DRAFT

GREAT POND STUDY

Submitted to:

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25 February 2021
Wood Project #: TF1969415

IMPORTANT NOTICE

This report was prepared exclusively for Town of Torbay by Wood Environment & Infrastructure Solutions, a Division of Wood Canada Limited (Wood). The quality of information, conclusions and estimates contained herein is consistent with the level of effort involved in Wood's services and based on: i) information available at the time of preparation, ii) data supplied by outside sources and iii) the assumptions, conditions and qualifications set forth in this report. This report is intended to be used by Town of Torbay only, subject to the terms and conditions of its contract with Wood. Any other use of, or reliance on, this report by any third party is at that party's sole risk.

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1.0 INTRODUCTION

Wood Environment & Infrastructure Solutions, a division of Wood Canada Limited (Wood), was retained by the Town of Torbay to conduct a study on the Great Pond Watershed (Drawing 1; Appendix A).

1.1 Background

The Town of Torbay retained CH2M Hill Canada Ltd to complete a feasibility study and conceptual cost estimate for water treatment facilities for both North Pond and Great Pond in 2011. Bench-scale testing results of raw water samples from Great Pond, collected in 2009, were used as the basis for a proposed water treatment process that would result in a Great Pond water system that would be in compliance with the Guidelines for Canadian Drinking Water Quality (e.g. 3-log reduction of cryptosporidium). Given that these raw water samples are now ten years old, there is a need to review more recent water quality sample data to establish treatment requirements for the Great Pond system.

The capital cost estimate of the water treatment process for Great Pond established in the CH2M Hill Canada Ltd 2011 study was approximately $13.2 million, with annual Operations and Maintenance (O&M) costs of $329,000. When compared to North Pond, the CH2M Hill (2011) study indicates Great Pond would have a higher capital and O&M cost due to the larger rated capacity and additional treatment required for iron and manganese control.

The proposed Great Pond water treatment plant (WTP) was designed for a maximum instantaneous production rates of 3.9 ML/day – a production rate based on the estimated maximum yield from the supply established in 2008 as 3900 m^3/day. The average flow was assumed to be 50% of the maximum flow (50% x 3900 = 1950 m^3/day) and the minimum flow was assumed to be 25% of the maximum flow (25% x 3900 = 975 m^3/day).

The treatment system designs proposed in the CH2M Hill Canada Ltd. (2011) for both North Pond and Great Pond include a 6.5 million Litre contact tank and reservoir. The reservoir was sized assuming an average daily water demand of 4,260 m3/day in the year 2031.

There is currently not enough information available to establish the reasonableness of the assumed 3900 m^3/day design capacity and sustainable yield of Great Pond as a water supply. A capacity assessment of Great Pond is required to establish the maximum available yield from the watershed which in turn is used to establish estimated capital investment and operational costs. In addition, a planning and land use review is required to establish Future planning issues that may arise should Great Pond be used as the source for a public water supply.

2.0 SCOPE OF WORK

The original scope of work consisted of the following:

- Source water study, including:
  - Watershed delineation
  - Bathymetric profile
  - Flow monitoring of the outflow of Great Pond
- Water balance;
- Planning and land use review;
- Distribution system review; and
- A water treatment plant options analysis.

The scope was ultimately changed to further include a wetted perimeter study within the source water study, while the distribution system review and water treatment plant options analysis were postponed due to findings within the source water study and water balance portions of the study, as discussed in Section 5.0.

3.0 METHODOLOGY

3.1 Source Water Study

Wood conducted a source water study of Great Pond to establish the storage capacity and to provide background data to establish a safe rate of water removal, that included a watershed delineation, bathymetric profile, discharge monitoring, and wetted perimeter study, as described in the following sections.

3.1.1 Watershed Delineation

The Great Pond watershed area was delineated using recently collected LiDAR information to provide a more precise watershed area than previously delineated.

3.1.2 Bathymetric Profile

To better characterize the water storage capacity of Great Pond, a detailed bathymetric survey was completed on June 5, 2020. The bathymetric survey was conducted using a differential GPS sonar unit attached to a Zodiac style inflatable boat. The unit links GPS and sonar technology in a digital environment so that depths and location (differential GPS) are digitally mapped.

The Lowrance sonar/GPS unit was set up in the field to collect combined positional and depth data once every second. The boat was generally moving at a rate of less than 2 metres per second (m/s) for optimal coverage. The unit has been tested using known survey pin locations for positional accuracy and has been recorded at being less than one metre. The error associated with sonar depth detection has been given as 1 centimetre (cm); however, weather conditions such as wave height and variable water temperatures can also affect this slightly.

Quality assurance/quality control (QA/QC) was conducted on all data collected with respect to validity (e.g., positional data and/or depth data acquired) prior to contour generation. Water surface elevation was recorded before and after surveys to better tie generated contours to elevation datum. Final contours were completed and assessed using GIS to provide a bathymetric contour of the study area.

3.1.3 Flow Monitoring

Unlike North Pond, where an approximation of the impact of demand on the water levels can be established (e.g. based on some flow metering, sporadic observations of water level, and the general observations of the pond's performance since the water supply came online), there is no baseline for establishing a threshold for demand of Great Pond as a water supply. As such, there is a need to conduct some feasibility-level estimate of inflow into Great Pond, that can serve as a comparison to the 3900 m^3/day assumed in the CH2M Hill (2011) study.

The outflow survey consisted of an elevation survey that can be tied to existing LiDAR data. The elevation survey included a cross section of the base of the outlet river. Measurements were conducted using standard procedures as outlined in Sooley *et al.* (1998) and McCarthy *et al.* (2007). Standard measurements such as wetted width, water depth and mean water velocity were recorded across each transect. Depth was recorded using a metre stick while mean velocity will be recorded using a Global Flow Probe (Model 101a). Wood's standard flow equipment provides instantaneous calculation of mean water velocity at an accuracy of +0.01m/s. This data was also be used to calculate discharge rates for each survey transect.

A dataloggers was installed at the outlet of Great Pond to conduct flow monitoring. The elevation data collected from the datalogger was calibrated with flow data to create a flow curve.

3.1.4 Wetted Perimeter

The Wetted Perimeter Method (WPM) is a fixed flow hydraulic rating method based on the hydraulic relationship between flow (i.e. discharge) and wetted river perimeter at selected transect(s) (Stalnaker et al. 1994). Using the relationship, the flow corresponding to the wetted perimeter (wetted width of the stream transect), which is needed to minimally protect all habitats, can be estimated. Figure 3-1presents a schematic of a wetted perimeter/flow relationship and indicates the point of inflection for that relationship. The point of inflection is taken as the flow below which dewatering would take place rapidly for the represented habitat. Field surveys typically cover the range of natural flows. Where this is not achievable, Manning's equation can be applied to estimate extreme values. Manning's equation is given by:

Velocity (m/s) = $R^{2/3} * S^{1/2} / n$ where

R = Hydraulic radius (Area / wetted perimeter) – see Figure 3-1

S = slope at transect

n = Manning's n.

The cross-sections, or transects, selected to determine the minimum flow for habitat protection is very important in this technique. The selected transects for assessment must stand as an index habitat for the rest of the river or river section being assessed (Stalnaker et al. 1994). Riffles are typically selected because cross sections in these areas exhibit sensitivity of width, depth and velocity to changes in flow. They are usually the shallowest habitat type found and as such, would indicate adequate water levels needed to protect all habitats. Therefore, once a minimum level of flow is estimated for a riffle, it is assumed that other habitat areas, such as pools and runs, are also satisfactorily protected. Because the shape of the channel can influence the results of the analysis, transects are usually located in areas that are wide, shallow, and rectangular.

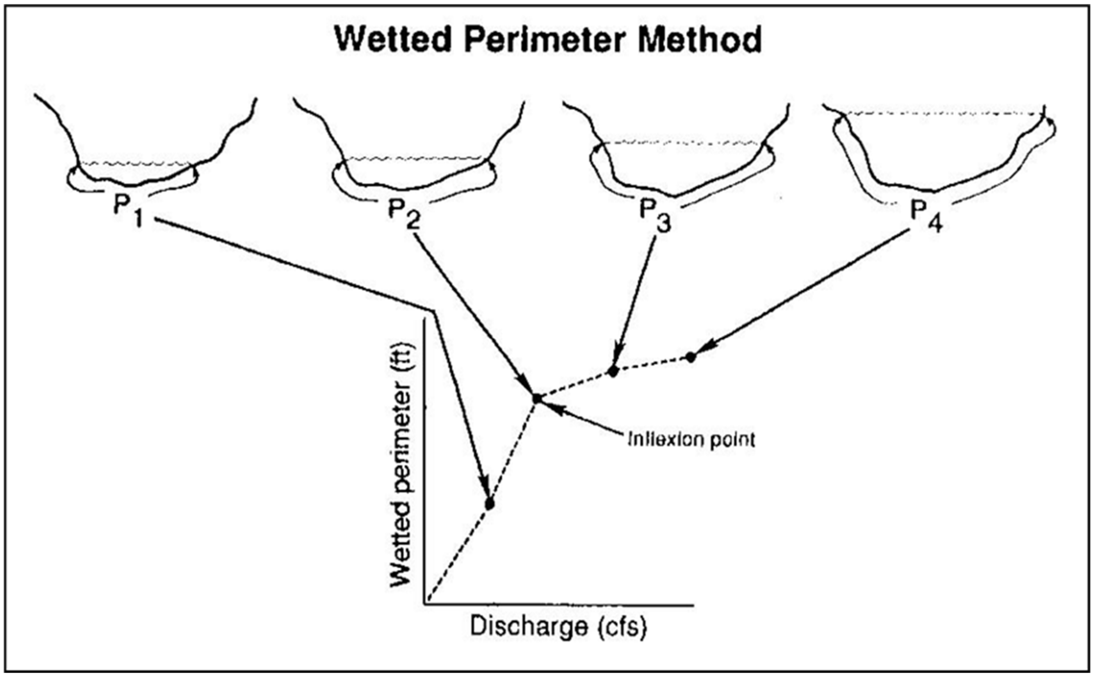

Figure 3-1: Example of wetted perimeter method to estimate instream flows (Nelson 1980).

The following assumptions apply to the WPM:

- the selected area is a suitable index of habitat for the rest of the river, i.e., if the minimum flow requirement is satisfied at the chosen sensitive location, it will be satisfied in other habitat types. The greater the number of transect locations, the higher the level of confidence in the minimum flow estimation;
- the point of inflection is a suitable surrogate for acceptable habitat, i.e., flow reductions below that point on the graph will result in loss of habitat quality; and
- all wetted area is equally important as habitat or to satisfy other biological criteria.

All information from each transect survey was used to create AutoCAD drawings of the transect. Using Manning's equation, the discharge at various water levels was then simulated using the profile and data provided by the AutoCAD drawing. The maximum water depth at each transect was used as the marker for an estimate of the water level associated with each simulated discharge. For each transect location, the water level was modeled from the measured levels by decreasing in 0.10m increments until the streambed was practically dry and increasing in 0.10 m increments until the water level reached the height of the streambed.

The transect profiles at these various water depths were simulated to get parameters needed to estimate discharges using Manning's equation. The estimated velocity values derived from Manning's equation were used to calculate discharges at each simulated water level.

3.2 Water Balance

A water-balance was conducted to evaluate how water moves within the Great Pond drainage area. The water-balance calculations account for water being added to a drainage area (e.g. precipitation) and removed from a drainage area (e.g. a river that flows out). An illustration of the hydrologic (water) cycle is shown in Figure 3-2.

A water-balance can be represented by the following equation:

$$P + SW_{in} + GW_{in} - GW_{out} - SW_{out} - ET - \Delta S = 0$$

Where P represents precipitation, SW_{in} represents surface water flow into the drainage area, GW_{in} represents groundwater inflow, GW_{out} represents groundwater outflow, SW_{out} represents surface water flow out, and ET represents evapotranspiration (evaporation and transpiration). All of these terms have the same units of depth (mm).

The number of variables in the above equation can be reduced through an assumption that over the long term (e.g. 30-years), changes in surface and groundwater storage are negligible, therefore ΔS=0. Groundwater flow into and out of the drainage area is assumed to be equal, so that the terms GW_{in} and GWout cancel each other out (i.e. the amount of flow into the system equals the amount of the flow out of the system over the year). The drainage area for each drainage area extends to the headwaters, as a result, there is no surface water flow coming in at the upstream boundary and SW_{in} =0.

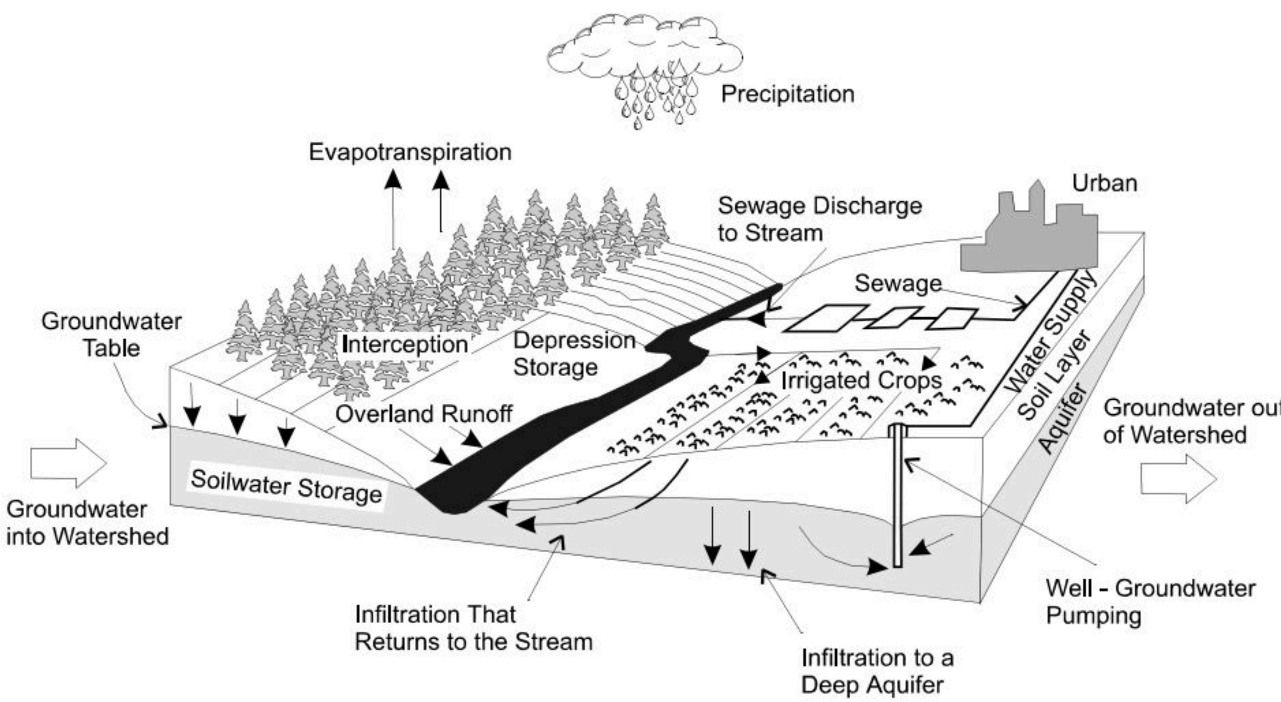

Figure 3-2: An illustration of the water cycle (Image Source: After et al. 1991)

The water-balance equation is therefore reduced to:

$$Precipitation - SW_{out} - ET = 0$$

A variety of methods exist for computing the terms in the above water-balance equation. The Thornthwaite and Mather (1955) methodology was the first to use air temperature and precipitation to compute a water balance that tabulates the additions, losses and changes in water storage at a location. The methods of computing the terms of the daily and monthly water balances have previously been discussed in Mather (1978) and Phillips (1976). A more recent version currently being used by Environment Canada to conduct water-balance assessments, uses daily temperature and precipitation data as the required inputs. The use of daily climatic data permits better modeling of snowmelt and improves the accounting of snow storage which is of particular importance in the Canadian climate.

