Disaster Analysis using xpswmm: *Some modelling tips*

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XP solutions

Flood – the most devastation disaster

Flood/Tsunami is one of the worst disaster in Japan and around the world. We still remember –

- **Boxing Day Tsunami** in Indian ocean 2004
  - Deaths - 230,000+ (14 countries)
  - Waves up to 30 meters

- **East Japan Tsunami** 2011
  - Deaths: 15,828 (missing 3,760)
  - Buildings destroyed: 125,000

- **Brisbane Flooding** in 2011
  - Deaths: 35 (missing 9)
  - Damages: A$30 billion

Source: wikipedia.org

Brisbane Flood (2011)

Source: www.abc.net.au

Japan Tsunami (2011)

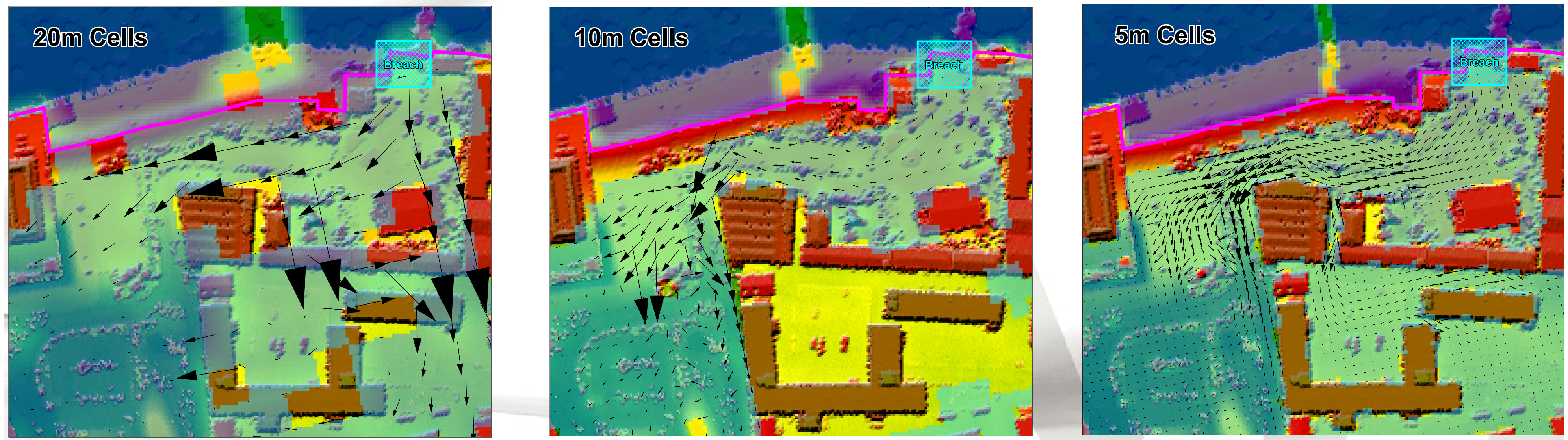
Source: www.abc.net.au

DTM Quality & Basic Decision

- DTM Quality – very important
  - Resolution of topography data
- River in 1D or 2D ?
  - Depends on river width and cell size
  - DTM quality to represent the river x-section
- Cell Size Selection
  - Small enough to meet hydraulic objectives
  - Large enough to minimise run-times
  - Coarser than DTM

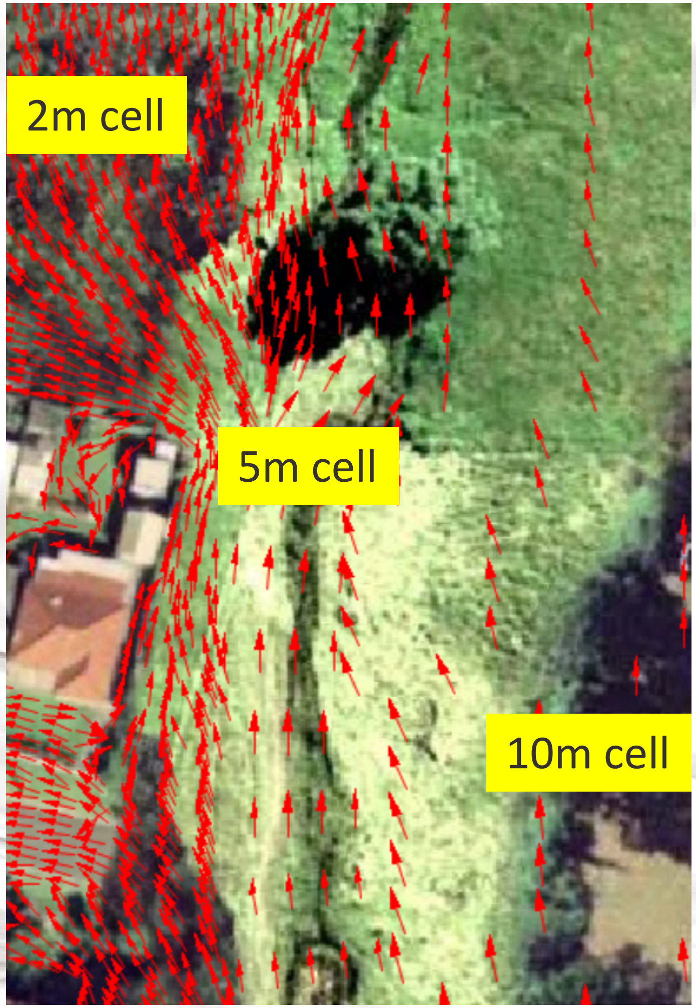
Garbage In, Garbage Out

Influence of Cell Size



Halving the cell size increases run-time by a factor of eight (8) – keep this in mind!

