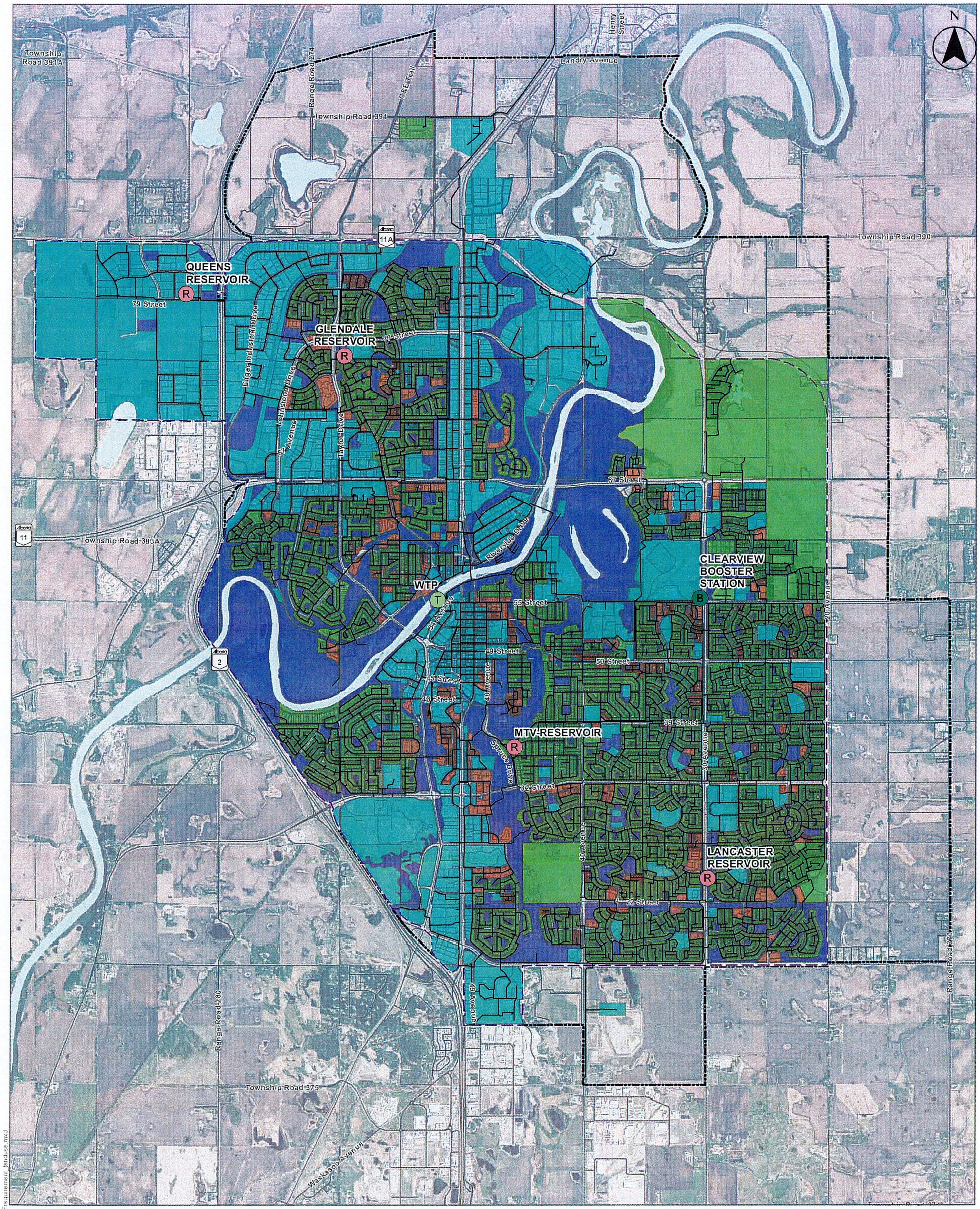


— Pipes

Red Deer City Limits

Existing Service Boundary (Infill Development)

Facilities

- B Booster Station
- R Reservoir
- T Water Treatment Plant

Fire Flow Required

- 0 l/s
- 75 l/s- Low Density Residential
- 180 l/s - Medium Density Residential
- 233 l/s - Commercial/Industrial

Completed By: AL
Date: 08/02/2022

Project No.: 110170064

Figure 4-23: Existing System - Fire Flow Requirement Based on Land Use

City of Red Deer Water Model Update

City of Red Deer

Stantec

A summary of the boundary conditions for each facility in the water distribution system for the maximum day demand with fire flow scenario is shown in the following Table.

