

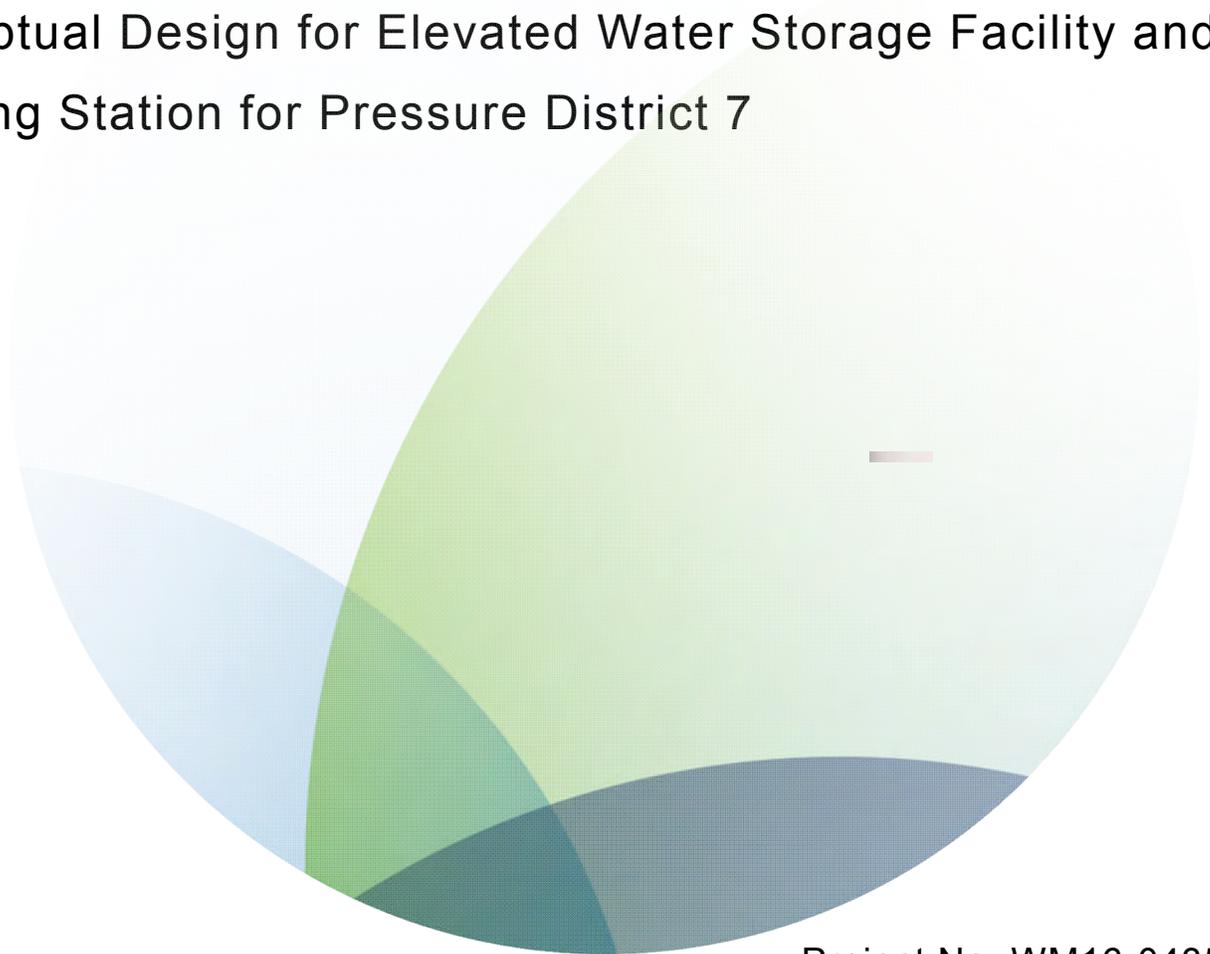


**APPENDIX A**  
**Technical Memorandum**  
**TM No. 1 Hydraulic Capacity Analysis**

# City of Hamilton

## Technical Memorandum No. 1 Hydraulic Analysis

Municipal Class Environmental Assessment and  
Conceptual Design for Elevated Water Storage Facility and  
Pumping Station for Pressure District 7



Project No. WM16-0435

August 2019



# COLE

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August 22, 2019  
Reference No. WM16-0435

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**Attention: Mr. Winston Wang**

**Municipal Class Environmental Assessment and Conceptual Design of  
Elevated Water Storage Facility and Pumping Station for Pressure District 7**

**Technical Memorandum No. 1 Hydraulic Analysis**

Cole Engineering Group Ltd. (COLE) was retained by the City of Hamilton to prepare a Hydraulic Analysis Report as part of the Municipal Class Environmental Assessment (EA) and Conceptual Design for a proposed PD7 Elevated Water Storage Facility (EWSF) and a proposed PD7 Pumping Station (PS).

*A solution is required to provide additional storage and pumping capacity to support the future growth within PD7 and PD23, to enhance water system security and reliability, and to meet the MECP guidelines and City design standards, while improving system operating efficiencies.*

This project is classified as a Schedule B and is being undertaken in accordance with the planning process outlined in the *Municipal Engineers Association Municipal Class Environmental Assessment* document (October 2000, amended in 2007, 2011 & 2015).

Best Regards,  
**COLE ENGINEERING GROUP LTD.**

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#### Issues and Revisions Registry

Identification	Date	Description of issued and/or revision
Draft Report	August 24, 2017	For review and discussion
Report	September 24, 2018	For submission
Report	January 28, 2019	For City Review
Report	February 12, 2019	For submission
Report	August 22, 2019	For submission

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Transmittal Letter

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## 1 Introduction

Cole Engineering Group Ltd. (COLE) was retained by the City of Hamilton to perform the Municipal Class Environmental Assessment (EA) and Conceptual Design for a proposed Pressure District 7 (PD7) Elevated Water Storage Facility (EWSF) and a proposed PD7 Pumping Station (PS).

PD7 is located in the southeastern section of the water distribution system in the City of Hamilton (City). PD7 is supplied from an existing (HD007) Highland Road Pumping Station (PS), which receives supply from PD5 or the Highland Road Reservoir (HDR07) and supplies water via (Binbrook PS, HD019) to PD23. PD7 currently functions as a closed system as no floating storage exists within PD7. **Attachment 1** shows the existing PD7 and PD23 water servicing area.

As per City's Water and Wastewater Master Plan 2006 (Master Plan 2006) and Hamilton Southeast Mountain Water Servicing Strategy (Stantec, 2013), additional PD7 pumping capacity (W-21, proposed HD07A PS) and the Elevated Water Storage Facility (W-23, proposed PD7 EWSF) are required to service future growth within PD7 and PD23, and address security of supply and water system balancing.

### 1.1 Other Suggested System Infrastructures Upgrades

The above subject projects will be assessed in conjunction with other infrastructure upgrades in the area as per the recommendations of the Hamilton Southeast Mountain Water Servicing Strategy (Stantec, 2013). These infrastructure upgrades (by others) include:

- i. Highland Road (HD007) PS was rebuilt in 2014 to include four pumps at 21.6ML/d each;
- ii. W-11 (Highland Road Reservoir Expansion). This reservoir is to be upgraded (e.g. to provide additional storage of 11.4ML), which is recommended to be commissioned by 2024 (as per Stantec, October 2013);
- iii. W-20 (HD019 Binbrook PS Upgrades): A 5ML/d upgrade to the Binbrook PS for a total firm capacity of 11.5ML/d to meet the 2031 maximum day demand of 11.4ML/d, which is recommended to be commissioned by 2020 (as per Stantec, October 2013); and,
- iv. Additionally, the existing PD23 EWSF (HDT23) needs to be upgraded by 1.7ML to achieve a total capacity of 5.1ML, which is recommended to be commissioned by 2020 (as per Stantec, October 2013).

Based on the review of the Stantec 2013 study, the PD23 system upgrade recommendations as identified in items (iii) and (iv) above were based on a fire flow requirement of 150L/s. Based on discussions with the City, the City has suggested a larger fire flow rate of 250L/s be used for PD23 analysis.

In addition, the required capacity of the proposed PD7 PS (HD07A) and the storage volume of the proposed PD7 EWSF are based on the assumption the proposed additional storage (1.7ML) for PD23 (Item (iv)) recommended to be commissioned by 2020, will not be provided until 2031, as suggested by the City.

The requirement of PD23 PS (HD019) capacity upgrades (W-20, or item (iii)) has been reviewed and provided for information only and will be confirmed as part of the current Master Planning Study and/or other studies to be undertaken by the City.

## 1.2 Scope of Work

As part of the Class EA and Conceptual Design for a proposed Elevated Water Storage Facility (EWSF) and a proposed Pumping Station (PS), Technical Memorandum No.1 Hydraulic Analysis (TM1) has been prepared. The objective of TM1 includes:

- Assessment of the need for additional capacity at the proposed PD7 PS (HD07A);
- Assessment of the need for additional storage volume at the proposed PD7 EWSF;
- Identification of system constraints; and,
- Evaluation of alternative solutions from a hydraulic standpoint.

## 2 Design Criteria

### 2.1 Water Demand

The design criteria requires that the distribution system is sized to convey the greater of peak hour demand flows or maximum day demand plus fire flows.

As per the Water and Wastewater Master Plan (2006):

- Average daily demand (Residential): 300 and 360L/cap/day - 360L/s is used for this hydraulic assessment;
- Average daily demand (Employment): 260L/employee/day;
- Maximum day peaking factor: 1.9; and,
- Peak hour peaking factor: 3.0.

### 2.2 Fire Flows

As per the City's Comprehensive Development Guidelines and Financial Policies Manual 2016, the fire flows are to be determined in accordance with the Water Supply for Public Fire Protection by the Fire Underwriters Survey FUS 1999.

As per the Water and Wastewater Master Plan 2006, fire flow rate criteria generally follows the MECF (MOE) 2008 guidelines with most pressure districts being planned for 250L/s.

The fire flow of 250L/s (with a duration 3.25-hours) for PD7 and 150L/s (with a duration of 2-hours) for PD7 were suggested in the Hamilton Southeast Water Servicing Strategy completed by Stantec, October 2013.

Based on current discussions with the City, a fire requirement of 250L/s (with a duration of 3.25-hours, as suggested in FUS) is to be used for this analysis for both PD7 and PD23.

### 2.3 System Pressures

As per the Water and Wastewater Master Plan (2006):

- Minimum pressure (under peak hour demand): 275kPa (40psi);
- Minimum pressure (Max day demand plus fire flow): 140kPa (20psi); and,
- Maximum pressure: 690kPa (100psi).

## 2.4 Water Storage

As per the MECP (MOE) 2008 design guidelines:

- Required storage (A+B+C): Fire storage plus equalization storage plus emergency storage;
  - A= Fire Storage;
  - B= Equalization storage (25% of maximum day demand); and,
  - C= Emergency storage [25% of (A+B)].

## 2.5 Selection of Watermain Sizes

The suggested Hazen-Williams C factors are used to size the new pipes as per MECP (MOE) 2008 design guidelines:

- 150mm: C=100;
- 200 – 250mm: C=110;
- 300 – 600mm: C=120; and,
- Over 600mm: C=130.

## 2.6 Pumping Station Capacity and Standby Power Supply

As per the Water and Wastewater Master Plan (2006), pumping stations are rated on their firm capacity to supply water. For each pressure district, the pumping station must provide local peak hour demand if there is no floating storage in the pressure district, or maximum day demand only if downstream pressure districts have sufficient floating storage.

As per the City of Hamilton Water Outstations Design Manual (Pumping and Storage) March 2016:

- Firm Capacity defined for closed distribution system: two largest pumps out of service, where there is one PS; one largest pump out of service, where there are two pumping stations;
- Firm Capacity defined for open distribution system: one largest pump out of service; and,
- Size one generator to provide standby power for building loads and operation of all equipment to provide firm pumping capacity. Provide two generators only if requested by the City.

