Future Water Supply

Village of Chester and Area
Chester, NS

Prepared For

The Municipality of the District of Chester

Prepared By

KVM Consultants Limited
Lower Sackville, NS

April 2011



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1.0 Introduction

Village of Chester and surrounding areas have historically used wells as a primary source of domestic water. In many cases, due to reduced well yields, homeowners must supplement their domestic water with cisterns, roof drainage and trucking.

A central water system has been a topic of discussion for many years. Conceptual engineering work was completed by Paul Wendt P.Eng. in 1967 and then again by Interprovincial Engineering in 1987. As a part of the Municipality's Integrated Community Sustainability Plan, drinking water supply is identified as a goal in long term planning. The Municipality has also expressed a desire to provide fire protection in addition to supplying drinking water.

The intent of this report is to establish infrastructure requirements and identify potential sites for the major components such as a water treatment plant, booster station and storage facilities.

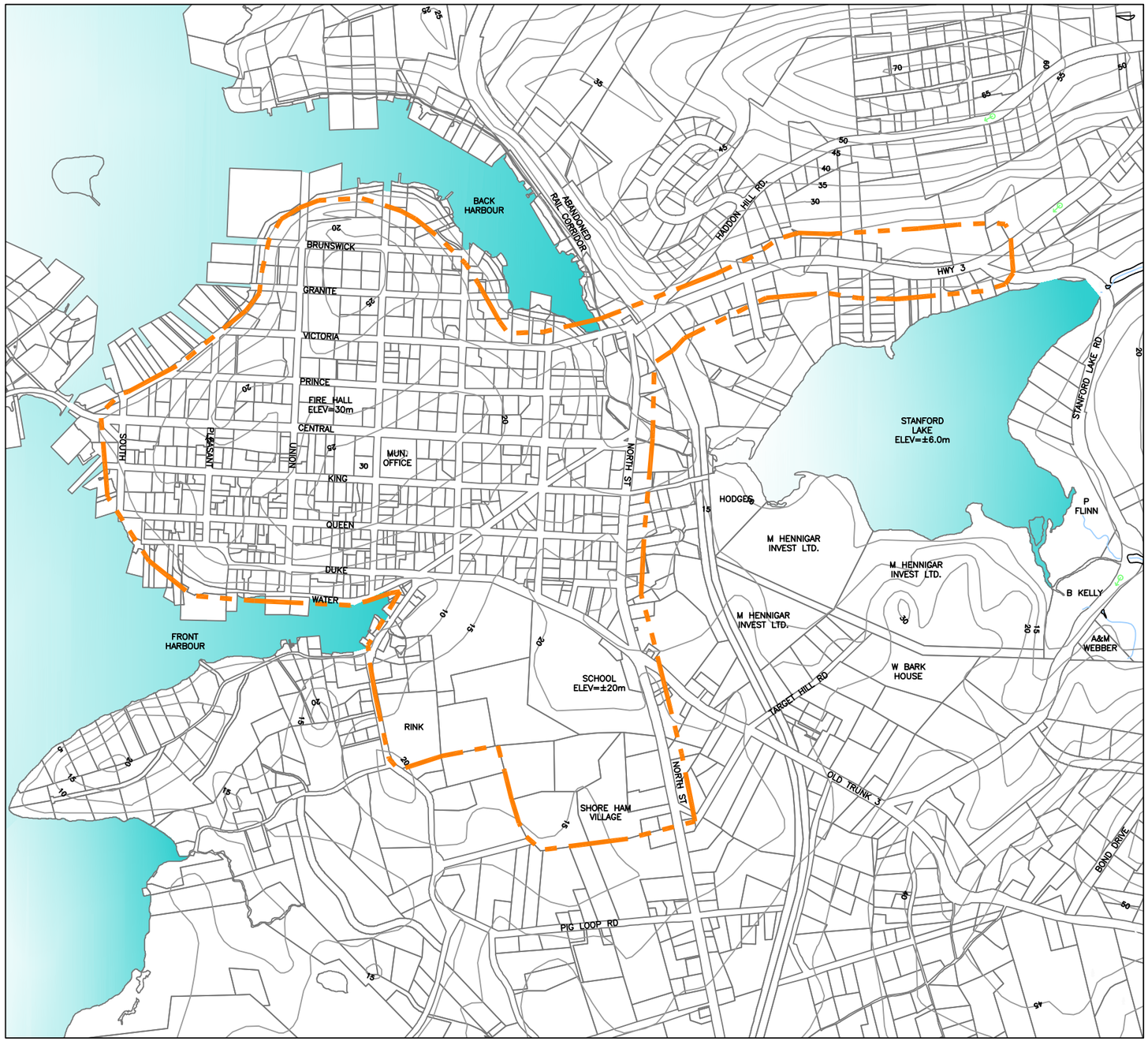
2.0 Water Service Boundary

Reportedly, the Village core is in the greatest need for central water and, accordingly, this exercise focuses on servicing the Village core.

