Wetlands Design Manual

Part D: Design tools, resources and glossary

Table of contents

Part D: Design tools, resources and glossary

Introduction

This section provides some of the necessary tools required for wetland design. The information supports **Part C** of the manual and should be consulted in tandem with the design procedures outlined.

Design tools

The wetland design process uses software that is available and frequently used by the Melbourne Water and land development industries. This section presents guidance regarding:

1. Hydrological event modelling
2. Continuous simulation (water quality, residence time and water level analysis)
3. Hydraulic analysis of flow velocities

Where the wetland designer is using hydrologic event modelling and one-dimensional hydraulic modelling, Melbourne Water **requires** the wetland designer to use RORB and HEC-RAS or other software specifically approved by Melbourne Water for wetland designs.

The continuous simulation modelling must be undertaken using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) or other software specifically approved by Melbourne Water for wetland designs.

Various terrain modelling packages are used across the industry and are acceptable to Melbourne Water. Melbourne Water's **preference** is that a software package such as 12D is used.

Hydrological modelling

The catchment hydrology can be estimated using a combination of the Rational Method and RORB runoff routing software.

The Rational Method

The Rational Method provides a simple estimation of the design peak flow rate. The Rational Method is recommended for use to:

- Calculate the design flow rate for small, simple catchments (less than 400 ha)
- Calibrate a RORB model

The Rational Method does not provide runoff volume or hydrograph shape and so cannot be used to size volume based assets such as retarding basins. The Rational Method is generally not suitable for catchments of unusual shape, with significant isolated areas of different hydrologic characteristics, with significant on-line or off-line storage, with a time of concentration greater than 30 minutes (where a high degree of reliability is required), and urban catchments greater than 400 ha in size.

Important note: For catchments less than 100 ha, Melbourne Water may accept the use of the Rational Method for sizing retarding basin storage volumes and designing other assets. However, project specific written consent from Melbourne Water must be obtained to confirm if this approach is acceptable. In all other situations RORB models must be prepared.

The Rational Method procedure is described in Book 4 of Australian Rainfall and Runoff (1997)[1]. Book 8 provides information specific to urban stormwater management.

Melbourne Water's Land Development Manual outlines the Rational Method procedure including all input parameters and/or sources in Section 5.3.2 Design of Stormwater Conveyance – Hydrologic and Hydraulic Design (available online):

http://www.melbournewater.com.au/Planning-and-building/Standards-and-specifications/Design-general/Pages/Hydrologic-and-hydraulic-design.aspx

RORB

The Melbourne Water recommended RORB modelling procedure includes:

1. Set-up of a preliminary RORB model of the catchment without any diversions or detention storages.
2. Calibration of the preliminary RORB model using the Rational Method
3. Use of the calibrated preliminary RORB model as basis for modelling future scenario/s with proposed diversions and/or detention storages.

[1] Engineers Australia (1997) *Australian Rainfall and Runoff*, Editor-in-chief D.H. Pilgrim, Engineers Australia, Barton, ACT.

Important note: To run a RORB model for a particular catchment, it is essential to have a set of parameters related to that catchment. To determine these parameters accurately you need to have sufficient observed flow data (for larger events) and rainfall data. When the telemetry information is not available, you have to use the rational method flow estimates for the catchment. Due to limitations of rational values when compare with observed data, Melbourne Water recommends the use of 100yr and 10yr calibrations. Also you need to be satisfied that the final set of parameter is reasonable by comparing against Melbourne Water, Dandenong Valley Authority and Australian Rainfall & Runoff (1997) equations.

Modelling scenarios

Modelling of the existing condition is to be based on the current planning zones (or historical if current zone is Urban Growth) and should only consider existing topography and infrastructure. Modelling of future conditions is to be based on the proposed planning zone and include all infrastructure (drainage, storage, etc.) and any changes to topography.

The full suite of design events required for the design of wetlands must be modelled. Generally, this includes (but is not limited to): Q1, Q2, Q5, Q10, and Q100. For all events, the full range of storm durations from 10 minutes to 72 hours must be run to identify the critical duration.

Important note: Generally, RORB underestimates flows for less than 10 year ARIs. Therefore, the designer needs to check and adjust if necessary RORB flow estimates for less than 10 year events using the Theoretical relationship between average recurrence intervals of annual and partial series floods in Australian Rainfall and Runoff (1997).

Delineation of RORB catchment and sub-catchment boundaries, nodes and reach alignments

The following requirements apply to the delineation (or review) of RORB sub-catchment areas, nodes and reach alignments:

- A catchment boundary must match adjoining catchment boundaries that have been provided by Melbourne Water.
- Sub-catchments must be delineated as is most appropriate for the 1 in 100 year ARI event.

- Sub-catchments, nodes and reaches must be named/numbered as recommended by Melbourne Water.
- Nodes must be located within and at the downstream end of each sub-catchment.
- Where relevant, the local Council drainage systems should be considered when delineating sub-catchments.

Fraction impervious methodology

The fraction impervious must be determined using the existing planning zones (as per the Planning Schemes Zones MapInfo table provided by Melbourne Water) as a starting point. The Developer must then assess the fraction impervious for each zone in a sub-catchment.

The fraction impervious must be reported in table format, detailing the fraction impervious for each zone within a sub-catchment as well as the overall fraction impervious for the sub-catchment. This must be reported as part of submissions made to Melbourne Water.

