Appendix D

Hydraulic Modelling Analysis

Town of Midland

Hydraulic Modelling Analysis

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Project Number: 60593529

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August 31, 2020

Andy Campbell, P.Eng.,
Executive Director Environment & Infrastructure
The Town of Midland
575 Dominion Avenue
Midland, Ontario, L4R 1R2

Dear Mr. Campbell:

Project No: **60593529**

Regarding: **Town of Midland Hydraulic Modelling Analysis**
Draft Report

AECOM is pleased to provide an electronic copy of our Hydraulic Modelling Analysis Report for the Town of Midland Waterworks Master Plan Update Study.

This report documents the model development, model validation results, findings of the system analysis and hydraulic evaluation for the water servicing strategy.

We look forward to your feedback to ensure this report meets your expectations. Should you have any questions, please let us know.

Sincerely,
AECOM Canada Ltd.

Benny Wan, P.Eng.
Hydraulic Modelling Lead
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Quality Information

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1. Introduction

AECOM was retained by the Town of Midland (the “Town”) to update the Town’s Waterworks Master Plan (MP). The previous Town of Midland Waterworks Master Plan was complete in 2013 and projected the waterworks requirements to meet the 2031 projected population growth. The current update is using the estimated population growth to 2041 to determine the required infrastructure upgrades and capital works to meet the level of service that allows for a sustainable water supply in the Town of Midland.

As part of the Town’s Waterworks Master Plan Update, AECOM has prepared hydraulic modelling analysis report that documents the model development, model validation results, findings of the system analysis, improvement alternatives considered, and the recommended preferred water servicing solution and associated infrastructure improvements.

2. Existing Water System Overview

The Midland water distribution system (WDS) consists of four (4) main pressure zones (PZ): East, West, Sunnyside, and Lescaut. The system consists of 5 booster pumping stations (BPS), roughly 120 km of watermains (with distribution mains size ranging from 150 mm to 400 mm diameter), 1 elevated tank, 4 standpipes (SP) and approximately 561 fire hydrants, among other water infrastructure assets. An overview of the Midland WDS is presented in Figure 2-1.

As summarized from the Town of Midland’s current Waterworks Master Plan (AECOM, Nov. 2013), the Town’s water supply is currently provided from a groundwater aquifer through four Points of Entry (POE) well sites that include the Highway 12 Treatment System (for Wells 7A and 7B), Hanly Treatment System (for Well 15), Penetanguishene Treatment System (for Well 9), and Vindin (Flume) Well Field (for Wells 6, 11, 12, 14, 16 and 17). The system consists of ten production wells, nine of which are currently active.

The East pressure zone is the largest and has the lowest hydraulic grade line. Water is pumped to the West, Sunnyside, and Lescaut pressure zones using booster pumping stations. Sunnyside and Lescaut are small pressure zones and do not have storage facilities directly associated with the pressure zone.

The supply source and water infrastructure for each PD is presented in Table 2-1.

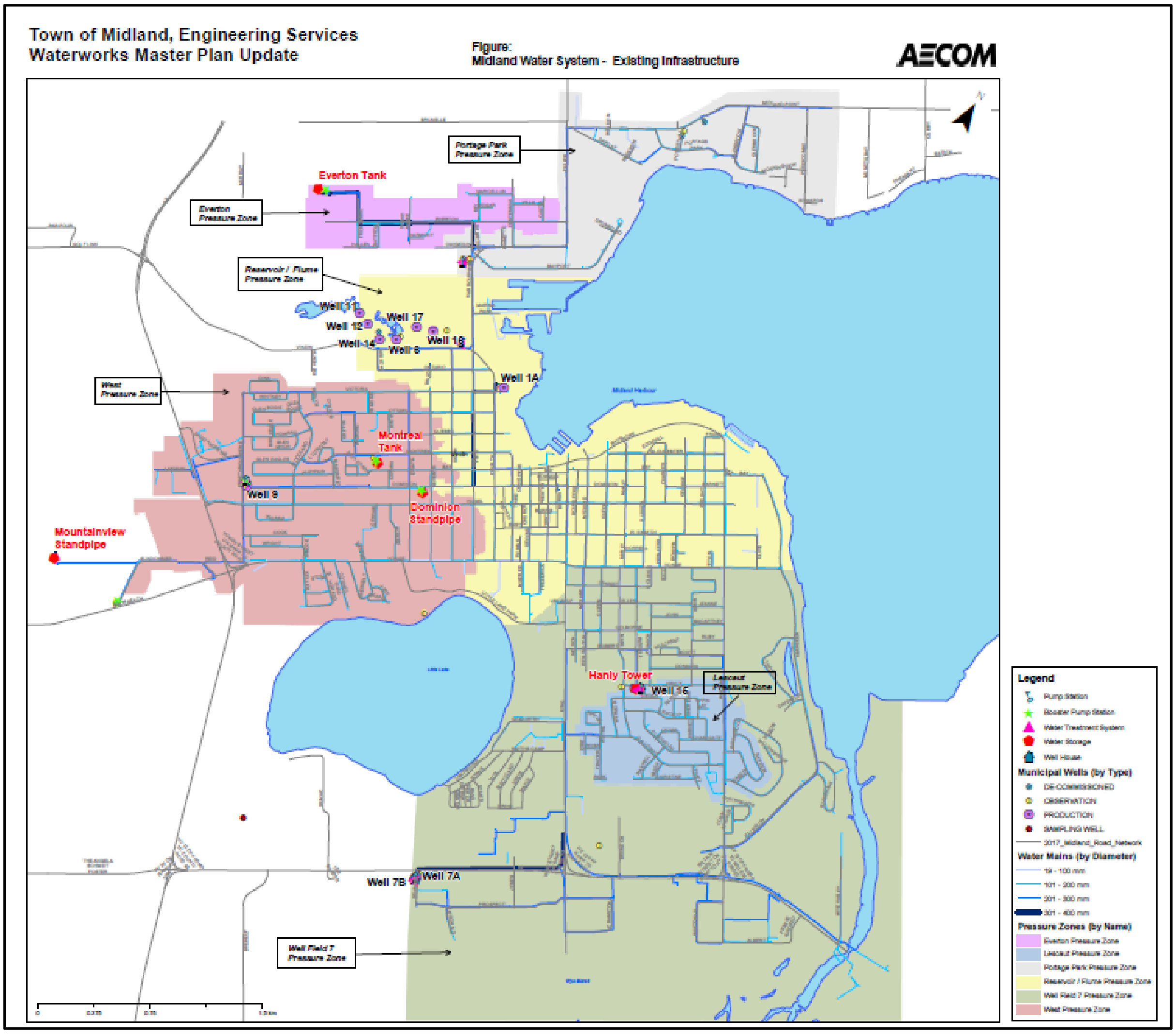

Figure 2-1: Overview of Midland Water Distribution System

Table 2-1: Midland Water Pressure Zones

Pressure Zone	Supply Source	Booster Pump Station	Storage Facility
East	Vindin Well field, Well 15, Wells 7A and 7B	--	Hanly Tower, Everton SP, Dominion SP
West	Well 9	Dominion BPS, Montreal BPS, Sundowner BPS	Montreal SP, Mountainview SP,
Sunnyside	--	Everton BPS	--
Lescaut	--	Hanly BPS	--

3. Hydraulic Model Development

The steady state scenarios were created in InfoWater Model to analyze system performance under existing (2011) and future (2031) demand conditions for the previous 2013 Waterworks Master Plan. In this Waterworks Master Plan Update, the previous steady state model (used as a basis for this study) was converted to twenty-four (24) hour Extended Period Simulation (EPS) model to perform model validation, system analysis and evaluate the water servicing strategies required to meet the Town's desired planning goals and objectives.

