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February 12, 2015

Mr. Cameron Deacoff
Planning and Infrastructure
Halifax Regional Municipality
88 Alderney Drive, 3rd Floor
Dartmouth, Nova Scotia

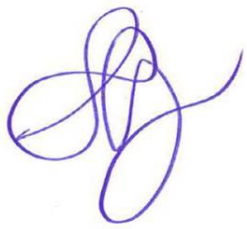
Dear Mr. Deacoff:

Project No: 60303077
Regarding: Sandy Lake Watershed Study – Additional Modeling Scenario

AECOM is pleased to submit the attached memorandum to complete an additional modeling scenario for the Sandy Lake Watershed Study included in the scope change dated December 12, 2014. This memorandum describes the land use changes previously discussed with HRM and quantifies how these potential land use changes may affect the phosphorus concentrations of Sandy Lake and Marsh Lake using the Lakeshore Capacity Model.

We look forward to your comments and are available for discussion at your request.

Sincerely,
AECOM Canada Ltd.



Steve Murphy, MBA, P.Eng.
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Memorandum

To	Cameron Deacoff	Page	1
CC	Steve Murphy		
Subject	Sandy Lake modeling scenario 2b		
From	Timothy Bachiu		
Date	February 12, 2015	Project Number	60303077

The Sandy Lake Watershed Study Final Report (AECOM 2014) was submitted by AECOM Canada Limited (AECOM) to Halifax Regional Municipality (HRM) on November 12, 2014. This study utilized the Lakeshore Capacity Model (LCM) to predict changes in lake phosphorus concentrations under existing conditions and under four different future development scenarios. The model, developed by Dillon and Rigler (1975) was calibrated on Canadian Shield lakes in Ontario (Dillon *et al.* 1986) and has since been applied to lakes in Nova Scotia (e.g. Brylinsky 2004, Jacques Whitford 2004; Soliman 2008; AECOM 2013). The LCM is a mass balance, steady state model that quantifies the natural and human phosphorus inputs to a watershed and estimates the resulting phosphorus concentrations of the watershed's lakes (MOE 2010).

Inputs to the model include:

1. Surface areas for each land use (e.g. forest, meadow, residential, etc.);
2. Phosphorus export coefficient for each land use;
3. Hydrologic inputs; and,
4. Point sources of phosphorus (e.g., septic systems, waste water treatment plant discharge and sanitary sewer overflows).

Using this information the model calculates:

- Hydrologic budget;
- Phosphorus loads from all land uses, point sources and septic systems; and,
- Predicted lake total phosphorus concentrations.

The model version used for the Sandy Lake Watershed Study was based on the version developed by Brylinsky (2004) for Nova Scotia lakes.

The four development scenarios used in the Sandy Lake Watershed Study include existing conditions and four future development scenarios:

1. Modeling Scenario 1: Existing Conditions;
2. Modeling Scenario 2: Future Developments;

3. Modeling Scenario 2a: Future Developments extended;
4. Modeling Scenario 3: Future Developments plus (a) Removal of Upland Waste Water Treatment Facility and (b) Sandy Lake Cottages converted to small lot residential supplied with waste water services; and
5. Modeling Scenario 4: Future Developments (Scenario 3) with Advanced Stormwater Management.

The Sandy Lake Watershed Study Area includes two subwatersheds identified in Figure 1; the Sandy Lake subwatershed and the Marsh Lake subwatershed. The land use distributions in each of the development scenarios are tabulated for the Sandy Lake subwatershed (**Table 1)** and the Marsh Lake subwatershed (**Table 2**). For a complete description of the land use definitions, modeling scenarios and the modeling results, refer to **Appendix E** of the Sandy Lake Watershed Study Final Report (AECOM 2014).