Although there are problem areas beyond the Village core, the lower density development does not appear to have impacted overall well yields with the exception of the Shoreham Village Seniors complex and Chandlers Cove condominium development; both of which have experienced reduced capacity issues. The service area used in the conceptual design is illustrated on Figure 1.0.

3.0 Population Projections

Most major components of a water system should be designed based on 20 to 25 year population projections. Population data was obtained from Statistics Canada for the Village and surrounding areas generally within the service area defined in Section 2.0. The census data is shown in Table 1. This area was created in 1991, derived from the provincial government's definition of a Class IV settlement for Municipal Grant purposes.



LEGEND

SERVICABLE BOUNDARY

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No.	Date	Revision Description	Appr'd
2	23 FEB 11	REVISED SERVICE BOUNDARY	KVM
1	22 MAR 10	ISSUED FOR APPROVAL	KVM

FIGURE 1.0

CHESTER WATER SUPPLY

PROPOSED WATER SERVICE BOUNDARY

Dwg. P04 | SCALE 1:10000 | DATE: May 04,2011

There are four enumeration/dissemination areas (060145, 060146, 060147, and 060148) within the area as illustrated on Figure 2.

Table 1 – Statistics Canada Census Data

Year	Population	Dwellings	Area (Ha)
2006	1,501	889	4.04
2001	1,590	838	3.88
1991	1,575		

Although the census data for previous years was based on a smaller area, Interprovincial Engineering Ltd. estimated the population in 1987 as 1449 persons and projected a 2 percent annual increase. However, based on the above census figures and population trends, it does not appear that any significant growth can be expected for the Chester area. The 25 year (2036) projected design population is therefore assumed to be 1500 persons.

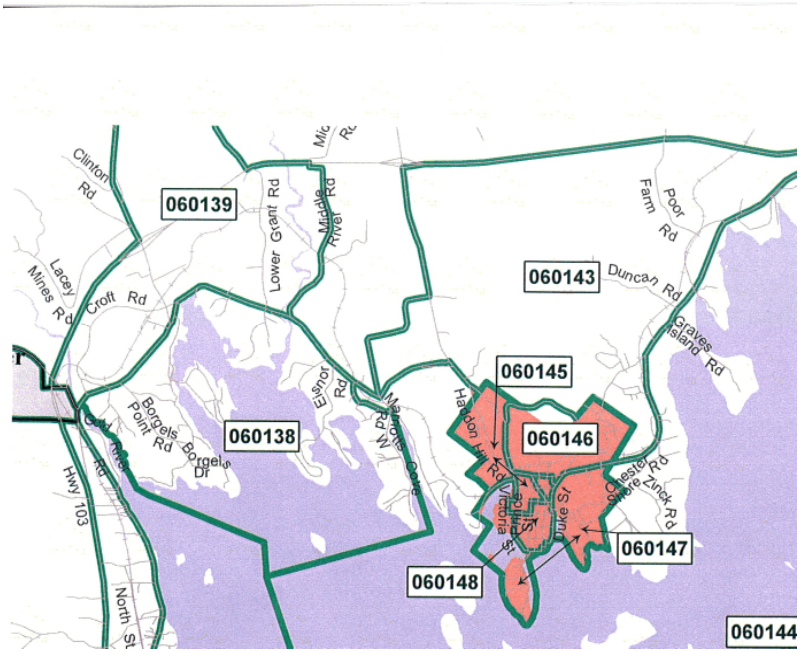


Figure 2.0 – Statistics Canada Dissemination Areas

4.0 Water Supply Design Criteria

4.1 Water Use and Estimated Demands

The key parameters that are considered in a water system design are Average Day Demand and the Maximum Day Demand.

The Average Day Demand is the average daily rate of flow of water in a year that must be supplied by the system to satisfy customer demands.

The Maximum Day Demand is the largest daily rate of flow of water in a year that must be supplied by the system to satisfy customer demands.