RORB model calibration and model parameters

The preliminary RORB model must be reconciled to a Rational Method estimated flow, unless it is specifically agreed with Melbourne Water that sufficient data is available to warrant a calibration to historic data.

The preliminary RORB model must have:

- no special storages;
- no diversions to separately route multiple flow paths (i.e. overland and underground flows); and
- a structure and reach types consistent with the assumptions of the Rational Method and the way in which the time of concentration is estimated.

Calibration at multiple locations within the catchment will be required when:

- the topography varies significantly across the catchment; and/or
- the land use varies (i.e. urban vs rural) across different parts of the catchment; and/or
- the size of the catchment is larger than 20 km^2 and/or
- the Developer considers it necessary.

As a minimum, the calibration checks must occur at the upstream end of the Melbourne Water drainage system. Some projects may require calibration at the upstream end of the modelled council drainage system, the catchment outlet and/or at confluences of drainage networks.

Important note: the designer must discuss calibration points and obtain approval from Melbourne Water prior to proceeding. The calibration must be to a 1 in 100 year and 1 in 10 year Rational Method Flow estimate, calculated in accordance with Australian Rainfall & Runoff (1997) and taking into account time of concentration calculation requirements outlined in this document.

Important note: Melbourne Water acknowledges that there may be some concerns with the calibration of a RORB model against the flow estimates from the Rational Method. The use of Melbourne Water regional parameters could be only reasonable if that is used with the understanding of the background information to see the relevance to a given catchment. For a given catchment rational method provides benefit as it could capture the effect of the local effects such as topography, imperviousness, and flow conveyance to determine the flows and thereby determine the key parameter for RORB runs. Melbourne Water considers that calibration against the rational flow estimates with sanity checks is the most reasonable approach at this time.

All **reach alignments** should be consistent with the assumptions for calculating the Rational Method flow for the catchment. Similarly, the **fraction impervious** should also be consistent between the preliminary RORB model and the fraction impervious used to estimate the Rational Method Coefficient of Runoff. The correlation between runoff coefficient and catchment fraction impervious is described in AR&R.

A value of 0.8 must be assigned to the exponent **m** unless the Developer believes this is inappropriate, in which case the recommended value is to be discussed with Melbourne Water prior to proceeding with this part of the work.

The parameter **kc** must be adjusted so the flow from the preliminary RORB model matches the Rational Method estimated flow.

The Australian Rainfall & Runoff (1997) method (Section 1.7 of Book II) must be used for the **Areal Reduction Factor** (ARF). ARFs need only be used for catchment areas greater than 400 hectares.

Suitable **initial loss** values must be determined by the developer. As a guide, the following values may be appropriate in the absence of better information:

- For urban catchments: Initial loss of 10 mm
- For rural catchments: Initial loss between 10 mm – 25 mm

Temporal patterns must be fully filtered.

Suitable **runoff coefficients** must be determined by the developer. As a guide, a value of 0.6 is often found to be suitable for an urban catchment for the 100 year ARI event. If the Developer proposes to use another value, the rationale for adopting that value must be discussed and agreed with Melbourne Water prior to undertaking this part of the work. For rural catchments, the Developer is to propose an approach to be used regarding the use of a Runoff Coefficient versus Initial loss/Continuous loss.

Calculating time of concentration

The method for calculating the time of concentration for the Rational Method is outlined in Melbourne Water's Land Development Manual Section 5.3.2 Design of Stormwater Conveyance – Hydrologic and Hydraulic Design (available online):

http://www.melbournewater.com.au/Planning-and-building/Standards-and-specifications/Design-general/Pages/Hydrologic-and-hydraulic-design.aspx

RORB model data

The .catg files of all scenario modelling, along with parameter files and IFD parameters and catchment plan/s in CAD or MapInfo format (with GDA 94 coordinate system), must be provided to Melbourne Water as part of carrying out the project.

All RORB reach alignments, node locations, sub-catchment and catchment boundaries are to be populated with appropriate descriptions, slopes, lengths to correspond with the RORB model code.

Continuous simulation modelling

MUSIC Guidelines

Melbourne Water has created the MUSIC Guidelines (2016) which recommend input parameters and modelling approaches for MUSIC users. The objectives of the MUSIC tool guidelines are to:

- Ensure a consistent scientifically based approach is applied to MUSIC models
- Provide guidance on methods specific to the Melbourne region without inhibiting innovative modelling approaches
- Reduce the time taken by Melbourne Water in assessing models.

The Melbourne Water MUSIC Guidelines should be read in conjunction with the MUSIC User's Manual (eWater). Users of this Wetland Manual are expected to be sufficiently trained in the use of MUSIC software and know how to use it appropriately.

If alternative methods or models to MUSIC are used, the developer must demonstrate to Melbourne Water's satisfaction that performance targets can be achieved.

MUSIC Auditor

The MUSIC auditor is a tool that has been developed for checking the parameter inputs to MUSIC models to ensure they comply with relevant guidelines and are within expected or reasonable ranges. The MUSIC Auditor is intended for use by suitably experienced professionals with an understanding of water sensitive urban design and MUSIC software.