Table 1: Sandy Lake subwatershed land use distribution for LCM modeling

Land Use Category	Interpretation	Scenario 1 (ha)	Scenario 2 (ha)	Scenario 2a (ha)	Scenario 2b (ha)	Scenario 3 (ha)	Scenario 4 (ha)
Forest	>70% forest cover	786.9	496.0	145.0	**112.8**	496.0	496.0
Deforested	From aerial photos	182.5	85.7	85.7	**49.4**	85.7	85.7
Wetland and wetland buffer	Wetlands database	52.3	113.6	113.6	**113.6**	113.6	113.6
Water	Ponds and lakes	81.4	81.4	81.4	**81.4**	81.4	81.4
Industrial	Disturbed ground, no parking lots, large buildings	107.7	105.4	105.4	**105.4**	105.4	105.4
Institutional	School	8.3	6.2	6.2	**9.2**	6.2	6.2
Commercial	Buildings and parking area	40.9	76.6	65.4	**67.0**	76.6	76.6
Roadway	From parcel fabric	71.3	87.3	87.3	**87.5**	87.3	87.3
Small Lot Residential	<0.5 ha	105.1	377.4	377.4	**390.2**	386.5	90.4
Small Lot Residential with ASM	<0.5 ha	n/a	n/a	n/a	**n/a**	n/a	296.1
Large Lot Residential	>0.5 ha	313.1	320.0	682.1	**733.0**	311.0	311.0
Park	As designated	41.6	41.6	41.6	**41.6**	41.6	41.6

ASM : Advanced Stormwater Management

Table 2: Marsh Lake subwatershed land use distribution for LCM modeling

Land Use Category	Interpretation	Scenario 1 (ha)	Scenario 2 (ha)	Scenario 2a (ha)	Scenario 2b(ha)	Scenario 3 (ha)	Scenario 4 (ha)
Forest	>70% Forest cover	386.2	353.7	353.7	**271.2**	353.7	353.7
Deforested	From aerial photos	137.1	129.8	129.8	**53.0**	129.8	129.8
Wetland	Wetlands database	34.2	34.2	34.2	**34.2**	34.2	34.2
Water	Ponds and Lakes	16.5	16.5	16.5	**16.5**	16.5	16.5
Industrial	Disturbed ground, no parking lots, large buildings	6.5	6.5	6.5	**6.5**	6.5	6.5
Institutional	School	0.0	0.0	0.0	**0.0**	0.0	0.0
Commercial	Buildings and parking area	2.5	2.5	2.5	**2.5**	2.5	2.5
Roadway	From parcel fabric	6.8	7.9	7.9	**7.9**	7.9	7.9
Small Lot Residential	<0.5 ha	8.0	18.2	18.2	**18.2**	18.2	8.0
Small Lot Residential with ASM	<0.5 ha	n/a	n/a	n/a	**n/a**	n/a	10.2
Large Lot Residential	>0.5 ha	26.6	53.9	53.9	**213.2**	53.9	53.9
Park	As designated	7.2	8.1	8.1	**8.1**	8.1	8.1

ASM: Advanced Stormwater Management

Additional information made available following the submission of the final report, indicated possible development in the watershed that was not accounted for in Scenarios 2 – Planned developments and 2a – Planned developments extended. At the request of HRM and following the scope change authorization on December 12, 2014, an additional modeling scenario was completed and the results are documented below.

Results

The additional modeling scenario is designated as *Scenario 2b – Revised Planned developments extended*. The land use distribution used in this modeling scenario is identified in **Figure 1** and the areas that have different land use in Scenario 2b compared to 2a are identified in **Figure 2**. The areas (hectares) of the land use types in Scenario 2b are compared to the previous modeling scenarios in **Table 1** (Sandy Lake subwatershed) and **Table 2** (Marsh Lake subwatershed). In the Sandy Lake subwatershed, the land use changes include forested and deforested land use to large lot residential land use in the northwestern portion of the subwatershed, and changes of forested to large lot and small lot residential in the eastern portion of the watershed. We assume the additional residential areas (large lot and small lot residential) will utilize on-site wastewater disposal (septic systems), which will contribute to the phosphorus budget of the subwatershed. The LCM accounts for the phosphorus contributions from septic systems by quantifying the phosphorus flux from residences within 300 m of a watercourse or lake. In Scenario 2b, we assume a total of 50 additional residences relying on septic systems will be within 300 m of a watercourse in the Sandy Lake subwatershed. In the Marsh Lake subwatershed the land use changes include forested and deforested land use to large lot residential land use in the eastern portion of the subwatershed and an estimated 15 residences relying on septic systems within 300 m of a watercourse.

The results of the previous modeling scenarios and the additional modeling scenario are included in the **Table 3**.

