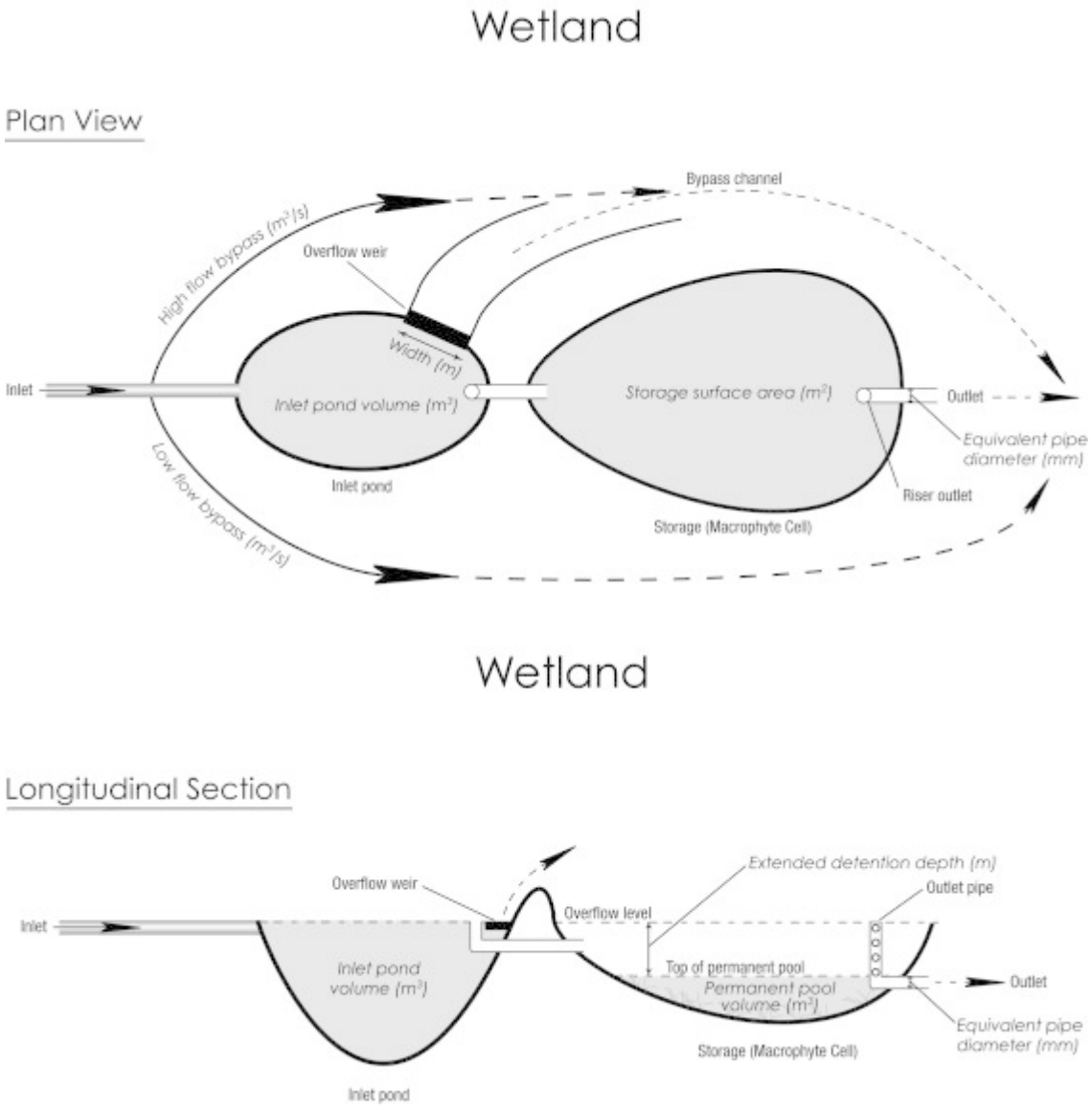
# Wetlands

A wetland is a treatment measure that is generally used for the removal of fine suspended solids and associated contaminants, as well as soluble contaminants. They can also provide significant storage for a range of storm events.