Multi - Grids



- Multi Grid option may necessary

  <u>For example</u>

  – *2m in Urban Area*

  – *5m in River*

  – *10m in Undeveloped Floodplain*

2D Theory

Inside the Black Box

The Equations:
Momentum Equation

How Velocity changes over time

Coriolis Force

Atmospheric Pressure

External Forces (Wind, Waves, ...)

Bed Resistance

Viscosity (Turbulence)

Inertia Term

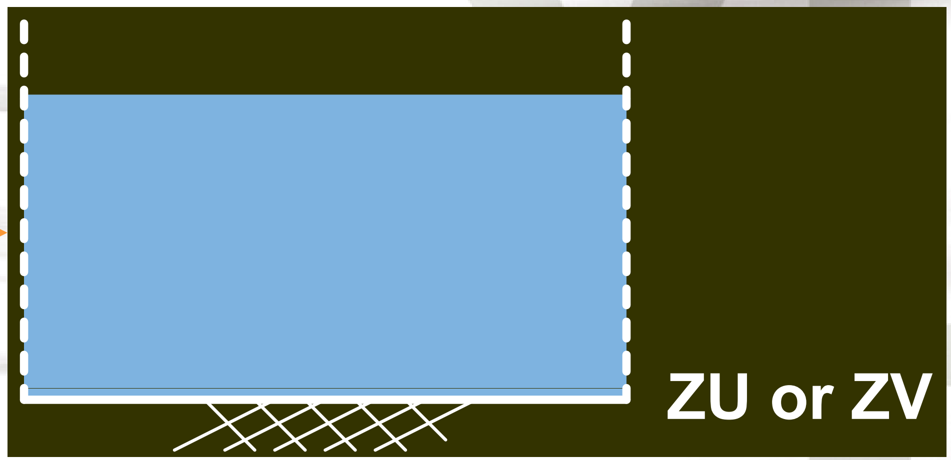
Gravity

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + c_f\, v + g\frac{\partial h}{\partial x} + g\,u\frac{\sqrt{u^2+v^2}}{C^2 H} - \mu\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}\right) + \frac{1}{\rho}\frac{\partial p}{\partial x} = F_x$$

