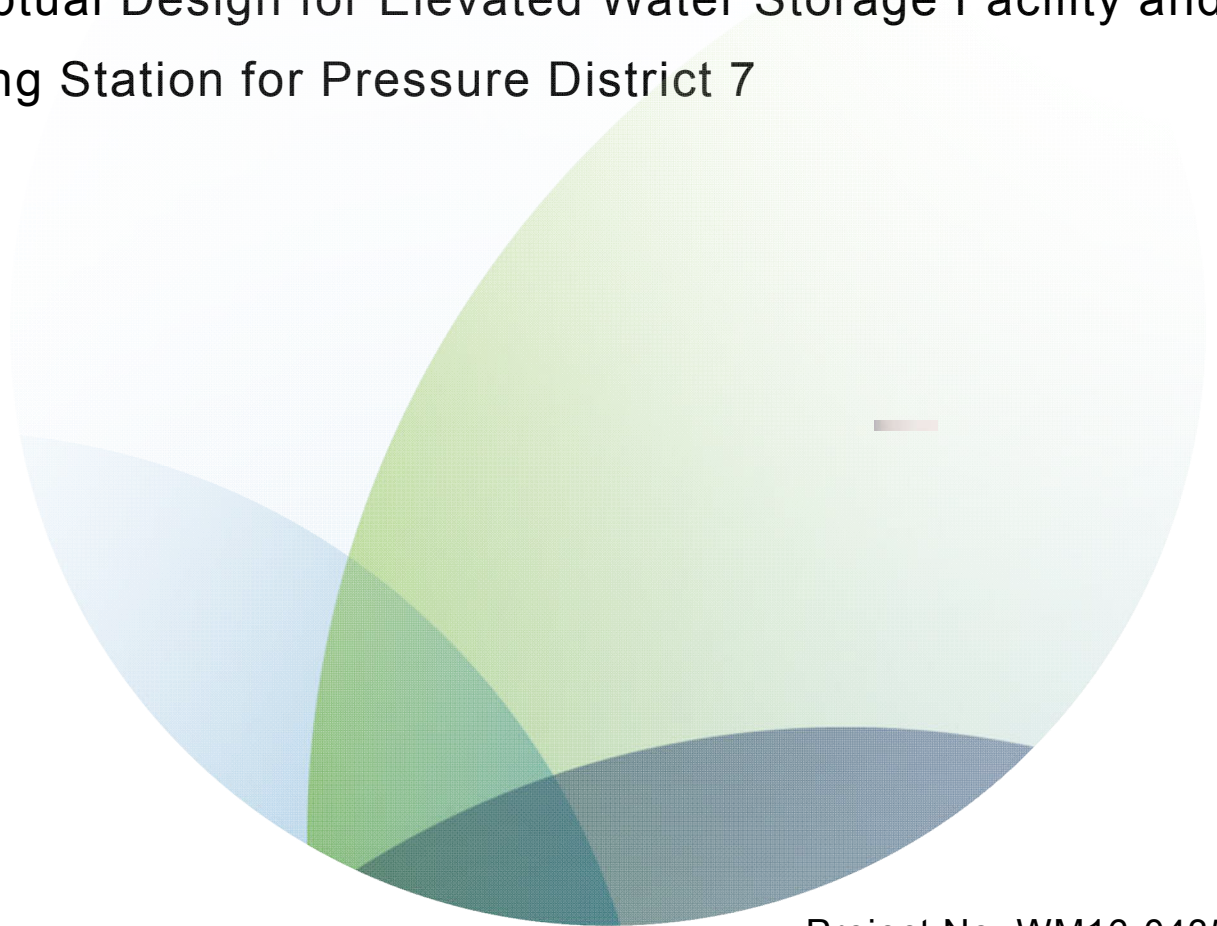


APPENDIX B
Technical Memorandum
TM No. 2 Conceptual Design Report

City of Hamilton

Technical Memorandum No. 2 Conceptual Design Report

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

Our Ref: WM16-0435

Winston Wang, P. Eng.
Project Manager
City of Hamilton
77 James Street North
Hamilton, ON, L8R 2K3

Attention: Mr. Winston Wang

**Re: Municipal Class Environmental Assessment and Conceptual Design of
Elevated Water Storage Facility and Pumping Station for Pressure District 7
Technical Memorandum No. 2 Conceptual Design Report**

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

The EWSF and PS facilities are being proposed to address future growth within Pressure District 7 (PD7) and to address security of supply and water system balancing. 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.

Shelley Kuan, P. Eng.
Project Manager and
Hydraulic Technical Lead
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PD/RS

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Report	September 24, 2018	For Submission
Report	January 28, 2019	For City Review
Report	February 11, 2019	For Submission
Report	August 22, 2019	For Submission

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1 Introduction

The City of Hamilton is planning to construct a new Elevated Water Storage Facility (EWSF) and a new Pumping Station (PS) to provide water supply for Pressure Districts (PD) 7 and 23. PD7 water system is currently a closed system. PD7 is located in the southeastern section of the City of Hamilton’s water distribution system and it is supplied from the Highland Road Pumping Station (HD007), which receives supply from PD5 or the Highland Road Reservoir (HDR07). The PD7 system also feeds sub-zone PD23 through the Binbrook Pumping Station (HD019). Sufficient storage and pumping capacities are provided in PD7 system under the existing condition.

The existing water system will not be able to maintain sufficient flow and pressures in the distribution system to support future growth. In addition, the existing system requires continuous pumping to meet varying demands, which results in high electricity and maintenance costs. It is the City’s objective to provide adequate water services to the residents, businesses and industries to meet community needs in an efficient and cost-effective manner. Therefore, a solution is required in PD7 to provide additional storage and pumping capacity to support the future growth in PD7 and PD23 systems, as well as to improve water system security and reliability, and to improve the efficiency and reduce operation and maintenance costs.

The project was identified as a Schedule ‘B’ project under the Municipal Class Environmental Assessment (EA) Process. This Class EA included an evaluation of environmental, social and cultural conditions as well as an assessment of the technical feasibility of the alternative water storage and pumping capacity solutions, documented in the Project File report.

The Class EA for the proposed PD7 Elevated Water Storage Facility (EWSF) and Pumping Station (PS) and presented alternative solutions. The alternative site locations are shown as shown left.

The preferred location for the elevated water storage facility was EWSF Site 3, West of Church Street and 20th Road intersection. This option is technically suitable and most cost effective, while having limited potential for environmental and socio-economic impacts.

The preferred location for the pumping station was PS Site 1 East of Centennial Parkway and Rymal Road East intersection. This location was determined since this solution offers the most cost effective, technically suitable and has limited potential for environmental and socio-economic impacts, while it has moderate potential for impact to archaeological resources.

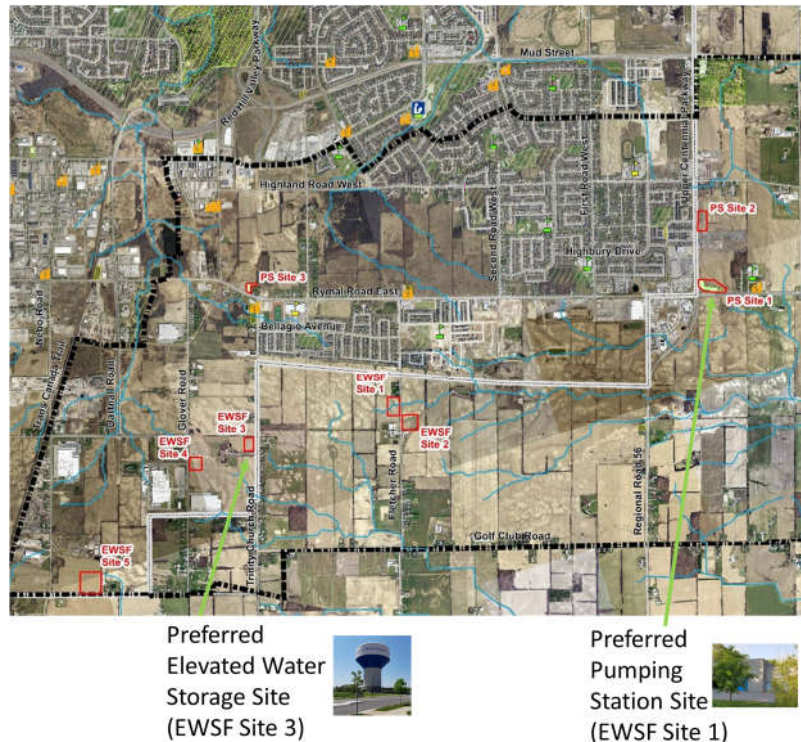


Figure 1.1 Locations for the Preferred EWSF and PS

This technical memorandum provides conceptual design considerations of the locations for both elevated water storage facility and pumping station.

