  

Toronto and Region Conservation Authority

Wetland Hydroperiod Guidance Document
(Complete final draft for consultation)

April 2020

Executive Summary

The "hydroperiod" of a wetland refers to the seasonal pattern of water level fluctuation, both above and below the soil surface. The hydroperiod is a significant factor determining wetland ecological community type and habitat function. The water depth and degree of soil saturation in a wetland act as ecological filters, allowing some species to thrive while preventing others from colonizing an area. Other factors can also determine wetland community composition, but hydroperiod is generally understood to be the most important single factor influencing community composition and structure at a broad level (Leck & Brock 2000; Mitsch & Gosselink 2007; Barton *et al.* 2008; Raulings *et al.* 2010; Johnson *et al.* 2014; Chandler *et al.* 2017; Moore *et al.* 2017).

This document summarizes the current state of knowledge about the hydroperiods of healthy wetland communities found in the Toronto and Region Conservation Authority (TRCA) jurisdiction, and in south-central Ontario more generally. (Note that riparian and coastal wetland types are not represented.) In defining a range of "normal" conditions for specific wetland communities, the intended uses of this information are:

1. To provide an indication of when a wetland could be impacted by a change in water level resulting from human activities. This could include adjacent land development or land use change (e.g. urbanization), water taking, or discharge of effluent into a wetland.

2. To provide a range of target conditions for use in wetland restoration projects. This information could be used either to target a specific community type for restoration, or to predict the ecological evolution of a restored site based on water level monitoring.

3. To provide an indication of when a wetland could be impacted by a change in water level resulting from extreme weather events (e.g. drought, heat waves, or extreme seasonal precipitation) and/or climate change over the long term.

There are a number of assumptions and limitations to the information presented in this document which readers should review before applying this information.

Toronto and Region Conservation Authority. 2020. Wetland Hydroperiod Guidance Document.

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BACKGROUND

Hydrology is arguably the most important factor determining wetland community structure, function, and composition (Leck & Brock 2000; Mitsch & Gosselink 2007; Barton *et al.* 2008; Raulings *et al.* 2010; Johnson et al. 2014; Chandler *et al.* 2017; Moore *et al.* 2017). Wetlands exist where land is seasonally flooded or where the water table is shallow, and are dominated by hydrophytic (water-loving) vegetation. Wetland plants have evolved special adaptations to survive in these particular conditions, and many species (referred to as "obligate" species) can live nowhere else. Many wildlife species, most notably amphibians but also some fish, also need wetlands to complete parts of their lifecycle.

Variations in wetland hydroperiod, or the seasonal pattern of water level fluctuation above and below the soil surface, create habitat niches. Water depth and degree of soil saturation act as important ecological filters, preventing facultative (non-obligate) wetland and upland species from colonizing an area by imposing physical and biogeochemical constraints. The root zone anoxia (oxygen depletion) that develops under flooded stagnant conditions not only directly inhibits diffusion of oxygen into soils, and thus normal plant respiration, but also increases concentrations of certain elements and compounds to levels that are toxic to some plants. As a result, the plants that are able to successfully exploit wetland environments have evolved a range of biological adaptations that allow them to survive in these harsh conditions.

The link between hydroperiod and wetland type has been intuitively understood for some time. Wetland communities frequently occur in a predictable sequence along a gradient of saturation. For example, swamps tend to occur at the drier end of the gradient, adjacent to upland forest communities, while marshes, dominated by emergent vegetation such as cattails, have standing water for a longer period of the year. Shallow aquatic wetlands occur in areas where shallow water is present year round and rarely, if ever, dry out. However, few studies have attempted to quantitatively describe the hydroperiods of different wetland communities. (One exception is northern peatlands which have been well studied, but which also tend to have very low species diversity.)

It is important to note that the wetlands described in this document are all associated with stagnant standing water rather than with rivers (riparian wetlands), where factors like sediment erosion, deposition, and higher nutrient inputs tend to play a larger role in shaping wetland community structure.

PURPOSE

The purpose of this document is to summarize the current state of knowledge about the hydroperiods of healthy wetland communities found in the TRCA jurisdiction, and in south-central Ontario more generally, based on monitoring data collected from 19 wetlands. (Note that riparian and coastal wetland types are not represented.) In defining a range of "normal" conditions for specific wetland communities, the intended uses of this information are:

1. To provide an indication of when a wetland could be impacted by a change in water level resulting from human activities. This could include adjacent land development or land use change (e.g. urbanization), water taking, or discharge of effluent into a wetland.

2. To provide a range of target conditions for use in wetland restoration projects. This information could be used either to target a specific community type for restoration, or to predict the ecological evolution of a restored site based on water level monitoring.

3. To provide an indication of when a wetland could be impacted by a change in water level resulting from extreme weather events (e.g. drought, heat waves, or extreme seasonal precipitation) and/or climate change over the long term.

This information is intended primarily to benefit planning ecologists who assess the likely impacts of land development and related activities (dewatering, effluent discharge, etc.) on adjacent wetlands. It may also benefit restoration ecologists and other users.

