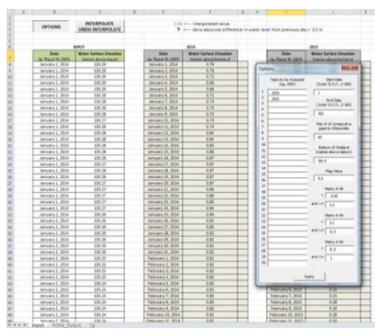
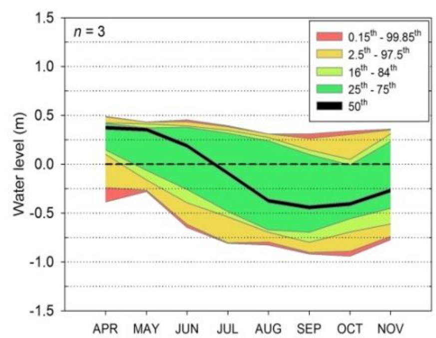
Wetland Hydroperiod Analysis Tool

(WHAT)

v.1.2, March 2018





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Please reference this software as:

Wetland Hydroperiod Analysis Tool, v.1.2, Toronto and Region Conservation Authority, 2018

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Overview:

The Wetland Hydroperiod Analysis Tool (WHAT) was designed to analyze wetland hydrology time series data to concisely describe the annual statistical distribution of water level depths. The statistical distribution of water levels in a wetland is referred to as the hydroperiod, and is an important determinant of a wetland's ecological structure and function. WHAT is based on The Nature Conservancy's Indicators of Hydrologic Alteration (IHA) software (TNC, 2009) but is designed to facilitate analysis of wetland data rather than streamflow data and uses a somewhat different set of metrics. The metrics produced by WHAT can be used to determine the hydroperiod of a wetland in a natural reference condition, to compare the hydroperiods of different wetlands, or to compare the pre-development hydroperiod to the modeled or monitored post-development hydroperiod for the purposes of a feature-based water balance analysis.

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1. Introduction

a. Wetland hydroperiod and ecological function

The hydroperiod of a wetland represents the cumulative sum of all of the various inflow and outflow processes contributing to its water balance (i.e. exchanges of surface water, groundwater, and atmospheric water), and is equivalent to the storage component under flooded conditions. The depth of water above and below the surface of a wetland acts as a selective ecological filter, preventing facultative wetland and upland species from colonizing an area by imposing physical and biogeochemical constraints, and controlling plant phenological development (Mitsch & Gosselink, 2007; Raulings *et al.*, 2010; Booth & Loheide, 2012). The root zone anoxia that develops under flooded stagnant conditions not only directly inhibits diffusion of oxygen and thus plant respiration via normal metabolic pathways, but also increases concentrations of certain reduced elements and compounds to levels that are toxic to some plants (Mitsch & Gosselink, 2007). 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 challenging conditions. Many researchers have hypothesized that hydroperiod is one of the most significant variables controlling wetland ecological structure and function across many different biogeoclimatic zones (Leck & Brock, 2000; Baldwin *et al.*, 2001; Johnson *et al.*, 2012; Johnson *et al.*, 2014; Moor *et al.*, 2017).

b. Assumptions of this approach

The use of hydroperiod as a dominant control variable on wetland ecological structure and function assumes that water depth, through its role in oxygen diffusion and soil redox chemistry, is the primary hydrological variable controlling vegetation community structure. In making this assumption, it is important to consider the wetland's position within the broader watershed. Simple water depth is more likely to be a controlling ecological variable where the wetland is mostly disconnected from larger drainage areas, because water flow velocity can confound the relation with water depth through its influence on sediment transport and the ability of plants to root. Similarly, the hydroperiod alone cannot account for differences in water quality. Wetlands with larger catchment areas are more likely to receive water with higher concentrations of dissolved minerals and nutrients. For hydroperiod comparisons between different wetlands, or between the same wetland at different times, it is important to ensure that the hydrological regimes, including water quality and catchment parameters, are broadly comparable. This analysis is best suited to headwater wetlands that are more isolated or are only seasonally connected to larger surface water drainage networks.

Another critical assumption of this approach is that the ground surface of the wetland can be represented by a single reference elevation value. In many cases, this approach will be valid, as wetlands often occur in flat areas such as current or former floodplains or on glaciolacustrine sediment deposits. For other cases, where there is a slight elevation gradient, it may be appropriate to define more than one reference elevation to describe separate pools or different vegetation communities present, taking the reference elevation as the average ground surface elevation within each distinct unit. In cases where the wetland basin deviates significantly from a horizontal surface, this assumption may not be valid. It is also important to note that, especially in wetlands with organic soils, defining a definite ground surface elevation with high precision can be difficult owing to micro-topography and soft muck or peat substrates. WHAT can be used to determine statistical distribution of water levels in the absence of a user-defined reference elevation surface (i.e. using the default reference elevation value of '0'); however, metrics #45-48 will not produce meaningful results in these cases, as they require negative (below ground surface) values to be encountered.