1.1 Purpose of Conceptual Design

This technical memorandum provides a summary of design considerations for the future design of the PD7 EWSF and PS. The elevated water storage facility and the pumping station will be proposed at two separated locations; once the preferred sites are confirmed, it is recommended that a preliminary design report be completed to confirm elevations and reservoir parameters and to refine the design basis.

It is anticipated that the elevated water reservoir will be tendered as a design-build contract; as such, the design-build proponent will be responsible for confirming and establishing all detailed design parameters design criteria require that the distribution system is sized to convey the greater of peak hour flows or maximum day plus fire flows.

1.2 Design Criteria

1.2.1 Design Standards and Guidelines

The following design standards and guidelines are relevant to the design of the elevated water storage facility and pumping station:

- City of Hamilton Engineering Guidelines for Servicing Land Under Development Applications;
- City of Hamilton Design Water Outstation Design Manual;
- City of Hamilton Water Station Security Standards;
- Ontario Provincial Standard Drawings and Specifications;
- MECP Design Guidelines for Drinking-Water Systems; and,
- AWWA Standards and Specifications.

1.2.2 Water Demand

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

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

1.2.3 Fire Flow

As per the City's Comprehensive Development Guidelines and Financial Policies Manual 2016, fire flow 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 Ministry of the Environment Conservation and Parks (MECP) guidelines with most pressure districts being planned for 250 L/s (with a duration of 3.25 hours).

These fire flows was used to estimate the required volume for the proposed EWSF and capacity of the proposed PS in the analysis.

1.2.4 System Pressure

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

- Minimum pressure (normal operation): 275 kPa (40 psi);
- Minimum pressure (Max day plus fire): 140 kPa (20 psi); and,
- Maximum pressure: 690 kPa (100 psi).

1.2.5 Water Storage

As per the MECP (MOE) design guidelines 2008:

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

1.2.6 Pumping Station Capacity and Standby Power Supply

As per the Water and Wastewater Master Plan (2006), pumping stations (PSs) are rated on their firm capacity to supply water. For each pressure district, the PSs must provide local peak demands if there is no storage in that pressure district, or maximum day demands if there is sufficient storage and have sufficient capacity to transfer maximum day demands for the subsequent pressure districts.

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 PSs;
- Firm Capacity defined for open distribution system: one largest pump out of service; and,
- Size 1 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 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 PSs serving pressure zones with adequate storage should be designed for the maximum day rate.

2 Requirement of System Capacity Upgrades

2.1 Water Demand and Population Projections

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

2.1.1.1 Historical Water System Demand

Based on a review and an analysis of the SCADA data for the years 2015 and 2016, the historical water demand for PD7 and PD23 is summarized in **Table 2.1**.

Table 2.1 Water Demand and Peaking Factor Estimations for PD7 and PD23 for Years 2015 and 2016 using Historical 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

2.1.1.2 Projected Water Demand

Table 2.2 shows the estimated water demand requirements for the PD7 system using the City's design criteria.

Table 2.2 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 2.1** with **Table 2.2**, the 2016 water demand as estimated from the 2016 SCADA data is virtually identical 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 2.2** 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 2.2** using the City' Master Plan design values will be used for the analysis and/or evaluation of the required capacity of the EWSF and PS.

Table 2.3 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 2.1** with **Table 2.3**, 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 2.3** 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) will be used for the analysis and/or evaluation of the required capacity of the EWSF and PS.

The historical water demand (in year 2015 and 2016) and the design or projected water demand for year 2016, 2021, and 2031 are detailed in the Hydraulic Analysis Technical Memo 1 (TM 1) and in the following sections as well as TM 1.

2.2 Water Storage Requirement

2.2.1 Storage Volume 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 3.4 ML. 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.

As shown in **Table 2.4**, additional storage is required for the PD7. Approximately 3.1 ML and 5.6 ML is required for 2021 and 2031, respectively. As shown in **Table 2.5**, additional storage is required for PD23. Approximately 2.0 ML, 2.5 ML, and 3.8 ML is required for 2016, 2021 and 2031, respectively.

Table 2.4 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 250 L/s for a duration of 3.25 hours
B) Equalization Storage	3.1	8.7	19.8	25% of max day water demand (see Table 2.2)
C) Emergency Storage	1.5	2.9	5.7	25% of (A+B)
Total Required Volume	7.6	14.5	28.4	
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 5.6 ML for PD7 in 2031

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

**Positive value indicates no additional storage requirement.

Table 2.5 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 250 L/s for a duration of 3.25 hours
B) Equalization Storage	1.4	1.8	2.8	25% of max day water demand (see Table 2.3)
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 2.6 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 Table 2-4
	PD23	-2.0	-2.5	-3.8	See Table 2-5
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 2.6**, sufficient storage capacity is available for PD7 and PD23 under existing condition (year 2016). Additional storage is required for the PD7 and PD23 (for Years 2021 and 2031). Approximately 5.6 ML and 9.4 ML is required for 2021 and 2031, respectively. A slightly larger EWSF 9.9 ML EWSF is recommended and to be used for the analysis.

2.2.2 Suggested Water Level for Proposed Storage Facility

Based on the review of PD7 system, the ground elevations within the water servicing areas are virtually within 195 m and 220 m, which were used in analysis.

In order to maintain the system pressure between 275 kPa and 700 kPa under normal operation (e.g. Average day, Maximum day, and peak hour). The suggested water low and high levels in the proposed PD7 EWSF are from 255 m and 265 m (HWL), for the maximum 10 meters variation between low-low and high-high levels in a EWSF as suggested by the City.

The ground elevations in the proposed 5 alternative EWSF sites are between 215 m and 218.5 m. The height is approximately 45.7 m (150 ft.), from the ground level to High Water Level (HWL). All five alternative EWSF sites seems feasible in terms of EWSF height.

Please note that the suggested low water level might be adjusted (e.g. low water level down to 250 m) to meet the design storage volume (9.9 ML) 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.

2.3 Pumping Capacity Requirement

As shown in TM1, the system capacity analysis for year 2016 (current), 2021, and 2031 are detailed in TM1 and as follows.

2.3.1 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 11.4 ML). PD7 currently operates as a closed system as no floating storage exists within PD7. The existing HD019 firm pumping capacity to PD23 is 6.5 ML/d. As shown in TM1, the 2016 pumping capacity requirement for the PD7 system (including PD23) is 18.1 ML/d, 40.1 ML/d and 26.1 ML/d under maximum day demand, maximum day demand plus fire flow and peak hour demand, respectively.

The existing (2016) firm pumping capacity is 43.2 ML/d (with two pumps out of service), which is greater than the 2016 required PD7 pumping flow rate of 40.5 ML/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 TM1.

2.3.2 2021 Design Condition

As shown in TM1, the water demand requirement for PD23 is 7.0 ML/d, 28.6 ML/d and 19.3 ML/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 1.5 m/s (or flow rate of 16.2 ML/d) is for a 400 mm suction watermain. Therefore, the maximum flow rate 16.2 ML/d is assumed to supply from PD7 to PD23 via the existing suction supply 400 mm watermain under the 2021 design condition.

For information only, it is assumed that the 2021 firm pumping capacity to PD23 is 16.2 ML/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 TM1.

As shown in TM1, the 2021 water demand requirement for PD7 is 34.7 ML/d, 56.3 ML/d and 54.8 ML/d under maximum day, maximum day plus fire and peak hour, respectively.

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

As shown in TM1, with assuming the HD019 firm pumping capacity 16.2 ML/d to PD23, the water level in the proposed PD7 EWSF would still be above 60% full water level 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.

2.3.3 2031 Design Condition

As shown in TM1, the water demand requirement for PD23 is 11.4 ML/d, 33.0 ML/d and 31.1 ML/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 31.2 ML/d (approximately equal to PD23 peak hour demand), as shown in TM1.

