Pond Feature Hydrologic Assessment

5150 Ninth Line, Mississauga

Prepared for

Mattamy (5150 Ninth Line) Limited

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1. Introduction

GeoProcess Research Associates Inc. (GRA) was retained by Mattamy (5150 Ninth Line) Limited to complete a hydrologic assessment of existing and proposed ponds to support an Environmental Impact Study (EIS) of a proposed development. Mattamy (5150 Ninth Line) Limited is proposing to develop a parcel of land located at 5150 Ninth Line (herein referred to as the Subject Lands), in the City of Mississauga, Ontario. The Subject Lands contain three artificial farm ponds, as described by Savanta (2020), that are proposed to be replaced by two amphibian pools. As per the request of the Credit Valley Conservation (CVC), GRA has completed the following hydrologic assessment on behalf of Mattamy (5150 Ninth Line) Limited to characterize existing and proposed pond hydroperiods.

2. Site Description

A portion of the Subject Lands is comprised of a naturalized mixed meadow that was historically maintained as an agricultural field for livestock and which has three dug farm ponds. One pond is situated to the west of the Subject Lands (herein referred to as West Pond) and the remaining two ponds are situated to the east and are hydraulically connected via a corrugated steel pipe (CSP) culvert. The eastern ponds are herein referred to as East Pond-A (upstream) and East Pond-B (downstream).

The Subject Lands are largely bound to the northwest by a woodlot owned by the City of Mississauga. A headwater drainage assessment conducted by Savanta (2020) identifies that this City woodlot's runoff concentrates along a headwater drainage feature (referred to as H1S1) that discharges into East Pond-A. Excess storage in East Pond-A is routed through a CSP to East Pond-B. Excess storage in East Pond-B is routed through a CSP outlet to headwater drainage feature H1S2. Runoff from the southwestern corner of the property concentrates along headwater drainage feature H3S1, which becomes H3S2 and then discharges into West Pond. West Pond does not contain any additional hydraulic connections. Site topography indicates that West Pond spills into the adjacent City woodlot area when storage capacity is exceeded, as verified by Savanta (2020) during their first-round site assessment. A summary of existing pond characteristics is presented in Table 1.

Table 1. Summary of Existing Pond Characteristics

Pond ID	Bottom Elevation [masl]	Top Elevation [masl]	Surface Area [m^2]	Outlet Type	Outlet Invert Elevation [masl]
East Pond-A	189.2[1]	190.6	172	CSP	190.26
East Pond-B	188.6[1]	190.4	79	CSP	190.25[2]
West Pond	190.4	191.8	346	Overflow	191.8

[1] Bottom elevation approximated from surveyed pond toe-of-slope contour line.
[2] East Pond-B CSP bottom rusted out (effective invert elevation unknown). Value assumed as ground elevation at CSP outfall.

The proposed Subdivision Draft Plan includes a buffer zone that includes a 10 m woodlot buffer adjacent to the staked dripline and a 2.8 m landscape buffer adjacent to the woodlot buffer. A modified swale having two amphibian pools is proposed for the woodlot buffer zone to capture runoff from the City woodlot. The proposed condition would involve replacing existing ponds East Pond-A and East Pond-B with a single Amphibian pool (herein referred to as East Amphibian Pool) and modifying the dimensions of West Pond (herein referred to as West Amphibian Pool). It is assumed that catchment runoff will predominantly discharge as sheet flow distributed across the buffer zone swale and inflows will be prorated to the two amphibian pools based on the proposed grading plan. Both amphibian pools are designed to store water up to a top elevation of 191.25 masl. Two double inlet catch-basins (DICB), each with an invert elevation of 191.30 masl, are proposed to capture excess pool storage (one DICB adjacent to each pool). A summary of the proposed amphibian pool characteristics is presented in Table 2 and an excerpt from the proposed buffer plan is provided in Figure 1.