The results of the Lakeshore Capacity Modeling for the Scenario 2b suggests the phosphorus concentrations in both Sandy Lake and Marsh will **exceed the Water Quality Objectives** set in the Sandy Lake Watershed Study Final Report (AECOM 2014).

Table 3: Lakeshore Capacity Modeling Results

Scenario	Sandy Lake Predicted Phosphorus (µg/L)	Marsh Lake Predicted Phosphorus (µg/L)
Scenario 1: Existing Conditions	12.0	11.0
Scenario 2: Planned Developments	15.8	13.7
Scenario 2a: Planned Developments extended	17.4	14.7
Scenario 2b: Revised Planned Development extended	**18.1**	**16.0**
Scenario 3: Planned Developments + removal of Uplands WWTF and Septic Systems near Sandy Lake	14.5	12.9
Scenario 4: Future Developments (Scenario 3) with Advanced Stormwater Management	12.8	11.5
Recommended Water Quality Objective	18	15

References:

AECOM. 2014. Sandy Lake Watershed Study Final Report. Prepared for Halifax Regional Municipality.

Brylinsky, M. 2004 User's Manual for Prediction of Phosphorus Concentration in Nova Scotia Lakes: A Tool for Decision Making Version 1.0. Acadia Centre for Estuarine Research. Prepared for the Nova Scotia Water Quality Objectives and Model Development Steering Committee, NS Department of Environment and Labour. 82 p.

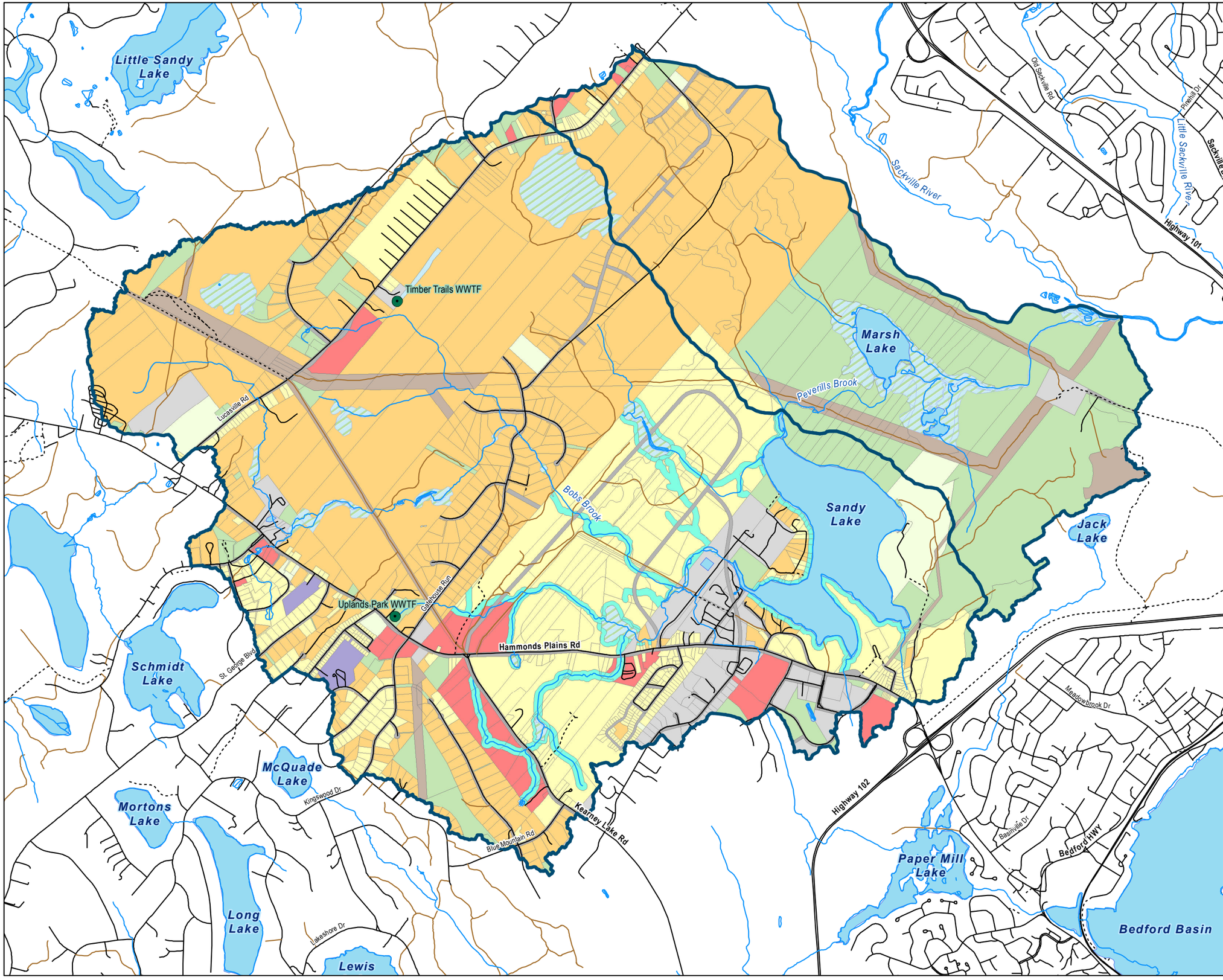
Dillon, P.J. and F.H. Rigler. 1975. A Simple Method for Predicting the Capacity of a Lake for Development Based on Lake Trophic Status. Journal of the Fisheries Research Board of Canada, Vol. 32 No. 9:1519-1531.