3.3 Planning and Land Use Review

A planning review was conducted to develop a clear understanding of the potential issues related to existing land use practices within the Great Pond watershed area. The planning review consisted of a comprehensive review of the following, as described in Section 5.3:

- Provincial Regulations, Policies and Land Use Interests;
- Regional Policies, Agreements and Land Use Interests;
- Town of Torbay Regulations and Land Use Interests; and
- Town Portugal Cove- St. Philip's Regulations and Land Use Interests.

4.0 RESULTS

4.1 Source Water Study

The source water study of Great Pond consisted of a watershed delineation, bathymetric profile, discharge monitoring, and wetted perimeter study, as described in the following sections.

4.1.1 Watershed Delineation

The Great Pond watershed area was delineated using recently collected LiDAR information to provide a more precise watershed area than previously delineated. The newly delineated watershed is shown on Drawing 2 (Appendix A), along with the NDAL (2008), the Town of Torbay and Town of Portugal Cove – St. Philip's protected watershed zones, for comparison.

Results indicate the watershed area delineation using LiDAR produced a significantly larger watershed area (~80 ha; Table 4-1) than the previous delineations that were likely completed using 1:50,000 scale NTS maps. It is recommended that land use mapping be updated to reflect the larger area.

Table 4-1: Area of Watershed Delineations

Watershed Delineation	Area (ha)
Wood (2020)	383.19
NDAL (2008	305.88

4.1.2 Bathymetric Survey

A bathymetric survey of Great Pond was completed by Wood staff on June 5, 2020 (Figure 4-1) to support the development of a geo-referenced bathymetric contour map of the water supply.

A bathymetric contour map of the water supply developed in ESRI ArcGIS is shown on Drawing 3 (Appendix A)

At the time of the bathymetric survey (June 5, 2020), the measured water surface elevation was 117.75 m. The lowest measured elevation at the bottom of the pond was 109.6 m, resulting in a maximum water depth at the time of survey of approximately 8.2 m.

A storage volume curve for Great Pond was established using the 3D analytical capabilities provided in ESRI ArcGIS (Table 4-2 and Figure 4-2). The calculated 2D surface area of the pond at the time of survey was 286,716 m^2 and the total storage volume was 884,192 m^3. At the time of the survey, there was approximately 271,271 m^3 contained within the top one (1) m of Great Pond.

As a point of comparison, the calculated 2D surface area of North Pond is 146,914 m2 and the total storage volume of North Pond is 792,691 m^3. There are approximately 150,400 m^3 (150.4 million litres) contained within the top one (1) m of North Pond and approximately 400,000 m^3 of water between the water surface (elevation 93.39 m) and the estimated elevation of the intake (elevation 90 m).

Figure 4-1: Great Pond Bathymetric Survey Equipment

In general, Great Pond has a significantly larger surface area than North Pond but only a marginally larger amount of storage volume (i.e. much of Great Pond is shallow, particularly the southwest portion). Approximately 58% of the total volume is contained within the top two (2) m of the pond.

The deepest portion of the pond is in the northwest corner, which will be beneficial if any future intake is to be sited near the outlet of the pond.

Table 4-2: Storage Volume Table for Great Pond Developed Using Bathymetric Data.

Reference Elevation	2D Surface Area (m^2)	Volume Below Reference Plane (m^3)	Volume difference between this elevation and the one below (m^3)
117.75	286,716	884,192	206,343
117	263,580	677,849	64,929
116.75	255,807	612,920	181,705
116	228,040	431,216	55,539
115.75	216,185	375,677	146,705
115	173,232	228,972	135,387
114	88,424	93,585	57,493
113	30,853	36,092	21,300
112	14,767	14,791	10,659
111	7,059	4,132	4,081
110	584	51	51
109.6	Bottom of Pond	0	0

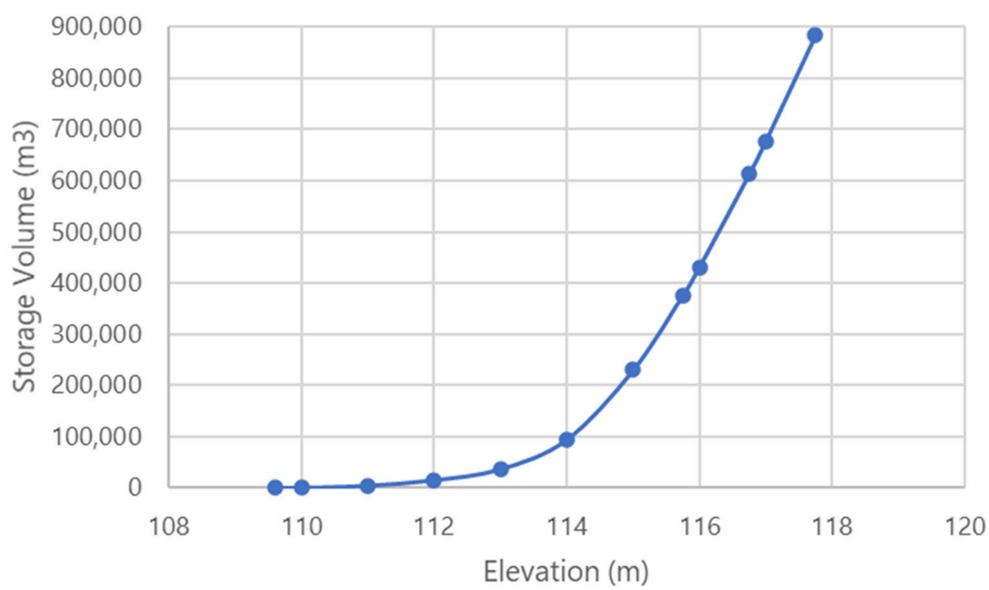

Figure 4-2: Great Pond Storage Volume Curve Developed Using Bathymetric Data.

4.1.3 Flow Monitoring

Pressure transducers were installed at the outflow of Great Pond, immediately downstream of Great Pond, and have been collecting data continuously since December 2019. One transducer is located in the stream, and measures water temperature and pressure, while a second sensor is located nearby to measure air pressure. This is used to calculate the depth of the transducer. During regular downloads, discharge transects (that measure flow rates in the stream) are also completed in order to develop a regression to estimate discharge based on water depth (Figure 4-4).

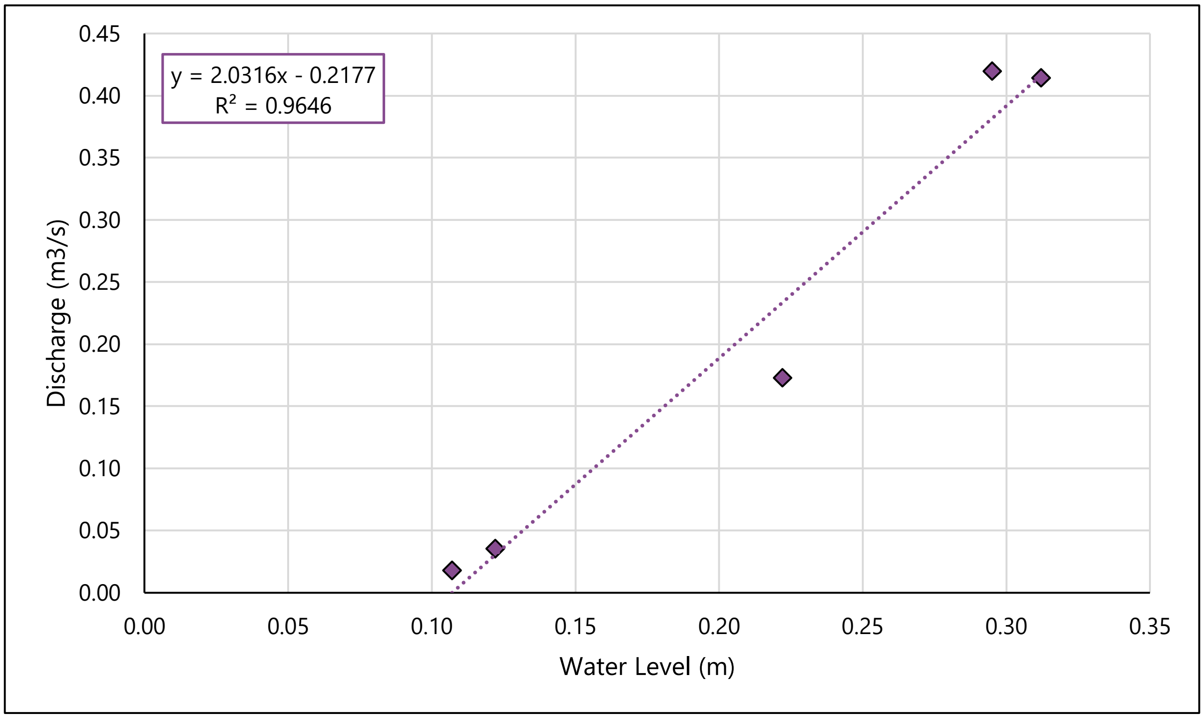

Figure 4-3: Discharge (m^3/s) vs. Stage (m).

Using the water level-discharge relationship presented above, discharge has been calculated throughout the period from December 2019 to early January 2021 (Table 4-2 and Figure 4-5). Figure 4-5 also presents the prorated discharge based on the gauging station in Northeast pond River (Station # 02ZM006). Both methods of discharge estimation produced similar mean annual discharges of approximately $0.16m^3/s$.

Table 4-3: Summary of estimated discharge from Great Pond

Discharge Measure	Mean Annual Discharge	50th Percentile Discharge	Maximum Discharge
Sensor Discharge	0.155	0.128	0.739
Prorated Discharge	0.166	0.081	5.676
Note	Prorated discharge based on Station # 02ZM006 which has 69 years of data available		

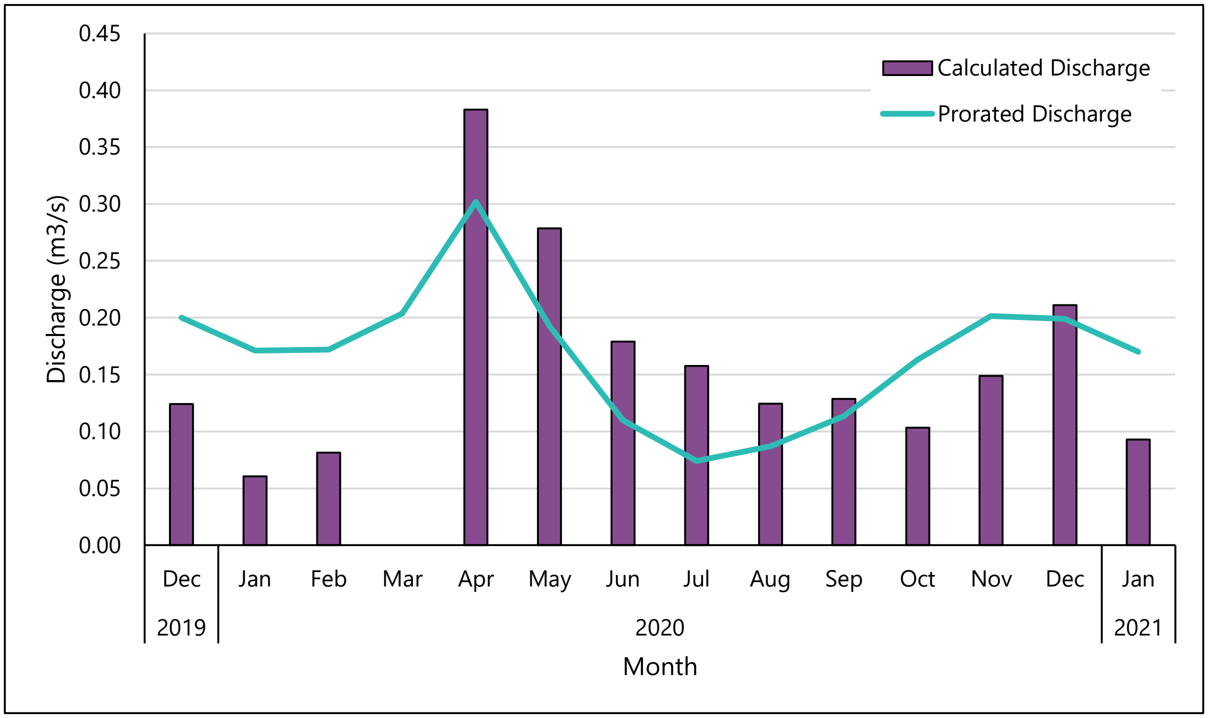

Figure 4-4: Calculated Discharge Leaving Great Pond, with Missing Data for March 2020.

4.1.4 Wetted Perimeter

Using cross sectional data collected on April 22, 2020, a wetted perimeter model was developed using Manning's N equation. This model shows an inflection point, which indicates the minimum discharge required to maintain wetted perimeter (i.e. available aquatic habitat). Figure 4-6 presents the modelled wetted perimeter and discharge, as well as measured wetted perimeter and discharge. As shown, the modelled inflection point is 0.08 m^3/s, while the measured inflection point is 0.04 m^3/s.

The wetted perimeter model has three key assumptions, as presented in Section 3.1.4. This transect location was chosen initially as a discharge monitoring transect. While the location is suitable for this purpose, it does not make it an ideal location for wetted perimeter assessments, specifically because it may not be considered a critical or sensitive habitat. In order to further define minimum flow release, further field surveys and discharge measurements are recommended.

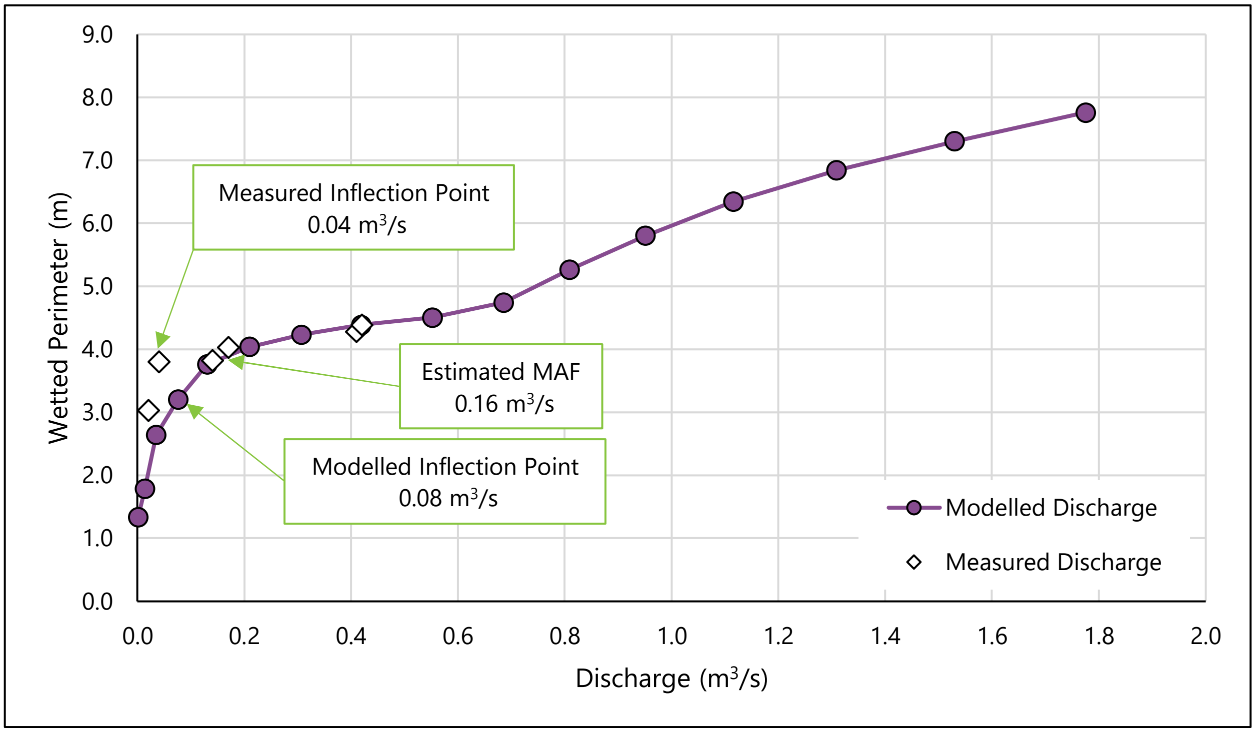

Figure 4-5: Wetted perimeter analysis for Great Pond Outflow.

