Appendix A

Climate Change
Technical Memorandum

MEMO

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Subject: Madoc Water, Wastewater and Stormwater Master Plan
Technical Memorandum – Climate Change

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Introduction

Climate change has the potential to alter weather patterns that can affect the water, wastewater, and stormwater infrastructure and facilities in Madoc. Climate change can affect the quality and quantity of the drinking water supply, collected wastewater and stormwater stream and the reliability of the local utilities (including electricity systems and natural gas services). This Technical Memorandum has been prepared to outline the potential effects of climate change on Madoc's Water Treatment Plant (WTP) and distribution, Wastewater Treatment Plant (WWTP) and collection, and stormwater infrastructure and potential areas of concern that should be addressed in future designs and upgrades of these facilities/systems.

Potential Effects

For the purposes of this report, climate change impacts associated with both changes in precipitation, ambient temperature and potential increased frequencies of tornadoes have been considered. The specific effects and extents of these impacts cannot be predicted. This document is designed as a qualitative identification of the potential impacts of climate change on water, wastewater, and stormwater infrastructure and should be considered in the design and implementation of future projects.

Water Facilities

Well #3 and Well #4 are considered groundwater under the direct influence of surface water. Wellhead protection areas surrounding each well are as shown in Attachment #1. The north-west quadrant of the study area and Deer Creek provide a direct pollution pathway to the water source for both wells. Increasing rainfall and high intensity events can result in upstream flooding of Deer Creek. This can lead to erosion and additional solids and turbidity in the creek, subsequently affecting raw water quality. A high intensity rainfall event has the potential to carry pollutants to wellhead protection areas through stormwater runoff, further affecting raw water quality. These factors can lead to additional use of water treatment chemicals, increase filter backwash frequency, and increased waste production at the WTP. Direct effects may include mobilization of organics or other compounds that may result in treated water quality not meeting Municipal Drinking Water License requirements. Water quality issues may include the increased presence of elements (e.g. iron, manganese, nitrates) in raw water that are above the treatment equipment capacities in the WTP which may result in exceedances of quality objectives.

The Permit to Take Water and Municipal Drinking Water License for Madoc's Drinking Water System have specified daily water taking limits for accommodate aquifer recharge based on a hydrogeological study completed in 2018. Aquifer levels from 2014 to 2024 were provided by OCWA Staff for Rollins Well #3. The lowest aquifer level over the 10-year period was observed in September 2016, likely due to moderate to severe drought conditions. Increasing temperatures and long-duration droughts (longer than 6-months) have the potential to limit aquifer recharge from surface water infiltration, which can limit the Madoc water supply. Quinte Conservation Authority has developed a Quinte Region Drought Plan in 2021 which should be reviewed and leveraged prior to commencing design of future water supply projects.

Increasing ambient temperatures and decreases in rainfall can influence the end users of the water, increasing demand on the WTP. Increased temperatures and decreased precipitation will increase the demand for aesthetic water uses (e.g. lawn watering) and personal cooling (e.g. splashpads, pools, etc). In rural areas, there is also risk that the increased temperatures and low precipitation will lead to higher instances of fires, which will increase the instantaneous demand for large volumes of water from the WTP and water storage facilities.

Increased temperatures on the power grid during long heat wave events can lead to longer or more frequent power failures/brown outs. This may increase the need for on-call operational staff to implement temporary back-up power generators at the pumphouses. There is no existing back-up power at the well pumphouses.

OCWA and Municipal Operations Staff provided anecdotal information that portable back-up power was required at Rollins Well #3 due to a power outage caused by strong winds or tornadoes. Increasing strong wind events have the potential to limit power supply to Madoc's well pumphouses due to damaged power lines from wind load, projectile debris, fallen trees and other large debris. Large debris and fallen power lines can limit access on arterial and local transportation routes, which can extend the response time for personnel access to water treatment and storage facilities. The May 21st, 2022, Derecho Event, a long convective storm with nearly continuous and damaging winds, which caused fatalities and significant damage across Southern Ontario and Quebec, generated 90 km/h to 130 km/h winds within Madoc and up to 175 km/h in areas less than 10km north of Madoc[1].

Wastewater Facilities

Increases in rainfall intensity and duration can also increase the overall volumes collected and managed in the collection system and the volume of wastewater at the Lagoon. Studies conducted in Southern Ontario by the Grand River Conservation Authority have noted that inflow and infiltration (I/I) can account for flows exceeding 4 times the expected wastewater flows (based on drinking water usage)[2]. This study further outlined that the extent of I/I is highly dependent on the wastewater collection system, while demonstrating the large potential impact of I/I as rainfall intensity, frequency, and duration increase.