The MUSIC Auditor is free for anyone to use within Melbourne Water's area of responsibility and can be accessed using the following website:

http://www.musicauditor.com.au/

How to determine residence time using continuous simulation

The wetland residence time is defined as the time a particle of water spends in the wetland. The residence time is predicted assuming plug flow between the wetland inlet and outlet. The residence time for a particle of water entering the wetland can be determined by counting the number of time-steps it takes for the water "in front" of that particle of water to be displaced from the wetland (refer Figure 1). This calculation can be done using wetland flux files generated in MUSIC.

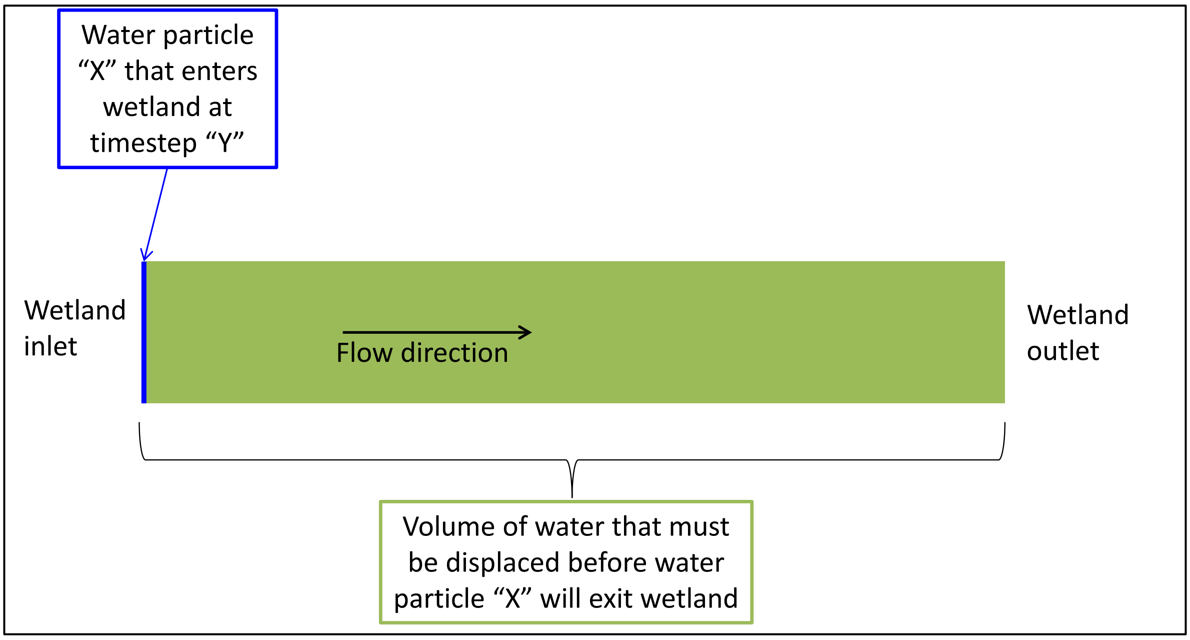

Figure 1 Residence time for a particle of water entering a wetland

The plug flow of water through the wetland is assumed to involve 100% of the extended detention volume and the upper parts of the permanent pool volume. Melbourne Water will accept calculation methods where up to 50% of the permanent pool volume is assumed to be involved in plug flow.

An iterative process is needed to identify a wetland configuration that achieves a 10th percentile residence time of at least 72 hours. A 10th percentile residence time of 72 hours means that the residence time will be 72 hours or more 90% of the time. The recommended method for predicting the 10th percentile residence time for a particular wetland configuration is described below.

Melbourne Water has created an online tool to assist practitioners predict wetland residence time.

Inundation frequency analysis & wet spells analysis

How to undertake an inundation frequency and duration analysis

Plant inundation (submergence) is a major constraint on the growth and species distribution of emergent macrophytes. Despite having a wide range of biochemical, molecular and morphological adaptations to inundation, many emergent macrophytes are highly sensitive to inundation, particularly in stormwater treatment wetlands where high turbidity can severely restrict photosynthesis.

An inundation frequency analysis is required to ensure that the plant species proposed for the wetland are able to cope with the expected wetland hydrology. Melbourne Water has created an online tool to assist practitioners undertake inundation frequency analysis.

Inundation frequency analysis – online tool

The following are manual steps that can be taken to do an inundation frequency analysis if the online tool is not used:

1. Use the plant height information in the tables within **Part A2** of this manual to determine the emergent macrophyte species (excluding ephemeral batter species) that, when mature, will be the shortest relative to NWL for both shallow and deep marsh zones. Note that the planting depth relative to NWL must be taken into account. For example, if a plant will be 500 mm high when mature, and will be planted at a depth of 200 mm, the height relative to NWL will be 300 mm.