The Town's hydraulic network model was updated to include the latest water infrastructures based on GIS distribution system data provided by the Town (as shown in red color in the Figure 3-1). The watermains connectivity was reviewed in the model. Water distribution system information (e.g. model elevation, C-factor, pump curve, storage facility, etc.) incorporated in the previous Town's steady state model were reviewed for the model development. The relevant storage and pumping station facilities information from the updated water model are presented in Table 3-1 and Table 3-2. Manufacturer pump curves and pump test information are not available to verify the modelled pump information.

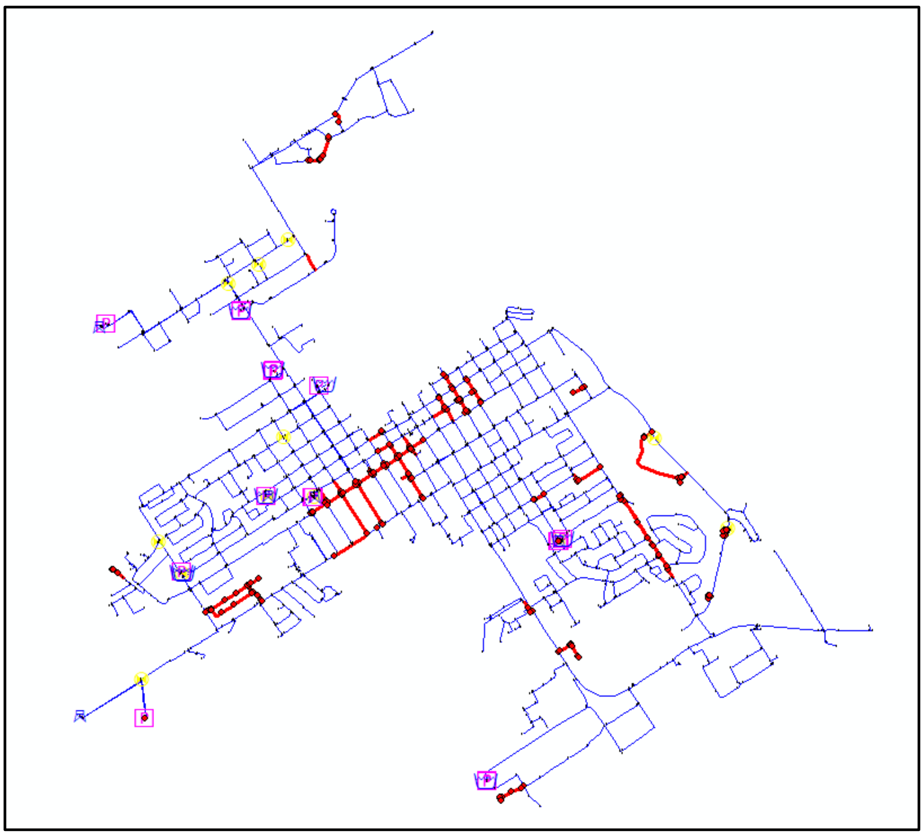

Figure 3-1: Town's Hydraulic Water Model

Table 3-1: Storage Facilities Characteristics

Storage Facility	Capacity (m3)	Base Elevation (m)	Low Water Level Elevation (m)	High Water Level Elevation (m)
Dominion SP	713	232.1*	232.1*	255.3
Montreal SP	2,881	234.0	234.0	242.7
Everton SP	5,863	239.0	239.0	255.0
Hanly Tower	950	219.0**	243.7	252.8
Mountainview SP	4,430	300.0	300.0	309.4

*Elevation adjusted based on 23.2 m high of Dominion SP

**Ground Elevation

Table 3-2: Pumping Station Facilities Characteristics

Pump Station	Type	Model Pump Information			
		Pump Label	Modelled Pump Curve Available	Design Head & Flow Modelled	Notes
Penetanguishene Treatment System	Well 9 Pump Station	Well_9	No	23 L/s @ 38 m TDH	
		Well_9FP	Yes	--	Fire Pump
Highway 12 Treatment System	Wells 7A & 7B Pump Station	Well_7A	Yes	--	
		Well_7B	Yes	--	
Hanly Treatment System	Well 15 Pump Station	Well_15	Yes	--	
Vindin (Flume) Treatment System	High lift pumping from Vindin (Flume) Well Field high lift well	Vindin_Flume_HLP1	No	45.5 L/s @ 79.3 m TDH	Alternating lead
		Vindin_Flume_HLP2	No	37.9 L/s @ 79.3 m TDH	Alternating lead
		Vindin_Flume_HLP3	No	63.1 L/s @ 79.3 m TDH	High Demand Backup
Dominion Avenue Booster Station	Booster Station	Dominion_BP1	Yes	--	
		Dominion_BP2	No	34.7 L/s @ 61 m TDH	
		Dominion_BP3	No	34.7 L/s @ 61 m TDH	Fire Pump
Montreal Street Booster Station	Booster Station	Montreal_BP1	Yes	--	
		Montreal_BP2	Yes	--	
		Montreal_FP	No	42.4 L/s @ 61 m TDH	Fire Pump
Everton (Sunnyside) Booster Station	Booster Station	Sunnyside_BP201	No	7.9 L/s @ 21 m TDH	Standby Pump
		Sunnyside_BP202	No		Duty Pump
		Sunnyside_BP203	No		Duty Pump
Sundowner Booster Station	Booster Station	Sundowner BP110	Yes	--	
		Sundowner BP120	Yes	--	
Hanly Booster Station	Booster Station	U7000	No	7.9 L/s @ 21 m TDH	
		U7002	No		
		U7004	No		

Elevation was assigned to the new added junctions based on the contour shapefile provided from the Town. Time-varying demand (diurnal pattern developed based on the flow balance calculation) and system operation and boundary condition were established for the EPS model development. Additionally, demand allocation was based on the previous MP water model. Global multipliers were applied to the demand in each PZ of the Town's water model, as discussed in Section 4.1. Future demands were allocated manually to model demand nodes as per the future growth areas, as discussed in Section 4.2.

4. Water Demand Analysis

4.1 Validation Period Demand

In order to support the model validation, available SCADA data (daily water production from the Midland groundwater well supply) for the last 6 years (2013-2018) was reviewed. The maximum total daily production was approximately occurred within the week of June 4 to June 11, 2018, summarized in the Table 4-1.

Table 4-1: Midland Total Daily Production Rate

Date	Vindin Well Field Total Daily Production (m3/d)	Well 9 Total Daily Production (m3/d)	Well 15 Total Daily Production (m3/d)	Well 7A Total Daily Production (m3/d)	Well 7B Total Daily Production (m3/d)	Total Daily Production (L/s)
June 4, 2018	4339	629	434	2240	1242	103
June 5, 2018	1908	432	633	1150	1303	63
June 6, 2018	1447	1180	627	858	2162	73
June 7, 2018	2201	1313	582	1182	2383	89
June 8, 2018	1867	953	635	3557	100	82
June 9, 2018	1236	1349	625	2648	1196	82
June 10, 2018	2542	1410	628	0	3583	94
June 11, 2018	3617	1419	632	1895	1258	102

The SCADA data (pump station discharge flow and storage facilities water levels) for the period of June 4 to June 11, 2018 was collected and reviewed for the model validation. System demand within each PZ of the Midland WDS was determined based on a flow balance calculation. Flow balance calculation accounted for the water supplied by well and booster pumps to the respective service area and storage accumulation (estimated based on water level variations and area of each storage facility) on an hourly basis, as illustrated in Figure 4-1.