For proposed systems without historical data, unit flows are used to estimate Average Day Demands based on the number and types of users. Chester is typically a residential community with supporting businesses that do not use significant volumes of water. Possibly the most significant factor is demands present during the summer months perpetuated by increased tourism. Other significant users of water are the school and the Shoreham Village seniors housing complex. Future commercial and institutional consumption is more difficult to estimate. Consumption will be dependent upon the particular activities and population of the organizations that locate within, and in close proximity to, the Village. For this assessment an additional daily allowance of 200 tourists dining in a restaurant three times and staying in a hotel in the Village and surrounding areas has been included.

Based on the above, future Average Day Demand is summarized in Table 2.

Table 2 – Water Demand Summary

Water Use	Population	Unit Average Day Demand (L/day/cap)	Average Day Demand (m^3/day)
Residential	1,500	410	615
Institutional	250	227	57
Commercial	200	57	11
Tourists	200	280	56
Total			**739**

The total estimated Average Day Demand is estimated to be 739 m^3/day (513 L/min or 136 usgpm). The future Maximum Day Demand is estimated to be 1848 m^3/day (1283 L/min or 339 usgpm) using a peaking factor of 2.5.

4.2 Source of Supply

The Wendt and Interprovincial reports evaluated potential raw water supply sources including groundwater and surface sources (Middle River, Spectacle Lake and Stanfield Lake). Both recommended Spectacle Lake due to its superior water quality and relatively undeveloped lakeshore.

Study work completed by earth-water Concepts in 2009 estimated the reliable lake yield to be approximately 1400 m^3/d (260 usgpm). The mean surface water elevation at the lake is 32.6 metres.

earth-water Concepts classified the water from Spectacle Lake as very soft, sodium-chloride type water with low TDS, low pH, and extremely low alkalinity.

4.3 Water Treatment

According to the earth-water Concepts report, although most of the water samples analyzed meet the GCDWQ (2007), the following treatment criteria will be required to ensure the integrity of the distribution system, customer plumbing systems and aesthetic quality of drinking water:

- Reduce the potential for THM formation
- Increase alkalinity
- Increase pH

4.4 Treated Water Storage

4.4.1 Design Criteria

4.4.1.1 Storage Volume

Storage in the form of above or below ground tanks is essential to meet several system requirements including peak balancing storage, fire protection and emergencies.

Treated water storage is required for balancing daily peak flows within the distribution system and filter backwash at the treatment plant. Distribution balancing storage is typically calculated at 25 percent of the Maximum Day Demand.

Reservoirs that accommodate fire protection are commonly sized to provide 2 to 3 hours of fire flow. Typical minimum fire flow rates for mixed residential development range between 7500 and 9500 L/min (2000 and 2500 usgpm). Previous correspondence with IAO recommended a fire flow of 7500 L/min (2000 usgpm) over a 2-hour duration for the residential areas and up to 9800 L/min (2600 usgpm) over 2 hours for the Shoreham Village Complex. Prior to detailed design IAO should be consulted for survey results that reflect conditions at the time of detailed design.

Emergency storage is provided for times of extended power outages, mechanical failures, watermain breaks or maintenance shutdowns. Emergency storage is typically calculated at 25 percent of the sum of peak balancing and fire storage.

In the sizing of a storage tank, consideration must also be given to minimizing dead storage and ensuring that there is adequate turnover of treated water to prevent deterioration of water quality.

Table 3 summarizes the design criteria and corresponding estimated storage volumes.

Table 3 – Treated Water Storage Volume Summary

Description	Criteria	Volume (m^3)
Peak Balancing Storage (A)	25% of Maximum Day Demand	462
Fire Protection Storage (B)	2 Hour duration at 9800 L/min fire flow	1176
Emergency Storage Storage (C)	25% of A + B	410
Total Estimated Storage		**2048**

4.4.1.2 System Pressures

It is important to establish criteria for minimum and maximum system pressures. Typically minimum acceptable system pressures range between 30 and 40 psi and maximum pressures between 80 and 100 psi.

Within the serviceable boundary, the highest ground is located in the centre of the Village near the fire hall with elevations of 30 metres.

4.5 Raw Water Transmission

Sizing of raw water transmission mains was completed for each alternative based on the following criteria.