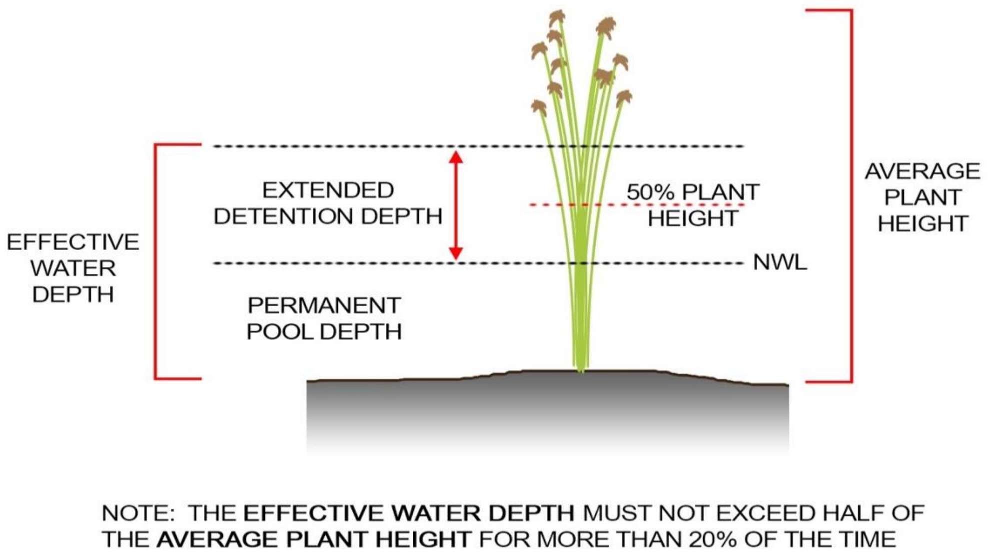

Figure 2 Plant height characteristics for inundation frequency analysis.

2. Create a six minute MUSIC model of the system in accordance with Melbourne Water's MUSIC Guidelines. Ensure the wetland node has an accurate stage-discharge and stage-storage relationship. These relationships should include any detention storage above wetland (e.g. retarding basin). This will require the use of the "Custom Outflow and Storage Relationship" option in MUSIC (refer to **Error! Reference source not found.**), unless the wetland has vertical sides and a single horizontal circular orifice outlet which is not in accordance with the Deemed to Comply criteria.

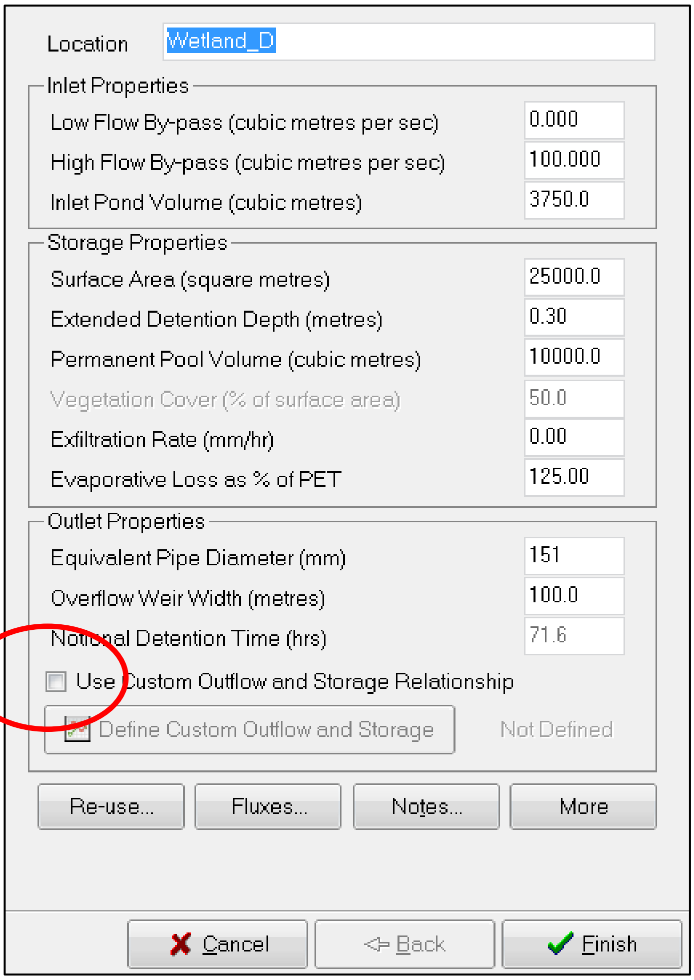

Figure 3 Custom Outflow and Storage Relationship option in MUSIC wetland nodes

3. Export a flux file from the wetland node. Use an online tool or steps below to analyse the flux file.

4. Delete all columns except for "outflows" and "storage". Use a pivot table in excel, or another data processing method, to determine the:

a. Total inflow volume for each day
b. Total outflow volume from the controlled outlet for each day (exclude overflows)
c. Average storage volume for each day

Important note: Your MUSIC model should run at a six minute time-step and post processing of the flux file should be used to determine these daily metrics rather than running the model at a daily time-step.

5. Determine the average "plug flow volume" for each day in the time-series by subtracting 50% of the permanent pool volume from the average storage volume calculated from the flux file.

6. For each day in the time-series, count the minimum number of proceeding days until the cumulative outflow volume equals the previous day's plug flow volume. Use this method to create a daily time-series of residence times.

7. Modify the residence time time-series so that it only includes values corresponding to days where the inflow is > 0 (this avoids double counting of parcels of water at the front end of the wetland).

8. Determine the 10^{th} percentile value of the daily time-series of residence times. If this 10^{th} percentile value is three days or more, the wetland configuration provides an acceptable residence time.

9. Determine the 20% percentile of the water level time-series using Excel or another data analysis method.

10. Ensure that the effective water depth (permanent pool depth plus extended detention depth) does not exceed half the average plant height for more than 20% of the time.