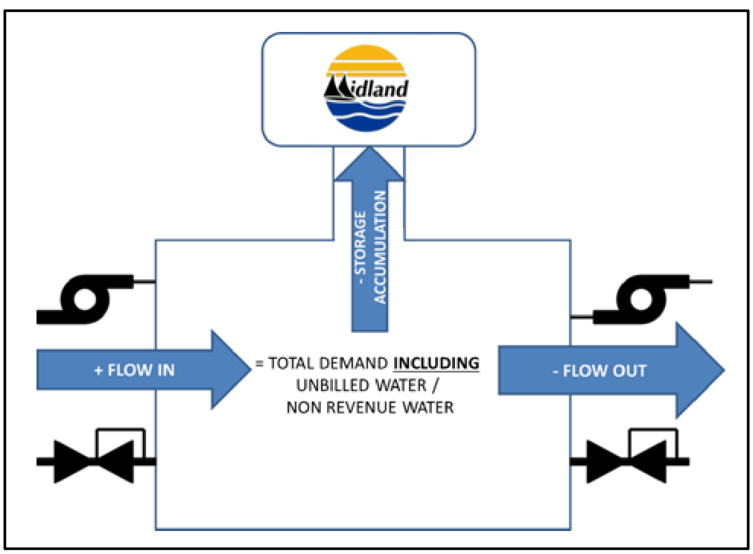

Figure 4-1: Simplified Schematic of Flow Balance Calculation

For this study, a 24-hour period (June 7, 2018) was selected for the model validation, as it represented typical demand diurnal pattern and average system demand for that period (June 4 to June 11, 2018). Based on the flow balance calculation and model demand allocation, the validation demand and diurnal pattern for each pressure zone, utilized for this study, are presented in Table 4-2. When performing the flow balance calculation for Sunnyside PZ, it was assumed that the only water supply source to Sunnyside PZ area was through the Everton BPS. As a result, there was zero demand factor for the first 5 hours of the 24-hour simulation (shown in Figure 4-2) because the SCADA showed no Everton BPS discharge flow during that time period. It could be some unmonitored transfer flow from East PZ to supply water to Sunnyside service area during that low demand period. However, that flow supply was small and would not cause a significant impact on the accuracy of the flow balance.

Table 4-2: Model Validation Demand

Pressure Zone	Modelled Validation Demand (L/s)	Demand Pattern ID
East*	59.6	East_West_JUN7-2018 (See Figure 4-2)
West*	20.4	
Lescaut**	7.1	
Sunnyside	1.6	SUNNYSIDE_JUN7-2018 (See Figure 4-2)
Total	88.7	

*Combined East and West demand assigned to the model.

**SCADA data for Hanly BPS not available to perform the flow balance calculation;

the daily demand (7 L/s) for Lescaut PZ, estimated by subtracting the total demand of east, west and sunnyside zones (82 L/s) from the total daily production (89 L/s) at Jun7, 2018 shown in Table 4-1.

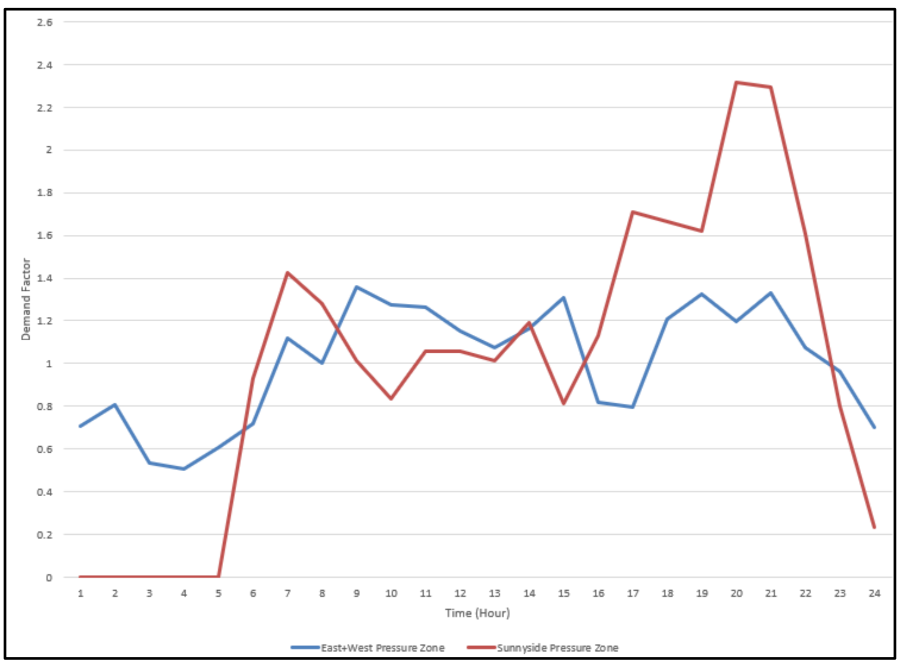

Figure 4-2: Demand Diurnal Period

4.2 System Analysis Demand

Water demand was estimated based on the following information:

- Residential and employment population by Zone.
- Per-capita consumption for Residential and Employment.
- Demand Peaking factor.

The total water demand (including transfer to Tay) under current (2018) MDD and future (2041) MDD were determined to be 125 L/s and 185 L/s, respectively. The total MDD by Pressure Zone is shown in Table **4-3**. Details of the demand calculation are presented in the Midland Waterworks Master Plan Update Preliminary Servicing Strategies Technical Memo, AECOM, dated March 18 2019.

Table 4-3: Midland Pressure Zone Water Demand

Total Average Demand By Zone (l/s)		2018	2021	2026	2031	2036	2041
East (including transfer to Tay)		47.9	55.3	57.7	59.1	62.9	66.9
Lescaut		3.8	3.8	3.8	3.8	3.8	3.8
Sunnyside		1.2	1.2	1.2	1.5	2.1	2.9
West		14.5	14.8	15.2	16.8	21.5	26.3
Total Demand - ADD (L/s)		**67.4**	**75.1**	**78.0**	**81.1**	**90.4**	**99.9**
Total Max Day Demand By Zone (l/s)		**2018**	**2021**	**2026**	**2031**	**2036**	**2041**
East (including transfer to Tay)		89.3	102.9	107.4	109.9	117.0	124.3
Lescaut		7.0	7.0	7.0	7.0	7.0	7.0
Sunnyside		2.2	2.3	2.3	2.7	4.0	5.3
West		26.8	27.3	28.1	31.0	39.7	48.7
Total Demand - MDD (L/s)		**125.3**	**139.6**	**144.9**	**150.7**	**167.8**	**185.3**

Future growth information was gathered from the Town of Midland Planning Department. Existing and planned development information and land use information was used to create theoretical parcels of land where growth is expected. The future demand projections were distributed by pressure zone and assigned in the model (highlighted in Figure 4-3).

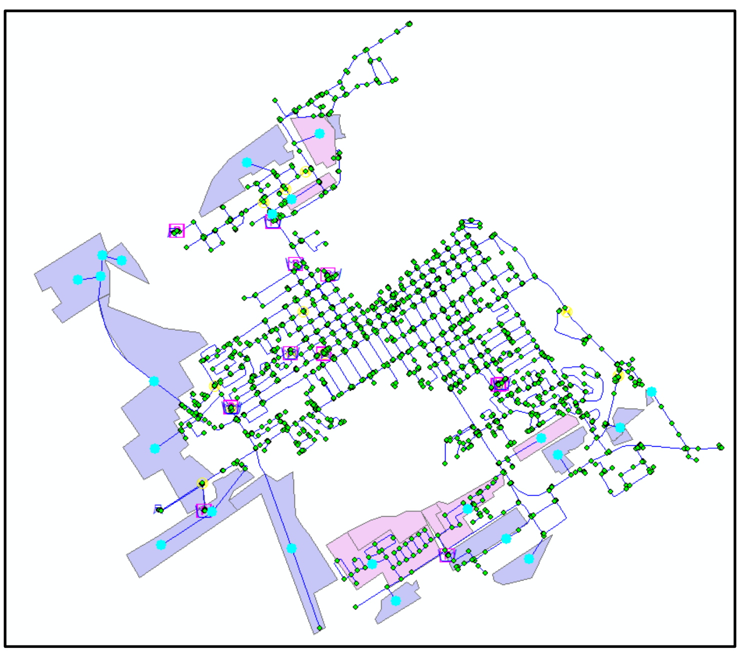

Figure 4-3: Future Growth Locations

5. Model Validation

5.1 Methodology

A high-level model validation for the Midland WDS was conducted using the available SCADA data to enhance the accuracy of the hydraulic model and increase the reliability of modelling results. The extended period simulation was performed over the 24-hour validation period (June 7, 2018). Prior to the model validation, initial model runs were conducted to resolve any significant errors and ensure overall model quality. The EPS model was set up to include system demands, demand patterns, pump operation status, control valve status and storage tanks starting water level based on the SCADA data.