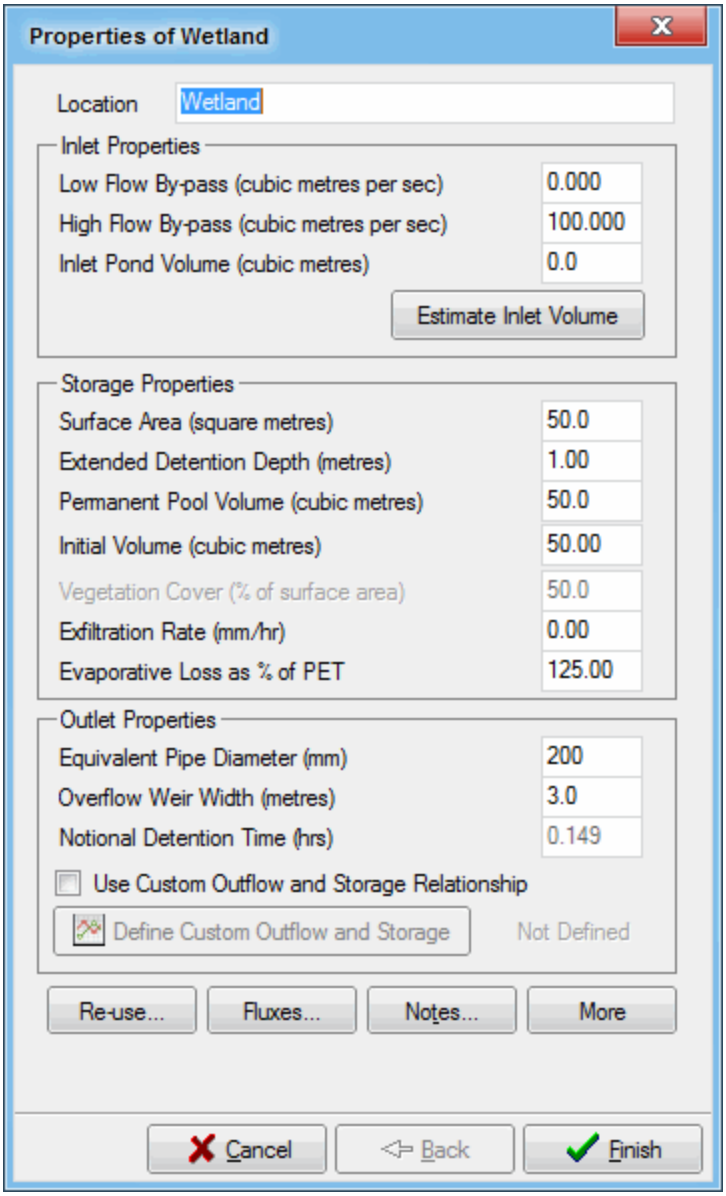
In music, the USTM uses a conceptual model of a wetland system that includes two cells; an inlet pond followed by the main wetland or macrophyte cell. Stormwater can bypass the whole system, when it falls below ("Low Flow Bypass") or exceeds ("High Flow Bypass") the predefined flow rates. The macrophyte cell has a permanent volume of water, with a low flow outlet pipe, whose invert is notionally set at the standing water level of this permanent pool. An overflow weir is located at an elevation equal to the extended detention depth above the standing water level of the permanent pool. A conceptual diagram of the wetland properties in music is presented below.




Conceptual diagram of wetland properties.

## Wetland Properties

The initial wetland properties dialogue box contains the parameters that describe the basic physical characteristics of the wetland system:




### Location

The location name (for example: "Queens Road Wetland") will be displayed under the wetland node icon on the main worksheet.

## Inlet Properties

The Inlet Properties define the physical characteristics of the inlet pond of the wetland system. It is assumed in the model configuration for a wetland that the macrophyte cell is preceded by a separate inlet pond. Flow is hydrologically routed through the wetland based on the characteristics defined by the user.

### Low Flow Bypass

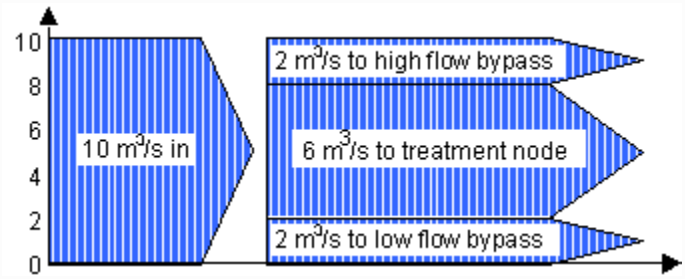
All of the stormwater that approaches the wetland below the user-defined Low Flow Bypass amount (in units of $m^3/s$) will bypass the wetland. Any flow above the Low Flow Bypass (subject to the presence of a High Flow Bypass) will enter and be treated by the wetland.