Floodplain areas were identified surrounding the Madoc Lagoon and the Rollins Street Sewage Pumping Station (SPS). Flooding in these areas can directly affect the physical area surrounding the Lagoon and pumping stations where the incoming flood waters can carry large volumes of debris into the wetwells and the large volumes of water can block personnel access to the facilities.

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[1] Northern Tornadoes Project 2022 Annual Report – University of Western Ontario
[2] Case Study: Lessons Learned on Assessing Vulnerability of WWTPs to Climate Change Impacts (2019) Grand River Conservation Authority

Increased temperatures on the power grid during long heat wave events can lead to longer or more frequent power failures/brown outs. This may increase the need for on-call operational staff to implement temporary back-up power generators at the sewage pumping stations.

Minor Stormwater System

Madoc's stormwater system performance was modelled based on a 2-year (minor) storm flow for Phase 1 of the Master Plan. The current stormwater system consists of several sub-systems which outlet to ten different locations within Madoc, including local stormwater ponds, Deer Creek, and other low-lying areas. Increasing frequency of major storm events, which exceed the design capacity of the existing storm system, can cause back-ups within the system leading to localized flooding. Anecdotally, there have been no recent instances of overtopping of Deer Creek within the Village of Madoc. However, flooding has been reported at Thompson Park, located between Elgin Street and St. Lawrence Street East and north of the Centre Hastings High School.

Climate Change Adaptation

Climate change adaptation refers to the resilience or vulnerability of the Madoc water, wastewater, and stormwater infrastructure due to changing climatic conditions. Climate change has the potential to alter weather patterns that can in turn affect municipal infrastructure in terms of flow volumes and the reliability of the local utility infrastructure.

Power Supply

Increasing ambient temperatures, and the increase in the duration of consistently high temperature "heat-waves" can increase demand on the power grid and lead to longer, or more frequent power failures/brown-outs. The emergency management and backup power system at the WTP pumphouses and WWTS sewage pumping stations may need to be capable of addressing the potential of longer and more frequent power grid failures. The extent of the risks will be highly dependent on the local power grid and the designs for the backup power systems will be site specific. There are two potential methods of addressing this concern:

1) Utilize renewable energy generation (e.g. solar power generation) at the pump stations to reduce or eliminate the reliance on the local grid (thereby decreasing or eliminating the effect of grid failures at the sites – this will also help with climate change mitigation at the various sites), or
2) Adequately size the backup power systems to address the increased risk of longer duration power outages.

Water Facilities and Distribution

Additional treatment processes may be considered to mitigate the potential issues associated with changes to the aquifer water quality as well as more extreme weather events.

The average, maximum day, and peak per capita water demands should also be re-evaluated regularly to ensure that the changes in societal water demand are proactively addressed. Warmer, drier weather may increase the frequency and intensity of fire events that will create additional demand on the WTP. Future expansions on WTP and storage facilities should evaluate the water demand and fire requirements based on local drivers, rather than meeting the minimum of standard practices. This will ensure the availability of water supply for climate events.

Wastewater Facilities and Collection

Pipe sizing: Higher intensity and duration precipitation events are likely to become more frequent, resulting in larger volumes of I/I that will need to be addressed by the collection system, any wastewater pumping stations, and the WWTS. Increased rainfall, especially in the form of high intensity or duration events can result in increased flow in the wastewater collection system. Future designs need to include provisions for this increased flow, and the extent of these provisions need to be collection system specific. These measures include the need to ensure collection pipes are sufficiently sized for the increased peak flow rates as well as adequate sizing of wetwells and pumps in sewage pumping stations.

Runoff and flooding risks: Pluvial flooding events are becoming more common as rainfall event intensity and duration are increasing due to climate change. These events can increase runoff into both the wastewater collection system and the WWTS. The current operating philosophy of the lagoons is to store and treat the wastewater for most of the year and to discharge for up to 45-days in the spring and up to 45-days in the fall. Disconnecting roof leaders and combined sewer sections will also help reduce influent flow to the Lagoon. There are a number of pumping stations and sanitary sewer manholes in the Madoc wastewater collection system that are within 150m of Deer Creek or within a floodplain. Flooding can result in additional stormwater intrusion into the wetwells and manholes. This large volume of water and the accompanying solids would then be conveyed to the Lagoon, decreasing the overall liquid storage capacity of the lagoon. Pumping stations and manholes should be designed to adequately address the risks of Deer Creek flooding events and should be regularly re-evaluated should the flooding extent and frequency change.

