start			S2Q4	J-4085	NW-4A	1054.2																	PRV Fed Zone
				3:57:00 PM	1172	88.80	S2PR4	J-1692	NW-4	1054.9	59.5	51.4	1096.7	1091.0	8.1	55.6	53.2	1093.9	1092.3	-3.9	-7%	1.8	4%				
							S2PS1	J-232	NW-5	1054.1	60.3	53.6	1096.5	1091.7	6.7	56.6	56.5	1093.9	1093.8	-3.7	-6%	2.9	5%				
							S2PS2	J-2067	NW-22	1055.0	59.3	52.3	1096.7	1091.8	7.0	55.4	55.1	1093.9	1093.7	-4.0	-7%	2.7	5%				
				End			S2PS3	J-1342	NW-34	1054.2	58.6	51.7	1095.4	1090.6	6.9	56.5	56.3	1094.0	1093.8	-2.1	-4%	4.6	9%				
				4:01:00 PM			S2PS4	J-1881	NE-4	1053.7	60.8	55.0	1096.5	1092.4	5.8	57.2	57.1	1093.9	1093.9	-3.7	-6%	2.1	4%				
Date	Flow set no.	Pressure Zone	Location	Hydrant Test No. & Time	Flow (GPM)	Flow (L/s)	Test ID	WaterGEMS Node	WaterGEMS Node / Hydrant	Hydrant Elev. (m)	Static (psi)	Residual (psi)	Static HGL (m)	Residual HGL (m)	Pressure Drop (psi)	Static (psi)	Residual (psi)	Static HGL (m)	Residual HGL (m)	Static Pressure Diff (psi)	% diff Static Pressure	Residual Pressure Diff (psi)	% diff Residual Pressure	Demand Boundary Conditions	Comments		
3-Oct-19	3	3N		Q1 Start			S3Q1	J-1326	NE-104	1086.0														0.92 ADD			
				4:52:00 PM	1192	90.32	S3PR1	J-385	NE-103	1084.5	72.4	55.2	1135.4	1123.3	17.2	75.6	56.0	1137.6	1123.9	3.2	4%	0.8	2%				
							S3PS1	J-1441	NE-101	1088.0	63.7	50.9	1132.8	1123.8	12.8	70.7	55.8	1137.7	1127.2	7.0	11%	4.8	10%				
							S3PS2	J-2295	NE-113	1096.5	54.9	41.9	1135.1	1126.0	13.0	58.4	43.4	1137.6	1127.1	3.5	6%	1.5	4%				
				End			S3PS3	J-1741	NE-120	1093.5	59.4	46.5	1135.3	1126.2	12.9	62.5	47.7	1137.5	1127.0	3.1	5%	1.2	3%				
				4:56:00 PM			S3PS4	J-467	NE-97	1088.3	66.8	54.5	1135.3	1126.7	12.3	70.0	55.2	1137.6	1127.1	3.2	5%	0.6	1%				
				Q2 Start			S3Q2	J-738	NE-98	1083.6																	
				5:10:00 PM	1271	96.30	S3PR2	J-1645	NE-99	1083.4	67.9	59.9	1131.2	1125.6	8.0	77.0	61.0	1137.6	1126.3	9.1	13%	1.1	2%				
							S3PS1	J-1441	NE-101	1088.0	64.0	50.9	1133.0	1123.8	13.1	70.7	56.2	1137.7	1127.5	6.7	10%	5.2	10%				
							S3PS2	J-2295	NE-113	1096.5	55.3	41.6	1135.4	1125.8	13.7	58.4	43.6	1137.6	1127.2	3.1	6%	2.0	5%				
				End			S3PS3	J-1741	NE-120	1093.5	59.9	45.3	1135.6	1125.4	14.6	62.5	47.5	1137.5	1126.9	2.6	4%	2.2	5%				
				5:11:00 PM			S3PS4	J-467	NE-97	1088.3	67.3	53.2	1135.6	1125.7	14.1	70.0	54.5	1137.6	1126.7	2.8	4%	1.4	3				



Date	Flow set no.	Pressure Zone	Location	Hydrant Test No. & Time	Flow (GPM)	Flow (L/s)	Test ID	WaterGEMS Node	Hydrant	Hydrant Elev. (m)	Field Result					Computer Result				Static Pressure Diff (psi)	% diff Static Pressure	Residual Pressure Diff (psi)	% diff Residual Pressure	Demand Boundary Conditions	Comments	
											Static (psi)	Residual (psi)	Static HGL (m)	Residual HGL (m)	Pressure Drop (psi)	Static (psi)	Residual (psi)	Static HGL (m)	Residual HGL (m)							
4-Oct-19	1	1S		Q1			S1Q1	J-721	SE-59	1067.1														0.92 ADD	Static pressure tests show that this set appears to be hydraulically disconnected from the system - potentially a closed valve. Removed this test set from comparisons.	
