Evaluating the Success of Feature-based Water Balance Implementation through the Development Review Process

(Complete final draft for consultation)

April 2020

Executive Summary

Certain types of natural features, especially wetlands, may be significantly impacted by urban development and land use change even where no development activities occur within the feature itself. Changes to the land surface draining to a feature resulting from construction of impervious surfaces like asphalt and concrete, or changes to the grade of the land surface, may alter the quantity and timing of water flowing to/from the feature. By altering the timing and quantity of flows to/from the feature, collectively referred to as its water balance, there is a risk that the feature will be degraded as it becomes too wet or too dry at the wrong time, resulting in loss of species or ecological functions, and potentially in hazardous site conditions such as tree die-back or nuisance flooding of adjacent areas.

Consideration of feature-based water balance (FBWB) in development design reduces the risk of these types of negative impacts and helps fulfil the wetland conservation objectives outlined in the Ontario Provincial Policy Statement and in other provincial policy and legislation. By re-directing water towards or away from wetlands through certain design elements such as roof drain collectors, infiltration trenches, or incorporation of parks/open space within the wetland catchment, the intent is that these mitigation measures help to preserve water balance and thus the associated ecological and hydrological functions of wetlands.

Water balance is one of the four objectives outlined in TRCA's *Stormwater Management Criteria* (2012), along with water quantity (i.e. flooding), water quality, and erosion. TRCA regulates interference with wetlands under the Conservation Authorities Act and has documented many cases where lack of due consideration for FBWB led to significant degradation of natural features, as well as issues with erosion, nuisance flooding, tree die-back, and related hazards. Municipalities and the public have an interest in ensuring that lands that are set aside for inclusion in a natural heritage system can continue to function as viable habitat and provide the same level of ecological services to local residents (e.g. water filtration, heat island reduction, aesthetic appreciation, etc.) as part of a complete, sustainable community design.

While TRCA and Credit Valley Conservation (CVC) first outlined the requirement for development proponents to consider FBWB in development proposals in 2012, at some sites this requirement was added prior to 2012. This document reviews three sites in TRCA jurisdiction where FBWB was incorporated into development design, and where development (circa 2009-2015) has since been completed.

The three development sites evaluated here provide evidence that FBWB mitigation can work to preserve the ecological and hydrological integrity of wetlands. At two of the three sites (Yonge West, wetlands W1 and W5) a relatively stable ecological and hydrological condition appears to have been achieved. At the third site (Beechridge), there appear to have been dramatic shifts in the site water balance accompanied by severe ecological degradation of the wetland flora and fauna. Given the relatively high ecological sensitivity of the Yonge West lands, the extended period of review of development proposals, and the fact that much of the land surrounding the two wetlands has been converted to parks or restored lands, these cases should perhaps be regarded as best case scenarios. Nonetheless, the example of the Yonge West W5 wetland demonstrated that it is possible to maintain ecological and hydrological functions, broadly speaking, while developing up to 59% of the contributing drainage area, at least within the particular landscape context of this site.

The temporal and spatial resolution of the data used to characterize change over time at the three sites varies widely, as do the data collection methods. This study is intended to provide a basis for future work evaluating the success of FBWB mitigation measures determined through the development review process. Few conclusions can be drawn on the basis of three study sites, and so it is important that the success of these mitigation measures is evaluated at a greater number of sites in the future.

Toronto and Region Conservation Authority. 2020. Evaluating the Success of Feature-based Water Balance Implementation through the Development Review Process.

Report prepared by: Neil Taylor, Research Analyst, Policy Planning, TRCA.

For information on this document please contact Neil Taylor – neil.taylor@trca.ca

Acknowledgements:

A special thanks to Lyndsay Cartwright for her assistance with analysis of ecological data and proposing methods to compare conditions over time.

Thank you to the following partners for their support:

The Great Lakes Protection Initiative
Region of Peel
City of Toronto
York Region
Durham Region
Credit Valley Conservation
Conservation Halton

TABLE OF CONTENTS

FIGURES AND TABLES

1. BACKGROUND

Conservation authorities in Ontario regulate development and interference within the valleys and floodplains of watercourses, in wetlands, and in other areas affected by certain natural hazards, as outlined in Section 28 of the Conservation Authorities Act (R.S.O. 1990, Chapter 27). In addition to having a regulatory role, conservation authorities also provide guidance and expertise to municipalities as a review body for applications made under the Planning Act and the Environmental Assessment Act. Acting as both a regulatory and a commenting body, conservation authorities seek to guide development in such a way as to preserve the integrity of the natural resources within a watershed.

Certain types of natural features, especially wetlands, may be significantly impacted by urban development and land use change even where no development activities occur within the feature itself. Changes to the land surface draining to a feature resulting from construction of impervious surfaces like asphalt and concrete, or changes to the grade of the land surface, may alter the quantity and timing of water flowing to/from the feature. By altering the timing and quantity of flows to/from the feature, collectively referred to as its water balance, there is a risk that the feature will be degraded as it becomes too wet or too dry at the wrong time, resulting in loss of species or ecological functions, and potentially in hazardous site conditions such as tree die-back or nuisance flooding of adjacent areas.

Consideration of feature-based water balance (FBWB) in development design reduces the risk of these types of negative impacts and helps fulfil the wetland conservation objectives outlined in the Ontario Provincial Policy Statement and in other provincial policy and legislation. By re-directing water towards or away from wetlands through certain design elements such as roof drain collectors, infiltration trenches, or incorporation of parks/open space within the wetland catchment, the intent is that these mitigation measures help to preserve water balance and thus the associated ecological and hydrological functions of wetlands.

Water balance is one of the four objectives outlined in TRCA's *Stormwater Management Criteria* (2012), along with water quantity (i.e. flooding), water quality, and erosion. TRCA regulates interference with wetlands under the Conservation Authorities Act and has documented many cases where lack of due consideration for FBWB led to significant degradation of natural features, as well as issues with erosion, nuisance flooding, tree die-back, and related hazards. Municipalities and the public have an interest in ensuring that lands that are set aside for inclusion in a natural heritage system can continue to function as viable habitat and provide the same level of ecological services to local residents (e.g. water filtration, heat island reduction, aesthetic appreciation, etc.) as part of a complete, sustainable community design.

While TRCA and Credit Valley Conservation (CVC) first outlined the requirement for development proponents to consider FBWB in development proposals in 2012, at some sites this requirement was added prior to 2012. This document reviews three sites in TRCA jurisdiction where FBWB was incorporated into development design, and where development (circa 2009-2015) has since been completed.