OVERVIEW OF DATA

The data used to produce the graphs and figures in this report was collected from 19 wetlands located across the watersheds of TRCA, Credit Valley Conservation (CVC), and Conservation Halton (CH). The locations of the monitoring sites are shown in Figure 1, while other characteristics of the monitoring sites are shown in Figure 2 along with the period of data coverage at each site. Water level data at each site was collected with a pressure transducer (water level logger) and a shallow well or piezometer.

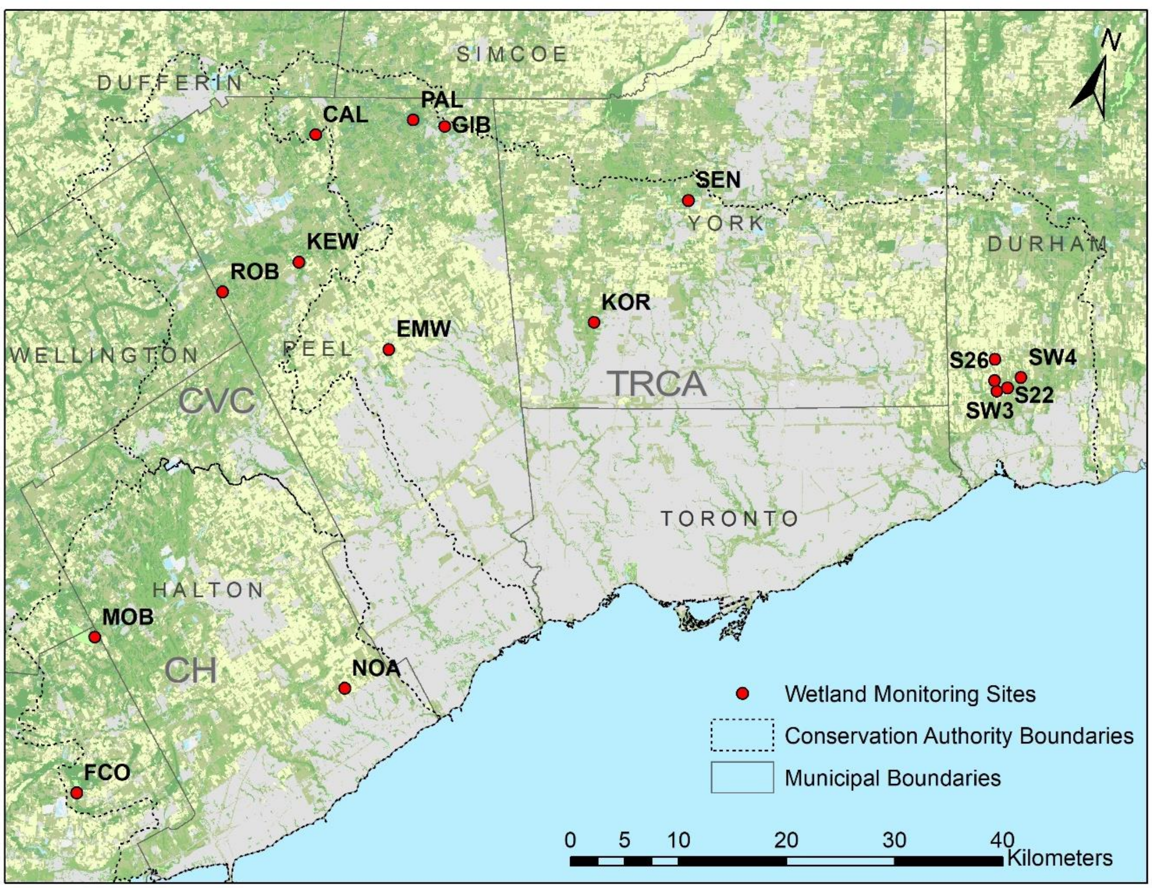


Figure 1: Wetland monitoring site locations

Site Code	Site Type	ELC Code	# Years Data	2013	2014	2015	2016	2017	2018	2019
CAL	MA	MAS2-1A	1							■
EMW	SW	SWD3-3	3		■			■	■	
FCO	MA	MAS2-2	6	■	■	■	■	■	■	
GIB	SA	SAM1-A	1							■
PAL	MA	MAS3-1A	1							■
KOR	MA	MAS2-1	5		■	■	■	■	■	
KEW-A	TH	SWTM3	6	■	■	■	■	■	■	
KEW-B	SW	SWD3-3	6	■	■	■	■	■	■	
MOB	SW	SWM1-1	6	■	■	■	■	■	■	
NOA	MA	MAS2-8	3	■	■	■				
ROB	SW	SWD6-1	6	■	■	■	■	■	■	
S22-A	SW	SWD3-2	5			■	■	■	■	■
S22-B	TH	SWT2-4	6		■	■	■	■	■	■
S26-A	SW	SWD3-2	3					■	■	■
S26-B	TH	SWT2-4	3		■			■		■
SEN	SA	SAM1-A	1							■
SW1	SW	SWD6-2	2					■	■	
SW3	MA	MAS2-8	3					■	■	■
SW4	SW	SWD2-A	3					■	■	■

Figure 2: Gantt chart showing number of complete years of data available at each site along with site type (MA=marsh; SW=swamp; TH=thicket swamp; SA=shallow aquatic) and Ecological Land Classification (ELC) code (after Lee et al., 1998).