Table 4.5: Existing System Fire Flow Analysis – Boundary Conditons

Water Treatment Plant			**Mountview Reservoir and Pumping Station**	
HLP 101 - 900 HP	ON		P1 – 150 HP	ON
HLP 102 - 700 HP	ON		P2 – 150 HP	OFF
HLP 103 - 350 HP	ON		P3 – 150 HP	ON
HLP 104 - 900HP	OFF		Station Outflow	55 L/s
Station Outflow	445 L/s		Hydraulic Grade Setpoint	940 m
Hydraulic Grade Setpoint	919 m		Reservoir Fill Rate	0 L/s
Glendale Reservoir and Pumping Station			**Lancaster Reservoir and Pumping Station**	
GDR P1 - 200 HP - Emergency Pump	ON		P1 – 75 HP	ON
GDR P2 - 125 HP	ON		P2 – 75 HP	ON
GDR P3 - 125 HP	OFF		P3 – 75 HP	ON
GDR P4 - 125 HP	OFF		P4 – 75 HP	OFF
Station Outflow	175 L/s		Station Outflow	118 L/s
Hydraulic Grade Setpoint	919 m		Hydraulic Grade Setpoint	940 m
Reservoir Fill Rate	0 L/s		Reservoir Fill Rate	0 L/s
Clearview Booster Station			**Queens Business Park Reservoir and Pumping Station**	
P1 – 125 HP	ON		P1 – 75 HP	ON
P2 – 125 HP	ON		P2 – 100 HP	ON
P3 – 125 HP	ON		P3 – 150 HP	ON
P4 – 125 HP	OFF		P4 – 150 HP	OFF
Station Outflow	110 L/s		Station Outflow	45 L/s
Hydraulic Grade Setpoint	940 m		Hydraulic Grade Setpoint	950 m
			Reservoir Fill Rate	0 L/s

4.5.1 Discussion on Existing System Fire Flow Analysis

Results of the fire flow analysis included the available fire flow at each junction in the system. The available fire flow was determined in WaterCAD by maintaining a minimum pressure of 150 kPa in the system, as identified in **Table 2-7**.The available fire flow at each junction was compared to the required fire flow at the junction (as outlined in **Table 2-6**), as dictated by the land use of the area where the junction is located. A junction is considered to satisfy the fire flow requirements if the available fire flow at that junction equals or greater than the required fire flow.

The following are discussion points emerging from the existing system fire flow analysis.

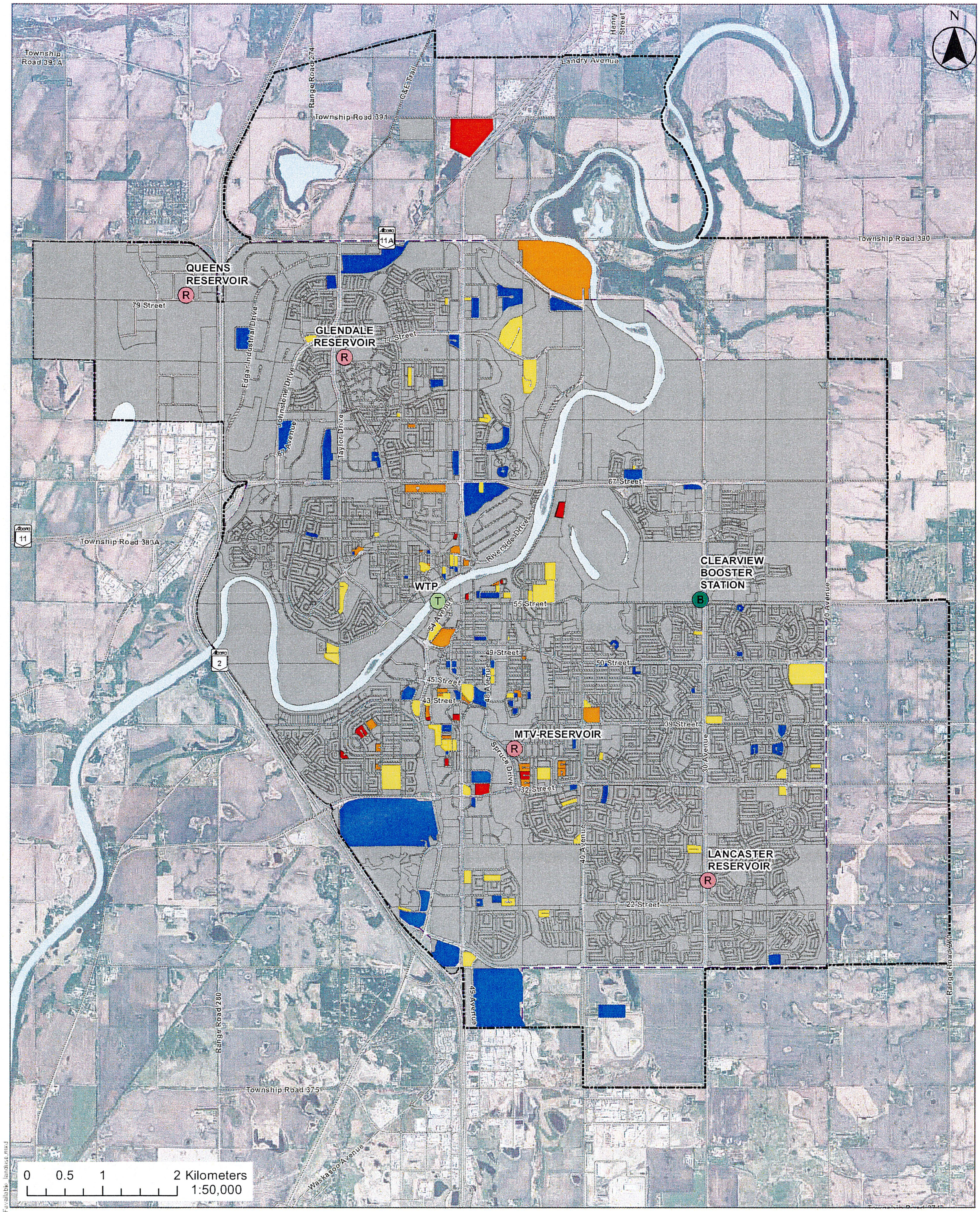
1. The fire flow analysis was conducted on all the junctions in the WaterCAD hydraulic model; however, it should be noted that the City's hydrants are the critical locations for fire flow availability. The analysis for capital upgrades considered fire flow availability at hydrant locations.