2. Hydroperiod Metrics

Table 1 below outlines the metrics that WHAT is capable of generating from user input data. Metrics are generated for each calendar year of input data; users can also select a subset of a calendar year (e.g. growing season) to use as the basis for annual statistics (see Section 3).

Table 1 – List of WHAT metrics and units

Metric #	Description	Units
1	monthly average water level (Jan)	(metres, relative to surface)
2	monthly average water level (Feb)	(metres, relative to surface)
3	monthly average water level (Mar)	(metres, relative to surface)
4	monthly average water level (Apr)	(metres, relative to surface)
5	monthly average water level (May)	(metres, relative to surface)
6	monthly average water level (Jun)	(metres, relative to surface)
7	monthly average water level (Jul)	(metres, relative to surface)
8	monthly average water level (Aug)	(metres, relative to surface)
9	monthly average water level (Sep)	(metres, relative to surface)
10	monthly average water level (Oct)	(metres, relative to surface)
11	monthly average water level (Nov)	(metres, relative to surface)
12	monthly average water level (Dec)	(metres, relative to surface)
13	monthly water levels Stdev.S (Jan)	(metres)
14	monthly water levels Stdev.S (Feb)	(metres)
15	monthly water levels Stdev.S (Mar)	(metres)
16	monthly water levels Stdev.S (Apr)	(metres)
17	monthly water levels Stdev.S (May)	(metres)
18	monthly water levels Stdev.S (Jun)	(metres)
19	monthly water levels Stdev.S (Jul)	(metres)
20	monthly water levels Stdev.S (Aug)	(metres)
21	monthly water levels Stdev.S (Sep)	(metres)
22	monthly water levels Stdev.S (Oct)	(metres)
23	monthly water levels Stdev.S (Nov)	(metres)
24	monthly water levels Stdev.S (Dec)	(metres)
25	maximum daily average water level	(metres, relative to surface)
26	maximum 10 day average water level	(metres, relative to surface)

Metric #	Description	Units
27	maximum 30 day average water level	(metres, relative to surface)
28	maximum 90 day water level	(metres, relative to surface)
29	minimum daily average water level	(metres, relative to surface)
30	minimum 10 day average water level	(metres, relative to surface)
31	minimum 30 day average water level	(metres, relative to surface)
32	minimum 90 day water level	(metres, relative to surface)
33	date of maximum daily average water level	(Julian day-of-year)
34	date of maximum 10 day average water level (centre of averaging window)	(Julian day-of-year)
35	date of maximum 30 day average water level (centre of averaging window)	(Julian day-of-year)
36	date of maximum 90 day water level (centre of averaging window)	(Julian day-of-year)
37	date of minimum daily average water level	(Julian day-of-year)
38	date of minimum 10 day average water level (centre of averaging window)	(Julian day-of-year)
39	date of minimum 30 day average water level (centre of averaging window)	(Julian day-of-year)
40	date of minimum 90 day water level (centre of averaging window)	(Julian day-of-year)
41	annual range (difference of 10-day annual max and 10-day annual min)	(metres)
42	monthly variance (average of the 12 monthly standard deviations in daily water level)	(metres)
43	rise rate (average of all positive differences between consecutive daily values)	(metres/day)
44	fall rate (average of all negative differences between consecutive daily values)	(metres/day)
45	dry-out date (first date where 10-day average water level is < -0.05 m relative to bottom of wetland)	(Julian day-of-year)
46	duration of spring flooding (# of days from user-inputted start of season until dry-out date)	(days)
47	total duration of inundation (# of days where water level is > -0.05m relative to bottom of wetland)	(days)
48	User Custom Range 1 (# of days of water level > -0.05m, and <= 0.2m) (relative to bottom of wetland)	(days)
49	User Custom Range 2 (# of days of water level > 0.2m, and <= 0.5m) (relative to bottom of wetland)	(days)
50	User Custom Range 3 (# of days of water level > 0.5m, and <= 1m) (relative to bottom of wetland)	(days)

- Metrics #1-24 are the monthly average water levels relative to the user defined ground surface elevation and the sample standard deviation of water level values for each month.
- Metrics #25-32 return the maximum and minimum water levels encountered (one-day water levels) as well as the maximum and minimum values obtained using an averaging window of 10, 30, and 90 days.