4.2 Water Balance

A water-balance assessment was conducted to evaluate how water moves within the Great Pond drainage area. The results are presented in the following sections.

4.2.1 Precipitation and Temperature

All available climatic data was retrieved for the Environment Canada St. John's A climate station (Climate ID 8403506, 47°37'20.000" N, 52°44'34.000" W, elevation 140.5 m; Environment Canada, 2020). Climate normals for St. John's are presented in Table 4-4. The mean monthly temperature ranges from -4.9 °C in February to 16.1 °C in August.

The monthly precipitation data for St. John's is reported as Total Rainfall (the amount of all liquid precipitation in millimetres such as rain, drizzle, freezing rain and hail observed at the location during a specified time interval), Total Snow (the amount of frozen/solid precipitation in centimetres, such as snow and ice pellets observed at the location during a specified time interval), and Total Precipitation (the sum of the total rainfall and the water equivalent of the total snow in millimetres observed at the location during a specified time interval). Total precipitation does not always equal rainfall plus one tenth of the snowfall in the statistical summary (e.g. missing observations is one cause of such discrepancies).

The average monthly total precipitation range at the climate station is 91.6 mm in July to 164.8 mm in December. The average annual total precipitation is 1534 mm. The historical data contains a record of the snow on the ground on the last day of each month, with the most snow on the ground at the end of January. Historically, the wettest year during the period of record was 1955, where the total precipitation was 1636 mm. The driest year during the period of record was 1989, where the total precipitation was 590 mm.

Table 4-4: Monthly Temperature and Precipitation Normals (1981–2010) for St. John's International Airport (Environment Canada, 2020).

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Average Temperature (°C)	-4.5	-4.9	-2.6	1.9	6.4	10.9	15.8	16.1	12.4	7.4	3	-1.5	5
Total Rain (mm)	66	61.6	84.8	96.1	97.9	97.5	91.6	100	129.6	153.7	124.8	102.9	1206.4
Total Snow (cm)	88.7	71	57.3	25.3	4.4	0	0	0	0	2.4	22.4	63.4	335
Precipitation (mm)	149.2	129.5	142.2	122.9	102.6	97.6	91.6	100	129.6	156.2	148.1	164.8	1534.2
Snow Depth at Month-end (cm)	31	30	15	1	0	0	0	0	0	0	2	12	8

4.2.2 Water Holding Capacity

The water holding capacity (WHC) of the soil in the area of interest is required to perform the water-balance calculations. WHC refers to the maximum amount of water that can be held in the capillaries of soil for the use of plants and it depends on the composition, structure and depth of the soil and the type of vegetation surface (Phillips 1976).

The surficial geology (Batterson, 2000) indicates the Great Pond watershed consists mainly of a thin till veneer (<1.5m) to a till blanket (>1.5m) Till typically consists of clay, silt, sand and boulders. For the purposes of this desktop assessment, the WHC used in the water-balance calculations was assumed to be 125 mm.

4.2.3 Estimating Monthly Runoff

Surplus water is the excess after the evaporation needs of the surface have been met (i.e. when actual evapotranspiration equals potential evapotranspiration) and soil storage has been returned to the water holding capacity (Johnstone and Louie 1983). The surplus within each drainage area was distributed into runoff and infiltration using Ontario MOE Guidelines (MOE 2003). The total infiltration in a month (of which some discharges back to the stream as base flow) was determined by considering topography, soils and cover as per MOE (2003) guidelines. For this desktop study, the soil in each drainage area is assumed to have an infiltration factor of 30% due to the hilly land, soil type, limited woodland cover and exposed bedrock). As a result, 70% of the monthly surplus ends up as runoff. The lake areas in each drainage area, which are assumed to contribute wholly to the volume of the lake with no infiltration losses, were assigned an infiltration factor of 0.

These are considered to be high-level estimates of surplus and infiltration, typically only applied on an annual basis. As such, in the following section, estimates of surplus, infiltration and runoff will be summarized for each drainage area on an annual-basis.

Thornthwaite water-balance calculations (St. John's Airport for the period of 1942-2019) were provided by the Climate Services division of Environment Canada are shown in Table 4-5. The average annual surplus for the period of analysis was 1016 mm. The total annual surplus is shown in Figure 4-6 for all years on record. The driest year with the least amount of surplus was 1989 (total precipitation = 1147 mm and total surplus = 590 mm). The wettest year with the greatest amount of surplus was 1955 (total precipitation 2068 mm and total surplus = 1636 mm).

The Newfoundland and Labrador Guidelines for the Design, Construction and Operation of Water and Sewerage Systems (ECCM, 2005) indicate a surface water quantity assessment should, demonstrate that, where possible, a minimum drought return period of one in fifty years should be used for calculating the safe yield. Assuming, the total annual precipitation data collected at the St. John's Airport location follows an extreme value distribution, the driest year 1989.

Table 4-5: Water Balance Averages for the Period of 1942-2019.

Month	TEMP (°C)	PCPN (mm)	RAIN (mm)	MELT (mm)	PE (mm)	AE (mm)	DEF (mm)	SURPLUS (mm)	SNOW (mm)	SOIL (mm)	ACCUM PCPN (mm)
January	-4.1	151	65	36	2	2	0	98	85	125	615
February	-4.7	135	53	34	2	2	0	85	133	125	749
March	-2.5	134	69	56	4	4	0	121	142	125	883
April	1.5	115	96	119	16	16	0	199	42	125	999
May	5.9	100	99	43	47	47	0	96	0	124	1098
June	10.7	94	94	0	80	80	0	23	0	115	1192
July	15.7	88	88	0	113	112	-1	8	0	82	1280
August	15.8	110	110	0	105	101	-4	10	0	81	1391
September	12.1	125	125	0	71	70	-1	32	0	103	1517
October	7.3	150	150	0	41	41	0	90	0	122	149
November	3.2	154	148	5	18	18	0	132	2	125	303
December	-1.5	160	104	23	5	5	0	122	35	125	463
Annual	4.9	1515	1201	316	504	498	-6	1016			

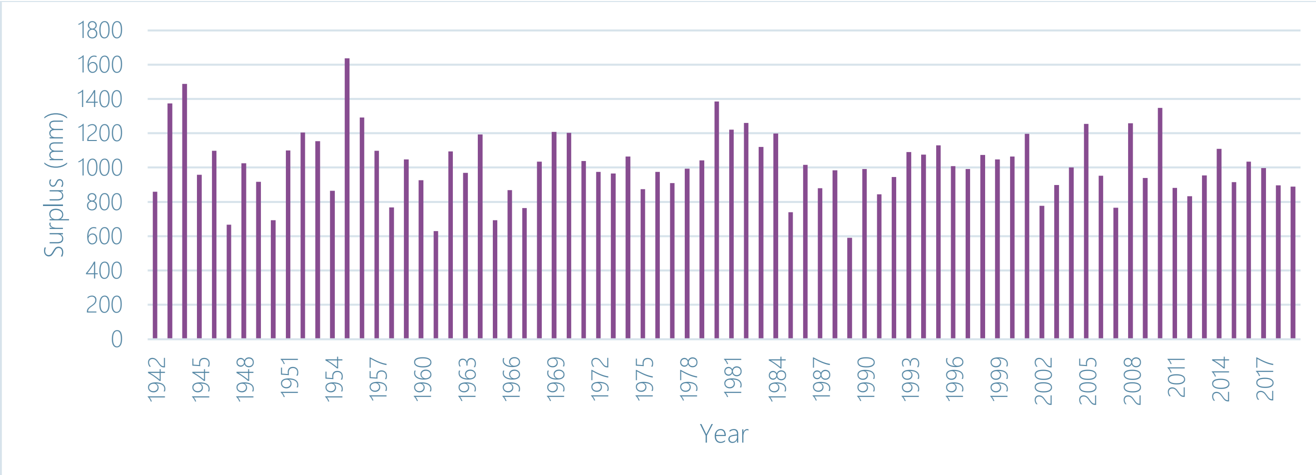

Figure 4-6: Total Surplus (mm) by Year as Determined by the Thornthwaite Water Balance.

4.2.4 Great Pond Drainage Area Water-Balance Results

The water balance calculations for the Great Pond drainage area (3.83km^2) are outlined in Table 4-5. Detailed calculations are included in Appendix B.

- **Average year:** total surplus is 3,890,133 m^3 and total infiltration is 1,079,993 m^3 resulting in a total surface runoff is 2,810,140 m^3. The average flow rate as determined in the water-balance calculations is 0.09 m^3/s (89 L/s).
- **Wet year:** total surface runoff is 4,521,893 m^3 (average flow rate of 0.14 m^3/s or 143 L/s).
- **Dry year:** total surface runoff is 1,640,032 m^3 (average flow rate of 0.05 m^3/s or 52 L/s).

4.3 Planning and Land Use Review

Various watershed areas have been identified for Great Pond. These include a boundary delineated by the Department of Municipal Affairs and Environment as a potential watershed area in 2008 (ECCM, 2019). The Torbay Municipal Plan identifies a larger watershed boundary including an extended area to the northwest (Town of Torbay, 2015). The Town of Portugal Cove-St. Philips has defined an area for the portion of Great Pond watershed within its boundaries (Town of Portugal Cove-St. Philips 2016). In 2020, Wood delineated a more detailed watershed boundary within both municipalities, which is referred to as the watershed in this review.

4.3.1 Provincial Regulations, Policies and Land Use Interests

Water Resources Act, SNL 2002

The Great Pond watershed delineated by the Department of Environment, Climate Change, and Municipalities is identified by the Government of Newfoundland and Labrador as a potential water supply (ECCM, 2019). While a potential future water supply may receive protection through Section 39 of the *Water Resources Act*, Great Pond does not presently have protection through provincial legislation (GNL, 2016).

Protecting a watershed area under the *Water Resources Act* requires submission of a "Protection of a Public Water Supply Area" application to the regional office of the Water Resources Management Division (WRMD). The application, which requires information about the watershed including major water supply name, location, consultant information, water quality and land use, is found at: https://www.gov.nl.ca/mae/files/waterres-regulations-appforms-dev-protected-area-fees.pdf. Once submitted, the application is reviewed by WRMD for completeness and accuracy. Additional information on existing or potential development activities may be requested and a site visit arranged. The watershed boundary is delineated, and the application is reviewed by the Interdepartmental Land Use Committee (ILUC) to identify development activities, potential land use conflicts with other resource use and interests of other departments and agencies (DMAE 2013; Government of NL No Date a).

Upon approval, a notice of designation is published in the Newfoundland and Labrador Gazette and the municipality receives confirmation. The municipality is required to give public notice of the designation through ads in local newspapers and/or posters in public spaces in the community (e.g., council office, community centre). The municipality is advised to post signage at suitable locations (e.g., access points) along the boundaries of the designated area. Digital maps of protected public water supply area boundaries are maintained in WRMD's Geographical Information System (GIS) on the Water Resources Portal website to identify the location of protected public water supply areas and to provide digital data (ECCM 2013; GNL No Date a). Provincial development proposals within a protected water supply area are forwarded to the municipality for comment.

Potential Water Supply Areas

A potential public water supply area may be protected under the same process as a public water supply area if one of the following conditions apply:

- it is demonstrated that the yield of the present source is inadequate to meet the present and future water demands of its users;
- the quality of the present source is not in compliance with existing drinking water quality guidelines and may pose a risk to the health of consumers;
- due to other factors as determined by the department.

Once protected, the provisions of Section 39 apply to the potential public water supply area from the date of the publication of the notice of the designation in the Newfoundland and Labrador Gazette. In the same manner as with protected public water supply areas, signs should be posted at suitable locations along the boundaries of the designated area for public information (ECCM, 2013). Provincial development proposals within a protected potential water supply area are also forwarded to the municipality for comment.

Expropriation Act

In Newfoundland and Labrador, the *Expropriation Act* provides the Provincial government, or a designate, with the power to expropriate land for public purposes. Section 3 of the *Act* outlines situations where expropriation may be permitted. Expropriation would only occur where the minister considers it necessary for purposes described in Section 3. Potential scenarios include: the owner refuses to sell, an agreement cannot be reached on compensation or terms, the owner is unknown or cannot be found after reasonable inquiry, the owner is incapable of conveying the land or their interest in it or for other reasons (GNL, 2019).

Urban and Rural Planning Act, 2000

Where a Newfoundland and Labrador municipality requires lands surrounding a water supply waterbody for protection, it may purchase the land from legal owners. Where this is not possible, the *Urban and Rural Planning Act, 2000*, Part 9 gives municipalities the right to expropriate property, land or an interest in land for the purpose of powers granted under the *Municipalities Act, 1999* (GNL, 2017a).

Municipalities Act, 1999

Under the *Municipalities Act, 1999* Part 7, a municipality may expropriate land, property or an interest in property for a variety of purposes including a public water supply system. A municipality may acquire waters for the purpose of providing a water supply for the municipality and may acquire, by purchase or expropriation, adjacent lands to prevent pollution of those waters (GNL, 2017b).

Forestry

In Newfoundland and Labrador, a permit is required for domestic cutting, which occurs mainly in fall and winter using ATVs or snowmobiles. Each permit allows harvesting of 7-9 m^3. Torbay is within the Provincial Zone 1 Forestry Management District, which has a current operations plan for the period of 2017-2021. Domestic cutting blocks are located throughout the District including in Torbay (Drawing 4; Appendix A). Operating Unit Area No. CC01603 Patrick's Path (369.7 ha) overlaps with the Great Pond Watershed (2020). The estimated annual domestic harvest in CC01603 is approximately 16,742 m^3 and recent cutting is evident off Great Pond Road / Whiteway Pond Road (Forest Service 2016). Forest access roads are located within the watershed connecting to Great Pond Road / Whiteway Pond Road and Woodfine's Lane (GNL, 2020a).

Domestic harvesting increased in Zone 1 in the last planning period. Demand for fuel wood is particularly high and anticipated to grow given the rising cost of other heating methods and decreased availability of fuel wood sources. No commercial cutting, silviculture blocks or planned forestry road construction are identified for Torbay (Forest Service, 2016).

Twenty (20) m No-Cut Buffers are located around most of the edge of Great Pond and streams leading into the Pond. Wider buffers are established where a waterbody is a protected water supply areas; the guidelines are attached to any cutting permits issued in the area and compliance is monitored. The Forest Service must receive annual approval under the *Water Resources Act* for harvesting within a protected watershed. Great Pond watershed is not identified as a protected water supply in the forestry plan. District Ecosystem Managers and planning teams may widen buffer widths to protect sensitive areas such as salmon spawning habitat, cabin areas or for aesthetic purposes (Forest Service, 2016).

Agriculture

Based on satellite imagery and field investigation, it appears that agricultural activity occurs in the Great Pond watershed (2020). It is likely that one or more sod farms with residences and outbuildings, are located on Great Pond Road / Whiteway Pond Road (Drawing 5; Appendix A).

