

Standard Operating Procedures for *Physical Habitat – 2D Hydraulic model*
Version 2.0

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Introduction

The Standard Operating Procedure (SOP) for Two Dimensional Hydraulic Modelling describes the purpose of the model for the lower Goulburn River LTIM, how the model will be developed, who is responsible for specific tasks and how the model outputs will be used and reported. The document is intended to be taken in the field when any data are collected to develop the model and should be updated throughout the life of the Long Term Intervention Monitoring Program to reflect any agreed changes to method or procedure.

Objectives and hypotheses

The main objective of the two-dimensional hydraulic modelling protocol is to develop explicit relationships between flow and physical habitat (e.g. pools, slackwaters etc.) and provide supporting information for analysis of biological response data. Once the model is developed a range of flow regimes can be analysed with respect to the availability of habitat provided. The models will be available for interrogation throughout the duration of LTIMP project and beyond. Since the Goulburn River has a geomorphically diverse channel, habitat availability will respond non-linearly with discharge. By tracking the change in habitat with discharge, we will better understand the biological response trends in fish at various life stages, as well as for vegetation and macroinvertebrates. For example, a weak response for fish relative to flow may be strengthened by using change in pool habitat during low flow as an explanatory variable. Conversely, if macroinvertebrates are not found to respond to flows, then the change in slackwater abundance during the preceding period may identify why. We will also be able to inform adaptive management where flow management can be modified to enhance outcomes.

The two-dimensional hydraulic model protocol addresses the following Selected Area specific questions:

- What discharge is required to establish productive habitat for larval juvenile recruitment, growth, and survival?
- What discharge is required to inundate habitat and facilitate seed dispersal for re-establishment of vegetation on the banks of the Goulburn?
- What discharge is required to create habitat for enhanced macroinvertebrate biomass?

The two-dimensional hydraulic models can be operated with flows at any level of regulation. Specifically, the focus will be on:

- Base flows and their role in providing habitat and retention of larval and juvenile fish and macroinvertebrates.
- Flow freshes that inundate bars and benches and how they influence seed dispersal, and vegetation wetting. The models will also contribute to explaining fish response.

Indicators

The development and operation of two-dimensional (2D) models that represent hydraulic habitat is a Category III indicator for the LTIM. That means it is not specifically required for any proposed Basin-scale analyses and there is no prescribed Standard Method for its use in the LTIM. The indicator was the highest ranked Category III indicator by the Goulburn River research and management team, based on its value in providing explanatory variables for a range of Category I indicators, as well as the potential for outputs to inform adaptive management. The 2D hydraulic models will complement measures on vegetation, adult fish populations, larval fish communities, and macroinvertebrate diversity and biomass. By surveying the riverbed and modelling stream flow at the same sites where other indicators will be measured 2D Modelling will provide a valuable resource to support other monitoring objectives. Without the information that the model will provide, we risk missing trends in the other biological data or misunderstanding the specific responses as they relate to delivered flows. 2D modelling will also be undertaken for the Edward-Wakool Selected Area (personal communication Robyn Watts).

Locations for monitoring

Sites for the 2D Model are co-located with other monitoring activities to maximise benefits for conjunctive activities. Bathymetric surveys for all four sites were required to develop topography for the 2D models. Bathymetric surveys are joined to aerially flown LiDAR surveys (made available by the CMA). Bathymetric



surveys will be captured by Austral Ecology using sonar technology in a remote controlled Z-boat. In Zone 2, survey and development of 2D models is at VEFMAP transects at Loch Garry and at McCoy's Bridge (see Table 1). In Zone 1 Moss Road and Darcys Track are to be selected.

Table 1. Proposed sites within Zone 2 for application of 2D modelling. Table indicates complementary studies that currently use these sites

Site Name	Zone	Zone	Easting	Northing	Complimentary studies
Moss Road	1	55	337452	5936179	VEFMAP
Darcy's Track-Gardiner Swamp	1	55	351770	5965722	VEFMAP, Short-term intervention monitoring
Loch Gary	2	55	345976	5987892	VEFMAP
McCoy's Bridge	2	55	330771	5994884	VEFMAP, Short-term intervention monitoring

Timing and frequency of sampling

Bathymetry survey of the channel bed will be conducted once at the beginning of the monitoring program. Development of the model from the surveyed data is a one-time activity. Models will be set up so that any flow scenario (up to bankfull discharge) can be assessed as an ongoing activity. This can be used to identify the most effective flow scenarios or delivery characteristics.

Two event based field visits will be undertaken to acquire velocity and depth data at all sites for two discharges to assist in model calibration. These field visits will target a low flow event (baseflow) and medium-high flow event (fresh). Velocity and depth measurements will be undertaken using an Acoustic Doppler Current Profiler (ADCP).

Responsibilities – identifying key staff

Field program

Dr. Geoff Vietz will be responsible for planning the monitoring activities including scheduling field events, securing required equipment, safety and training, and managing model development. Field assistance will be provided during the field components (topography and velocity measurements) and all field staff will be led through a manual of 'Safety while surveying watercourses', a manual previously developed by Geoff Vietz. Safety relating to vehicle use will be based on protocols developed by the University of Melbourne.

Field surveys will be directed by Geoff Vietz and undertaken by Austral Ecology. Geoff Vietz will be responsible for preparing the 2D models and running the models through the various scenarios required.