The monitoring sites also share the following attributes:

- The wetlands are in a reference condition, meaning that the surrounding catchment land use and corresponding hydrology are believed to have been stable for a decade or longer. The ecology of the wetland could therefore be expected to be in equilibrium with the site's hydrology. Note that none of these wetlands are true reference sites, in that their surficial catchments have all been impacted to varying extents by human activities (e.g. agriculture, roads, forest management) but that they are nonetheless among the best examples of their respective community types in the greater Toronto area.

- The sites are headwater wetlands generally associated with stagnant or very slowly moving water and not with watercourses exceeding a first order stream (as per the Strahler system; Strahler 1957).

- Wetlands are sorted into four type categories (marsh, swamp, thicket swamp, and shallow aquatic) based on the number of sites available in order to differentiate sample populations at the coarsest level of community structure. Without a larger number of sites, it is not possible to group sites at a finer level of ecological detail. Neither bogs nor fens are included as both are rare in the TRCA jurisdiction, comprising <1% of all wetlands by area.

- Where three letter site codes are appended with "-A" or "-B", multiple distinct wetland communities have been monitored at a single large site (i.e. at a single point on the map in Figure 1).

- For a calendar year of monitoring data to be included in these analyses, it had to have fewer than 30 consecutive days of missing data and fewer than 60 days of missing data in total. The site also had to remain in a reference condition for that year (i.e. be unimpacted by any land use change or development within the catchment).

Assumptions and limitations

The following assumptions and limitations are associated with the approach outlined here:

- Each wetland can be represented as a flat, homogeneous ecological unit with a single ground surface elevation (as per Figure 3). This assumption was determined to be appropriate for this analysis but may not be appropriate for some very large wetlands or wetlands occurring on sloped surfaces. Monitoring equipment is generally located as close as possible to the center of the ecological unit.
- Notwithstanding the assumption above, accurately determining the ground surface elevation in a wetland is not a trivial problem due to variable water levels, hummocks and depressions, and the presence of soft organic and muck soils. Ground surface elevation may be challenging to determine with the level of accuracy required here and should be regarded as a source of uncertainty.
- The general assumption in this analysis is that wetland hydroperiod is the dominant variable controlling community type and structure. This does not discount that other factors also interact to shape community structure and may even be dominant determinants of wetland community at some sites. Among these other factors are physical composition of the soil profile (partly reflected in the hydrology), water and soil chemistry, nutrient loading rate, initial ecological trajectory, and interactions between these factors.
- The further the water level in a wetland falls below ground surface, the greater the difficulty of accurate comparisons between sites becomes. This is due to the interaction between soil properties, such as porosity and specific yield, and water level as measured in a well. Sites should be broadly comparable when the water level is in the shallow subsurface (less than about 50 cm below surface).

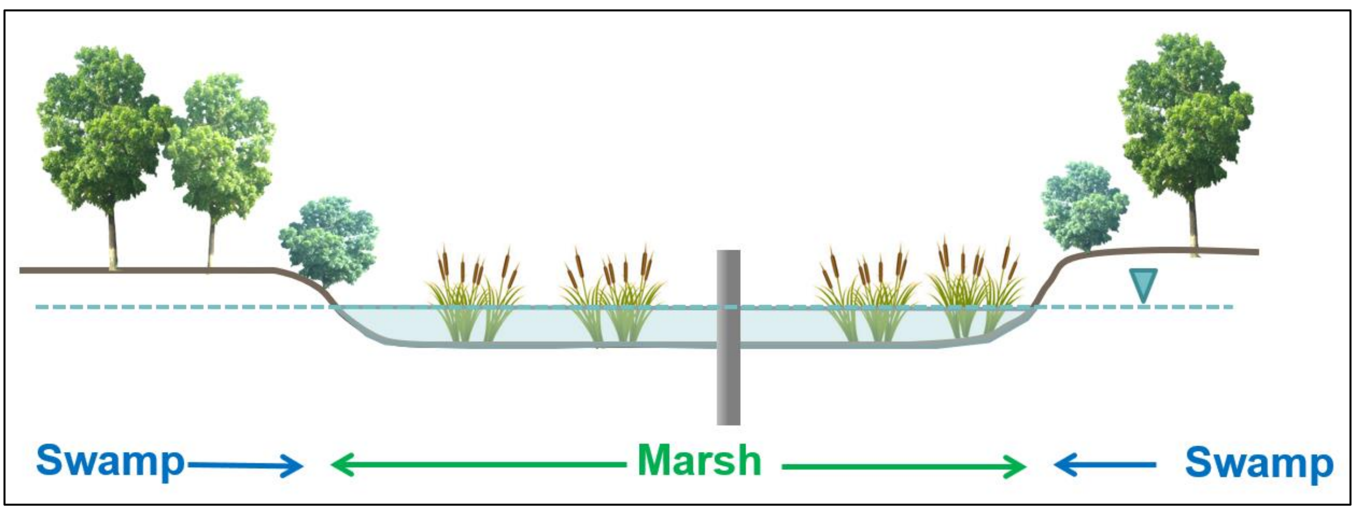


Figure 3: Representation of a wetland as a flat, homogeneous ecological unit with a single ground surface elevation. Multiple wetland community types are shown in this figure, with monitoring equipment at center.