2. There are several areas that do not have sufficient available fire flows. A detailed list of proposed upgrades was developed to address the areas that are not compliant with the standards, and this list of capital upgrades is presented in **Section 4.6** of this Report.

3. Pump capacities in the pump stations are not considered to be an issue with the delivery of fire flows in the existing system.

4. The Glendale Pumping Station is critical for the delivery of fire flows to the Edgar Industrial Area in the north-west corner of the Water Treatment Plant Pressure Zone. As a result, it is recommended that fire storage be maintained at the Glendale Reservoir.

The available fire flow based on land use is shown in **Figure 4-24**. The available fire flows at each junction in the water model is shown in **Figure 4-25**.



Pipes

Red Deer City Limits

Existing Service Boundary (Infill Development)

Facilities

B Booster Station

R Reservoir

T Water Treatment Plant\Reservoir

Available Fire Flow As Percentage of the Desired Fire Flow

Red	0% - 25%
Orange	25% - 50%
Yellow	50% - 75%
Blue	75% - 100%
Grey	>100%

Completed By: AL
Date: 08/02/2022

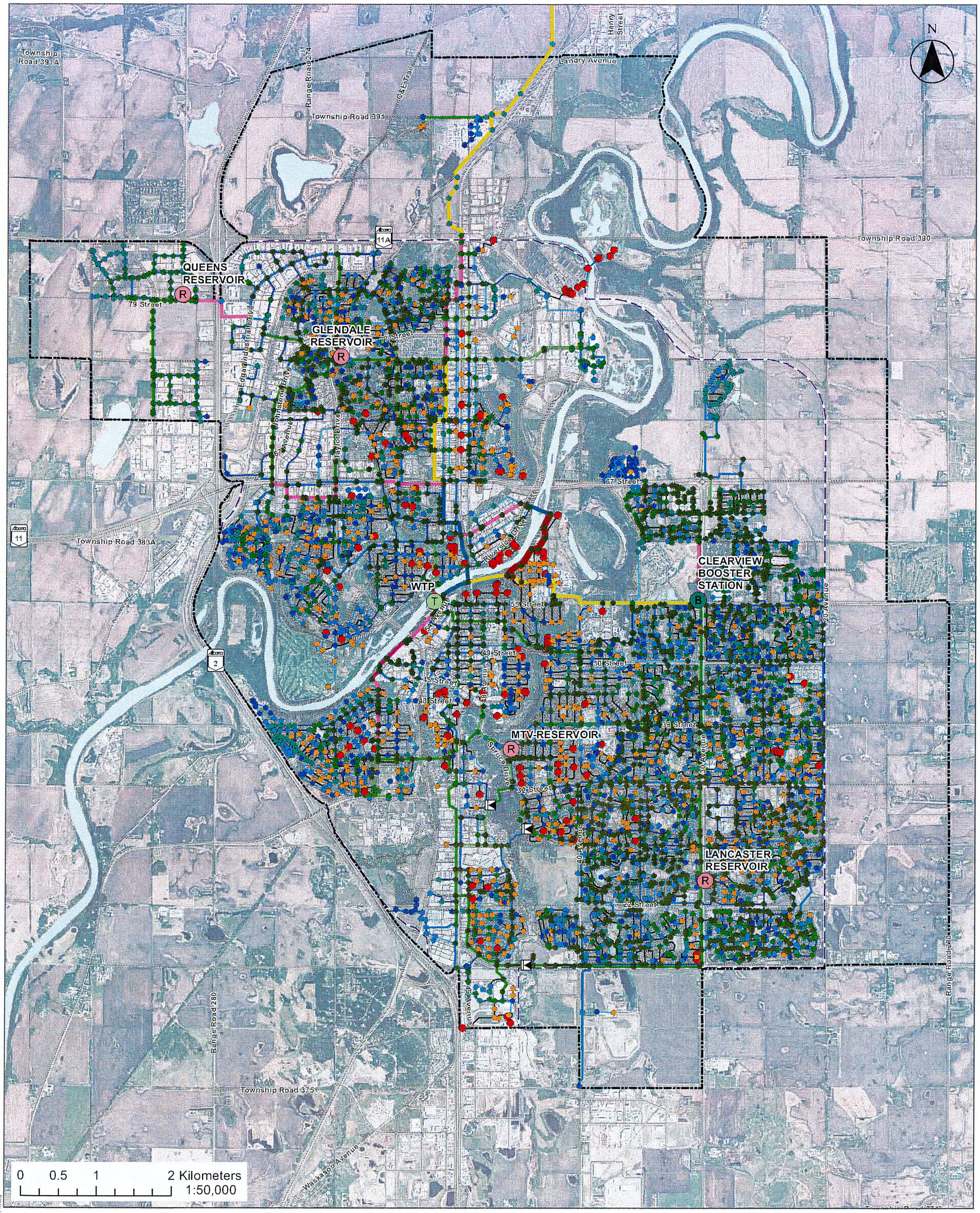
Project No.: 110170064

Figure 4-25: Existing System - Availiable Fire Flow Percentage of the Desired Fire Flow Based on Land Use

City of Red Deer Water Model Update

City of Red Deer

Stantec



Pressure Reducing Valve	
Red Deer City Limits	
Existing Service Boundary (Infill Development)	

Facilities
- B Booster Station
- R Reservoir
- T Water Treatment Plant

Available Fire Flow
- <75 l/s
- 75 - 135 l/s
- 135 - 180 l/s
- 180 - 233 l/s
- 233 - 300 l/s
- 300 - 400 l/s
- >400 l/s

Pipe Network Diameter

<all other values>	450 mm
>1200 mm	400 mm
1200 mm	350mm
1050 mm	300 mm
900 mm	250mm
750 mm	200mm
600 mm	150 mm
500 mm	100 mm

Completed By: AL
Date: 08/02/2022

Project No.: 110170064

Stantec

Figure 4-26: Existing System Available Fire Flow (l/s) - Velocity Unlimited

City of Red Deer Water Model Update

City of Red Deer

4.6 Recommendations from the Existing System Analysis

The analysis of the existing system showed that some pressures were outside of the current design standards for both the MDD and PHD scenarios, however, all were considered to be within an acceptable range. The reservoir fill analysis showed that the night filling scenario led to distribution system pressures below the current service standards, however they are also deemed to be within an acceptable range and no complaints have been received.