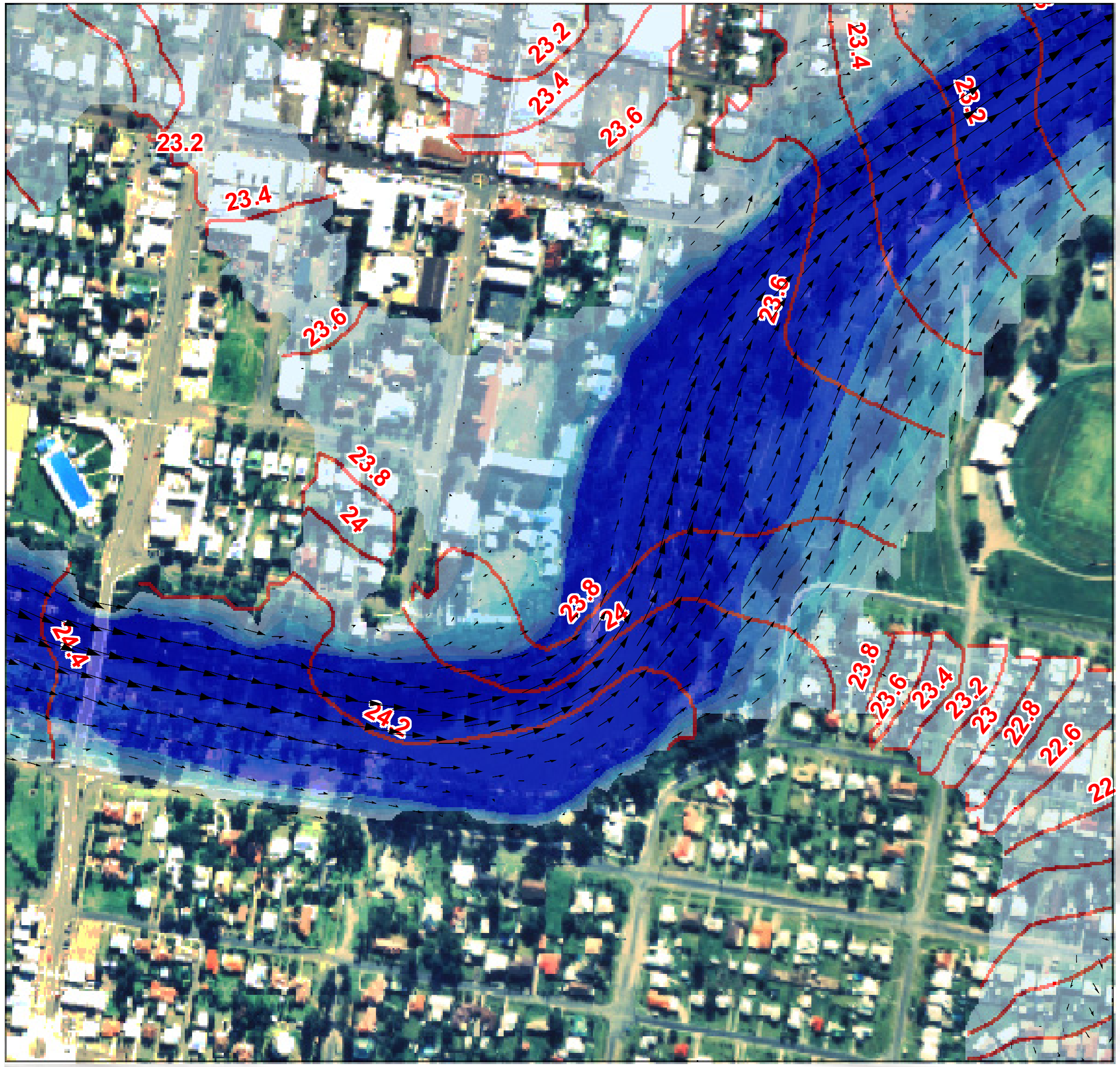
Important Terms: Bed Resistance

- Manning's Roughness (n)
- Often it is the most dominant term
- When compared with 1D, 2D n-value maybe:
  - Higher
    (due to no side friction)
  - Lower
    (little or no need to account for form losses)

No side friction



Important Terms: Inertia

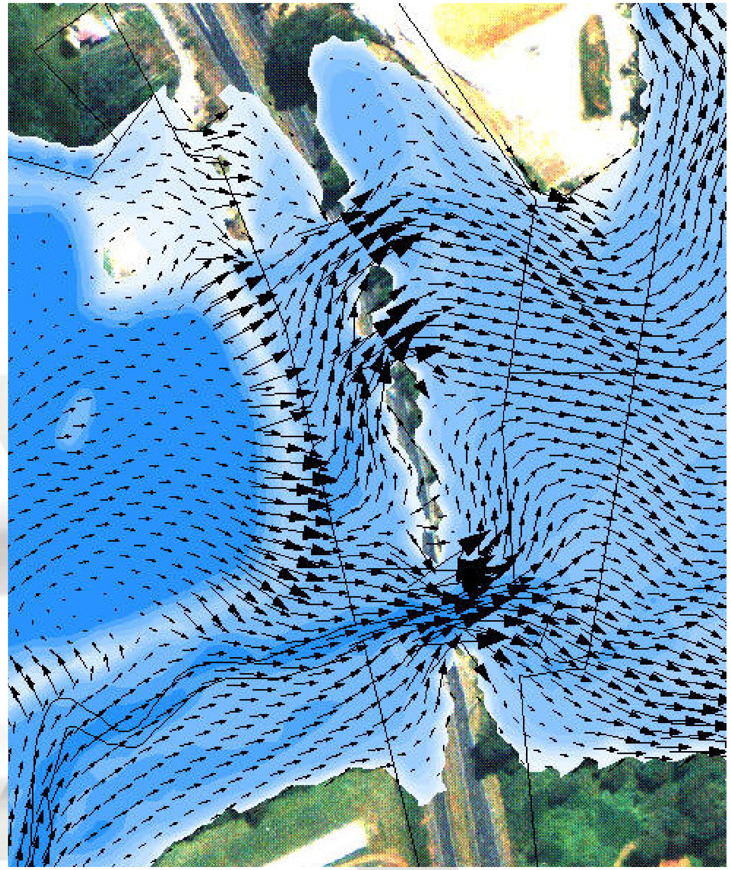


- Very important where velocity
  - Speeds up or slows down
  - Changes direction
- Essential at structures and bends

- 0.4m superelevation across the river banks at bend (20 m deep & 4 m/s)

