APPENDIX 1

WELL CAPACITY & STORAGE NEEDS TECH MEMO

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TECHNICAL MEMORANDUM

To:	Ahmad Sarwar	**RVA:**	215933
From:	Gian Carlo Manigbas		
Copies:	Andrew McGregor		
Date:	July 20, 2023		
Subject:	Carlisle RSA Well Capacity and Storage Requirements		

1.0 Project Scope

R.V. Anderson Associates Limited (RVA) has been retained by the City of Hamilton (the City) to provide engineering services for the Carlisle Water Storage Facility Municipal Class Environmental Assessment (EA) and Conceptual Design (the project).

As part of the first phase of the project, this Technical Memorandum (Tech Memo) was developed and updated to discuss the initial calculations of the required well supply and capacity for the Carlisle Rural Settlement Area (RSA) based on its population projection and water consumption data received from the City. These calculations were compared against the existing and future water demands of the system to determine the need for additional supply capacity to service the area.

2.0 Introduction

The Carlisle RSA is currently being supplied by four (4) groundwater wells, while storage is provided by one (1) elevated tank with a total volume of 1,400 m^3.

Table 2.1 shows the rated capacity and the maximum allowable flow rate that can be taken from each well based on the Drinking Water Works Permit (DWWP, 2019) and the Permit to Take Water (PTTW, 2021). As shown in the table, the total combined yield that can be taken from the groundwater wells is 49.8 L/s.

Table 2.1: Carlisle RSA's Existing Well Capacity

Wells	Rated Capacity per DWWP (L/s)	Max. Allowable Capacity per PTTW (L/s)
FDC01	9.8	9.8*
FDC02	9.8	
FDC05	15.0	15.0
FDC03R	25.0	25.0
Total Capacity		49.8
Firm Capacity		24.8**

*PTTW indicated that the supply from either or both FDC01 and FDC02 shall not exceed an annual daily average flow rate of 9.8 L/s.

**Firm capacity is defined as the total flow rate with the largest well taken out of service.

According to the *10 State Recommended Standards for Water Works (Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers, 2018)*, it is recommended that the total developed groundwater source capacity (unless otherwise specified by the review authority), shall be equal or exceed the maximum day demands with the largest producing well out of service, which in Carlisle RSA's case, the firm capacity is 24.8 L/s with the largest supply well (FDC03R) out of service. This can be considered a conservative approach considering the worst-case scenario where the largest well is offline (i.e., due to maintenance or repair for an extended duration, etc.) and that the remaining wells should supply and meet the required water demands under maximum day conditions.

In addition to determining the current supply capacity of the existing water supply system of Carlisle RSA, the present and future population and the water demands were identified to provide estimates for additional storage and supply capacity improvements to service the area for present and future conditions.

3.0 Carlisle RSA Population

This section documents the basis for calculations of the Carlisle RSA's existing and future populations and with reference to its existing and future maximum day water demands.

3.1 Population Density

Given that the Carlisle RSA is a rural settlement and may differ from other parts of the City of Hamilton, it is recommended to use a population density that is specific to its land classification. By doing so, the total population within the area was identified based on multiple sources which were found and used as references to the population estimates. These sources were identified as follows:

1. Statistics Canada Census between the years 2011 and 2021
2. City of Hamilton Standards (Water)
3. City of Hamilton's Development Charge Study (Watson & Associates, 2019)
4. City Estimates based on GIS Parcels

Table 3.1 shows the Carlisle RSA's population density comparison between the data sources mentioned above. Accordingly, the total current population (2022) based on the City estimates is 2,608 people. Historical population data sources collected from the Statistics Canada Census between the years 2011 and 2021 were used to determine the population density for Carlisle RSA with a measured population of 2,363 people and an estimated density of 3.05 persons per unit (PPU). In addition, according to the data sources, a population density of 2.81 PPU is currently being used for the existing population with developed land parcels based on the City Standards.