2. PURPOSE

The purpose of this document is to evaluate the success of implementation of FBWB through the development review process, looking at three specific development sites where FBWB was incorporated into development design. The intent of this review is to answer the question, to the extent possible: Were design measures intended to mitigate the effects of development on adjacent hydrologically-sensitive features successful in doing so? This question effectively divides into two components:

a) Did mitigation design measures succeed in maintain the wetland's hydrological regime, relative to pre-development conditions?

b) Whether or not the hydrological regime remained stable over time, how have the ecological communities (flora and fauna) present in the wetland changed pre- to post-development?

The intent is that the results reported here can serve as a template for further work evaluating the success of FBWB implementation, as more sites incorporating more advanced and well-documented mitigation designs come online in the coming years.

2.1 Caveats and assumptions

It is important to note that the design measures being evaluated in this review were intended to mitigate the *hydrological effects* of development and land use change on adjacent wetlands. However, it is well understood that urban development can impact adjacent ecosystems in many different ways. For example, in addition to altering water balance, urban development can impact adjacent ecosystems through noise, light, movement of soils, introduction of exotic species, and increased mortality of native fauna due to interactions with road traffic, pedestrians, and their pets. The long-term ecological health of wetlands and other natural features will be dictated not only by adjacent development but by its context within the broader landscape; for example, whether they are connected to or isolated from large contiguous areas of natural habitat.

For the purposes of this review, it is assumed that all impacts to hydrology relative to pre-development conditions are as a result of the altered land use and local drainage patterns (and are not due to long-term dewatering, effects of more distant activities, etc.). While it is almost impossible to determine this conclusively, this is the most reasonable conclusion in each case.

3. METHODS

3.1 Review of development files

The development review files associated with each development site were retrieved using TRCA's Central Filing Number (CFN) system. The CFN files contain development proposals, site plans, and associated technical studies (engineering, ecological, geotechnical, hydrogeological, etc.) at various stages of the development review process. The CFN files for all development sites date from roughly 1996 to 2015. The CFN files vary in terms of completeness of record, ranging from some nearly complete records to others where significant technical reports or site plans are missing. Additionally, the final site plans are rarely identified as such, as they are always subject to re-submission until the required permits have been granted. Therefore, it was assumed in reviewing the CFN files that the latest dated file on record represented the final development proposal, representative of as-built conditions. Where possible, TRCA staff and technical consultants were contacted to attempt to fill in gaps in the development record, and aerial orthophotos for each calendar year were examined to supplement data on the timeline of development.

3.2 Water level data

Pre-development wetland water level data, where available, was collected by consultants as part of the suite of site characterization studies. Where data was not available, figures showing wetland water level were digitized to approximate, with a high degree of accuracy, the underlying data. Water level data was only used where it could be tied to a surveyed geodetic elevation in metres above sea level.

Post-development data was collected by installing shallow piezometers into each of the three impacted wetlands. A pressure transducer (water level logger) was used to record water levels in the piezometers, and water levels were recorded both inside and outside the piezometer to ensure that readings were representative of ambient external water levels. The top of the piezometers were professionally surveyed to establish a fixed geodetic datum from which to measure water levels and compare with pre-development conditions.

3.3 Ecological data

Pre-development ecological data collected by consultants as part of site characterization studies was compiled to determine baseline ecological conditions. The baseline data compiled included both floral and faunal data. Various collection methods were used at the three impacted wetlands, such as vegetation transect and quadrat data, site-scale flora and fauna inventories, and different types of amphibian surveys. All available data at each site was compiled, but the spatial precision of the data and the ability to compare post- to pre-development conditions varied considerably. A more detailed description of available data is provided with the site overviews in the following section.

Post-development data was collected using three main methods:

- Collection of Ecological Land Classification (ELC) data, completed in summer 2019.
- Frog call surveys, completed in spring and summer 2019. At the Yonge West site, it was possible to precisely match survey locations and seasonal timing, whereas at the Beechridge site, approximate survey locations were used.
- Annual vegetation transect data, available at the Yonge West W1 wetland (only) from the approximate start of development in 2009 through until 2019.

4. REVIEW OF DEVELOPMENT SITES

The impacts to three wetlands situated within two development sites were evaluated. Two of these wetlands fall within one very large development site in Richmond Hill, Ontario, referred to as Yonge West, and are differentiated by the consultant naming convention of W1 and W5. The second development site, Beechridge

Farms (hereafter simply Beechridge), is located in Ajax, Ontario. The location of both sites within the TRCA jurisdiction is shown in Figure 1.