Table 2. Summary of Proposed Amphibian Pool Characteristics

Pond ID	Bottom Elevation [masl]	Top Elevation [masl]	Surface Area [m^2]	Outlet Type	Outlet Invert Elevation [masl]
East Amphibian Pool	190.75	191.25	90	DICB	191.3
West Amphibian Pool	190.75	191.25	111	DICB	191.3

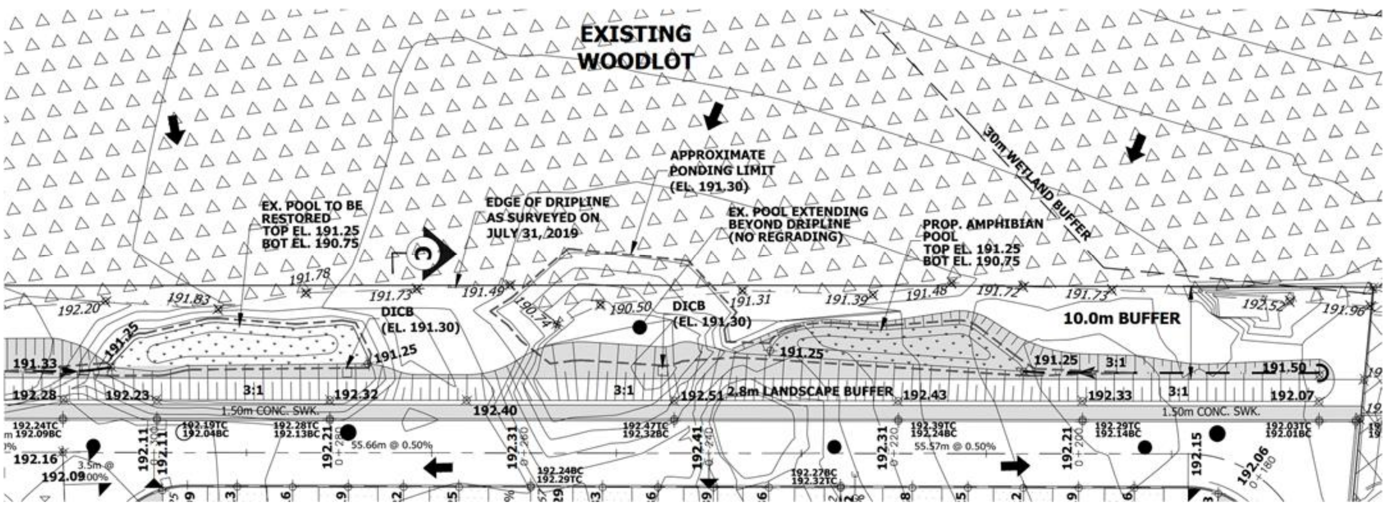

Figure 1. Proposed buffer with amphibian pools (from Urbantech)

3. Methods

A series of hydrologic water balances were completed for each pond/pool in sequence to evaluate existing and proposed conditions. Balances were completed for each individual pond/pool to predict daily water depths for three hydrologic scenarios corresponding to a relatively wet, dry, and average year. The purpose of modelling a range of hydrologic scenarios was to characterize the expected range of typical conditions. The results of the hydrologic water balances were used to determine the hydroperiod of each individual pond/pool under each hydrologic scenario.

Each water balance accounted for pond inflows, outflows (overflow or culvert outflow), evapotranspiration (ET) losses, and change in volumetric storage to determine water level depth at a daily timestep as demonstrated in Figure 2. The following assumptions were made for the scope of this assessment:

1. Winter periods (January and February) and explicit calculation of snow storage and snowmelt were excluded. Water balances accounted for winter snowmelt volumes by assuming full pond storage at the start of the modelling period (March).
2. Gains or losses due to groundwater interactions were not included.

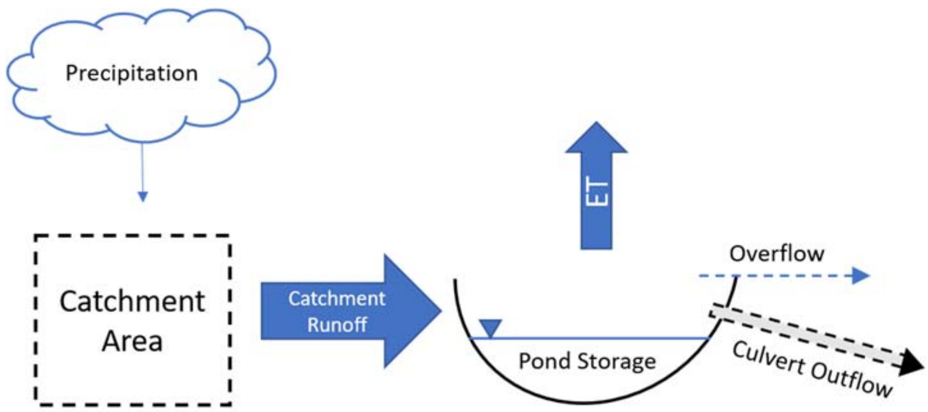

Figure 2. Water Balance Schematic

3.1. Inflows

Daily pond inflows or runoff from the existing and proposed site conditions were obtained from a stormwater management (SWM) model developed using EPA SWMM software. For existing conditions, a high-resolution lidar digital terrain model (DTM) was used to delineate catchment areas for West Pond and East Pond-A (hydraulically connected to East Pond-B) as shown in Figure 3.