Laboratory requirements (if any)

N/A

Procedure for transferring knowledge to new team members

The model and all relevant data will be stored on the central file directory for the project that will be hosted on the University of Melbourne server and on a dedicated shared Dropbox folder so that it will be available to current and future staff members, as necessary. Experience with 2D modelling is an essential requirement for the main modeller. In the unlikely event that Geoff is not available a colleague of Geoff's will be identified who is capable of undertaking the field work and developing the 2D models, based on the method of model development described in detail by Vietz et al. 2013¹.

¹ Vietz, G. J., Sammonds, M. J., Stewardson, M. J., 2013, Impacts of flow regulation on slackwaters in river channels, *Water Resources Research* **49**(4):1797.



Monitoring methods

Equipment

The recommended 2D hydraulic model, River2D, which is designed for fish habitat modelling, is freely available software. The sonar Z-boat-based bathymetric survey will be joined to previously available LiDAR data to develop topography for the model in GIS software (e.g. ArcGIS). Bathymetric surveys could also be undertaken using a Total-Station and motor boat (as originally proposed), though the resolution (number of data points) and accuracy would be considerably lower. Calibration and verification of the model will be undertaken using field velocity measurements at two discharges using an ADCP. The ADCP is owned and managed by the University of Melbourne and calibrated as per the manufacturer's specifications.

Monitoring Protocol

The standard method is based on that described by Vietz et al. (2013), see Appendix A, and includes:

1. Site selection
2. Survey of bathymetry of the channel bed over a distance of 300 to 400 m
3. Integration of bathymetric and LiDAR software in a GIS package
4. Development of the River2D model
5. Calibration of the River2D model using field measured velocities
6. Developing flow-physical habitat relationships
7. Using flow-physical habitat relationships with flow scenarios (both current and future) to determine the contribution of CEW deliveries

On point 2, topographic survey of channel bathymetry must be of a reasonably high density (e.g. 1000 bed points over 400 m), and appropriate accuracy (+/- 15cm). The use of the sonar boat greatly exceeded the required resolution and accuracy, being limited more by computer power than available data. Key in-channel features such as large woody debris and large trees should be identified to assist in interpreting the data and determining roughness values.

Quality Assurance

Quality control and quality assurance protocols are documented in the Quality Plan developed as part of the MEP for all Selected Areas.

Field measured velocities will be used to calibrate and verify the model and modelling must be undertaken by an experienced operator.

Laboratory methods

N/A

Development of hydraulic model

River2D is the preferred model for this task because:

- River2D was specifically developed to replicate local-scale hydraulic conditions within a natural channel
- River2D can simulate flow adjacent to complex structures including large eddies and slackwaters
- River2D has been widely used to characterise hydraulic habitat and results have been verified with reasonable accuracy, and



- River2D has a user-friendly graphical interface with excellent output for visualisation of hydraulic conditions

Development of the hydraulic model should follow the method defined by Steffler and Blackburn (2002): <http://www.river2d.ualberta.ca/Downloads/documentation/River2D.pdf> . In summary, bathymetric survey and LiDAR should be joined within a spatial program (e.g. ArcGIS) to produce a good topographic representation of the site. The inbuilt River2D model RiverBed can also be used to create bed topography. The topographic surface should then be loaded into the RiverMesh module to create nodes and the bed mesh. A general-fill node spacing of 3 m or less should be used within the channel bed, and a node spacing less than 6 m should be used for the floodplain.

The topographic mesh is then loaded into River2D. Boundary conditions including roughness will rely on interpretation by the model developer of conditions within that topography based on field inspection and images. Large features such as fallen trees may need to be represented by topography rather than roughness, and breaklines should be used to delineate major flow lines such as the thalweg, toe of bank and top of bank at a minimum. Flow conditions at the outlet (rating curve) can be developed using a flow gauge or a one-dimensional model (such as HEC RAS).

Calibration should be undertaken by comparison of gauged discharges with water surface levels and surveyed water slopes for at least two discharges ranging from base flow to a flow fresh. Based on the results modifications should be made to the key model parameters of surface roughness and eddy viscosity, as well as channel topography, to improve model accuracy.

The model should be run through a range of discharges from near zero to bankfull discharge to develop a flow-habitat rating curve. Flows should range from, at the least, low flow (e.g. 500 ML/d for the Goulburn River) to large freshes (e.g. 7000 ML/d) and greater.

The accuracy of modelling outputs should be represented as standard errors between the modelled hydraulic conditions and the measured hydraulic conditions.

Data analysis/Reporting

Scenario modelling using hydraulic model

- Run model for a range of discharges from low flows to the highest managed event
- Characterise and define habitats (e.g. slackwaters, pool habitat) based on local biotic requirements (e.g. Vietz et al. 2013)
- Output the area of slackwater or pool habitat for each discharge as xyz nodes
- Analyse nodes for each discharge to develop regression relationships for each physical habitat for a range of discharges
- Use regression relationships to produce flow-habitat time series for a the desired scenarios
- Quantify changes between flow scenarios (with CEW deliveries/without CEW deliveries) in terms of total available area of habitat, habitat patch sizes etc.



Attachment 1 Attachments

Data management: Main variables from physical habitat analysis

Variable	Description	Data type	Required	Range
AssessmentUnitID	River system on which assessment takes place	String		
AssessmentSite	Site at which assessment takes place	String		
SlackwaterTotalArea	Total area of slackwater habitat over flow scenario	Number		
SlackwaterMeanPatchSize	Mean patch size of slackwaters	Number		
PoolTotalArea	Total area of pool habitat over flow scenario	Number		
PoolMeanPatchSize	Mean patch size of slackwaters	Number		