- Metrics #33-40 return the Julian day-of-year (1 to 365) associated with Metrics #25-32. Note that Metric #35 (date of maximum 30 day average water level), for example, has a minimum possible value of 15, since this is the first Julian day-of-year for which a value can be obtained.
- Metrics #41-44 are self-explanatory annual summary statistics describing the total water level range, average monthly variance, and average rates of water level increase and decrease.
- Metrics #45-46 describe the first date when the 10-day moving average water level drops below -0.05 m (that is, >5 cm below the ground surface), and the number of days from the user-defined first day-of-year to the dry-out date, respectively. A value of -0.05 m was selected over a value of 0 m to recognize that the surface of the wetland will still be completely saturated when the water table is only 0.05 m beneath the surface, and that the existence of microtopography in a wetland means that some areas will still likely have ponded water in these cases, despite the water level being below the average ground surface elevation. The use of a 10-day running average attempts to reduce some of the "noise" in the hydroperiod signal to make metrics #45-46 more robust and representative of a distinct period of dry-out. Note that if the first water level value encountered is below -0.05 m, metric #45 will return a value of 0 and metric #46 will be equal to the first user-defined day-of-year. If no water level is encountered over the entire year that is below -0.05 m, metric #45 will return a value of 'n/a' and metric #46 will be equal to the total number of days in the user-defined analysis year.
- Metric #47 returns the total number of days where the water level is above -0.05 m. It is identical to metric #46 except that it considers the duration of inundation in the fall period as well as the spring period.
- Metrics #48-50 return the number of days that the water level range falls between a user-defined set of elevations. The elevation values can relate to an ecological or hydrological function, threshold, or process that is deemed to be of particular significance at a given wetland.

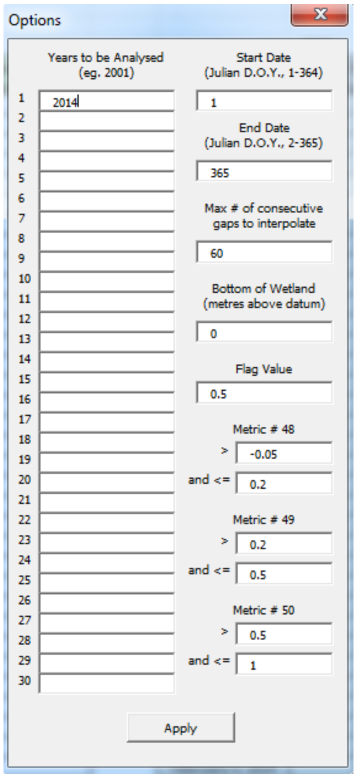
3. Using WHAT

a. Inputting data

WHAT requires input data to be in the format of daily average water levels, including levels both above and below the ground surface of a wetland. The user pastes data into the **Input** tab that has been formatted into two columns: *Col 1:* unique date (e.g. March 14, 2001); and *Col 2*: water level relative to any datum, in units of metres (e.g. 221.5). Water level values between -9999 and 99999 are accepted. Up to 30 years of daily average water level data can be analyzed at one time. If there are gaps in the data, the user can click the **INTERPOLATE** button to linearly interpolate values across these gaps. In the options dialogue, the user can also set a maximum number of consecutive gap days across which it is deemed appropriate to interpolate. Once the interpolate function has been used, certain input and output cells will be frozen and/or have fixed values, so it is important to click **UNDO INTERPOLATE** if the user changes any analysis options or input data.

b. User-defined parameters

After clicking **OPTIONS** to open the options dialogue, the user has the following analysis options to choose from:



- Years to be analyzed: up to 30 unique years can be entered
- Start date: Julian day-of-year (1 to 364) that will be the start date of analysis for each year to be analyzed
- End date: Julian day-of-year (2 to 365) that will be the end date of analysis for each year to be analyzed
- Maximum number of consecutive gaps to interpolate: the maximum number of consecutive gap days across which the user deems it reasonable to interpolate (this may be important to avoid comparing metrics derived mainly or only from interpolated values between different years or conditions/scenarios)
- Bottom of wetland: the elevation of the wetland ground surface; this value is used to derive certain metrics about the length of time that a wetland is inundated versus dry at surface
- Flag value: the change in daily water level, in metres, that triggers a value to be flagged as suspicious, to aid in data QA/QC
- Metric #48: the user can input two values and WHAT will return the number of days that the water level remains between these two values.
- Metric #49: same as above
- Metric #50: same as above

Click **Apply** to apply settings.

c. Copying output

In the **Active_Output** tab, the user can view the calculated values for each metric and for each year of data selected for analysis. Click **COPY TO NEW WORKBOOK** to copy the metric descriptions and results to a new Excel workbook for further analysis.

4. References

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