As shown in TM1, additional supply pumping capacity to PD7 and PD23 is required prior to year 2031. With the HD019 Binbrook PS firm pumping capacity of 31.2 ML/d to PD23, the required pumping capacity for the proposed PD7 PS (HD07A) is approximately 60.3 ML/d prior to year 2031. The water level in the proposed PD7 EWSF would be above 50% full level 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.

2.3.4 Suggested Pump TDH for Proposed PD7 Pump

As per TM1, four pumps are to be proposed for the PD7 PS Site 1 and firm capacity of 60.3 ML/d (with one largest pump out of service), the estimated TDH at the proposed PD7 PS Site 1 is as follows:

- i. Minimum TDH is approximately 30.8 m (say 31 m). This includes minimum static head 18.8 m (= LWL 255 m at proposed EWSF Site 3 – HWL 236.2 m at PD5 pump suction), local PS station head losses 3 m, plus 9 m of PD7 system head;
- ii. Maximum TDH is approximately 48.6 m (say 49 m). This includes maximum static head 36.6 m (= HWL 265 m at proposed EWSF Site 3 – LWL 228.4 m at PD5 pump suction, local PS station head losses of 3 m, plus 9 m of PD7 system head; and
- iii. TDH operating ranges are between 31 m and 49 m and rated head is approximately 40 m,

A detailed hydraulic analysis the proposed PD7 PS will be required to fine-tune the pump capacity requirement (e.g., pump firm capacity, TDH) during the design stage and/or after the preferred Elfrida growth plan is selected as well as the pumping capacity and suction supply to PD23. In addition, Variable Frequency Drive (VFD) Pumps may be considered to allow pumps to operate more efficiency.

3 Permits and Approvals

Review and approvals from the following agencies will be required prior to construction:

- Ministry of the Environment, Conservation, and Parks (MECP);
- Drinking Water Works Permit (DWWP) Amendment;
- DWWP Schedule 'C' for watermain extension;
- Environmental Compliance Approvals;
- Building Permit;
- Site Plan Approval;

- Zoning Bylaw Variance;
- NAV Canada Notification;
- John C. Munro Hamilton International Airport Notification;
- Transport Canada Notification;
- Approvals from or notification to Horizon Utilities, Bell Canada, and Rogers may also be required and should be determined at the detailed design stage; and,
- Additional Criteria and Constrains for Site Selection of Elevated Water Storage Facility.

4 Elevated Water Storage Facility Conceptual Design

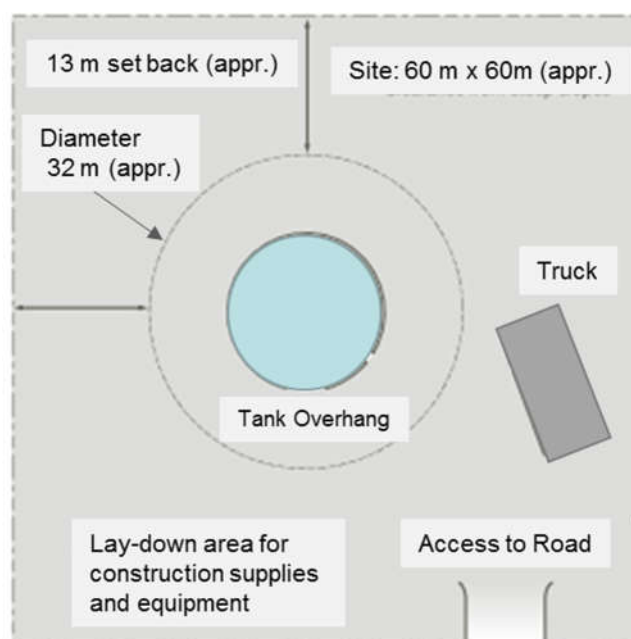
The preferred site for the PD7 Elevated Water Storage Facility is located West of Trinity Church Road and south of Rymal Road East.

4.1 General

As shown in TM1, the suggested water low and high levels in the proposed PD7 EWSF are 255 m and 265 m (HWL), for a maximum of 10 meters variation between low-low and high-high levels in a EWSF as suggested by the City.

It should be noted that the suggested low water level might be adjusted (e.g., 3 m lower and low water level down to 252 m) to meet the desired storage volume (9.9 ML) 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.



The elevated water storage facility design complies with the City's **Figure 4.1 Conceptual Layout for Elevated Water Storage Facility** Water Outstations Design Manual (Pumping and Storage) Revision No. 1, dated March 2016 and has included the associated requirements for the elevated water storage facility. The typical drawing details related to elevated water storage facility are shown in Drawings WO-ET 1 in Water Outstations Design Manual (Pumping and Storage) Revision No. 1 (dated March 2016). A typical EWSF site layout is shown in **Figure 4.1**.

4.2 Site Works

4.2.1 Access and Parking

Vehicular access driveway design and routing to the elevated water reservoir will depend on the specific property selected. Parking should be provided in accordance with the Zoning Bylaw and would depend on the outcome of the Zoning Bylaw Variance. At a minimum, four standard parking spaces (variable

depending on the City's needs and Zoning Bylaw) should be provided for operations and maintenance workers. In addition, one accessible parking space should be provided, per the Integrated Accessibility Standards (O.Reg. 191/11) "Type A" (2400 mm wide).

4.2.2 Stormwater Management

Stormwater management for the site should be designed in accordance with City design standards.

4.2.3 Overflow Drainage

The site will need an overland drainage area for any dechlorinated water discharging from the dechlorination chamber. Details, such as size and infiltration characteristics, are to be determined at the detailed design stage.

4.2.4 Security

It is recommended that the site be fenced and well lit. All applicable provisions in the City Water Station Security Standards shall also be followed.

4.2.5 Watermain Connection and Water Servicing

A 400 mm diameter watermain (size to be verified during detailed design) will be used to connect the reservoir to the existing distribution system. Water servicing for use in the rechlorination process, washroom, and eyewash will be provided from an internal water service connection complete with backflow preventer. Tepid water to be provided to eyewash.

4.2.6 Sanitary Servicing

It is recommended that a connection to the existing sanitary system along Trinity Road. Details, such as size, are to be determined during detailed design.

4.2.7 Utilities

Proposed utilities include 600 Volt, 3 phase hydro (to be verified during detailed design stage) and fibre optic telecommunications lines. No natural gas services are planned for the site. Hot water would be provided by electric water heaters. A standby generator with automatic transfer switch (ATS) is recommended for emergencies in case of loss of hydro power.

4.2.8 Tower Mounted Cellular Antenna

The City may wish to consider letting portions of the roof of the elevated water storage facility for cellular antenna installation (by others). This would require that the roof be designed for future antenna attachment. The site would also need provision for access to the antenna for maintenance by the lessee. This would provide the City with potential revenue in exchange for use of the space. Provision for attachment of a future antenna can be established at the detailed design stage. The approximately Tower dimension is as follows:

- Tank volume: 9.9 ML;
- Tank diameter: 32 m;
- Pedestal diameter: 17 m; and,
- Tank height: 47 m.

4.3 Environmental Protection Measures

The construction of the proposed PD7 Elevated Water Storage Facility is not expected to create any significant environmental impacts. The proposed works should be constructed in such a manner that, to the fullest possible extent, adverse impacts on the cultural and natural environment of the project area would be minimized. All recommendations for mitigation made in natural environment, archeological, and cultural heritage reports should be followed, as detailed in the Class EA Project File Report. The mitigation measures outlined in the following sections are recommended to ensure that any short term disturbances are managed by the best available methods.

4.3.1 Sedimentation and Runoff Controls

The potential for sediment related impacts is highest where construction activities occur near watercourses (i.e. swales, roadside ditches, creeks, etc.). Specific mitigation measures should be incorporated in the Contract Drawings and Specifications to prevent sediments from travelling overland. Other measures should include the supply, installation and maintenance of temporary sediment control fencing surrounding the site and temporary stockpile areas. The ditches and swales should also be provided with temporary straw bale check dams during construction and permanent rock check dams where necessary. In addition, the Contractor should be required to follow the practices described in the "Erosion and Sediment Control Guidelines for Urban Construction", December 2006, prepared by the Greater Golden Horseshoe Area Conservation Authorities. The contractor will be required to submit an erosion and sediment control plan for approval prior to commencing any work in the area.