Table 3.1: Existing Population Density Based on Historical Data

Source of Data -->	Census 2011	Revised Census 2011*	Census 2016	Census 2021	City Standard (2022 max)	DC Study** ('New'max)	City Estimates (2016)	City Estimates (2022)	Storage Memo (2015)***	Selected
Measured population	2363	1879	1869	1858	-	-	1869	2608	2363	
Measured dwellings & apartments	776	629	629	626	-	-	640	889	776	
People per unit	3.05	2.99	2.97	2.97	2.81	3.41	2.92	2.93	3.05	**3.05**

** Census in Carlisle RSA for the year 2011 was revised in 2016 which resulted in a reduced Carlisle area.*

*** Development Charge Study for the whole City may not be applicable and the population may be too high for Carlisle.*

**** Refers to Carlisle Water Storage Memo (WSP, 2015)*

In regard to the population density for future developments, new households in the City of Hamilton have a planned population density of 3.41 PPU according to the *DC Background Study (Watson & Associates, 2019)*.

As discussed with the City, as a conservative approach based on the data shown in Table 3.1, population densities of 3.05 PPU and 3.41 PPU were selected to calculate Carlisle RSA's current (developed land parcels) and future (undeveloped land parcels) populations, respectively. These selected population densities were also used to determine the water demands to be serviced by the Carlisle RSA supply wells and distribution system based on its GIS parcels for land use as discussed in the following sections.

3.2 Current Serviced Population

In Carlisle RSA, there are currently two types of water service connections to its residential dwellings, these are: (1) public connection to the municipal water supply network and (2) private connection to a confined or unconfined aquifer through a well. In order to estimate the additional capacity and storage needed to meet the future water demands of Carlisle RSA, the existing population currently being serviced by the municipal system was identified.

Based on the latest GIS data received by RVA on May 23rd, 2023, there are currently six hundred eleven (611) water meters on record that are connected to the Carlisle RSA's water distribution system. Based on the discussion with the City, a total of six hundred and ten (610) water meter connections are from single-family detached homes, and one (1) meter is currently connected to an apartment building with a total of forty (40) units (based on City data).

Table 3.2 shows the number of properties within Carlisle RSA based on the parcels from the GIS data and the comparison between different data sources and records per the available years. Accordingly, the estimated current population within the area based on the *City records is **1,930 people** [(610 single-detached units x 3.05 PPU) + (40 apartment units x 1.74 PPU)] which is the highest estimated population from the data sources available and can be considered as conservative.

** The City Records include the GIS data of Carlisle with the number of existing dwellings with water meters plus the PPU factor of 1.74 for apartment buildings which was based on the Future Growth information provided by the City through email on April 27th, 2023 as discussed during the first stakeholder meeting dated April 11, 2023*

Table 3.2: Carlisle RSA's Current Population Being Serviced

Source of Data -->	City Estimates (2014)	Storage Memo (2015)	GIS Parcels (2015)	GIS Parcels (2021)	City Records (2023)	GIS Data (2023)	Selected
Properties on municipal supply	590	603	630	608	611	610	**611**
Population on municipal supply	1800	1840	1922	1854	1930	1927	**1930**

3.3 Future Population

This subsection provides a discussion about the references used in estimating the future population of Carlisle RSA. The population density of 3.41 PPU was used to estimate the area's projected future population with undeveloped land parcels based on the City's Development Charge Study. It was assumed that the ultimate buildout (future condition) for the rural settlement area is the year 2051.

Based on the information and data received by RVA, there are three (3) components that comprise the future population count within Carlisle RSA. These components are as follows:

- Potential Population to be Serviced by New Municipal Connections
- Future Development Population
- Secondary Dwelling Population

3.3.1 Potential Population to be Serviced by New Municipal Connections

The potential population to be serviced by the new municipal water connections include parcels that are not yet connected to the municipal supply which may become connected to the municipal service via new connections.

Table 3.3 shows the potential population to be serviced via new connections within Carlisle RSA based on various sources of data. Accordingly, the maximum dwellings for conversion to the municipal supply have populations of 287, 250, 293, and 284 based on the City estimates, the calculations from the Water Storage memo by WSP, the GIS parcels, and the data provided by the City, respectively. RVA used the population density of 3.41 PPU (single-detached homes) based on the estimates provided under Section 3.1 for all the potential new connections with developed land parcels that are currently not connected to the municipal system.