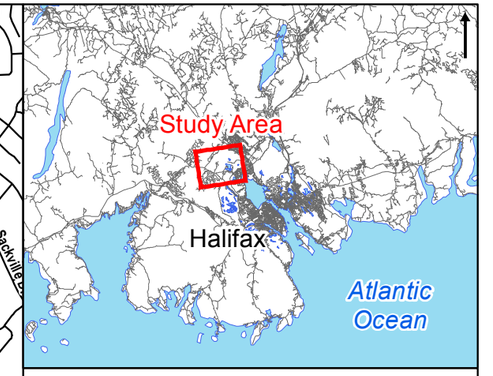
Dillon, P.J., K.H. Nicholls, W.A. Scheider, N.D. Yan, and D.S. Jeffries. 1986. Lakeshore Capacity Study, Trophic Status. Ontario Ministry of Municipal Affairs. Research and Special Projects Branch. Queens Printer for Ontario. ISBN 07743 80772

Jacques Whitford. 2004. Bedford West Planning Area Subwatershed Management Plan. Prepared for: Annapolis Group Inc. May 2004.

MOE Ministry of the Environment. 2010. Lakeshore Capacity Assessment Handbook – Protecting water quality in inland lakes on Ontario's Precambrian Shield

Soliman, 2008 Watershed Scale Modelling of Phosphorus and Dissolved Oxygen Concentrations in Nova Scotia Lakes: Implications for Water and Habitat Quality, Restoration Goals and Development Capacity, M.Sc. Thesis, Faculty of Arts and Science, Trent University, 126 p.





Legend

- Wastewater Discharge Point
- Watercourses
- Roads
- Trails
- Gravel Roads
- Sandy Lake Subwatersheds

Land Use Classifications

- Commercial
- Deforested
- Forest
- Industrial
- Institutional
- Park
- Small Lot Residential (<0.5 ha)
- Large Lot Residential (>0.5 ha)
- Roadway
- Water
- Wetland
- Wetland/Watercourse Buffer