Mining

Mining data is available through the Newfoundland and Labrador Geoscience Atlas. No exploration licences or mining leases are in the Great Pond watershed (2020). A quarry is located near Great Pond partially within the watershed (Drawing 6; Appendix A). It appears that this quarry is inactive as the permit expired in 2014 (GNL, 2020a).

Hunting and Trapping

Torbay is within various hunting zones. Permitted activities include moose hunting, which occurs usually from September to December and small game (willow and rock ptarmigan, ruffed and spruce grouse and snowshoe hare) hunting generally from September to March each year. Caribou and black bear management areas surrounding Torbay are closed to hunting. Torbay is in trapping Zone B, where various species may be harvested (Government of NL 2020b). Trapping generally occurs in winter when fur quality is optimal. While this information is not detailed enough to confirm the level of activities in Torbay, hunting and trapping may occur within the Great Pond watershed.

Stewardship Association of Municipalities

In 1997, the Town of Torbay signed a Municipal Wetland Stewardship Agreement with the Stewardship Association of Municipalities (SAM). A Stewardship Zone, which covers more than half of the Municipal Boundary area, encompasses most of the major wetlands and waterfowl habitat within the Town (Drawing 7; Appendix A). Within the Stewardship Zone, conservation areas (significant waterfowl habitats) have been identified at Western Island Pond, Gosse’s Pond (also known as Goose Pond), Upper Three Corner Pond, Jones Pond Riparian Zone, The Gully and the Shoreline Conservation Area. The Habitat Conservation Plan for Torbay allows canoeing, hiking, photography, bird watching and opportunities to learn about wetlands and waterfowl conservation. Applications for development located within the Stewardship Zone and conservation areas are reviewed by Council, which also refers these development proposals to Wildlife Division, Department of Municipal Affairs and Environment for review and comment. Council may use mitigating measures to reduce habitat degradation that may result from development within the Stewardship Zone (Town of Torbay, 2015). The Stewardship Zone encompasses Great Pond, but all Management Units are outside the Great Pond watershed (2020).

4.3.2 Regional Policies, Agreements and Land Use Interests

Development of land in Torbay is subject to regional policies. These were examined to determine if they may affect the potential for Great Pond as a water supply.

St. John's Urban Region Regional Plan

The St. John's Urban Region Regional Plan (SJURRP) seeks to enhance development to accommodate population growth within the City of St. John's and adjacent areas to maximize use of existing roads, water and sewerage and other services. The SJURRP identifies Torbay as a local centre, which is to be developed within the limits of the following identified constraints: existing and future municipal services; financing for capital works; infilling within developed areas; capital expenditures on the regional road network; capacity of existing local roads; capacity of school facilities; and protection of regional resources (e.g., agricultural and forest lands, watersheds and scenic resources). Residential development in local centres would generally be low density, consisting mainly of single-family dwellings (Town of Torbay, 2015). Municipal plans are to be aligned with the SJURRP, but this plan should not pose challenges for protection of Great Pond and its watershed. Protection of this watershed would support population growth by allowing more dense housing development.

Trail Systems

The Eastern Avalon has extensive trail systems including the East Coast Trail and Grand Concourse, which are both partly located in Torbay. The Father Troy, a 5 km section of the East Coast Trail, connects Torbay to Flatrock. The Silver Mine Head Path connects to Middle Cove also along the coast (Town of Torbay 2020). None of these trails are within the Great Pond watershed (2020).

4.3.3 Municipal Regulations, Policies and Land Use Interests

Town of Torbay

The portion of Great Pond watershed (2020) that is within the Town of Torbay is governed by the Town's Municipal Plan and Development Regulations. The following sections describe the policies and development regulations relevant to the Great Pond watershed along with existing and potential future land use in Torbay.

Municipal Planning and Development Regulations

The Town of Torbay has a current Municipal Plan and Development Regulations for the period of 2015 to 2025. The Great Pond watershed is mostly contained within the Watershed (WAT) Zone. Rural (RUR) and Residential Large Lot (RLL) land use zones overlap in small areas of the watershed south of the intersection of Torbay Bypass Road and Bauline Line (Town of Torbay 2015). See Drawing 8 (Appendix A).

Based on policy statements in the Municipal Plan, Torbay's Watershed (WAT) Zone is intended to preserve the water quality of North Pond, South Pond and Great Pond as municipal water supplies or potential future sources of drinking water. The boundaries of the WAT Zone are intended to encompass all lands that drain into these waterbodies (Town of Torbay 2015). However, this is currently not the case for Great Pond.

The current Municipal Plan includes policies that are, or could potentially be, applicable to Great Pond watershed:

- Uses permitted in Watershed areas may include passive recreation (e.g., hiking, picnicking). Structures required for erosion control or other environmental conservation purposes may be permitted. No form of urban development shall be permitted. All proposals for development are subject to approval by the Department of Environment, Climate Change, and Municipalities, Water Resources Management Division.
- No development or activities that would adversely affect water quality shall be carried out in a Watershed area.
- To comply with Department of Municipal Affairs and Environment standards, existing residential

development in the Great Pond Watershed may be required to be removed if Great Pond is developed as a municipal water supply.

- Council shall cooperate with the Town of Portugal Cove-St. Philip's to ensure that no development that could adversely affect water quality occurs within the Great Pond Watershed.
- Selective wood harvesting may be permitted within Watershed areas, subject to approval of the Department of Environment, Climate Change and Municipalities. Maintaining water quality is the overriding priority (Town of Torbay, 2015).

The Torbay Development Regulations indicate that the only permitted use within the WAT zone is Conservation. Forestry, agriculture or antennae may be permitted at the discretion of Council provided they are complementary to permitted uses (i.e., Conservation) and will not adversely affect the quality or quantity of water in the waterbody identified as a water supply source. Selective forestry activities, agriculture and maintenance, and limited extension of existing uses, may be permitted provided they will not have detrimental effects on water quality (Town of Torbay, 2015). All existing development in Great Pond watershed appears to be within the WAT Zone.

The Residential Large Lot (RLL) Zone permits development of single dwellings and recreational open space. Discretionary uses include double dwellings, row dwellings, apartment buildings, places of worship, educational facilities, convenience stores, childcare facilities, offices, medical and professional services, personal services, light industry, traditional agriculture (i.e., hobby farming), boarding house residential and antennae (Town of Torbay 2015). As there appears to be no current development within the portions of the RLL Zone that overlap with the 2020 watershed area, these areas could be rezoned as WAT.

The Rural (RUR) Zone permits agriculture, forestry, recreational open space and conservation. Discretionary uses include single dwellings, general industry, mineral workings, antennae, places of worship and cemeteries (Town of Torbay 2015). As there appears to be no current development within the portions of the RUR Zone that overlap with the 2020 watershed area, these areas could be rezoned as WAT.

Various Crown Lands grants have been issued in Torbay. Thirteen (13) are located within the Great Pond watershed (Crown Lands 2019). These are zoned as WAT, RLL and RUR as per the Municipal Plan.

Environmentally Sensitive Areas

Along with the SAM Conservation Areas, the Torbay Municipal Plan identifies environmentally sensitive areas as steep slopes, wetlands, areas prone to landslides and rockfalls, and a 30 m buffer along the sea wall. These areas are identified in the Future Land Use Map as Conservation Areas (Town of Torbay 2015). No Conservation Areas are identified within the Great Pond watershed.

The Torbay Municipal Plan identifies a floodway (1:20 year flood zone) as an area subject to the most frequent flooding and the floodway fringe (1:100 year flood zone) as an area that may be flooded but less frequently and receives less damage. These areas are identified to reduce the risk of future damage (Town of Torbay 2015). No floodways and floodway fringes are within the Great Pond watershed.

Stormwater Detention

The Town of Torbay has established engineering design guidelines for subdivisions. These include net zero stormwater runoff from proposed developments. Stormwater detention systems must be designed to temporarily store the difference in volume between the 100-year 24-hr post-development peak discharge runoff for the planned development and the 100-year 24-hr pre-development runoff (Town of Torbay 2016).

Trail Development in Torbay

Municipal trails have been established in Upper Three Corner Pond Park, along Western Island Pond, at Woodbridge Park and along Island Pond Brook (Drawing 9; Appendix A). None of these trails are within the Great Pond watershed (Town of Torbay 2020). The Torbay Open Space Management Strategy proposes a larger scale multi-use trail system referred to as the Inner Loop and Outer Loop (Town of Torbay, 2010). A portion of the Outer Loop would be in the Great Pond watershed (2020).

Existing Land Use in the Great Pond Watershed

While much of the land within the Great Pond watershed (2020) in Torbay is undeveloped, various land uses currently exist within the watershed. The following list describes these areas based on a desktop study using the Town of Torbay's EagleView system. Field reconnaissance was used to clarify some of the observations.

- A portion of Bauline Line passes through the Great Pond watershed (2020).
- Residential and / or seasonal properties are located within the Great Pond Watershed (2020). One property is located on an extension of Pondside Lane and another on Great Pond Road / Whiteway Pond Road. Whole, or portions of, 10 to 15 properties on either side of Bauline Line are within the watershed (Drawing 9; Appendix A). Properties within the watershed appear to include houses or cabins and outbuildings, cleared areas (e.g., lawns and potentially hobby farms), hard surfaces such as roads and driveways, boat launches and stored automobiles and / or recreational vehicles.
- Agricultural development(s), possibly one or more sod farms with residences and outbuildings, are located on Great Pond Road / Whiteway Pond Road within the Great Pond watershed (2020).
- Several roads (paved and unpaved), dirt tracks and ATV trails begin at the terminus of Great Pond Road / Whiteway Pond Road extending to cleared areas (e.g., domestic cutting, agriculture areas) and an inactive gravel pit (accessed from Indian Meal Line). ATV trails extend to a pond that is within the Torbay WAT Zone but outside of the Great Pond watershed (2020). This trail crosses a stream that runs into Great Pond. This stream appears to have been forded.
- An easement runs from a power substation at the Torbay Bypass Road and Whiteway Pond Road through the Great Pond watershed (2020) on its way to Flatrock.
- Several areas north of Great Pond Road / Whiteway Pond Road have trails and domestic cutting.
- A stream that runs beneath Bauline Line via a culvert empties into Great Pond. The stream connects to Big River, which runs adjacent to an agricultural area off Three Island Pond Road.

Future Development in Torbay

Torbay's 2015-2025 Municipal Plan and Development Regulations anticipate future residential development. Approximately 50 units per year were developed in each of the 10 years leading up to the new plan. Relevant policies include providing an adequate amount of serviced land to accommodate residential development within the municipality and encouraging residential infilling in existing neighbourhoods. The Municipal Plan indicates that Torbay has ample land designated for future residential growth. Development of large residential lots has proceeded along Indian Meal Line, Marine Drive and Bauline Line. Higher density development has been constrained by the cost of extending municipal services to undeveloped areas (Town of Torbay, 2015). However, the Town of Torbay has not undertaken studies to estimate the number of potential lots based on servicing scenarios and / or land suitability or capability.

Torbay's General Land Use Policies for subdivisions identifies land bordering developed residential areas as suitable for future large-scale residential development. Council will subject proposed subdivision developments to a comprehensive evaluation. The content of this evaluation will include:

- an investigation of physical features of the site and the opportunities and constraints to development. Where possible, the layout of proposed lots and roads shall conform to the topography;
- an outline of how the proposed subdivision will integrate with existing development and roads and services on adjacent lands and provide for future access to undeveloped lands in the area;
- ensure compatibility between the subdivision and surrounding land uses, both existing and future; and
- review of municipal servicing proposals by the developer and the public costs of providing and maintaining these services (Town of Torbay 2015).

Residential Subdivision Areas (RSAs) are identified in the Municipal Plan as tracts of undeveloped land that border developed residential areas and may be suitable for future large-scale residential development. No development shall take place in these areas until the land has been appropriately zoned in the Torbay Development Regulations (Town of Torbay, 2015). Eight such areas are identified on the Land Use Zoning Map.

In RSA zones that require municipal water and sewerage, the developer shall submit a subdivision plan, showing how the proposed development will connect to the remainder of the RSA zone and adjacent development. In RSA zones that permit development without municipal water and sewerage, the developer shall submit a design scheme for the entire RSA zone, showing how the proposed development will connect to adjacent development. Lot sizes shall conform to standards of the Residential Large Lot zone (Town of Torbay, 2015).

In areas near municipal services, Council shall require the installation of municipal water and sewerage for new development. In areas that are sufficiently remote from existing municipal services, Council may consider development without municipal water and sewerage (Town of Torbay, 2015).

The Future Land Use map indicates proposed or suggested future access points and future road links into Residential areas. The access points and road links shall be reserved until a subdivision design is approved by Council. In areas that require full municipal services, the developer shall submit a subdivision design for the proposed area, showing road layout, proposed lots, open space and servicing plan. The developer shall identify how the proposed development will connect to adjacent development (Town of Torbay, 2015).

Town of Portugal Cove-St. Philips

The portion of Great Pond watershed that falls within the Municipal Boundary of the Town of Portugal Cove-St. Philips is governed by the Town's Municipal Plan and Development Regulations. Much of the land in the watershed within Portugal Cove-St. Philips is also undeveloped. The following sections describe the policies and development regulations relevant to the Great Pond watershed along with existing land use in Portugal Cove St. Philips.

Municipal Planning and Development Regulations

The Town of Portugal Cove-St. Philips's Municipal Plan and Development Regulations cover the period of 2014 to 2024. Most of the Great Pond watershed area that extends within the Portugal Cove-St. Philips Municipal Boundary is zoned as Protected Watershed (PW) by the Municipality and the rest is zoned as Rural (RUR) (Town of Portugal Cove-St. Philips, 2014). This section discusses policies and development regulations relevant to Great Pond watershed.

Portugal Cove-St. Philips has several policy statements that apply to the portion of Great Pond watershed that falls within its Municipal Boundary:

- The Town ensures that the location of any potential new conservation or approved discretionary land uses development do not conflict with the regional water supply agreement.
- Owners / operators of land within designated watershed areas are responsible for protecting the water supply.
- All discretionary land uses (e.g., antennae, forestry, passive recreational uses such as hiking trails) and any other development activities, proposed to be within the designated watershed areas are referred to the Department of Environment and Conservation for prior approval.
- The Portugal Cove-St. Philips Municipal Plan is referred to the Town of Torbay for comments related to the potential Great Pond Water Supply.
- Any development proposals are referred to the Town of Torbay for comments related to the potential Great Pond Water Supply.
- Conservation uses related to managing and protecting designated watershed areas may be considered by Council as a permitted use (Town of Portugal Cove-St. Philips, 2014).
- Council shall not consider, support or permit any form of urban land development within Watershed Protection Areas (Town of Portugal Cove-St. Philips, 2014).

The Portugal Cove-St. Philips Development Regulations indicate that Conservation is the only permitted land use within the Protected Watershed (PW) Zone. Discretionary uses include antennae, forestry and recreational open space (Town of Portugal Cove-St. Philips, 2014).

Permitted uses within the Rural (RUR) Zone include agriculture, conservation, forestry and recreational open space. Discretionary uses include animal, antennae, cemetery, commercial residential (tourist cottage only), general industry (resource-based only), light industry (resource-based only), mineral working, outdoor assembly, single dwelling, veterinary, private and commercial wind turbines (Town of Portugal Cove-St. Philips 2014).

Existing Land Use in the Great Pond Watershed

Development is limited in the Great Pond watershed (2020) within the Town of Portugal Cove-St. Philips. Windy Heights Farm is located on Bauline Line Extension extends to the northeast in the headwaters of Great Pond watershed (2020). This farm produces hay and nursery sod. In 2019, Windy Heights began to produce gourmet mushrooms in an indoor, chemical free facility year-round (Windy Heights, 2020; GNL, No Date b).