- Minimum velocity of 1.0 m/sec
- Flow rate equal to Average Day Demand
- Minimum pressure at water treatment plant

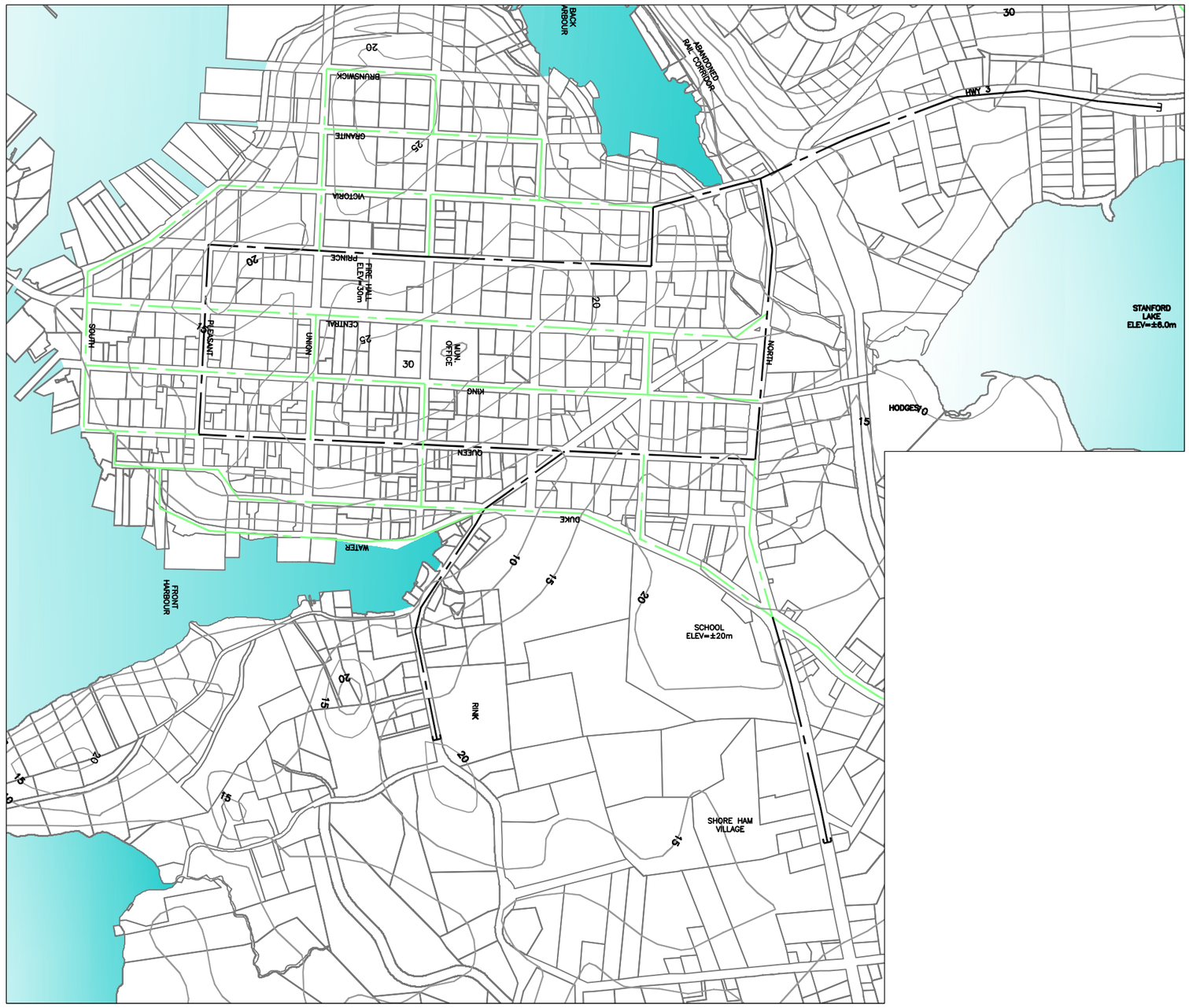
4.6 Treated Water Pumping System

Pumping of treated water will be required between the water treatment plant and the elevated storage facilities. The most practical solution is to locate pumping facilities at the water treatment plant.

4.7 Distribution Pipe Network

Figure 3.0 illustrates the proposed overall distribution system.

System modeling was performed to determine the minimum pipe diameters required to service the entire water service boundary.



LEGEND

- PRIMARY DISTRIBUTION
- RAW WATER TRANSMISSION
- TREATED WATER TRANSMISSION & DISTRIBUTION

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FIGURE 3.0

CHESTER WATER SUPPLY

OVERALL DISTRIBUTION

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A distribution pipe network model was developed using the following design criteria.

- Minimum 40 psi pressure during Average Day Demand conditions
- Minimum 20 psi pressure during fire flow conditions
- Minimum 30 psi pressure during Maximum Hour Demand conditions
- Maximum 80 psi pressure during low flow conditions

The distribution system was modeled using WaterCad software. The results are provided in Appendix B.