The following criteria are indicated in the Design Guidelines for Drinking-Water Systems, MECP (MOE), 2008:

- If no or inadequate storage is available, the proposed booster PS should be designed in a manner that will allow it to supply all of the extreme flow conditions; and,
- Booster pumping stations serving pressure zones with adequate storage should be designed for the maximum day demand rate.

### 3 Water Demand and Population Projections

The historical water demand (in years 2015 and 2016) and the design or projected water demand for year 2016, 2021 and 2031 are detailed in the following sections.

#### 3.1 Historical Water System Demand

**Table 3.1** presents a summary of historical water demand for PD7 and PD23 based on a review and analysis of the SCADA data for the years 2015 and 2016. **Attachments 2.1** shows the typical high daily water demand curves for PD7 and PD23 in 2015 and 2016 using Historical SCADA. The peak hour demand occur around 20:00 (8:00PM) and low demand period around 03:00 (3:00AM).

**Table 3.1 Water Demand and Peaking Factor Estimations for PD7 and PD23 (2015-2016 Data)**

Design Condition	PD7, SCADA Data				PD23, SCADA Data			
	Demand (ML/d)		Peaking Factor		Demand (ML/d)		Peaking Factor	
	2015	2016	2015	2016	2015	2016	2015	2016
Average Day	6.3	6.8	1	1	1.6	1.9	1	1
Maximum Day	9.5	10.1	1.5	1.5	2.9	3.5	1.8	1.8
Peak Hour	15.8	16.1	2.5	2.4	8.3	9.1	5.2	4.8

The diurnal water demand curves of June 19, 2016 for both PD7 and PD23 were used to extrapolate the projected demands for years 2021 and 2031. In order to match the projected maximum day demand and peak hour flow rate for Years 2021 and 2031, the diurnal water demand curves for June 19, 2016 (e.g., hours near the low and peak hour demand periods) have been slightly modified as shown in **Attachment 2.2**. The modified demand curves representing 2021 and 2031 are used to evaluate system capacity and determine the requirement for PD7 pumping capacity as shown in **Section 5** below.

#### 3.2 Projected Water Demand

**Table 3.2** shows the estimated water demand requirements for the PD7 system using the City's design criteria.

**Table 3.2 PD7 Population and Population-based Water Demand Projections**

Year	Population		Demand (ML/d)			
	Residential	Employment	Avg. Day	Max Day*	Max Day + Fire	Peak Hour*
2016	13,002	7,093	6.5	12.4	34.0	19.6
2021	45,052	7,888	18.3	34.7	56.3	54.8
2031	109,152	8,954	41.6	79.1	100.7	124.9

\*The water demand peaking factors (e.g. 1.9 for maximum day and 3.0 for peak hour as per City's Master Plan 2006) were used.

Comparing **Table 3.1** with **Table 3.2**, the 2016 water demand as estimated from the 2016 SCADA data is very close to the 2016 average day demand in PD7. The projected maximum day and peak hour demand rates using the City's design criteria as shown in **Table 3.2** are higher than the water demand as estimated from the 2015 and 2016 SCADA data, due to higher peaking factors.

For a conservative design, the projected PD7 water demand (for Years 2021 and 2031) shown in **Table 3.2** using the City' Master Plan design values are used for the analysis and/or evaluation of the required capacity of the EWSF and PS.

**Table 3.3** shows the estimated water demand requirements for the PD23 system using the City's design criteria.

**Table 3.3 PD23 Population and Population-based Water Demand Projections**

Year	Population		Demand (ML/d)			
	Residential	Employment	Avg. Day	Max Day*	Max Day + Fire	Peak Hour*
2016	7,586	951	3.0	5.7	27.3	15.5
2021	10,135	1,236	3.7	7.0	28.6	19.3
2031	15,234	1,924	6.0	11.4	33.0	31.1

\*The water demand peaking factors (e.g. 1.9 for maximum day as per City's Master Plan 2006 and 5.2 for the peak hour as per 2015 and 2016 SCADA data review) were used.

Comparing **Table 3.1** with **Table 3.3**, the 2016 water demand in PD23 as estimated from the 2015 and 2016 SCADA data is higher than the 2016 average day water demand estimated using the City' Master Plan design values.

For a conservative design, the projected PD23 water demands shown in **Table 3.3** using the maximum day peaking factor 1.9 as per City's Master Plan 2006 and the peak hour peaking factor 5.2 (from 2015 and 2016 SCADA data review) are used for the analysis and/or evaluation of the required capacity of the EWSF and PS.

## 4 Water Storage Requirement

The required water storage for PD7 and PD23 is based on maximum day demand and fire flow as per the City's guideline. The existing available storage in PD23 is 3.4ML. Based on the projected populations for PD7 and PD23, the required storage and storage deficits under the 2016 (existing), 2021 and 2031 conditions are estimated below in **Table 4.1**, **Table 4.2** and **Table 4.3**, respectively.

As shown in **Table 4.1**, additional storage is required for the PD7. Approximately 3.1ML and 5.6ML of storage is required for 2021 and 2031, respectively. As shown in **Table 4.2**, additional storage is required for PD23. Approximately 2.0ML, 2.5ML and 3.8ML of storage is required for 2016, 2021 and 2031, respectively.

**Table 4.1 Estimated Required System Storage for PD7**

Storage	Required Storage Volume (ML)			Remark
	2016	2021	2031	
A) Fire	2.9	2.9	2.9	Fire flow 250L/s for a duration of 3.25 hours
B) Equalization Storage	3.1	8.7	19.8	25% of max day water demand (see <b>Table 3.2</b> )
C) Emergency Storage	1.5	2.9	5.7	25% of (A+B)
Total Required Volume	7.6	14.5	28.4	

Storage	Required Storage Volume (ML)			Remark
	2016	2021	2031	
Available Storage in Highland Road Reservoir	11.4	11.4	11.4	
Planned additional Storage*	0	0	11.4	
Storage Shortfall**	3.7	-3.1	-5.6	Storage shortfall of 5.6ML for PD7 in 2031

\*Planned additional storage assumes that the recommended additional storage (W-11) of 11.4ML from the Highland Road Reservoir (HDR07) to be in service by year 2024.

\*\* Positive value indicates no additional storage requirement.

**Table 4.2 Estimated Required System Storage for PD23**

Storage	Required Storage Volume (ML)			Remark
	2016	2021	2031	
A) Fire	2.9	2.9	2.9	Fire flow 250L/s for a duration of 3.25 hours
B) Equalization Storage	1.4	1.8	2.8	25% of max day water demand (see <b>Table 3.3</b> )
C) Emergency Storage	1.1	1.2	1.4	25% of (A+B)
Total Required Volume	5.4	5.9	7.2	
Available Storage in PD23	3.4	3.4	3.4	
Planned Additional Storage	0	0	0	Assumed no planned additional storage
Storage Shortfall	-2.0	-2.5	-3.8	Storage shortfall of 3.8 ML for PD23 in 2031

**Table 4.3 Estimated Required System Storage for PD7 and PD23**

PD7 + PD23		Storage Requirement (ML)			Remark
		2016	2021	2031	
Shortfall Storage	PD7	3.7	-3.1	-5.6	See <b>Table 4.1</b>
	PD23	-2.0	-2.5	-3.8	See <b>Table 4.2</b>
Storage Shortfall*		1.7	-5.6	-9.4	Storage shortfall of 9.4 ML for both PD7 and PD23 in 2031

\*Positive value indicates no additional storage requirement.

Based on Table 4.3, sufficient storage capacity is available for PD7 and PD23 under existing conditions (2016). Additional storage is required for the PD7 and PD23 for 2021 and 2031. Approximately 5.6ML and 9.4ML is required for 2021 and 2031, respectively. A slightly larger EWSF 9.9 ML EWSF is recommended. To minimize confusion with the tank size, the system analysis was based on the larger size of EWSF (9.9ML), since there is only 5% different in volume, when compared with the required minimum storage volume of 9.4 ML.

## 5 Evaluation of System Capacity

The schematic of the water demand for the PD7 and PD23 systems are summarized in **Attachment 3, 4** and **5** for the 2016, 2021 and 2031 conditions.

**Attachments 6.1 to 6.4** show the hydraulic analysis completed to evaluate system capacity and determine the proposed PD7 pumping capacity requirements for the PD7 and PD23 systems for 2021 and 2031 conditions. **Attachments 6.1 to 6.4** include critical scenarios for peak hour and maximum day demand plus fire flow conditions for both PD7 and PD23.

For illustration purposes, the following assumptions were made on the water levels in the proposed PD7 EWSF and existing PD23 HDT23 to estimate the proposed PD7 PS capacity requirements:

- Initial water levels: near their 75% full water levels prior to the fire events (under the maximum day demand plus fire flow conditions); and,
- Final water level: lowest water levels equal to or higher than 30% full water levels during fire events and/or peak hours in the evening around 20:00 (8PM).

The PD7 pumping capacity requirements for year 2016 (current), 2021 and 2031 are detailed as follows.

### 5.1 2016 Design Condition

PD7 is supplied from the existing Highland Road PS (HD007), which receives supply from PD5 or the Highland Road Reservoir (HDR07 with storage volume of 11.4ML). PD7 currently operates as a closed system as no floating storage exists within PD7. The existing HD019 firm pumping capacity to PD23 is 6.5ML/d. As shown in **Attachment 3**, the 2016 pumping capacity requirement for the PD7 system (including PD23) is 18.1ML/d, 40.1ML/d and 26.1ML/d under maximum day demand, maximum day demand plus fire flow and peak hour demand, respectively.

The existing (2016) firm pumping capacity is 43.2ML/d (with two pumps out of service), which is greater than the 2016 required PD7 pumping flow rate of 40.5ML/d, the water demand under the maximum day demand plus fire flow. The existing HD007 PS would be sufficient to supply not only maximum day plus fire flows, but also peak hour flows under the existing (2016) design condition. No additional PD7 pumping capacity is required under year 2016, as shown in **Attachment 3**.

### 5.2 2021 Design Condition

As shown in **Attachment 4**, the water demand requirement for PD23 is 7.0ML/d, 28.6ML/d and 19.3ML/d under maximum day demand, maximum day demand plus fire flow and peak hour demand, respectively.

As per MECP (MOE) 2008 design guidelines, the suggested maximum design velocity 1.5m/s (or flow rate of 16.2ML/d) is for a 400mm suction watermain. Therefore, the maximum flow rate of 16.2ML/d is assumed to be supplied from PD7 to PD23 via the existing suction supply 400mm watermain under the 2021 design condition.

For information only, it is assumed that the 2021 firm pumping capacity to PD23 is 16.2ML/d. The lowest water level in the existing HDT23 is approximately equal to 30% full water level during the fire event under the 2021 design conditions, as shown in **Attachment 6.1**.

As shown in **Attachment 4**, the 2021 water demand requirement for PD7 is 34.7ML/d, 56.3ML/d and 54.8ML/d under maximum day, maximum day plus fire and peak hour, respectively.

The Highland Road (HD007) pumping capacity required would be 64.8ML/d, if one pump was out of service (for an open distribution system) after the commissioning of the proposed PD7 EWSF.

As shown in **Attachment 6.2**, with assuming the HD019 firm pumping capacity 16.2ML/d to PD23, the water level in the proposed PD7 EWSF would still be above 60% under the maximum day plus fire flow condition. The existing HD007 PS, together with the proposed PD7 EWSF would be sufficient to supply not only maximum day plus fire flows, but also peak hour flows to year 2021. No additional PD7 supply pumping capacity to PD7 (and PD23) is required by year 2021. However, additional PD7 supply pumping capacity (e.g., proposed PD7 PS) may be required shortly after year 2021. The timeframe for the proposed PD7 PS depends on the growth rate in the Elfrida community and is to be confirmed as part of the current Master Planning study.

### 5.3 2031 Design Condition

As shown in **Attachment 5**, the water demand requirement for PD23 is 11.4ML/d, 33.0ML/d and 31.1ML/d under maximum day demand, maximum day demand plus fire flow and peak hour demand, respectively.