5.0 DISCUSSION AND RECOMMENDATIONS

Discussion and recommendations are provided below for the source water study and water balance and the planning review.

5.1 Source Water Study and Water Balance

The watershed area that was delineated for this study using LiDAR is approximately 80 ha larger than the previously delineated watershed area (NDAL, 2008), as well as the watershed areas used in municipal zoning.

The calculated 2D surface area of Great Pond at the time of survey was 286,716 m^2 and the total storage volume was 884,192 m^3. At the time of the survey, there was approximately 271,271 m^3 contained within the top one (1) m of Great Pond. In general, Great Pond has a significantly larger surface area than North Pond but only a marginally larger storage volume, since much of Great Pond is shallow, particularly the southwest portion. Approximately 58% of the total volume is contained within the top two (2) m of the pond.

Results of the bathymetric survey indicate that the deepest portion of the pond is in the northwest corner, which is the ideal location for a water intake is to be sited near the outlet of the pond.

The results of the water balance indicate that flow rate in an average year is 0.09 m3/s (89 L/s), rate of 0.14 m^3/s (143 L/s) in a wet year, and 0.05 m^3/s (52 L/s) in a dry year. Given the provincial guidance to use a minimum drought return, the available recharge that could potentially be used for drinking water is 0.05 m^3/s, with an approximate average available demand of 2000 m^3/day (Table 5-1).

Table 5-1: Anticipated Demand for Great Pond and Current Demand at North Pond.

m3/day	North Pond	Great Pond
Average demand	1300	2000
Peak demand	2600	4000
Instantaneous	2600	4000

The results of the flow monitoring indicate a mean annual discharge of approximately 0.16m^3/s, which corresponds well with the calculated flow rate for a wet year.

The results of the wetted perimeter study indicate a measured inflection point is 0.04 m^3/s, which is a preliminary minimum flow release value to the Big River. Given the current available flow for a drinking water treatment plant is 0.05 m^3/s and the preliminary nature of the wetted perimeter study, additional aquatic surveys are recommended in the full Big River watershed (see Drawing 11; Appendix A) to further determine the actual available flow for a drinking water supply at Great Pond.

Recommended fish and fish habitat surveys include:

- Fish species presence and relative abundance in Great Pond;
- Fish species presence and abundance in Great Pond outflow;
- Fish species presence and abundance in Big River;
- Detailed habitat surveys in Great Pond;

- Detailed habitat surveys in Great Pond outflow; and,
- Selected habitat surveys in Big River downstream of Great Pond outflow.

Additional pressure transducers installed near the end of Big River, in Flatrock, NL are also recommended to determine the contribution of Great Pond to the overall Big River discharge.

5.2 Planning Review

The following recommendations were identified through the planning review:

- Should Torbay decide to use Great Pond as a future drinking water source, the Town should apply to have Great Pond watershed (2020) designated as provincially protected.
- It is recommended that the town amend the WAT zone to include all the land in the watershed boundaries delineated within this project.
  - As there appears to be no current development within the portions of the RLL Zone that overlap with the 2020 watershed area, these areas could be rezoned as WAT in the Municipal Plan and Development Regulations.
  - As there appears to be no current development within the portions of the RUR Zone that overlap with the 2020 watershed area, these areas could be rezoned as WAT in the Municipal Plan and Development Regulations.
- To comply with Department of Environment, Climate Change, and Municipalities regulations, existing residential development in the Great Pond Watershed will require review, as removal may be required if Great Pond is designated as a municipal water supply.
- The Town could request, through the District 1 Ecosystem Managers and planning teams that wider forestry buffers be implemented around Great Pond.
- The Town should pursue and agreement with the Town of Portugal Cove-St. Philips regarding future land use in the Great Pond watershed (2020).
- To better understand future development opportunities and constraints, the Town of Torbay could undertake studies to estimate the number of potential lots based on servicing scenarios and / or land suitability or capability.

6.0 CLOSURE

This report has been prepared for the exclusive use of the Town of Torbay. The water and wastewater sampling and analyses were conducted using standard practices and in accordance with written requests from the client. No further warranty, expressed or implied, is made. The conclusions presented herein are based solely upon the scope of services and time and budgetary limitations described in our contract. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Wood accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report. The limitations of this report are attached in Appendix C.

Yours sincerely,

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7.0 REFERENCES

After, M., Davis, D. and A. Cornwell. 1991. Introduction to Environmental Engineering.

CH2M Hill Canada Ltd. 2011. Technical Memorandum: Feasibility Study and Conceptual Cost for a Water Treatment Facility for the Town of Torbay.

Batterson, M.J. 2000. Landforms and Surficial Geology of the St. John's Map Sheet (NTS 1N/10), Newfoundland Department of Mines and Energy, Geological Survey, Mapp 99-19, Open File 001N/10/0661.

Government of Newfoundland and Labrador, Department of Environment, Climate Change and Municipalities (ECCM). 2005. Guidelines for the Design, Construction and Operation of Water and Sewerage Systems. Available at: https://www.gov.nl.ca/eccm/waterres/waste/groundwater/report/.

Government of Newfoundland and Labrador. No Date a. Protect Your Water Source: A Guide to Managing Surface Water Drinking Sources. Available at: https://www.gov.nl.ca/mae/files/waterres-quality-drinkingwater-pdf-protect-your-water-source.pdf

Government of Newfoundland and Labrador. No Date b. Farm Guide. Available at: https://www.gov.nl.ca/farm-guide/

Government of Newfoundland and Labrador. 2017a. Urban and Rural Planning Act, 2000. Available at: https://www.assembly.nl.ca/Legislation/sr/statutes/u08.htm

Government of Newfoundland and Labrador. 2017b. Municipalities Act, 1999. Available at: https://www.assembly.nl.ca/Legislation/sr/statutes/m24.htm

Government of Newfoundland and Labrador. 2016. Water Resources Act and Regulations. Available at: https://www.assembly.nl.ca/legislation/sr/titleindex.htm#W

Government of Newfoundland and Labrador. 2019. Expropriation Act. Available at: https://www.assembly.nl.ca/Legislation/sr/statutes/e19.htm

Government of Newfoundland and Labrador. 2020a. Geoscience Atlas. Available at: https://geoatlas.gov.nl.ca/Default.htm

Government of Newfoundland and Labrador. 2020b. 2020-21 Hunting and Trapping Guide. Available at: https://www.gov.nl.ca/hunting-trapping-guide/2020-21/

DFO. 2012. Standard Methods Guide for the Classification and Quantification of Fish Habitat in Rivers of Newfoundland and Labrador for the Determination of Harmful Alteration, Disruption or Destruction of Fish Habitat (Draft). Fisheries and Oceans Canada, St. John's, NL.

Department of Fisheries, Forestry and Agrifoods, Forest Service of Newfoundland and Labrador. 2016. Five Year Sustainable Forest Management Plan. Available at: https://www.mae.gov.nl.ca/env_assessment/projects/Y2016/1863/1863_Registration_Document.pdf

Department of Fisheries and Land Resources, Crown Lands. 2019. Public Land Inquiries. Available at: https://www.flr.gov.nl.ca/lands/index.html

Department of Environment, Climate Change and Municipalities, Water Resources Management Division. 2013. Management of Protected Water Supply Areas. Available at: https://www.gov.nl.ca/mae

Department of Environment, Climate Change and Municipalities. 2019. Newfoundland and Labrador Water Resources Management. Available at: https://www.mae.gov.nl.ca/waterres/

Environment Canada, 2020. Weather data for St. John's A Weather Station. Available at: https://climate.weather.gc.ca/climate_data/daily_data_e.html?StationID=50089

Johnstone, K. and Louie, P. 1983. Water Balance Tabulations for Canadian Climate Stations. Hydrometeorology Division of the Canadian Climate Centre for Atmospheric Environment Science.

McCarthy, J.H., C. Grant, D. Scruton. 2007. Classification and Quantification of Fish Habitat in Rivers of Newfoundland and Labrador (Draft). Fisheries and Oceans Canada, St. John's, NL.

MOE. 2003. Stormwater Management Planning and Design Manual. Ontario Ministry of the Environment.

Nelson, F.A. 1980. Evaluation of selected instream flow methods in Montana. Proceedings of the Annual Conference of the Western Association of Fish and Wildlife Agencies: 412- 432.

Newfoundland Design Associated Limited (NDAL). 2008. Town of Torbay Water Supply Study – 2008 Update.

Phillips, D.W., 1976: Tabulations du bilan hydrique mensuel pour des stations climatologiques canadiennes. DS #4-76, Service de l'environnement atmosphérique, Environnement Canada, Downsview (Ontario).

Sooley, D.R., E.A. Luiker and M.A. Barnes. 1998. Standard Methods Guide for Freshwater Fish and Fish Habitat Surveys in Newfoundland and Labrador: Rivers and Streams. Fisheries and Oceans, St John's, NF. 50pp.

Stalnaker, C., Lamb, B. L., Henriksen, J., Bovee, K., & Bartholow, J. (1995). The instream flow incremental methodology: a primer for IFIM. National Biological Service Fort Collins Co Midcontinent Ecological Science Center.

Thornthwaite, C. 1948. An approach toward a rational classification of climate. Geographical Review, 38: 55-94.

Thornthwaite, C.W. and J. R. Mather, 1955: The Water Balance. Publications in Climatology, Vol. 8, No. 1, Drexel Institute of Technology, Centerton, New Jersey.

Town of Portugal Cove-St. Philips. 2014. Municipal Plan and Development Regulations 2014-2024. Available at: https://pcsp.ca/services/documents-applications/

Town of Torbay. 2010. Torbay Open Space Management Strategy. Available at: https://torbay.ca/site/uploads/2016/05/OSMS-Master-Doc_Final-Draft_FEB_edits.pdf

Town of Torbay. 2015. Municipal Plan and Development Regulations 2015-2025. Available at: https://torbay.ca/site/uploads/2016/08/Torbay-Municipal-Plan-2015-2025-1.pdf

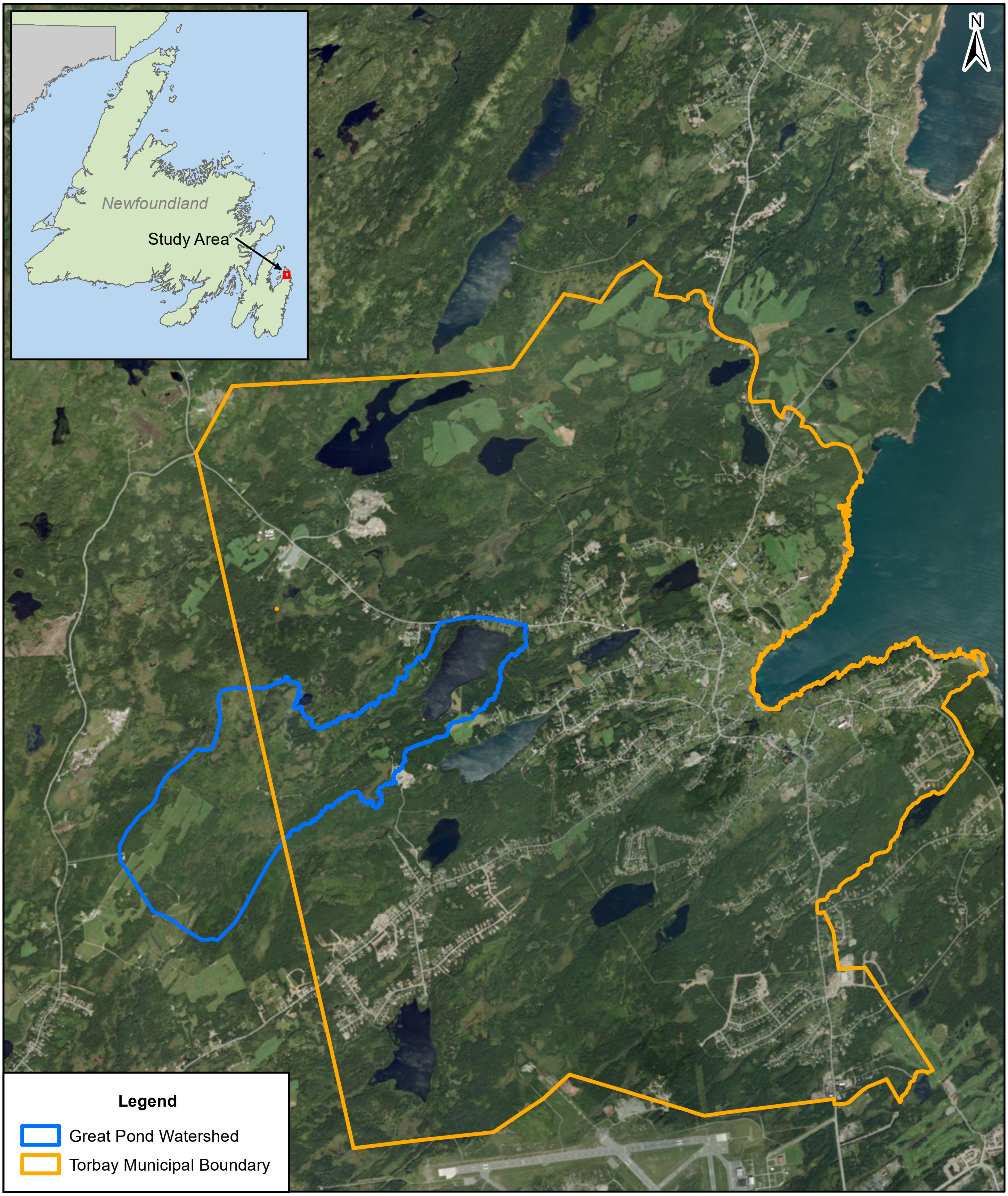
Town of Torbay. 2015. Habitat Conservation Plan for the Town of Torbay.

Town of Torbay. 2016. Engineering Design Guidelines for Subdivisions.