5.0 Facility Siting

5.1 Water Treatment Plant

5.1.1 Site Selection Criteria

Selecting a plant location should be approached with an objective towards minimizing operating and capital costs. The significant variable for operating costs is pumping. Other issues that should be taken into consideration include:

- Minimum site size
- Related site works and access roads
- Raw water transmission main route and pumping
- Common site for treatment and pumping
- Chlorine contact times
- Backwash and other waste disposal options including proximity to sanitary sewer systems
- Proximity to three phase power
- Land use and ownership
- Proximity to treated water storage
- Cost comparisons

5.1.1.1 Minimum Site Footprint

In selecting a suitable site, one has to consider not only the WTP building size but also chemical delivery, employee parking, and miscellaneous equipment storage. For this conceptual exercise a minimum area of 4000 m^2 (1.0 acre) was considered. If the parcel will also accommodate an above ground storage reservoir, then a 8000 m^2 (2.0 acre) allowance is recommended.

5.1.1.2 Related Site Works and Access Roads

To minimize construction and maintenance costs the site should be located in close proximity to a maintained public highway.

5.1.1.3 Raw Water Transmission Main Route and Pumping

To avoid the need for raw water pumping, consideration should be given to locating the treatment plant such that adequate flow can be supplied by gravity. Depending on transmission main size and associated hydraulic losses, it is possible to deliver raw water by gravity to a large portion of the study area. Another consideration is the availability of rights-of-way or easements between Spectacle Lake and the water treatment plant.

5.1.1.4 Common Site for Treatment and Pumping

Previous study work considered separate locations for treatment and pumping systems. It is typically more cost effective to consolidate pumping and treatment facilities under one roof. For this exercise, it was assumed that the pumping equipment will be housed at the water treatment plant.

5.1.1.5 Chlorine Contact Times

The treatment plant and treated water storage facilities should be in close proximity to the users. Chlorine residuals in distribution systems are difficult to maintain where there is a long distance between the treatment facility and the extreme ends of the distribution system.

5.1.1.6 Backwash and Other Waste Disposal Options Including Proximity to Sanitary Sewer Systems

In comparison to treating wastes on site, it is more economical to discharge treatment plant wastes to an existing sewerage system. For this exercise, it was assumed that treatment plant wastes will be directed to the current wastewater treatment plant.

5.1.1.7 Proximity to Three Phase Power

Limiting the need to upgrade or extend 3 phase power will

minimize development costs.

5.1.1.8 Land Use and Ownership

Municipal infrastructure should always be sited with consideration to current land use and ownership of not only the site but also adjacent properties. This exercise has only considered previously commercially used or vacant parcels of land for the treatment plant and reservoir. Further, the sites considered are not immediately adjacent to existing dwellings.

5.1.1.9 Proximity to Treated Water Storage

The plant's proximity to the treated water storage will greatly affect operating and capital costs in the form of pumping and transmission main sizing.

5.1.1.10 Cost Comparisons

Most of the criteria above are reflected in the cost comparisons of alternative sites. A cost analysis of the proposed alternative water treatment plant and reservoir sites is performed in Section 6.0.

5.1.2 Treatment Plant Site Selection

Previous study work by Paul Wendt and Interprovincial Engineering suggested a WTP located (i) at Spectacle Lake, (ii) near the corner of the Old # 3 Highway and the Target Hill Road, or (iii) adjacent to the Stanford Lake Road (Flinn property). The options were reevaluated and subsequently option (i) was excluded primarily because the site is not easily accessed by public roads. Option (ii) was excluded because of the excessive length of the raw water transmission main.

To supply a new WTP by gravity from Spectacle Lake, consideration has to be given to the hydraulic grade line between the lake and the proposed WTP site. Based on the assumptions presented in Appendix A "Design Calculations", the highest WTP floor elevation that can be supplied by gravity is between elevation 25.0 and 30.0 metres. The greater the distance between the WTP site and the lake, the lower the WTP site has to be to accommodate friction loses in the transmission main.