### High Flow Bypass

When the stormwater inflow rate exceeds the user-defined High Flow Bypass amount (in units of $m^3/s$), only a flow rate equal to the High Bypass Flow (less that specified in any Low Flow Bypass) will enter and be treated by the wetland. All of the stormwater flow in excess of the High Flow Bypass amount will bypass the wetland and will not be treated by the wetland.

Tip Box

The Low and High Flow Bypasses are assumed to occur simultaneously. So for a Low Flow Bypass of 2m$^3$/s, a High Flow Bypass of 8m$^3$/s, and inflow of 10m$^3$/s:




### Inlet Pond Volume

The inlet pond volume in wetland systems provides a pre-treatment of the stormwater prior to its discharge into the macrophyte cell of the wetland. Pre-treatment of stormwater discharging into the wetland includes sedimentation of coarse to medium-sized particles and hydrologic control by facilitating a by-pass of flow around the macrophyte zone when the water level in the macrophyte zone has reached its maximum extended detention depth. music models the performance of these pre-treatment functions using the inlet pond volume, assumed to be a permanent pool and defined in m$^3$, as the principal parameter.

The button Estimate Inlet Volume allows you to specify various parameters for the inlet volume. This is described in more details further below.

## Storage Properties

The Storage Properties define the physical characteristics of the macrophyte cell of the wetland system.

### Surface Area

Defines the surface area of the wetland pond in m$^2$. The hydrologic routing analysis calculates the volume of water in storage during a storm event by multiplying the depth of water in the pond by this surface area. The surface area of the wetland is assumed to be equivalent to the area covered by water at half the extended detention depth. This is to account for the fact that music does not account for batter slopes, hence the extended detention storage is treated as a straight sided tank

### Extended Detention Depth

Defines the normal operating depth of water within the macrophyte zone of the wetland in metres. Water depths in excess of the extended detention depth discharge from the wetland via the overflow weir. The treatment of discharges via the overflow weir is dependent on whether the wetland system being modelled includes an inlet pond for pre-treatment of stormwater. If an inlet pond volume has been specified, the discharge over the overflow weir is considered to have undergone pre-treatment in the form of primary sedimentation and to have by-passed the macrophyte zone of the wetland; otherwise, discharge over the overflow weir is considered as not being treated and will adopt the pollutant concentrations of the inflow.

### Permanent Pool Volume

The wetland system has a permanent volume of water which does not affect the hydrologic routing of a storm event through the system. However, this permanent pool does affect the hydraulic retention time during a storm event, and so affects the treatment of contaminants that flow into the wetland. The Permanent Pool Volume is defined in m$^3$ and is available for stormwater reuse abstraction.

### Initial Volume

This specifies the volume of the wetland at time-step zero (or prior to the model run).

### Vegetation Cover

This parameter is disabled in this version of music. In subsequent versions, it may be enabled to account for various vegetation coverage and subsequent impact on treatment performance.

### Exfiltration Rate

Seepage from the permanent pool of a wetland system into the underlying soil can be modelled by defining the exfiltration rate (mm/hr). Representative exfiltration rates for different soil types are provided in the table below. The water that seeps from the permanent pool of the wetland is lost from the catchment, and cannot re-enter the system downstream. Contaminants in the water that is lost to exfiltration are removed from permanent pool, along with the exfiltrated water and are also lost from the catchment. Representative exfiltration rates for different soil types are shown in the following table.

| Soil Type | Median Particle Size (mm) | Saturated Hydraulic Conductivity | |
|---|---|---|---|
| | | (mm/hr) | (m/s) |
| Gravel | 2 | 36000 | $1 \times 10^{-2}$ |
| Coarse sand | 1 | 3600 | $1 \times 10^{-3}$ |
| Sand | 0.7 | 360 | $1 \times 10^{-4}$ |
| Sandy loam | 0.45 | 180 | $5 \times 10^{-5}$ |
| Sandy clay | 0.01 | 36 | $1 \times 10^{-5}$ |

### Evaporative Loss

Evaporation from the permanent pool of a wetland system can be modelled by defining the evaporative loss rate, defined as a percentage of the daily Potential Evapotranspiration data contained in the Meteorological Template used to create the model. The water that evaporates from the permanent pool of the wetland is lost from the catchment. Contaminants in the water that is lost to evaporation remain within the permanent pool. The default value is set to 125% to represent the additional losses likely to occur through transpiration by the wetland vegetation.