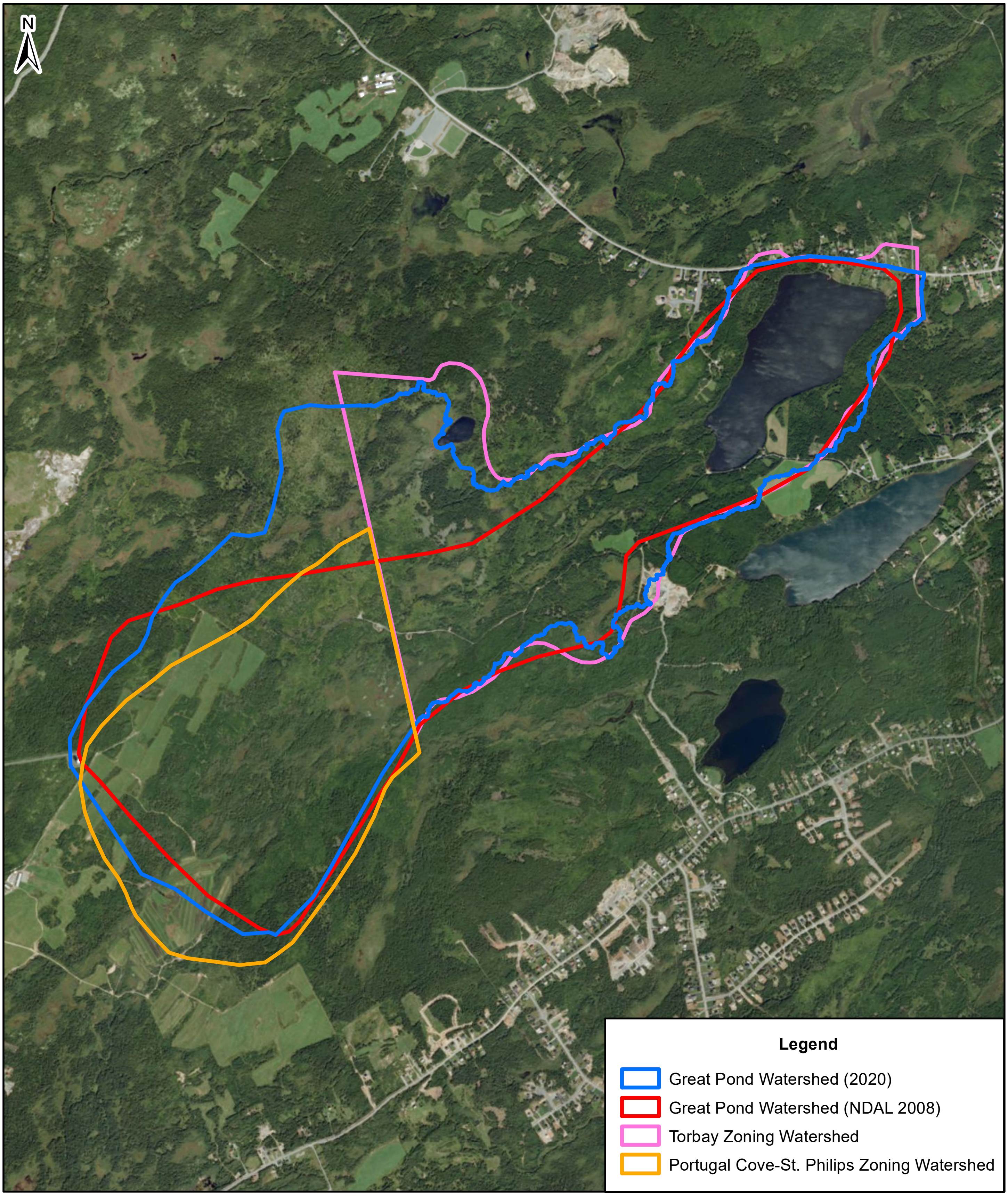
Town of Torbay. 2020. Trails. Available at: https://torbay.ca/visitor/trails/

Windy Heights Farm. 2020. Home. Available at: http://www.sodkings.ca/index.php.

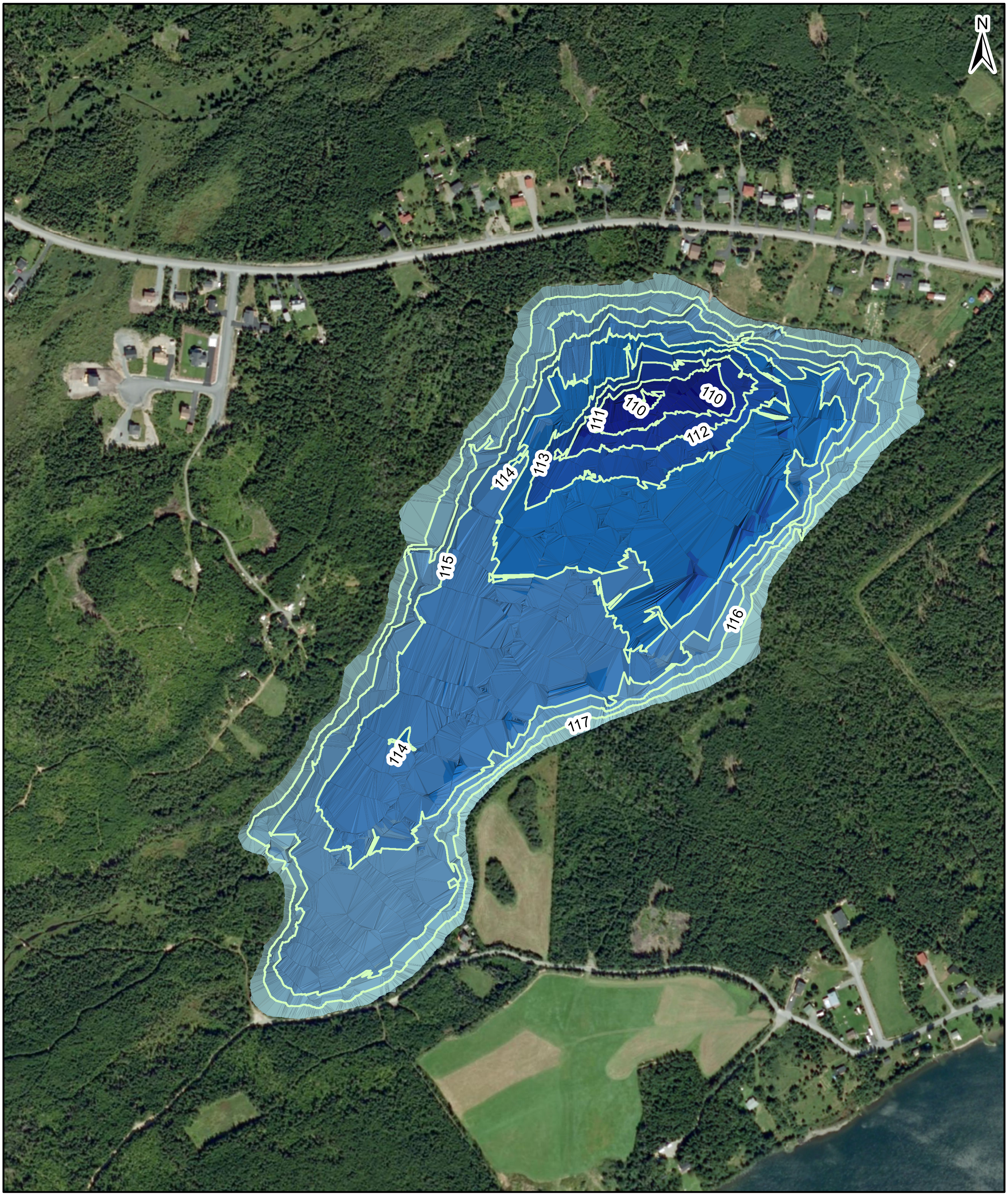
APPENDIX A: MAPS



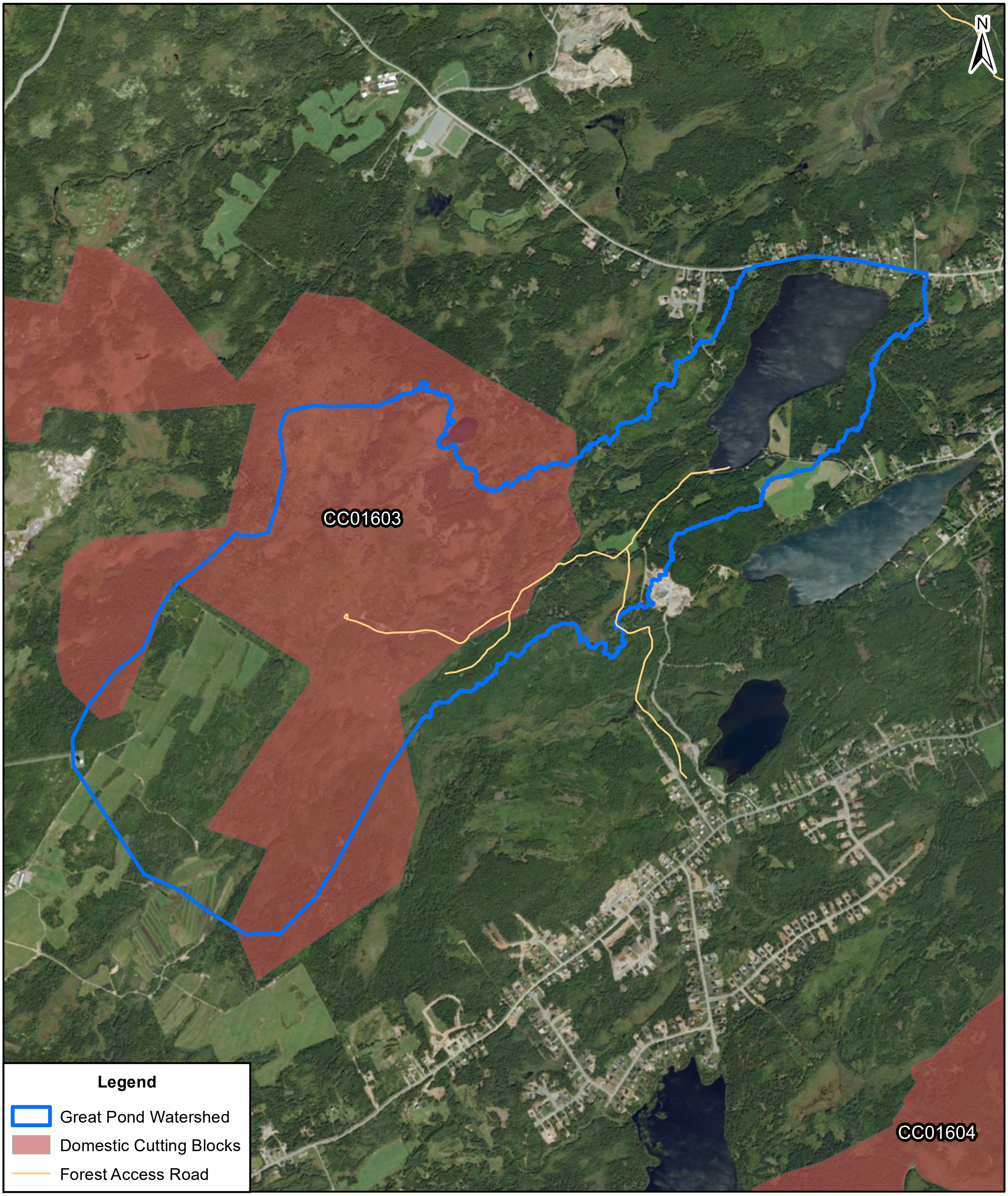
Wood 133 Crosbie Road St. John's, NL, A1B 4A5 (709) 722-7023	DWN BY: J. ABBOTT	PROJECT NAME: TORBAY GREAT POND STUDY AREA	DATE: FEBRUARY 2021
	CHKD BY: T. PRAAMSMA		PROJ No. TF1969415
CLIENT: TOWN OF TORBAY	SCALE: 0 0.65 1.3 Kilometers	PROJECT TITLE: SITE PLAN	DRAWING No. 1



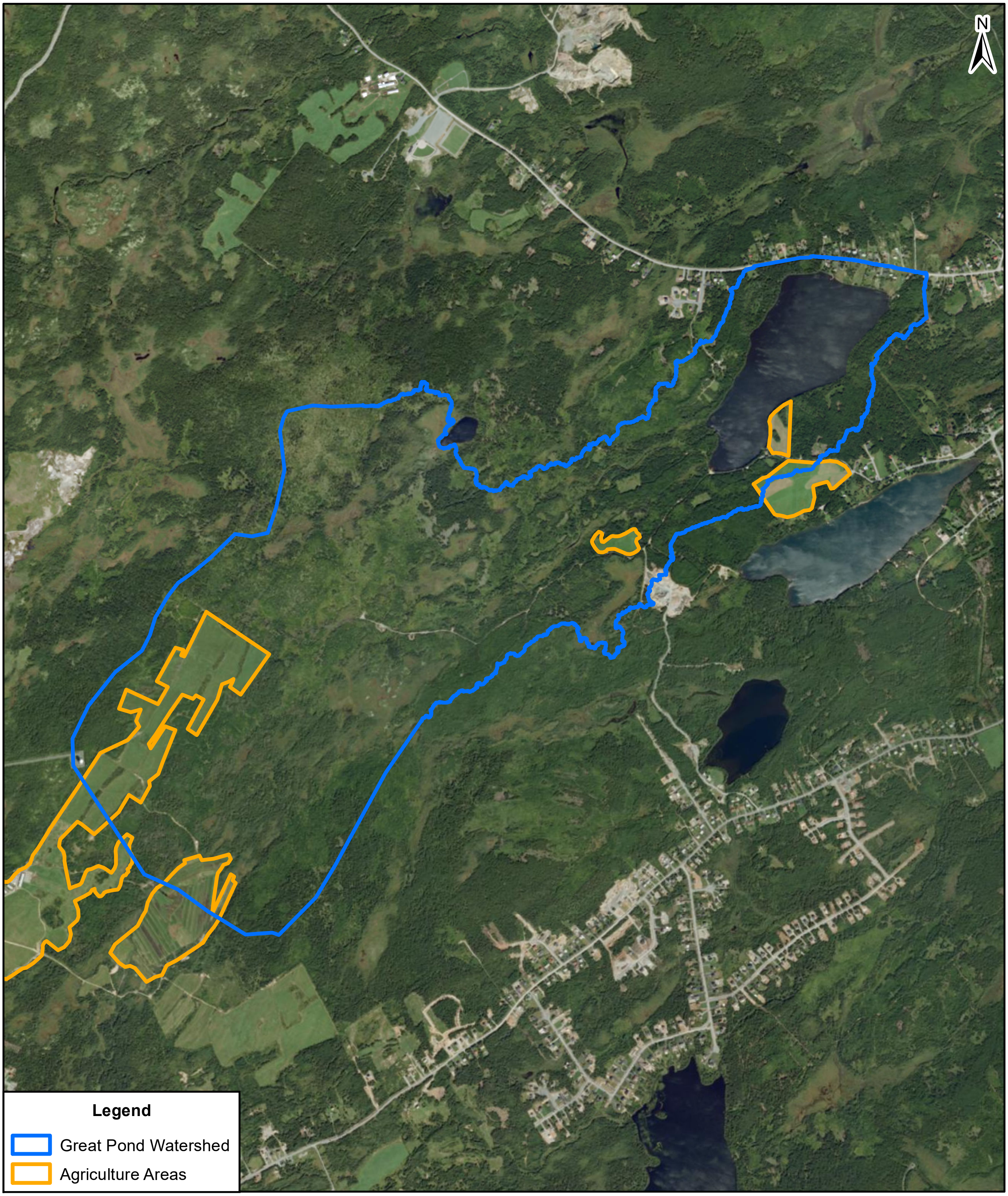
wood. Wood 133 Crosbie Road St. John's, NL, A1B 4A5 (709) 722-7023	DWN BY: J. ABBOTT	PROJECT NAME: TORBAY GREAT POND STUDY AREA	DATE: FEBRUARY 2021
	CHKD BY: T. PRAAMSMA		PROJ No. TF1969415
CLIENT: TOWN OF TORBAY	SCALE: 0 250 500 Meters	PROJECT TITLE: WATERSHED DELINEATIONS	DRAWING No. 2



Wood 133 Crosbie Road St. John's, NL, A1B 4A5 (709) 722-7023	DWN BY: J. ABBOTT CHKD BY: T. PRAAMSMA	PROJECT NAME: TORBAY GREAT POND STUDY AREA	DATE: FEBRUARY 2021 PROJ No. TF1969415
CLIENT: TOWN OF TORBAY	SCALE: 0 75 150 Meters	PROJECT TITLE: BATHYMETRY	DRAWING No. 3