A capital upgrade plan was developed based on the analysis of the existing system for ADD, MDD, PHD, NF, and fire flow. To differentiate between the areas that are extremely deficient and areas that are only slightly deficient, each improvement that was identified is prioritized based on **Table 4-5**.

Table 4-6: Upgrade Prioritization

Priority Level	A	B	C	D
Description	Deficiency requires immediate attention	Area is deficient and should be considered for upgrades for future capital plans	Area is deficient and should be considered for upgrades if work is completed in adjacent areas	Area is very slightly deficient, and upgrades are not recommended at this time

The capital upgrades with A and B priorities are listed in the following **Table 4-6**, which lists the first 25 capital improvements. **Appendix B** contains a complete list of capital upgrades including A, B, C, and D priorities for the existing system and the maps highlighting the locations of the proposed improvements.

Please note that all the recommendations are based on hydraulic modeling alone and further verification is required to determine if the noted deficiencies require upgrades to the system. For the purposes of this study, the fire flow requirements were based only on land use. There are several other factors that can influence the fire flow requirement for a building, and some of these factors include occupancy type, building footprint, height of building, number of storeys, construction classification, roof construction, automatic sprinklers, the contents of the building, and the building's exposure. These factors are outlined in the Fire Underwriters Survey Risk Assessment Form.

The following is a recommended procedure to confirm fire flow deficiencies that were identified using the hydraulic model.

1. Identify all types of buildings that will be serviced by the hydrant that has been noted as deficient.
2. Establish the building(s) that will have the largest fire flow requirement from the hydrant and complete a calculation of the required fire flow for that building using the standards from the Fire Underwriters Survey – Water Supply for Public Fire Protection
3. If the calculation of required fire flow is less than the available fire flow shown in the hydraulic model, the recommended upgrades can be disregarded, and the investigation is complete.
4. If the calculation of required fire flow is more than the available fire flow shown in the hydraulic model, proceed to step #5.
5. Complete a field hydrant flow test to confirm the fire flow available from the hydrant in relation to the available fire flow shown in the hydraulic model.
6. Re-evaluate the recommendation for upgrades to the system based on the results.