Hydraulic analysis of flow velocities

An initial check of maximum wetland velocities (sediment pond and macrophyte zone) can be undertaken using a simple calculation (maximum flow rate divided by smallest cross sectional flow area). This will produce a conservative estimate of the maximum velocity. If the velocities estimated by this preliminary calculation are less than the prescribed limits, no further flow velocity analysis is required. If the prescribed limits are exceeded, a HEC-RAS model is required to obtain a more accurate estimate of flow velocities.

Manual calculation

The manual velocity calculation involves the following steps:

1. Identify the following peak design flow rates:
   a. Peak flow rate through the sediment pond during the critical:
      i. 10 year ARI event
      ii. 100 year ARI event
   b. Peak flow rate through the macrophyte zone during the critical:
      i. three month ARI event
      ii. 10 year ARI event
      iii. 100 year ARI event

2. Determine the peak water level in the sediment pond during the critical 10 year ARI event[2] (e.g. if the sediment pond is not within a retarding basin and overflow outlet is a weir, use the weir equation to determine the head of water needed to pass the peak 10 year ARI flow over the weir). If the sediment pond is within a retarding basin use RORB to determine the peak 10 year ARI water level.

3. Determine the narrowest part of the sediment pond in the direction of flow between the inlet and overflow outlet. Determine the width between the batters at the location at:
   a. NWL; and
   b. the peak 10 year ARI water level.

4. Determine the cross section flow area at the narrowest point of the sediment pond by multiplying the distance between NWL and the peak 10 year ARI water level by the average of the two widths determined in Step 3.

---

[2] Note this method assumes the peak 100 year ARI flow occurs when the water level in the sediment pond is equal to the peak 10 year ARI water level.

5. Estimate the 100 year ARI flow velocity at the narrowest point of the sediment pond by dividing the peak 100 year ARI flow rate by the cross sectional area determined in Step 4. Ensure the 100 year flow velocity does not exceed 0.5 m/s (in accordance with Deemed to Comply Condition SP3).

6. Determine the peak water level in the macrophyte zone during the critical 10 year ARI event[3] (e.g. if the macrophyte zone is not within a retarding basin and the overflow outlet is a weir, use the weir equation to determine the head of water needed to pass the peak 10 year ARI flow over the weir). If the macrophyte zone is within a retarding basin, use RORB to determine the peak 10 year ARI water level.

7. Determine the narrowest part of the macrophyte zone in the direction of flow between the inlet and outlet. Determine the width between the batters at the location at:
    a. NWL;
    b. TEDD; and
    c. the peak 10 year ARI water level.

8. Determine the cross section flow area at the narrowest point of the macrophyte zone:
    a. For the three month ARI event, multiply the EDD by the average of the NWL and TEDD widths determined in Step 7.
    b. For the 100 year ARI event, multiply the distance between the NWL and the peak 10 year ARI water level by the average of the NWL width (7a) and the peak 10 year ARI water level width (7c).

9. Estimate the three month ARI flow velocity at the narrowest point of the macrophyte zone by dividing the peak three month ARI flow rate by the cross sectional area determined in Step 8a. Ensure the three month flow velocity does not exceed 0.05 m/s (in accordance with Deemed to Comply Condition MZ9).

10. Estimate the 100 year ARI flow velocity at the narrowest point of the macrophyte zone by dividing the peak 100 year ARI flow rate by the cross sectional area determined in Step 8b. Ensure the 100 year flow velocity does not exceed 0.5 m/s (in accordance with Deemed to Comply Condition MZ9).

---

[3] Note this method assumes the peak 100 year ARI flow occurs when the water level in the macrophyte zone is equal to the peak 10 year ARI water level.

HEC-RAS

The Hydrologic Engineering Centre of the US Army Corps of Engineers developed the River Analysis System (HEC-RAS) software. The software allows the user to perform one-dimensional steady and unsteady river calculations (US Army Corps HEC RAS manual) through interaction with the graphical user interface.

HEC-RAS comprises four river analysis components: (i) steady flow water surface profiles, (ii) unsteady flow simulation, (iii) sediment transport/movable boundary computations, and (iv) water quality analysis. The steady flow water surface profile component can be used to estimate wetland flow velocities.

Getting started

The HEC-RAS software and supporting resources (user's manual, applications guide and the hydraulic reference manual) is freely available at:

http://www.hec.usace.army.mil/software/hec-ras/downloads.aspx

This manual assumes that the user is familiar with the steps required to set-up a basic steady flow simulation project in HEC-RAS.

The HEC-RAS user's manual provides an overview of installation, getting started, entering and editing geometric and flow input data, modelling components and processes, and using the output results. The user's manual also contains simple example applications.

The hydraulic reference manual provides the background theory (equations, assumptions, and modelling approaches) to HEC-RAS.

The applications guide contains a series of examples to demonstrate the various modelling aspects (data requirements and modelling approach) with supporting illustrations.

The geometry file

This file is used to:

- Define geometric data (e.g. geometry exported from terrain modelling package)
- Specify the hydraulic roughness (Manning's *n*)
- Where applicable, specify bridge/culvert, inline and lateral structure information

HEC-RAS can import geometric data in several different formats (GIS, HEC-RAS, and others). The HEC-RAS format may be used when importing geometric data from 12d Model.