The model was validated against available SCADA data. Comparisons were made between simulation results and SCADA data for pump station flow, pressure and storage facilities level data. Adjustments were made to the model as required, followed by additional model runs until sufficient accuracy was achieved. Typical adjustment as necessary were made that included adjustments to pump curves or trunk main C-factors.

5.2 Validation Results

Storage facilities level variations as well as pump station flow and pressure were compared against SCADA data. Model outputs for pump stations flow and pressure, and storage facilities levels were plotted against SCADA data.

Measures for evaluating the model validation accuracy included a comparison of simulated versus field measured flow, pressure and level based on the following:

- Graphical comparison between model outputs and field recorded data to ensure that maximum and minimum, flow direction and the overall difference in tank level trajectories are within the acceptable model accuracy.
- Graphical comparison between model outputs and field recorded data to ensure that the pump station flow and pressure are within the acceptable model accuracy.

Figure 5-1 to Figure 5-3 present validation results for the storage facilities, control valve (Sundowner tower outlet controlled at PRV location on Sundowner Road) and pumping stations within the Midland WDS.

The overall modelling accuracy for tank levels, pressures and flows are shown in Table 5-1.

Table 5-1: Summary of Model Validation Accuracy

Type	Model Accuracy
Level	96%
Pressure	90%
Flow	81%

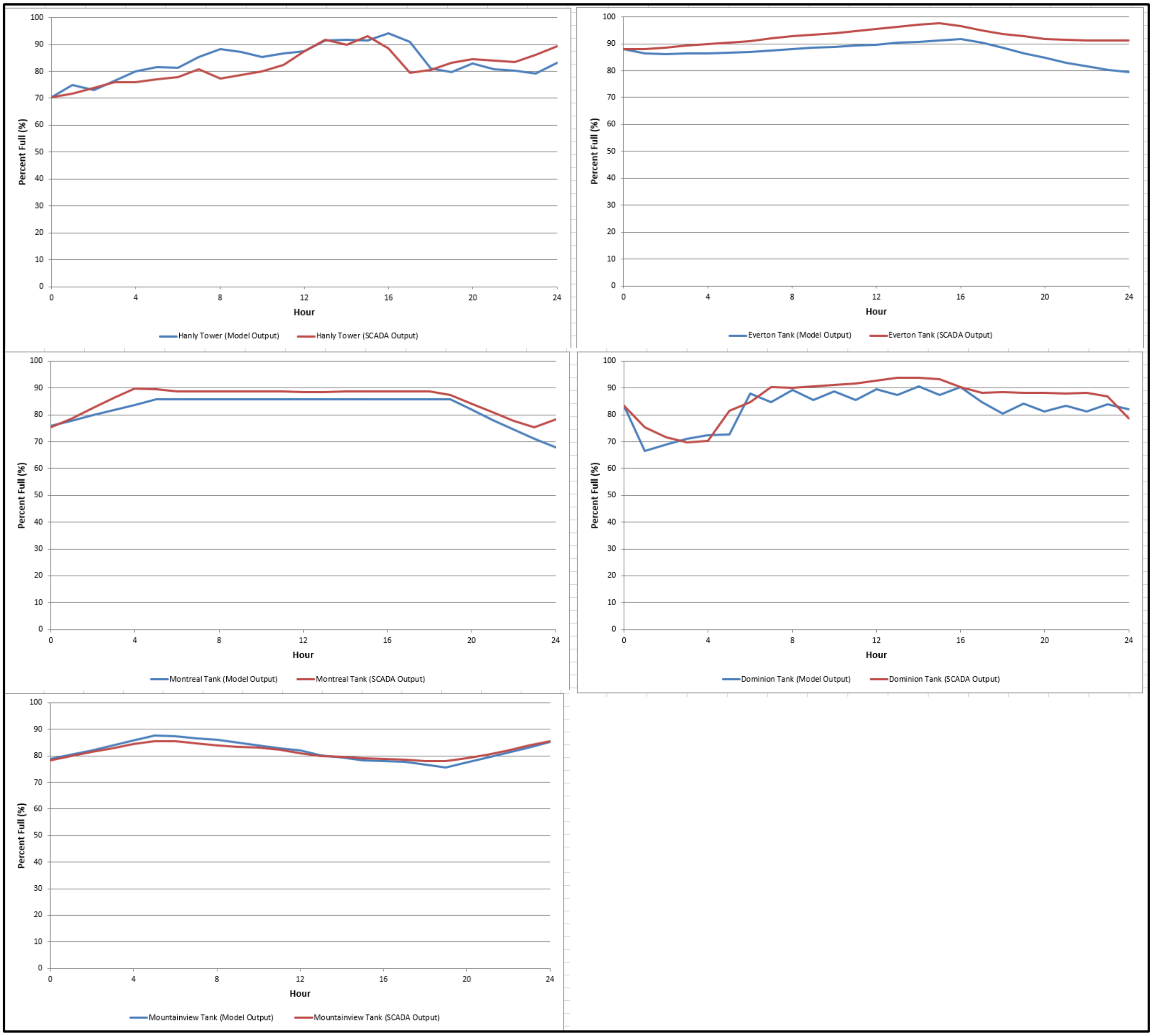

Figure 5-1: Validation Result- Storage Facilities Level

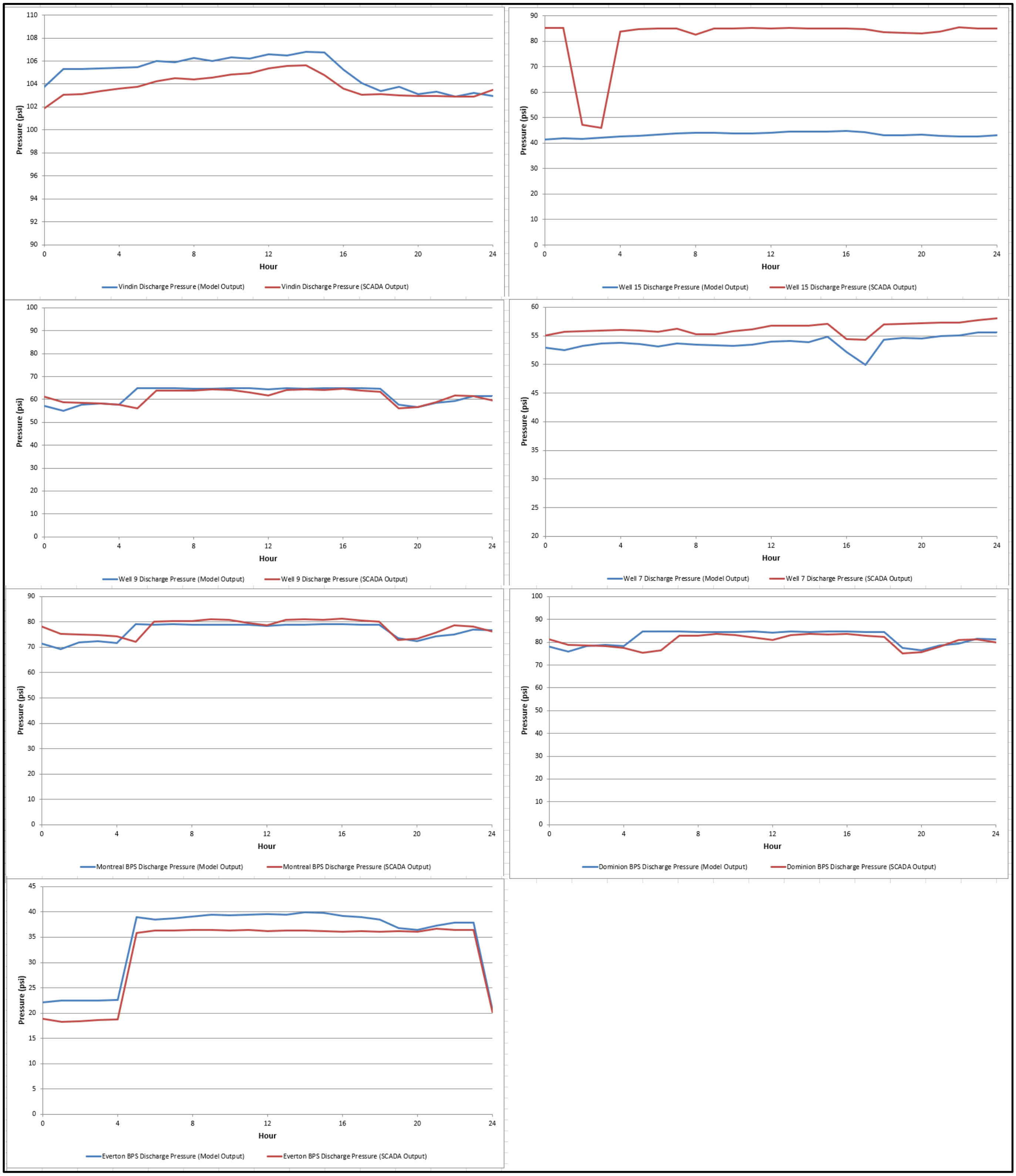

Figure 5-2: Validation Result – Pump Stations Discharge Pressure

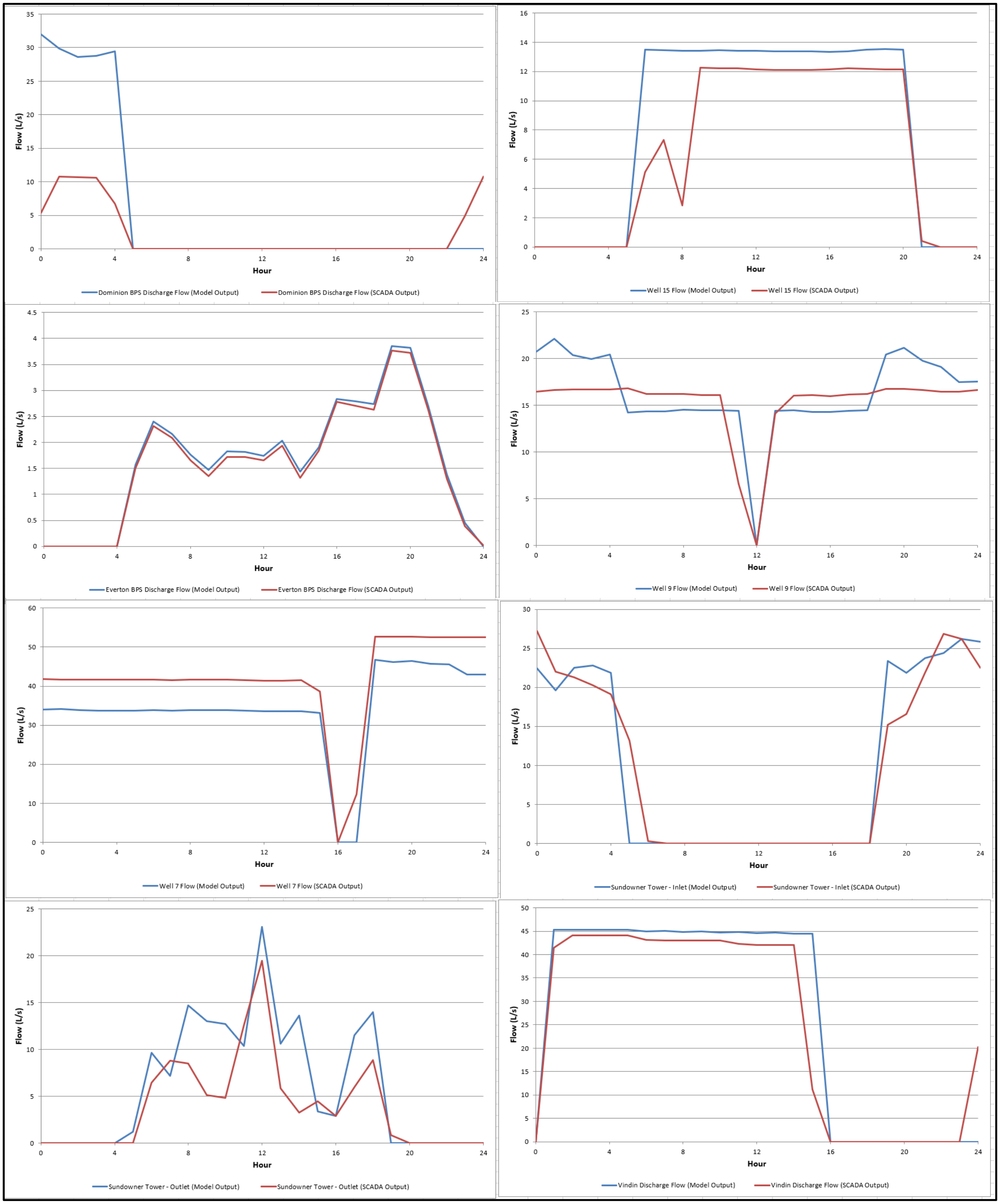

Figure 5-3: Validation Result – Pump Stations and Control Valve Flow

The following summarizes the key conclusions from the validation results:

- Storage Facility Levels
  - Everton SP levels generally follow the SCADA level variations within an acceptable range.
  - Other storage facilities levels closely follow the SCADA level range.
- Pumping Station Discharge Pressures