## Outlet Properties

The physical characteristics of the outlet pipe and weir are defined in this section of the dialogue box.

### Equivalent Pipe Diameter

Defines the equivalent diameter of the outlet pipe (this may not be the diameter of the pipe itself, but the equivalent diameter of its orifices). The outlet pipe is notionally set with an invert at the standing water level of the permanent pool. The Equivalent Pipe Diameter is defined in mm. The wetland dialogue box will display the notional detention time, based on the wetland volume, and the Equivalent Pipe Diameter.

Tip Box

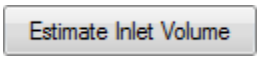
Use the Notional Detention Time display to check whether the designed wetland properties (volumes and Equivalent Pipe Diameter) give approximately the required detention time. For more information, refer to Wong et al. (1998).

### Overflow Weir Width

Defines the width of the overflow weir for the main wetland pond. The overflow weir will only start to carry a discharge of water once the depth in the pond reaches the Extended Detention Depth defined above. The Overflow Weir Width is defined as a length in metres.

### Custom Storage-Discharge-Height Relationship

A custom pipe flow, weir flow and storage relationship can be specified to represent custom outlet and storage configurations for wetland nodes. The outflow relationships can either replace or add to the standard music outflows. More information on how to use the custom outflow and storage facility is available here.

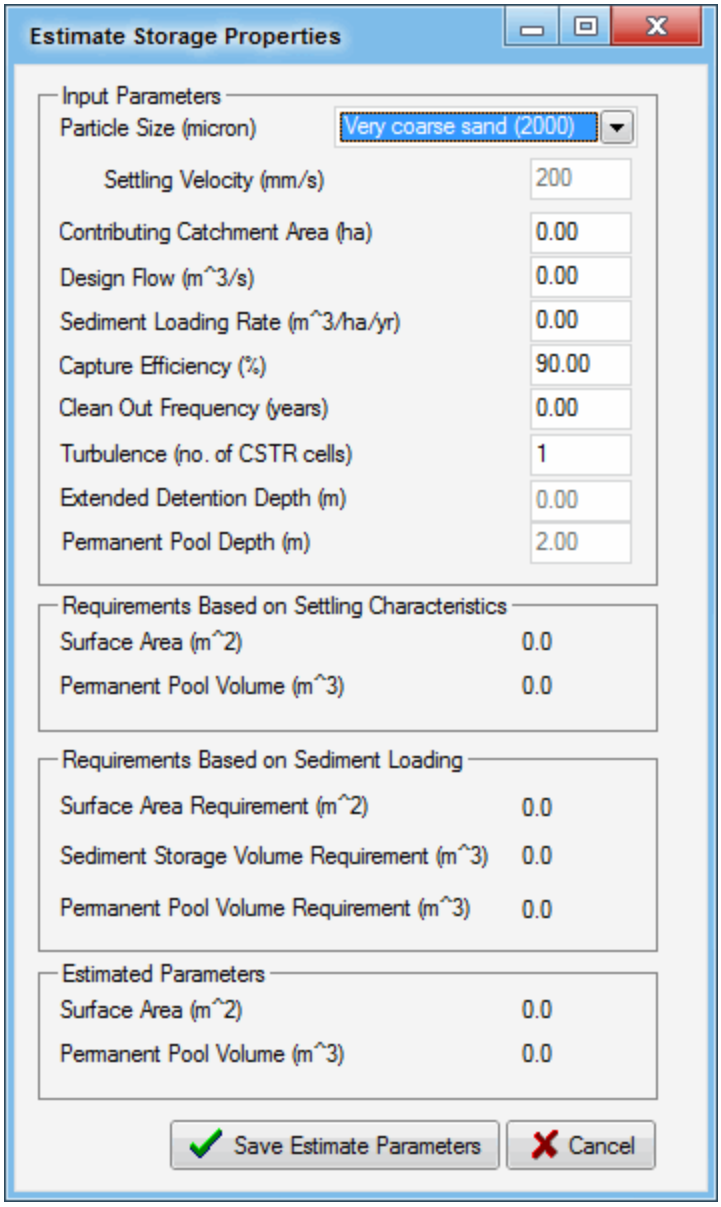



There is an option to set up the initial volume of the wetland. Clicking this button will open the Estimate Storage Properties dialog box:

## Input Parameters

This defines the input parameters of the inlet.