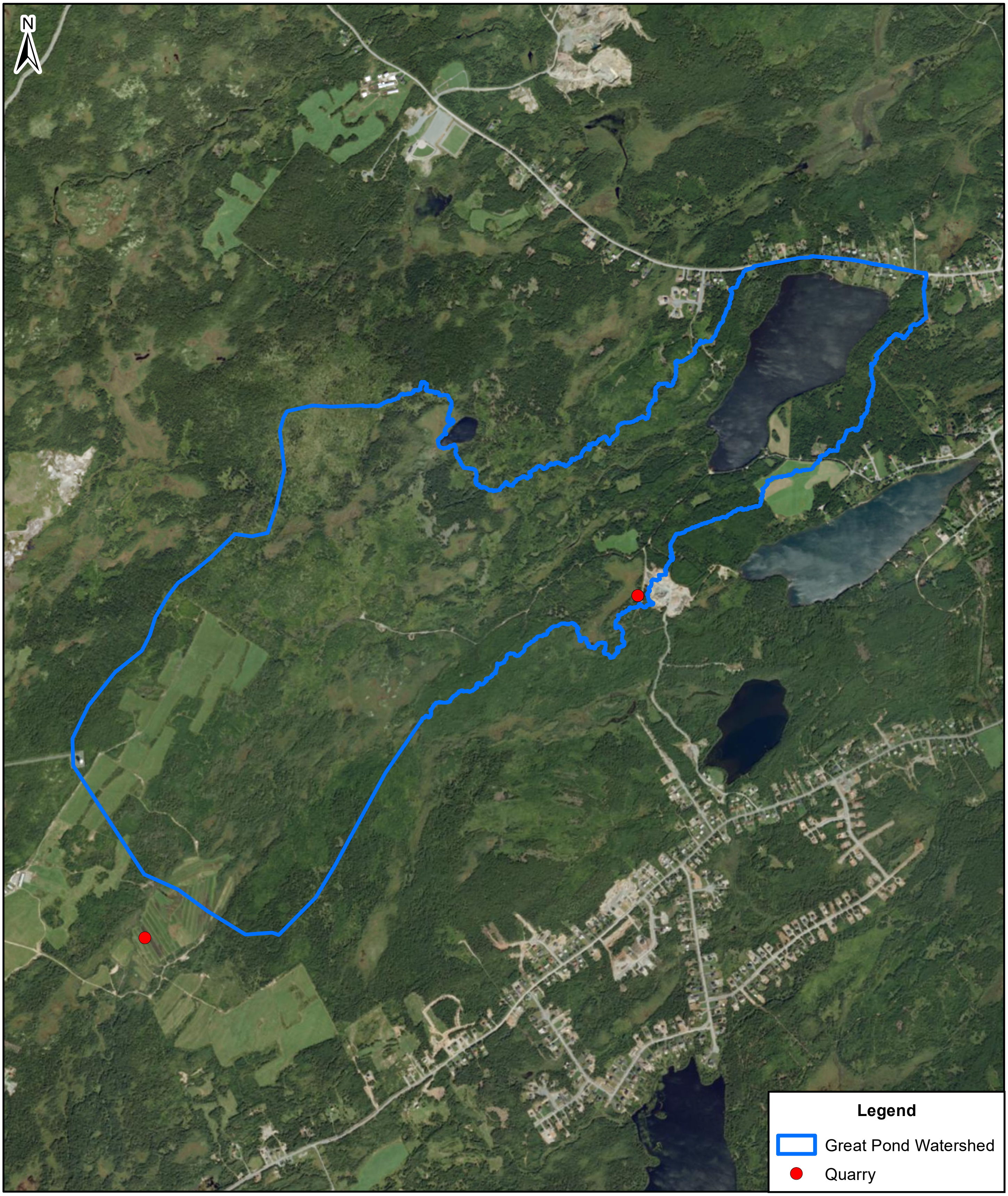


Wood 133 Crosbie Road St. John's, NL, A1B 4A5 (709) 722-7023	DWN BY: J. ABBOTT	PROJECT NAME: TORBAY GREAT POND STUDY AREA	DATE: FEBRUARY 2021
	CHKD BY: T. PRAAMSMA		PROJ No. TF1969415
CLIENT: TOWN OF TORBAY	SCALE: 0 280 560 Meters	PROJECT TITLE: FORESTRY	DRAWING No. 4



Wood
133 Crosbie Road
St. John's, NL, A1B 4A5
(709) 722-7023

Wood, 133 Crosbie Road, St. John's, NL, A1B 4A5, (709) 722-7023	DWN BY: J. ABBOTT	PROJECT NAME: TORBAY GREAT POND STUDY AREA	DATE: FEBRUARY 2021
CLIENT: TOWN OF TORBAY	CHKD BY: T. PRAAMSMA		PROJ No. TF1969415
	SCALE: 0 250 500 Meters	PROJECT TITLE: AGRICULTURE	DRAWING No. 5



Wood 133 Crosbie Road St. John's, NL, A1B 4A5 (709) 722-7023	DWN BY: J. ABBOTT	PROJECT NAME: TORBAY GREAT POND STUDY AREA	DATE: FEBRUARY 2021
CLIENT: TOWN OF TORBAY	CHKD BY: T. PRAAMSMA	PROJECT TITLE: QUARRYING	PROJ No. TF1969415
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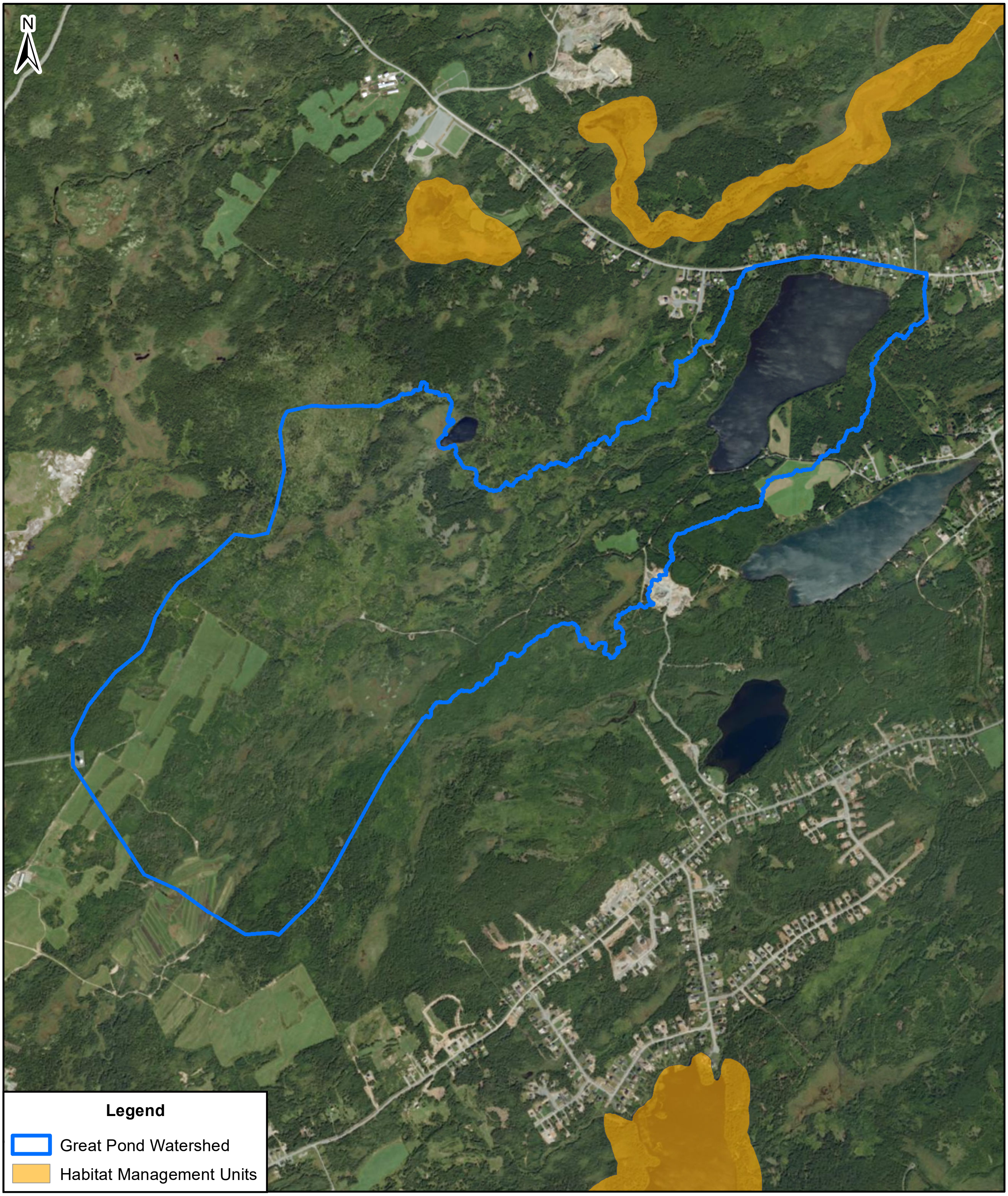
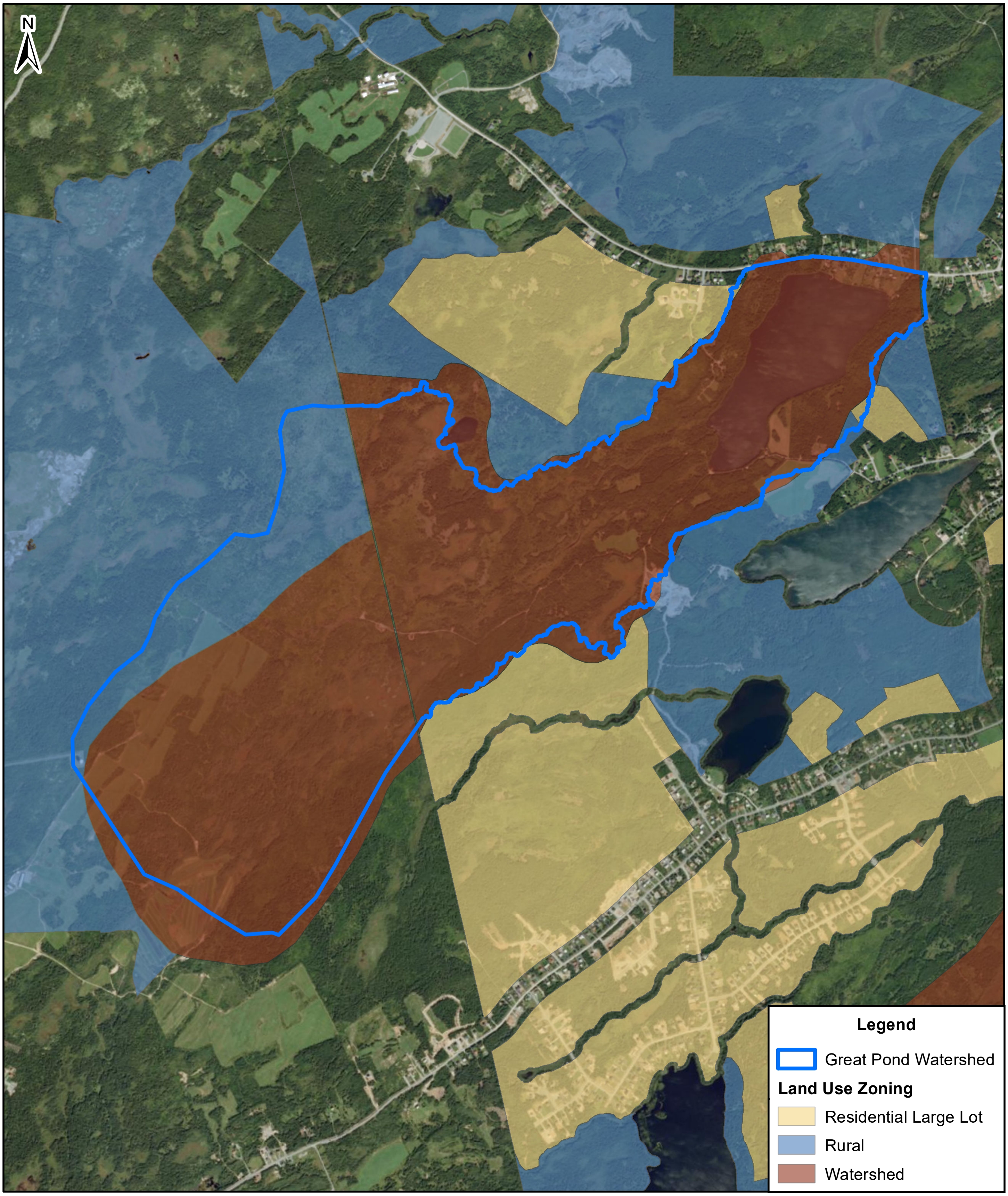
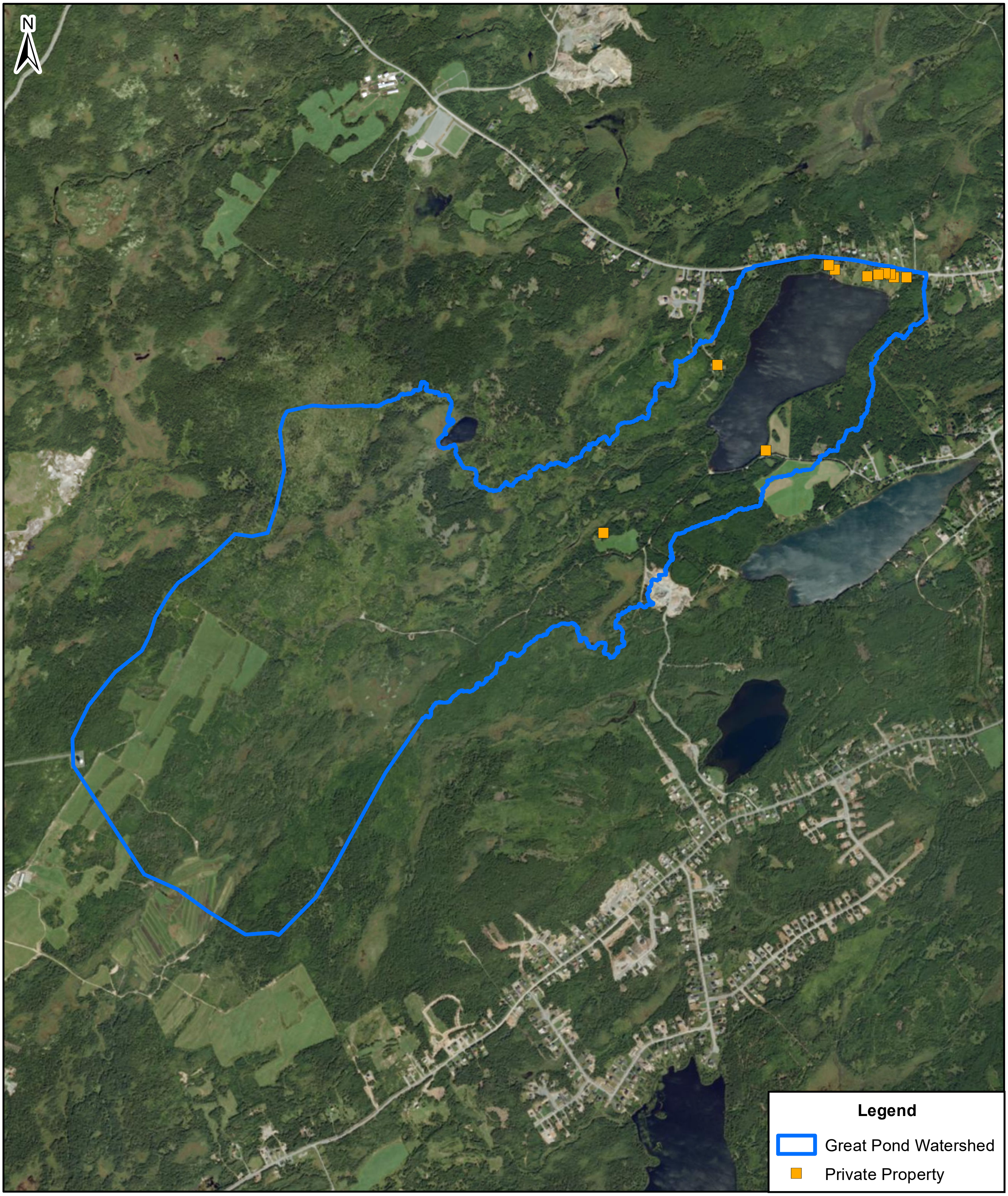