  - The SCADA data for Well 15 discharge pressure indicated a significant high pressure for almost entire 24-hour period, compared to the model results. However, the overall system modelling accuracy was acceptable for the long-range planning exercise; further confirmation of the metering accuracy should be confirmed via field investigation.
  - Other PS discharge pressures closely matched the SCADA data.
  - Please note that SCADA discharge pressure data for Hanly BPS was not available.
- Pumping Station Discharge Flows
  - Vindin HLPS, Everton BPS and Sundowner tower inlet at Sundowner BPS indicated a good match with the SCADA flows.
  - In general, Well 7, Well 9, and Well 15 pump stations flows follow the SCADA flow range.
  - Dominion BPS modelled flow was significantly higher than the SCADA. However, the overall system modelling accuracy was acceptable for the long-range planning exercise; it is recommended that Town perform a pump testing and/or SCADA flow meter calibration to confirm the accuracy.
  - Please note that SCADA discharge flow data for Montreal and Hanly BPS were not available.
- Control Valve Station Discharge Flow
  - The Sundowner tower outlet flow controlled at the PRV generally follows the SCADA data.

6. Water Servicing Strategy

As the validation results (for flow, pressure and level) were within the acceptable accuracy, the validated model was considered adequately reliable to assess the system performance. System improvement alternatives were identified and evaluated based on performance criteria for system pressure.

6.1 System Analysis Criteria

The following criteria were used to identify system deficiencies:

- Minimum system pressure = 40 psi
- Maximum system pressure = 100 psi
- Minimum system pressure during fire flow events = 20 psi
- Minimum available fire flow at 20 psi residual system pressure = 38 L/s (for residential area) and 75 L/s (for industrial area), as per the Town's design standards 2012.

6.2 Baseline Scenario (Do Nothing)

The following Section summarizes the system performance for current (2018) and future (2041) system conditions under average day, maximum day and fire flow demand conditions without any implementation of new servicing strategy or new infrastructure improvement.

