DALHOUSIE UNIVERSITY
FACULTY OF ENGINEERING

Mitigating Urbanization and Climate Change Impacts on Marsh Lake Hydrology with LID Technology

Department of Civil and Resource Engineering

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Client: Sandy Lake Conservation Association

Marsh Lake: Treasured Wetland

Marsh Lake is a high-conservation-value wetland located in the Greater Sandy Lake Watershed. Its function is threatened by urbanization and climate change.

Figure 1. Marsh Lake Wetland (DUC, 2020)

Project Objective

The objective of the project is to **maintain the hydrologic regime** of the Sandy Lake watershed, through watershed protection and stormwater management, to a level which preserves the function of Marsh Lake Wetlands.

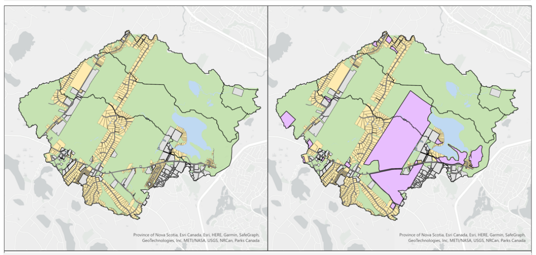
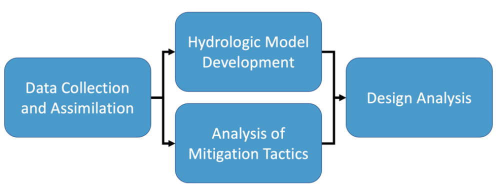


Figure 2. Current (left) and Proposed Development (right) in the Watershed

Design Process



Data Collection & Assimilation

Data was collected from GIS data bases and field visits to develop the hydrologic model. This included:

- Stream and Lake Outlet Geometry
- Stream Flow Recordings
- Continuous Stream Stage for 3 Months
- Impervious Area of Watershed
- Surface Soil Properties

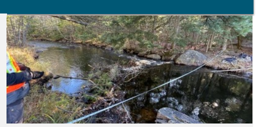


Figure 3. Marsh Lake Outlet

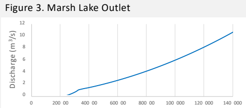


Figure 3. Marsh Lake Storage-Discharge Curve

Hydrologic Analysis

A hydrologic analysis was performed to estimate and predict the hydrologic regime trends of Marsh Lake under natural, current, and proposed development conditions.

Watershed Delineation

- The watershed was delineated and divided into 4 sub-basins.

Model Development

- The watershed was modeled using HEC-HMS.
- Inputs to the model included historical weather data, sub-basin lag times, stage-discharge and stage-storage relationships.

Climate Change Considerations

- RCP 2.6 and 8.5 were used to model future climate scenarios.
- RCP 8.5 was found to cause a greater variance to yearly depth trends in the wetland.

Modelling Various Development Conditions

- Development scenarios were represented within the model by varying the impervious percentage parameter. This value was zero for natural conditions.
- The proposed development will add 1000 acres of 1-acre to 2-acre residential lots.

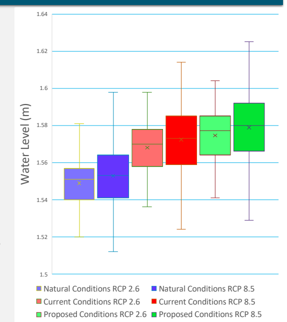


Figure 4. Water Level in Marsh Lake for 2040-2070

Low Impact Development

Low impact development (LID) technologies offer valuable methods of mitigating impacts of urbanization and climate change. LIDs were evaluated based on their ability to:

- Capture runoff from impervious areas.
- Increase infiltration rates.
- Preserve natural partitioning of water in the watershed.

Based on these criteria rain gardens were selected as the most effective LID for the residential lots in the watershed.