### Particle size




The average diameter of the targeted sediments. Units are in microns ($1e^{-6}$m).

### Settling velocity

Velocity of the particle when settling, during the sedimentation process. In other words, the velocity of the particle into water under gravity and Archimedes constraints.

### Contributing Catchment Area

Area of the catchment contributing to pollutant generation.

### Design Flow

The ideal flow that can be handled by the wetland.

### Sediment Loading Rate

Volume of sediments expected to be received (in ha/yr).

### Capture Efficiency

The proportion of total volume entering the basin that is targeted to settle.

### Clean Out Frequency

The frequency of wetland maintenance (in years). In other words, how often is the basin emptied and cleaned out.

### Turbulence

This is the number of CSTR cells.

### Detention Depth

The depth from the top of the permanent pool to the top of the overflow weir. The inlet pond of a wetland has a detention depth of 0.

## Estimates

The required area (A) of a sedimentation basin should be defined using the equation shown below:

$$R = 1 - \left[ 1 + \frac{1}{n} \cdot \frac{V_s}{Q / A} \cdot \frac{(d_e + d_p)}{(d_e + d^*)} \right]^{-n}$$

where

$R$ fraction of target sediment removed

$V_s$ settling velocity of target sediment (see the table below)

$Q/A$ applied flow rate divided by basin surface area

$n$ turbulence or short-circuiting parameter

$d_e$ extended detention depth (m) above permanent pool level

$d_p$ depth (m) of the permanent pool

$d^*$ depth below the permanent pool level that is sufficient to retain the target sediment (m) - adopt 1.0m or $d_p$, which is lower

The table below lists the typical settling velocities ($V_s$) of sediments under 'ideal conditions' (velocity in standing water)

(Source: Maryland Dept. of Environment 1987 in Engineers Australia 2003)

| Classification of particle size | Particle diameter (µm) | Settling velocities (mm/s) |
|---|---|---|
| Very coarse sand | 2000 | 200 |
| Coarse sand | 1000 | 100 |
| Medium sand | 500 | 53 |
| Fine sand | 250 | 26 |
| Very fine sand | 125 | 11 |
| Coarse silt | 62 | 2.3 |
| Medium silt | 31 | 0.66 |
| Fine silt | 16 | 0.18 |
| Very fine silt | 8 | 0.04 |
| Clay | 4 | 0.011 |

### Surface Area Requirement

Surface area required by the previously fixed depth.

### Sediment Storage Volume Requirement

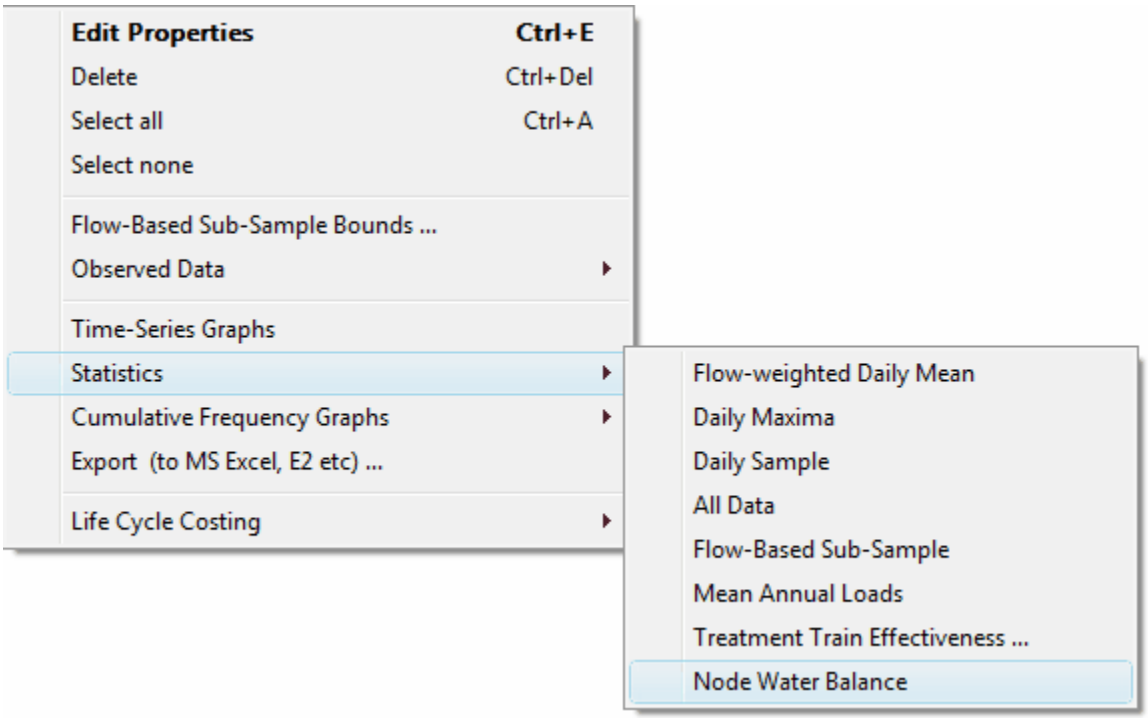
Volume requirement according to sediment loading (which is the efficiency load*flow*contributing area).