6.2.1 Current System Analysis

Figure 6-1 and Figure 6-2 provides a color-coded representation of minimum system pressures under the current average day demand (ADD) and maximum day demand (MDD) conditions. The distribution system pressure dropped below 40 psi in the area south of Little Lake on Highway 12 between King Street and Country Road #93 located at higher ground elevation under the current ADD and MDD.

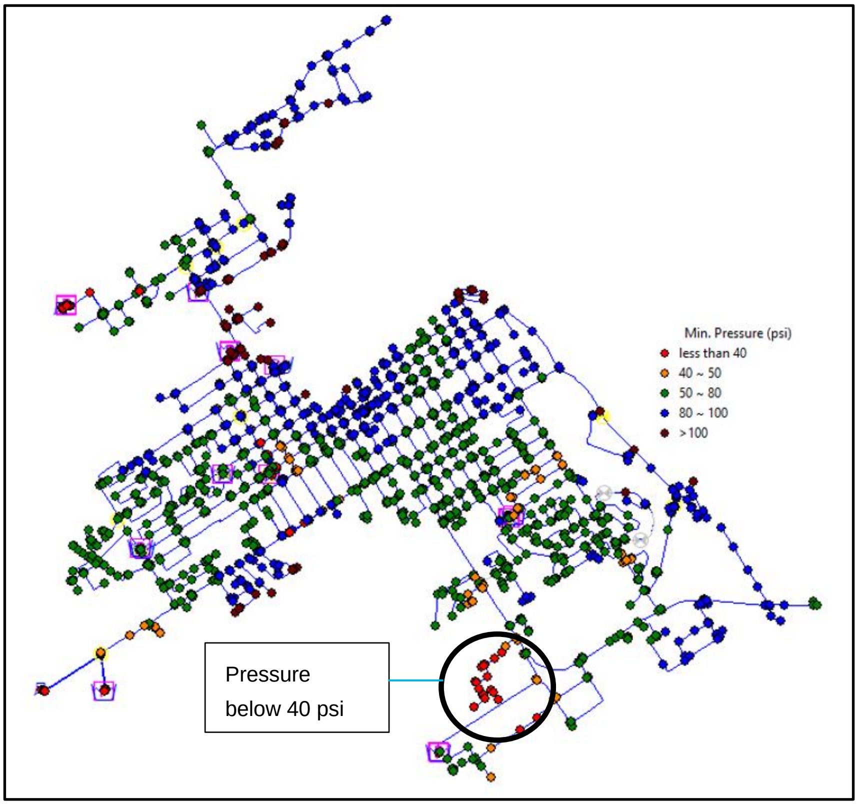

Figure 6-1: Minimum System Pressure under Current ADD

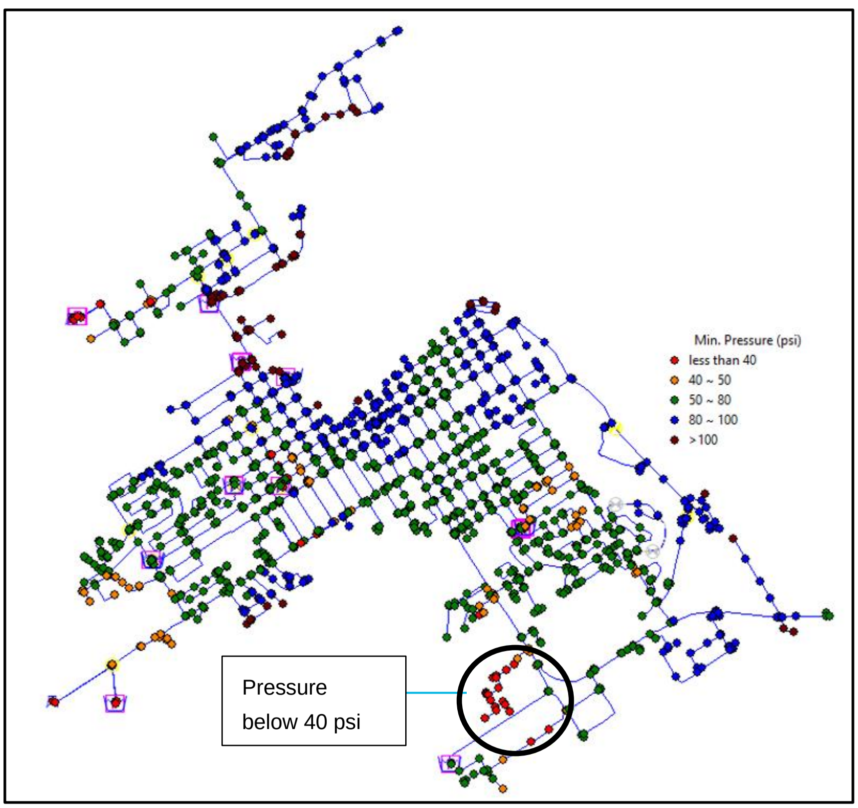

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Figure 6-2: Minimum System Pressure under Current MDD

6.2.2 Future System Analysis

Figure 6-3 and Figure 6-4 provides a color-coded representation of minimum system pressures under the future average day demand (ADD) and maximum day demand (MDD) conditions. The low-pressure areas (at Hwy12 and King St.) identified in the current demands were further expanded under the future conditions. Additionally, another low-pressure issue was identified in the future growth location along Balm Beach Road East located at high ground elevation.