Table 1. LID Sizing and Mitigation Impact

Lot Size	Rainfall (mm)	Garden Depth (inches)	Surface Area (ft²)	Mitigation Factor
2 Acre	40	20	800	0.75
1 Acre	35	20	500	0.75
1/4 Acre	25	12	300	0.50

Recommended LID sizes were determined using 24-hour rainfall events of 1.2-to-0.6-year return periods. Mitigation factors represent an estimate of the percentage of impervious surface runoff the LID can effectively collect on each lot.

Rain Garden Design

Perennial native plants such as flowers, shrubs and grass are recommended because they are suited for the climate and will return each year. Bed material should be a blend of compost and sand, topped with a thick layer of mulch. The soil should have an infiltration rate of at least 15 mm/hour to allow for adequate drainage between rainfalls (Jamieson et al., 2016). The garden must overflow into a stormwater collection system to reduce the risk of flooding.

Figure 5. An Artistic Depiction of a Typical Rain Garden Design

LID Mitigation Analysis

Rain Garden mitigation effectiveness was modelled and analyzed by applying the mitigation factors to the impervious areas added in the proposed development.

Sensitivity Analysis

- An analysis of 1/4-acre lots for all the new proposed development area was included to analyze the impacts of more extreme urbanization.
- Changes to water depth and partitioning were more extreme, and mitigation was less effective for this scenario.

Marsh Lake Water Levels

- The water levels can be seen in Figure 6. It is shown that the proposed development causes a slight increase to average depth and range.
- Mitigation through LID partially returns the values towards current conditions.

Flow Partitioning in Most Urbanized Sub-Basin

- Yearly totals showed an increase in direct flow for proposed conditions.
- LID reduced that increase. This would cause less surface contamination from impervious areas to enter directly into the watershed.

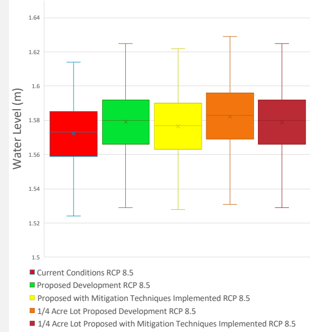


Figure 6. Water Level in Marsh Lake for 2040-2070 with LID

Unit Cost Analysis

The cost to build a rain garden including labour, mulch, sand and compost mix, stones, and native plants is in the range of \$10-\$20/ft².

Once installed, the annual maintenance costs to keep a rain garden functioning is roughly \$60-\$80/hour, at 1 hour of labour/100 ft².

Table 2. LID Cost Analysis

Lot Area	Installation Cost	Annual Maintenance Cost
2-acre Residential (800 ft² Garden)	\$8,000-\$16,000	\$480-\$640
1-acre Residential (500 ft² Garden)	\$5,000-\$10,000	\$300-\$400
¼-acre Residential (300 ft² Garden)	\$3,000-\$6,000	\$160-\$240

Health Safety & Environment

In HRM property owners are responsible for drainage and stormwater flow on their property. If incorrectly implemented rain gardens can cause flooding and landslides. To prevent these scenarios from occurring it is recommended that:

- Rain gardens must be placed at least 3 m away from all buildings.
- The infiltration rate of the soil must be assessed before installation.
- Areas with steep slopes should be avoided.

Conclusion & Recommendations

Analysis of LID technologies and hydrologic modelling of the Sandy Lake Watershed with HEC-HMS for natural, current, and proposed conditions, with and without mitigation revealed:

- Rain gardens were the ideal LID technology for the development.
- Climate Change and urbanization had small, but noticeable impacts on the hydrologic regime of Marsh Lake.
- Mitigation via the implementation of rain gardens onto the new residential lots reduced these impacts.

Recommendations for Development

- Rain gardens should be implemented into the new residential lots to mitigate urbanization impacts on the watershed.
- Marsh Lake hydrology should be monitored for further change as the development progresses.

References

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Credit Valley Conservation. (2010). *Low Impact Development Stormwater Management Planning and Design Guide.* Retrieved from: https://cvc.ca/wp-content/uploads/2014/04/LID-SWM-Guide-v1.0_2010_1_no-appendices.pdf

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