Minor Stormwater System

Increased rainfall from minor storms, within the stormwater system capacity, have the potential to convey pollutants and debris to outlets within wellhead protection areas. Pre-treatment devices, such as drain inlet inserts and oil/grit separators should be considered in high-density urban areas, areas with high erosion potential, and other areas with high pollutant load.

Increasing frequency of intense rainfall events can exceed the stormwater system capacity and have the potential to cause localized flooding and convey runoff pollutants to local water ways. There are few areas within Madoc with roadside ditches to convey overland flow. Catch basins at low points in the road system and upsizing of storm sewers may be considered to control overland flow paths. To promote groundwater infiltration and control peak flows, green infrastructure, low impact development strategies, and stormwater storage should be considered for new developments and municipal infrastructure upgrades.

Climate Change Mitigation

Climate change mitigation refers to measures used to reduce a project's expected production of greenhouse gas (GHG) emissions and impacts on carbon sinks. A project’s GHG emissions can be categorized as operating carbon (emitted during the operation phase), and embodied carbon (emitted during the manufacturing and construction phase).

Water Treatment System

A WTP’s operating carbon consist of direct emissions from combustion of fossil fuels on site (e.g. gas for space heating) and indirect emissions from consuming energy that was generated from off-site combustion of fossil fuels (e.g. electricity generated from gas power plants).

Indirect emissions can be mitigated by reducing the electricity consumption on site through energy efficiency measures such as selecting premium efficiency motors, or using variable frequency drives for pumps, decreasing backwashing frequency, or dynamic modelling of the distribution system to optimize storage tank filling and peak energy demand. Optimizing operations by reducing high-lift pump operation during filter backwash cycles can also be considered to reduce the peak energy demand of the WTP.

Wastewater Treatment System

A WWTS's operating carbon consist of direct emissions from combustion of fossil fuels on site (e.g. gas for space heating), indirect emissions from consuming energy that was generated from off-site combustion of fossil fuels (e.g. electricity generated from gas power plants) and emissions from the use of vehicles for operational purposes.

In the current Madoc wastewater system, direct emissions are minimal as the only combustion of fossil fuels comes from the use of temporary backup generators at the pumping stations. Fuel switching for the backup power system can be considered to further reduce the direct emissions.

Indirect emissions can be mitigated by reducing the electricity consumption on site through energy efficiency measures such as selecting premium efficiency motors or using variable frequency drives for pumps.

For both water and wastewater facilities, indirect emissions can be further mitigated through the generation of zero GHG emission clean electricity, through the addition of solar photovoltaic systems or other, small scale, energy generation systems on site. Once the operating carbon of a facility is reduced through energy efficiency measures, fuel switching and on-site renewable energy generation, the embodied carbon becomes the vast majority of a facility's lifetime GHG emissions and has a greater impact on climate change as it is entirely emitted before the facility is operational. Concrete and steel are the largest contributors to a building's embodied carbon content. The embodied carbon of existing infrastructure has already been emitted and cannot be changed; however, as the infrastructure is upgraded, adjustments in specifications for materials can enable major reductions in embodied carbon.

Conclusion

The Ministry of the Environment, Conservation and Parks (MECP) document titled Considering Climate Change in the Environmental Assessment Process Guide (2017), sets out the Ministry's expectation for considering climate change in the preparation, execution and documentation of environmental assessment studies and processes. The information within this memorandum provides an overview of some impacts that climate change may have on the water, wastewater and stormwater infrastructure and some of the potential ways to mitigate these risks. Further review of the potential mitigation measures should be considered by the Municipality and OCWA when proceeding with additional planning for their water, wastewater, and stormwater infrastructure.

It is recommended that the Municipality consider the following aspects during future project planning to mitigate climate change risks and adapt to potential future climate change events:

- Implement backup power systems at Well #3 and #4;
- Implement backup power systems at sewage pump stations and wastewater treatment lagoon;
- Consider upsizing sanitary and stormwater infrastructure to accommodate increased wet weather flows and Inflow and Infiltration (I&I);
- Undertake an I&I study and flow monitoring program to identify areas of high I&I;
- Disconnect roof leaders, combine storm sewers, and combine sanitary sewers to reduce peak flows, and
- Promote water conservation during summer and/or drought conditions.
- Consider climate change effects during the detailed design of projects to be implemented.