Table 3.3: Potential Population to be Serviced by New Municipal Connections

Source of Data -->	City Estimates (2014)	Storage Memo (2015) Phase 1	Storage Memo (2015) Phase 2	Storage Memo (2015) Total	GIS Parcels* (2015)	City Records (2023)	Selected
Max dwellings for conversions to municipal supply	287	110	140	250	293	284	
Max population for conversions to municipal supply	979	376	478	853	1000	969	**969**

**GIS parcel count includes individual units within a multiple-unit complex that reside in the same parcel location (i.e., apartment buildings).*

Notes:

- *According to the Carlisle Water Storage Memo (2015) by WSP, the new connections to the municipal supply have two (2) phases, these are:*
  - *Phase 1 – connection for the properties that front the water main and can easily connect.*
  - *Phase 2 – properties within the RSA that may connect in the future but don't face a watermain at this point.*

  It should be noted that these data and information were provided for the purpose of comparison to other data references to ensure that the approach taken for the calculation accounts for reasonable conservatism as a safety factor to the design. The population density projections were not developed based on the WSP (2015) Memo.
- *Reference to the City's Record (2023) data provided in the table above include City GIS Data, City of Hamilton Zoning By-Law, Rural Hamilton Official Plan, Water Production Data, Water Billing (Consumption) Data, and Drinking Water Summary Reports.*

Based on City records, Carlisle RSA has a total of 895 developed land parcels. A total of 611 land parcels are currently connected to the municipal system, while the remaining 284 land parcels have their own water supply, mainly from underground wells. Accordingly, based on City records, a total of 969 additional people (284 x 3.41 PPU) can potentially connect to the municipal system in the future.

Subsequently, City records were then compared to the City's GIS data of land parcels. Accordingly, there is a total of 293 developed land parcels that are not connected to the municipal system which is the highest estimated total number of developed land parcels from all data sources. Furthermore, the highest estimated population of 1,000 people (293 units x 3.41 PPU) based on the GIS data of land parcels.

Based on the data shown in Table 3.3 and the information provided above, the maximum population of 969 people from the latest City records was selected as the maximum population that will have potential new connections to the municipal system with reasonable

conservatism for the demand estimates and for consistency with the City's data and records.

3.3.2 Future Development Population

Table 3.4 shows the Carlisle RSA's estimated future development population based on the City estimates (2014), the Water Storage memo by WSP (2015), and the latest data and information for undeveloped land parcels based on City records. According to the City estimates, the highest total projected future population number based on the available undeveloped land parcels is sixty-nine (69) people. This number was derived from the 20 undeveloped land parcels with a population density of 3.41 PPU (20 units x 3.41 PPU) for future residential developments. However, based on the City's latest updates (dated April 2023) for undeveloped properties/land parcels, only fourteen (14) additional single-family detached homes are available for future development within the Carlisle RSA; therefore, this number was used as a basis for future development population estimates resulting in forty-eight (48) people (14 x 3.41 PPU).

Table 3.4: Future Development Population

FUTURE DEVELOPMENT POPULATION						
		Storage Memo (2015)				
Source of Data -->	City Estimates (2014)	Phase 1	Phase 2	Total	City Records (2023)	Selected
Parcels/Units available for future developments	20	4	13	17	14	
Future development population	69	14	45	58	48	**48**

3.3.3 Secondary Dwelling Population

Based on correspondence with the City, secondary dwelling units in Carlisle will not be approved until adequate municipal water servicing is in place. In addition, there was no data and information available at the time of writing this tech memo to estimate the number of secondary dwelling units. Therefore, the population for the secondary dwelling units was assumed to be zero.

3.3.4 Total Future Population

Based on Carlisle RSA's existing population and the three components to estimate the total future population described in Sections 3.2 and 3.3, the total future population to be

serviced within the rural settlement area is 2,947 people. This future population count was then used to calculate the future maximum day water demands.

4.0 Water Demands

This section provides a discussion of the water demand calculations to be serviced by Carlisle RSA's water distribution system.

4.1 Average Day Demand Historical Data

The historical average day demand consumption data within Carlisle RSA from multiple data sources were collected and analyzed to calculate the per capita demand in L/cap/day.

Table 4.1 summarizes the historical data of the average day demand consumption within Carlisle RSA based on the billing records, the WSP storage memo, the City records, and the City's Drinking Water Report. The average day demand consumption was calculated based on the assumption that the water demand consumption and behavioral pattern (which may be affected by the water conservation measures) will continue under future conditions.

The recorded average day demand from 2015 to 2022 based on the latest data from the City and the Drinking Water Report is 702 m^3/d with a resulting average day demand per capita of 365 L/cap/day. It should be noted that conservation measures were implemented in the summer of 2004 and between the years 2015 to 2019 within Carlisle and will be maintained in the future according to the City.