- All the normal uncertainties and limits of precision with respect to data loggers and pressure transducers apply, including uncertainty introduced by barometric compensation of water level data.
- Given the complexity of the dataset, with the specific years and number of years of data available varying from site to site, it was not possible to systematically control for "year" as a factor (in a statistical sense) without excluding a large proportion of the dataset. Therefore, the data for each site type has been lumped together to produce the graphs and statistics reported, under the assumption that the data taken together capture a representative range of conditions across time and space.

WETLAND HYDROPERIOD SUMMARIES

How to read the summaries

The following pages include summaries of the characteristics and hydroperiod data for four different types of wetland. The four types of wetland here cover most types of wetlands encountered in south-central Ontario, excluding bogs, fens, and wetlands associated with larger streams or waterbodies. Although monitoring sites were all instrumented to be comparable with one another, these sites were set up over a period of several years by different agencies and for multiple different purposes, and so the number of sites in each category is not the same. For the shallow aquatic wetland type, the two sites were established in 2018 and so there are only two sites with one full year (2019) of data represented.

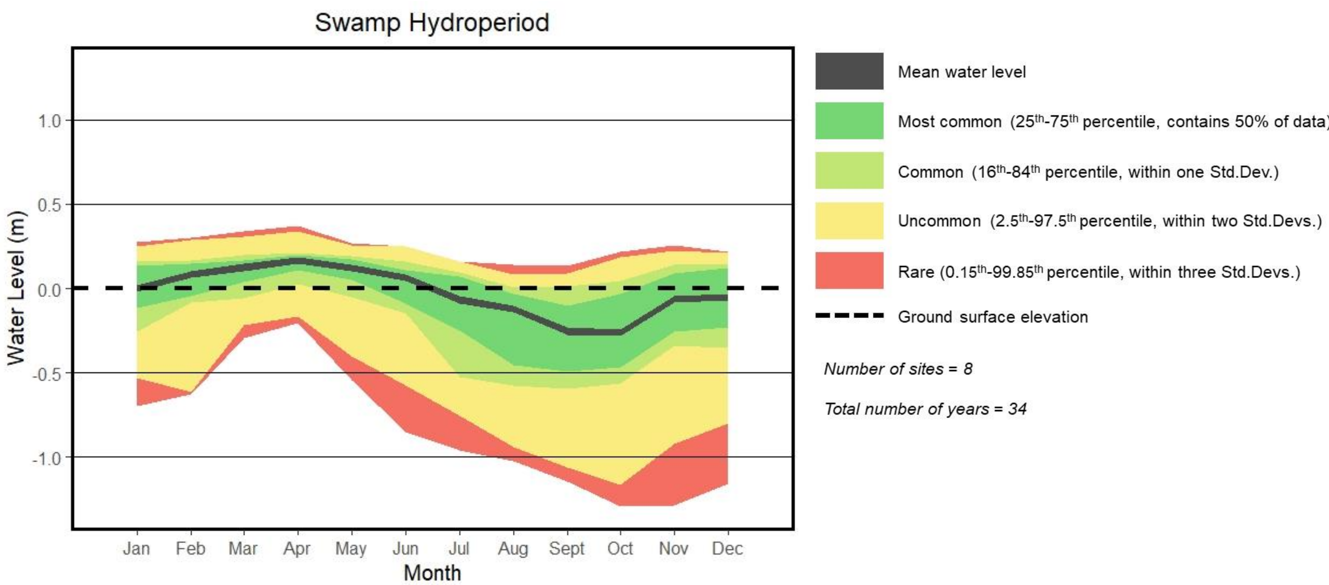
Each page shows the range of water level conditions encountered in a given type of wetland, as summarized using the following:

- A wetland hydroperiod "ribbon diagram", showing the range of monthly-average water levels encountered, relative to measured average ground surface. Coloured bands correspond to the proportion of data 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 number of sites and the total number of monitored years of data are shown in the legend.
- A table outlining conditions in terms of maximum and minimum water levels, the date that free-standing water typically disappears, the total annual period of inundation, and the annual duration of water levels exceeding 0.3 m depth.
    - The table metrics were determined using the Wetland Hydroperiod Analysis Tool (WHAT, v.1.2; TRCA, 2018). Further documentation on methods for determining these metrics is available in this document. Note that the first three metrics are calculated using a 10-day running average to capture general water level trends while reducing sensitivity to potential errors in monitoring data (hourly to daily) resulting from barometric compensation, ice effects, and other sources.

Swamps

Image: A silver maple swamp in early spring with characteristic flooding.

Swamps, one of the four wetland classes defined in the Ontario Wetland Evaluation System (OWES), are described as wooded wetlands with 25% cover or more of trees (OMNR, 2014). Vegetation cover may consist of coniferous and/or deciduous trees, tall shrubs, herbs, and mosses (OMNR, 2014). Swamps are characteristically flooded during spring, may remain waterlogged for large portions of the year, and do not commonly have deep peat accumulation (OMNR, 2014).