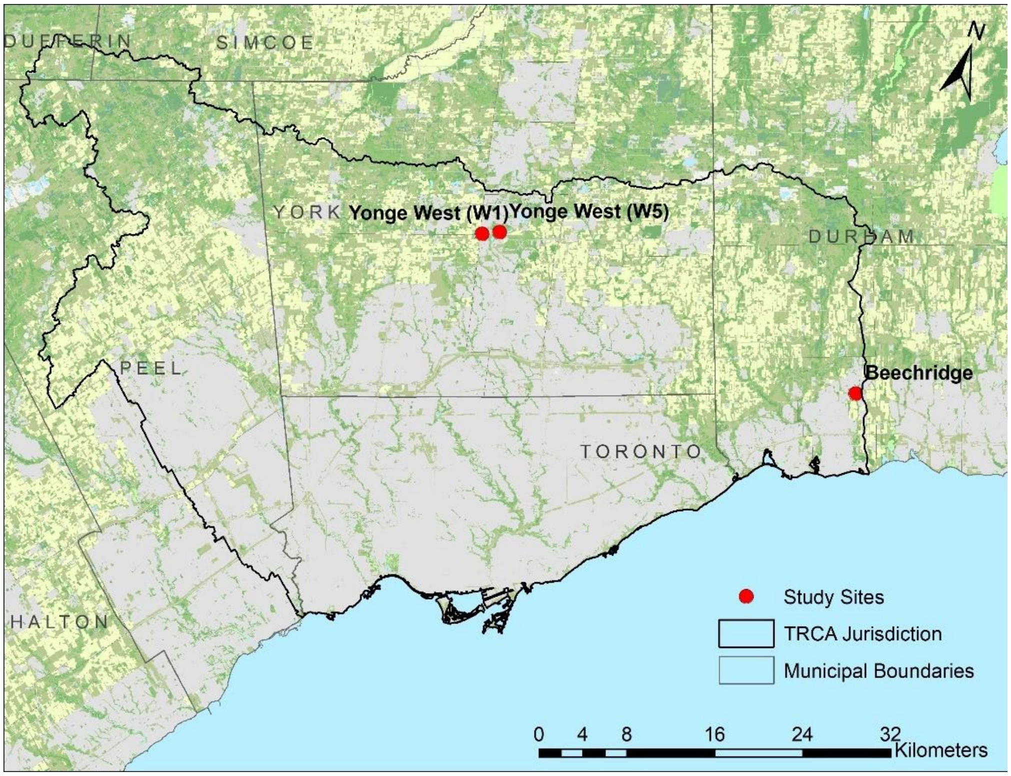

Figure 1: Map of development sites

4.1 Yonge West

4.1.1 Site overview

The Yonge West site in Richmond Hill consists of an area of land roughly square in shape, of dimensions 2 x 2 km, bounded by Bathurst and Yonge streets on the west and east, and by Jefferson Side Road on the south. The proposals to develop the site were contentious and spent several years being adjudicated by the Ontario Municipal Board. In addition to the ecological value of the land in question, and the presence of glacially-formed isolated kettle lakes, the complete development of the land would have split the Oak Ridges Moraine, a provincially significant geological and ecological landform, in two, which was perceived to be a concern for east-west connectivity along the Moraine. The land between the development to the north and south is now managed by TRCA for public use as the Oak Ridges Corridor Conservation Reserve. Water balance of the wetlands and waterbodies on the site emerged as a key concern in the review of the development proposals. A detailed map of the site is shown in Figure 2 along with the location of the two wetlands in question.

Development of the site started with land clearing and grading in 2008-2009, with development being mostly to entirely complete by about 2015. Post-development data were collected in 2019-2020.

Figure 2: Yonge West site map, showing locations of wetlands W1 and W5 and approximate contributing areas of RDC systems

4.1.2 Water balance mitigation measures

Given the known pre-development catchments of wetlands W1 and W5, the proposed development surrounding the wetlands was projected to divert significant quantities of runoff and groundwater away from the wetlands via roads, rooftops, and sewer drainage. A water balance study by Schaeffers Engineering (2003; only available in summary form) calculated an annual deficit of 50,000 m^3 of water to the entire development site from runoff alone, not including any loss to groundwater recharge. To mitigate the reduction in runoff, a Roof Drain Collector (RDC) system was proposed whereby clean runoff from rooftops could be directed to rear yard soakaway pits via a so-called third-pipe conveyance system to compensate for the calculated water balance deficit. Additional mitigation measures to address any outstanding deficit resulting from decreased groundwater recharge are referred to in the report, though these were to be dealt with in a separate (then forthcoming) study.

For wetland W1, a 29% post-development reduction in the catchment area was projected, from 29.9 to 21.2 ha. To compensate for the loss of runoff, an RDC system conveying 2.4 ha of rooftop drainage area from 150 housing units was proposed. Flow from the RDC system was designed to be conveyed to the wetland via a bioswale at the southeast corner of the wetland. The approximate area contributing roof drainage to the RDC system is outlined in red, while the location of the bioswales (there appear to be two) is indicated by the red arrow.

For wetland W5, a more dramatic 59% post-development reduction in the catchment area was projected, from 32.1 to 13.1 ha. To offset this runoff reduction, an RDC system was designed to convey 5.12 ha of rooftop drainage from 320 housing units. The RDC system drains to the wetland via a bioswale along the southern edge of the wetland. The estimated area contributing roof drainage to the RDC system for wetland W5 is outlined in red, with the bioswale is indicated by the red arrow.

4.1.3 Available data

The available pre- and post-development data is outlined in Table 1 below:

Table 1: Summary of data available for the Yonge West site

Variable	Data Type	W1 Wetland		W5 Wetland	
		Pre(<2009)	Post(≥2013)	Pre(<2009)	Post(≥2013)
ELC	ELC Community Polygons	TRCA 2006	–	TRCA 2006	TRCA 2019
Flora	Wetland Vegetation Transects	TRCA 2008	TRCA (2009-2019)	–	–
Frogs	Frog call count	Consultant (2006-2007)	TRCA (2009-2019)	Consultant (2006-2007)	TRCA 2019
Hydrology	Water Level	Consultant (2004-2005)	TRCA (2019-2020)	Consultant (2004-2005)	TRCA (2019-2020)

4.1.4 Yonge West (W1) evaluation

The comparison of water levels, pre- to post-development, is shown below in Figure 3:

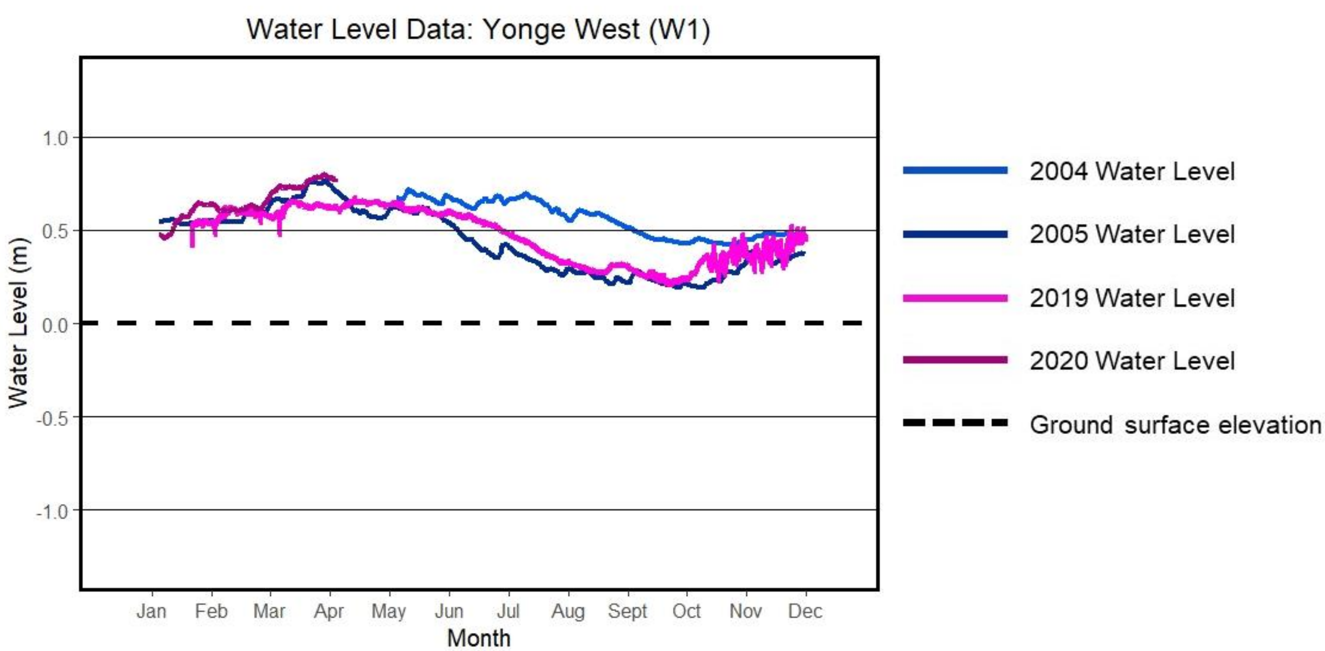

Figure 3: Water levels at Wetland W1, pre- and post-development

From Figure 3, it is clear that there has been little, if any, change in the water levels within the wetland based on the two years of pre-development baseline available. The post-development water levels are essentially fully encompassed by the levels measured pre-development. Interpretation of aerial orthophotos also does not suggest any significant change in the area of open water.

It is worth noting that neither 2004 nor 2005 were anomalous precipitation years, with total precipitation amounts measured at Pearson Airport station within 5% of the 1981-2010 climate normal of 786 mm. 2019 was a slightly anomalously high precipitation year, with 20% more than the 1981-2010 normal (950 mm recorded).

In terms of ecological data, ELC data was only available at the W1 wetland for the pre-development condition and so could not be compared on this basis over time. However, comparison between the 2006 ELC layer and aerial orthophotos from 2018 suggest little change in the distribution of ELC classes or the extent of open water over time (Figure 4). The white area circled in Figure 4 indicates an area of the site where some tree dieback has occurred and there are more scattered patches of open water; this is near the southeast corner of the wetland where the bioswale is understood to convey water to the wetland, and so this may be due to the more concentrated flow (relative to pre-development) being received at this location. At the landscape scale, the structure of the wetland appears to have remained relatively consistent over time.

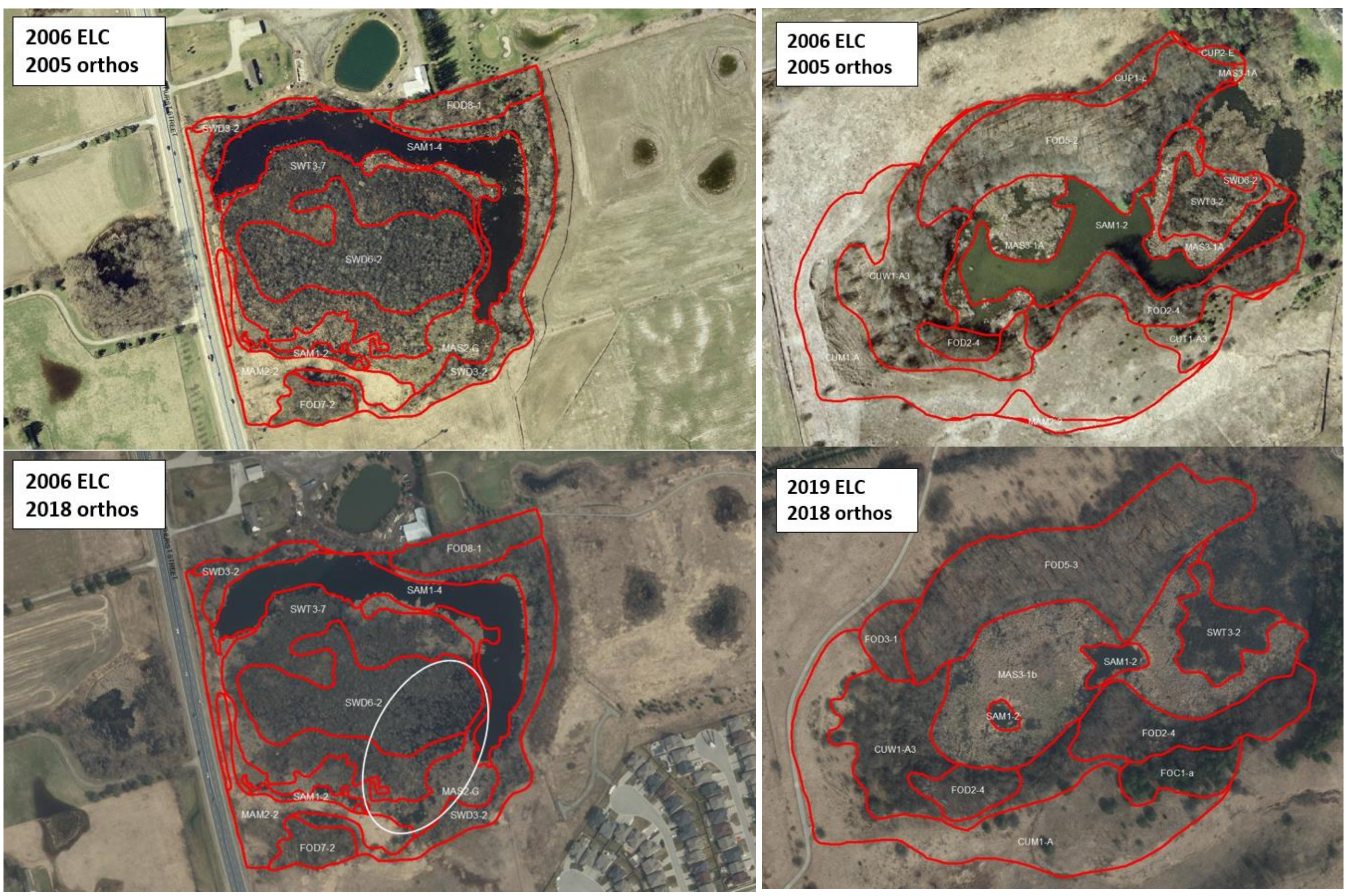

Figure 4: Changes observed in ELC community extent 2006-2019 and orthophotos for wetlands W1 (left) and W5 (right)

Wetland W1 was the only wetland to contain a vegetation transect, which has been measured annually since 2009, allowing for a higher resolution of change-over-time analysis. The data was analyzed according to the floristic quality index (FQI), mean coefficient of conservatism (Mean cc), proportion of exotic and native species, and the proportion of species of local conservation concern (as determined using TRCA's L-rank system); the results are shown in Figure 5. While the data are quite "noisy", as indicated by the generally high p-values (not meeting standard criteria for statistical significance), some trends can nonetheless be observed. The proportion of native plant species has been decreasing over time, with a corresponding increase in exotic species proportion, at a level that approaches standards thresholds of statistical significance ($p=0.114$) at a low to moderate rate of about 0.5% per year. This trend towards a higher proportion of exotic species is observed at many sites within or adjacent to urban areas. The only trend that was significantly significant at the $\alpha=0.05$ level was the proportion of species of local conservation concern (% L1-L3 ranked species), which has declined from about 23% to 14% over 2008-2019.

