Sustainable Groundwater Supply for Griffin's Pond, Halifax Public Gardens

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Client: WSP Consulting and the Halifax Regional Municipality

Introduction

The Halifax Public Gardens, as seen in **Figure 1,** is a major tourist attraction located within Halifax. One of the main aspects of the area is Griffin's Pond. This pond has experienced a reduction in water levels over past summer seasons. The goal of the project is to provide the Pond with a **sustainable groundwater supply** under dry conditions.

Figure 1 – *Google Maps image of Halifax Public Gardens.*

Water Quality

- Groundwater in Halifax contains high levels of iron. When mixed with water of low pH (such as surface water), iron dissolves and precipitates when exposed to air.
- Groundwater quality was compared to surface water quality guidelines to determine their compatibility for mixing, as seen in **Table 1**.

Table 1 – *Average well water quality from existing wells (T. Bachiu per. comm., 2020) compared to CCME Water Quality Standards for the Protection of Aquatic Life (CCME, 2007).*

	pH	DO (mg/L)	Iron (mg/L)	Nitrate (mg/L)	Arsenic (μg/L)
Well Water Quality	7.11	-	12	<0.05	1
CCME Guideline	6.5 – 9.0	5.5 – 9.5	0.3	13	< 5

Climate Change Impact

Water Availability Projection

Representative Concentration Pathway (RCP) is a climate modelling trajectory based primarily on greenhouse gas concentrations; RCP 1.6 is the goal of the Paris Agreement, and RCP 8.5 is a worst-case scenario. Using climate data from projections of RCP 2.6, 4.5, and 8.5 out to 2100, water availability was calculated by subtracting potential evapotranspiration from total precipitation.

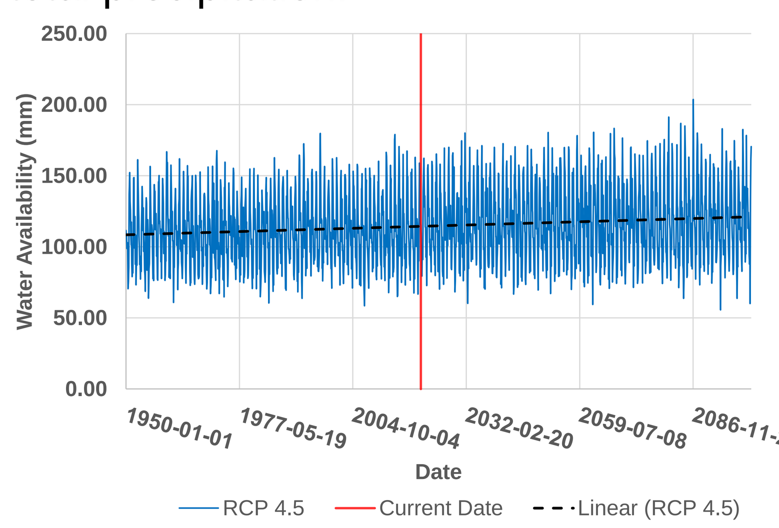

Figure 2 – *Projected water availability for RCP 4.5 from 1950 to 2100*

- For all scenarios: no major concern for drought, water availability remains relatively constant with mild increase.
- RCP 8.5 has a greater increase in availability than RCP 4.5, which has a greater increase than RCP 2.6.

Climate Change Impacts on Water Budget

Precipitation rates in Halifax have increased annually. However, as can be seen in the **Figure 3**, precipitation rates over the last 5 years during the typical drought months have dropped significantly, which means decreased inflow for the pond.

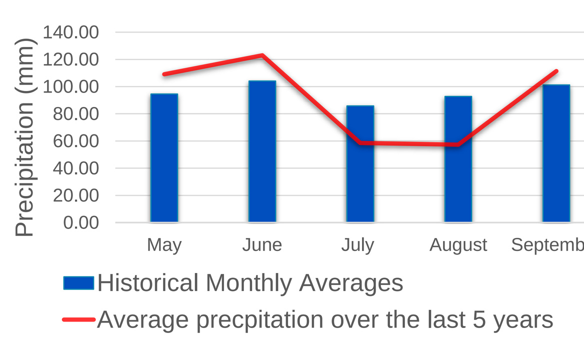

Figure 3 – *Analysis of precipitation rates for Halifax*

- On top of this, potential evapotranspiration rates have increased, meaning more water loss for the pond.

Surface Water Depletion

Groundwater will be pumped into Griffin's Pond; this pumping must not result in water being drawn from the pond. Using the USGS analytical solution solver for the **Hunt (2003) Equation,** surface water depletion is **negligible**. The inputs in **Table 1** were used for the calculation. The Hunt (2003) Equation was considered adequate for this analysis because the stratigraphy from the well logs indicated that the pond bottom is separated from the aquifer by an aquitard.