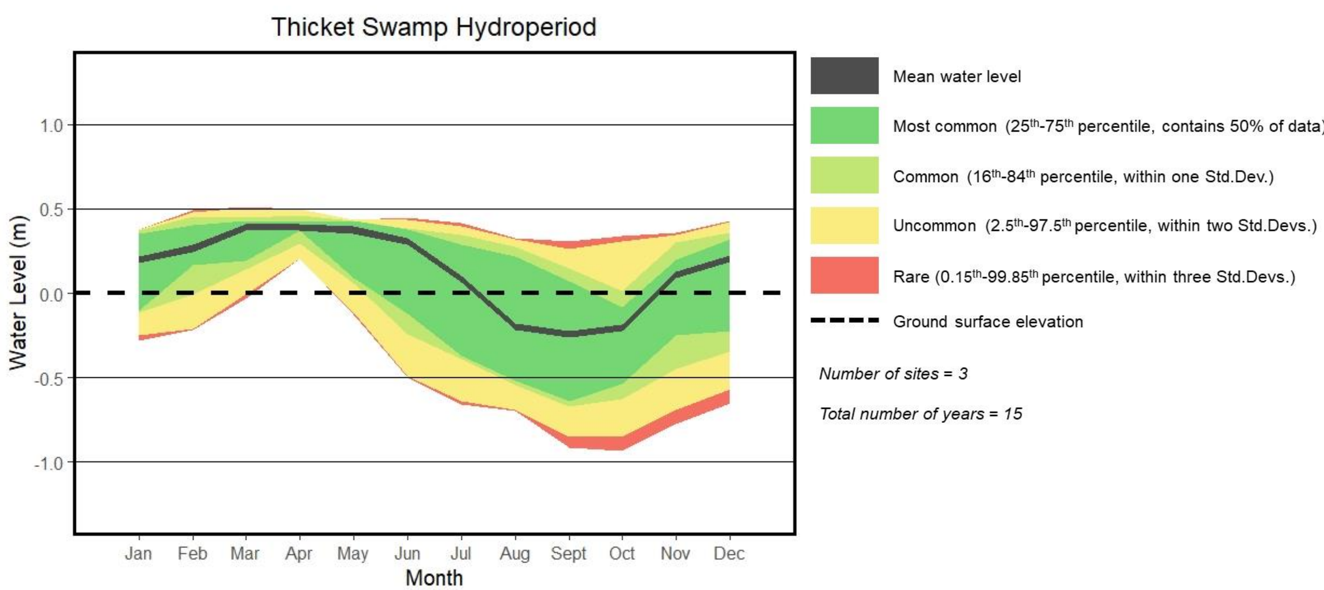
Parameter	Average Value	25th–75th percentile
Max. Water Level (10-day avg.)	0.22 m	0.14 to 0.26 m
Min. Water Level (10-day avg.)	-0.48 m	-0.67 to -0.32 m
Dry-out Date	Jan 1*	Jan 1 to Jul 13
Total Duration of Inundation (Days)	218	147 to 286
Days of Inundation > 0.3 m	0	0 to 2

*indicates that inundation is typically only in spring and that most sites are dry at start of calendar year

Thicket swamps

Thicket swamps are a sub-type of swamp described as wooded wetlands with 25% cover or more of shrubs (Lee *et al.*, 1998; OMNR, 2014). They are distinguished from treed swamps by the predominance of shrub cover. Thicket swamps are characterized by thick growths of tall shrubs such as willow species, red-osier dogwood, buttonbush and speckled alder (OMNR, 2014). They are recognized as a separate wetland sub-type in the Southern Ontario ELC system as well as in the OWES.

Image: A buttonbush thicket swamp in early summer.