4.3.2 Contamination of Soil through Spills and Leaks

During construction and operation, site contamination can be avoided by ensuring that the fuel storage, refuelling and maintenance of equipment is handled properly and not allowed in or adjacent to drainage swales on site, or roadside ditches. No storage of fuel during construction activities shall be permitted. However, fuel shall be permitted to be delivered for construction equipment refuelling only and not for storage. A Spill Prevention Plan should be developed, implemented, and maintained to ensure that construction activities do not increase the risk of a release of fuel, oils, or other hazardous materials to the environment. The Contractor should be required to submit a detailed response and action plan for dealing with the containment and cleanup of any spills during construction, and also maintain a spill response kit on-site at all times during construction. The contractor will be required to submit an erosion and sediment control plan for approval prior to commencing any work in the area.

4.3.3 Dust, Noise and Vibration

There will be potential for dust, noise and vibration during construction of the PD7 PS and site works. Water should be used by the Contractor as necessary to control dust along the access road. The Contractor should be responsible for cleaning mud from the adjacent surface of Rymal Road East or Upper Centennial Parkway, as required, for the duration of the Contract. A mud mat would also be constructed at the entrance to the access road to minimize mud tracking onto Church Trinity Road. Construction activities should be restricted to normal working hours, in accordance with local noise bylaws.

Vibration is not expected to have any significant effect on the properties adjacent to the elevated water storage facility. If necessary, the Contractor should be required to monitor all construction activities and maintain vibration levels to acceptable levels.

4.3.4 Construction Traffic

Impacts on local traffic during construction will be minimized by requiring that the Contractor provide adequate warning signs and if necessary, traffic control measures on Church Trinity Road. The Contractor should be required to submit a detailed Traffic and Pedestrian Management Plan for the City's approval, prior to commencing any work in the area.

4.4 Process Mechanical

4.4.1 General Piping and Valving

A minimum 400 mm diameter watermain would be constructed to connect the elevated water reservoir to the existing distribution system, complete with butterfly valves for isolation and other appurtenances. All sizing should be verified at the detailed design stage. Separate 400 mm diameter inlet and outlet riser pipes would be provided into the storage cell from the single 400 mm diameter inlet/outlet line in the valve room of the elevated water reservoir. This piping arrangement allows for improved circulation of water in the storage cell to maintain water quality. The typical drawing details related to elevated water storage facility are shown in Drawings WO-ET 1 in Water Outstations Design Manual (Pumping and Storage) Revision No. 1 (dated March 2016).

A bi-directional electromagnetic flowmeter would be installed on the 400 mm common inlet/outlet header to monitor and record both reservoir inflow and outflow rates and volumes. The flow signal from the bidirectional flowmeter would also be utilized for disinfection dosing. A modulating butterfly valve with motorized actuator would be provided on the reservoir inlet to facilitate reservoir filling and emptying. The valve would be controlled by SCADA and operated in response to system pressures dictating whether to fill or empty the tank. Piping and valving in the valve room should be insulated.

4.4.2 Overflow Piping

Overflow piping would be provided to prevent filling and over-pressurizing of the storage cell and direct excess water away from the structure. A 400 mm diameter overflow pipe (size to be verified at detailed design) would be provided inside the storage cell. In the event of an overflow emergency, an overflow alarm would be triggered, which would be automatically relayed to the SCADA system and Woodward Water Treatment Plant control room.

4.4.3 Elevated Water Storage Facility Drainage

Isolation valves would permit isolation of the PD7 Elevated Water Storage Facility from the rest of the pressure district and allow the reservoir to be completely drained, permitting access for regular inspection and maintenance purposes. Water can be discharged through the overflow piping to the dechlorination chamber and drainage area on the elevated water reservoir site.

4.4.4 Pressure Relief

A pressure relief valve (PRV) for system surcharges is provided at the existing HD007 PS and the proposed new HD007A PS. Adequacy of the surge protection at the at the HD007 PS and the proposed new HD007A should be verified at detailed design.

4.5 Reservoir Circulation

In order to improve the water turn over or water mixing performance, a reservoir circulation system is recommended. The reservoir circulation system is discussed in **Subsection 4.5.1**.

4.5.1 Hydrodynamic Mixing System

In addition to the separate inlet and outlet riser pipes, a multi-port hydrodynamic mixing system should be installed inside of the reservoir to promote mixing, minimize loss of disinfectant residual and mitigate ice formation due to short-circuiting and water stagnation in the tank.

4.5.2 Circulation Pump

A circulation pump, pump control valve for throttling, and associated piping would enable water to be pumped from the outlet piping into the inlet piping to promote mixing of the water stored inside the elevated reservoir during periods of low system demands and increase water movement to reduce the formation of ice inside the reservoir during winter operation. The pump would also provide adequate mixing of disinfectant injected into the riser piping for top-up chlorination, if necessary. A water heater will be provided for use in winter months to further prevent ice formation. The circulation pump should be sized to provide sufficient flow to displace the riser pipe contents and to mix the reservoir contents completely within 8 to 10 hours. The circulation pump would be operated at operator-adjustable intervals to promote mixing of water inside the tank.

4.5.3 Chlorination

A rechlorination system Chlorination will be applied will be provided at the elevated water storage facility as necessary. Based on the City's practice, 12% sodium hypochlorite and chemical injection pump will be used. The purpose of the chlorination disinfection system would be to dose chlorine to water flowing into the elevated water reservoir, in the event that low free chlorine residual is measured.

Chlorination system design shall be in conformance with City's design standards. The typical drawing details related to chlorination systems are shown in Drawings WO-CH 1 to 7 in Water Outstations Design Manual (Pumping and Storage) Revision No. 1, dated March 2016.

The chlorination system would be installed in a separate chemical room located inside the support shaft. Details of the chlorination system, such as storage tank and chemical injection pumping capacity, shall be established at detailed design. The chemical room would be equipped with a chemical containment area, a separate exterior entrance, eyewash, chemical flushing line, sample sinks, exhaust fans, and a tepid water line to an emergency eyewash.

4.5.4 Monitoring Chlorine Residual

Continuous chlorine residual analyzers will be installed before the two application points to monitor and control chlorination. Chlorination system design shall be in conformance with City of Hamilton installations.

Two sets of on-line chlorine residual analyzers would be provided at the elevated water reservoir with a range of 0 to 5 mg/L. Analyzer Set 1 would draw a continuous sample from the inlet riser to measure the free and total chlorine residual of water entering the main storage cell of the tank. Analyzer Set 2 would draw a continuous sample from the outlet pipe to measure the free and total chlorine residual of water leaving the reservoir and entering the distribution system. The typical analyzer installation and sample line details are shown in conceptual drawing WO-IC-2 in Water Outstations Design Manual (Pumping and Storage) Revision No. 1 (dated March 2016).

Alarm contacts would be provided from each analyzer for high free and total chlorine residual, low free and total chlorine residual and analyzer fault alarms. In the event of low free or total chlorine residual, an audible alarm and beacon alarm would be activated at the tank. The alarms would also be automatically

relayed to the SCADA system and to the Woodward WTP central control room. The electrically-actuated reservoir isolation valve could also be programmed to automatically close to prevent water from entering the distribution system in the event of a low free chlorine residual event.

4.5.5 Dechlorination Facilities

An inline dechlorination chamber would be provided on the overflow/drain piping to permit the Operators to manually introduce dechlorination chemicals during reservoir overflow or draining operations, prior to release to the environment. The overflow/drain pipe would discharge to the property. Details of the dechlorination chamber, such as location and size, shall be established at detailed design.

4.6 Operational Strategy

4.6.1 General

The proposed elevated water reservoir is intended to provide water equalization, fire and emergency storage in the PD7 system. The proposed storage facility would be filled from the existing HD007 PS and/or proposed HD007A PS with the water level in the elevated water reservoir determining discharge control valve open/close status. The control strategy is discussed in the following subsection. A Process Narrative providing a more detailed description of the control strategy should be developed during detailed design, once the preferred operational strategy is confirmed and the hydraulic modelling of the reservoir and system has been completed.