				Start			S1PR1	J-1167	SE-58	1061.7	33.6	40.6	1085.4	1090.2	-6.9	57.4	50.0	1102.1	1096.9	-	-	-	-			
				12:42:00 PM	1024	77.59	S1PS1	J-2283	SE-55	1064.1	51.3	45.7	1100.1	1096.1	5.7	53.9	47.1	1101.9	1097.2	-	-	-	-			
							S1PS2	J-1184	SE-40	1060.5	42.4	50.0	1090.3	1095.7	-7.6	59.2	52.5	1102.2	1097.4	-	-	-	-			
				End			S1PS3	J-1334	SE-61	1063.0	47.3	47.4	1096.3	1096.3	-0.1	55.7	48.3	1102.2	1096.9	-	-	-	-			
				12:45:00 PM			S1PS4	J-797	SE-78	1069.6	55.9	37.6	1108.9	1096.0	18.3	46.0	39.2	1101.9	1097.2	-	-	-	-			
				Q2			S1Q2	J-452	SE-57	1063.4																PS4 (Hydrant SE-78) not compared due to suspected equipment error.
				Start			S1PR2	J-1167	SE-58	1061.7	55.9	45.0	1101.0	1093.3	10.9	57.4	49.5	1102.1	1096.5	1.5	3%	4.5	10%			
				12:27:00 PM	1062	80.47	S1PS1	J-2283	SE-55	1064.1	49.2	42.1	1098.6	1093.6	7.1	53.9	46.7	1101.9	1096.9	4.7	10%	4.6	11%			
							S1PS2	J-1184	SE-40	1060.5	55.4	47.8	1099.5	1094.1	7.6	59.2	52.1	1102.2	1097.1	3.8	7%	4.2	9%			
				End			S1PS3	J-1334	SE-61	1063.0	60.0	43.7	1105.2	1093.8	16.2	55.7	48.0	1102.2	1096.8	-4.3	-7%	4.3	10%			
				12:30:00 PM			S1PS4	J-797	SE-78	1069.6	67.3	34.0	1116.9	1093.5	33.3	46.0	38.8	1101.9	1096.8	-	-	-	-			
				Q3			S1Q3	J-447	SE-54	1059.0																PS4 (Hydrant SE-78) not compared due to suspected equipment error.
				Start			S1PR3	J-110	SE-53	1061.1	57.3	47.1	1101.3	1094.2	10.2	58.5	50.3	1102.2	1096.4	1.2	2%	3.2	7%			
				1:03:00 PM	1172	88.80	S1PS1	J-2283	SE-55	1064.1	52.6	43.5	1101.0	1094.6	9.1	53.9	45.8	1101.9	1096.3	1.3	2%	2.3	5%			
							S1PS2	J-1184	SE-40	1060.5	50.2	48.9	1095.8	1094.9	1.2	59.2	51.1	1102.2	1096.4	9.0	18%	2.2	4%			
				End			S1PS3	J-1334	SE-61	1063.0	54.7	46.0	1101.5	1095.4	8.7	55.7	48.2	1102.2	1096.9	1.0	2%	2.1	5%			
				1:06:00 PM			S1PS4	J-797	SE-78	1069.6	62.4	35.5	1113.5	1094.5	27.0	46.0	38.0	1101.9	1096.3	-	-	-	-			
				Q4			S1Q4	J-768	SE-37	1061.1																PS4 (Hydrant SE-78) not compared due to suspected equipment error.