Wood 133 Crosbie Road St. John's, NL, A1B 4A5 (709) 722-7023	DWN BY: J. ABBOTT	PROJECT NAME: TORBAY GREAT POND STUDY AREA	DATE: FEBRUARY 2021
	CHKD BY: T. PRAAMSMA		PROJ No. TF1969415
CLIENT: TOWN OF TORBAY	SCALE: 0 250 500 Meters	PROJECT TITLE: HABITAT MANAGEMENT UNITS	DRAWING No. 7

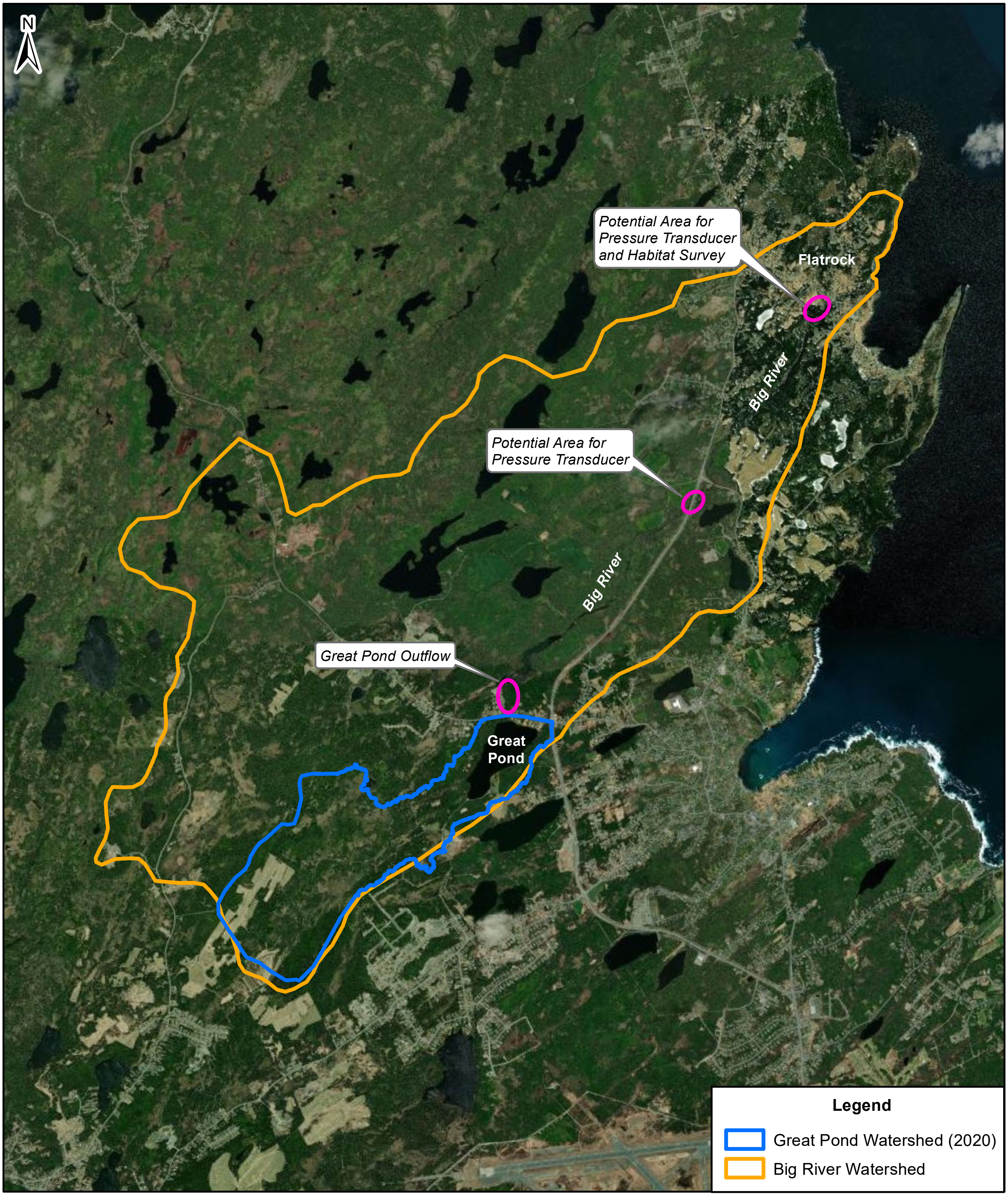


Wood 133 Crosbie Road St. John's, NL, A1B 4A5 (709) 722-7023	DWN BY: J. ABBOTT	PROJECT NAME: TORBAY GREAT POND STUDY AREA	DATE: FEBRUARY 2021
	CHKD BY: T. PRAAMSMA		PROJ No. TF1969415
CLIENT: TOWN OF TORBAY	SCALE: 0 250 500 Meters	PROJECT TITLE: MUNICIPAL ZONING	DRAWING No. 8

Wood 133 Crosbie Road St. John's, NL, A1B 4A5 (709) 722-7023	DWN BY: J. ABBOTT	PROJECT NAME: TORBAY GREAT POND STUDY AREA	DATE: FEBRUARY 2021
	CHKD BY: T. PRAAMSMA		PROJ No. TF1969415
CLIENT: TOWN OF TORBAY	SCALE: 0 250 500 Meters	PROJECT TITLE: ROADS, TRAILS AND POWERLINES	DRAWING No. 9



Wood 133 Crosbie Road St. John's, NL, A1B 4A5 (709) 722-7023	DWN BY: J. ABBOTT	PROJECT NAME: TORBAY GREAT POND STUDY AREA	DATE: FEBRUARY 2021
CLIENT: TOWN OF TORBAY	CHKD BY: T. PRAAMSMA	PROJECT TITLE: PRIVATE PROPERTIES	PROJ No. TF1969415
	SCALE: 0 250 500 Meters		DRAWING No. 10



Wood 133 Crosbie Road St. John's, NL, A1B 4A5 (709) 722-7023	DWN BY: J. ABBOTT	PROJECT NAME: TORBAY GREAT POND STUDY AREA		DATE: FEBRUARY 2021
CLIENT: TOWN OF TORBAY	CHKD BY: T. PRAAMSMA			PROJ No. TF1969415
	SCALE: 0 630 1,260 Meters	PROJECT TITLE: BIG RIVER WATERSHED		DRAWING No. 11

APPENDIX B: WATER BALANCE CALCULATIONS

Water Balance -Average Year

Great Pond Watershed	km2	m2
Watershed Area	3.83	3.83E+06
Lake Area	0.29	2.87E+05
125 mm SMC Area	3.54	3.54E+06

	Thornthwaite Averages (For the period 1942-2019)											Total Surplus			Infiltration			Runoff		
	TEMP deg C	PRECIP mm	RAIN cm	MELT mm	PE mm	AE mm	DEF mm	SURP mm	SNOW mm	SOIL mm	ACC P mm	Total Surplus m3	Average Surplus L/s	L/min	Total Infiltration m3	Average Infiltration L/s	L/min	Total Runoff m3	Average Runoff L/s	L/min
JAN	-4.1	151	65	36	2	2	0	98	85	125	615	389,963	146	8,736	104,173	39	2,334	285,790	107	6,402
FEB	-4.7	135	53	34	2	2	0	85	133	125	749	339,312	140	8,415	90,354	37	2,241	248,959	103	6,175
MAR	-2.5	134	69	56	4	4	0	121	142	125	883	466,010	174	10,439	128,621	48	2,881	337,389	126	7,558
APR	1.5	115	96	119	16	16	0	199	42	125	999	733,498	283	16,979	211,534	82	4,897	521,964	201	12,083
MAY	5.9	100	99	43	47	47	0	96	0	124	1098	355,351	133	7,960	102,047	38	2,286	253,305	95	5,674
JUN	10.7	94	94	0	80	80	0	23	0	115	1192	85,510	33	1,979	24,449	9	566	61,061	24	1,413
JUL	15.7	88	88	0	113	112	-1	8	0	82	1280	21,178	8	474	8,504	3	190	12,674	5	284
AUG	15.8	110	110	0	105	101	-4	10	0	81	1391	36,866	14	826	10,630	4	238	26,237	10	588
SEP	12.1	125	125	0	71	70	-1	32	0	103	1517	128,868	50	2,983	34,016	13	787	94,852	37	2,196
OCT	7.3	150	150	0	41	41	0	90	0	122	149	350,148	131	7,844	95,669	36	2,143	254,479	95	5,701
NOV	3.2	154	148	5	18	18	0	132	2	125	303	506,707	195	11,729	140,314	54	3,248	366,393	141	8,481
DEC	-1.5	160	104	23	5	5	0	122	35	125	463	476,722	178	10,679	129,684	48	2,905	347,037	130	7,774
Annual	4.9	1515	1201	316	504	498	-6	1016				3,890,133			1,079,993			2,810,140		

Water Balance - Wet Year

Great Pond Watershed	km2	m2
Watershed Area	3.83	3.83E+06
Lake Area	0.29	2.87E+05
125 mm SMC Area	3.54	3.54E+06

	Thornthwaite Averages (For the period 1942-2019)											Total Surplus			Infiltration			Runoff		
	TEMP	PRECIP	RAIN	MELT	PE	AE	DEF	SURP	SNOW	SOIL	ACC P	Total Surplus	Average Surplus		Total Infiltration	Average Infiltration		Total Runoff	Average Runoff	
	deg C	mm	cm	mm	mm	mm	mm	mm	mm	mm	mm	m3	L/s	L/min	m3	L/s	L/min	m3	L/s	L/min
JAN	-1.4	264.6	187.9	68.9	3.8	3.8	0	253	76.4	125	648.5	971,226	363	21,757	268,935	100	6,025	702,291	262	15,732
FEB	-3.4	152.2	106.2	73.9	3.6	3.6	0	176.5	48.5	125	800.7	667,996	276	16,567	187,617	78	4,653	480,379	199	11,914
MAR	-2.5	162.4	50.5	37.1	2.1	2.1	0	85.5	123.3	125	963.1	348,911	130	7,816	90,885	34	2,036	258,026	96	5,780
APR	-1	191.8	79.4	76.6	5	5	0	150.9	159.2	125	1154.9	588,240	227	13,617	160,404	62	3,713	427,836	165	9,904
MAY	3.7	168.3	168.3	159.2	31.4	31.4	0	296.1	0	125	1323.2	1,088,418	406	24,382	314,750	118	7,051	773,668	289	17,331
JUN	10.4	188.5	188.5	0	77.9	77.9	0	110.6	0	125	1511.7	423,598	163	9,806	117,566	45	2,721	306,032	118	7,084
JUL	14.7	88.8	88.8	0	107	107	0	0	0	106.6	1600.5	-5,276	-2	-118	0	0	0	-5,276	-2	-118
AUG	15.2	97.6	97.6	0	101	101	0	0	0	103	1698.1	-1,032	0	-23	0	0	0	-1,032	0	-23
SEP	11.4	66.4	66.4	0	67.8	67.8	0	0	0	101.6	1764.5	-401	0	-9	0	0	0	-401	0	-9
OCT	6.4	209	209	0	36.4	36.4	0	149.2	0	125	209	578,145	216	12,951	158,597	59	3,553	419,548	157	9,398
NOV	2.8	319.8	319.8	0	14.9	14.9	0	304.9	0	125	528.8	1,167,767	451	27,032	324,104	125	7,502	843,663	325	19,529
DEC	-2.6	158.3	107.5	3.3	1.1	1.1	0	109.7	47.5	125	687.1	433,770	162	9,717	116,609	44	2,612	317,161	118	7,105
Annual	4.5	2067.7	1669.9	419	452	452	0	1636.4				6,261,362			1,739,469			4,521,893		

Water Balance - Dry Year

Great Pond Watershed	km2	m2
Watershed Area	3.83	3.83E+06
Lake Area	0.29	2.87E+05
125 mm SMC Area	3.54	3.54E+06

	Thornthwaite Averages (For the period 1942-2019)											Total Surplus			Infiltration			Runoff		
	TEMP	PRECIP	RAIN	MELT	PE	AE	DEF	SURP	SNOW	SOIL	ACC P	Total Surplus	Average Surplus		Total Infiltration	Average Infiltration		Total Runoff	Average Runoff	
	deg C	mm	cm	mm	mm	mm	mm	mm	mm	mm	mm	m3	L/s	L/min	m3	L/s	L/min	m3	L/s	L/min
JAN	-6	141.8	33.4	24.3	1	1	0	56.6	131.9	125	525.7	240,919	90	5,397	60,165	22	1,348	180,755	67	4,049
FEB	-7.1	119	48.4	36.1	1.7	1.7	0	82.8	166.4	125	644.7	327,016	135	8,111	88,015	36	2,183	239,001	99	5,928
MAR	-5	102.5	9.8	30.6	1.7	1.7	0	38.8	228.4	125	747.2	166,380	62	3,727	41,244	15	924	125,137	47	2,803
APR	2.6	45.8	43.8	230.4	20.2	20.2	0	254	0	125	793	907,334	350	21,003	269,998	104	6,250	637,336	246	14,753
MAY	7.9	21.3	19.9	1.4	60.4	60.4	0	0	0	85.9	814.3	-11,211	-4	-251	0	0	0	-11,211	-4	-251
JUN	11.8	109.4	109.4	0	87.4	87.4	0	0	0	107.9	923.7	6,308	2	146	0	0	0	6,308	2	146
JUL	15.3	97.8	97.8	0	110.7	110.7	0	0	0	95	1021.5	-3,699	-1	-83	0	0	0	-3,699	-1	-83
AUG	17.3	70.7	70.7	0	113.9	113.9	0	0	0	51.8	1092.2	-12,386	-5	-277	0	0	0	-12,386	-5	-277
SEP	13.1	83.4	83.4	0	76.6	76.6	0	0	0	58.7	1175.6	1,950	1	45	0	0	0	1,950	1	45
OCT	6.3	91.7	91.7	0	36.2	36.2	0	0	0	114.1	91.7	15,913	6	356	0	0	0	15,913	6	356
NOV	3.2	130.4	116	8.7	20	20	0	93.8	5.7	125	222.1	364,013	140	8,426	99,708	38	2,308	264,305	102	6,118
DEC	-4.9	133.4	55	9.3	0.4	0.4	0	63.9	74.8	125	355.5	264,549	99	5,926	67,925	25	1,522	196,624	73	4,405
Annual	4.5	1147.2	779.3	340.8	530.2	530.2	0	589.9				2,267,087			627,055			1,640,032		

APPENDIX C: LIMITATIONS

Limitations

1. The work performed in this report was carried out in accordance with the Standard Terms of Conditions made part of our contract. The conclusions presented herein are based solely upon the scope of services and time and budgetary limitations described in our contract.
2. The report was prepared in accordance with generally accepted science and/or engineering practices for the exclusive use of the Town of Torbay. No other warranties, either expressed or implied, are made as to the professional services provided under the terms of our contract and included in this report.
3. Third party information reviewed and used to develop the opinions and conclusions contained in this report is assumed to be complete and correct. This information was used in good faith and Wood does not accept any responsibility for deficiencies, misinterpretation or incompleteness of the information contained in documents prepared by third parties.
4. The objective of this report was to assess water and wastewater quality properties at the site, within the context of our contract and existing regulations within the applicable jurisdiction. Evaluating compliance of past or future owners with applicable local, provincial and federal government laws and regulations was not included in our contract for services.
5. Our observations relating to the condition of environmental media at the site are described in this report. It should be noted that compounds or materials other than those described could be present in the site environment.
6. The findings and conclusions presented in this report are based exclusively on the field parameters measured and the chemical parameters tested at specific locations. It should be recognized that subsurface conditions between and beyond the sample locations may vary. Wood cannot expressly guarantee that subsurface conditions between and beyond the sample locations do not vary from the results determined at the sample locations. Notwithstanding these limitations, this report is believed to provide a reasonable representation of site conditions at the date of issue.