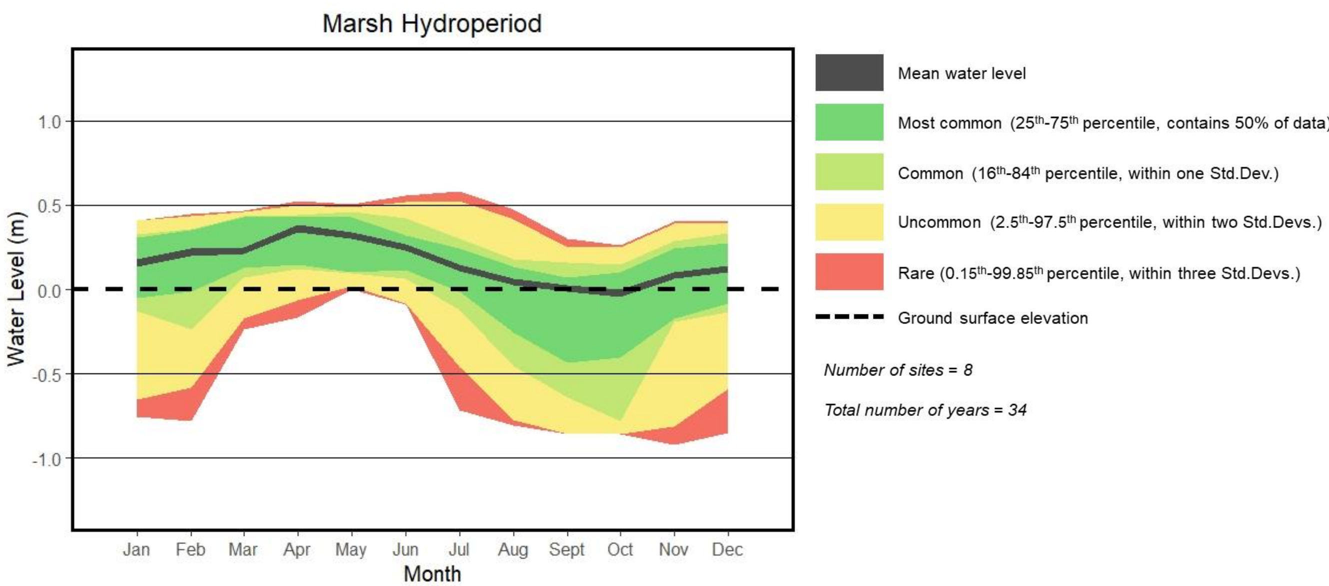
Parameter	Average Value	25th–75th percentile
Max. Water Level (10-day avg.)	0.45 m	0.39 to 0.51 m
Min. Water Level (10-day avg.)	-0.42 m	-0.67 to -0.22 m
Dry-out Date	Apr 4*	Jan 1 to Aug 11
Total Duration of Inundation (Days)	281	146 to 318
# Days WL > 0.3 m	182	43 to 192

*includes years with initial dry conditions as well as years with no dry-out

Marshes

Image: A large cattail marsh in late fall.

Marshes are wetlands where the predominant vegetation consists of emergent non-woody plants such as rushes, cattails, bulrushes, sedges, grasses and herbs (OMNR, 2014). Low shrubs such as sweet gale, red-osier dogwood, waterwillow, and winterberry may also occur, while tree and shrub cover remains ≤25% (Lee *et al.* 1998; OMNR, 2014). Whereas in the OWES system, wetlands dominated by submergent and floating vegetation are considered “open marshes”, a sub-type of marsh, for the purposes of this document we make a distinction between the two (as per the Southern Ontario ELC system and Canadian Wetlands Classification System).



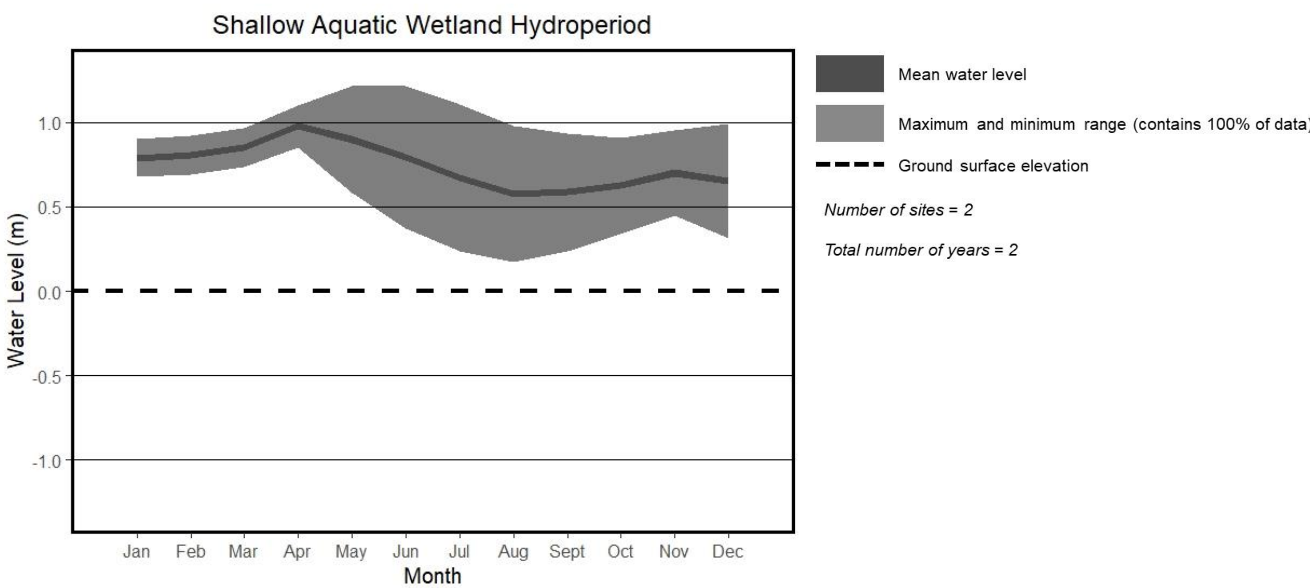
Parameter	Average Value	25th–75th percentile
Max. Water Level (10-day avg.)	0.47 m	0.34 to 0.54 m
Min. Water Level (10-day avg.)	-0.17 m	-0.78 to -0.04 m
Dry-out Date	Jul 12*	Jan 1 to Dec 27
Total Duration of Inundation (Days)	295	226 to 361
# Days WL > 0.3 m	98	28 to 153

*includes years with initial dry conditions as well as years with no dry-out

Shallow Aquatic Wetlands

Image: a water lily – bullhead lily mixed shallow aquatic wetland bordering a permanent lake.