4.6.2 Reservoir Level Control

The PD7 Elevated Water Storage Facility would form an integral part of the PD7 distribution system providing pressure equalization as well as fire and emergency storage. The facility would be designed to maintain pressure in the distribution system within prescribed operating limits while providing required equalization, emergency, and fire storage capacity. Water levels in the reservoir would be maintained within the desired working range through the operation of the control valve at the existing HD007 PS and proposed HD007A PS. When supply from HD007 PS and/or HD007A exceeds demand, the surplus water would be directed into the elevated water reservoir and the level would rise until the HWL is reached. During normal operation, the working level in the elevated reservoir would be set between 255 m (50% full water level) and 259 m (90% full water level) (adjustable and to be confirmed during detailed design).

4.7 Structural Design

Structures will be designed, as a minimum, to conform to all applicable sections of AWWA D100 and AWWA D107, and design and construction requirements of the National and Ontario Building Codes (NBCC) and Ontario Building Code (OBC), the Ontario Support Program Act, 1997, and the requirements of Occupational Health and Safety Act (OHS) and local regulations.

4.7.1 Geotechnical Information

GeoPro was retained by the City to prepare a desktop geotechnical study based on terms of reference prepared by Cole Engineering Group Ltd. The report concluded that the elevated water storage facility development is likely geotechnically feasible at all the alternate sites. However, the study is not sufficient for design purpose and suggested that additional geotechnical and hydrogeological investigation programs for the preferred elevated water storage facility site will be required prior to detailed design to provide adequate information, such as soil type and ground water, for purposes of siting an elevated water storage facility.

4.7.2 Structural Design Loads

The structural design would have to take into account all loads including dead load, water and ice loads, wind and earthquake forces and all secondary forces due to temperature, moisture, creep and shrinkage effects. The design will conform to all applicable sections of AWWA D100 and AWWA D107, and design and construction requirements of the National and Ontario Building Codes. In addition, the effects of movements and loads from surface and wall ice thrusts would be considered in conjunction with rapid drawdown of stored water.

Contractors would be required to submit a design brief and drawings stamped by a Professional Engineer licensed in Ontario with their tender for evaluation. The successful Contractor would be required to submit complete foundation, shoring, reservoir construction, and erection shop drawings including all design calculations bearing the stamp of a Professional Engineer licensed in Ontario and experienced in the design of water storage facilities to the Consultant for review prior to fabrication. The design would be based on Limit States Design (LSD) principles as applicable, with foundation design addressing both Ultimate Limit States (ULS) and Serviceability Limit States (SLS).

4.7.3 Foundation and Support Structure

The design and construction of the foundation and support structure for the pumping station must be in accordance to the Ontario Building Code and CSA Specification CAN3 A23.3 latest edition for reinforced concrete structures.

4.7.4 Steel Reservoir Requirements

The stored water would be contained within a welded steel tank. All steel plates should be Grade 300W and conform to CAN3-G40 series, latest revision. The inside of steel tank should be galvanized or coated per AWWA standard. A corrosion allowance of a minimum 2 mm as suggested by the City may be used for the design (to be confirmed with City during detailed design stage), although the corrosion allowance of a minimum 1.6 mm (1/16") should be provided in accordance to AWWA D100. Welded Carbon Steel Tanks for Water Storage and AWWA D107 – Composite Elevated Tanks for Water Storage. All welds, materials and welding equipment would conform to CSA Specification W59 and W47, latest revisions, with all welding carried out by companies certified to Division 1 or 2 of CSA W47.1, latest revision. Reservoir erection procedures and general requirements would conform to AWWA D100 and AWWA D107, including "Inspection and Testing". An independent Inspection Agency will inspect both shop and field welds including radiographic, vacuum, and ultrasonic testing.

4.8 Building Services and Systems

4.8.1 General

The elevated water reservoir would include an office and washroom for City staff use. The washroom should be accessible and in compliance with the Accessibility for Ontarians with Disabilities Act. An electric water heater would be provided to supply hot water to the washroom and emergency shower.

4.8.2 Building Security

The building security system will consist of:

- Door Switches/Contacts installed on all exterior doors;
- Illegal Entry Keyed Switch in the PLC panel; and

- Door switches to be tied into one alarm signal that is relayed to the PLC/SCADA.

A security camera should also be installed on the reservoir pedestal with monitoring at the Woodward WTP central control room. Additional security requirements may be established at the detailed design stage and in accordance with the City of Hamilton Water Station Security Standards.

4.8.3 Heating and Ventilation

The heating and ventilation systems within the elevated water reservoir would be designed and installed in accordance with the Ontario Building Code.

Electric unit heaters should be provided in each room to maintain temperatures above 10°C during the winter months. The respective unit heaters would be provided with built in thermostats. The support shaft would not be heated. The riser pipes should be insulated and heat traced.

A cooling system may be required for the Electrical and Control Room to maintain temperatures within manufacturer recommended ranges. The City may also wish to cool manned spaces.

4.8.4 Plumbing

Floor drains connecting to a main header would drain by gravity to the sanitary sewer. Wastewater from the following sources would also drain to the header:

- Washroom;
- Condensate from the storage cell access tube and valve room piping and dehumidifier;
- Emergency shower and eyewash;
- Sample sink;
- discharge from Chlorine residual analyzers discharge; and,
- Discharge from backflow preventers, air release valves and other process equipment.

4.8.5 Fire Protection

Fire protection will be provided in accordance with the Ontario Building Code. No overhead sprinklers or fire hose would be provided. Portable fire extinguishers suitable for the proposed structure and conforming to requirements of the Fire Code.

4.8.6 Obstruction Beacon

The elevated water reservoir should be equipped with an obstruction beacon located on the top of the tank, typical of any obstruction beacon on radio towers, etc., to warn aircraft. The beacon would feature automatic switchover of duty/standby lamps, in the event of a failure. Failure of the obstruction beacon would generate an alarm to the RPU. Due to the proximity to the John C. Munro Hamilton International Airport, additional requirements may need to be met (to be determined during detailed design stage).

4.9 Electrical, Control and Instrumentation

4.9.1 General

All electrical equipment would be housed indoors, with exception of the standby generator. The Electrical and Control room would house the motor control centre (MCC), programmable logic controller (PLC) and remote processing unit (RPU), power distribution panels, lighting panels, security system panel, and other

electrical support equipment. All enclosures shall follow NEMA ratings appropriate to the installation location, to be verified at detailed design. Lightning protection shall be required to prevent damage to the electrical, instrumentation, and control equipment. A Grounding Study, Arc Flash Hazard Assessment, and Coordination Study may be required and it is recommended that the need be assessed during detailed design.

4.9.2 Electrical Design Standards

The detailed design of the elevated water reservoir electrical and control and instrumentation components should conform to the latest revisions of the following minimum standards:

- Canadian Electrical Safety Code;
- Ontario Electrical Safety Code, and all bulletins;
- Ontario Hydro Power Commission Requirements;
- Building Code of Ontario, O. Reg. 350/06;
- Local applicable codes and regulations (City of Hamilton and Horizon Utilities);
- Grounding to CSA C22.3;
- City Design Standards; and,
- City SCADA Standards.

4.9.3 Hydro Servicing

Permanent power consisting of 600V/3-phase/60 Hz supply (to be verified during detailed design) to the site and a service entrance should be extended to the facility via poles and underground wiring in directly buried rigid PVC ducts. The Contractor would be responsible for supplying and installing a temporary power service on-site to suit the construction phase. All work on transformation of the primary power supply should be coordinated with Horizon Utilities. The hydro meter would be installed on the exterior wall of the elevated reservoir, in a lockable, weatherproof enclosure, as per Horizon Utilities requirements.

4.9.4 Standby Power

It is recommended that an Uninterruptible Power Supply (UPS) be used to provide power to the PLC, RPU, and Security System. The UPS would also provide temporary standby power to essential instrumentation such as the flow meter, pressure transmitters and chlorine residual analyzers.

A permanent standby power generator would be installed at this facility, to be sized to power all equipment and building services. Provide natural gas if available for generators up to 125 kW; otherwise, provide diesel. This unit would be located outside in a sound attenuating weatherproof outdoor enclosure complete with a double walled diesel fuel tank sized to operate the generator for 24 hours. The fuel storage tank will have minimum height of 600 mm to facilitate the installation and proper operation of level switches. This is in-line with COH requirement. The maximum load scenario for elevated reservoir operation using standby power is described as:

- Water chlorination system is operating;
- Circulation pump is operating;
- All heating equipment and heat tracing in the station is running;

- All building lighting in the station is energized;
- All security features are operating;
- Any emergency equipment is operating; and,
- All other essential loads are running, such as control and instrumentation; and
- 25% spare capacity will be required.