- Geometric data created in 12d Model is imported to HEC-RAS in HEC-RAS format by selecting *File* | *Import geometry Data* | *HEC-RAS Format* from within the geometric data editor window. The HEC-RAS user's manual (pp. 6-131 to 6-137) provides supporting information for the process.

The wetland geometry file should be created using the following steps:

1. Determine a "design line" or centreline of flow as it passes through the system (typically the longest route through the deepest parts of the wetland. Note that the design line may be different for the three month and 10 to 100 year events, in which case two geometry files will be required.

2. Define suitably spaced cross sections along the design line (typically 20 to 50 m spacing depending on wetland size). The top of the ephemeral batters should generally be used as the left and right bank station.

3. Mark the cross section locations on a scale plan and measure the downstream reach lengths for left over bank (LOB), right over bank (ROB) and channel flow.

4. Determine suitable Manning's roughness coefficients for different sections of the wetland geometry. Note that variable Manning's n values can be defined by selecting "Options – Horizontal Variation in n values" in the cross section geometry editor. The HEC-RAS user's manual recommends Manning's n values for common waterway types (Table 3-1 from pp 3-14 to 3-16 in the HEC-RAS User's Manual).

   Typical Manning's n values are:

Low flows	0.08 (normal) relating to channels not maintained, weeds and brush uncut, dense weeds as high as flow depth
High flows	0.03 to 0.05 -> adopt 0.035 (normal) relating to flood plains, pasture no brush, high grass

   Note: the Manning's n value for low flows is not listed in the HEC-RAS Manual, but has been sourced from Chow (1959)[4], which is referenced in the HEC-RAS Manual.

[4] Chow, V.T. (1959) Open-channel hydraulics. McGraw- Hill Book Co., New York, 680 p.

Check steady flow velocities

The steady flow velocities should be checked using the following steps:

1. Enter the peak three month and 100 year flow rates into the HEC-RAS model as steady flow data.

2. Adopt the NWL for the downstream boundary condition for the peak three month flow.

3. Adopt the peak 10 year water level (determined as part of the manual calculations described in the previous section) as the downstream boundary condition for the peak 100 year ARI flow.

4. Run the model using the steady flow option.

5. View the Profile Output Summary table in HEC-RAS and check that:
    a. For all cross sections in the sediment pond and macrophyte zone the peak 100 year ARI flow velocities are less than 0.5 m/s
    b. For all cross sections in the macrophyte zone, the peak three month ARI flow velocities are less than 0.05 m/s.

If the peak 100 year ARI steady flow velocities exceed the Deemed to Comply thresholds, modify the wetland configuration. If the peak 100 year ARI steady flow velocities complies with the thresholds but the peak three month ARI velocity in the wetland does not, either proceed with checking the unsteady three month velocities or modify the wetland configuration.

Check unsteady three month flow velocities

The unsteady three month flow velocities should be checked using the following steps:

1. Determine the flow duration for the critical three month ARI event and construct an approximate flow hydrograph for this event (using RORB output data for the one year event).

2. Determine volume of water in the critical three month ARI event (area below hydrograph).

3. Estimate the wetland outflow hydrograph by assuming:
    a. The volume of water in the inflow hydrograph is equal to the volume of water in the outflow hydrograph
    b. The outflow hydrograph is a triangular shape

c. The outflow hydrograph peaks after 36 hours and finishes at 72 hours.

Important note:

Typical Manning's n values are:

Low flows	0.08 (normal) relating to channels not maintained, weeds and brush uncut, dense weeds as high as flow depth
High flows	0.03 to 0.05 -> adopt 0.035 (normal) relating to flood plains, pasture no brush, high grass

The Manning's n value for low flows is not listed in the HEC-RAS Manual, but has been sourced from Chow (1959), which is referenced in the HEC-RAS Manual.

4. In HEC-RAS:
    a. set the upstream boundary condition to be the critical three month ARI hydrograph (from Step 1)
    b. set the downstream boundary condition to be the outflow hydrograph (from Step 3)
    c. set the Initial Stage for the downstream boundary condition to the wetland NWL.

Resources

Planning

The following key strategies and plans detail how Melbourne Water manages its water assets:

- Waterways and Drainage Strategy

Formally known as the Waterways Operating Charter, the strategy outlines our responsibilities, goals, services and work programs in managing waterways, drainage and floodplains.

- Flood Management and Drainage Strategy

This strategy aims to minimise flood risks to public health and safety, property and infrastructure. It defines five flood management objectives, and outlines actions to achieve these and guide our priorities and expenditure.

- Healthy Waterways Strategy

This strategy outlines our role in managing rivers, estuaries and wetlands in the Port Phillip and Westernport region. The strategy set priorities, actions and targets for improving waterway health 2013/14 to 2017/18.

- Stormwater Strategy

The Stormwater Strategy is closely linked to the Healthy Waterways Strategy and covers the same five-year period. It focuses on managing stormwater to protect and improve the ecosystem health of waterways and bays.

- Better bays and waterways

Better Bays and Waterways defines our economic, social, and environmental values, the threats to these values, and our commitments through an adaptive management approach to improve the water quality of our rivers, creeks and marine environments for a more sustainable future.

Design

Melbourne Water has produced the following range of guidelines which may be of use or further interest to the wetland designer.

