2D Modelling In InfoWorks ICM
Maribyrnong River Catchment

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Acknowledgements:
Andy Chan (MW), Nigel Pugh (MW), Gavin Hay (GHD) and Mardi Medwell-Squier (GHD)
Presentation Outline

1. Background
2. Study Objectives
3. Model Build
4. Outcomes
Introduction

- Melbourne Water investigating new planning tools
- InfoWorks WS / ICM / CS for Water / Wastewater
- TUFLOW / HECRAS / SWMM etc. for Flooding & Drainage
- InfoWorks ICM for Flooding & Drainage?? – some advantages:
  
  - Uniform modelling approach
  - Familiarity with InfoWorks packages
  - Consistent assumptions for broad brush model
  - Potential integration with existing water/wastewater models
Purpose of This Study

- Develop a 2D only rain-on-grid model to:
  - Simulate a suite of design storms
  - Investigate verification/validation methods
  - Identify flood hazards
  - Sensitivity analysis – Manning’s n roughness
  - Sensitivity analysis – bathymetry
  - Sensitivity analysis – terrain modifications
Study Area

Maribyrnong River Catchment
Model Build
2D Zone

Rural Model
Area: 1100 km²
Element Size: 400-900 m²
Total 2D Elements: 1,945,000

Urban Model
Area: 300 km²
Element Size: 100-225 m²
Total 2D Elements: 1,819,000
Ground Model

DTM10 VicMap

1m LiDAR Melbourne Water
Bathymetry

Better representation of river channel

1) → Ground model based on LiDAR.
2) → Ground model with bathymetry included.

LEGEND
Elevation (mAHD)
-5
-4.99 to -3
-2.99 to -1
-0.99 to 1
1.01 to 3
≥ 3
Terrain Modifications

At crossings to represent culverts/bridges
**Terrain Modifications**

To better represent storages
Terrain Modifications

To include flood walls or levees
Roughness Zones

- Based on land use zones
- Some cleanup required
Infiltration Zones & Runoff Coefficients

- Used same roughness zone polygons as infiltration zone polygons

- For each Infiltration Surface type, the following settings were used:
  - Infiltration Type: Fixed
  - Fixed Runoff coefficient calculated as per equation below:

\[ RC = (0.9 \times FI) + (RC_{ARI} \times (1 - FI)) \]

Where:
RC is the fixed runoff coefficient
FI is the fraction impervious
RC_{ARI} is the runoff coefficients for pervious surfaces per ARI
Rainfall & Initial Loss

Initial Loss: 20 mm

Initial Loss: 10 mm

Areal Reduction Factors not applied
Boundary Conditions / Initial Conditions
Simulation of a Range of Storm Durations

- 100 Year ARI - 1, 2, 6, 9, 12, 24, 48, 72 hour durations
- Run duration - 3 days
Outcomes
Simulation of a Range of Storm Durations

- Run all 8 durations
- Export max results to CSV
- Determine the max water level across all durations at each 2D element – “maxmax”
Simulation of a Range of Storm Durations

Some challenges...

Setup & Run Times
- 2-4 hours per run
- ~3-5 minutes real time per hour model time

Exporting Results
- GIS Formats (.SHP or .MID/MIF) – large file size ~400MB each
- CSV format (~70MB each)
- Time to export ~1-2 hours

Post Processing
- Scripts developed externally
- Processing points to ASC grids – renders faster
Simulation of a Range of Storm Durations

Simplify with single storm duration?