The generator would be equipped with an integral control panel that includes controls for the generator, a protection relay, a circuit breaker and a battery charger. The start/stop control of the generator would be directed by the automatic transfer switch (ATS) located in the Electrical and Control Room. The generator is subject to applicable approvals, such as air and noise. Approvals and any associated additional studies are to be completed at the design stage. The generator will have ancillary breaker for annual local testing (of the generator).

4.9.5 SCADA Integration

The City of Hamilton SCADA Standards will be used for the design. All necessary SCADA programming required to operate the elevated water reservoir remotely from the City of Hamilton Woodward WTP central control room would be included in the construction contract. Communication with the SCADA network, including Highland Road PD5 Reservoir (HDR07), proposed PD7 PS (HD007A), existing PD7 PS (HD007), PD23 PS (HD019) and Woodward WTP would be via fibre optic cable, DSL connection, or telephone line in accordance with current City standards and practices. Remote SCADA monitoring should include flow rates, valve position, chlorine residuals and reservoir level. Remote control of the circulation pump would be possible via the SCADA system. The chlorine residual levels would be displayed and recorded on the Operator Interface Terminal (OIT) located in the Electrical and SCADA Room. All alarms would be automatically relayed via the SCADA network to the Woodward WTP central control room.

4.9.6 Heat Tracing

In order to ensure that the inlet and outlet riser pipes do not freeze, each pipe would be heat traced and insulated. The heat tracing system shall be installed as per City's standard. The heat tracing control system would be entirely operator-adjustable and have continuous temperature outputs and auxiliary dry contacts for the purpose of alarm monitoring.

4.9.7 Cathodic Protection

An impressed current cathodic protection system would be provided for the protection of the submerged interior protective reservoir coating system. The cathodic protection system would be designed, set-up and calibrated in accordance with the latest AWWA Standard D104-97 to provide continuous year round operation and maintain polarized steel structure potentials and continuous current output of at least 200 micro-amperes per square foot of coated steel. A current source (Rectifier) would be provided to automatically adjust current output to accommodate changing water level within the reservoir and changing chemical/physical parameters of the water/storage cell interface.

4.10 Conceptual Cost Estimates for Elevated Water Storage Facility

A conceptual construction cost estimate is presented in **Table 4.1**.

Table 4.1 Conceptual Cost Estimates for Elevated Water Storage Facility

Scope	Amount (\$Million)
Elevated Water Reservoir (9.9 ML)	\$5.5
Rechlorination and Recirculation System	\$0.2
Process and Electrical Works	\$0.8
Site Works	\$0.5
Watermain Extension	\$0.3
Engineering (10% of construction costs)	\$0.7
City's Internal Resources/Staffing (10% of construction and engineering costs)	\$0.8
Land Acquisition (Land owned by the City)	\$0.5
Utility and Testing Allowances	\$0.3
Sub-total Cost	\$9.6
Contingency (30%)*	\$2.9
Estimated Total	\$12.5

*A contingency of 30% is also included in this cost.

5 Pumping Station Conceptual Design

5.1 General

Four pumps are recommended for the PD7 PS Site 1 and firm capacity of 60.3 ML/d (with one largest pump out of service), As per TM1, the estimated TDH operating ranges are between 31 m and 49 m and the rated head is approximately 40 m.

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.

5.1.1 Site Works

The proposed PD7 Pumping Station will require a building measuring approximately 30 m x 25 m in plan area. It depends on the setback requirement from street and proposed development in the neighbouring land. The site area requirement is approximately 60 m x 45 m, with assuming a requirement of 10 m setback, plus access to roadway. It may require 30 m buffer from site to the edge of wetland (e.g. wetland near PS Site 1). Site works will include property perimeter CLF, asphalt driveway and parking area, exterior lighting, an exterior diesel exhaust stack, and landscaping. A typical PS site layout is shown in **Figure 5.1**.

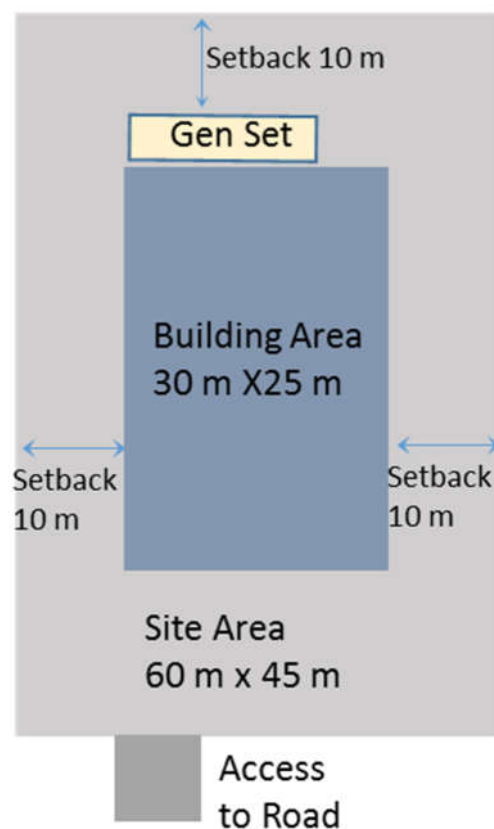


Figure 5.1 Conceptual Layout for Pumping Station

5.1.2 Site Services

Storm drainage and site runoff drainage will be directed to the storm sewer on the proposed Rymal Road East or Upper Centennial Parkway system (to be confirmed during detailed design stage). Normal treated water usage at the Booster Station will be confined to general cleaning, personnel hygiene uses and instrumentation use. A small service connection can be obtained from the watermain outlet header.

Wastewater will be connected to the sanitary sewer on the proposed Rymal Road East or Upper Centennial Parkway system to be confirmed during detailed design stage.

5.1.3 General Layout

The general layout of the pumping station showing the location of the pumps, piping arrangement and position of the valves is shown on the City's Conceptual design drawings WO-PS-1 to 4.

5.1.4 Pipes and Appurtenances

All internal station piping will be SS 316L. All external mains will be PVC meeting AWWA standards. All pipes and appurtenances shall be designed for a working pressure of 690 kPa, and a test pressure of 1035 kPa. All ferrous watermain fittings and materials will be cathodically protected by the installation of anodes. Bedding and backfill for all watermains will be in accordance with OPS Standards. Tracer wire will be provided on all PVC watermains to permit future location.

5.2 Geotechnical Investigation

Based on the desktop geotechnical study, pumping station development is likely feasible at all the alternate sites geotechnically. However, the study is not sufficient for design purposes. Additional geotechnical and hydrogeological investigation programs for the preferred site prior to detailed design will be required to provide adequate information for purposes of siting a pumping station.

5.3 Environmental Protection Measures

The construction of the proposed PD7 Pumping Station is not expected to create any significant environmental impacts. The proposed works should be constructed in such a manner that, to the fullest possible extent, adverse impacts on the cultural and natural environment of the project area would be minimized. All recommendations for mitigation made in natural environment, archeological, and cultural heritage reports should be followed, as detailed in the Class EA Project File Report. The mitigation measures outlined in the following sections are recommended to ensure that any short term disturbances are managed by the best available methods.

5.3.1 Sedimentation and Runoff Controls

The potential for sediment related impacts is highest where construction activities occur near watercourses (i.e. swales, roadside ditches, creeks, etc.). Specific mitigation measures should be incorporated in the Contract Drawings and Specifications to prevent sediments from travelling overland. Other measures should include the supply, installation and maintenance of temporary sediment control fencing surrounding the site and temporary stockpile areas. The ditches and swales should also be provided with temporary straw bale check dams during construction and permanent rock check dams where necessary. In addition, the Contractor should be required to follow the practices described in the “Erosion and Sediment Control Guidelines for Urban Construction”, December 2006, prepared by the Greater Golden Horseshoe Area Conservation Authorities. The contractor will be required to submit an erosion and sediment control plan for approval prior to commencing any work in the area.