Finally, in terms of frog species using the site, there was a downward trend in the number of species of local conservation concern (L1-L3 ranked species) at W1 between 2006 and 2019, although the trend was only approaching significance ($p=0.053$). This downward trend represents the gradual decline in wood frog occurrence and calling code. Although not detected in 2006, wood frogs were detected in 2007 at a calling code of 1, in 2009 as a full chorus and in 2010 and 2011 as 3 individuals. This species has only been detected once post-2011 and that detection involved only 1 individual recorded in 2017. However, the site continues to support viable populations of grey treefrog, green frog, and Northern leopard frog for the time being.

Conclusion: Overall, the Yonge West W1 wetland appears to be in a relatively stable ecological condition, with a relatively modest decline in overall ecological quality, as determined from the distribution of communities at the landscape level as well as measures of floral and faunal diversity and composition. The largest change to the site may be the gradual apparent decline in the diversity of frog species and the proportion of sensitive species using the site, most notably the decline in wood frog population. The site hydrology appeared to remain within historical observed conditions, as supported both from water level monitoring as well as aerial orthophotos. Given the conversion of 29% of the wetland catchment to urban land cover, this suggests that the water balance mitigation measures are functioning as intended.

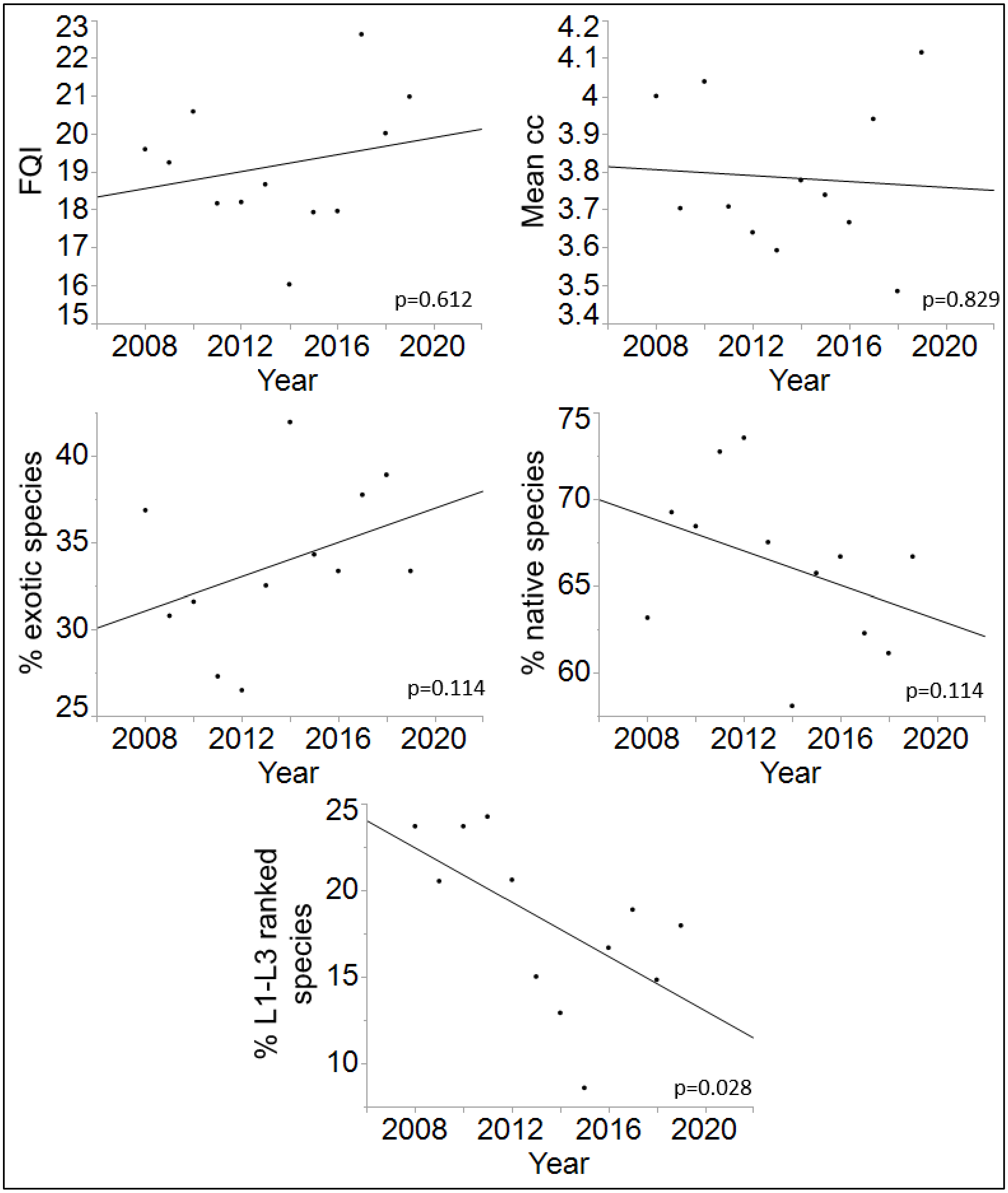

Figure 5: Results from analysis of wetland vegetation transect survey data for wetland W1

4.1.5 Yonge West (W5) evaluation

The comparison of water levels, pre- to post-development, is shown below in Figure 6:

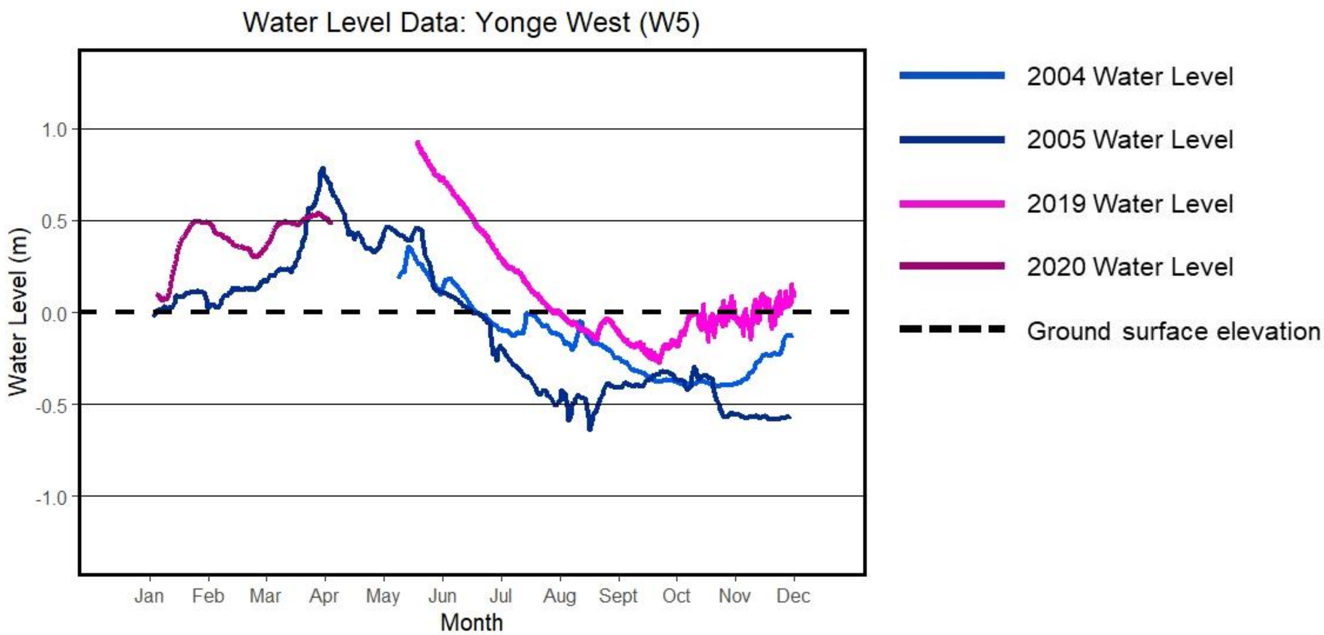

Figure 6: Water levels at Wetland W5, pre- and post-development

As with wetland W1, the hydrology of wetland W5 seems not to have departed drastically from pre-development conditions. The water levels in 2019 are approximately 0.5 m higher than historically observed conditions for mid-May through mid-July. This may reflect a long-term shift in hydrology towards wetter conditions but may simply reflect the 20% additional precipitation over the 1980-2010 climate normal (as measured at Pearson airport station). However, the period of post-development monitoring is slightly shorter at wetland W5, with only 11 months of monitoring, making it more difficult to verify this. It should be noted that all water levels have been referenced to surveyed elevations, but are expressed here in metres relative to local ground surface for convenience.

At the W5 wetland, ELC data and frog call data were available to evaluate any changes in ecological condition over time. Within the wetland proper (as opposed to the adjacent upland communities), the biggest change over the period 2006-2019 is the increase in area of the narrow-leaved cattail community (MAS3-1B) which nearly doubled in size (+88%; Figure 4). There was a concomitant decrease in the area occupied by a shallow aquatic duckweed community (SAM1-2; -85%). This would suggest a possible trend towards drier conditions, although it may also simply reflect a natural process of succession and expansion of the cattails within the wetland. Available water level data suggest a possible wetting trend, which would tend to favour the explanation of natural succession in the shift of communities within the wetland.

In terms of frog data, the data was more limited at wetland W5 than at W1, but some preliminary observations can be made. An increasing trend was observed in species richness and calling code (a proxy for population size), while the number of species of local conservation concern (L-ranks L1-L3) remained constant over time. These data suggest that conditions in the wetland have not become less favourable for amphibian breeding habitat over time, although they may also reflect the change in the surrounding landscape from predominantly agricultural to park land and redistribution of amphibian populations within these surroundings.

Table 2: Change over time in species occurrence and richness, maximum calling code, and number of species of local conservation concern at wetland W5

Variable	2006	2007	2019
Species present and max. calling code	SPPE-3 WOFR-2 GRTF-2	SPPE-3 WOFR-3 GRTF-3 GRFR-1	SPPE-3 WOFR-3 GRTF-3 GRFR-1 NLFR-2
#L1-L3 ranked frog species	3	3	3
Species richness	3	4	5

SPPE-spring peeper; WOFR-wood frog; GRTF-grey treefrog; GRFR-green frog; NLFR-Northern leopard frog

Conclusion: The Yonge West W5 wetland appears to be in a relatively stable ecological condition, with the site continuing to function as viable habitat for native wetland vegetation and frogs. It is unclear whether the shift within the wetland from shallow aquatic-type ELC communities towards emergent vegetation is the result of a shift in hydrology or natural succession processes, but available water level data does not support any decrease in water levels over time. Recruitment of breeding amphibians has increased over time in both species richness and population, as approximated by calling codes, which is a positive sign, although the trend in the surrounding landscape as a whole cannot be deduced from this fact alone. Given the very large post-development reduction of 59% in the contributing drainage area to the wetland, the lack of detectable ecological degradation within the available data suggests that the water balance mitigation measures are having their intended effect on the site hydrology.

4.2 Beechridge

4.2.1 Site overview

The Beechridge site is located in Ajax, Ontario, and is situated between urban development to the south, a Canadian Pacific rail line to the north, and natural heritage lands surrounding Carruthers Creek to the east (Figure 7). While the site itself was developed between approximately 2012 (land clearing and grading) and 2015, there was further development of the lands to the east of Carruthers Creek and to the north of the railway over the period roughly 2008-2012. The consideration of water balance for the wetlands and the natural heritage lands along the eastern edge of the site was raised as a concern early on in the review of the development proposal, circa 2003-2004. The specific wetland for which FBWB was considered is the one highlighted in green outline in Figure 7, which has a small tributary running through it. The approximate boundaries of the development site, which were used to aggregate species lists and ELC communities in the pre-development data, are outlined in red. Another small patch of wetland habitat, referred to as the “Pocket Wetland”, is present at the northwest corner of the site. As the consultant fauna data was aggregated to the scale of the entire development site, this was an important consideration.