Sandy Lake Area Watershed Study

Scenario 2b: Potential Development in the Sandy Lake Watershed

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AECOM		**Figure 1**

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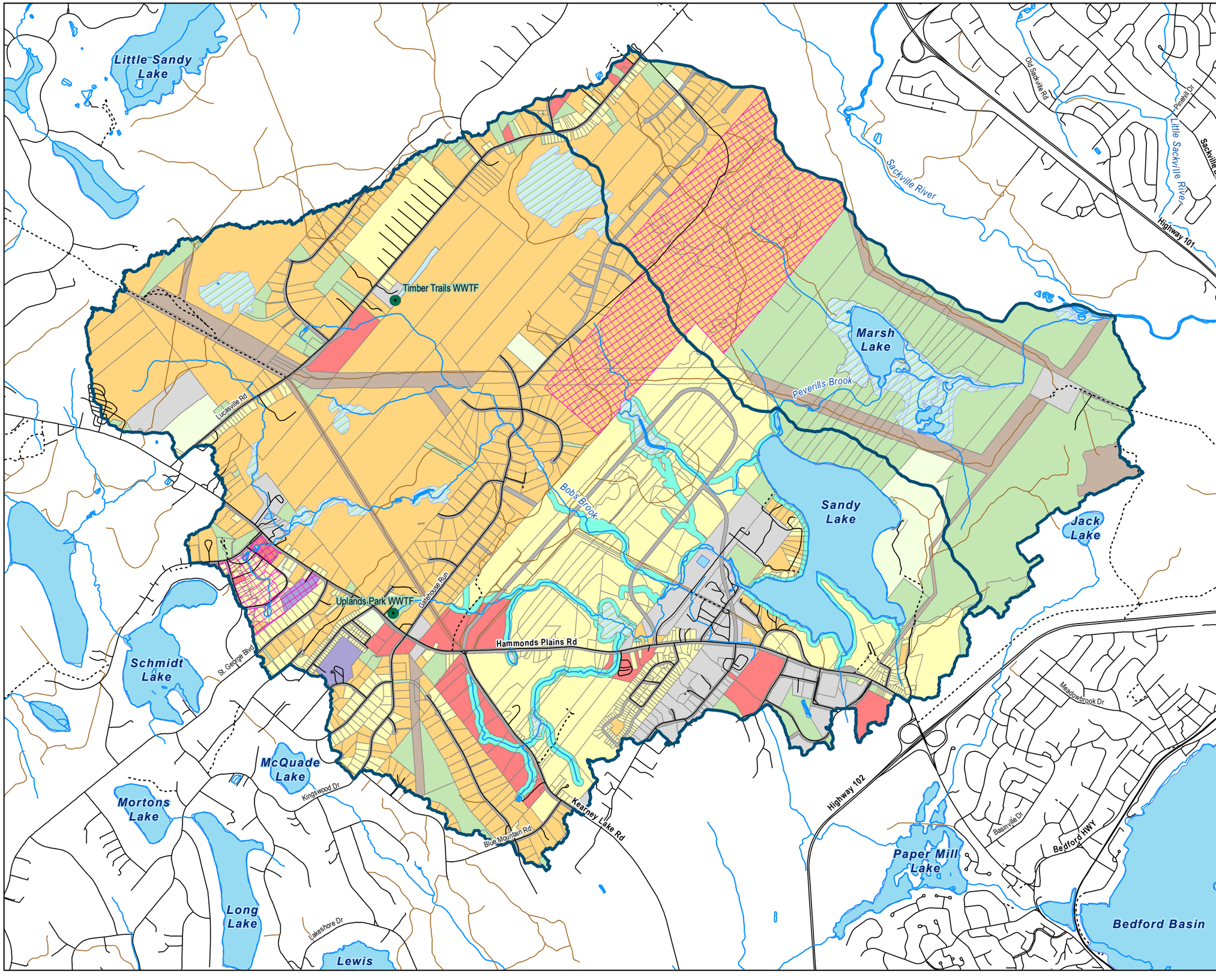

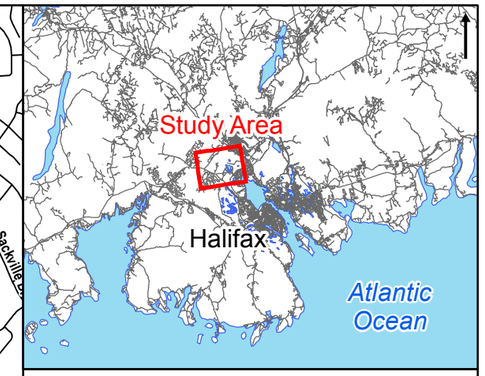

Legend

- Wastewater Discharge Point
- Watercourses
- Roads
- Trails
- Gravel Roads
- Sandy Lake Subwatersheds

Land Use Classifications

- Commercial
- Deforested
- Forest
- Industrial
- Institutional
- Park
- Small Lot Residential (<0.5 ha)
- Large Lot Residential (>0.5 ha)
- Roadway
- Water
- Wetland
- Wetland/Watercourse Buffer
- Scenario Differences (Versus Scenario 2a)

Sandy Lake Area Watershed Study

Scenario 2b: Potential Development - changes from Scenario 2a cross-hatched

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Figure 2

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