Critical VS 48 hour

Critical VS 9 hour
Verification Methodology

- BOM Flood Frequency Analysis (FFA)
- Regional Flood Frequency Estimation (RFFE)
- Flooding Overlays
- Volume balance checks – errors within 0%-5%
Verification Methodology

BOM Flood Frequency Analysis (FFA)

Regional Flood Frequency Estimation (RFFE)

Flooding Overlays

Volume balance checks – errors within 0%-5%

Water Data Online

2D Modelling In InfoWorks ICM Maribyrnong River Catchment
Verification Methodology

BOM Flood Frequency Analysis (FFA)

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Volume balance checks – errors within 0%-5%

2D Modelling In InfoWorks ICM Maribyrnong River Catchment
## Verification Methodology

### BOM Flood Frequency Analysis (FFA)

<table>
<thead>
<tr>
<th>Gauge ID</th>
<th>Gauge Name</th>
<th>ICM Model</th>
<th>FFA 100y Q (m³/s)</th>
<th>FFA 100y D (m)</th>
<th>Modal Q (m³/s)</th>
<th>Modal D (m)</th>
<th>% Diff Q</th>
<th>% Diff D</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>230200</td>
<td>Maribyrnong Rv @ Keilor</td>
<td>Urban</td>
<td>700</td>
<td>11.4</td>
<td>812</td>
<td>8.25</td>
<td>16%</td>
<td>-28%</td>
<td></td>
</tr>
<tr>
<td>230202</td>
<td>Jackson Ck @ Sunbury US</td>
<td>Urban</td>
<td>380</td>
<td>7.75</td>
<td>420</td>
<td>7.27</td>
<td>11%</td>
<td>-6%</td>
<td>Gauged point ~100 yr ~450m³/s</td>
</tr>
<tr>
<td>230205</td>
<td>Deep Ck @ Bulla</td>
<td>Urban</td>
<td>500</td>
<td>6.25</td>
<td>611</td>
<td>8.75</td>
<td>22%</td>
<td>40%</td>
<td>Gauged point ~60yr ~600m³/s</td>
</tr>
<tr>
<td>230204</td>
<td>Riddells Ck @ Riddells Ck</td>
<td>Rural</td>
<td>62.5</td>
<td>1.75</td>
<td>268</td>
<td>4.82</td>
<td>32%</td>
<td>175%</td>
<td>Gauged point ~85yr ~72.5m³/s</td>
</tr>
<tr>
<td>230206</td>
<td>Jackson Ck @ Gisborne</td>
<td>Rural</td>
<td>140</td>
<td>3.7</td>
<td>149</td>
<td>3.62</td>
<td>6%</td>
<td>-2%</td>
<td>Gauged point ~60yr ~150m³/s</td>
</tr>
<tr>
<td>230210</td>
<td>Saltwater Ck @ Bullengarock</td>
<td>Rural</td>
<td>127</td>
<td>3.2</td>
<td>106</td>
<td>2.92</td>
<td>-17%</td>
<td>-9%</td>
<td></td>
</tr>
<tr>
<td>230211</td>
<td>Emu Ck @ Clarkefield</td>
<td>Rural</td>
<td>730</td>
<td>5.75</td>
<td>275</td>
<td>4.36</td>
<td>-62%</td>
<td>-24%</td>
<td>Limited data at higher end of curve</td>
</tr>
<tr>
<td>230222</td>
<td>Gisborne Ck US Roslyne Reservoir</td>
<td>Rural</td>
<td>60</td>
<td>3</td>
<td>46</td>
<td>7.27</td>
<td>-23%</td>
<td>142%</td>
<td>Limited data at higher end of curve</td>
</tr>
<tr>
<td>230223</td>
<td>Slaty Ck @ Roslyne Reservoir</td>
<td>Rural</td>
<td>70</td>
<td>1.6</td>
<td>51</td>
<td>3.85</td>
<td>-27%</td>
<td>141%</td>
<td>Limited data at higher end of curve</td>
</tr>
<tr>
<td>230232</td>
<td>Deep Ck @ Bolinda</td>
<td>Rural</td>
<td>310</td>
<td>4.6</td>
<td>478</td>
<td>8.24</td>
<td>54%</td>
<td>36%</td>
<td>Limited data at higher end of curve</td>
</tr>
</tbody>
</table>

### Regional Flood Frequency Estimation (RFFE)

### Flooding Overlays

### Volume balance checks – errors within 0%-5%

2D Modelling In InfoWorks ICM Maribyrnong River Catchment
Verification Methodology

BOM Flood Frequency Analysis (FFA)

Regional Flood Frequency Estimation (RFFE)