Figure 7: Map of Beechridge development site

4.2.2 Water balance mitigation measures

A functional servicing report from 2012, involving a consortium of consultants led by consultant Bird & Hale, indicates that, of the 7 ha of the wetland catchment within the development lands, 4.66 ha (67%) would be developed to a low density residential land use. The wetland was calculated to receive 18,300 m^3 annually from the site through a combination of surficial and sub-surficial flow pathways (contributing 8,500 m^3 and 9,800 m^3, respectively). Based on these calculations, 1.2 ha of rooftop area was proposed to be directed to an RDC system, with additional natural drainage from the west of the development site to be directed towards the wetland as well. It was stated that the proposed solution would maintain the water balance, contributing 18,900 m^3 of water per year to the wetland, although the ratio of surface water to groundwater was projected to shift (to 11,800 m^3 and 7,100 m^3, respectively).

Development review files do not indicate that any consideration was given to water balance for the small Pocket Wetland in the northeast of the site.

4.2.3 Available data

The available data for the Beechridge site is summarized in Table 3 below.

Table 3: Summary of available data for the Beechridge wetland

Variable	Data Type	Pre(<2012)	Post(>2015)
ELC	ELC Community Polygons	Consultant 2004	TRCA 2019
Frogs	Species list	Consultant 2004	TRCA 2015, 2019

Variable	Data Type	Pre(<2012)	Post(>2015)
Hydrology	Water Level	(consultant data could not be located)	TRCA (2019-2020)

Pre-development water level data, while referred to in multiple technical reports, could not be located by either TRCA staff or the consultants involved who could be reached. Therefore only post-development water level data was used, which was compared with typical hydroperiods observed for marsh communities as determined from six high quality reference monitoring sites.

4.2.4 Beechridge wetlands evaluation

The measured post-development water levels in the Beechridge wetland are shown in Figure 8 below. Unfortunately, although pre-development monitoring was undertaken, this data could not be located in spite of best efforts to do so. In lieu of being able to compare the pre- and post-development wetland water levels, it is instructive to compare the water levels recorded in 2019 and 2020 with those that would typically be expected at marsh wetlands. The data for comparison comes from TRCA's wetland hydrology monitoring network, which includes six marshes considered to be in excellent ecological condition. The data from these sites covers the period from roughly 2013-2019.

In Figure 8, the coloured bands represent the proportion of water level data, measured relative to local ground surface elevation, falling within given percentile ranges. As the data used were highly non-normally distributed, percentile ranges are used in lieu of standard deviations, with the light green, yellow-orange, and percentile bands being equivalent to one, two, and three standard deviations, respectively, in terms of the proportion of the data they bound. The darker green and grey bands correspond to the bands containing 50 percent of the data and the overall mean water level, respectively.

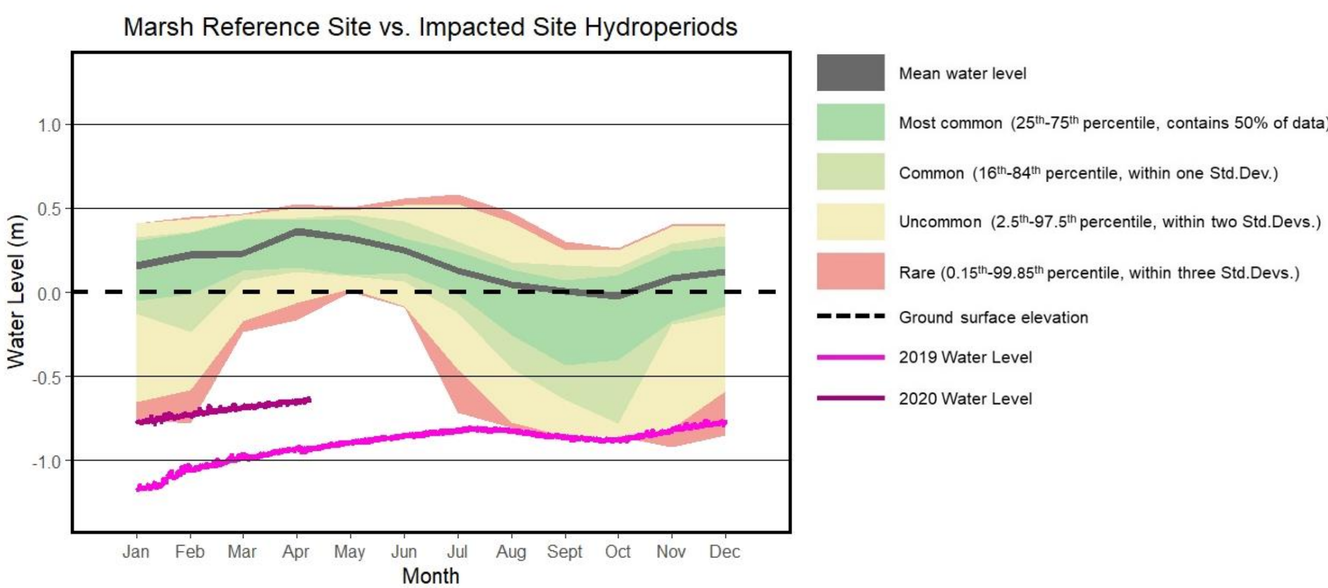

Figure 8: Comparison of measured water levels at Beechridge and typical hydroperiod for marsh communities

The water level observed at Beechridge can be seen to be significantly below that which would be expected in a reference condition marsh, at times falling more than a metre below the typically observed water level. This indicates that a significant hydrological shift has likely occurred at the site, presumed to be attributable to the adjacent urban development and the subsequent removal of contributing drainage area to the wetland.

In terms of ecological conditions, there were several major changes in ELC community type and extent (Figure 9). The most notable change was that the Beechridge wetland has been subjected to an invasion of *Phragmites australis*, an aggressive exotic plant that invades and dominates emergent marsh communities in particular. There was a decrease in the amount of shallow aquatic areas in the middle and southern sections of the wetland between 2004 and 2019 (Table 7, Figure 6). These areas changed to emergent vegetation dominated by common reed (Phragmites australis) and cattails (Typha *spp.*) in the middle section and white willow (Salix alba) and cattails (Typha spp.) in the southern section. In the northern section, areas of white ash deciduous forest and cattails were lost and replaced by areas of open water (Pondweed Mixed Shallow Aquatic – SAM1-4) along with numerous dead and fallen trees visible in the 2018 orthophotos. The only other wetland community identified in the 2004 ELC was a Green Ash Mineral Deciduous Swamp (SWD2-2) just north of the aquatic area in the south. By 2019, this area was reclassified as Willow Mineral Deciduous Swamp (SWD4-1) and Forb Mineral Meadow Marsh (MAM2-10). In 2019, a young Red (Green) Ash Mineral Deciduous Swamp (SWD2-2) was identified in the northwest section of the wetland. This community was not identified at this location in 2004.