As noted in Table 4.1, a surge in total annual consumption occurred within the Carlisle RSA in the year 2016 based on the City records. Accordingly, there is about a 19% increase (835 m^3/d) in the average day demand consumption compared to an average consumption rate of 702 m^3/d from year 2015 to year 2022 which was taken into consideration since the data was based on the daily water demand consumption (happens frequently per year). According to City data, this year experienced long periods of dry-weather conditions, resulting in a lower supply of available water supply and higher water consumption within the area.

Table 4.1: Average Day Demand Historical Data

EX. AVERAGE DAY DEMAND																
Source of Data -->	Billing Records	Storage Memo (2015)					City Records				Drinking Water Report					
	Average 2011-2013	2009	2010	2011	2012	2013	2015	2016	2017	2018	2019	2020	2021	2022	2015-2022	2009-2022
Total Annual Consumption (m3)	276539	305108	290704	216427	283918	284287	260500	304868	238458	258972	226411	287777	259091	298197		
Existing service population	1839	1839	1839	1839	1839	1839	1922	1922	1922	1922	1930	1930	1930	1930		
Average Day Demand (m3/d)	758	836	796	593	778	779	714	835	653	710	619	785	708	**814**	**702**	**722**
per capita (L/cap/d)	412	455	433	322	423	424	371	435	340	369	321	407	367	**422**	**365**	**381**

Furthermore, a substantial increase in water consumption can be observed starting from the year 2020 with an average of 15% increase in average daily consumption rate compared to years 2015 to 2019, possibly due to COVID-19 where most people stayed at home with a hybrid work model. According to the City's SCADA data, the highest water consumption recorded during the summer was of the year 2022 with a total volume of 147,928 m^3 from the months of June to August mainly due to irrigation. An average of 14% increase in water consumption compared to the previous year was also recorded outside the summer months for the year 2020 to the year 2022 because of the hybrid work model.

Since the hybrid work model is still being implemented and considered permanent by some if not most industries, an alternate approach to the dry weather experienced in 2016 that may overestimate the additional storage requirements and also considering the City's conservation measures within the area, the water consumption rate recorded in the year 2022 with a total average annual consumption rate of **814 m^3/d** and a resulting average daily demand per capita of **422 L/cap/d** (due to the hybrid work model) can be considered more of a reasonable estimate of Carlisle RSA's average daily demand. On this basis, the values mentioned above are recommended for future estimates.

4.2 Historical Maximum Day Demand

Table 4.2 summarizes the historical data based on the City records of maximum day water demand consumptions within the Carlisle RSA from 2015 to 2022. The recommended maximum day demand peaking factors, based on the Ministry of Environment, Conservation, and Parks (MECP) (population of less than 2,000 people) and the Water and Wastewater Master Plan of the City of Hamilton, were also included in the table for comparison purposes.

Table 4.2: Historical Maximum Day Demand

	City Records*				Drinking Water Report**								
	2015	2016	2017	2018	2019	2020	2021	2022	MECP Recommended (pop. <2000)	Master Plan (2006)	2015-2018	2015-2022	Selected
Average Day Demand (m3/d)	714	835	653	710	619	785	708	814	Eq. MDD:				
Maximum Day Demand (m3/d)	2216	2735	1725	2164	2279	2704	2432	2648	1755		2210	2363	**2363**
MDD peaking factor	3.1	3.3	2.6	3.0	3.7	3.4	3.4	3.3	2.5	3.0	3.04	3.4	**3.4**

** The maximum day demands from 2015 to 2018 were based on the City of Hamilton's Daily Summer Demands Data which includes months from May to September of each year. These months are typically when the highest water demand occurs.*

*** The maximum day demands from 2019 to 2022 were based on the Drinking Water Systems Annual Summary and Water Quality Report of the City of Hamilton. The detailed data was shown in Appendix A-5.*

Based on Table 4.3, the calculated maximum day demand consumption rate for the Carlisle RSA is 2,363 m^3/d and a resulting peaking factor of 3.4. These are the average values derived from the year 2015 to 2022. This peaking factor is reasonably higher than the recommended values from the MECP guidelines and the master plan report and is considered appropriate as it is based on actual water consumption data from the Carlisle RSA. As mentioned in Section 4.1, it was assumed that the current water demand pattern (which may be affected by water conservation measures) will continue in the future due to the limited supply capacity and potentially observed further low water conditions due to climatic changes.