Suitable locations for a water treatment plant are illustrated on

Figure 4.0 based on the following criteria:

- Supplied by gravity from Spectacle Lake
- Maximum 25.0 metre ground elevation
- Within pumping distance to an existing sewage collection system
- Within 100 metres a public road
- Within 500 metres of existing three phase power supply
- Within 1000 metres of potential reservoir sites
- Parcels containing dwellings have been excluded from the site selection

Based on the constraints mapping and a windshield survey, the following parcels have been identified as possible sites for a WTP plant:

Table 4 – Summary of Potential Water Treatment Plant Sites

Site	PID	Owner
WTP #1	60140332	Chandler
WTP #2	60147147	Bond
WTP #3	60146750	Hennigar
WTP #4	60094497	Flinn

5.2 Treated Water Storage

5.2.1 Site Selection Criteria

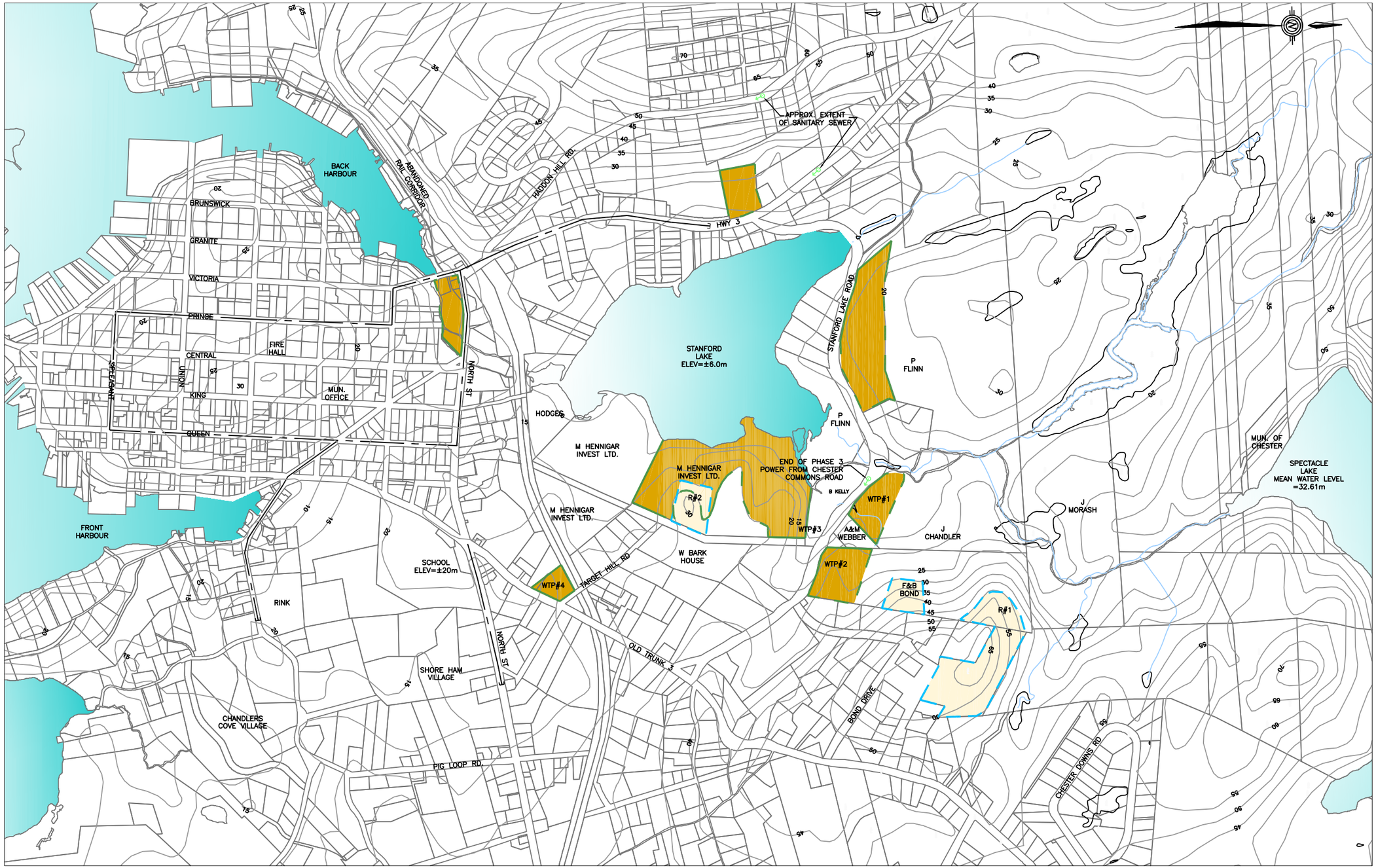
Many of the site selection criteria for a treatment plant also apply to a reservoir. The main goal is to minimize operation and capital costs.