### Permanent Pool Volume Requirement

Twice the sediment storage volume.

There is an option to re-use water from the wetland, by specifying a demand. Refer to Water Re-use from Treatment Nodes for more information about the Re-use button.

You can use the node water balance report to obtain basic information on the overall water balance at the wetland, including basic information on reuse at the node.  To do this, select node water balance from the list of available reporting boxes by right clicking on the node.



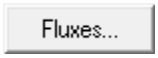

A reporting window will then be presented showing the water balances for various inflows and outflows at the wetland as shown below.

Node Water Balance - Wetland

| | Flow (ML/yr) | TSS (kg/yr) | TP (kg/yr) | TN (kg/yr) | GP (kg/yr) |
|---|---|---|---|---|---|
| **Flow In** | 7.38 | 1331.59 | 2.96 | 20.56 | 188.99 |
| **ET Loss** | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Infiltration Loss** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Low Flow Bypass Out** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **High Flow Bypass Out** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Pipe Out** | 7.29 | 699.85 | 1.82 | 16.75 | 0.00 |
| **Weir Out** | 0.01 | 1.09 | 0.00 | 0.02 | 0.00 |
| **Transfer Function Out** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Reuse Supplied** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Reuse Requested** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **% Reuse Demand Met** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **% Load Reduction** | 1.06 | 47.36 | 38.34 | 18.41 | 100.00 |

Decimal Places 2

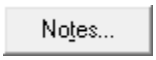
The Fluxes... button can also be used to save data on the water re-use demand and supply at every time-step should that be required (see below).




It is possible to record flux data for the wetland:

- inflow rate and water quality
- outflow rate and water quality
- low and high flow bypass rate and water quality
- overflow rate and water quality
- total outflow rate (sum of outflow, bypasses and overflow) and water quality
- computed water levels and storage
- water re-use demand and actual volume supplied.

Refer to Treatment Devices for more information about fluxes.