Table 2 – *Inputs to the USGS analytical solution solver for the Hunt (2003) equation.*

Parameter	Units	Input Value
Distance from the Well to the Pond	ft	106
Transmissivity (T) [1]	ft^2/day	377
Storage Coefficient (S) [1]	-	7.6E-05
Specific Yield of Aquitard[2]	-	Approx. 0
Hydraulic Conductivity of the Aquitard[2]	ft/day	2.8E-07
Stream Width	ft	245
Thickness of the Aquitard	ft	19
Distance from Streambed to the Bottom of the Aquitard	ft	34
Pumping Rate[3]	gpm	73
Timeframe for Pumping	Days	90

[1] Calculated using pumping test data and a Cooper-Jacob Straight Line Method (Time-Drawdown Method).
[2] The stratigraphy from the well log indicates that the aquitard is composed of relatively unfractured slate.
[3] Pumping rate > 23,000 L/day. According to the Activities Designation Regulations (1194-95), an approval is required.

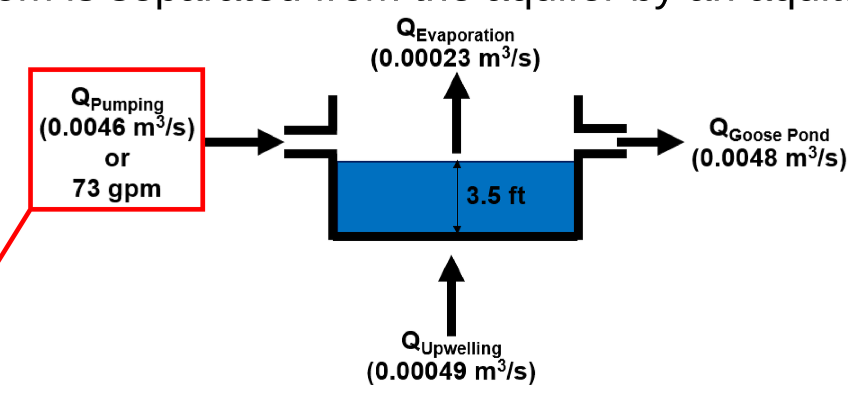

Figure 4 – *Steady-state mass balance for Griffin's Pond.*

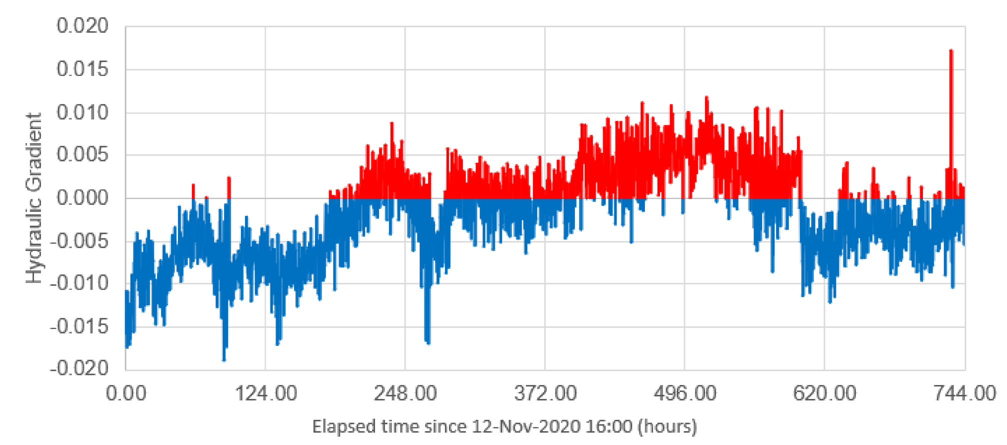

Figure 5 – *Hydraulic gradient from data acquired through piezometer and stilling well sampling at Griffin's Pond from 12-Nov-2020 to 14-Dec-2021; positive (red) indicates pondwater infiltrating into the groundwater system, and negative (blue) indicates groundwater recharging the pond; used in conjunction with slug test data to calculate upwelling flowrate via Darcy's Law.*

Final Design

The final design consists of pumping an existing well on Wanderer's Grounds and piping the water to the pond underneath Sackville Street. It will include a well water level and a pond water quality monitoring program.

Well Water Level Monitoring Program

- The Solinst Level logger 5 will be connected to the SolinstL5 Direct Read Cable to continuously record drawdown data.
- Flow will be continually measured using a digital flow meter.

Pond Water Quality Monitoring Program

- Continuous monitoring using a EXO2 multiparameter sonde (that measures DO, pH, turbidity, and temperature) connected to a Storm 3 Data Logger.
- Manual bi-weekly water testing will be performed to verify continuous data. This will be performed by a trained Public Garden employee by taking water samples for lab analysis during the summer months at six locations, shown in **Figure 7**.