Additional criteria include:

- Proximity to service area
- Minimum reservoir elevation

5.2.1.1 Proximity to Service Area

The reservoir's proximity to the service area will greatly affect capital costs in the form of transmission main sizing. The further the reservoir is from the Village, the larger the transmission main will be in order to overcome the increased



LEGEND

- POTENTIAL WTP SITES
- POTENTIAL RESERVOIR SITES

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FIGURE 4.0

CHESTER WATER SUPPLY

WATER TREATMENT PLANT & RESERVOIR SITES

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friction losses.

5.2.2 Minimum Reservoir Elevation

Criteria which will influence the design elevations for a reservoir are:

- Minimum operating pressure of 40 psi at the highest ground elevation to be serviced (+/- 30 metres) during periods of Maximum Hour Demand.
- Minimum operating pressure of 20 psi during fire flow conditions of 9800 L/min (2600 usgpm) at Shoreham Village.
- Maximum operating pressure of 100 psi at the lowest ground elevation to be serviced (+/- 5.0 metres) during low flow periods.
- Practical transmission pipe size to minimize friction loss between the reservoir and the Village Core and Shoreham Village.

Calculations provided in Appendix 1 indicate that the water level in the reservoir should be between 65 metres and 70 metres in order to satisfy the minimum and maximum system pressure requirements. Assuming a maximum height of 37 metres (120 ft) for an above ground reservoir, it should be located on ground above 28 metres to support the above criteria.

5.2.3 Treated Water Storage Site Selection

Previous study work by Paul Wendt and Interprovincial Engineering suggested elevated storage reservoirs located (i) on Central Street near the current fire hall, (ii) on Haddon Hill, and (iii) near Lookoff Hill. The options were reevaluated and subsequently options (i) and (ii) were excluded because the reservoir was too far from the WTP. The treated water transmission main from the WTP would have been excessively long, increasing the operating and capital costs.

Suitable locations for a reservoir are illustrated on Figure 4.0 based on the following criteria:

- Minimum 28.0 metre ground elevation
- Within 1000 metres of potential water treatment plant sites
- Within 1500 metres of service area

- Parcels containing dwellings have been excluded from the site selection

Based on the constraints mapping and a windshield survey, the following parcels have been identified as possible sites for an above ground reservoir:

Table 5 – Summary of Potential Treated Water Storage Sites

Site	PID	Owner
R #1	60147147	Bond
R #2	60146750	Hennigar

6.0 Site Selection Scenario Analysis

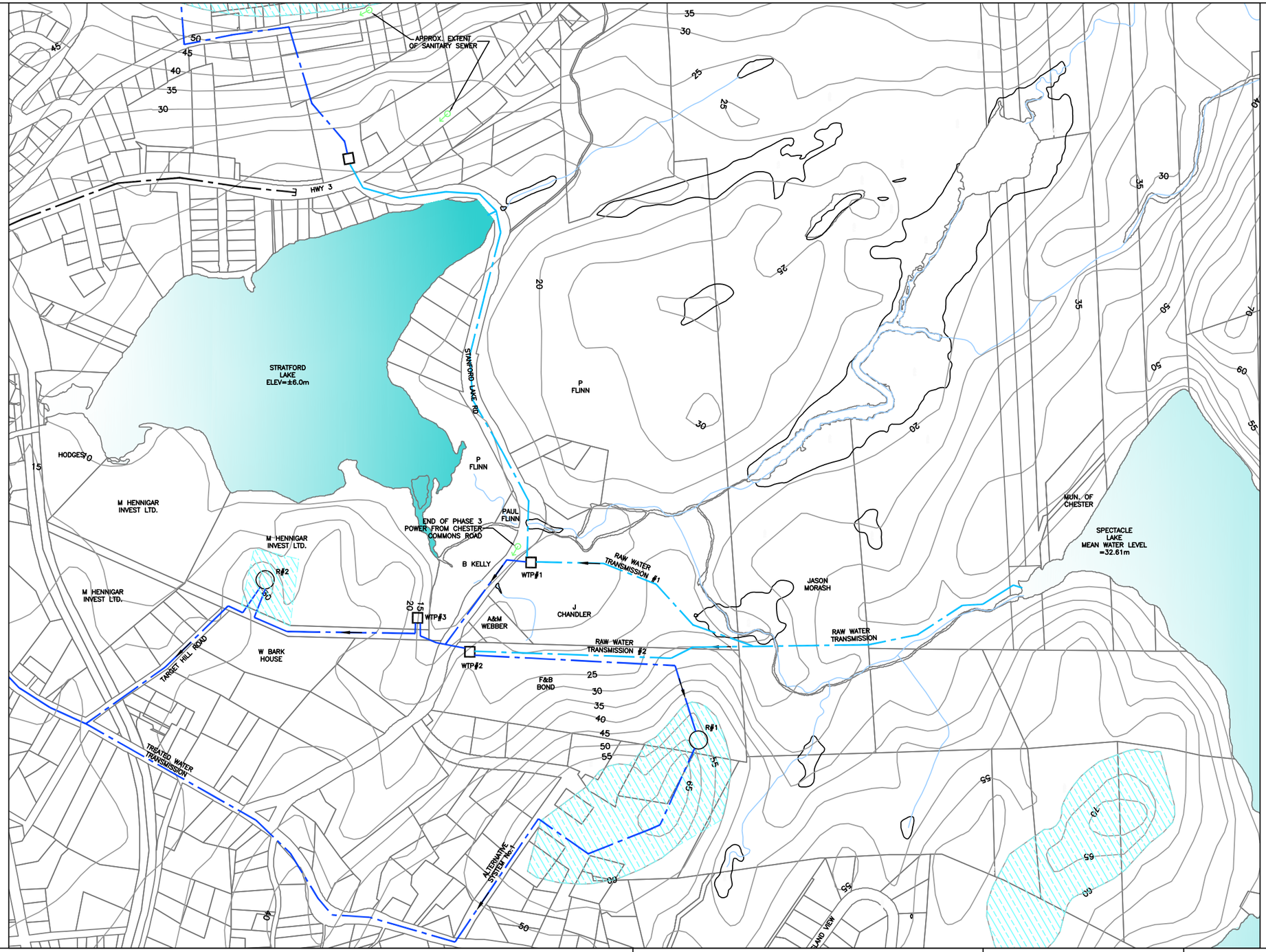
Six scenarios of water treatment plant and reservoir locations were considered and are illustrated on Figure 5.0. A cost estimate matrix was prepared taking into consideration the site development costs and relative location costs for several options. The cost matrix is provided in Table 6.