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- BOM Flood Frequency Analysis (FFA)
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Verification Methodology

<table>
<thead>
<tr>
<th>Location</th>
<th>100y Flow (m³/s)</th>
<th>Model Flow (m³/s)</th>
<th>% Diff Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep Creek In</td>
<td>522</td>
<td>562</td>
<td>8%</td>
</tr>
<tr>
<td>Emu Creek In</td>
<td>171</td>
<td>353</td>
<td>107%</td>
</tr>
<tr>
<td>JacksonCk_In</td>
<td>373</td>
<td>401</td>
<td>8%</td>
</tr>
<tr>
<td>Maribyrnong River Out</td>
<td>806</td>
<td>752</td>
<td>-7%</td>
</tr>
</tbody>
</table>

Results look OK but...some caveats with the RFFE estimates...

Lower accuracy where the catchment:
• Size is outside the recommended tolerances of 0.5 - 1000 km², i.e. Maribyrnong River catchment is approximately 1400 km²
• Is highly urbanised or developed
• Contains a large storage structure e.g. Rosslynne Reservoir
• Has an “unusual” shape as was determined for the Emu Creek catchment.
Verification Methodology

BOM Flood Frequency Analysis (FFA)

Regional Flood Frequency Estimation (RFFE)

Flooding Overlays (FO)
Land Subject to Inundation Overlay (LSIO)
Special Building Overlays (SBO)

...assumed to be results from previously developed flood models

Volume balance checks – errors within 0%-5%
Verification Methodology

- BOM Flood Frequency Analysis (FFA)
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Verification Methodology

BOM Flood Frequency Analysis (FFA)

<table>
<thead>
<tr>
<th>562x579</th>
<th>2DModelling In InfoWorksICM Maribyrnong River Catchment Verification Methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Volume balance report</strong></td>
<td><strong>Estimated balance error (m3):</strong> 3236146.2362&lt;br&gt;<strong>Final volume (m3):</strong> 20025124.0023</td>
</tr>
</tbody>
</table>

**Inflows:**
- **IR** → Rain (m3): 48202756.7675, 38.15%
- **IDL** → Level boundaries (m3): 30327.3032, 0.02%
- **IBI** → Inflow boundaries (m3): 78121516.1712, 61.83%

**Total Inflow (m3):** 126354630.2419, 100.00%

**Outflows:**
- **CI** → Infiltration (m3): 15971498.1575, 14.59%
- **CDL** → Level boundaries (m3): 31842451.8636, 93.51%
- **CBI** → Inflow boundaries (m3): 0.2272, 0.00%
- **CBN** → Normal boundaries (m3): 1976696.3408, 1.81%

**Total Outflow (m3):** 109499765.5099, 100.00%

**Net inflows:**
- **MR** → Rain (m3): 48202756.7675
- **MI** → Infiltration (m3): -15971498.1575
- **MBL** → Level boundaries (m3): -31842451.8636
- **MBI** → Inflow boundaries (m3): 78121516.1712
- **MBN** → Normal boundaries (m3): -1976696.3408

**Net total inflow (m3):** 16854923.8580

**Volume balance summary:**
- **VBE** → Volume balance error (m3): -65945.0068
- **VBE** = **FV-IT+OT**
- **VBE** = **VBE** + **% of inflow + outflow**

Less than 5%
Flood Hazard

MW Flood Mapping Guidelines

5.4. Safety Risk in Roads
The Safety Risk polygons are to be determined at all points within the flood extent other than within parcels. These categories for Safety Risk in Roads are defined by Melbourne Water in terms of the velocity and depth of floodwaters in the 100 year ARI event, as follows:

- High Risk (Safety Risk value = 3)
  velocity x depth > 0.8 cumeas/m, or depth > 0.8 metres
- Medium Risk (Safety Risk value = 2)
  0.4 < velocity x depth <= 0.8 cumeas/m, or 0.4 < depth <= 0.8 metres
- Low Risk (Safety Risk value = 1)
  velocity x depth <= 0.4 cumeas/m, or depth <= 0.4 metres