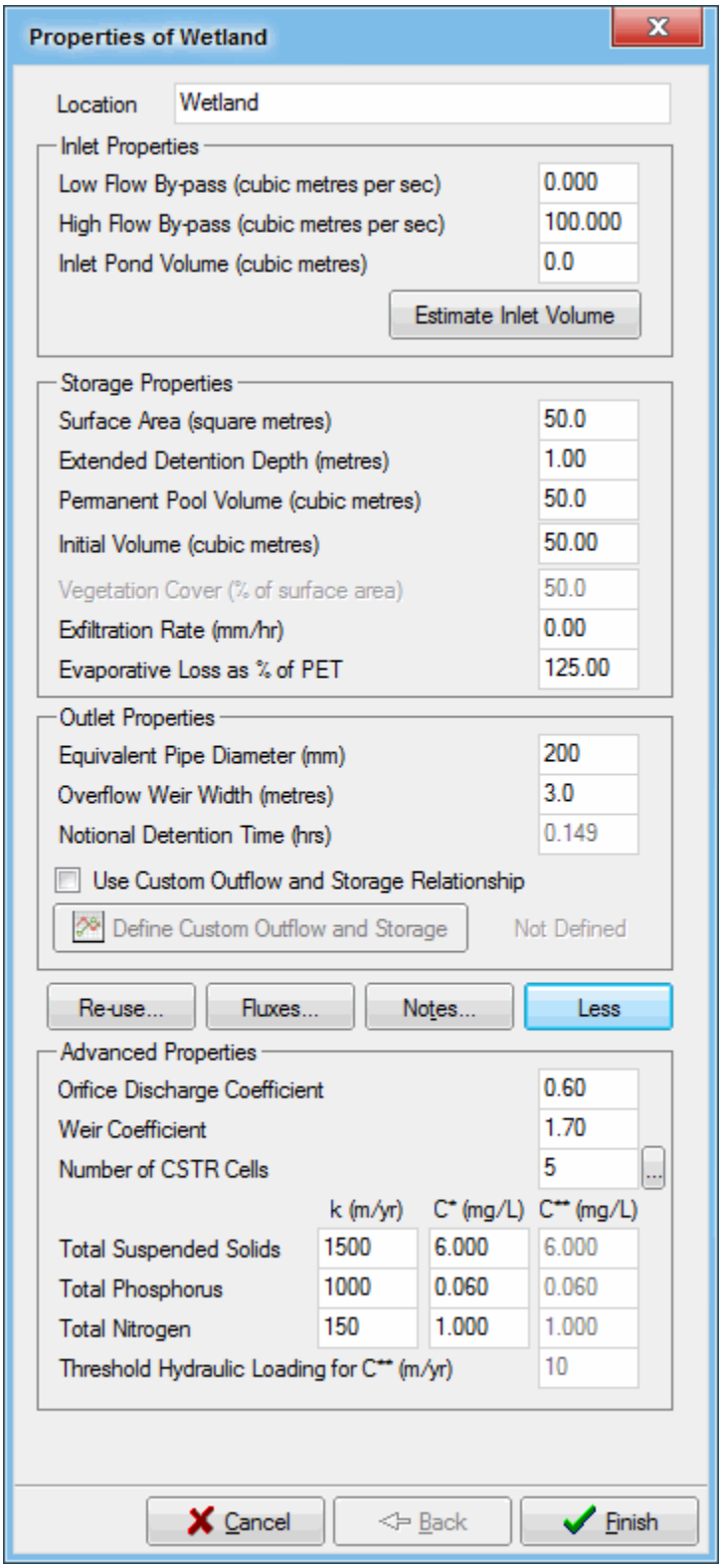



The Notes button allows you to record any important details or assumptions for the wetland (for example, you may provide an explanation of how the volume was calculated, or how the notional detention time was selected). It is good practice to provide notes of any important assumptions used in creating the model, for future reference by others.

## Advanced Wetland Properties

The advanced properties section (opened using the

button) of the wetland properties dialog box (shown below) displays the parameters that describe the hydraulic characteristics for the outflow structures, and the parameters that describe the treatment process in the wetland.




### Orifice Discharge Coefficient

The low flow outlet from the wetland is modelled as a circular orifice with an invert at the notional standing water level of the permanent pool. Although a default value of 0.6 is adopted in the model, you can set any appropriate value between 0 and 1 (more information is available from most hydraulics text books).

### Weir Coefficient

The overflow weir carries a discharge when the water level in the wetland exceeds the Extended Detention Depth. The overflow weir is modelled as a sharp crested weir whose discharge equation is given by:

$$Q = C_w L H^{3/2}$$

where:

Q Discharge over the weir

Cw Weir Coefficient

L Overflow weir width

H Height of pond above the Extended Detention Depth.

The default Weir Coefficient of 1.7 may be altered if desired.

For details about CSTR cells, refer to Treatment Devices. For wetlands, an infinite number of CSTRs would replicate the effects of plug flow through the wetland system. music defaults to 4 CSTR cells for constructed wetlands, however, as the shape of the system can vary markedly dependent on design, the number of CSTR cells that is required to represent the hydraulic efficiency of the design is dependent on that shape. Also note parameter values, which are specific to wetlands:

- k and C* - The rate at which each contaminant is treated, and the background concentration for each contaminant will be different within a wetland and different values should be adopted for each contaminant;
- C** - Defines the baseflow background concentration for ephemeral wetland systems (ie. zero permanent pool volume) when the hydraulic loading of the wetland falls below the Threshold Hydraulic Loading. This value is introduced to represent the operation of an ephemeral wetland under baseflow conditions, and is only able to be adjusted if the permanent pool volume is set to zero. C** is normally lower than C*. For more information regarding the C* and C** properties, see The First Order Kinetic (k - C*) Model.

## Tip Box

Where a permanent pool is present in the wetland, only a single background concentration C* applies. The parameters for C** and Threshold Hydraulic Loading will only be enabled when the permanent pool volume is set to zero.