Table 4-7: Capital Improvements for Existing System

Item No.	Description of System Deficiency	Priority	Improvement	
			Pipe Size (mm)	Length (m)
1	*Insufficient Fire Flows on 34th Street east of 49th Avenue (Completed in 2016).*	*A*	*250*	*710*
2	Insufficient fire flow for commercial / industrial and R3 residents on 54th Avenue.	B	200	325
3	*Improve hydraulic performance on the east end of 55th street. (Construction completed in 2015)*	*B*	*300*	*850*
4	Insufficient fire flow to residential multifamily and commercial development on 47th Avenue.	B	200	325
5	All hydrants on 50th Avenue north of 67th Street that are fed from 150 mm pipes are deficient in fire flows for commercial / industrial land use	B	350	1200
6	Insufficient fire flow at Arena south of 43rd Street.	B	200	430
7	*Insufficient fire flow for multifamily site on 54th Avenue Cres. (Completed in 2021)*	*B*	*200*	*725*
8	Insufficient fire flow to R1 residential area north of 55th Street from 48A Avenue to 47A Avenue. The pipes in the area are all 150 mm CI pipes.	B	200	830
9	*Insufficient fire flow to R1 residential close fed by single 150 mm CI pipe (Completed in 2021)*	*B*	*200*	*185*
10	Insufficient fire flow to R1 residential close fed by single 150 mm CI pipe on Piper Drive.	B	200	190
11	Insufficient fire flow to hydrant in R1 residential area.	B	200	65
12	Insufficient fire flow to R1 residential area north of 55th Street from 48A Avenue to 47A Avenue. Pipes in the area are all 150 mm CI pipes.	B	200	830
13	Insufficient fire flow for R1 residential area on 43A Avenue.	B	150	145
14	Insufficient fire flow for R1 residential area on 56th Avenue.	B	200	290
15	Improve hydraulics for the supply of water to the Mountview Reservoir.	B	400	350
16	*Insufficient fire flow to hydrant at 47 A Avenue and 54th Street(Construction completed in 2017)*	*B*	*200*	*100*
17	Insufficient fire flow for Mountview School on 34th Street.	B	250/200	275

Item No.	Description of System Deficiency	Priority	Improvement	
			Pipe Size (mm)	Length (m)
18	Insufficient fire flow for Annie L Gaetz School on Mitchell Avenue.	B	200	80
19	Insufficient fire flow for hydrant at Eastview Middle School.	B	350/200	240
20	Insufficient fire flow available for R3 residential on 44th Ave.	B	300	310
21	Insufficient fire flow for hydrant located at River Glen School	B	300	360
22	Insufficient fire flow along 42 A Avenue near to Lindsay Thurber Comprehensive High School	B	300	700
23	Insufficient fire flows in commercial / industrial area. (60th Street)	B	300	600
24	Insufficient fire flow for Hydrants on 47A Avenue for multifamily land use.	B	200	700
25	Insufficient fire flow at 51st Avenue and 48th Street.	B	200	120

Notes:
.1 The recommendation table from 2013 Water Distribution Study report is used here for capital improvement tracking. The improvement items in gray color are the completed items. No further improvement is recommended for these items.
.2 The rest of the improvement items with more details are included in the ***Appendix B****.*
.3 We understand the City may not be installing any new 350mm pipes. In that case the proposed 350mm pipes can be upsized to a 400mm pipe.
.4 The Garden Heights and Evergreen subdivisions are currently serviced with single mains based on the relaxation from the City. It is suggested that the City has the second mains installed as soon as possible to these two subdivisions and lower the potential risk of water supply interruption.

5 Emergency Response Analysis

It is commendable to see that the city, which many of us call home, is being proactive with emergency response planning as the climate and extreme weather events are becoming increasingly unpredictable and uncertain. The goal of this task is to determine how the WTP and all pumping stations will perform under emergency conditions for the existing system.

In this section, three emergency events were analyzed as follows:

1. Tracing analysis: assess how accidental spill contamination migrates
2. 900 mm Trunk Analysis: assess the impact when the 900 mm trunk is off-line
3. Fire Pump Analysis: assess the impact of the Olymel fire pump running

Details and results of the three analyses were illustrated in the following subsections.

5.1 Tracing Analysis

5.1.1 Tracing Analysis Methodology

Security of drinking water has a top priority for water utilities around the world. One of the major security concerns is contamination – regardless being intentional or unintentional – that may occur at any location at the water sources or along the water distribution network. Identifying possible contaminant sources and being aware of the behavior of contaminant movement and propagation from the possible injection points is useful for the decision makers to better prepare for these emergency scenarios and be ready with a response plan.

Source trace analysis in WaterCAD can be used to track water throughout a system over time. It calculates the percentage of water reaching a node from a particular source. To simulate the pollutant migration, the calibrated steady state WaterCAD hydraulic model was converted into a trace analysis model by defining the reservoirs as trace sources (also known as trace nodes) and estimate the trace frontlines of the water from each on-line reservoir at different time steps (i.e., 1, 6, and 12 hours). However, the trace analysis model required the steady state model to be converted to an extended period simulation (EPS) model so the movement and propagation of contaminants can be assessed.

The EPS model was developed at this stage by introducing the time related components to the model including the water demand diurnal pattern (**Figure 2-6**) and pump controls. The trace analysis was conducted for the ADD and MDD demand scenarios. In EPS, the PHD is already included in the MDD scenario.

Since the results would differ based on the operation of the pumping stations, the following scenarios were simulated for each of the two demand scenarios:

a. WTP, Clearview and Queens running

b. WTP, Clearview and Glendale running

c. WTP, Clearview and Lancaster running

d. WTP, Clearview, Lancaster and Mountview running

e. All pumping stations running

5.1.2 Tracing Analysis Results and Conclusions

The results for the various on-line reservoir scenarios and the two demand scenarios (i.e., ADD and MDD) are presented in color coded trace percentage contour maps, which will provide visual aids for the Operations team to prepare valve shut off plans, public notifications, etc. at the time of spill contamination. The figures were presented in **Appendix C**.