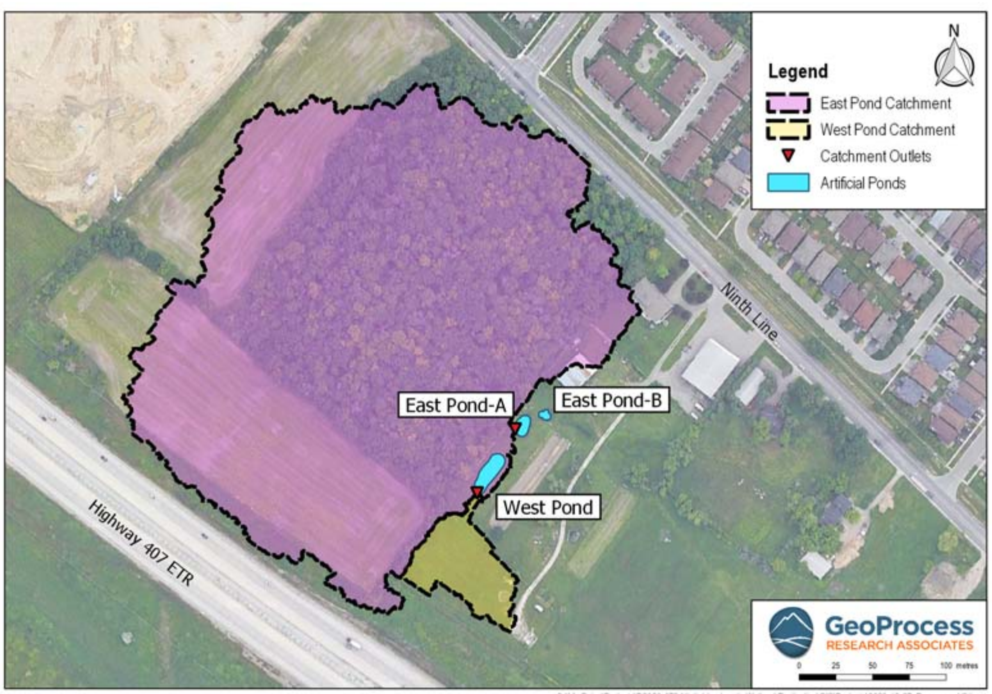

Figure 3. Existing Pond Catchment Areas

The proposed conditions catchment area was obtained from the Urbantech SWM report (Urbantech, 2020). Many of the EPA SWMM hydrologic input parameters were also obtained from the Urbantech report. One notable difference is that depression storage was set to a value of 0 mm, which deviates from Urbantech's parameter value of 5 mm. Setting this specific parameter value was necessary to undertake continuous analysis using the Curve Number infiltration method adopted by Urbantech. Model input parameters for existing and proposed conditions are summarized in Table 3.

Table 3. EPA SWMM Hydrologic Input Parameters

Parameter	Existing East Pond Catchment	Existing West Pond Catchment	Proposed Swale Catchment
Catchment Area [Ha]	7.70	0.34	6.45
Slope [%]	2.5	2.5	2.5
Depression Storage [mm]	0	0	0
Surface roughness (n) [-]	0.4	0.15	0.4
Infiltration Curve No. [-]	74	74	74

The EPA SWMM model was executed under the three hydrologic scenarios (wet, dry, and average years) to obtain corresponding daily time-series of inflows. The selection of historical daily data representative of these scenarios is described in Section 3.1.1.

3.1.1. Precipitation Data

Historical climate data was obtained online from Environment and Climate Change Canada (ECCC) climate station records. Daily synoptic data was interpolated from all stations located within a 20 km radius of the Toronto Pearson International Airport station following an inverse distance weighting (IDW) approach to represent regional climate trends. A statistical analysis was subsequently completed to identify representative years corresponding to each of the three hydrologic scenarios. 2016 data was used for the dry year scenario as it is among the 12th percentile of historical annual precipitation on record in the observed area and represents a recent "dry" year. 2010 data was used for the average year scenario as it is among the 56th percentile of historical annual precipitation on record in the observed area. 2019 data was used for the wet year scenario as it is among the 90th percentile of historical annual precipitation on record in the observed area and represents a recent "wet" year.