Shallow aquatic wetlands are a type of wetland occupying the ecotone between wetlands deep open-water aquatic systems. They are recognized as a distinct wetland type in the Southern Ontario ELC system and Canadian Wetland Classification System (NWWG, 1997), characterized by water < 2m deep present for all or most of the year with <25% of the surface occupied by standing emergent or woody plants. In OWES these wetlands are referred to as open-water marshes. Vegetation is dominated by submergent vegetation or floating aquatic plants. Shallow aquatic wetlands also play an important role in the lifecycle of several fish species.



Parameter	Average Value	Min-Max
Max. Water Level (10-day avg.)	1.07 m	0.92 to 1.23 m
Min. Water Level (10-day avg.)	0.53 m	0.17 to 0.90 m
Dry-out Date	N/A	Dry-out not observed
Total Duration of Inundation (Days)	365	365
# Days WL > 0.3 m	289	237 to 341

Wetlands as Amphibian Habitat

Image: A northern leopard frog in a marsh.

In addition to providing habitat for unique plant species assemblages, wetlands play a critical role in the completion of lifecycles for many amphibians. Frogs and salamanders may use wetlands seasonally to breed and lay eggs or may require wetlands and ponds to overwinter. For some species, the fact that wetlands dry out seasonally is an important habitat feature that prevents predation by fish. Known wetland and aquatic habitat lifecycle requirements for salamander and frog species are outlined in **Appendix A** as Gantt charts. For species requiring wetland or aquatic habitat, there should be at least some standing water for the entire duration outlined in the Gantt chart for the wetland to function as effective habitat. Some wetlands may function as more effective habitat if they do not contain standing water for the periods not overlapping with lifecycle requirements.