The following observations and conclusions can be drawn from the trace analysis for the above trace source, operational, and demand scenarios:

- Having different pressure zones using local pumping/booster stations (e.g., East Hill and Queens Business Park Pressure Zones) or PRVs (e.g., South Pressure Zone) creates barriers to the contaminant propagation until it reaches the water feeding point(s) of the pressure zone. In addition, having pressure zones allows infection of the downstream zones from the upstream ones, but not the opposite direction.
- Once the contaminant migrates from a source node and reaches another pumping/booster station, the new station acts as a new trace node and the contaminant propagates faster in the downstream watermains.
- The South and Queens Business Park pressure zones are the least vulnerable to contamination sourcing from the WTP. The Queens Business Park Pressure Zone catches infection only from its own pumping/booster station. The South Pressure Zone can be contaminated from Mountview and Lancaster when considered trace nodes.
- The WTP pumping station is the most critical as it leads to the greatest contaminant propagation being the main source of water to the water supply system including the other pumping/booster station. The Clearview pumping station comes in the second place being the source to the East Hill and South pressure zones.
- The Clearview pumping station can receive contamination from the WTP in 6-8 hours depending on the running pumping/booster stations and demand scenario.

- Minimal impact on the regional customers was observed when Glendale is the source node. The greatest impact is when the WTP is the source node as most of the regional demands are satisfied directly from WTP.

It should be noted that the above observation and conclusions are based on EPS trace analysis of the calibrated WaterCAD model for the specified analysis duration. Limitations of the hydraulic calibration of the WaterCAD model and properties of the contaminants may impact the movement, propagation, and residence of the contaminant within the water supply system. Longer time trace analysis would result in wider propagation of contamination, unless defensive actions were taken, such as isolating the contaminated area by closing valves.

5.2 900 mm Trunk Analysis

As an arterial trunk, the 900 mm diameter discharge pipe from the WTP high lift pump station is a critical part of the distribution system. In the Water Master Plan Leakage Study (Stantec, 2013), a portion of the 900 mm steel pipe from 1977 was identified as a pipe with a high likelihood of failure based on the pipe age and leak history. Although there is a parallel 500/400 mm trunk that can still supply a portion of water to meet the demands, the loss of the 900 mm could be a highly impactful event as only a small portion of the WTP high lift pump station pumps' capacity can be utilized through the 500/400 mm parallel pipe to meet the demands in the WTP pressure zone. Consequently, the Clearview booster station output capacity will be reduced due to the reduced residual pressure on the suction side. To assist the City in preparing for response to such an emergency, the hydraulic model was revised to simulate if the 900 mm discharge trunk from the WTP was unavailable.

5.2.1 900 mm Trunk Analysis Methodology

The 900 mm supply trunk analysis was conducted by running the hydraulic EPS model for 48 hours in a MDD scenario. The 900 mm trunk is closed to simulate an event of the trunk outage due to planned repair or an unplanned emergency. As the 900 mm trunk was closed, water produced from the WTP was supplied to the distribution system solely through the 400/500 mm trunk. It is assumed that the WTP can produce enough water to fill up the local reservoirs (Bellevue and Clearwell) in the WTP to meet the demands. Since most of the regional customers have large storage reservoirs, the City can inform the regional customers to fill up their reservoirs before shutting off the supply. However, the model simulated the system performance with and without the regional demands to find out if it the regional demand has a significant impact on the Level of Service (LOS).

For such a serious emergency event when the 900 mm trunk is unavailable, pressures are expected to drop below 300 kPa, but still might be greater than 140 kPa. The pressure drop can be tolerated for a short period of time, similar to a fire flow event. Hence, the LOS failure of the water system was defined as when pressures are lower than 140 kPa in this emergency case. This LOS failure is referred as emergency LOS failure.

To allow for longer operation without having an emergency LOS failure, initial conditions of the water system components were optimized as follows:

- The water demands in the simulations were set at MDD level.
- Water storage at all pumping stations to be utilized throughout the analysis.
- Water storage in all reservoirs was set at 100% and 75% full at start of the analysis. The 100% full simulation represents the planned shutdown scenario in which the reservoirs were filled to 100% before the 900 mm trunk was shut off. The 75% full simulation represents the unplanned shut down on a normal MDD day.
- At the beginning of the analysis, only the WTP, Clearview and Queens pump stations were operational.
- Pumping stations with reservoirs started operating when the pressure on the discharge header decreased below 300 kPa.
- As the Glendale reservoir is filled through its discharge line, filling of the Glendale reservoir will lead to residual pressure lower than 300 kPa, which can trigger the Glendale pumps to start. Due to this concern the Glendale reservoir was not filled.
- The Lancaster reservoir utilizes the same pipe for discharge and filling. Filling the Lancaster can lower the residual pressures in the vicinity below 300 kPa. In the simulation, the filling did not happen.
- As the filling line to Mountview reservoir is separated from its discharge line, the Mountview reservoir can be filled when the residual pressure in the filling line is higher than 140 kPa. The filling started when the reservoir fullness dropped below 75%. The filling rate was set at 100 L/s.
- With a separated filling line, the filling of Queens reservoir was allowed when the residual pressure at the Edgar Industrial Dr. is higher than 140 kPa. The filling started when the reservoir level dropped below 50%. The filling rate to Queens reservoir was set at 50 L/s.
- In the North Red Deer Regional line, the PSV shuts the regional flow off when the upstream pressure of the PSV drops at or below 586 kPa.
- In the WaterCAD model, the 900 mm diameter trunk was taken off-line at 12AM, which is also the simulation start time.