Important Terms: Viscosity/Turbulence

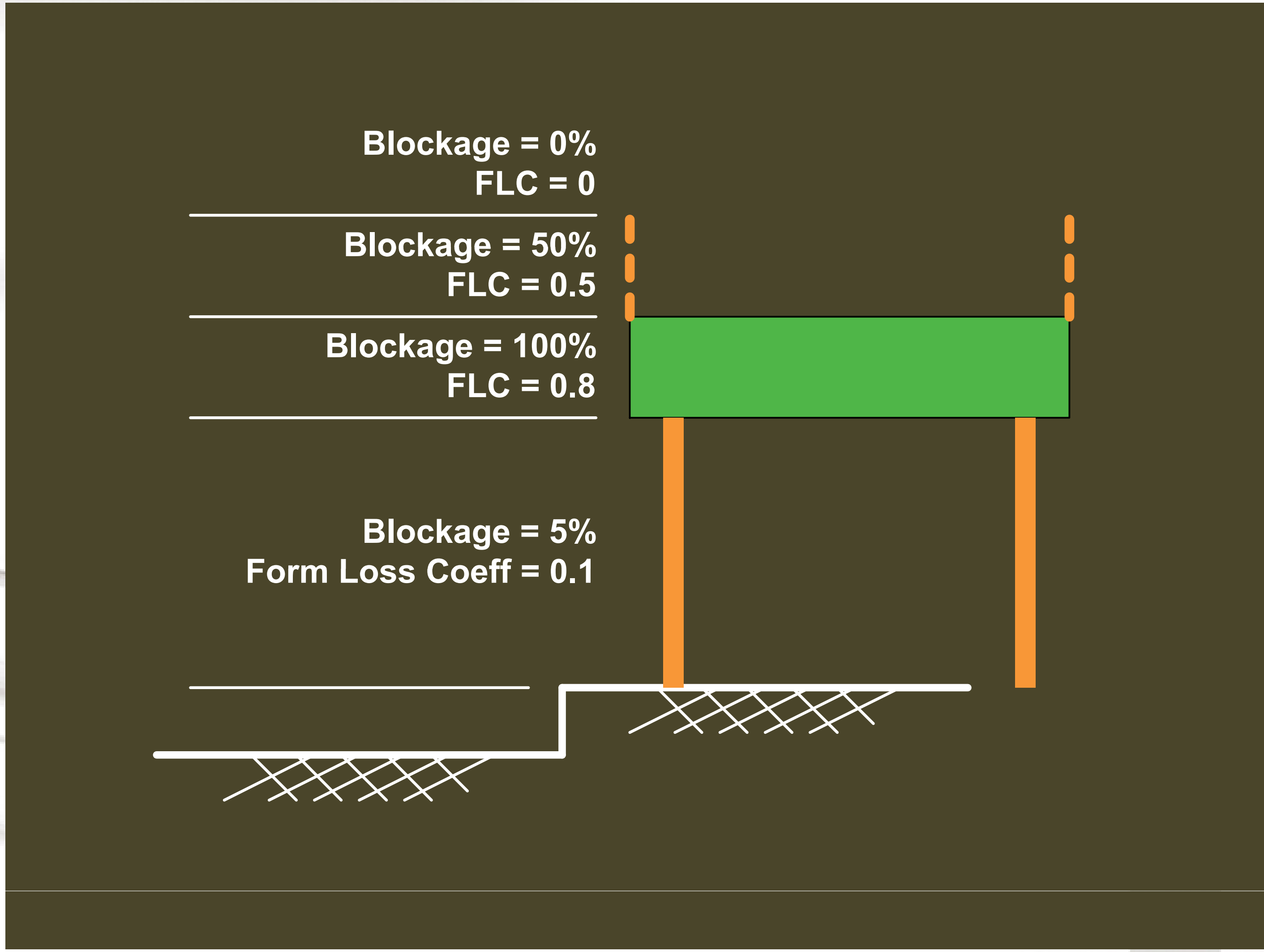
- Important where bed resistance term does not dominate and a rapid changes in velocity occur – usually:
  - Where Manning's n values are low and/or in deep water zone
  - And where there is Flow constrictions
- Smagorinsky formula is preferred (default)
  (Varies coefficient based on velocity gradient)
- Some 2D schemes omit this term



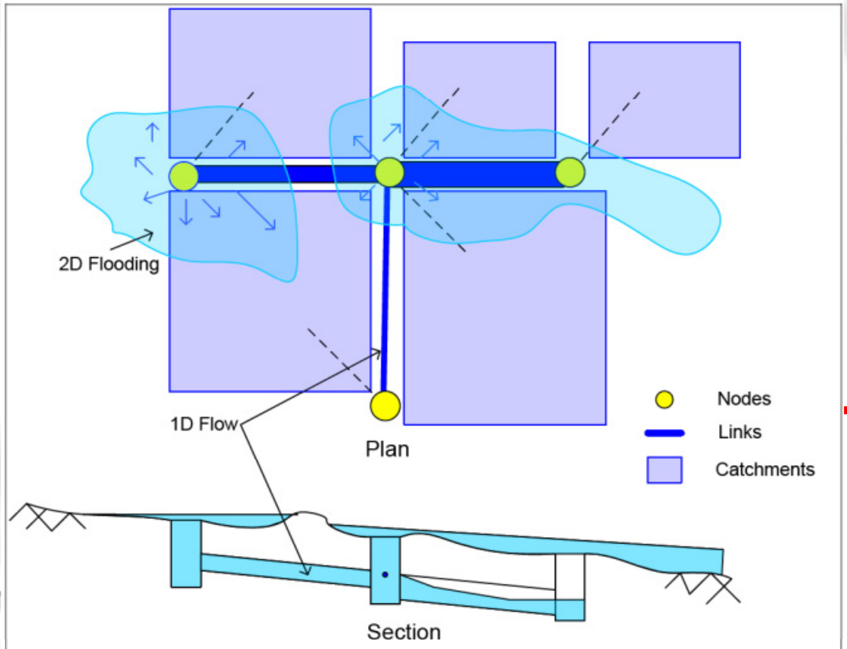
Important Terms: Additional Energy Loss

- Energy dissipated as heat due to changes in velocity magnitude and/or direction
- Pronounced at
  - Bends
  - Flow constrictions (structures)
    - Basement floors
    - Subway stations
    - Bridge piers
    - 3D effects
    - Expansion losses at Vena Contracta
- Represented as “Form loss” coefficient
  - Proportion of dynamic head ($V^2/2g$) lost
  - Usually it would be a calibration parameter