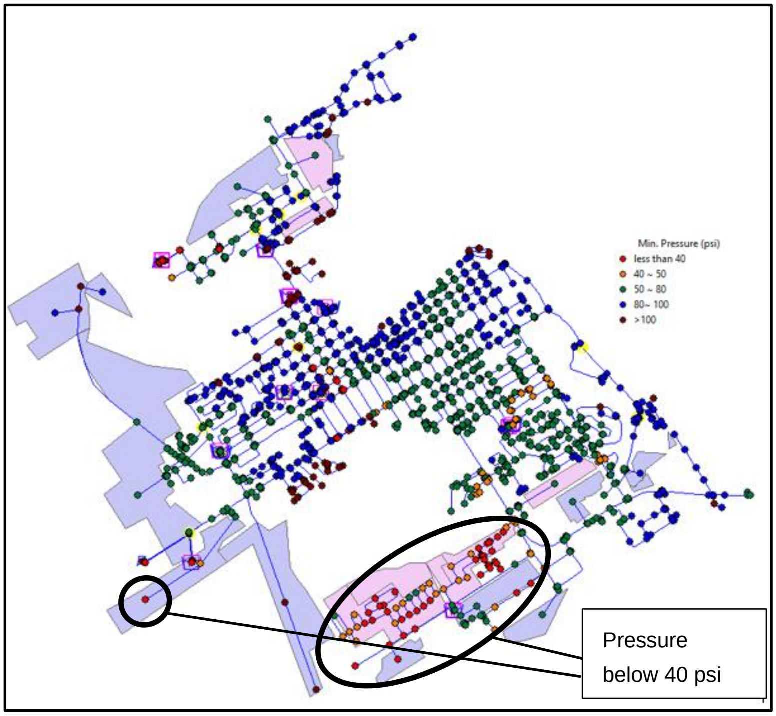

Figure 6-3: Minimum System Pressure under Future ADD

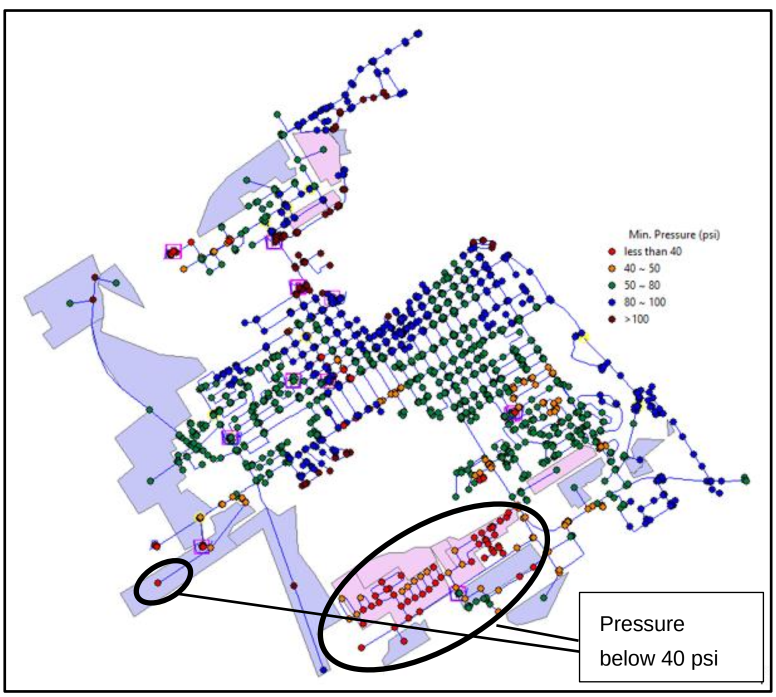

Figure 6-4: Minimum System Pressure under Future MDD

6.2.3 Fire Flow Analysis

The fire flow analysis was conducted as steady-state runs. Fire flow capacity was measured by determining the available fire flow at 140 kPa (20 psi) pressure limits for junction nodes within the Midland WDS under maximum day demand plus fire flow scenario. Figure 6-5 and Figure 6-6 show the model results under the fire flow conditions.

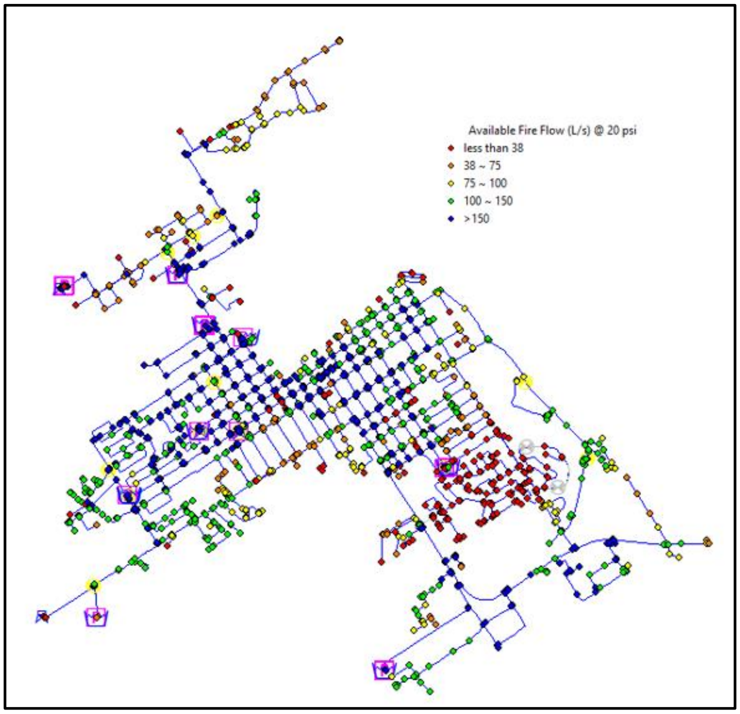

Figure 6-5: Available Fire Flow under Current MDD

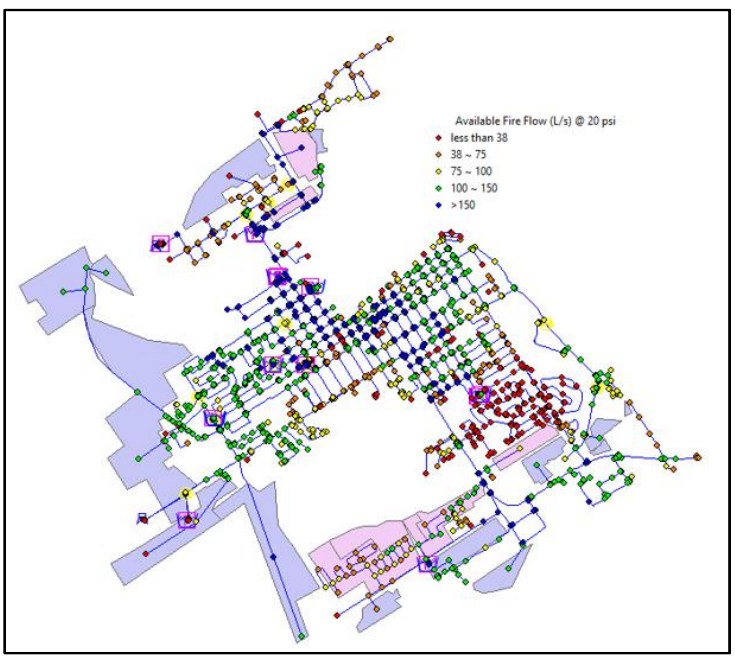

Figure 6-6: Available Fire Flow under Future MDD

The fire flow runs under current and future MDD indicated that the Midland water system is generally sufficient to provide the minimum residential fire flow of 38 L/s (as per the Town design standards), except for the Lescaut pressure zone as there do not have sufficient pump capacity to meet the fire flow demands. Please note that the fire flow results for the Sunnyside pressure zone was assumed with supply near Sunnyside Road and Everton Road from the East pressure zone.

6.3 Evaluation of Servicing Alternative Solutions

Based on the system evaluation through the desktop analysis (summarized in Section 4 of the Master MP Update Report) and the above noted hydraulic modelling analysis (for the Baseline Scenario) results, five (5) system issues and respective servicing strategy alternatives were identified, as shown in Table 6-1. Some of the servicing alternatives were evaluated for technical feasibility (ability to meet long-term water servicing requirements for the servicing area) using the hydraulic modelling analysis, as descried in Table 6-1.

Table 6-1: System Issues and Solutions

System Issues	Identified Alternatives		Detailed Hydraulic Modelling Evaluation Required
Issue 1: Need more storage in East Zone to address storage deficiencies	Alternative 1A	Install new tank in the area of Wells 7A/7B	Yes; Incorporated in Alternatives 4A and 4B
Issue 2: Need more groundwater supply to address water supply deficiencies	Alternative 2A	Abandon Well 1A and Well 12 and Commission Sundowner Well	No; For supply security and reliability purpose
Issue 3: Need more pump capacity in Lescaut and Sunnyside to address pump capacity deficiencies	Alternative 3A	Upgrade pump capacity of Hanly BPS	No; This alternative deemed technically viable to provide sufficient pumping to supply Lescaut service area under normal and fire flow conditions
	Alternative 3C	Upgrade pump capacity of Everton BPS	No; This alternative deemed technically viable to provide sufficient pumping to supply Sunnyside service area under normal and fire flow conditions
Issue 4: Address Low Pressure in Area South of Little Lake on Highway 12 between King St. and County Road #93	Alternative 4A	New pressure zone and new BPS at Hwy 12 and King St. area.	Yes
	Alternative 4B	New trunk watermain for future growth west zone. Connect area south of Little Lake to west pressure zone via County Road 93.	Yes
Issue 5: Need redundancy of supply in the Sunnyside Zone	Alternative 5A	Construct twin 300 mm watermain on Harbourview Road.	No; For redundancy purpose

In addition to the above, a new local BPS at Balm Beach Road is recommended to improve the low-pressure deficiency in that future growth area. For the purposes of the MP Update study, detailed hydraulic evaluation for the Alternatives 4A and 4B (incorporating Alternative 1A) are presented in the following Sections.

6.3.1 Alternative 4A – New South PZ with New BPS

This water servicing alternative proposes a new pressure zone and a new BPS, with a new storage tank in East PZ (Alternative 1A). In addition, installation of the new tank in East zone (with capacity of 5.38 ML and high-water level elevation modelled as 253 m) can replace the aging Dominion SP. The capacity of the new BPS was modelled as 40 L/s @ 18 m TDH.