Additional pumping capacity at HD019 Binbrook PS is required to meet the PD23 water demand requirement. For information only, the required 2031 firm pumping capacity at HD019 Binbrook PS for PD23 is 31.2ML/d (approximately equal to PD23 peak hour demand), as shown in **Attachment 6.3**.

As shown in **Attachment 6.4**, additional supply pumping capacity to PD7 and PD23 is required prior to year 2031. With the HD019 Binbrook PS firm pumping capacity of 31.2ML/d to PD23, the required pumping capacity for the proposed PD7 PS (HD07A) is approximately 60.3ML/d (firm capacity) prior to year 2031. The water level in the proposed PD7 EWSF would be above 50% under the maximum day plus fire flow condition.

The existing HD007 PS plus the proposed PD7 PS (HD07A), together with the proposed PD7 EWSF would be sufficient to supply not only maximum day plus fire flows, but also peak hour flows to year 2031.

It should be noted that additional PD7 supply pumping capacity (e.g., proposed PD7 PS) may be required much sooner than year 2031. The timeframe for the proposed PD7 PS (HD07A) depends on the growth rate in the Elfrida community and is to be confirmed as part of the current Master Planning Study.

## 6 System Constraints

Based on the above system capacity analysis, the existing PD7 and PD23 water systems are not able to maintain sufficient flow and pressures in the distribution system to support future development. Both pumping capacity and additional water storage are required for the PD7 and PD23 systems.

The Problem / Opportunity Statement for this Class EA Study can be phrased as follows:

*A solution is required to provide additional storage and pumping capacity to support the future growth within PD7 and PD23, to enhance water system security and reliability, and to meet the MECP guidelines and City design standards, while improving system operating efficiencies.*

## 7 Alternative Solutions

The Do Nothing alternative would not meet growth and resolve flow requirements. The Do Nothing alternative was eliminated from further consideration. The alternative solutions for elevated water storage facility and PS locations are evaluated as follows.

## 7.1 Alternative Elevated Water Storage Facility Sites

Five alternative elevated water storage facility sites (EWSF) were identified based on a system review, through discussion with the City, and review of the background information. It is preferable to construct the elevated water storage facility near a high ground area for hydraulic performance.

The five alternative water storage sites are shown in **Attachment 1**. The five site locations for the elevated water storage facility were compared by analyzing the hydraulic performance of the PD7 system using a 2021 demand condition. The design condition for 2031 will be reviewed together with the proposed PD7 PS under **Section 7.2**. **Table 7.1** shows the relevant evaluation criteria and the hydraulic performance in PD7 for each site.

**Table 7.1 Evaluation Criteria and Hydraulic Performance for Elevated Water Storage Facility Site**

Criteria	Elevated EWSF Sites 1 and 2	Elevated EWSF Site 3	Elevated EWSF Site 4	Elevated EWSF Site 5
System Pressure: Minimum Pressure within PD7 under peak hour (psi)	41psi	41psi	<40psi*	<40psi*
Fire Flow Capability (e.g. near local high point at Townhouse Residential area northwest of Upper Centennial Parkway and Rymal Road East)	290L/s	280L/s	270L/s	250L/s
Location in Pressure District	PD7	PD7	PD6	PD6
Distance to Demand Centre (Urban Expansion Area), km	0.0	0.1	0.7	1.5
Distance to Existing PD7 Network (km)	0.5	0.0	0.5	2
Ground Elevation (m)	215 and 216	218.5	218.5	216

\* Other infrastructure upgrades (e.g., watermain upgrades along the existing PD7 system) will be required to improve the system pressure.

### 7.1.1 System Pressure

EWSF Sites 4 and 5 are within PD6 and farther away from the critical location of Townhouse Residential area northwest of Upper Centennial Parkway and Rymal Road East. The minimum system pressure is below 40psi for both EWSF Sites 4 and 5 under the 2021 condition with the proposed PD7 EWSF level near 258m with firm pumping capacity from Highland Road PS (HD007). EWSF Sites 4 and 5 do not meet the minimum pressure requirement of 40psi. Other infrastructure upgrades (e.g., watermains upgrades along the existing PD7 system) will be required to improve the system pressure (e.g., system pressure greater than 40psi under peak hour).

EWSF Sites 1, 2 and 3 provide a minimum pressure within PD7 of approximately 41psi, which meets the minimum 40 psi requirement under the peak hour demand condition.

PS Sites 1, 2 and 3 are the preferred EWSF sites in term of system pressure, when compared with EWSF Sites 4 and 5.

### 7.1.2 Fire Flow Capacity

Based on the system configuration, available fire flow at the Townhouse Residential (local high point) near Highgate Drive and Highbury Drive (Northwest of Upper Centennial Parkway and Rymal Road East) is used

to evaluate fire flow. This location is both remote from the proposed EWSFs and relatively high in elevation and has a larger fire flow requirement. For comparison purposes, the available fire flows in the area from the alternative EWSF sites were assessed.

All EWSF sites can provide larger than 250L/s fire flow to the local high point on Highbury Drive in the existing townhouse residential area northwest of Upper Centennial Parkway and Rymal Road East, assuming the EWSF level is 258m and two existing Highland Road pumps are online. The available fire flow capacities from EWSF Sites 1, 2 and 3 are greater than EWSF Sites 4 and 5, since they are nearer to the local high point location.

### **7.1.3 Location in Pressure District**

Elevated EWSF Sites 1, 2 and 3 are within PD7 system and Site 4 and 5 are within PD6. The pipeline connection to Elevated EWSF Sites 1, 2 and 3 can be used as part of the local PD7 system. Overall, Sites 1, 2 and 3 will require less space and pipeline than Sites 4 and 5.

### **7.1.4 Distance to Demand Centre**

EWSF Sites 1, 2 and 3 are adjacent to the demand centre (e.g. Urban Expansion) providing better hydraulic capacity than Sites 4 and 5.

### **7.1.5 Distance to Network System**

EWSF Site 3 is the closest to existing infrastructure and has the shortest pipe installation requirement.

### **7.1.6 Ground Elevation**

EWSF Sites 3 and 4 are at the highest ground elevation and therefore would require the shortest pedestal.

## **7.2 Alternative Pumping Station Sites**

Based on the PD7 system hydraulics, the water is supplied from PD5 system and additional pumping capacity is required to support the proposed development in PD7 and PD23. The proposed PD7 PS (HD007A) together with the existing PD7 Highland Road PS (DD007) will provide water to PD7 and PD23 systems, as well as to fill the proposed PD7 EWSF. It is recommended to install four pumps with a firm capacity of 60.3ML/d.

Three alternative PS sites were identified based on review of the background information, and in discussions with the City.

The pumping stations are to be sized to provide the peak hour demand and maximum day plus fire flow. Standby power supplies are required to be provided at these pumping stations as per the City's design guidelines. The sizing and assessment of pumping stations was based on the 2031 Demand Scenario with firm capacity from both Highland Road PS and proposed PD7 PS with the proposed EWSF at Site 3.

**Table 7.2** shows the evaluation criteria and hydraulic performance in PD7 for each PS location.

**Table 7.2 Evaluation Criteria and Hydraulic Performance for Pumping Station Site**

Criteria	PS Site 1	PS Site 2	PS Site 3
System Pressure: Minimum Pressure within PD7 under peak hour (psi)	44	44	<40psi*
Fire Flow Capability (e.g. near local high point at Townhouse Residential area northwest of Upper Centennial Parkway and Rymal Road East)	>300L/s	>300L/s	250L/s
Feasibility to fill proposed PD7 EWSF	Yes	Yes	Challenge**
Distance to Demand Centre (Urban Expansion Area), km	0.0	0.0	0.7
Required Pump Total Dynamic Head, TDH (m)***	Lower	Lower	High
Land Availability	Yes	No	No

\* Other infrastructure upgrades (e.g., watermain upgrades along the existing PD7 system near PS Site 3) will be required to improve the system pressure.

\*\*see Section 7.2.2 for details.

\*\*\* see Section 9 for details.

### 7.2.1 System Pressure

PS Site 3 is within the existing PD7 system and located near the low ground area (e.g., ground elevation around 195m). In order to maintain the system maximum pressure of 700kPa, the maximum system head would be approximately 265m (=195+70m) in the area. In other words, the suggested maximum pump discharge head is 265m, if the proposed PD7 PS (PD007A) is located at PS Site 3. The minimum system pressure is below 40psi with the proposed PD7 EWSF level near 258m and firm pumping capacity from both Highland Road PS (HD007) and the proposed PD7 PS (HD07A). Overall, PS Site 3 does not meet the minimum pressure requirement of 40psi. Other infrastructure upgrades (e.g., watermains upgrades along the existing PD7 system near PS Site 3) will be required to improve the system pressure (system pressure greater than 40psi under peak hour).

PS Sites 1 and 2 provide a minimum pressure within PD7 of approximately 41psi, which meets the minimum 40psi requirement under the peak hour demand condition.

PS Site 1 and Site 2 are the preferred PS sites in term of system pressure, when compared with PS Site 3.

### 7.2.2 Fire Flow Capacity

Based on the system configuration, available fire flow at the Townhouse Residential (local high point) near Highgate Drive and Highbury Drive (Northwest of Upper Centennial Parkway and Rymal Road East) is used to evaluate fire flow. This location is both remote from the proposed PSs and relatively high in elevation and has a larger fire flow requirement. For comparison purposes, the available fire flows in the area from the alternative PS sites were assessed.

All PS sites can provide larger than 250L/s fire flow to the local high point on Highbury Drive in the existing townhouse residential area northwest of Upper Centennial Parkway and Rymal Road East assuming the EWSF level is near 258m and two pumps are online from both Highland Road PS (HD007) and the proposed PD7 PS (HD07A). The available fire flow capacities from PS Sites 1 and 2 are greater than PS Site 3, since they are nearer to the local high point location.

### 7.2.3 Feasibility to Fill Proposed PD7 EWSF

PS Site 3 is within the existing PD7 system and located near the low ground area (e.g., ground elevation around 195m). In order to maintain the system maximum pressure of 700kPa, the maximum system head would be approximately 265m (=195+70m) in the area. In other words, the suggested maximum pump discharge head at Site 3 is 265m, which is virtually equal to the suggested TWL of the proposed PD7 EWSF. It may be a challenge, possibly not feasible to fill the proposed PD7 EWSF when the tank is near its HWL.

In addition, PS Site 3 requires significant system upgrades to both the suction and discharge systems to provide the design flow to the system. PS Sites 1 and 2 are within Elfrida area and the proposed watermain from the PS Sites 1 and 2 to the proposed EWSF sites can be sized properly and installed through the future development in Elfrida area.

PS Site 3 is not a preferred site in term of EWSF filling / system operations. PS Sites 1 and 2 are preferred over PS Site 3.

### 7.2.4 Distance to Demand Centre

PS Sites 1 and 2 are adjacent to the demand centre (e.g. Urban Expansion) providing better hydraulic capacity than PS Site 3.

### 7.2.5 Required Pump TDH

PS Sites 1 and 2 are adjacent to the demand centre (e.g. Urban Expansion) providing better hydraulic capacity than PS Site 3. The proposed watermain from the PS Sites 1 and 2 to the proposed EWSF sites can be sized properly to minimize the pump TDH requirement and installed through the future development in Elfrida area.

### 7.2.6 Land Availability

PS Site 1 is the City owned land and a more achievable location than PS Sites 2 and 3.

## 8 Suggested Water Level for Proposed Elevated Water Storage Facility

Based on the review of the PD7 system, ground elevations within the water servicing areas are within 195m and 220m. To maintain system pressure between 275kPa and 700kPa under normal operation (e.g., Average day demand, Maximum day demand and Peak hour demand), the suggested water low and high levels in the proposed PD7 EWSF are 255m and 265m (HWL), for a maximum of 10m variation between low-low and high-high levels in a EWSF as suggested by the City.

Previously, in **Section 7.1**, EWSF Sites 4 and 5 were determined not to be the preferred locations from a hydraulic standpoint. The ground elevations at the proposed five (5) alternative EWSF sites are between 215m and 218.5m. The height is approximately 45.7m (150ft), from the ground level to High Water Level (HWL). All five alternative EWSF sites seem feasible in terms of EWSF height.