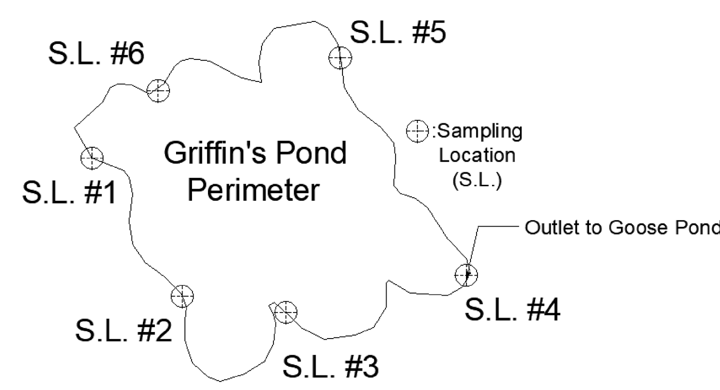

Figure 6 – *Manual sampling locations*

Piping Distribution Network

- The existing piping distribution network that connects the well to Griffin's Pond was analyzed using pressurized pipe and culvert hydraulics and it was determined that it can not support the required flow of 73 gpm/0.0046 m^3/s.

Existing Well Upgrades

- The existing surface pump will be upgraded to a submersible pump that can support 73 gpm. Drawdown will not exceed the actual pump depth based on a well efficiency of 0.8 and the Cooper-Jacob method.

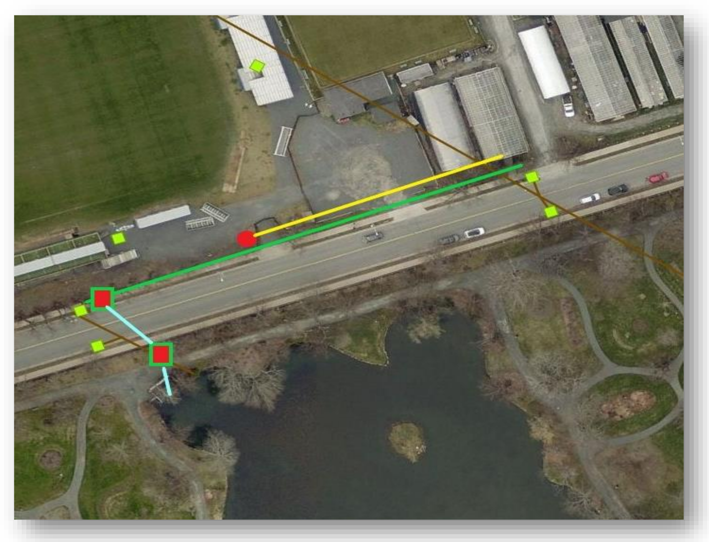

Figure 7 – *Proposed location for the piping network (Geldhart, 2021).*

Conclusion and Recommendations

From the analysis, it was determined that Griffin's Pond needs an inlet flow rate of 73 gpm to achieve an upper objective of a 2-week hydraulic retention time. Based on further analysis of existing infrastructure, it is concluded that the existing well on Wanderer's Grounds could be used in conjunction with a submersible pump and a new piping distribution network to support this flow.

In future development of the project, we recommend:

- A monitoring program be implemented to ensure sustainable yield and maintain pond aesthetics.
- An application for approval of to withdraw 73 gpm according to the Activities Designation Regulations (1994-95).
- A longer, static pumping rate test be done to refine confidence in transmissivity and storativity values..

Sustainability

A solar array has the potential to offset energy demands of the ground water supply system (pump, meters, controllers, etc.)

- Four available surfaces on sheds near Wanderer's Grounds.
- If all surfaces are used, system has a total yearly output of ≅15,000kWh, with a **Simple Payback of approx. 23 years**.

Figure 8 – *Areas available for solar array on Wanderer's Ground Utility Shed.*

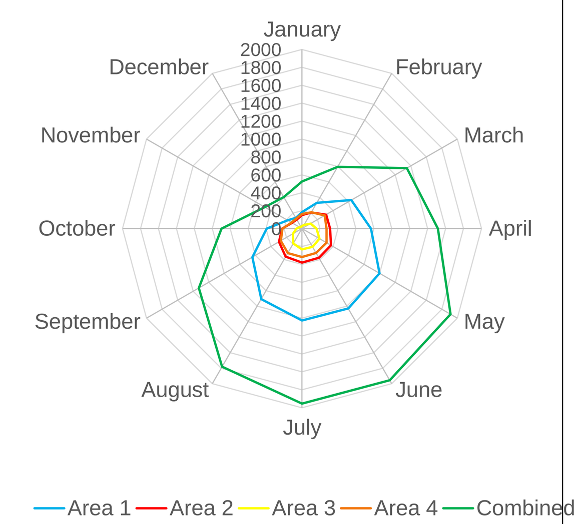

Figure 9 – *Monthly power output (kWh) breakdown for the four areas.*

Analysis of monthly output shows that the array would produce more power during summer months, which is when the water supply system would need power most.

Health and Safety

- Compliance with municipal regulations and Dalhousie standards were applied to accomplish this project safely.
- Risk assessments were completed on the vegetation surrounding the pond, the aquatic life and wildlife, water chemistry interactions, construction work, employees, and Public Garden users.

The risks were determined to be **LOW** with appropriate mitigative measures.

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