Using the above operating conditions, depletion time of the reservoir water storage with 100% full reservoirs is presented in following **Table 5-1**.

Table 5-1: Depletion Time of The Reservoirs in 100% Full Scenario

Reservoir	Storage Depletion Time (Hours)	
	With Regional Demands[1]	Without Regional Demands
Queens	Not depleted[2]	Not depleted
Glendale	19[3]	42[4]
Mountview	Not depleted[5]	Not delepted[5]
Lancaster	16	16

Notes:
1. *The flow to regional line is shut off when the upstream pressure to PSV is lower than 586 kPa.*
2. *Queens Reservoir was filled at 50 L/s.*
3. *Glendale pumping started at 8th hour when pressures dropped below 300 kPa.*
4. *Glendale pumping started at 31st hour when pressures dropped below 300 kPa.*
5. *Mountview was filled at 100 L/s.*

Water storage depletion for the four reservoirs in the 100% full scenario (planned shutdown scenario) with and without the NRD regional demands are presented in **Figure 5-1** and **Figure 5-2**.

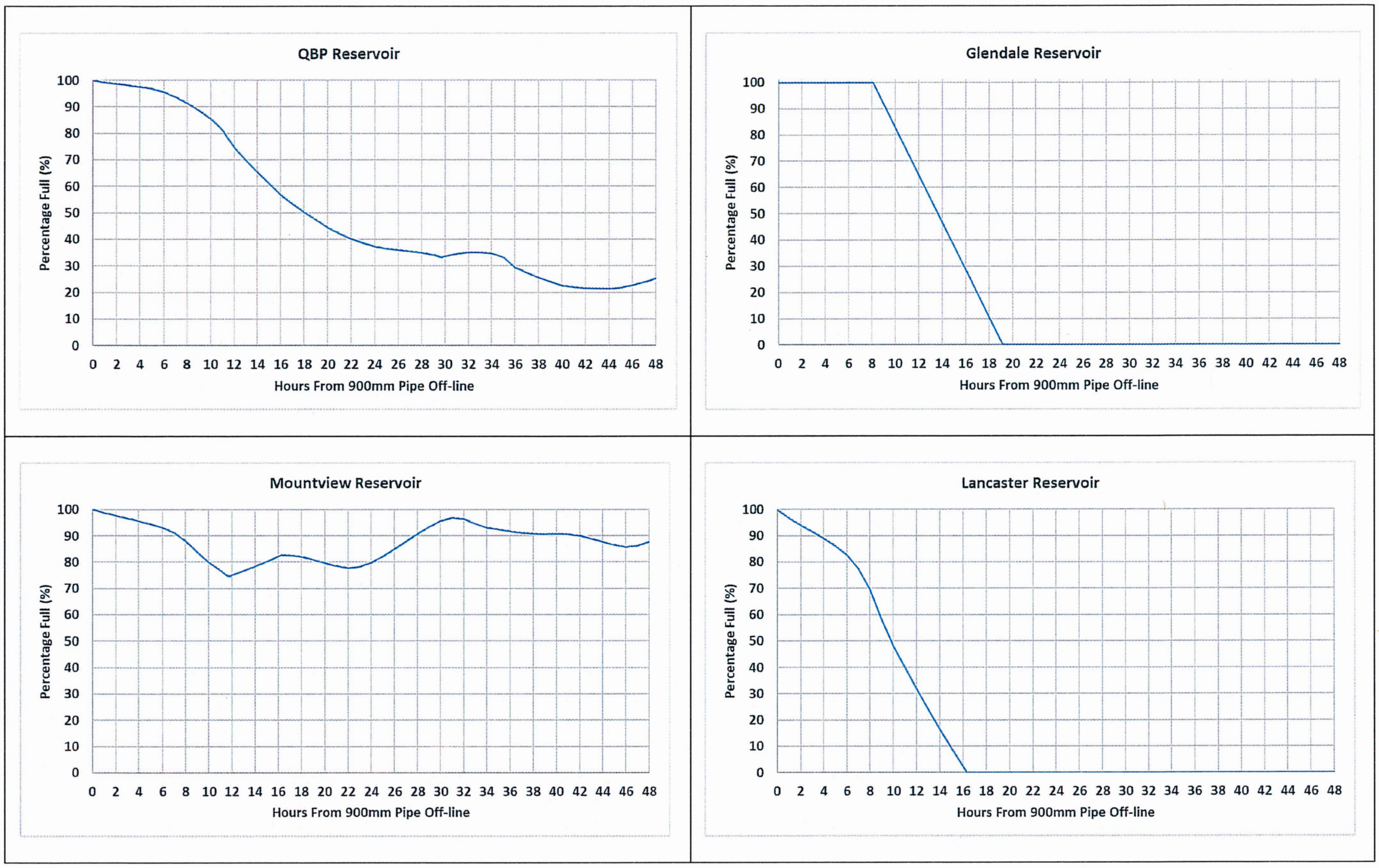


Figure 5-1: Reservoirs Full Percentages With the Regional Demands: 100% Full Scenario