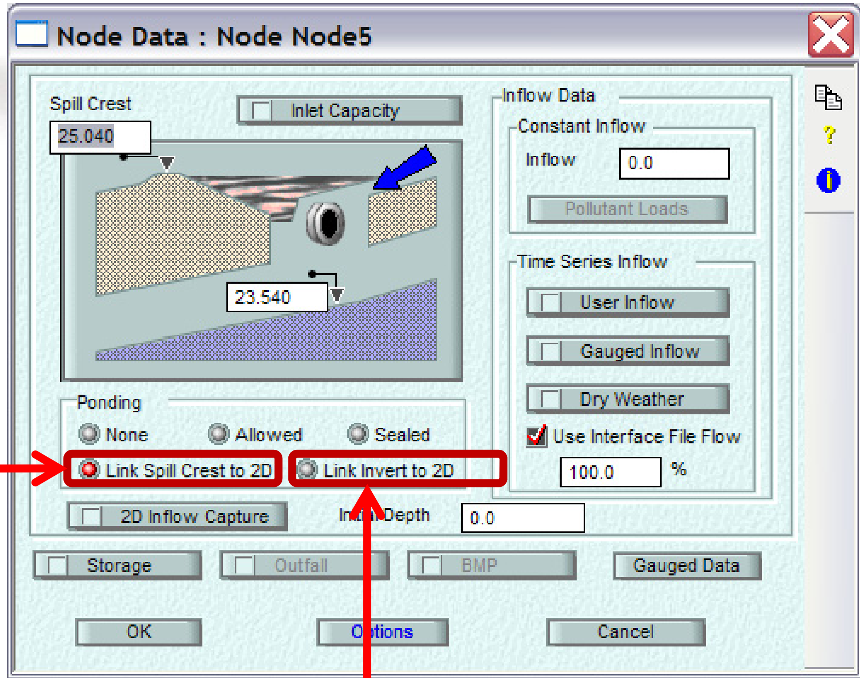
Layered Blockage



1D Manhole & 2D Linking



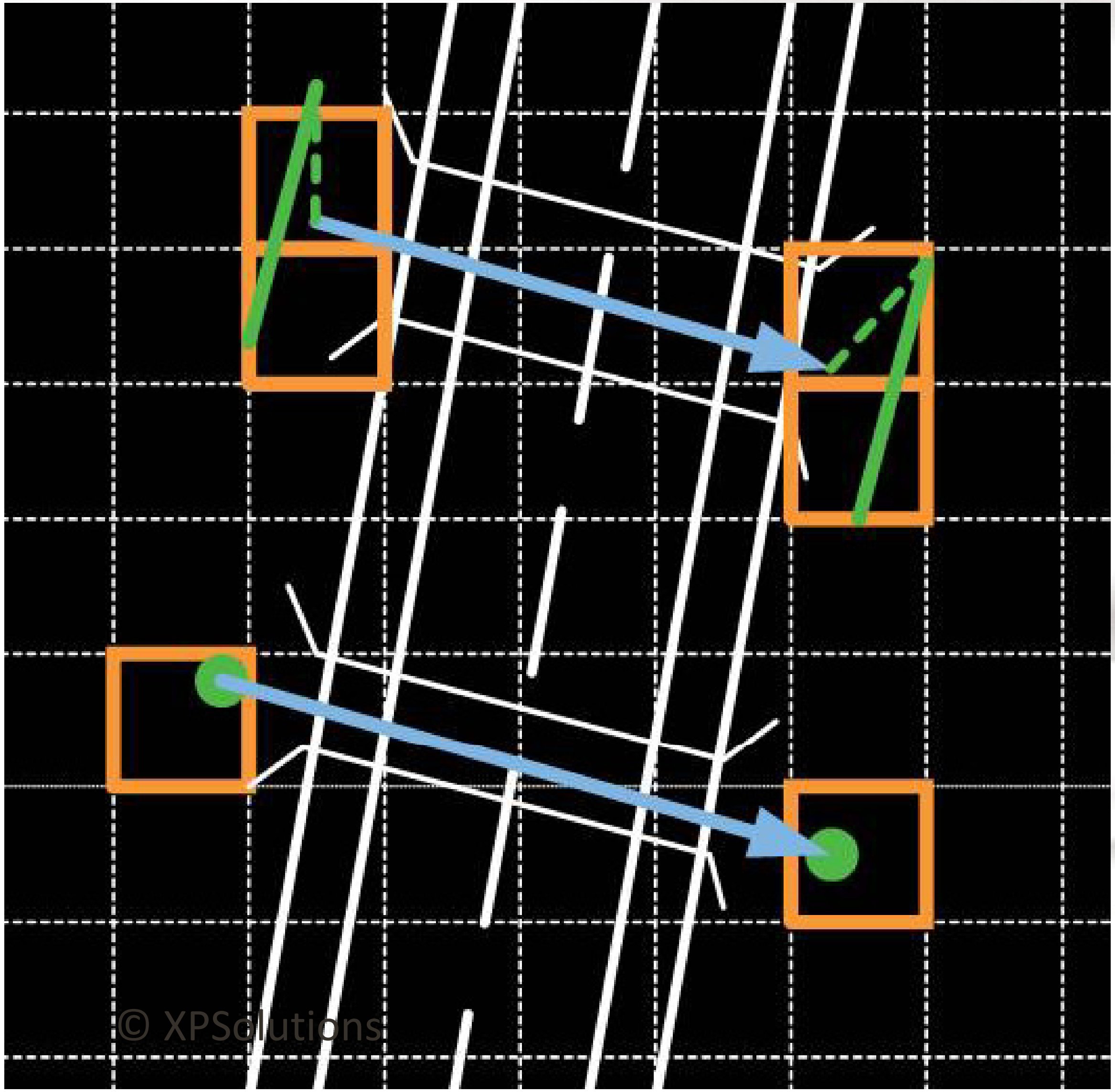
Link to Spill – Manhole



Link to Invert: Culvert