3.2. Evapotranspiration Losses

Hydrologic losses due to evapotranspiration (ET) were incorporated into the water balances. Daily ET losses were estimated from an empirical temperature-based ET model developed by Hargreaves (1985). The Hargreaves equation estimates reference evapotranspiration (ET_0) which represents the potential ET capacity of a uniform surface of short vegetation assuming moisture is readily available.

The open water bodies of the existing and planned ponds/pools may be subject to higher than modelled rates of evaporation due to their shallow depth. Warmer water in the ponds and the additional convection from open-water areas typically see higher than reference potential ET over ponds and wetlands. To provide an upper bound to this analysis, a scalar was applied to the Hargraves ET_0 values to estimate open water evaporation. Open water ET estimates were derived by scaling up ET_0 values by a Class-A pan coefficient of

1.2, which represents evapotranspiration conditions for an open water body (pan) surrounded by short vegetation with light wind and high relative humidity (Doorenbos & Pruitt, 1977).

Both the reference ET and open-water ET estimates were considered in the analysis to illustrate the range of pond levels under both plausible ET regimes. It should be noted that both estimates of potential ET represent conservative estimates of the actual ET uptake as unidealized environmental conditions often contribute to actual ET losses that are considerably less than ET_0 estimates.

3.3. Outflows

Volumetric losses to outflows in water balances were governed by the unique outlet characteristics of each pond/pool as summarized in Table 1 and Table 2, respectively. When inflows generated a water surplus greater than the maximum storage capacity of a given pond, the equivalent excess volume was categorized as overflow and routed as a system loss. For the existing ponds, maximum storage capacity was defined by the respective pond top elevation. For the proposed pools, maximum storage capacity was defined by the DICB invert elevation. Any water in the pond/pool above the given top elevation or outlet invert elevation was then routed as a loss from the system on a daily timestep. This represents a conservative approach as excess ponding volumes did not affect subsequent daily water depths. In the case of existing East Pond-A and -B, which are hydraulically connected through a CSP and discharge to headwater drainage feature H1S2, special considerations were made to route volumes through the system. When inflows to East Pond-A generated a water depth higher than the respective outlet invert, the volume above the invert was categorized as outflow and routed to East Pond-B. When the water depth of East Pond-B exceeded the respective outlet invert, the volume above the invert was categorized as outflow and routed as a system loss.

3.4. Volumetric Storage

Cumulative depth-area-storage relationships were defined for all ponds/pools to facilitate water balance calculations. A bathymetric survey of the existing ponds was completed by GRA on October 13, 2020, using a survey-grade global navigation satellite system (GNSS) receiver with enabled real-time kinematic (RTK) corrections (+/- 0.04 m error). The bathymetric survey data was supplemented by topographic survey data collected by J.D. Barnes Ltd. for the City of Mississauga. Survey data was used to develop a triangular irregular network (TIN) surface of each existing pond. A tabular stage-area-storage relationship following an average end area method at 0.2 m contour intervals was subsequently exported for each pond. Individual TIN surfaces of the proposed amphibian pools were generated from the proposed site grading plan provided by Urbantech. A tabular stage-area-storage relationship following an average end area method at 0.05 m contour intervals was subsequently exported for each amphibian pool.

4. Results

A summary of total precipitation and ET loss summed over the 10-month duration (March - December) for each hydrologic scenario is presented in Table 4. A summary of the total runoff simulated by the EPA SWMM model for existing and proposed conditions is presented in Table 5. Detailed water balance results are located in Appendix A.