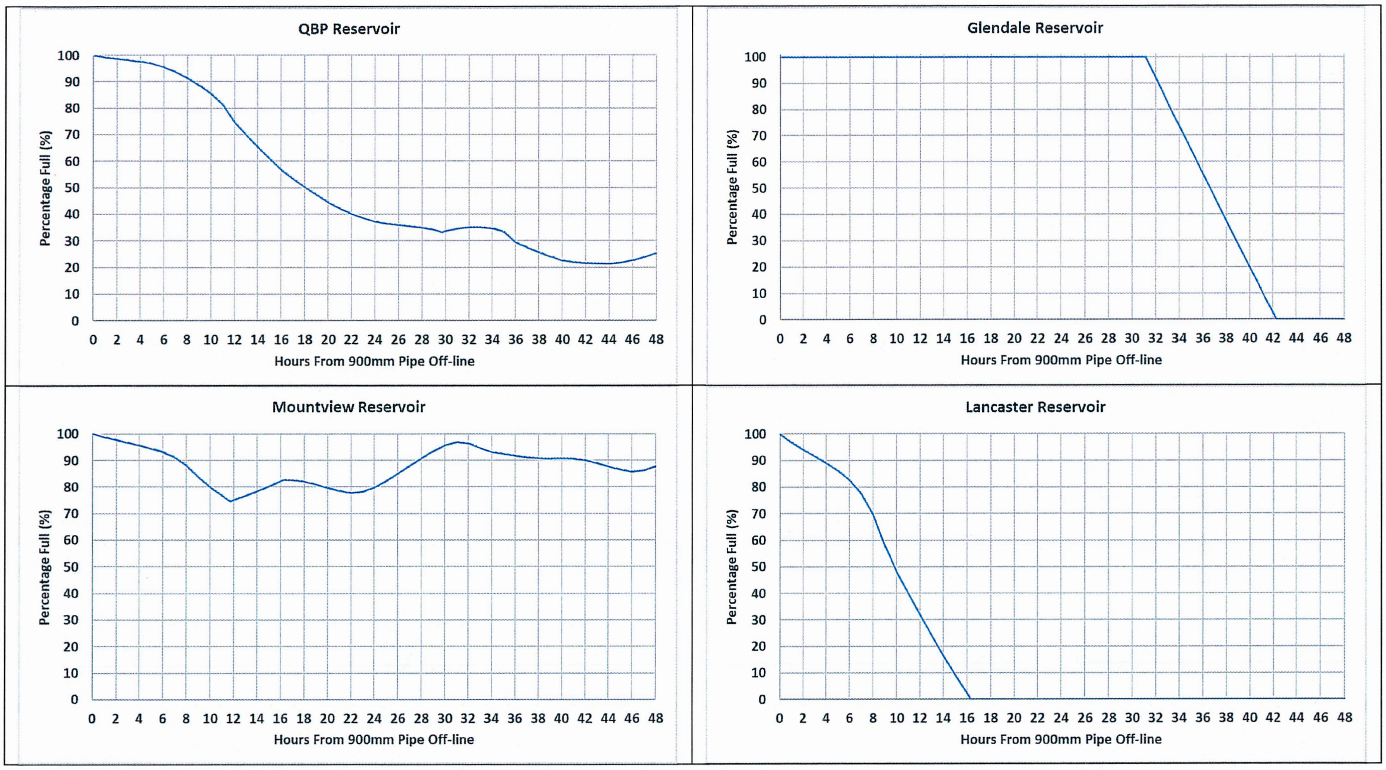


Figure 5-2: Reservoirs Full-Percentages Without the Regional Demands: 100% Full Scenario

In the 48-hour simulation, the drop of the pressures was mainly caused by the Glendale and Lancaster reservoirs depletion which led to the pumps stop pumping in these two pump stations. However, the system did not fail the emergency LOS in the 48 hours simulation as the residual pressures throughout the distribution mains did not drop lower than 140 kPa. **Figure 5-3** presents the distribution system residual pressures at the 45th hour when most of the residual pressures in the north of Red Deer River were lower than 300 kPa but higher than 140 kPa when the NRD regional flow was not totally shut off.

The simulation of the system performance indicated that without the NRD regional demands, the water distribution mains did not fail the emergency LOS neither. **Figure 5-4** presents the distribution system residual pressures at the 45th hour when the system has the lowest residual pressures which are between 140 kPa to 300 kPa without the NRD regional demands.