Table 6 – Water Treatment Plant & Reservoir Site Cost Comparison

Description	Option A WTP #1 R #1	Option B WTP #1 R #2	Option C WTP #2 R #1	Option D WTP #2 R #2	Option E WTP #3 R #1	Option F WTP #3 R #2
Raw water transmission	$460,000	$460,000	$487,000	$487,000	$536,000	$536,000
Water treatment plant	$3,200,000	$3,200,000	$3,200,000	$3,200,000	$3,200,000	$3,200,000
Treated water storage	$1,050,000	$2,940,000	$1,050,000	$2,940,000	$1,050,000	$2,940,000
Treated water transmission	$1,000,000	$410,000	$890,000	$340,000	$940,000	$310,000
Total Estimated Cost	**$5,710,000**	**$7,010,000**	**$5,627,000**	**$6,967,000**	**$5,726,000**	**$6,986,000**

As shown in Table 5, Option C is the most cost effective scenario to construct a new water treatment plant and storage facilities. This option is attractive also because both facilities would be located on the same parcel of land which simplifies the land acquisition process. There is little variation in estimated cost between Options A, C, or E so if there were any concerns in locating the water treatment plant at the proposed location, either of the other options would be feasible.

The major component affecting the overall cost is the water storage reservoir. The reservoir constructed at a higher ground elevation of 60.0 metres provides a substantial cost savings



LEGEND

- POSSIBLE WATER TOWER LOCATION
- RAW WATER TRANSMISSION
- TREATED WATER TRANSMISSION

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FIGURE 5.0

CHESTER WATER SUPPLY

WATER TREATMENT PLANT & RESERVOIR SITE ALTERNATIVES

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over one constructed at a lower elevation of 30.0 metres.

7.0 Cost Estimates

The following is a breakdown of the major costs for the implementation of the proposed water system.

Table 7 – Water System Pre-Design Cost Estimate

Description	Cost
Raw water transmission	$687,000
Water treatment plant	$3,200,000
Treated water storage	$1,050,000
Treated water transmission	$890,000
Distribution	$4,600,000
Subtotal	**$10,427,000**
Engineering & Contingency (25%)	$2,606,000
Total Capital Cost	**$13,033,000**

8.0 Recommendations

The major component sizing and siting as part of the pre-design work carried out in this study include:

- Using Spectacle Lake as a raw water source.
- Locating a new water treatment plant and a new reservoir near Stanford Lake Road.

9.0 References

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