The model results under future 2041 MDD confirmed that the minimum system pressure at Hwy 12 and King St. with the proposed improvement (Alternative 4A) will be above 40 psi, as shown in

Figure 6-7.

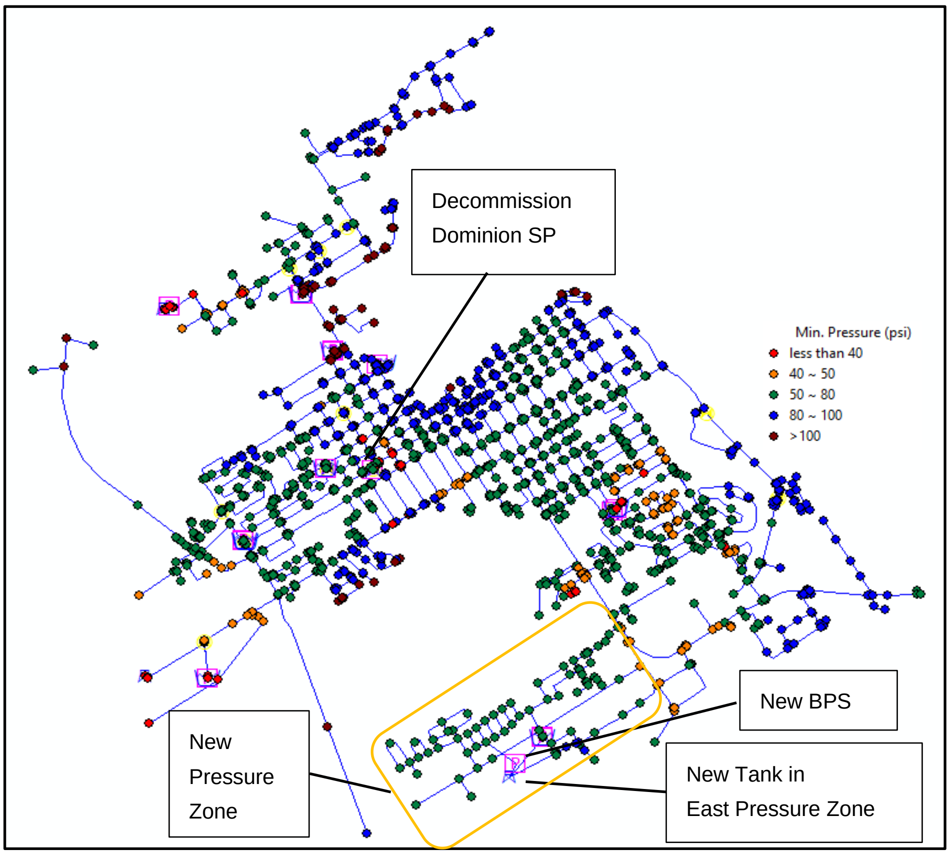

Figure 6-7: Minimum System Pressure under Future 2041 MDD with Alternative 4A

6.3.2 Alternative 4B – New Trunk Watermain connected to West PZ

This water servicing alternative requires a new 300 mm trunk watermain along Highway 93 with a new storage tank in East PZ (Alternative 1A). This trunk main will connect the area south of Little Lake to existing West Pressure Zone. Additionally, Alternative 4B requires Dominion BPS upgrade, as well as upsizing of the discharge and suction watermains for Dominion BPS.

The model results under future 2041 MDD confirmed that the minimum system pressure at Hwy 12 and King St. with the proposed improvement (Alternative 4B) will be above 40 psi, as shown in Figure **6-8**.

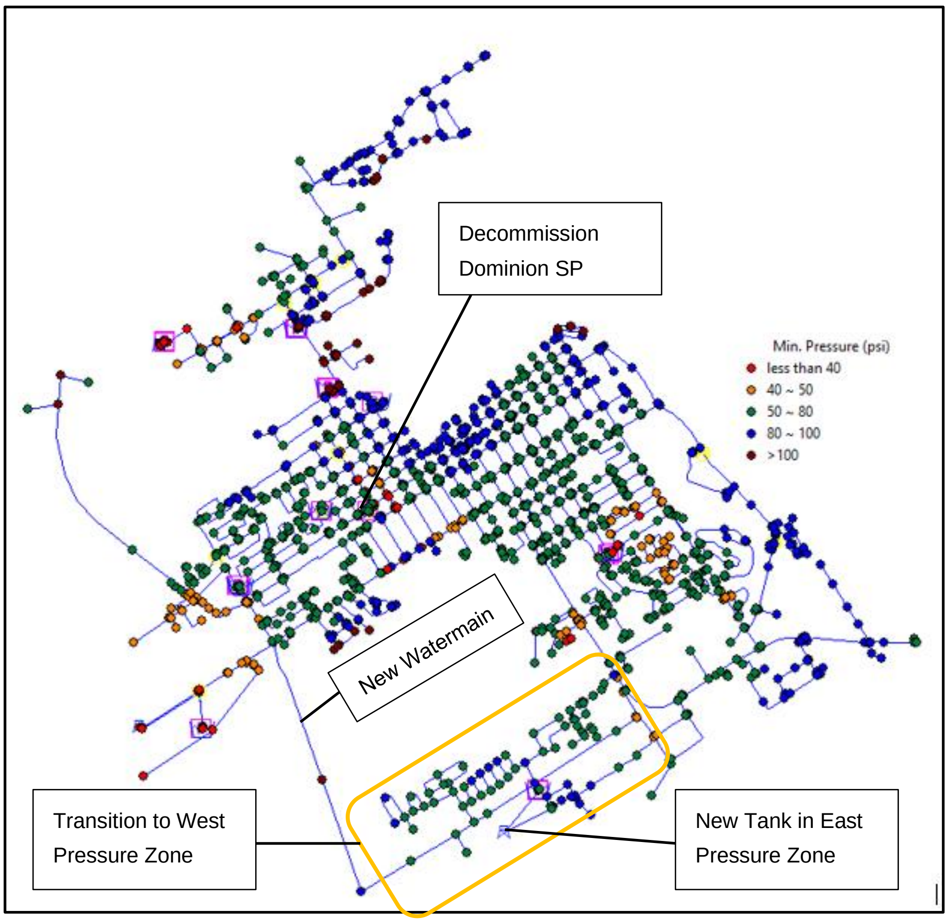

Figure 6-8: Minimum System Pressure under Future 2041 MDD with Alternative 4B

7. Conclusions

The Midland water distribution system were modelled using the InfoWater hydraulic modelling software platform. As part of this study, the previous steady-state hydraulic model was reviewed and updated to the EPS model, based on latest infrastructures included in the GIS database, storage facilities information as well as pumping stations infrastructure and controls data provided by the Town.

A detailed flow balance calculation was developed based on available SCADA data (flow and level) and system's daily demands, and demand diurnal patterns were determined.

The model was validated based on the available SCADA. Overall, the hydraulic validation accuracy meets the acceptable level of accuracy. The validated hydraulic model was utilized to assess the system performance under current (2018) and future (2041) demand conditions. Several modelling scenarios were created, and current and future capacity concerns/ bottlenecks were identified during normal operating conditions. System improvement alternatives were identified and evaluated based on performance criteria for system pressure.

Based on the system hydraulic evaluation, low system pressures experienced around the area north of Highway 12 and west of King Street under current and future demand conditions. There were two (2) alternatives: Alternative 4A (New Pressure Zone created near Hwy 12 and King St. Area) and Alternative 4B (Connect to West Pressure Zone) identified to address the low-pressure issues. Hydraulic analysis was completed to evaluate the identified water servicing strategies. Based on the hydraulic modelling evaluation, both servicing strategies (Alternative 4A and Alternative 4B) are feasible to mitigate the low-pressure issues to provide sustainable water service under the current and future conditions.

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