5.3.2 Contamination of Soil through Spills and Leaks

During construction and operation, site contamination can be avoided by ensuring that the fuel storage, refuelling and maintenance of equipment is handled properly and not allowed in or adjacent to drainage swales on site, or roadside ditches. No storage of fuel during construction activities shall be permitted. However, fuel shall be permitted to be delivered for construction equipment refuelling only and not for storage. A Spill Prevention Plan should be developed, implemented, and maintained to ensure that construction activities do not increase the risk of a release of fuel, oils, or other hazardous materials to the environment. The Contractor should be required to submit a detailed response and action plan for dealing with the containment and cleanup of any spills during construction, and also maintain a spill response kit on-site at all times during construction. Provisions should be included in the Contract Specifications for addressing contaminated soils, if encountered during the excavation for the watermain/sewer or PD7 PS building and/or foundation.

5.3.3 Dust, Noise and Vibration

There will be potential for dust, noise and vibration during construction of the PD7 PS and site works. Water should be used by the Contractor as necessary to control dust along the access road. The Contractor should be responsible for cleaning mud from the adjacent surface of Rymal Road East or Upper Centennial Parkway, as required, for the duration of the Contract. A mud mat would also be constructed at the

entrance to the access road to minimize mud tracking onto Rymal Road East or Upper Centennial Parkway during material hauling. Construction activities should be restricted to normal working hours, in accordance with local noise bylaws.

Vibration is not expected to have any significant effect on the properties adjacent to the PD7 PS. If necessary, the Contractor should be required to monitor all construction activities and maintain vibration levels to acceptable levels.

5.3.4 Construction Traffic

Impacts on local traffic during construction will be minimized by requiring that the Contractor provide adequate warning signs and if necessary, traffic control measures on Rymal Road East and/or Upper Centennial Parkway. The Contractor should be required to submit a detailed Traffic and Pedestrian Management Plan for the City's approval, prior to commencing any work in the area.

5.4 Process Mechanical

5.4.1 General Piping and Valving

A 750 mm diameter watermain would be constructed to connect the suction header of the pumping station to the proposed PD5 distribution system along Upper Centennial Parkway (as per Centennial Parkway Trunk Watermain and Sanitary Sewer and Related Master Plan Projects, by Hatch Mott McDonald, 2009 and Hamilton Southeast Mountain Water Servicing Strategy – Final, by Stantec 2013). All sizing should be verified at the detailed design stage. The typical drawing details related to PS layout are shown in Drawings WO-PS 1 to 4 in Water Outstations Design Manual (Pumping and Storage) Revision No. 1 (dated March 2016).

5.4.2 Pressure Relief

A pressure relief valve (PRV) for system surcharges is provided at the existing HD007 PS and the proposed new HD007A PS. Adequacy of the surge protection at the at the HD007 PS and the proposed new HD007A should be verified at detailed design.

5.4.3 Chlorination

A rechlorination system will be applied at the discharge header of the PD7 Pumping Station. The purpose of the chlorination disinfection system would be to dose chlorine to water flowing into the distribution system, in the event that low free chlorine residual is measured at the suction of the PS. Based on the City's practice, 12% sodium hypochlorite and chemical injection pump will be used.

Chlorination system design shall be in conformance with City's design standards. The typical drawing details related to chlorination systems are shown in Drawings WO-CH 1 to 7 in Water Outstations Design Manual (Pumping and Storage) Revision No. 1 (dated March 2016).

The chlorination system would be installed in a separate chemical room located inside the support shaft. Details of the chlorination system, such as storage tank and chemical injection pumping capacity, shall be established at detailed design. The chemical room would be equipped with a chemical containment area, a separate exterior entrance, eyewash, chemical flushing line, sample sinks, exhaust fans, and a tepid water line to an emergency eyewash.

5.4.4 Monitoring Chlorine Residual

Continuous chlorine residual analyzers will be installed before the two application points to monitor and control chlorination. Chlorination system design shall be in conformance with City of Hamilton installations.

Two sets of on-line chlorine residual analyzers would be provided at the elevated water reservoir with a range of 0 to 5 mg/L. Analyzer Set 1 would draw a continuous sample from the inlet riser to measure the free and total chlorine residual of water entering the main storage cell of the tank. Analyzer Set 2 would draw a continuous sample from the outlet pipe to measure the free and total chlorine residual of water leaving the reservoir and entering the distribution system. The typical analyzer installation and sample line details are shown in conceptual drawing WO-IC-2 in Water Outstations Design Manual (Pumping and Storage) Revision No. 1 (dated March 2016).

Alarm contacts would be provided from each analyzer for high free and total chlorine residual, low free and total chlorine residual and analyzer fault alarms. In the event of low free or total chlorine residual, an audible alarm and beacon alarm would be activated at the tank. The alarms would also be automatically relayed to the SCADA system and to the Woodward WTP central control room. The electrically-actuated reservoir isolation valve could also be programmed to automatically close to prevent water from entering the distribution system in the event of a low free chlorine residual event.

5.5 Operational Strategy

The proposed PD7 PS is intended to provide additional water supply to PD7 and PD23 systems. The proposed PD7 storage facility would be filled from the existing HD007 PS and/or proposed HD007A PS with the water level control in the storage facility.

When supply from HD007 PS and/or HD007A exceeds demand, the surplus water would be directed into the elevated water reservoir and the level would rise until the HWL at the proposed PD7 elevated tank is reached, the modulating valve at the elevated water reservoir would close and the HDR007 reservoir and HD007 PS and/or HD007A PS would continue to supply the distribution system to meet demands.

Operations would be able to use the level signal feedback to remotely adjust the intake valve and start or stop the pumps at the existing HD007 PS and/or proposed HD007A PS. During normal operation, the working level in the elevated reservoir would be set between 258 m and 263 m (adjustable).

5.6 Architecture

The BPS will be designed architecturally to blend with the existing environment, while maintaining an aesthetically pleasing look. Both the exterior and interior building materials and finishes are selected for low life cycle costs. Spaces will be designed to be useful and practical. Adequate room will be allowed to service equipment.

Noise potential and impact on neighborhood. To the extent possible, orient the engine generator, building air intake louvers, and building, wet well, and odor control fans to direct noise away from the adjacent neighborhood. An effort also shall be made to make the architecture of the pump station blend with the local surroundings.

The proposed PS will be designed to meet the requirements of the Ontario Building Code.

5.7 Structural Design

Structures will be designed, as a minimum, to conform to the Ontario Building Code (OBC), the National Building Code of Canada (NBCC), the Ontario Support Program Act, 1997, and the requirements of Occupational Health and Safety Act (OHSA) and local regulations.

5.7.1 Geotechnical Information

Based on the desktop geotechnical study, pumping station development is likely feasible at all the alternate sites geotechnically. However, the study is not sufficient for design purposes. Additional geotechnical and hydrogeological investigation programs for the preferred site prior to detailed design will be required to provide adequate information for purposes of siting a pumping station.

5.7.2 Structural Design Loads

The structural design would have to take into account all loads including live loads, dead load, water and ice loads, wind and earthquake forces and all secondary forces due to temperature, moisture, creep and shrinkage effects. The design will conform to all applicable sections of AWWA D100 and AWWA D107, and design and construction requirements of the National and Ontario Building Codes.

In addition, resonance of pumps, generators, and similar vibration produced by equipment will be checked against the natural frequency of the supporting concrete slabs. Natural frequency of suspended concrete slabs subjected to vibration will be designed such that the natural frequency of the slab with respect to the vibration from the equipment will be outside of the following limits: Less than one-half and Greater than twice. As for the sheet-pile driving, a pre/post condition survey of the surrounding structures will be carried out even though vibration effect from the pile driving will unlikely affect the neighborhood.

Although the interior of all buildings will be ventilated to control humidity, there will still be some possibility of corrosion in the interior environment because of the water-handling functions. Building materials and surface finishes have been chosen to suit the indoor environment, based on experience in other similar facilities. Stainless steel or commercial aluminum or FRP will be used throughout the reservoir and pumping station where applicable.

Contractors would be required to submit a design brief and drawings stamped by a Professional Engineer licensed in Ontario with their tender for evaluation. The successful Contractor would be required to submit complete foundation, shoring, reservoir construction, and erection shop drawings including all design calculations bearing the stamp of a Professional Engineer licensed in Ontario and experienced in the design of water storage facilities to the Consultant for review prior to fabrication. The design would be based on Limit States Design (LSD) principles as applicable, with foundation design addressing both Ultimate Limit States (ULS) and Serviceability Limit States (SLS).