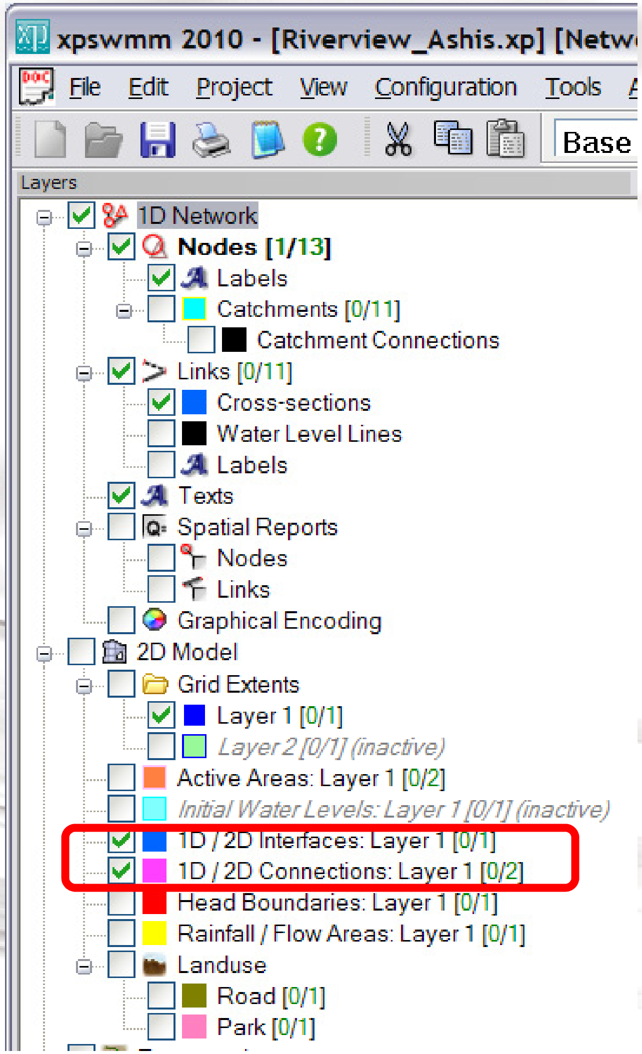
1D Culvert & 2D Linking

Culvert Through an Embankment

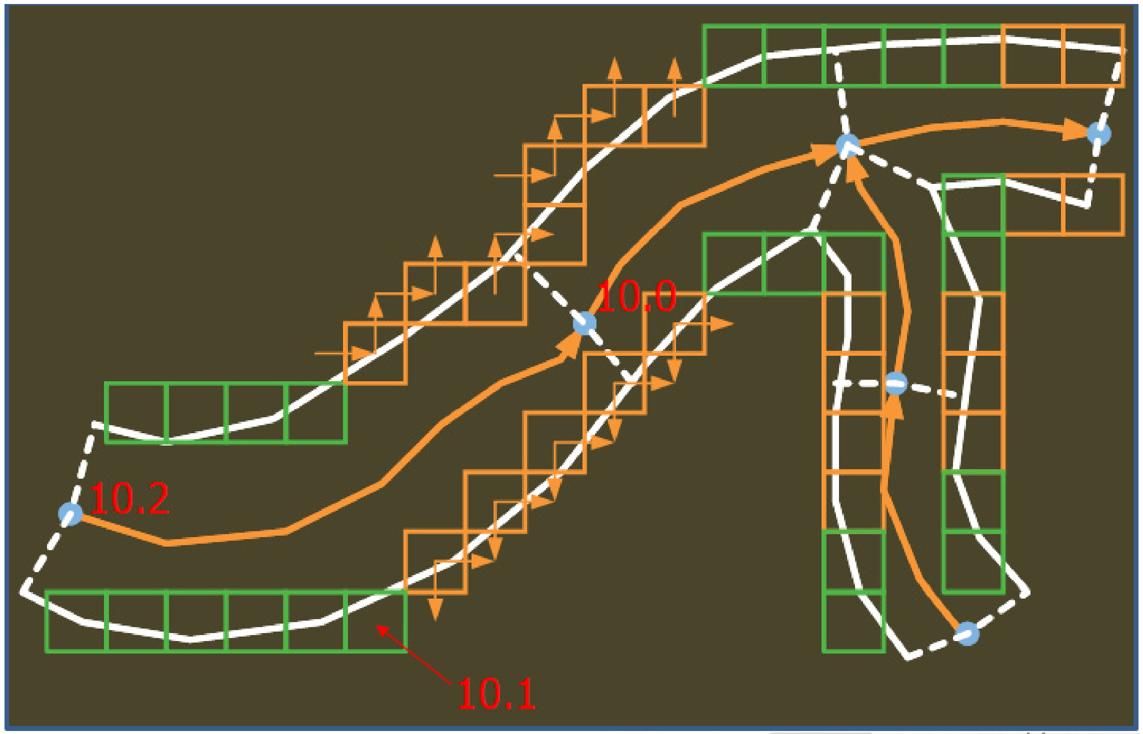


- Large 1D structure linked to several 2D cell