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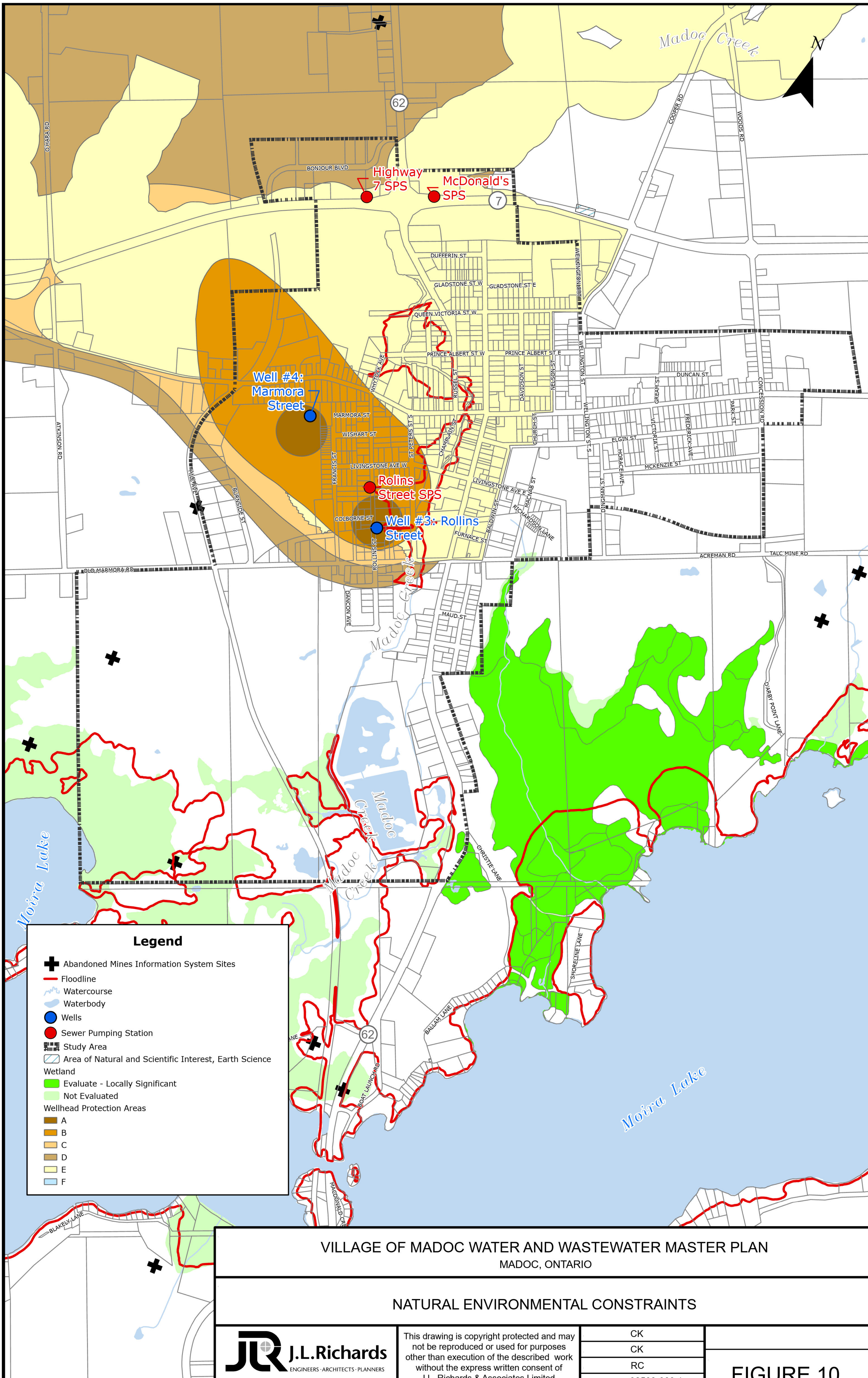
Attachments:

1) Natural Environmental Constraints



VILLAGE OF MADOC WATER AND WASTEWATER MASTER PLAN

MADOC, ONTARIO

NATURAL ENVIRONMENTAL CONSTRAINTS

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FIGURE 10

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