4.3 Future Projected Water Demands

Table 4.3 summarizes the estimated projected future average day and maximum day demands for the Carlisle RSA as discussed in the previous sections. Using the population estimates in Section 4.1, the average day per capita demand in Section 4.1, and the resulting MDD peaking factor in Section 4.2, the future (2051 ultimate build-out as per GRIDs study) maximum day demand is 4,271 m^3/d.

Table 4.3: Projected Future Average Day and Maximum Day Demands

FUTURE MAXIMUM DAY DEMAND		
Projected service population		2947
ADD per capita (L/cap/d)		422
MDD peaking factor		3.4
Future Average Day Demand (m3/d)		1243
Future Maximum Day Demand (m3/d)		4226

5.0 Storage Requirements

A water storage is needed in a water distribution system to supply peak demands or fire flows when these are greater than the capability of water supply source. The storage is also needed for emergency situations such as a temporary failure of the supply. The Carlisle RSA water distribution system currently has an existing elevated tower with a total storage of 1,400m^3 of storage. The following subsections document the basis and calculations used to estimate the additional storage volume needed for Carlisle RSA under both the existing and future demand conditions.

5.1 Sizing Guidelines

According to the Design Guidelines for Drinking Water Systems (MECP, 2008), the following criteria can be used to size storage facilities:

Total Storage Requirement = A + B + C

where:

A = fire storage

B = equalization storage (typically equal to 25% of maximum day demand)

C = emergency storage (typically equal to 25% of [A + B])

5.2 Fire Flow Storage

The MECP design guidelines stipulate that it is the municipality's responsibility to decide if and how much fire protection should be provided within their water distribution system. According to the City of Hamilton's Target Available Fire Flows for Different Land Uses, the fire flow requirements within Carlisle RSA can be based on its land use as summarized in Table 5.1.

Table 5.1 – City of Hamilton Target Available Fire Flows based on Land Use

Land Use	Target Available Fire Flow (L/s)
Commercial	150
Small I/I (<1800m^3)	100
Industrial	250
Institutional	150
Residential Multi (>3 units)	150
Residential Medium (3 or fewer units)	125
Residential Single	75
Residential Single (Dead End)	50

Based on the table above, the recommended fire flow requirement for the Carlisle RSA is 75 L/s for residential areas with single-detached homes, 50 L/s for single-detached homes supplied by a dead-end watermain, and 150 L/s for the apartment building (residential medium). Considering a duration of 2 hours for firefighting purposes, the total volume required for each residential is 540 m^3 for residential areas with single-detached homes,

360 m^3 for single-detached homes supplied by a dead-end watermain, and 1,080 m^3 for the apartment building. As a conservative approach, the highest calculated volume of **1,080 m^3** was selected for fire flow storage.

The selected fire flows were based on the GIS parcels provided by the City where the residential dwellings were identified as single-family detached homes and an apartment building.

5.3 Storage Requirements

As per the MECP design guidelines, the equalization storage is a factor of the maximum day demand, while the emergency supply storage is a factor of both the maximum day demand and the fire flow requirements. For this purpose, the total storage required was calculated following the MECP guidelines as documented in Section 5.2.

Table 5.2 and Table 5.3 summarize the additional storage volumes required for the existing and future demand conditions. Based on the calculations shown in Table 5.2, the total storage requirement under the current demand condition was estimated to be 2,089 m^3. Considering the current available storage volume of 1,400 m^3, the required additional storage to meet the existing water demands (both domestic and fire flows) under current maximum day demand conditions was estimated to be **689 m^3**.

Table 5.2: Storage Requirements for the Existing System

Basis of Fire Storage, A-->	Current Storage Requirements
A = Fire Storage (m^3)	1080
Current MDD (m^3/d)	2363
B = Equalization Storage (25%MDD) (m^3)	591
C = Emergency Storage (25%[A+B]) (m^3)	418
Total Storage = A+B+C (m^3)	2089
Existing Storage (m^3)	1400
Current Additional Storage Required (m^3)	689
Current ADD (m^3)	814
Total Storage Turnover (#days per turnover)	2.6

Table 5.3 shows the storage requirements under future maximum day demand conditions. Accordingly, the water storage volume requirement under the ultimate build-out (2051 based on GRIDs study) was estimated to be 2,685 m^3. Considering Carlisle RSA's existing available storage volume of 1,400 m^3, the additional storage volume needed to meet future demands under maximum day demand conditions was estimated to be **1,285 m^3**.