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APPENDIX A: AMPHIBIAN SPECIES LIFECYCLE TIMING CHARTS

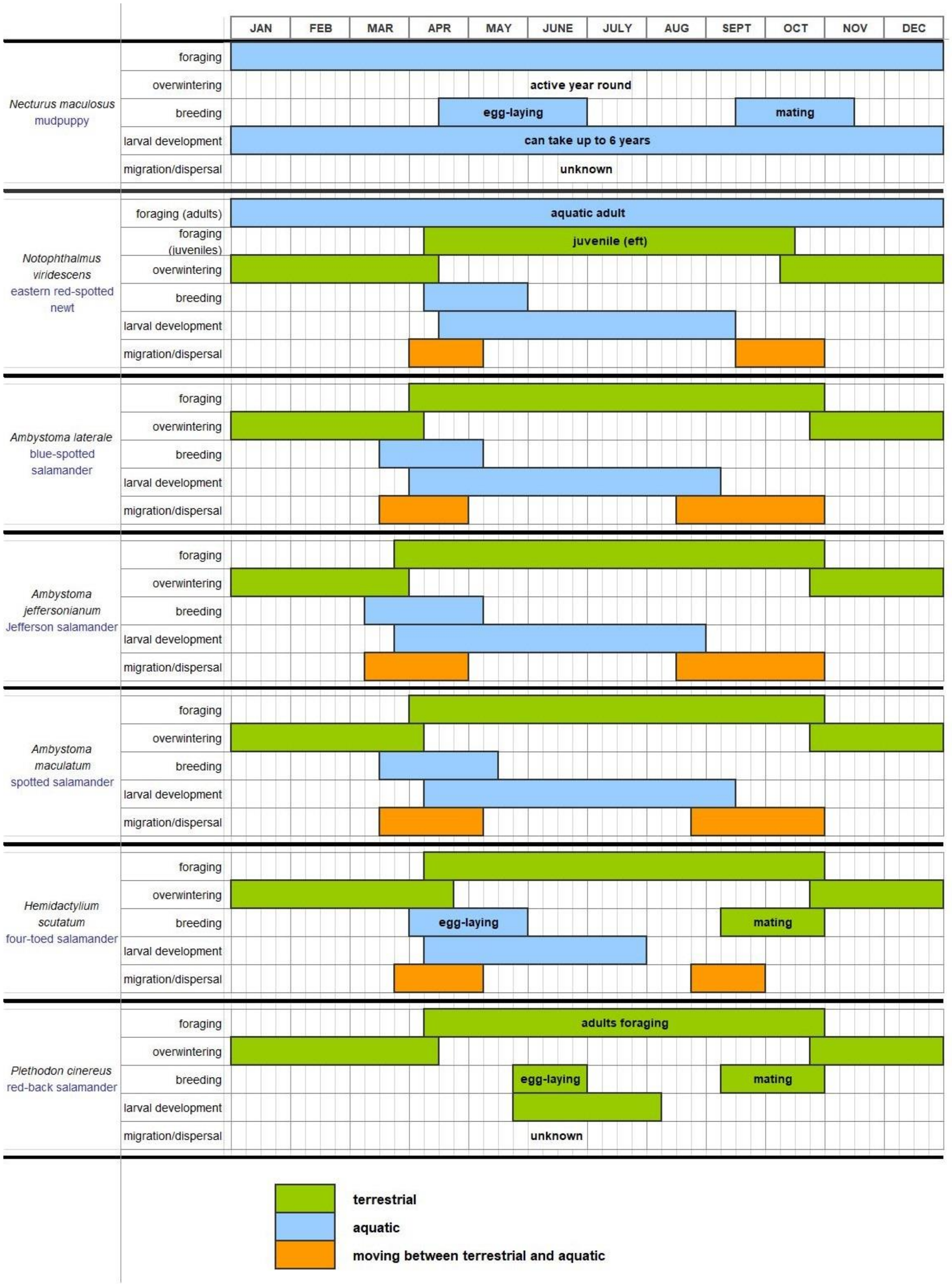

Figure 4: Lifecycle requirement timing chart for salamanders in the TRCA jurisdiction.

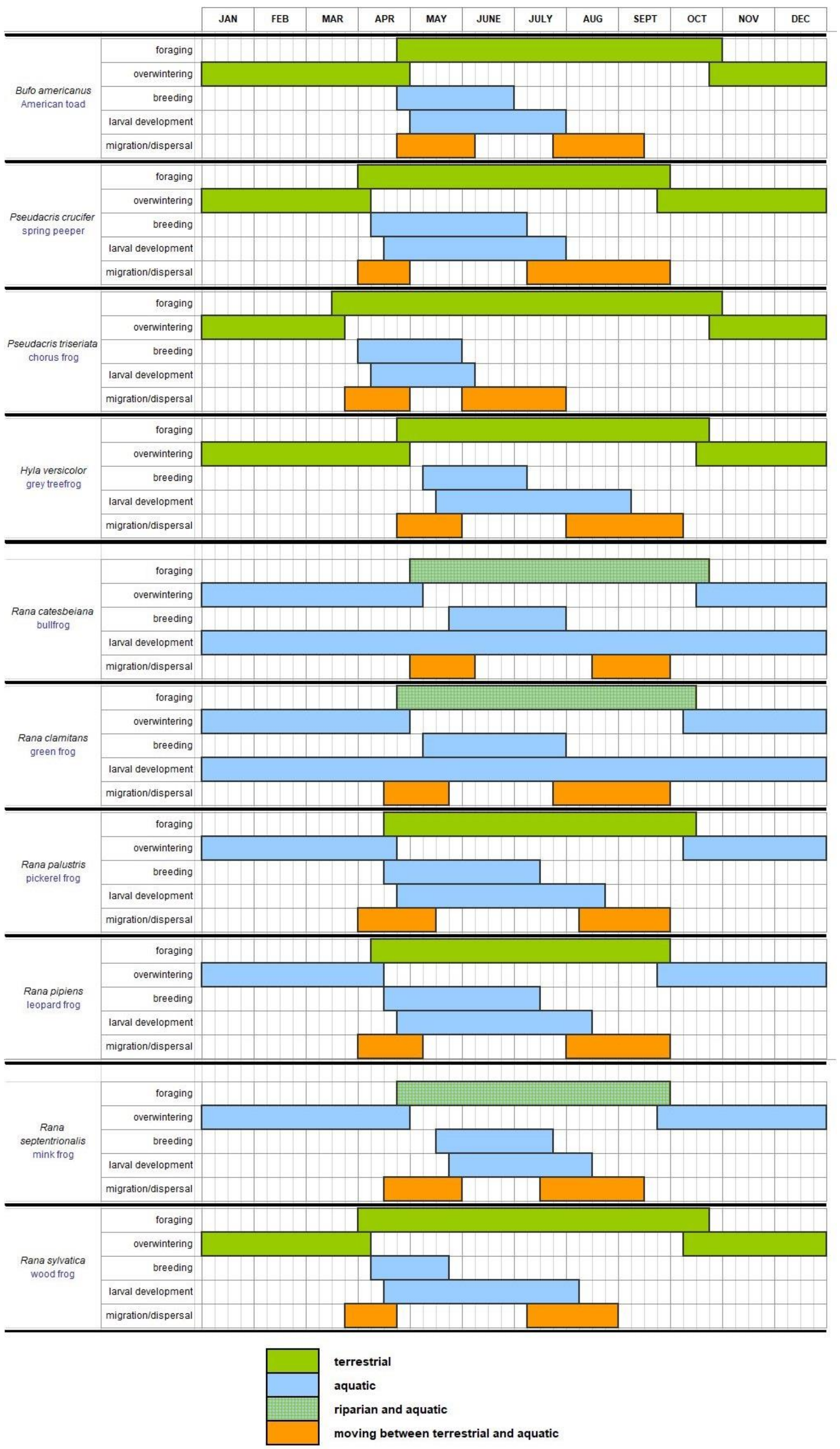

Figure 5: Lifecycle requirement timing chart for frogs in the TRCA jurisdiction.