				Start			S1PR4	J-562	SE-36	1060.0	58.5	50.5	1101.1	1095.5	8.0	59.9	53.2	1102.2	1097.4	1.4	2%	2.6	5%			
				12:12:00 PM	1085	82.21	S1PS1	J-2283	SE-55	1064.1	52.5	43.2	1100.9	1094.5	9.2	53.9	46.8	1101.9	1096.9	1.4	3%	3.5	8%			
							S1PS2	J-1184	SE-40	1060.5	55.4	48.7	1099.4	1094.8	6.6	59.2	52.0	1102.2	1097.0	3.8	7%	3.2	7%			
				End			S1PS3	J-1334	SE-61	1063.0	60.0	45.6	1105.2	1095.1	14.3	55.7	48.8	1102.2	1097.3	-4.3	-7%	3.2	7%			
				12:14:00 PM			S1PS4	J-797	SE-78	1069.6	67.3	35.3	1116.9	1094.4	32.0	46.0	39.0	1101.9	1097.0	-	-	-	-			



Date	Flow set no.	Pressure Zone	Location	Hydrant Test No. & Time	Flow (GPM)	Flow (L/s)	Test ID	WaterGEMS Node	WaterGEMS Node / Hydrant	Hydrant Elev. (m)	Field Result					Computer Result				Static Pressure Diff (psi)	% diff Static Pressure	Residual Pressure Diff (psi)	% diff Residual Pressure	Demand Boundary Conditions	Comments	
											Static (psi)	Residual (psi)	Static HGL (m)	Residual HGL (m)	Pressure Drop (psi)	Static (psi)	Residual (psi)	Static HGL (m)	Residual HGL (m)							
4-Oct-19	2	1N		Q1			S2Q1	J-1838	NW-23	1055.7														0.92 ADD	PRV Fed Zone	
				Start			S2PR1	J-2274	NW-12	1054.8	59.1	51.3	1096.3	1090.8	7.8	56.1	54.0	1094.2	1092.8	-3.0	-5%	2.8	5%			
					3:03:00 PM	1107	83.88	S2PS1	J-232	NW-5	1054.1	59.8	54.0	1096.1	1092.0	5.9	56.6	56.0	1093.9	1093.4	-3.2	-5%	2.0			4%
							S2PS2	J-2067	NW-22	1055.0	58.7	52.5	1096.3	1091.9	6.2	55.4	54.8	1093.9	1093.6	-3.3	-6%	2.3	4%			
				End			S2PS3	J-1342	NW-34	1054.2	58.1	51.7	1095.1	1090.6	6.5	56.5	55.5	1094.0	1093.2	-1.6	-3%	3.8	7%			
					3:07:00 PM		S2PS4	J-1881	NE-4	1053.7	61.1	56.0	1096.7	1093.1	5.1	57.2	57.0	1093.9	1093.8	-3.9	-6%	1.0	2%			
				Q2			S2Q2	J-1643	NW-2	1053.4																PRV Fed Zone
				Start			S2PR2	J-2274	NW-12	1054.8	60.7	45.6	1097.4	1086.8	15.1	56.1	55.4	1094.2	1093.7	-4.6	-8%	9.8	21%			
					3:19:00 PM	1085	82.21	S2PS1	J-232	NW-5	1054.1	59.7	56.2	1096.0	1093.5	3.5	56.6	55.9	1093.9	1093.4	-3.1	-5%	-0.2		0%	
							S2PS2	J-2067	NW-22	1055.0	58.5	55.2	1096.2	1093.8	3.3	55.4	55.1	1093.9	1093.8	-3.2	-5%	-0.1	0%			
				End			S2PS3	J-1342	NW-34	1054.2	57.9	54.1	1094.9	1092.2	3.8	56.5	54.9	1094.0	1092.8	-1.4	-2%	0.8	2%			