Table 5.3: Storage Requirements for the Future System

Basis of Fire Storage, A-->	Future Storage Requirements
A = Fire Storage (m^3)	1080
Future MDD (m^3/d)	4226
B = Equalization Storage (25%MDD) (m^3)	1057
C = Emergency Storage (25%[A+B]) (m^3)	534
Total Storage = A+B+C (m^3)	2671
Existing Storage (m^3)	1400
Future Additional Storage Required (m^3)	1271
Future ADD (m^3)	1243
Total Storage Turnover (#days per turnover)	2.1

As a conservative approach, it is ideal to have 2 to 3 days' worth of storage volume in the tank (assuming under average day demand condition) to deal with unexpected emergencies or system shutdowns where the water system is not operable for an extended period of time. The tables above include calculations for the number of days for a complete tank turnover. Given these considerations, the additional storage volume required to meet the Carlisle RSA's existing and future water demands is **1,271 m^3**.

6.0 Summary

Figure 6.1 shows a graph with a comparison between the calculated population projections, water demands, and well storage capacity in Carlisle RSA with the following key observations:

- The historical ADD and MDD water consumptions from 2009 to 2022 follow an almost flat to a slight downtrend slope (**Figure 6.1B**, top graph). This means the

water demands are almost consistent within the nine-year period and that there is no significant change in water demand which is to be expected from rural settlement areas such as Carlisle.

- RVA analyzed the City of Hamilton's historical data from 2009 to 2022 to determine the future demand per capita and the future MDD multiplier. These factors were then used to calculate the future average day and maximum day demands (**Figure 6.1.B, top graph**). The City's future MDD peaking factor were based on actual monitoring data from 2015 to 2022.

- When the firm capacity (2,143 m^3/d or 24.8 L/s) under existing conditions was compared against the average of the maximum day consumptions from 2015 to 2022 (i.e. 2,284 m^3/d or 26.4 L/s), it revealed a need to increase the firm water supply capacity (**Figure 6.1.A**, top-left graphs) as follows:

    - Additional 141 m^3/d (1.7 L/s) under existing demand conditions.

    - Additional 2,083 m^3/d (24.1 L/s) under future demand conditions (ultimate build-out year 2051)

- In order to sufficiently meet the water demands under maximum day existing and future demand conditions, an additional supply capacity of 2,160 m^3/d (25 L/s) is recommended for redundancy to improve the firm capacity and supply flow rate to 4,303 m^3/d (**Figure 6.1.A**, top-left graph).