- MUSIC Guidelines
- WSUD Engineering Procedures: Stormwater[5]
- Waterway Corridors Greenfield Development Guidelines
- Flood retarding basins design and assessment guidelines
- Waterway Crossings Guidelines
- Stormwater connections
- Constructed Waterways in Urban Developments Guidelines
- Shared Path Guidelines
- Jetties Guidelines
- Guidelines for development in flood prone areas
- Building in flood prone areas
- Land Development Manual
- Australian Rainfall and Runoff
- Constructed Shallow Lake Systems – Design Guidelines for Developers
- Urban Stormwater: Best Practice Environmental Management Guidelines

[5] Melbourne Water (1995) WSUD Engineering Procedures: Stormwater. CSIRO Publishing, Collingwood. 304 pp.

Maintenance

A maintenance agreement must be provided to Melbourne Water as part of the detailed design package. The maintenance agreement outlines all of the activities associated with maintaining the treatment wetland, and provides for the separation of maintenance tasks in situations where a wetland may be jointly managed by a Council and Melbourne Water.

The maintenance agreement comprises of up to four components:

- Schedule 2 – Council maintenance works
- Schedule 3 – Melbourne Water maintenance works
- Plan of assets
- Priority weeds list

The maintenance agreement package should also include an Asset Operation Plan which provides a brief description of the wetland operation, including all of the key functional components (which must be clearly labelled on the plan of the asset), any site access issues (site entry, pit access keys) and any other associated management information.

Copies of the Melbourne Water maintenance agreement template (including a completed Maintenance Agreement Schedule example) can be downloaded from the Land Development Manual website:

http://www.melbournewater.com.au/Planning-and-building/Forms-guidelines-and-standard-drawings/Documents/Maintenance-Agreement-Package.zip

A schedule of wetland inspection and maintenance requirements is available on our website to assist with the preparation of the maintenance agreement. A wetland inspection and maintenance checklist is also provided on our website. The checklist should be used during inspection and maintenance, as it provides a list of the key inspection elements, and is a permanent record of the maintenance activities undertaken.

Glossary

Term	Definition
Adhere	To stick (e.g. suspended sediment sticking onto a biofilm coating the stem of a macrophyte stem).
Algae	Simple photosynthetic plants that live in water or moist places (Source: Melbourne Water).
Algal bloom	A rapid increase in the mass of one or more algae, usually caused by a change in the flow, light, temperature or nutrient levels of the water in which it lives.
Amenity	Attractiveness or community value.
Aquatic ecosystem	The community of organisms living within or immediately adjacent to water (including riparian and foreshore zones).
Australian Height Datum (AHD)	A measure of height above mean sea level.
Average Recurrence Interval (ARI)	A statistical estimate of the average period in years between a flood occurrence of a given magnitude. The ARI of a flood event gives no indication of when a flood of that size will occur next.
Bathymetry	Topography or the configuration of the underwater land surface.
Batter slopes	An edge that slopes backwards from perpendicular.
Beneficial use	A use of the environment which is conducive to public benefits, welfare, safety, health or aesthetic enjoyment all which requires protection from waste, emissions, deposits and/or noise.
Best practice	The best combination of techniques, methods, processes or technology used in an industry sector or activity that demonstrably minimises the environmental impact of that industry sector or activity.
Biofilm	A gelatinous sheath of algae and micro-organisms, including benthic algae and bacteria, formed on gravel and sediment surfaces and surfaces of macrophytes.
Biological treatment	Using natural processes to breakdown high nutrient and organic loading in water.
Biological uptake	The transfer of a substance (typically nutrients) from water or soil to a living organism such as plants or micro-organisms (a biofilm).
Bypass route	A channel or pipe conveying overflows from the sediment pond around the macrophyte zone.
Catchment	All land which drains to a specific location such as a wetland.

Wetland	Water system for the purpose of removing pollutants from stormwater containing pond, marsh and swamp features.
Controlled outlet	An outlet that controls the discharge rate when the water level is between normal water level (NWL) and top of extended detention (TEDD). The controlled outlet is configured to provide the required residence time and water level regimes for the plants.
Deemed to Comply (DTC)	Set of wetland design conditions that are satisfactory to Melbourne Water. If a wetland design does not comply with one or more of the Deemed to Comply conditions it may not be accepted by Melbourne Water.
Deep marsh	Underwater vegetated parts of the wetland that are between 150 and 350 mm below normal water level (NWL).
Denitrification	The biological conversion of nitrate to nitrogen gas, nitric oxide or nitrous oxide.
Design Flow	Calculated flow used to size engineering structures to a defined standard.
Discharge	The volume of flow passing a predetermined section in a unit of time.
Dispersive soils	Soils in which clay content has a high percentage of sodium and is structurally unstable and disperses in water into basic particles i.e. sand, silt and clay. Dispersible soils tend to be highly erodible and present problems for successfully managing earth works.
Ephemeral	Temporary or intermittent (e.g. a wetland that dries up periodically)
Ephemeral batter	Land around the perimeter of a wetland that slopes towards the wetland and is above the normal water level (NWL) and below the top of extended detention (TEDD).
Epiphyte	A plant that grows on another plant for physical support but is not parasitic.
Extended detention depth (EDD)	Distance between normal water level (NWL) and the overflow weir crest.
Gross pollutant trap (GPT)	A structure used to trap large pieces of debris (>5 mm) transported through the stormwater system.
HEC-RAS	A computer program that models the hydraulics of water flow through channels. The program is one-dimensional and was developed by the US Department of Defence, Army Corps of Engineers in 1995.
Inlet pipe	Pipe(s) conveying water into the sediment pond.