					3:21:00 PM		S2PS4	J-1881	NE-4	1053.7	61.0	57.8	1096.6	1094.3	3.2	57.2	56.8	1093.9	1093.7	-3.8	-6%	-0.9	-2%			
				Q3			S2Q3	J-445	NE-3	1052.1																PRV Fed Zone
				Start			S2PR3	J-2274	NW-12	1054.8	61.3	55.0	1097.8	1093.4	6.3	56.1	55.6	1094.2	1093.9	-5.2	-8%	0.7	1%			
					3:40:00 PM	1129	85.54	S2PS1	J-232	NW-5	1054.1	58.9	53.3	1095.5	1091.5	5.6	56.6	56.0	1093.9	1093.4	-2.3	-4%	2.7	5%		
							S2PS2	J-2067	NW-22	1055.0	57.9	53.3	1095.7	1092.5	4.6	55.4	55.2	1093.9	1093.8	-2.5	-4%	1.9	4%			
				End			S2PS3	J-1342	NW-34	1054.2	57.2	51.7	1094.4	1090.6	5.4	56.5	56.0	1094.0	1093.6	-0.6	-1%	4.3	8%			
					3:45:00 PM		S2PS4	J-1881	NE-4	1053.7	60.2	54.0	1096.0	1091.7	6.1	57.2	56.1	1093.9	1093.2	-3.0	-5%	2.0	4%			
				Q4			S2Q4	J-4085	NW-4A	1054.2																PRV Fed Zone
				Start			S2PR4	J-1692	NW-4	1054.9	59.5	51.4	1096.7	1091.0	8.1	55.6	53.2	1093.9	1092.3	-3.9	-7%	1.8	4%			
					3:57:00 PM	1172	88.80	S2PS1	J-232	NW-5	1054.1	60.3	53.6	1096.5	1091.7	6.7	56.6	56.5	1093.9	1093.8	-3.7	-6%	2.9	5%		
							S2PS2	J-2067	NW-22	1055.0	59.3	52.3	1096.7	1091.8	7.0	55.4	55.1	1093.9	1093.7	-4.0	-7%	2.7	5%			
				End			S2PS3	J-1342	NW-34	1054.2	58.6	51.7	1095.4	1090.6	6.9	56.5	56.3	1094.0	1093.8	-2.1	-4%	4.6	9%			
					4:01:00 PM		S2PS4	J-1881	NE-4	1053.7	60.8	55.0	1096.5	1092.4	5.8	57.2	57.1	1093.9	1093.9	-3.7	-6%	2.1	4%			



Date	Flow set no.	Pressure Zone	Location	Hydrant Test No. & Time	Flow (GPM)	Flow (L/s)	Test ID	WaterGEMS Node	WaterGEMS Node / Hydrant	Hydrant Elev. (m)	Field Result					Computer Result				Static Pressure Diff (psi)	% diff Static Pressure	Residual Pressure Diff (psi)	% diff Residual Pressure	Demand Boundary Conditions	Comments
											Static (psi)	Residual (psi)	Static HGL (m)	Residual HGL (m)	Pressure Drop (psi)	Static (psi)	Residual (psi)	Static HGL (m)	Residual HGL (m)						
3-Oct-19	3	3N		Q1 Start			S3Q1	J-1326	NE-104	1086.0														0.92 ADD	
							S3PR1	J-385	NE-103	1084.5	72.4	55.2	1135.4	1123.3	17.2	75.6	56.0	1137.6	1123.9	3.2	4%	0.8	2%		
				4:52:00 PM	1192	90.32	S3PS1	J-1441	NE-101	1088.0	63.7	50.9	1132.8	1123.8	12.8	70.7	55.8	1137.7	1127.2	7.0	11%	4.8	10%		