Table 4. Summary of Climate Data Totals

Scenario	Year	Total Precipitation [mm]	Low-Range Total ET [mm]	High-Range Total ET [mm]
Dry	2016	546	892	1071
Average	2010	738	858	1029
Wet	2019	807	796	955

Table 5. Summary of Modelled Runoff Totals

Scenario	Condition	Catchment Outlet	Total Runoff [mm]	Runoff Coefficient [-]
Dry	Existing	East Pond	65	0.12
Dry	Existing	West Pond	69	0.13
Dry	Proposed	Modified Swale	65	0.12
Average	Existing	East Pond	170	0.23
Average	Existing	West Pond	172	0.23
Average	Proposed	Modified Swale	170	0.23
Wet	Existing	East Pond	176	0.22
Wet	Existing	West Pond	166	0.21
Wet	Proposed	Modified Swale	169	0.21

The resulting water balance daily depths for each pond/pool under the three hydrologic scenarios are presented in Figure 4 to Figure 6. The water balance results demonstrate that for all hydrologic scenarios both the existing and proposed ponds/pools maintain a continuous hydroperiod. This conclusion is particularly notable for the dry year scenario (Figure 4) as the ponds/pools demonstrate the ability to maintain water under typically dry conditions. During a prolonged period of virtually zero inflow (June 2016 to mid-August 2016), the proposed amphibian pools lower to a minimum depth of around 0.2 m (high-range ET) but rapidly recharge following a competent rainfall. The proposed amphibian pools generally demonstrate greater resiliency to dry periods than the existing ponds due to their smaller surface area. The average year scenario results (Figure 5) for East Pond-A and -B, and the proposed amphibian pools exhibit regular cycles of inflow and loss. West Pond does not exhibit the same degree of fluctuation because of its considerably smaller catchment area. The wet year scenario results (Figure 6) demonstrate that West Pond and the proposed amphibian pools maintain full capacity for most of the year. East Pond-A and -B exhibit frequent cycles of inflow and outflow as water volumes are hydraulically routed through the connected system. Water depths rarely drop below the respective East Pond inverts during the wet year scenario.

The results align with the conceptual model describing hydrologic alterations to the site. The proposed pools have a similar catchment area to the existing East Ponds, and thus are expected to receive similar runoff inputs (assuming the woodlot remains the same as existing conditions). The smaller volume of the proposed pools makes them more sensitive to runoff events, resulting in less runoff volume required to maintain water in the pools. Potential evapotranspiration losses from the planned replacement pools are smaller owing to the reduced area of new pools. While the surface areas and depths of the proposed pools are smaller than the existing ponds, the surface water balance completed in this assessment predicts similar hydroperiod characteristics between the existing and proposed features. A continuous hydroperiod is expected in the proposed amphibian pools to be sited on the Subject Lands.