5.7.3 Foundation and Support Structure

The design and construction of the foundation and support structure for the pumping station must be in accordance to the Ontario Building Code and CSA Specification CAN3 A23.3 latest edition for reinforced concrete structures.

5.8 Building Services and Systems

5.8.1 General

The pumping station would include an office, pump house and washroom for City staff use. The washroom should be accessible and in compliance with the Accessibility for Ontarians with Disabilities Act. An electric water heater would be provided to supply hot water to the washroom and emergency eyewash.

5.8.2 Building Security

The building security system will consist of:

- Door Switches/Contacts installed on all exterior doors;
- Illegal Entry Keyed Switch in the PLC panel; and
- Door switches to be tied into one alarm signal that is relayed to the PLC/SCADA.

A security camera should also be installed on the reservoir pedestal with monitoring at the Woodward WTP central control room. Additional security requirements may be established at the detailed design stage and in accordance with the City of Hamilton Water Station Security Standards.

5.8.3 Heating and Ventilation

The heating and ventilation systems within the PS would be designed and installed in accordance with the Ontario Building Code.

Electric unit heaters should be provided in each room to maintain temperatures above 10°C during the winter months. The respective unit heaters would be provided with built in thermostats. The support shaft would not be heated. The riser pipes should be insulated and heat traced.

A cooling system may be required for the Electrical and Control Room to maintain temperatures within manufacturer recommended ranges. The City may also wish to cool manned spaces.

5.8.4 Plumbing

Floor drains connecting to a main header would drain by gravity to the sanitary sewer. Wastewater from the following sources would also drain to the header:

- Washroom;
- Condensate from the storage cell access tube and valve room piping and dehumidifier;
- Emergency shower and eyewash;
- Sample sink;
- discharge from Chlorine residual analyzers discharge; and
- Discharge from backflow preventers, air release valves and other process equipment.

5.8.5 Fire Protection

Fire protection will be provided in accordance with the Ontario Building Code. No overhead sprinklers or fire hose would be provided. Portable fire extinguishers suitable for the proposed structure and conforming to requirements of the Fire Code.

5.9 Sanitary Drains

Sanitary and floor drains will discharge to sanitary sewer along Rymal Road East or Upper Centennial Parkway (to be determined during detailed design stage).

5.10 Water Servicing

Station service water will be obtained from the proposed PS discharge header and the connection will be provided with isolation valve, water meter and backflow preventer. The water meter will be provided by the City for installation by the Contractor. Backflow preventer valves will conform to the City's requirements.

5.11 Electrical, Control and Instrumentation

5.11.1 General

All electrical equipment would be housed indoors, with exception of the standby generator. The Electrical and Control room would house the motor control centre (MCC), programmable logic controller (PLC) and remote processing unit (RPU), power distribution panels, lighting panels, security system panel, and other electrical support equipment.

All enclosures shall follow NEMA ratings appropriate to the installation location, to be verified at detailed design. Lightning protection shall be required to prevent damage to the electrical, instrumentation, and control equipment. A Grounding Study, Arc Flash Hazard Assessment, and Coordination Study may be required and it is recommended that the need be assessed during detailed design.

5.11.2 Electrical Design Standards

The detailed design of the elevated water reservoir electrical and control & instrumentation components should conform to the latest revisions of the following minimum standards:

- Canadian Electrical Safety Code;
- Ontario Electrical Safety Code, and all bulletins;
- Ontario Hydro Power Commission Requirements;
- Building Code of Ontario, O. Reg. 350/06;
- Local applicable codes and regulations (City of Hamilton and Horizon Utilities);
- Grounding to CSA C22.3;
- City Design Standards; and,
- City SCADA Standards.

5.11.3 Hydro Servicing

Permanent power consisting of 600V/3-phase/60 Hz supply (to be verified during detailed design) to the site and a service entrance should be extended to the facility via poles and underground wiring in directly buried rigid PVC ducts. The Contractor would be responsible for supplying and installing a temporary power service on-site to suit the construction phase. This requirement will be fully discussed with Horizon Utilities. All work on transformation of the primary power supply should be coordinated with Horizon

Utilities. The hydro meter would be installed on the exterior wall of the elevated reservoir, in a lockable, weatherproof enclosure, as per Horizon Utilities requirements.

5.11.4 Standby Power

It is recommended that an Uninterruptible Power Supply (UPS) be used to provide power to the PLC, RPU, and Security System. The UPS would also provide temporary standby power to essential instrumentation such as the flow meter, pressure transmitters and chlorine residual analyzers.

A permanent standby power generator would be installed at this facility, to be sized to power all equipment and building services. Provide natural gas if available for generators up to 125 kW; otherwise, provide diesel. This unit would be located outside in a sound attenuating weatherproof enclosure complete with a double walled diesel fuel tank sized to operate the generator for 24 hours. The fuel storage tank will have minimum height of 600 mm to facilitate the installation and proper operation of level switches. This is in-line with COH requirement. The maximum load scenario for elevated reservoir operation using standby power is described as:

- Pumping firm capacity;
- Water chlorination system is operating;
- Circulation pump is operating;
- All heating equipment and heat tracing in the station is running;
- All building lighting in the station is energized;
- All security features are operating;
- Any emergency equipment is operating;
- All other essential loads are running, such as control and instrumentation; and
- 25% spare capacity will be required

The generator would be equipped with an integral control panel that includes controls for the generator, a protection relay, a circuit breaker and a battery charger. The start/stop control of the generator would be directed by the automatic transfer switch (ATS) located in the Electrical and Control Room. The generator is subject to applicable approvals, such as air and noise. Approvals and any associated additional studies are to be completed at the design stage.

5.11.5 SCADA Integration

The City of Hamilton SCADA Standards will be used for the design. All necessary SCADA programming required to operate the elevated water reservoir remotely from the City of Hamilton Woodward WTP central control room would be included in the construction contract.

Communication with the SCADA network, including Highland Road PD5 Reservoir (HDR07), proposed PD7 storage facility, existing PD7 PS (HD007), PD23 PS (HD019) and Woodward WTP would be via fibre optic cable, DSL connection, or telephone line in accordance with current City standards and practices. Remote SCADA monitoring should include flow rates, valve position, chlorine residuals and reservoir level. Remote control of the circulation pump would be possible via the SCADA system. The chlorine residual levels would be displayed and recorded on the Operator Interface Terminal (OIT) located in the Electrical and SCADA Room. All alarms would be automatically relayed via the SCADA network to the Woodward WTP central control room.

5.12 Conceptual Cost Estimates for Pumping Station

A conceptual construction cost estimate in 2018 dollars for the proposed pumping is presented in **Table 5.1**.

Table 5.1 Conceptual Cost Estimates for Pumping Station

Scope	Amount (\$Million)
Pumping Station building (30 m x 20 m)	\$4.0
Rechlorination and Recirculation System	\$0.2
Process and Electrical Works	\$4.8
Site Works	\$2.0
Watermain Extension (to be included by City's other Projects)	\$0.0
Engineering (10% of construction cost)	\$1.1
City's Internal Resources/Staffing (10% of construction and engineering cost)	\$1.2
Land Acquisition (Land owned by the City)	\$0.5
Utility and Testing Allowances	\$2.0
Sub-total Cost	\$15.8
Contingency (30%)	\$4.7
Estimated Total	\$20.5

A contingency of 30% is also included in this cost. This cost estimates do not include watermain extension, which will be required and be included in the City's projects by others.

6 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.

Given anticipated growth within the study area, a proposed EWSF with a recommended storage volume of 9.9 ML (HWL 265.0 m) is required by year 2021 and a proposed PD7 Pumping Station (PS) with capacity of 60.3 ML/d (at rated head of 40 m) is required prior to 2031 (e.g., may be required shortly after year 2021).

The conceptual cost is approximately \$12.5 Million and \$20.5 Million for the proposed EWSF and PS, respectively.

A detailed hydraulic analysis of the proposed PD7 PS will be performed to fine-tune the EWSF operational water, as well as pump capacity requirement (flow and TDH) during the design stage and/or after the preferred Elfrida growth plan is selected.

The 2021 and 2031 timelines are premised on the projected growth and are subject to change based on actual population growth and development approvals.