It should be noted that the suggested low water level might be adjusted (e.g., low water level down to 250m) to meet the design storage volume (9.9ML) for the proposed EWSF.

A detailed hydraulic analysis will be required to fine-tune the height, diameter and the requirement of the operational water levels of the proposed EWSF, once a preferred growth plan in Elfrida is identified.

## 9 Suggested Pump Total Dynamic Head for Proposed PD7 PS

The proposed PD7 PS (HD007A) together with the existing PD7 Highland Road PS (DD007) will provide water to PD7 and PD23 systems, as well as fill the proposed PD7 EWSF.

Previously, in **Section 7.2**, PS Site 3 was determined not to be the preferred locations from a hydraulic standpoint. Consequently, The required Total Dynamic Head (TDH) is only provided for PS Site 1 and PS Site 2.

PS Site 1 and PS site 2 are located within the Elfrida growth area. The proposed watermain for the connections between the proposed PD7 PS and the proposed PD7 EWSF are planned to be constructed as part of the Elfrida development.

The referred growth plan, including watermain layouts within the Elfrida area is to be undertaken by the City. The TDH pump requirement for the proposed PD7 pump station depends on the proposed watermain layouts and size within the Elfrida growth area.

Since PS Site 1 and PS Site 2 are close to each other, the required pump TDH at PS Site 1 or PS Site 2 would be similar.

For information only, the estimated TDH of the proposed PD7 PS is based on the following information:

- The preferred EWSF Site is EWSF Site 1, EWSF Site 2 or EWSF Site 3;
- The preferred PS Site is PS Site 1 or Site 2;
- A typical design headloss value of 0.0015m/m for the proposed watermains (approximately 6km) along Elfrida community between the proposed PD7 PS Site 1 and EWSF Site 3 (the EWSF site is further away from the proposed PD7 PS Site 1) and the estimated head loss is 9m when required flow to fill the proposed PD7 EWSF Site 3.
- Local station head losses within the proposed PD7 PS: 3m (along suction and discharge pipeline system);
- Suction head at proposed PD7 PS: Approximately equal the HDR05 Kenilworth PD5 Reservoir level between LWL 228.4m to HWL 236.2m;
- Proposed PD7 EWSF Site 3 water level between LWL 255m to HWL 265m (to be determined during detailed design stage); and,
- Four pumps are to be proposed for the PD7 PS Site 1 and firm capacity of 60.3ML/d (with one largest pump out of service), the estimated TDH at the proposed PD7 PS Site 1 is as follows;
  - Minimum TDH is approximately 30.8m (say 31m). This includes minimum static head 18.8m (=LWL 255 m at proposed EWSF Site 3 – HWL 236.2m at PD5 pump suction), local PS station head losses 3m, plus 9m of PD7 system head;
  - Maximum TDH is approximately 48.6m (say 49m). This includes maximum static head 36.6m (=HWL 265m at proposed EWSF Site 3 – LWL 228.4m at PD5 pump suction, local PS station head losses 3m, plus 9 m of PD7 system head. See section below for an alternative maximum TDH estimation using maximum system head approach; and,
  - TDH operating ranges are between 31m and 49m and rated head is approximately 40m.

The required maximum pump TDH is also estimated using the maximum system head consideration approach is shown below:

- Ground elevations range from 205m to 210m in the Elfrida growth area near the proposed PD7 PS Site 1 and PS Site 2, at southeast of Regional Road 56 and Rymal Road West;
- Suggested maximum discharge head at the proposed PD7 PS is lower than 275m in order to maintain the system maximum pressure of 700kPa, or 70m (=275m-205m); and,
- Estimated maximum pump TDH is around 49.6m (=275m-228.4m-3m, see above).

Based on the above analysis using two approaches, the required maximum pump TDH is approximately 49m. A detailed hydraulic analysis of the proposed PD7 PS will be required to fine-tune the pump capacity (flow and TDH) during the design stage and/or after the preferred Elfrida growth plan is selected.

## 10 Conclusions and Recommendations

Based on the above analysis, it was concluded that system upgrades in the form of additional storage and pumping capacity are required to support the planned development in PD7 and PD23.

The conclusions and recommendations are summarized as follows:

### 10.1 2016 (Existing) Condition

- Storage Volume Requirement: Sufficient storage capacity is provided in PD7 system under the 2016 condition; and,
- Pumping Capacity Requirement: Sufficient pumping capacity is provided in PD7 system under the 2016 condition.

### 10.2 2021 Design Condition

- Storage Volume Requirement: An additional 3.1 ML of storage for PD7 will be required; and,
- Pumping Capacity Requirement;
  - Sufficient pumping capacity is not provided in PD7 system under the 2021 condition, if PD7 functions as a closed system as no floating storage currently exists within PD7; and,
  - Sufficient pumping capacity is provided in PD7 system under the 2021 condition, if PD7 would become an open system with floating storage.

### Recommended Solutions under 2021 Demand Condition

Install an elevated water storage facility. A minimum storage capacity of 9.4ML is required, a 9.9ML EWSF is recommended. EWSF Sites 1, 2 and 3 are better locations than Sites 4 and 5, from a hydraulic standpoint. The suggested max water level of the EWSF is to be confirmed as part of the current Master Planning Study and/or through detailed design.

Based on the discussions with City staff on March 19, 2018, a larger PD7 EWSF (e.g. 9.9ML) and/or possibly more than one EWSF may be considered to provide system operation flexibility. This is to be confirmed as part of the current Master Planning Study and/or through detailed design. The main scope of this Class EA and conceptual design assignment is to select the preferred location for one PD7 EWSF and one PD7 PS. For the purpose of the EA assignment, it is assumed that approval is required for the larger size EWSF (9.9ML).

### 10.3 2031 Design Condition

- Pumping Capacity Requirement: Additional PD7 firm pumping capacity of 60.3ML/d is required prior to year 2031; and,

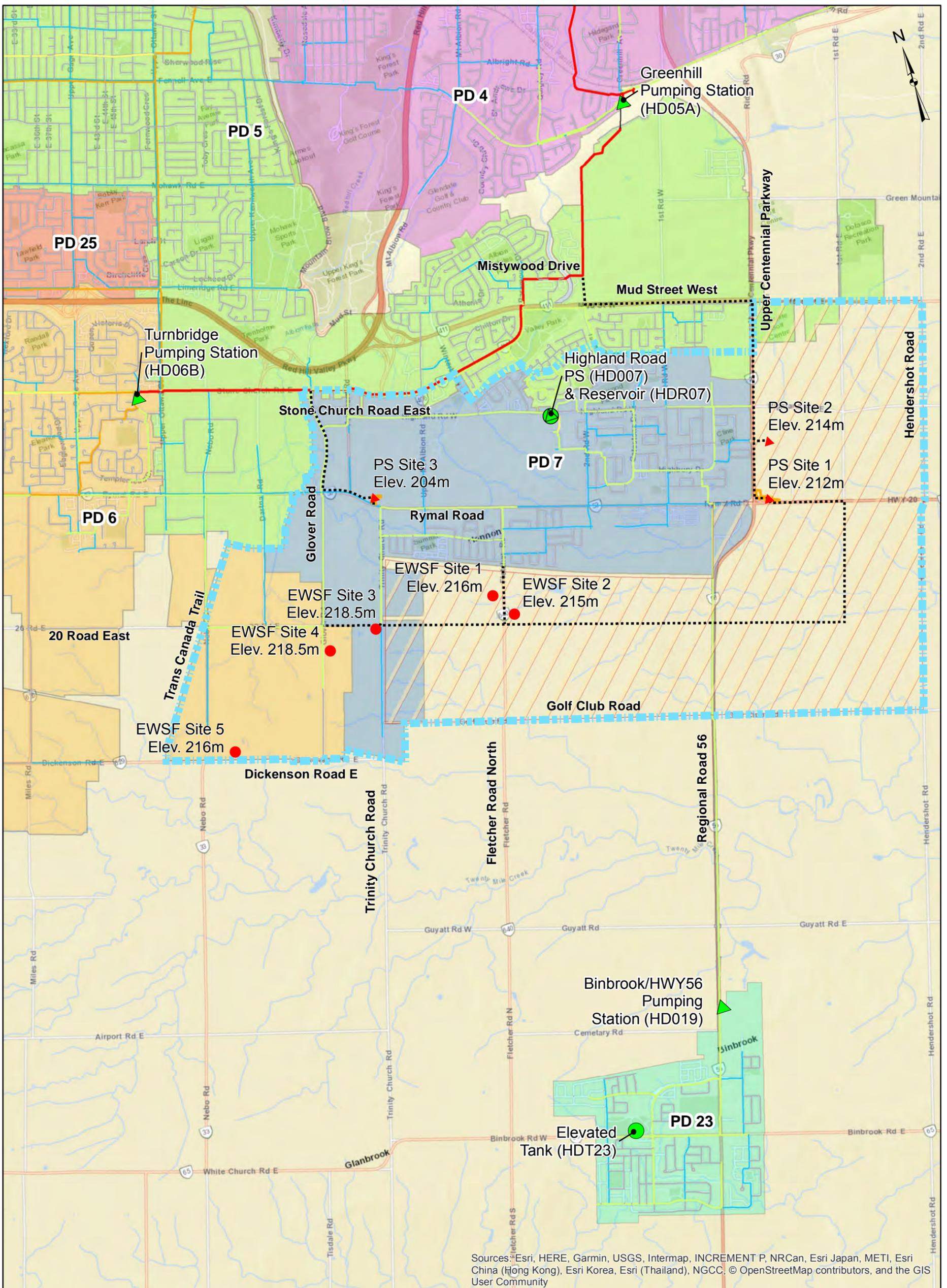
- The required PD7 PS capacity and timeline will be confirmed as part of the current Master Planning study and/or detailed design.

#### **Recommended Solutions under 2031 Demand Condition**

Install the proposed PD7 PS prior to 2031 as it may be required shortly after year 2021. PS Sites 1 and 2 are better locations than Site 3, from a hydraulic standpoint. For information only, if PS Site 1 or PS Site 2 is selected as the preferred PS site, the estimated pump TDH ranges between 31m and 49m and rated head is approximately 40m, when the firm pumping capacity 60.3ML/d is operating at this location – to be confirmed as part of the current Master Planning Study and/or through detailed design.

#### **10.4 Infrastructure Requirement and Servicing Timeline**

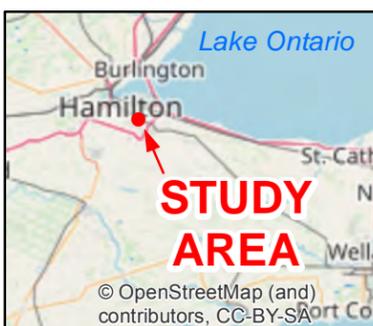
Given anticipated growth within the study area, a proposed PD7 Elevated Water Storage Facility (EWSF) is required by year 2021 and a proposed PD7 Pumping Station (PS) is required prior to 2031 (e.g., may be required shortly after year 2021). The 2021 and 2031 timelines are premised on the projected growth and are subject to change based on actual population growth and development approvals.



Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

**LEGEND**

- Study Area Boundary
- City Owned Sites
- Urban Expansion
- Potential Location**
- Elevated Water Storage Facility (EWSF)
- Pumping Station (PS)
- Proposed Watermain
- Existing Location**
- Pumping Station (PS)
- Water Storage Facility
- Pumping Station & Storage Facility
- Existing Watermain**
- Size (mm)**
- ≥1500
- 1200
- 750-1050
- 450-600
- 400
- 350
- 300
- 250
- ≤200



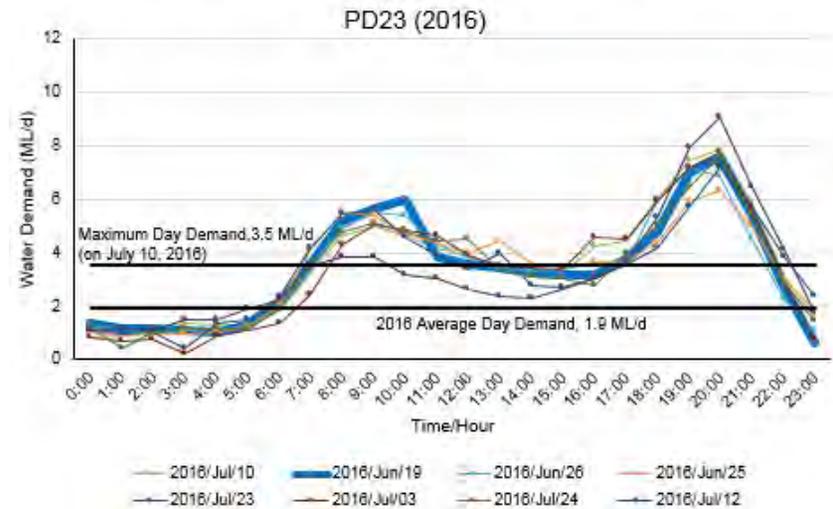
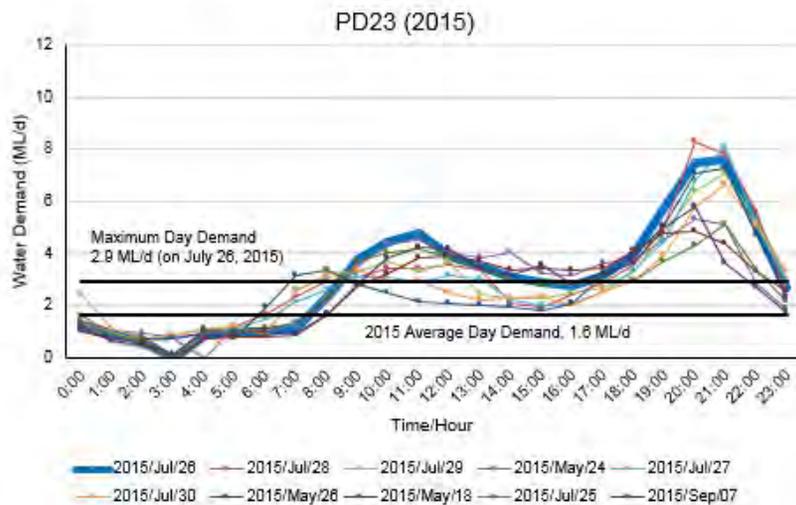
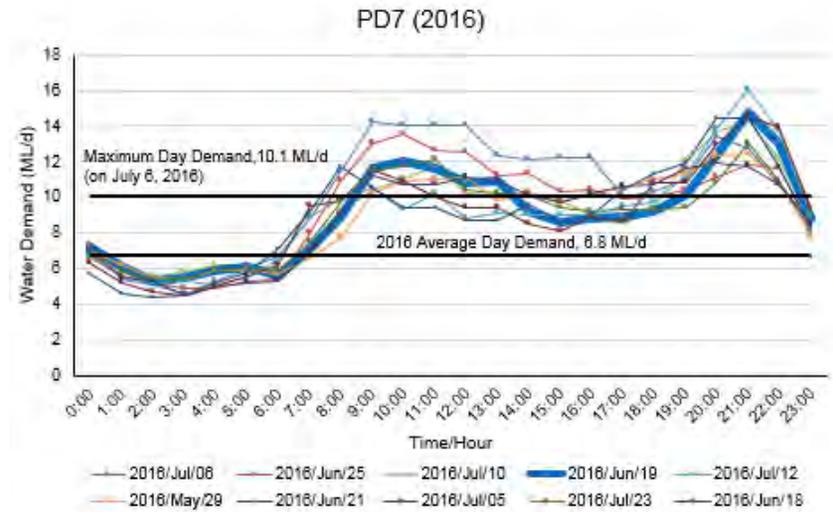
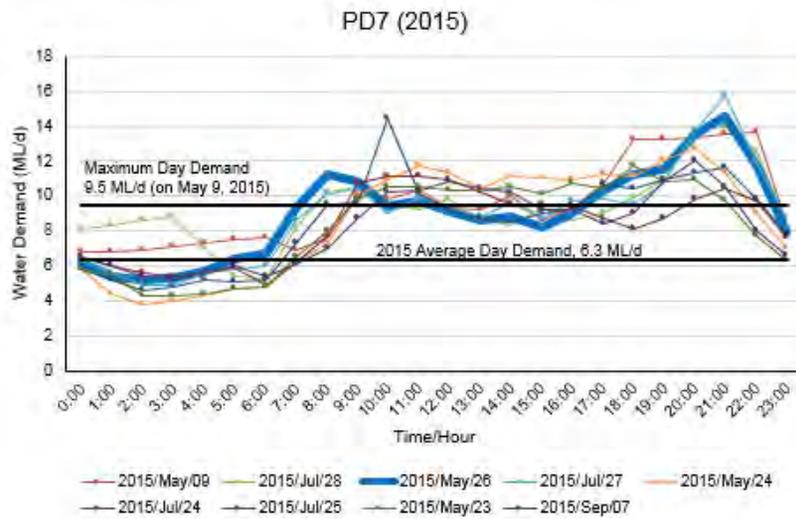
SCALE 1:36,100

PROJECT Class EA and Conceptual Design for Pressure District 7 Elevated Water Storage Facility & Pumping Station City of Hamilton

TITLE **PD7 and PD23 Water System**

DATE: Dec. 2018	PROJECT: WM16-0435
GIS	
DESIGN	
CHECK	

Attachment 1



**Legend**

Typical High Daily Water Demand Curves

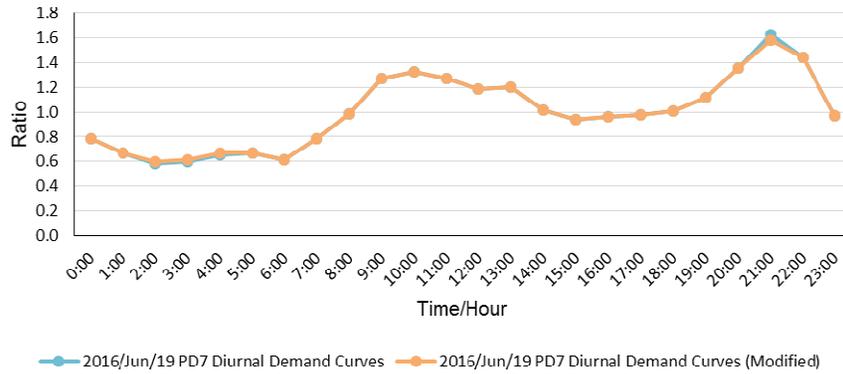
Municipal Class EA and Conceptual Design of Elevated Water Storage Facility and Pumping Station for PD7  
City of Hamilton



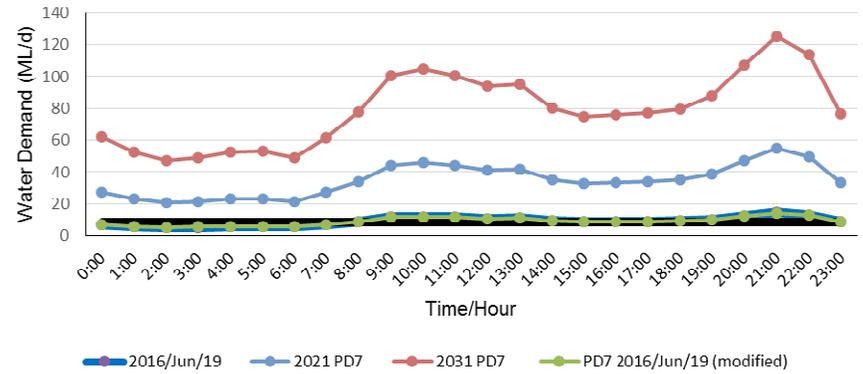
Typical High Daily Water Demand Curves for PD7 and PD23 in Years 2015 and 2016

