Northern Rivers Resilience Initiative – Frequently Asked Questions

Technical information

1. What are the technical specifications of the model?

- The hydrodynamic module of the MIKE21 Flow Model FM of MIKE ZERO 2024 for Linux (hereafter referred to as MIKE21 FM) is based on the numerical solution of the two-dimensional incompressible Reynolds averaged Navier-Stokes equations, assuming hydrostatic pressure.
- Primitive variable equations are discretised using an element-centred finite volume method. The spatial domain is discretised into non-overlapping elements, which can be either triangular or quadrilateral (DHI, 2024).
- The finite volume method sets up an Equivalent Riemann Problem (ERP) across each element interface and solves it to determine the variable fluxes between elements.
- The technique used in MIKE21 FM applies the HLLC scheme (approximate Riemann solver) by Toro et al (1994). This scheme significantly improves the results for the velocities in areas with steep gradients in the bathymetry, e.g. along riverbanks and steep slopes near the hill tops and shoreline. The approach treats the problem as one-dimensional in the direction perpendicular to each element interface (Guinot, 2003).
- MIKE21 FM has two options for time integration accuracy, with these being a first order explicit Euler method (referred to as the lower temporal order scheme), and a second order Runge Kutta method (referred to as the higher temporal order scheme).
- There are also two options for spatial integration, with the second order (higher order) accuracy being achieved through a variable gradient reconstruction technique prior to the ERP formulation (DHI, 2024). In this assessment the latest version of the flexible mesh model (MIKE21 FM) with GPU support and for Linux application was used for modelling the entire Richmond River catchment for floodplain inundation modelling.
- The use of GPU and Linux applications allows for higher and faster computational capabilities which are necessary to run the model for the entire Richmond River catchment at high spatiotemporal resolutions. The model developed for this

assessment uses spatial rainfall as inputs (rain on grid) rather than the conventional way of using observed streamflow as inputs. The model generates spatial runoff on each grid at every time step and routes it through the catchment. This version of the model also accounts for spatial and temporal soil infiltration and soil moisture based on measured spatial soil properties and does not need any initial and continuing losses to be calibrated for each flood event.

- The flexible mesh model is preferable over the classic MIKE21 regular grid model when highly detailed elevation data (e.g. LiDAR) are available because the model allows selection of very small mesh elements for the area of interest and the alignment of mesh nodes to relevant physical features (i.e. riverbanks and relevant structures such as weirs, levees, and elevated roads).

2. What data was used to build the model?

- The model design is based on detailed spatial representation of the catchment's biophysical characteristics such as soils (infiltration rates, soil storage capacity, etc.) and landscapes (roughness, flow paths, flow direction, structures, vegetation, etc.) and will include existing large infrastructure such as bridges and culverts, specifically:
    - spatial rainfall data
    - topography data (LiDAR and bathymetry)
    - surface roughness data
    - initial surface water levels
    - initial soil moisture across the catchment
    - infiltration layers (sourced from soils data).

3. What outputs does the model provide?

- The hydrodynamic model provides a range of outputs at model grid scale. Results for the following variables can be recorded if required:
    - flows
    - total water depths
    - water surface elevation
    - U and V components of water velocity
    - precipitation and evaporation
    - soil saturation
    - infiltrated water volume.
- CSIRO can also modify the model settings to produce outputs against additional variables including (note that the model run times increase substantially if all these outputs are written at every timestep):

- still water depth
- P and Q fluxes
- U and V components of wind velocity
- air pressure
- drag coefficient
- eddy viscosity
- CFL number
- convergence angle.

4. Will specific software be required to access and work with the results?

- No specific software is required to access the model results as provided by CSIRO, but a MIKE licence (which can be purchased from DHI) will be needed to undertake any simulations or change inputs and run the model.

5. Why was the MIKE21 model selected?

- As a numerical flood modelling exercise, representing flow behaviour on a floodplain of this size and complexity is a difficult and challenging exercise.
- While two-dimensional models such as MIKE21 FM are well-suited to apply to a floodplain of this type, the size, detail, and complexity of the floodplain necessarily requires compromise decisions to be made by the modeller. Such decisions need to fit within the limitations and constraints of the modelling software and the computational capacity of the available computing hardware. After several discussions within the project team and discussions and feedback from the community consultations, it was agreed to develop a detailed representation of the entire modelling domain (~7000 km^2) with 10,197,863 million grids/mesh elements.
- The model has been set up using the flexible mesh approach of MIKE21 FM where higher resolution meshes are used for the key areas representing the streams, major infrastructure and floodplain, and the less flood prone areas are represented by coarser meshes.
- The entire modelling domain is divided into roughly five zones – major streams, minor streams, low-lying floodplain which often gets flooded, surrounding floodplain which usually gets flooded and rest of the floodplain which seldom gets flooded. All major infrastructure is also considered explicitly.
- The maximum floodplain inundation extent map derived from Remote sensing imagery (by combining all 1 in 2, 1 in 5, 1 in 10 and 1 in 20 year events) was used to define the mesh resolution across the floodplains. Very detailed high resolution mesh is used for the major streams to represent the stream conveyance capacity accurately and the mesh is gradually coarsened across the other four zones.

- The main aim in setting up the mesh is to get the most accurate representation of the entire catchment as possible while making sure that the total number of mesh elements stay within the limits of what the model can handle, and the simulation times also remain realistic.
- These decisions have been taken to service a compromise between the level of detail in the model (i.e. the number and size of model elements) and the model computation duration (i.e. model run time).
- This approach ensures the development of fit-for-purpose model with spatial resolutions that are suitable to represent most of the important streams, floodplain channels, terrain characteristics and other water infrastructure in sufficient detail.