Temporal changes in frog communities were qualitatively assessed at the Beechridge development due to a limited amount of data (2004, 2015 and 2019). Frog communities have changed within the subject property from six species found in 2004 to only two species in 2015 and 2019 (Table 4). Several species were detected in 2004 that were not detected in 2015 or 2019 including American toad, spring peeper, wood frog and Northern leopard frog. Several of these species, most notably spring peeper and wood frog, are known to be more sensitive to nearby urban development, and it seems likely that these species have been extirpated from the site.

Conclusion: The water balance at the Beechridge site appears to have changed dramatically from pre- to post-development. It is assumed that this change can be attributed primarily to the development of the Beechridge site, and that the water balance mitigation design measures are not functioning as intended. This assertion is supported by observations that pipes draining towards the wetland, presumed to be the intended conveyance system, never appear to flow. However, the impoundment of water appearing in the 2005 orthophotos suggests the possibility that an impoundment that had previously created an online pond in the tributary flowing through the wetland was removed sometime between 2005 and 2015, draining the wetland. In ecological term, the site has been significantly degraded, with *Phragmites australis* expanding to cover much of the area of the marsh, and the loss of four of the six frog species detected pre-development at the site. It seems likely that the drying of the site has created a situation whereby emergent marsh plants could be outcompeted by aggressive exotic plants, and has reduced the available amphibian breeding habitat at the site. However, development activities to the north and east of the site cannot be disregarded, as the site has become isolated from the larger natural heritage system, excepting connections through the north-south corridor surrounding the watercourse.

Figure 9: Changes in distribution and area of ELC communities over time at Beechridge site; TRCA fauna species records shown in right side insert

Table 4: Temporal changes in frog species detection over the extent of the Beechridge development site

Variable	2004	2015	2019
Species detected on site (both Beechridge Wetland and Pocket Wetland)	GRFR GRTF AMTO SPPE WOFR NLFR	GRFR GRTF	GRFR GRTF

SPPE-spring peeper; WOFR-wood frog; GRTF-grey treefrog; GRFR-green frog; NLFR-Northern leopard frog; AMTO-American toad

5. CONCLUSION AND FUTURE WORK

The Yonge West W1 wetland appears to be in a relatively stable ecological condition, with a relatively modest decline in overall ecological quality, as determined from the distribution of communities at the landscape level as well as measures of floral and faunal diversity and composition. The largest change to the site may be the gradual apparent decline in the diversity of frog species and the proportion of sensitive species using the site, most notably the decline in wood frog population. The site hydrology appeared to remain within historical observed conditions, as supported both from water level monitoring as well as aerial orthophotos. Given the conversion of 29% of the wetland catchment to urban land cover, this suggests that the water balance mitigation measures are functioning as intended.

The Yonge West W5 wetland appears to be in a relatively stable ecological condition, with the site continuing to function as viable habitat for native wetland vegetation and frogs. It is unclear whether the shift within the wetland from shallow aquatic-type ELC communities towards emergent vegetation is the result of a shift in hydrology or natural succession processes, but available water level data does not support any decrease in water levels over time. Recruitment of breeding amphibians has increased over time in both species richness and population, as approximated by calling codes, which is a positive sign, although the trend in the surrounding landscape as a whole cannot be deduced from this fact alone. Given the very large post-development reduction of 59% in the contributing drainage area to the wetland, the lack of detectable ecological degradation within the available data suggests that the water balance mitigation measures are having their intended effect on the site hydrology.

The water balance at the Beechridge site appears to have changed dramatically from pre- to post-development. It is assumed that this change can be attributed primarily to the development of the Beechridge site, and that the water balance mitigation design measures are not functioning as intended. This assertion is supported by observations that pipes draining towards the wetland, presumed to be the intended conveyance system, never appear to flow. However, the impoundment of water appearing in the 2005 orthophotos suggests the possibility that an impoundment that had previously created an online pond in the tributary flowing through the wetland was removed sometime between 2005 and 2015, draining the wetland. In ecological term, the site has been significantly degraded, with *Phragmites australis* expanding to cover much of the area of the marsh, and the loss of four of the six frog species detected pre-development at the site. It seems likely that the drying of the site has created a situation whereby emergent marsh plants could be outcompeted by aggressive exotic plants, and has reduced the available amphibian breeding habitat at the site. However, development activities to the north and east of the site cannot be disregarded, as the site has become isolated from the larger natural heritage system, excepting connections through the north-south corridor surrounding the watercourse.

The three development sites evaluated here provide evidence that FBWB mitigation can work to preserve the ecological and hydrological integrity of wetlands. At two of the three sites (Yonge West, wetlands W1 and W5) a relatively stable ecological and hydrological condition appears to have been achieved. At the third site (Beechridge), there appear to have been dramatic shifts in the site water balance accompanied by severe ecological degradation of the wetland flora and fauna. Given the relatively high ecological sensitivity of the Yonge West lands, the extended period of review of development proposals, and the fact that much of the land surrounding the two wetlands has been converted to parks or restored lands, these cases should perhaps be regarded as best case scenarios. Nonetheless, the example of the Yonge West W5 wetland demonstrated that it is possible to maintain ecological and hydrological functions, broadly speaking and within the particular landscape context of this site, while developing up to 59% of the contributing drainage area.

The temporal and spatial resolution of the data used to characterize change over time at the three sites varies widely, as do the data collection methods. This study is intended to provide a basis for future work evaluating the success of FBWB mitigation measures determined through the development review process. Few conclusions can be drawn on the basis of three study sites, and so it is important that the success of these mitigation measures is evaluated at a greater number of sites in the future.

REFERENCES

Bird Studies Canada. 2009. Marsh Monitoring Program Participant's Handbook for Surveying Amphibians. Published by Bird Studies Canada in cooperation with Environment Canada and the U.S. Environmental Protection Agency.

Natural Heritage Information Centre (NHIC). 2020. https://www.ontario.ca/page/get-natural-heritage-information

Toronto and Region Conservation Authority (TRCA). 2016. Wetland Vegetation Monitoring Protocol - Terrestrial Long-term Fixed Plot Monitoring Program – Regional Watershed Monitoring and Reporting. https://trca.ca/conservation/environmental-monitoring/environmental-monitoring-resource-library/#protocols

Toronto and Region Conservation Authority (TRCA). 2019. Data Collection Method for TRCA Terrestrial Biological Inventories. Environmental Monitoring and Data Management.

www.trca.ca