Inlet pool	Open water at the most upstream end of a macrophyte zone.
Inlet zone	See Sediment pond.
Intermediate pool	An open water section within the macrophyte zone located between the inlet and outlet pools. Not all wetlands have intermediate pools.
Lake	Lakes, like ponds, are artificial bodies of open water usually formed by a simple dam wall with a weir outlet structure. A lake is usually created for amenity and landscaping purposes.
Lined channel	Constructed open drain that is designed to convey stormwater to a downstream waterway.
Macrophyte	A type of vegetation, such as reeds, used in wetlands. They are plants that grow in waterlogged conditions.
Macrophyte zone	Vegetated section of a wetland.
MUSIC	The acronym used for the Model for Urban Stormwater Improvement Conceptualisation software developed by the Cooperative Research Centre for Catchment Hydrology to model urban stormwater management schemes.
Normal water level (NWL)	The top of the permanent pool. Above this level water will be discharged from the macrophyte zone via the controlled outlet.
Notional detention time	The nominated time for the detention of stormwater in a wetland.
Nitrification	The process by which ammonia is converted to nitrites and then nitrates.
Nutrients	Organic substances such as nitrogen or phosphorous in a water.
Permanent pool	The level of water retained within a basin below the invert of the lowest outlet structure
Plan of Subdivision	Lodged under Section 22 of the Subdivision Act 1988, when a single title is divided into two or more new parcels of land. The Plan of Subdivision will show the reserve that a wetland will sit within.
Pond	Ponds, like lakes, are artificial bodies of open water usually formed by a simple dam wall with a weir outlet structure. Typically the water depth is greater than 1.5m.
Open water	Unvegetated parts of a wetland.
Outlet pool	Open water at the most downstream end of a macrophyte zone.
Overflow	Outlet (e.g. pit or weir) that conveys flows when the water level exceeds the top of extended detention (TEDD).
Referral	An authority nominated in Section 55 of the Planning and

Authority	Environment Act 1987 that has statutory powers to provide conditions or object to a planning permit application.
Residence time	The time it takes for water to flow from the inlet to the outlet. Refer to advice provided in **Part D** on how to determine residence time using continuous simulation, and also to the Melbourne Water **online tool** that can be used to calculate wetland residence time.
Retarding basin	A temporary flood storage system used to reduce flood peaks. A basin designed to temporarily detain storm or flood waters, to attenuate peak flows downstream to acceptable levels. Also known as a retention basin.
RORB	RORB is a computer program that is used to calculate flood hydrographs from rainfall and other channel inputs. It can be used to design retarding basins and to route floods through channel networks.
Safety bench	An upper submerged batter that has a mild slope to minimise aquatic safety risks for those who inadvertently enter wetlands.
Sedimentation	A primary treatment process that removes pollutants through gravity settling. Sedimentation occurs at reduced flow velocities and thereby causes particles to settle.
Sediment accumulation zone	Lower part of a sediment pond's permanent pool that is intended to collect sediment for subsequent removal.
Sediment dewatering area	Space close to sediment pond for dewatering material excavated from the sediment pond prior to removing from site.
Sediment pond	Used to retain coarse sediments from runoff. They are typically incorporated into pond or wetland designs. Also known as an inlet zone or sedimentation basin.
Shallow marsh	Underwater vegetated parts of the wetland that are between 0 and 150 mm below normal water level (NWL).
Spells analysis	Using results of continuous flow simulation to determine the frequency and duration of consecutive wet and dry conditions.
Stormwater	Rainfall runoff from all urban surfaces.
Stormwater harvesting	The collection and storage of rainfall that runs off impervious surfaces for subsequent use.
Submerged batter	Underwater edge of wetland that slopes down from normal water level (NWL).
Submerged marsh	Underwater vegetated parts of the wetland that are between 350 and 700 mm below normal water level (NWL).
Suspended solids	Small solid particles which remain in suspension in water as a colloid or due to the motion of the water. It is used as one

	indicator of water quality.
Suspension	A mixture of small solid particles dispersed in a liquid. The solid particles are large enough to settle out of the liquid if left undisturbed.
Terrestrial plant	A plant that grows on or in land (i.e. not in water).
Terrestrial batter	Land around the perimeter of a wetland that slopes towards the wetland and is above the top of extended detention (TEDD).
Top of extended detention depth (TEDD)	The height at which an overflow outlet (e.g. weir) is engaged. Below this level, wetland outflow rates are determined by the controlled outlet.
Transfer pipe/weir	Connection to allow stormwater to flow from a sediment pond into a macrophyte zone.
Treatment train	A series of treatment measures to provide an overall approach to the removal of pollutants from catchment runoff.
Velocity	The rate of movement of an object (e.g. a water particle).
Water quality	The physical, chemical and biological characteristics of water in relation to a set of standards.
Water sensitive urban design (WSUD)	WSUD embraces a range of measures that are designed to avoid, or at least minimise, the environmental impacts of urbanisation. WSUD recognises all water streams in the urban water cycle as a resource.
Waterway	A defined watercourse with identifiable flow. A waterway's catchment is typically greater than 60 hectares.