DATE:	PROJ. No.:	FIGURE No.:
Jan 2019	WM16-0435	Attachment 2.1

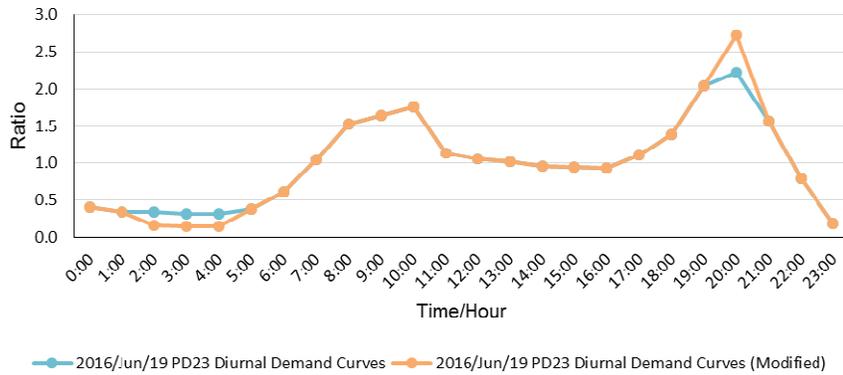
PD7 Max Day Diurnal Demand Curves



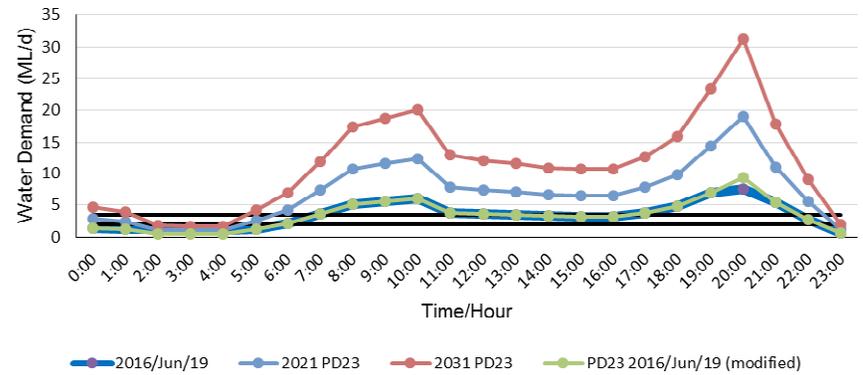
PD7 Max Day Demand Curves



PD23 Max Day Diurnal Demand Curves



PD23 Maximum Day Demand Curves



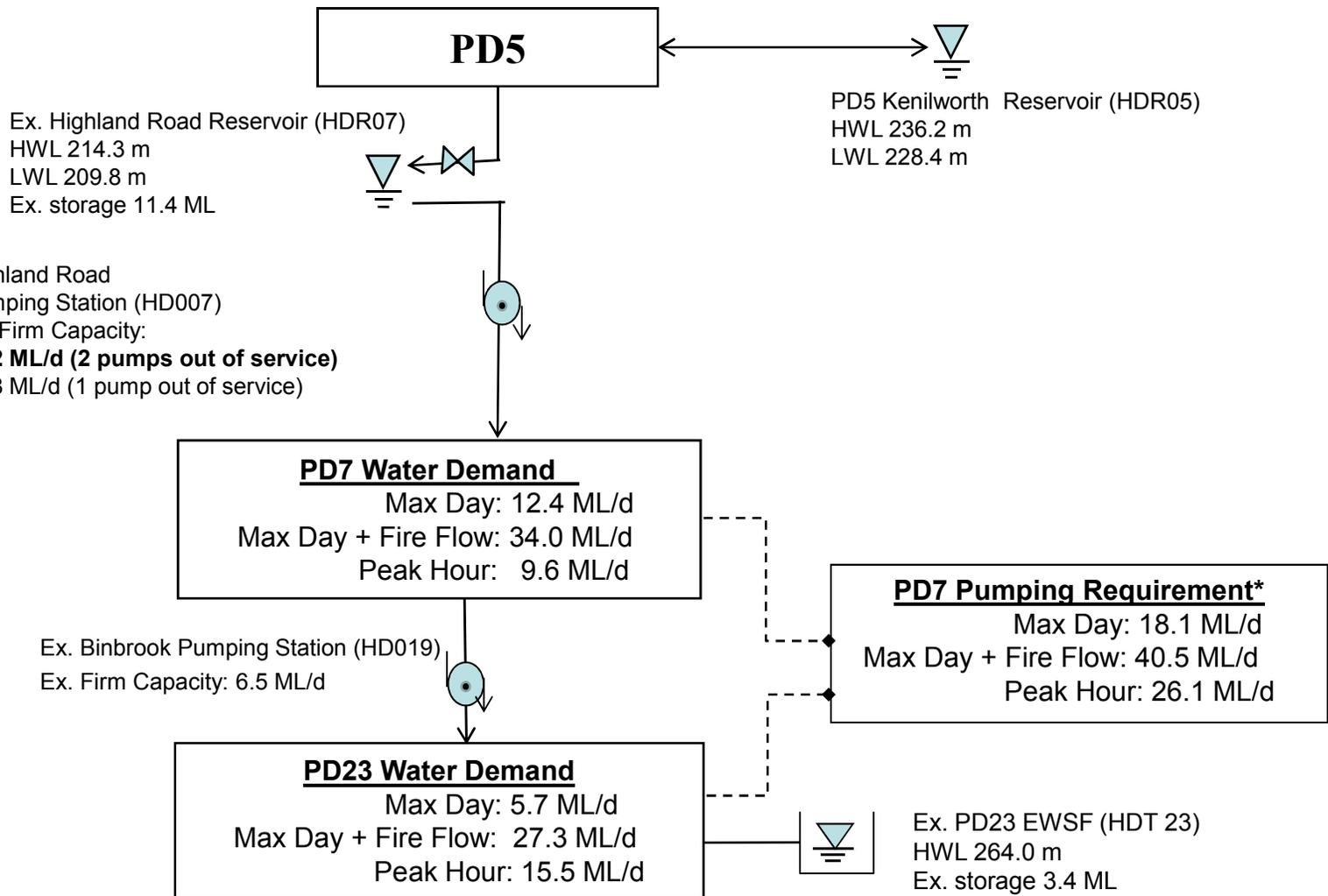
**Legend**

Municipal Class EA and Conceptual Design of Elevated Water Storage Facility and Pumping Station for PD7  
City of Hamilton



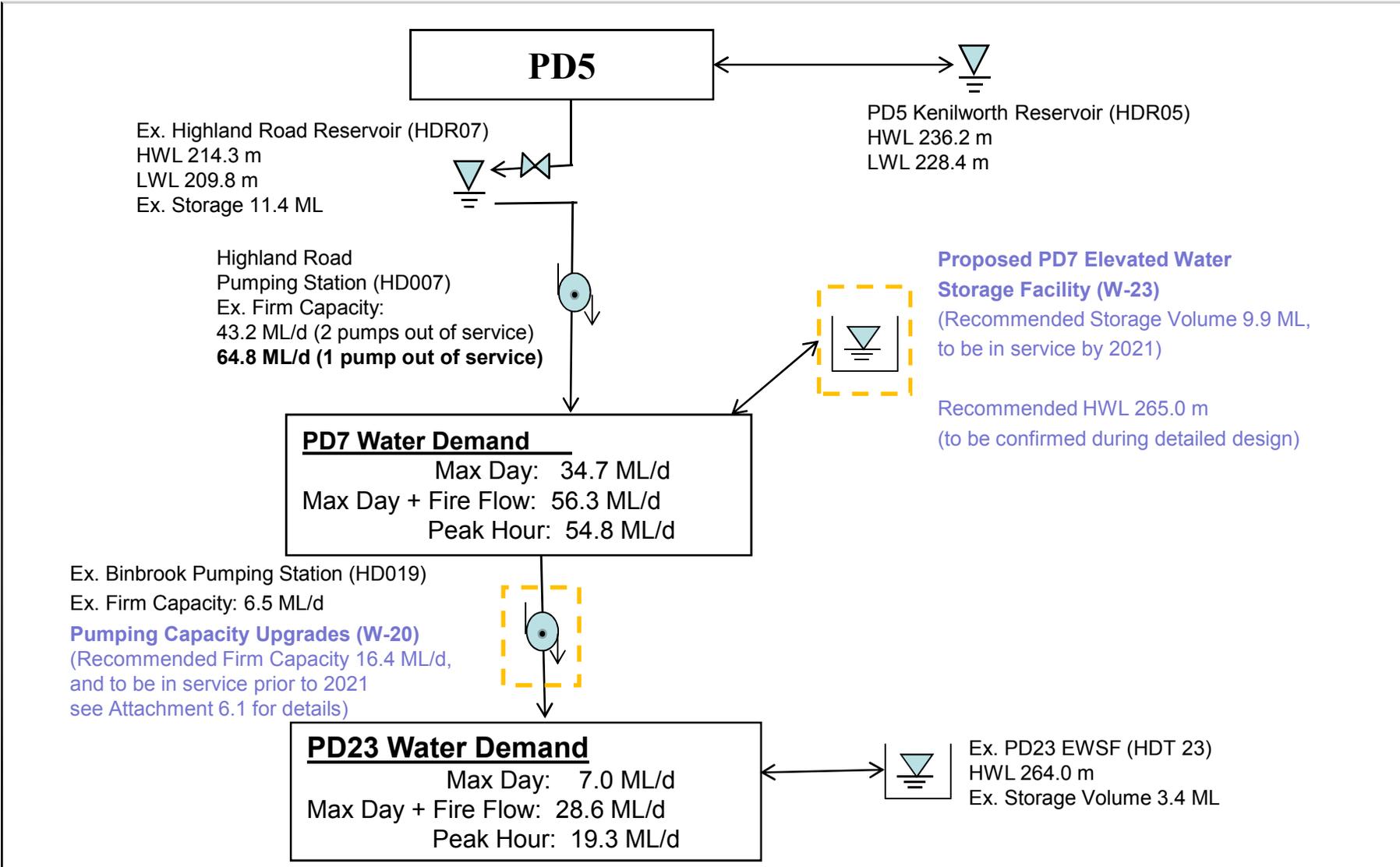
Diurnal Water Demand and Maximum Day Demand Curves for PD7 and PD23

DATE:	PROJ. No.:	FIGURE No.:
Jan 2019	WM16-0435	Attachment 2.2

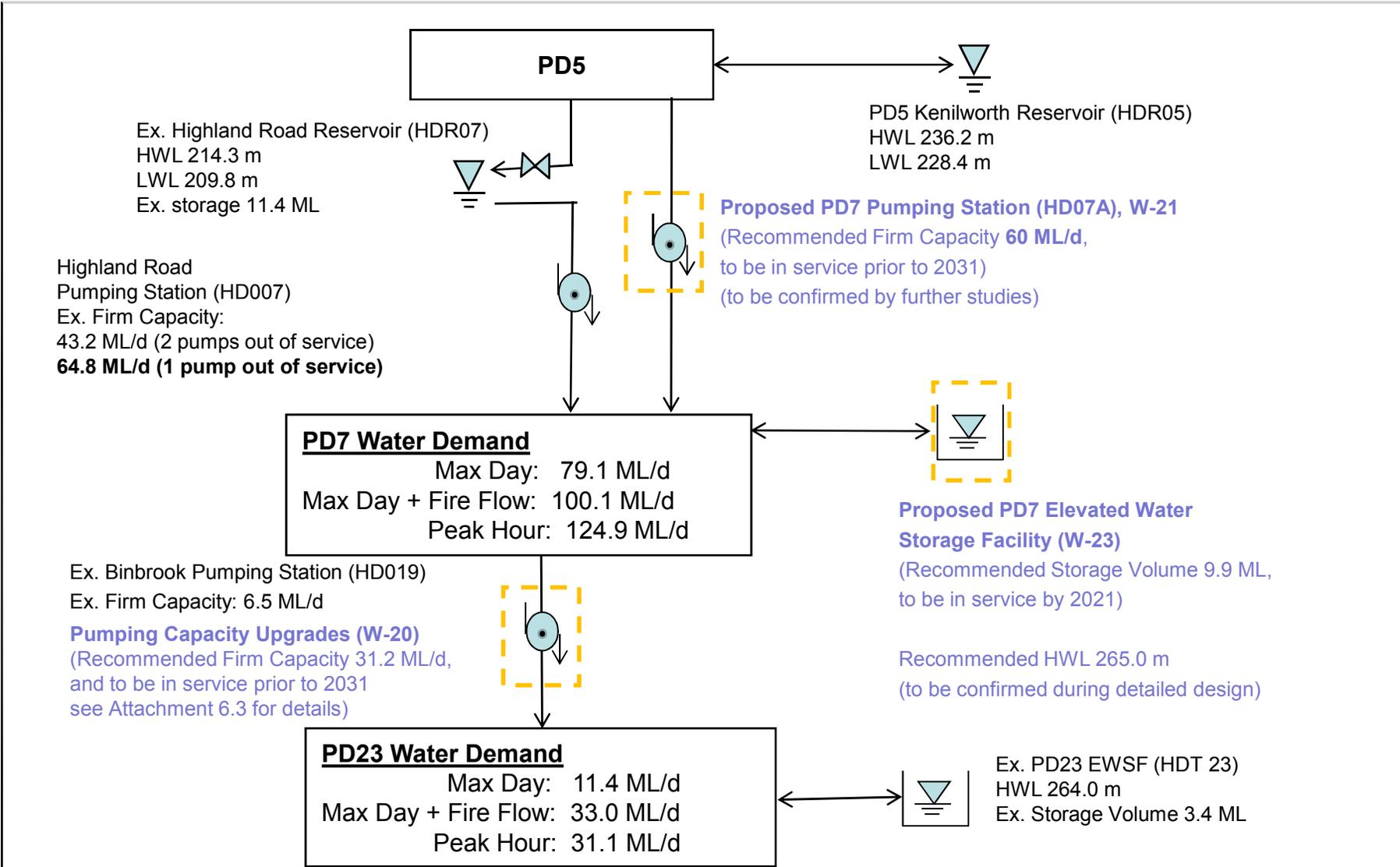


\* PD7 pumping requirement = PD7 water demand + Ex. HD019 firm pumping capacity

<p><b>Legend</b></p>  Pumping Station  In-ground Reservoir  Elevated Water Storage Facility		<p>Note: All units in ML/d`</p>  Altitude Control Valve		<p>Municipal Class EA and Conceptual Design of Elevated Water Storage Facility and Pumping Station for PD7          City of Hamilton</p> 		<p>2016 Water System Schematic for PD7 and PD23</p>		
				<p>DATE: Jan 2019</p>		<p>PROJ. No.: WM16-0435</p>	<p>FIGURE No: Attachment 3</p>	



<p><b>Legend</b></p>  Pumping Station  In-ground Reservoir  Elevated Water Storage Facility		<p>Note: All units in ML/d`</p>  Altitude Control Valve	<p>Municipal Class EA and Conceptual Design of Elevated Water Storage Facility and Pumping Station for PD7          City of Hamilton</p> 	<p>2021 Water System Schematic for PD7 and PD23</p>		
DATE:	PROJ. No.:	FIGURE No.:				
Jan 2019	WM16-0435	Attachment 4				



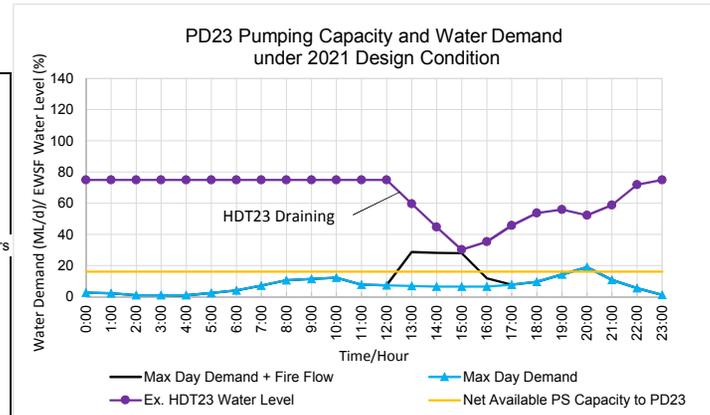
<p><b>Legend</b></p>  Pumping Station  In-ground Reservoir  Elevated Tank or EWSF		<p>Note: All units in ML/d</p>  Altitude Control Valve	<p>Municipal Class EA and Conceptual Design of Elevated Water Storage Facility and Pumping Station for PD7          City of Hamilton</p> 	<p>2031 Water System Schematic for PD7 and PD23</p>		
DATE:	PROJ. No.:	FIGURE No.:				
Jan 2019	WM16-0435	Attachment 5				