ICM Hazard Ratings

<table>
<thead>
<tr>
<th>Max Hazard</th>
<th>Maximum Flood Hazard Rating value during simulation. Flood Hazard Rating is calculated using the DEFRA Hazard formula presented in technical reports FD2320/TR2 and FD2521/TR1: HR = d x (v + 0.5) + DF</th>
</tr>
</thead>
</table>
|            | Where:
|            |   d = depth of flooding (m)  
|            |   v = velocity of floodwaters (m/s)  
|            |   DF = Debris Factor  
|            | Where Debris Factor is assumed to be:
|            |   0.5 for depths < 0.25m  
|            |   1.0 for depths > 0.25m  
|            | as used in Table 4 of the document: Explanatory Note for FD2320 and FD2321 |

ARR 2016 Flood Hazard Classifications

H6 - unsafe for vehicles and people. All building types considered very unsafe. Flooding is likely to cause loss of life. Some buildings may be carried away by floodwaters.

H5 - unsafe for vehicles and people. All buildings vulnerable to structural damage. Some low robust building types vulnerable to failure.

H4 - unsafe for people and vehicles.

H3 - unsafe for vehicles, children and the elderly.

H2 - unsafe for small vehicles.

H1 - generally safe for people, vehicles and buildings.
Flood Hazard

Normally classified by velocity-depth product (or unit flow in ICM)
Sensitivity Analysis

- Manning’s n
- Bathymetry
- Terrain Modifications
Sensitivity Analysis – Manning’s n

This analysis aims to test the sensitivity of flows and levels to “catchment runoff” type roughness values for shallow flows in comparison to “main flow path” type roughness values as currently applied in the base model.

Ideally, a depth-varying roughness approach would be undertaken to apply the different roughness at different depths, as suggested by ARR.

However, there is currently no capability to apply a depth-varying Manning’s in InfoWorks ICM.
Sensitivity Analysis – Manning’s n

2D Modelling In InfoWorks ICM Maribyrnong River Catchment
Sensitivity Analysis - Bathymetry

This sensitivity analysis aims to investigate the impacts on flows and levels if no bathymetry data was included in the model.

This could very well be the case for many catchments as bathymetry data is not always readily available.
Sensitivity Analysis - Bathymetry

Modelled 100y 48h - Maribyrnong Outlet

Time (d hh:mm:ss)

Flow (m³/s)

Base

No Bathy

Difference (m)

-2.55 -1
-0.99 -0.5
-0.49 -0.3
-0.29 -0.1
-0.05 -0.05
-0.05 0.1
0.05 0.5
0.51 -1
1.01 -2

2D Modelling In InfoWorks ICM Maribyrnong River Catchment
Sensitivity Analysis – Terrain Modifications

This sensitivity analysis aims to investigate the impacts on flows and levels if no terrain modifications were included in the model.
Sensitivity Analysis – Terrain Modifications

Modelled 100y 48h - Maribyrnong Outlet

Time (d hh:mm:ss)

Flow (m³/s)

Difference (m)

2D Modelling In InfoWorks ICM Maribyrnong River Catchment
Conclusions

- Develop a 2D only rain-on-grid model to:
  
  - Simulate a suite of design storms
    - should be undertaken in at least the first instance to identify critical durations
    - If changes in storage or routing are being considered the critical design storm durations should be reviewed
  
  - Investigate verification/validation methods
    - Some challenges with the methods
    - Suitability of data
    - Poor representation of some channels in model
    - Key benefit – data is easy to obtain
  
  - Identify flood hazards
    - Not much additional effort
    - May be useful for future planning
  
  - Sensitivity analysis – Manning’s n roughness
    - Depth-varying manning’s n would be ideal
    - Further develop model by separating “catchment runoff” zones and “flow path” zones
  
  - Sensitivity analysis – bathymetry
    - Bathymetry data should be included where available
    - Waterway profile should be approximated using the best available information where LiDAR is not appropriate
  
  - Sensitivity analysis – terrain modifications
    - some form of representation required, especially in a 2D only model
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