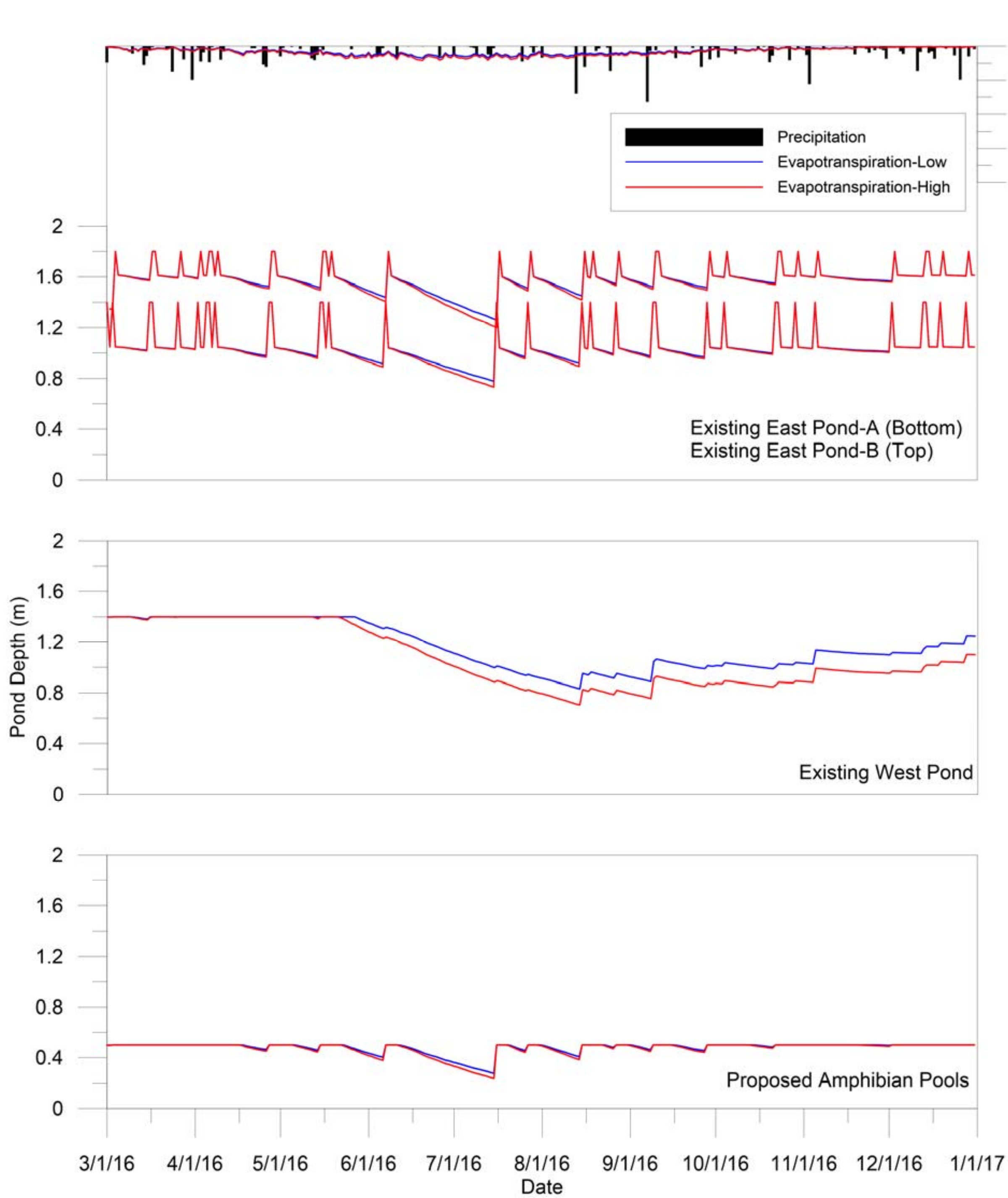

Figure 4. Dry Year (2016) Water Balance Pond Depths

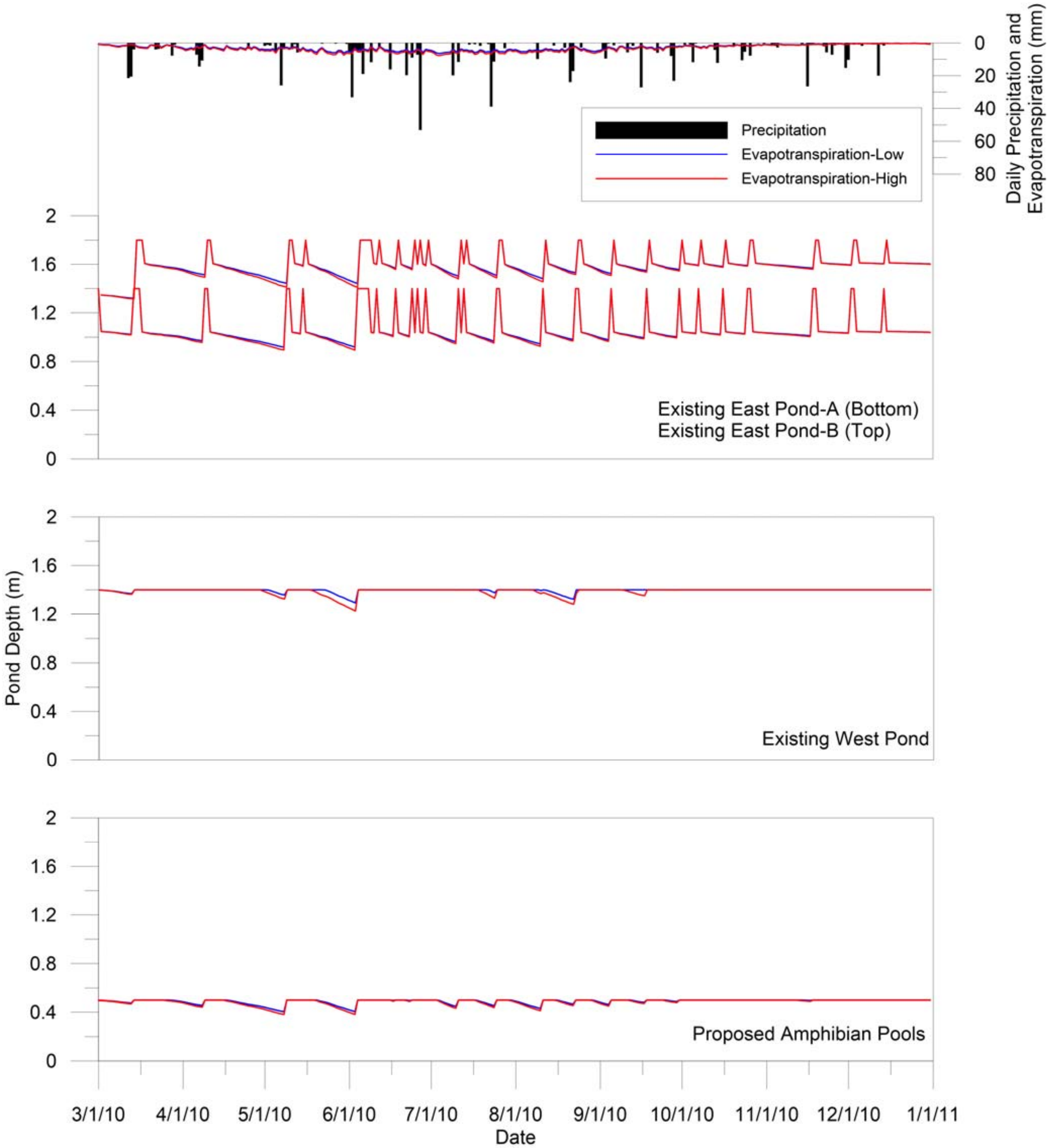

Figure 5. Average Year (2010) Water Balance Pond Depths

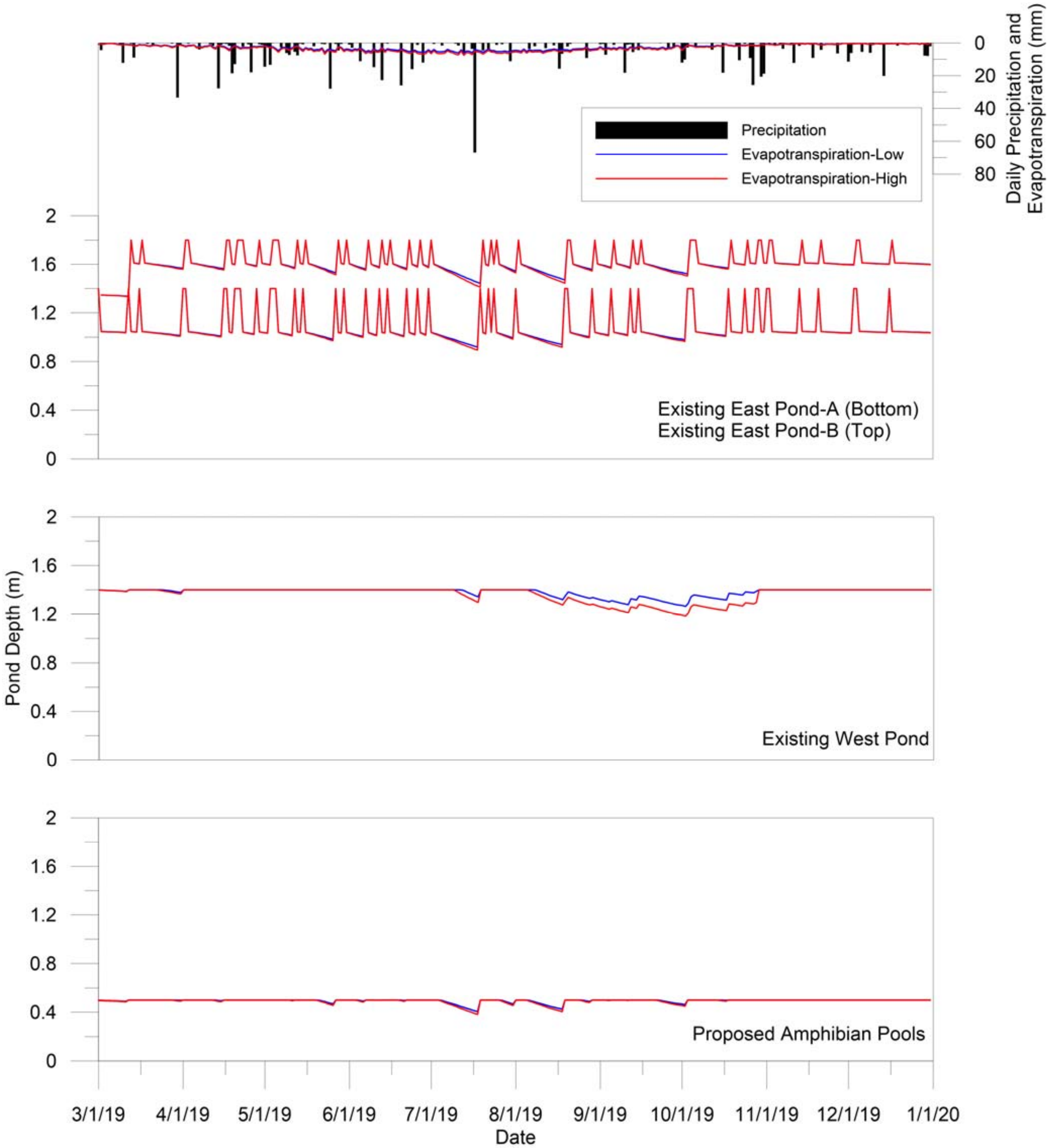

Figure 6. Wet Year (2019) Water Balance Pond Depths

5. Limitations

This assessment is limited to the modelling assumptions underpinning the hydrologic performance of the existing artificial ponds on the Subject Lands and the proposed amphibian pools in the new buffer. Any considerations regarding flood hazards resulting from the inundation of the proposed buffer zone are beyond the scope of this assessment. Additional limitations are noted as follows:

- This assessment excludes winter months (January and February) and does not explicitly simulate snow storage and snowmelt hydrologic processes. Instead, water balances accounted for winter snowmelt volumes by assuming full pond storage at the start of the modelling period (March). This assumption was tested by executing the water balances with zero initial storage. The resulting pond/pool depths were relatively insensitive to this condition in all scenarios except for the existing West Pond during the dry year; however, the West Pond still maintained a continuous hydroperiod.
- This assessment excludes consideration of groundwater interactions. Savanta (2020) concluded that groundwater interactions were not anticipated based on their review of a Geotechnical Investigation Report provided by DS Consultants Ltd. As a result, water balances focus on surficial hydrologic processes only, which are the anticipated primary driver of the water balance.