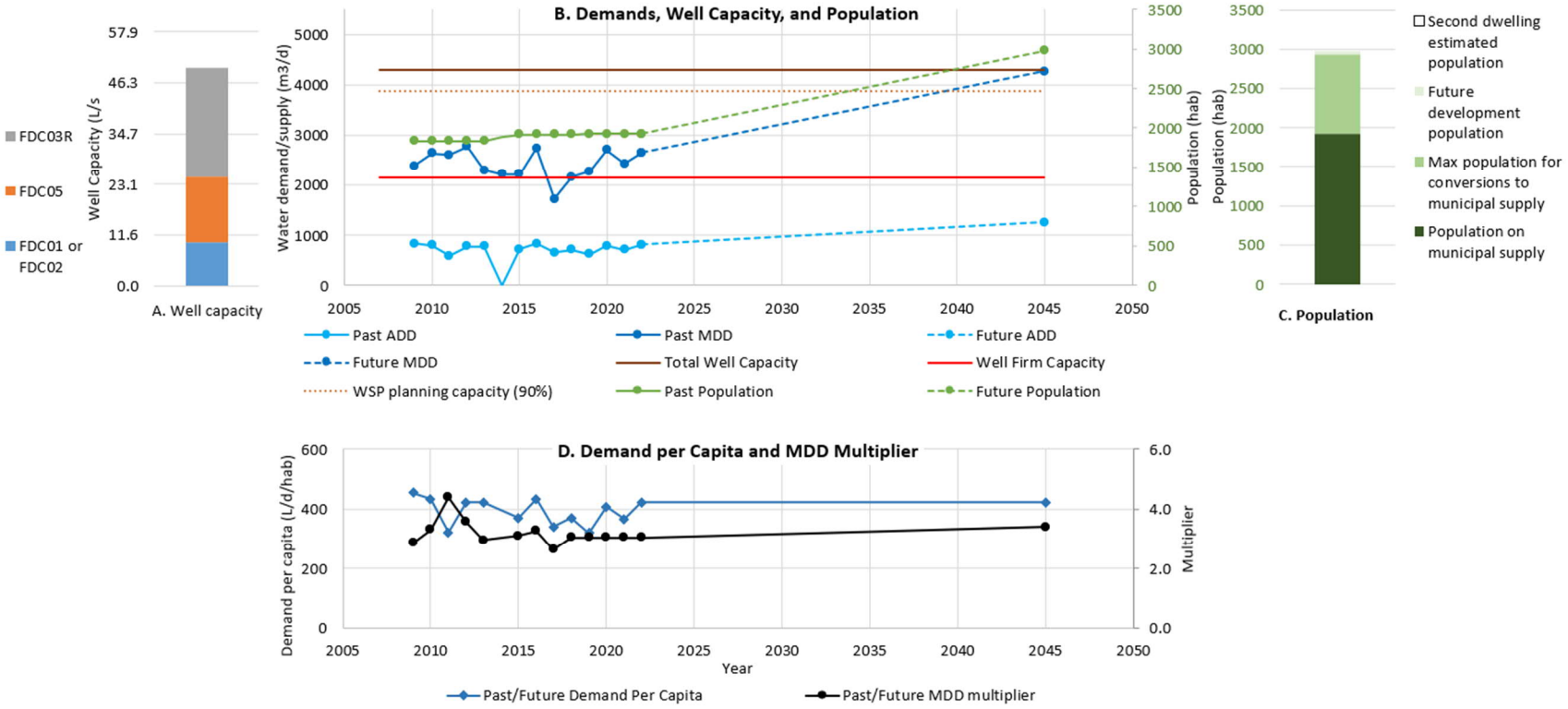

Figure 6.1: Water Demands, Well Capacity, and Population Data in Carlisle RSA

7.0 New Redundant Well FDC03RR

As noted in the previous Section, when the firm capacity (2,143 m^3/d or 24.8 L/s) under existing conditions was compared against the average of the maximum day consumptions from 2015 to 2022 (i.e. 2,284 m^3/d or 26.4 L/s), it revealed a need to increase the firm water supply capacity by 141 m^3/d (1.7 L/s) under existing demand conditions and 2,083 m^3/d (24.1 L/s) under future demand conditions (ultimate build-out year 2051). In order to sufficiently meet the water demands under maximum day existing and future demand conditions, an additional supply capacity of 2,160 m^3/d (25 L/s) is recommended for redundancy to improve the firm capacity and supply flow rate to 4,303 m^3/d (49.8 L/s).

It was determined that the supply/capacity requirement could be addressed by a redundant / back up well (Well FDC03RR) located at the largest Carlisle well site of well FDC03R near 84 Acredale Road. Based on construction records, a well and aquifer performance assessment and comprehensive groundwater quality assessment undertaken through a detailed hydrogeological investigation, it was confirmed that the FDC03RR is suitable to be used as a redundant production well, thereby addressing the identified Firm capacity requirements and negating the need to locate additional groundwater supply wells within the community.

8.0 Conclusions

The following summary and conclusions were provided based on RVA's assessment of the Carlisle Rural Settlement Area's (RSA's) additional capacity and storage requirements:

1. Population densities of 3.05 PPU and 3.41 PPU were selected to calculate Carlisle RSA's current (developed land parcels) and future (undeveloped land parcels) population which were based on historical population data sources collected from the Statistics Canada Census between the years 2011 and 2021 and the *DC Background Study (Watson & Associates, 2019)*, respectively.

2. Table 3.2 shows the existing number of properties and population being supplied by the municipal system within Carlisle RSA based on the parcels from the GIS data and the comparison between different data sources and records per the available years. Accordingly, the estimated current population within the area based on the City records is 1,930 people [(610 single-detached units x 3.05 PPU) + (40

apartment units x 1.74 PPU)] which is the highest estimated population from the data sources available and can be considered as conservative.

3. Based on Carlisle RSA's existing population and the three components of the future projected population as described under Section 3.2 and Section 3.3, respectively, the total future population to be serviced within the rural settlement area is **2,947 people**.