### Attachment 6.1 PD23 System Capacity Analysis under 2021 Demand Condition

Time/Hour	PD23 (HD019) Pumping Capacity			2021 PD23 Water Demand				Water Supply to other PD	Net Available PS Capacity to PD23	PD23 Surplus/Deficit Capacity <sup>1</sup>		Existing HDT23 (3.4 ML)	
	Ex. HD019 PS Capacity	HD019 PS Upgrades	Total PD Supply Capacity	Diurnal Demand Curves	Max Day Demand	Fire Flow	Max Day Demand + Fire Flow			ML/d	ML/d	ML/d	ML/hr
	ML/d	ML/d	ML/d	Ratio	ML/d	ML/d	ML/d	ML/d	ML/d	ML/d	ML/d	ML	%
0:00	6.5	9.7	16.2	0.41	2.8		2.8	0.0	16.2	13.4	0.6	2.6	75
1:00	6.5	9.7	16.2	0.34	2.4		2.4	0.0	16.2	13.8	0.6	2.6	75
2:00	6.5	9.7	16.2	0.16	1.1		1.1	0.0	16.2	15.1	0.6	2.6	75
3:00	6.5	9.7	16.2	0.15	1.0		1.0	0.0	16.2	15.2	0.6	2.6	75
4:00	6.5	9.7	16.2	0.14	1.0		1.0	0.0	16.2	15.2	0.6	2.6	75
5:00	6.5	9.7	16.2	0.37	2.6		2.6	0.0	16.2	13.6	0.6	2.6	75
6:00	6.5	9.7	16.2	0.60	4.2		4.2	0.0	16.2	12.0	0.5	2.6	75
7:00	6.5	9.7	16.2	1.05	7.3		7.3	0.0	16.2	8.9	0.4	2.6	75
8:00	6.5	9.7	16.2	1.52	10.7		10.7	0.0	16.2	5.5	0.2	2.6	75
9:00	6.5	9.7	16.2	1.65	11.6		11.6	0.0	16.2	4.6	0.2	2.6	75
10:00	6.5	9.7	16.2	1.76	12.3		12.3	0.0	16.2	3.9	0.2	2.6	75
11:00	6.5	9.7	16.2	1.13	7.9		7.9	0.0	16.2	8.3	0.3	2.6	75
12:00	6.5	9.7	16.2	1.06	7.4		7.4	0.0	16.2	8.8	0.4	2.6	75
13:00	6.5	9.7	16.2	1.02	7.1	21.6	28.7	0.0	16.2	-12.5	-0.5	2.0	60
14:00	6.5	9.7	16.2	0.95	6.7	21.6	28.3	0.0	16.2	-12.1	-0.5	1.5	45
15:00	6.5	9.7	16.2	0.93	6.5	21.6	28.1	0.0	16.2	-11.9	-0.5	1.0	30
16:00	6.5	9.7	16.2	0.93	6.5	5.4	11.9	0.0	16.2	4.3	0.2	1.2	35
17:00	6.5	9.7	16.2	1.11	7.7		7.7	0.0	16.2	8.5	0.4	1.6	46
18:00	6.5	9.7	16.2	1.39	9.8		9.8	0.0	16.2	6.4	0.3	1.8	54
19:00	6.5	9.7	16.2	2.05	14.4		14.4	0.0	16.2	1.8	0.1	1.9	56
20:00	6.5	9.7	16.2	2.73	19.1		19.1	0.0	16.2	-2.9	-0.1	1.8	52
21:00	6.5	9.7	16.2	1.57	11.0		11.0	0.0	16.2	5.2	0.2	2.0	59
22:00	6.5	9.7	16.2	0.79	5.5		5.5	0.0	16.2	10.7	0.4	2.4	72
23:00	6.5	9.7	16.2	0.18	1.2		1.2	0.0	16.2	15.0	0.6	2.6	75
				Average	7.0								
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9	Col 10	Col 11	Col 12	Col 13	Col 14

<sup>1</sup> "-" values denotes flow draining from proposed PD7 EWSF and "+" values denotes PD23 firm pumping capacity is greater than water demand.

Ex. PD23 (HD019) PS Capacity	Col 2	=	Time/hour
Requirement of PD23 (HD019) PS Upgrades	Col 3	=	Firm Capacity (ML/d)
Total PD23 PS Supply Capacity	Col 4	=	Additional Firm Capacity (ML/d)
Diurnal Demand Curves	Col 5	=	Col 2 + Col 3
2031 PD23 Max Day Demand Curves	Col 6	=	Modified curves based on PD23 Demand on June 19, 2016
Fire Flow	Col 7	=	Col 5 * 2021 Max day demand 7.0 ML/d
Max Day Water Demand + Fire Flow	Col 8	=	Fire flow rate of 250 L/s (21.6 ML/d) and a duration of 3.25 hours
Proposed Water Supply to other PD	Col 9	=	Col 6 + Col 7
Net PS Capacity to PD23	Col 10	=	0 (ML/d)
PD23 Surplus/Deficit Capacity (ML/d)	Col 11	=	Col 4 - Col 9
PD23 Surplus/Deficit Capacity (ML/Hr.)	Col 12	=	Col 10 - Col 8
Ex. PD23 HDT23 Accumulative Storage Volume	Col 13	=	Col 13 - Col 12
Ex. PD23 HDT23 Water Level	Col 14	=	Col 13 / 3.4*100%

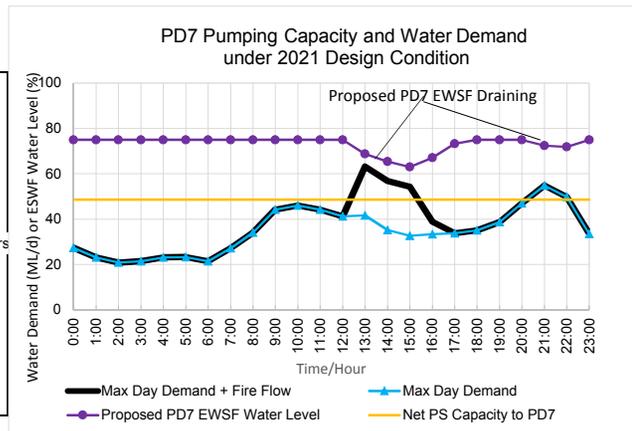


### Attachment 6.2 PD7 System Capacity Analysis under 2021 Demand Condition

Time/Hour	PD7 Pumping Capacity			PD7 Water Demand (2021)				Proposed PD23 (HD019) PS Capacity	Net PS Capacity to PD7	PD7 Surplus/ Deficit Capacity <sup>1</sup>		Proposed PD7 EWSF	
	Ex. Highland Road (HD07) PS Capacity	Proposed PD7 PS (HD07A)	Total PD Supply Capacity	Diurnal Demand Curves	Max Day Demand	Fire Flow (ML/d)	Max Day Demand + Fire Flow			ML/d	ML/hr	Accumulative Volume	Proposed PD7 EWSF Water Level
	ML/d	ML/d	ML/d	Ratio	ML/d	ML/d	ML/d	ML/d	ML/d	ML/d	ML/hr	ML	%
												7.4	75
0:00	64.8	0	64.8	0.79	27.3		27.3	16.2	48.6	21.3	0.9	7.4	75
1:00	64.8	0	64.8	0.67	23.2		23.2	16.2	48.6	25.4	1.1	7.4	75
2:00	64.8	0	64.8	0.60	20.8		20.8	16.2	48.6	27.8	1.2	7.4	75
3:00	64.8	0	64.8	0.62	21.4		21.4	16.2	48.6	27.2	1.1	7.4	75
4:00	64.8	0	64.8	0.67	23.1		23.1	16.2	48.6	25.5	1.1	7.4	75
5:00	64.8	0	64.8	0.67	23.3		23.3	16.2	48.6	25.3	1.1	7.4	75
6:00	64.8	0	64.8	0.62	21.4		21.4	16.2	48.6	27.2	1.1	7.4	75
7:00	64.8	0	64.8	0.78	27.1		27.1	16.2	48.6	21.5	0.9	7.4	75
8:00	64.8	0	64.8	0.98	34.1		34.1	16.2	48.6	14.5	0.6	7.4	75
9:00	64.8	0	64.8	1.27	44.2		44.2	16.2	48.6	4.4	0.2	7.4	75
10:00	64.8	0	64.8	1.33	46.0		46.0	16.2	48.6	2.6	0.1	7.4	75
11:00	64.8	0	64.8	1.27	44.2		44.2	16.2	48.6	4.4	0.2	7.4	75
12:00	64.8	0	64.8	1.19	41.2		41.2	16.2	48.6	7.4	0.3	7.4	75
13:00	64.8	0	64.8	1.20	41.6	21.6	63.2	16.2	48.6	-14.7	-0.6	6.8	69
14:00	64.8	0	64.8	1.01	35.2	21.6	56.8	16.2	48.6	-8.2	-0.3	6.5	65
15:00	64.8	0	64.8	0.94	32.7	21.6	54.3	16.2	48.6	-5.7	-0.2	6.2	63
16:00	64.8	0	64.8	0.96	33.4	5.4	38.8	16.2	48.6	9.8	0.4	6.6	67
17:00	64.8	0	64.8	0.97	33.8		33.8	16.2	48.6	14.8	0.6	7.3	73
18:00	64.8	0	64.8	1.01	35.0		35.0	16.2	48.6	13.6	0.6	7.4	75
19:00	64.8	0	64.8	1.12	38.7		38.7	16.2	48.6	9.8	0.4	7.4	75
20:00	64.8	0	64.8	1.35	47.0		47.0	16.2	48.6	1.6	0.1	7.4	75
21:00	64.8	0	64.8	1.58	54.8		54.8	16.2	48.6	-6.2	-0.3	7.2	72
22:00	64.8	0	64.8	1.44	49.8		49.8	16.2	48.6	-1.3	-0.1	7.1	72
23:00	64.8	0	64.8	0.97	33.5		33.5	16.2	48.6	15.0	0.6	7.4	75
				Average	34.7								
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9	Col 10	Col 11	Col 12	Col 13	Col 14

<sup>1</sup> "-" values denotes flow draining from proposed PD7 EWSF and "+" values denotes PD7 firm pumping capacity is greater than PD7 water demand.