- A range of ET losses was estimated using the Hargraves (1985) empirical temperature-based reference ET model. Resulting Hargreaves ET_0 values were adopted as a low-range estimate and subsequently scaled up by a Class-A pan coefficient of 1.2 to establish a high-range estimate more representative of shallow open water (Doorenbos & Pruitt, 1977). The range of ET values is generally considered to be conservative as unidealized environmental conditions often contribute to actual ET losses that are considerably less than ET_0 estimates. As a result, water balances may have underestimated pond depth; however, this is a conservative approach in the context of hydroperiod characterization.
- Hydraulic routing through East Pond-A and -B is a complex process that was simplified for this assessment. Hydraulic routing is typically modelled at a finer timescale; however, in the context of a broad hydrologic water balance, results are dictated by daily inputs and losses, thus this simplification is justified.
- The bottom of the CSP outlet at East Pond-B was found to be rusted out during the bathymetric survey. As a result, the outlet invert was approximated as the ground surface elevation at the outfall, which is most likely lower than the effective invert. The potential impact of this approximation is that the water balance may be underestimating depth; however, this result is conservative in the context of hydroperiod characterization.
- Under proposed conditions, catchment runoff is assumed to predominantly discharge as sheet flow distributed across the buffer zone modified swale. As a result, inflows are prorated to the two amphibian pools based on the proposed grading plan.
- Direct rainfall onto pond/pool surfaces was considered a relatively minor input and excluded from water balance calculations. This exclusion contributes to a more conservative analysis in the context of hydroperiod characterization.

6. Conclusions

The hydrologic performance of three existing artificial (dug) farm ponds situated on the Subject Lands, and two proposed amphibian pools was evaluated by completing a series of surface water balances under a range of hydrologic scenarios. Each water balance accounted for inflow, outflow, ET loss, and volumetric storage to determine water level depth at a daily timestep. The results demonstrate that the existing ponds and proposed pools all maintain a continuous hydroperiod for hydrologic scenarios corresponding to a dry, average, and wet year.

7. References

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Pond Feature Hydrologic Assessment
5150 Ninth Line, Mississauga

Prepared for Mattamy (5150 Ninth Line) Limited

October 30, 2020

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Appendix A

Water Balance Calculations

Digital Appendix can be downloaded following this link:

https://drive.google.com/drive/folders/1HnbvtyJxHus9Yp_XZsryyGzlCOcCsHXt?usp=sharing