							S3PS2	J-2295	NE-113	1096.5	54.9	41.9	1135.1	1126.0	13.0	58.4	43.4	1137.6	1127.1	3.5	6%	1.5	4%		
				End			S3PS3	J-1741	NE-120	1093.5	59.4	46.5	1135.3	1126.2	12.9	62.5	47.7	1137.5	1127.0	3.1	5%	1.2	3%		
				4:56:00 PM			S3PS4	J-467	NE-97	1088.3	66.8	54.5	1135.3	1126.7	12.3	70.0	55.2	1137.6	1127.1	3.2	5%	0.6	1%		
				Q2 Start			S3Q2	J-738	NE-98	1083.6															
							S3PR2	J-1645	NE-99	1083.4	67.9	59.9	1131.2	1125.6	8.0	77.0	61.0	1137.6	1126.3	9.1	13%	1.1	2%		
				5:10:00 PM	1271	96.30	S3PS1	J-1441	NE-101	1088.0	64.0	50.9	1133.0	1123.8	13.1	70.7	56.2	1137.7	1127.5	6.7	10%	5.2	10%		
							S3PS2	J-2295	NE-113	1096.5	55.3	41.6	1135.4	1125.8	13.7	58.4	43.6	1137.6	1127.2	3.1	6%	2.0	5%		
				End			S3PS3	J-1741	NE-120	1093.5	59.9	45.3	1135.6	1125.4	14.6	62.5	47.5	1137.5	1126.9	2.6	4%	2.2	5%		
				5:11:00 PM			S3PS4	J-467	NE-97	1088.3	67.3	53.2	1135.6	1125.7	14.1	70.0	54.5	1137.6	1126.7	2.8	4%	1.4	3%		
				Q3 Start			S3Q3	J-610	NE-117	1099.3															
							S3PR3	J-428	NE-116	1096.2	55.6	40.5	1135.3	1124.7	15.1	59.0	36.5	1137.7	1121.8	3.3	6%	-4.0	-10%		
				4:14:00 PM	902	68.34	S3PS1	J-1441	NE-101	1088.0	64.1	53.8	1133.0	1125.8	10.3	70.7	56.3	1137.7	1127.5	6.6	10%	2.5	5%		
							S3PS2	J-2295	NE-113	1096.5	55.4	44.2	1135.5	1127.6	11.2	58.4	43.3	1137.6	1127.0	3.0	5%	-1.0	-2%		
				End			S3PS3	J-1741	NE-120	1093.5	59.9	48.0	1135.6	1127.3	11.9	62.5	47.2	1137.5	1126.7	2.6	4%	-0.8	-2%		
				4:17:00 PM			S3PS4	J-467	NE-97	1088.3	67.3	56.8	1135.6	1128.3	10.5	70.0	55.2	1137.6	1127.1	2.7	4%	-1.6	-3%		
				Q4 Start			S3Q4	J-4649	NE-110	1093.8															
							S3PR4	J-1179	NE-109	1093.0	60.3	46.4	1135.4	1125.6	13.9	63.3	46.2	1137.5	1125.5	3.0	5%	-0.2	0%		
				4:38:00 PM	1062	80.47	S3PS1	J-1441	NE-101	1088.0	63.9	52.4	1132.9	1124.8	11.5	70.7	56.0	1137.7	1127.3	6.8	11%	3.6	7%		
							S3PS2	J-2295	NE-113	1096.5	55.2	42.4	1135.3	1126.4	12.8	58.4	42.4	1137.6	1126.4	3.2	6%	0.0	0%		
				End			S3PS3	J-1741	NE-120	1093.5	59.7	47.3	1135.5	1126.8	12.4	62.5	47.4	1137.5	1126.8	2.8	5%	0.1	0%		
				4:41:00 PM			S3PS4	J-467	NE-97	1088.3	67.1	55.9	1135.5	1127.7	11.2	70.0	55.1	1137.6	1127.1	2.9	4%	-0.8	-1%		