Sample Calculations - PD7 Pumping Capacity Requirement			
	Col 1	=	Time/hour
Ex. Highland Road (HD07) PS Capacity	Col 2	=	Firm Capacity 64.8 ML/d
Proposed PD7 (HD07A) PS Capacity	Col 3	=	Firm Capacity 0 ML/d
Total PD7 PS Supply Capacity	Col 4	=	Col 1 + Col 2
Diurnal Demand Curves	Col 5	=	Modified curves based on PD7 Demand on June 19, 2016
2031 PD7 Max Day Demand Curves	Col 6	=	Col 5 * 2021 max day demand 34.7 ML/d
Fire Flow	Col 7	=	Fire flow rate of 250 L/s (21.6 ML/d) and a duration of 3.25 hours
Max Day Water Demand + Fire Flow	Col 8	=	Col 6 + Col 7
Proposed Water Supply to PD23 via HD019 PS	Col 9	=	Firm Capacity (ML/d)
Net PS Capacity to PD7	Col 10	=	Col 4 - Col 9
PD7 Surplus/Deficit Capacity (ML/d)	Col 11	=	Col 10 - Col 8
PD7 Surplus/Deficit Capacity (ML/Hr.)	Col 12	=	Col 11 / 24
Proposed EWSF Accumulative Storage Volume	Col 13	=	Col 13 - Col 12
Proposed EWSF Water Level	Col 14	=	Col 13 / 9.9 * 100%



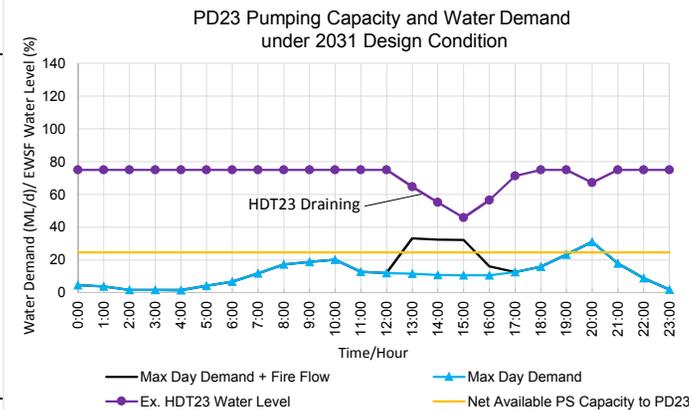
### Attachment 6.3 PD23 System Capacity Analysis under 2031 Demand Condition

Time/Hour	PD23 (HD019) Pumping Capacity			2031 PD23 Water Demand				Flow to other PD	Net Available PS Capacity to PD23	PD23 Surplus/Deficit Capacity <sup>1</sup>		Existing HDT23 (3.4 ML)	
	Ex. HD019 PS Capacity	HD019 PS Upgrades	Total PD Supply Capacity	Diurnal Demand Curves	Max Day Demand	Fire Flow	Max Day Demand + Fire Flow			ML/d	ML/d	ML/hr	ML
	ML/d	ML/d	ML/d	Ratio	ML/d	ML/d	ML/d	ML/d	ML/d	ML/d	ML/hr	ML	%
0:00	6.5	24.7	31.2	0.41	4.6		4.6	0.0	24.7	20.1	0.8	2.6	75
1:00	6.5	24.7	31.2	0.34	3.9		3.9	0.0	24.7	20.8	0.9	2.6	75
2:00	6.5	24.7	31.2	0.16	1.8		1.8	0.0	24.7	22.9	1.0	2.6	75
3:00	6.5	24.7	31.2	0.15	1.7		1.7	0.0	24.7	23.0	1.0	2.6	75
4:00	6.5	24.7	31.2	0.14	1.6		1.6	0.0	24.7	23.1	1.0	2.6	75
5:00	6.5	24.7	31.2	0.37	4.3		4.3	0.0	24.7	20.4	0.9	2.6	75
6:00	6.5	24.7	31.2	0.60	6.9		6.9	0.0	24.7	17.8	0.7	2.6	75
7:00	6.5	24.7	31.2	1.05	11.9		11.9	0.0	24.7	12.8	0.5	2.6	75
8:00	6.5	24.7	31.2	1.52	17.4		17.4	0.0	24.7	7.3	0.3	2.6	75
9:00	6.5	24.7	31.2	1.65	18.8		18.8	0.0	24.7	5.9	0.2	2.6	75
10:00	6.5	24.7	31.2	1.76	20.1		20.1	0.0	24.7	4.6	0.2	2.6	75
11:00	6.5	24.7	31.2	1.13	12.8		12.8	0.0	24.7	11.9	0.5	2.6	75
12:00	6.5	24.7	31.2	1.06	12.0		12.0	0.0	24.7	12.7	0.5	2.6	75
13:00	6.5	24.7	31.2	1.02	11.6	21.6	33.2	0.0	24.7	-8.5	-0.4	2.2	65
14:00	6.5	24.7	31.2	0.95	10.9	21.6	32.5	0.0	24.7	-7.8	-0.3	1.9	55
15:00	6.5	24.7	31.2	0.93	10.6	21.6	32.2	0.0	24.7	-7.5	-0.3	1.6	46
16:00	6.5	24.7	31.2	0.93	10.6	5.4	16.0	0.0	24.7	8.7	0.4	1.9	56
17:00	6.5	24.7	31.2	1.11	12.6		12.6	0.0	24.7	12.1	0.5	2.4	71
18:00	6.5	24.7	31.2	1.39	15.9		15.9	0.0	24.7	8.8	0.4	2.6	75
19:00	6.5	24.7	31.2	2.05	23.4		23.4	0.0	24.7	1.3	0.1	2.6	75
20:00	6.5	24.7	31.2	2.73	31.1		31.1	0.0	24.7	-6.4	-0.3	2.3	67
21:00	6.5	24.7	31.2	1.57	17.9		17.9	0.0	24.7	6.8	0.3	2.6	75
22:00	6.5	24.7	31.2	0.79	9.0		9.0	0.0	24.7	15.7	0.7	2.6	75
23:00	6.5	24.7	31.2	0.18	2.0		2.0	0.0	24.7	22.7	0.9	2.6	75
				Average	11.4								
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9	Col 10	Col 11	Col 12	Col 13	Col 14

<sup>1</sup> "-" values denotes flow draining from proposed PD7 EWSF and "+" values denotes PD23 firm pumping capacity is greater than water demand.

#### Sample Calculations - PD23 Pumping Capacity Requirement

	Col 1	=	Time/hour
Ex. PD23 (HD019) PS Capacity	Col 2	=	Firm Capacity (ML/d)
Requirement of PD23 (HD019) PS Upgrades	Col 3	=	Additional Firm Capacity (ML/d)
Total PD23 PS Supply Capacity	Col 4	=	Col 2 + Col 3
Diurnal Demand Curves	Col 5	=	Modified curves based on PD23 Demand on June 19, 2016
2031 PD23 Max Day Demand Curves	Col 6	=	Col 5 * 2031 Max day demand 11.4 ML/d
Fire Flow	Col 7	=	Fire flow rate of 250 L/s (21.6 ML/d) and a duration of 3.25 hours
Max Day Water Demand + Fire Flow	Col 8	=	Col 6 + Col 7
Proposed Water Supply to other PD	Col 9	=	0 (ML/d)
Net PS Capacity to PD23	Col 10	=	Col 4 - Col 9
PD23 Surplus/Deficit Capacity (ML/d)	Col 11	=	Col 10 - Col 8
PD23 Surplus/Deficit Capacity (ML/Hr.)	Col 12	=	Col 11 / 24
Ex. PD23 HDT23 Accumulative Storage Volume	Col 13	=	Col 13 - Col 12
Ex. PD23 HDT23 Water Level	Col 14	=	Col 13 / 3.4*100%



### Attachment 6.4 PD7 System Capacity Analysis under 2031 Demand Condition

Time/Hour	PD7 Pumping Capacity			2021 PD7 Water Demand				Proposed PD23 (HD019) PS Capacity	Net Available PS Capacity to PD7	PD7 Surplus/Deficit Capacity <sup>1</sup>		Proposed PD7 ESWF			
	Ex. Highland Road (HD07) PS Capacity	Proposed PD7 PS (HD07A)	Total PD Supply Capacity	Diurnal Demand Curves	Max Day Demand	Fire Flow (ML/d)	Max Day Demand + Fire Flow			ML/d	ML/d	ML/d	ML/hr	Accumulative Volume	Proposed PD7 EWSF Water Level
												7.4	75		
0:00	64.8	60.3	125.1	0.79	62.3		62.3	31.2	93.9	31.6	1.3	7.4	75		
1:00	64.8	60.3	125.1	0.67	52.8		52.8	31.2	93.9	41.1	1.7	7.4	75		
2:00	64.8	60.3	125.1	0.60	47.4		47.4	31.2	93.9	46.5	1.9	7.4	75		
3:00	64.8	60.3	125.1	0.62	48.8		48.8	31.2	93.9	45.1	1.9	7.4	75		
4:00	64.8	60.3	125.1	0.67	52.7		52.7	31.2	93.9	41.2	1.7	7.4	75		
5:00	64.8	60.3	125.1	0.67	53.0		53.0	31.2	93.9	40.9	1.7	7.4	75		
6:00	64.8	60.3	125.1	0.62	48.8		48.8	31.2	93.9	45.1	1.9	7.4	75		
7:00	64.8	60.3	125.1	0.78	61.8		61.8	31.2	93.9	32.1	1.3	7.4	75		
8:00	64.8	60.3	125.1	0.98	77.8		77.8	31.2	93.9	16.1	0.7	7.4	75		
9:00	64.8	60.3	125.1	1.27	100.7		100.7	31.2	93.9	-6.8	-0.3	7.1	72		
10:00	64.8	60.3	125.1	1.33	104.9		104.9	31.2	93.9	-11.0	-0.5	6.7	68		
11:00	64.8	60.3	125.1	1.27	100.8		100.8	31.2	93.9	-6.9	-0.3	6.4	65		
12:00	64.8	60.3	125.1	1.19	93.9		93.9	31.2	93.9	0.0	0.0	6.4	65		
13:00	64.8	60.3	125.1	1.20	94.9	21.6	116.5	31.2	93.9	-22.6	-0.9	5.5	55		
14:00	64.8	60.3	125.1	1.01	80.2	21.6	101.8	31.2	93.9	-7.9	-0.3	5.1	52		
15:00	64.8	60.3	125.1	0.94	74.5	21.6	96.1	31.2	93.9	-2.2	-0.1	5.0	51		
16:00	64.8	60.3	125.1	0.96	76.1	5.4	81.5	31.2	93.9	12.4	0.5	5.5	56		
17:00	64.8	60.3	125.1	0.97	77.1		77.1	31.2	93.9	16.8	0.7	6.3	63		
18:00	64.8	60.3	125.1	1.01	79.8		79.8	31.2	93.9	14.1	0.6	6.8	69		
19:00	64.8	60.3	125.1	1.12	88.3		88.3	31.2	93.9	5.6	0.2	7.1	71		
20:00	64.8	60.3	125.1	1.35	107.2		107.2	31.2	93.9	-13.3	-0.6	6.5	66		
21:00	64.8	60.3	125.1	1.58	124.9		124.9	31.2	93.9	-31.0	-1.3	5.2	53		
22:00	64.8	60.3	125.1	1.44	113.6		113.6	31.2	93.9	-19.7	-0.8	4.4	45		
23:00	64.8	60.3	125.1	0.97	76.4		76.4	31.2	93.9	17.5	0.7	5.1	52		
				Average	79.1										
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9	Col 10	Col 11	Col 12	Col 13	Col 14		

<sup>1</sup> "-" values denotes flow draining from proposed PD7 EWSF and "+" values denotes PD7 firm pumping capacity is greater than PD7 water demand.

Sample Calculations - PD7 Pumping Capacity and EWSF Volume Requirement			
	Col	=	Time/hour
Ex. Highland Road (HD07) PS Capacity	Col 2	=	Firm Capacity 64.8 ML/d
Proposed PD7 (HD07A) PS Capacity	Col 3	=	Firm Capacity 60.0 ML/d
Total PD7 PS Supply Capacity	Col 4	=	Col 1 + Col 2
Diurnal Demand Curves	Col 5	=	Modified curves based on PD7 Demand on June 19, 2016
2031 PD7 Max Day Demand Curves	Col 6	=	Col 5 * 2031 max day demand 79.1 ML/d
Fire Flow	Col 7	=	Fire flow rate of 250 L/s (21.6 ML/d) and a duration of 3.25 hours
Max Day Water Demand + Fire Flow	Col 8	=	Col 6 + Col 7
Proposed Water Supply to PD23 via HD019 PS	Col 9	=	Firm Capacity (ML/d)
Net PS Capacity to PD7	Col 10	=	Col 4 - Col 9
PD7 Surplus/Deficit Capacity (ML/d)	Col 11	=	Col 10 - Col 8
PD7 Surplus/Deficit Capacity (ML/Hr.)	Col 12	=	Col 11 / 24
Proposed EWSF Accumulative Storage Volume	Col 13	=	Col 13 - Col 12
Proposed EWSF Water Level	Col 14	=	Col 13 / 9.9 * 100%

