RUNOFF IN URBAN AREAS

Urban Catchment Modelling

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Session Outline

• Characteristics of Urban Modelling
• Selecting a Model
• Model Application

Why Model?

• Rapid calculation across large spatial and temporal domains
• Testing of multiple suites of parameters and inputs
• Better calibration to best represent the real world conditions
• Readily documented and reviewed
• Better assessments and design outcomes
Characteristics of Urban Modelling

- Impervious Cover
- Conveyance Systems
- Hydraulic Structures (including volume management facilities)

Also
- Complex landuse patterns (changes spatially and temporally)
- Data intensity
- Stakeholders

Characteristics of Urban Modelling

- Impervious Cover
  - Imp% is basic hydrologic model parameter
  - Reduces infiltration and decreases lag
  - Two types of impervious cover described in ARR
    - Directly connected
    - Indirectly connected
  - Effective Impervious Area (EIA) as a proportion of Total Impervious Area (TIA)
  - EIA/TIA between 50% and 70% (refer Book 5)
  - TIA may be more suitable in some circumstances
  - Importance of a quality Imp % estimate not the same in every application
  - A well-constructed model with adequate spatial scale should account for effective impervious area and connectivity effects

Characteristics of Urban Modelling

- Conveyance Systems
  - Artificial linings support steeper than natural slope resulting in decreased lag
  - Alters flow characteristics
  - Physical processes are explicitly modelled by most hydraulic models
  - Requires detailed schematisation
  - Conduit type, Cross-sectional dimensions, Length, Slope, Hydraulic parameters
Hydraulic Structures

- Localised Afflux
- Floodplain storage and hydrograph attenuation
- Tail water levels for upstream drainage
- Cross-catchment diversion of flow
- Bed scour and local stream morphology
- Blockage scenarios
- Model requires detailed physical description: dimensions, elevations etc.

Selecting a Model

- Rational Method
- Time Area Method, Extended Rational Method
- Runoff Routing
- Continuous Simulation
- Hydrology coupled to 1D hydraulic model
- Direct Rainfall ('Rain on Grid')
- Runoff Routing coupled to 2D hydraulic model
- One-dimensional hydraulic model
- Two-dimensional hydraulic model
- Pipe network models
- Water quality models
Selecting a Model

Question 1: What capabilities do you need?

- Runoff generation and surface routing
- Channel and storage routing
- Structure hydraulics

Tables 9.6.1 and 9.6.2 assign a capability (limited, moderate, strong) to each type of model across these key areas.

<table>
<thead>
<tr>
<th>Urban Model Type</th>
<th>Runoff generation and surface routing</th>
<th>Channel and storage routing</th>
<th>Structure Hydraulics</th>
<th>Other specific capabilities or limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrology Type</td>
<td>Limited</td>
<td>Note</td>
<td>Note</td>
<td>Partial flow routing capability, limited rainfall intensity models, requires manual input for some processes, limited calibration tools.</td>
</tr>
<tr>
<td>New model develop</td>
<td>Moderate</td>
<td>None</td>
<td>None</td>
<td>Can be used for medium-intensity, low-volume events, requires manual input for some processes, limited calibration tools.</td>
</tr>
<tr>
<td>Old model develop</td>
<td>Strong</td>
<td>Moderate</td>
<td>Limited</td>
<td>Full range of hydraulic models (routing, erosion, sediment transport, etc.), requires manual input for some processes, limited calibration tools.</td>
</tr>
</tbody>
</table>

Example Model Platforms (where relevant):
- HYDROMOD, INFOWATERS
- MIKE21, HEC-HMS, SWAT
- DRAINMOD, DRAINMODFLOW, DRAINMODSWAT
- RTN, TRIM2000, IRRIGS

Hydrology and Hydraulics

- Runoff routing: Limited
- Channel and storage: Moderate
- Structure Hydraulics: Strong
- Other specific capabilities or limitations: Partial flow routing capability, limited rainfall intensity models, requires manual input for some processes, limited calibration tools.
Question 2: What is your model’s spatial scale?

<table>
<thead>
<tr>
<th>Lot</th>
<th>Site</th>
<th>Neighbourhood</th>
<th>Precinct</th>
</tr>
</thead>
<tbody>
<tr>
<td>A small parcel of land with 1 or 2 buildings</td>
<td>A large parcel of land with several buildings. Sometimes a small number of low-rise buildings.</td>
<td>Many parcels of land each with a mixture of low-rise and mid-rise buildings.</td>
<td>Hundreds of parcels of land with either low-rise or high-rise buildings. A large number of townhouse complexes combined with several high-rise buildings.</td>
</tr>
</tbody>
</table>

Number of flood generation processes increase with scale (Table 9.6.4)

More model capability required for larger catchments
Question 3: What is your flood magnitude of interest?

Not all hydrologic models capable across range of flood magnitudes

Selecting a Model

Question 2 and 3 lead to Figure 9.6.1

Not all hydrologic models are capable across range of flood magnitudes AND model scales

Question 4: What hydraulic model is suitable?

- Is flow behaviour 1D or 2D
- Proportion of flow underground
- Importance of storage
Selecting a Model

Other factors:
- simplest model, capable of the necessary calculations
- availability of sufficient input data
- parameter research
- output data capabilities
- cost
- user familiarity with the model

Model Application

- Design rainfall depths from BOM
- Temporal patterns, ARF, climate change factors, pre-burst from ARR Datahub

Model Application - Rainfall

- Design rainfall depths from BOM
- Temporal patterns, ARF, climate change factors, pre-burst from ARR Datahub
Model Application - Losses

- ‘Initial Loss/Continuing Loss’ Loss model recommended
- For urban catchments apply the following hierarchy:
  1) locally derived data
  2) Regional losses as per Book 5 Ch 3.5 i.e. for:
  - Datahub provides storm loss. Burst Loss = Storm Loss – Preburst

Model Application - Property Runoff

- Basic ‘building block’ of most urban models.
- Limited number of flood generation processes
- Physical definition should be sufficient to allow local effects to be determined
- Deemed to comply and Rational Method solutions can be considered for property drainage on simple sites e.g. AS/NZS 3500.3
- Continuous simulation may become important for volume harvesting and water quality design (resolve joint probability problems)

Model Application - Sub-catchment runoff

- Second ‘building block’ for urban models
- Landuse complexity, storage effects, variations in rainfall temporal patterns and pre-burst rainfall become more important
- Runoff routing or continuous simulation models more relevant (volume or joint probability)
- May be some opportunity for simplified definition of catchment
**Model Application – Inlet to Outlet**

- Third ‘building block’
- Multiple sub-catchment flows accumulate at junctions.
- Some simplification of catchment necessary.
- Coupled 1D or 2D hydrology and hydraulic models suggested.
- Ensemble of patterns in hydrology with at least one pattern taken through to hydraulic model.
- Refer ‘Brownfields’ case study

**Urban Catchment Modelling Summary**

- Models have become necessary tools in modern practice
- Urban modelling has a number of special characteristics (impervious cover, conveyance systems and structures)
- To select a model identify:
  - Capabilities required
  - Model spatial scale
  - Flood magnitudes of interest
- When applying models consider the amount of physical simplification that is suitable for each model building block

Thankyou