- Small 1D structure linked to single 2D cell

1D River & 2D Linking



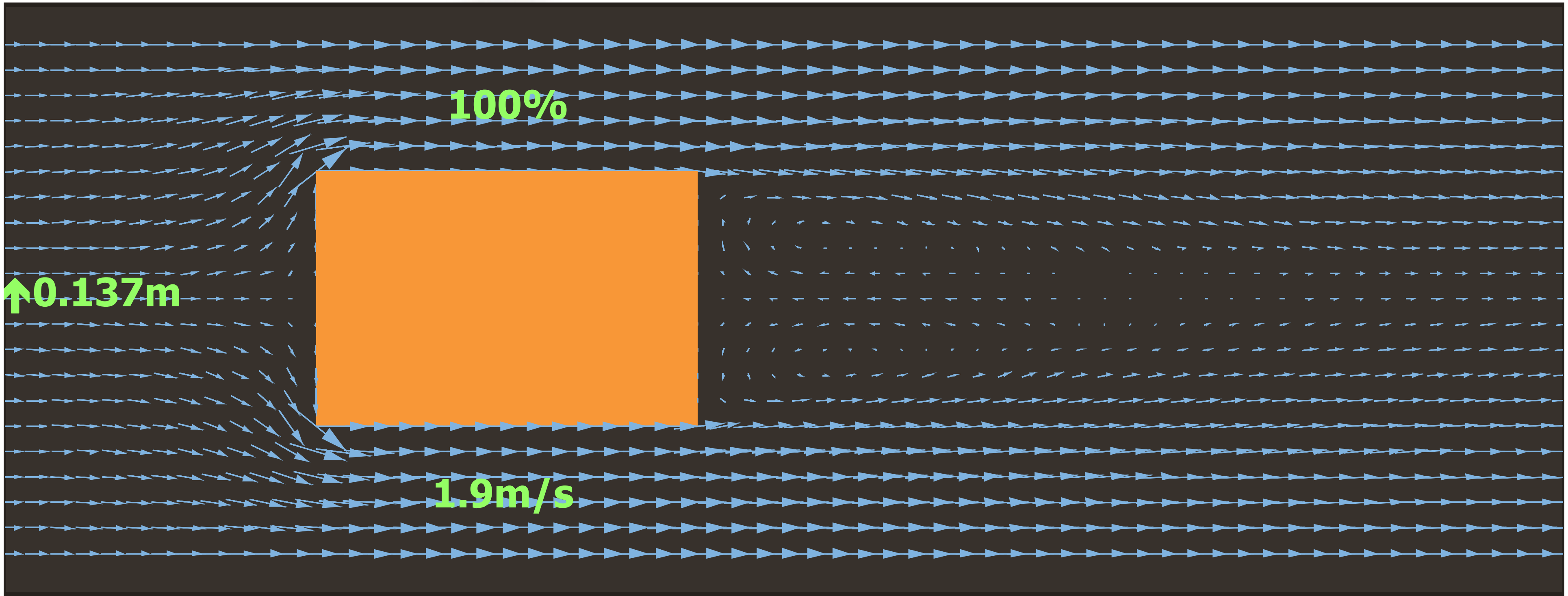
- Create 1d/2d interface line **along river banks**
- Connect 1d nodal point to 1d/2d interface line