4. Using the population estimates in **Section 4.1**, the average day per capita demand in **Section 4.1,** and the resulting MDD peaking factor in **Section 4.2**, the future (2051 ultimate build-out) average day and maximum day demands are **1,243 m^3/d 4,226 m^3/d**, respectively.

5. Carlisle RSA currently has a total available storage volume of 1,400 m^3. Considering this, the required additional storage to meet the existing water demands (both domestic and fire flows) under current maximum day demand conditions was estimated to be **689 m^3**, while the additional storage volume needed to meet future demands under maximum day demand conditions was estimated to be **1,271 m^3**.

6. In order to sufficiently meet the water demands under maximum day existing and future demand conditions, an additional supply capacity of 2,160 m^3/d (25 L/s) is recommended for redundancy to improve the firm capacity and supply flow rate to 4,303 m^3/d (49.8 L/s).

7. The supply/capacity requirement has been addressed by a redundant / back up well (Well FDC03RR) located at the largest Carlisle well site of well FDC03R.

9.0 References

Census Profiles:

- https://www12.statcan.gc.ca/census-recensement/2011/dp-pd/prof/details/page.cfm?Lang=E&Geo1=POPC&Code1=1255&Geo2=PR&Code2=10&Data=Count&SearchText=&SearchType=Begins&SearchPR=01&B1=All&Custom=&TABID=1

- https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=POPC&Code1=1255&Geo2=PR&Code2=

35&SearchText=Carlisle&SearchType=Begins&SearchPR=01&B1=All&GeoLevel=PR&GeoCode=1255&TABID=1&type=0

- https://www12.statcan.gc.ca/census-recensement/2021/dp-pd/prof/details/page.cfm?Lang=E&SearchText=carlisle&DGUIDlist=2021S05101255&GENDERlist=1&STATISTIClist=1&HEADERlist=0

Estimated Population and Dwellings in 2016 and 2022:

- Correspondences with the City on Dec 17, 2022 (GRIDS2 - population_job projections_ Carlisle RSA)

Standard Persons Per Unit:

- Correspondences with the City on Apr 01, 2022 (Carlisle Water Storage Calculations - Request for Info)
- Correspondences with the City on May 26, 2023 (Revised Population Data & Storage Requirements)

Max dwellings for conversions to municipal supply:

- 'Population data from various source' Spreadsheet (City of Hamilton, 2014)
- Carlisle Water Storage Memo (WSP, 2015)
- Correspondences with the City on May 26, 2023 (Revised Population Data & Storage Requirements)
- Received GIS Parcels (City of Hamilton, 2015)
    - Counting includes various units in one same address (apartments)

Parcels/Units available for future developments:

- 'Population data from various source' Spreadsheet (City of Hamilton, 2014)
- Carlisle Water Storage Memo (WSP, 2015)
- Correspondences with the City on Apr 13, 2023 (Peer Review Comments – TM1)

Annual Consumption for Average Day Demand Computation:

- Billing Records and Serviced Households from 2011 to 2013
- Data from 2009 to 2013 documented in Carlisle Water Storage Memo (WSP, 2015)
- City Records from 'Carlisle full year reads 2015-2019' Spreadsheet

Maximum Day Demand:

- Max Daily Consumption from the '2009 to 2019 - daily summer demands' Spreadsheet
- 2019 City of Hamilton Drinking Water Systems Annual Summary and Water Quality Report
- 2020 City of Hamilton Drinking Water Systems Annual Summary and Water Quality Report
- 2021 City of Hamilton Drinking Water Systems Annual Summary and Water Quality Report
- 2022 City of Hamilton Drinking Water Systems Annual Summary and Water Quality Report
- SCADA – Water Production Data from 2019 to 2022
- Water Billing (Consumption) Data from 2019 to 2022
- Correspondences with the City on May 18, 2023 (Revised Population Data & Storage Requirements)

Guidelines and Standards:

- Design Guidelines for Drinking Water Systems (MECP, 2008)
- Carlisle Water Storage Memo (WSP, 2015)
- Fire Underwriters Survey Calculations (see Appendix A) (RVA, 2022)
- City of Hamilton Watermain Fire Flow Requirement Design Guidelines Policy, 2019

- 10 State Recommended Standards for Water Works (Great Lakes-Upper Mississippi river Board of State and Provincial Public Health and Environmental Managers, 2018)

Information on Wells:

- Permit To Take Water (PTTW, 2021)
- Drinking Water Works Permit (DWWP, 2019)