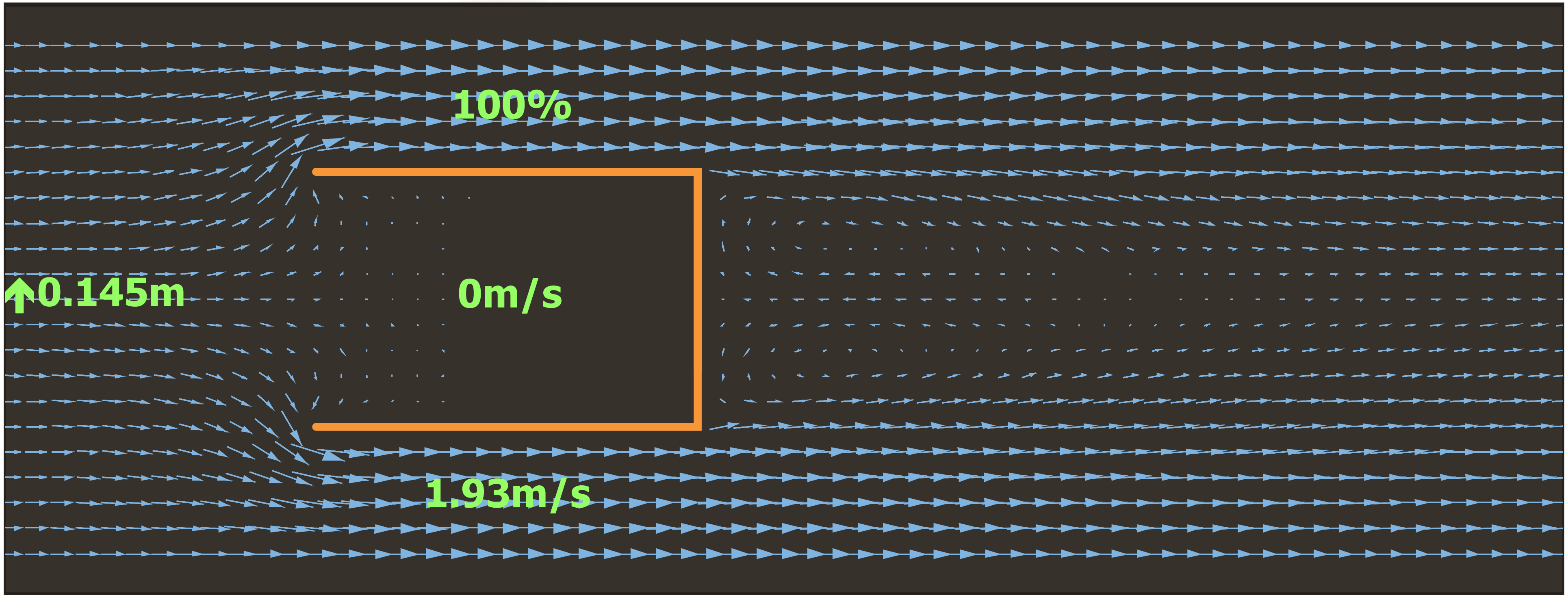
Modelling Buildings?

Queanbeyan, Dec 2010

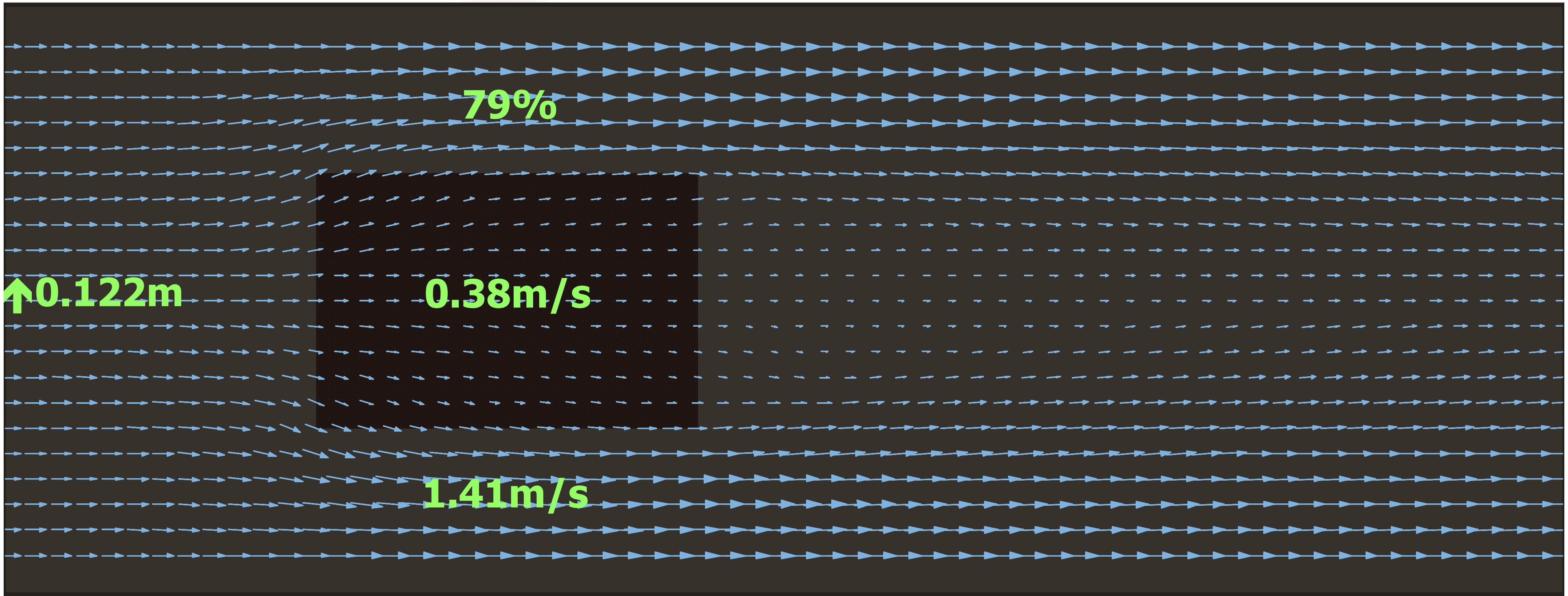
Modelling Buildings
Block Cells Out



Modelling Building Walls Blocked/Open Upstream

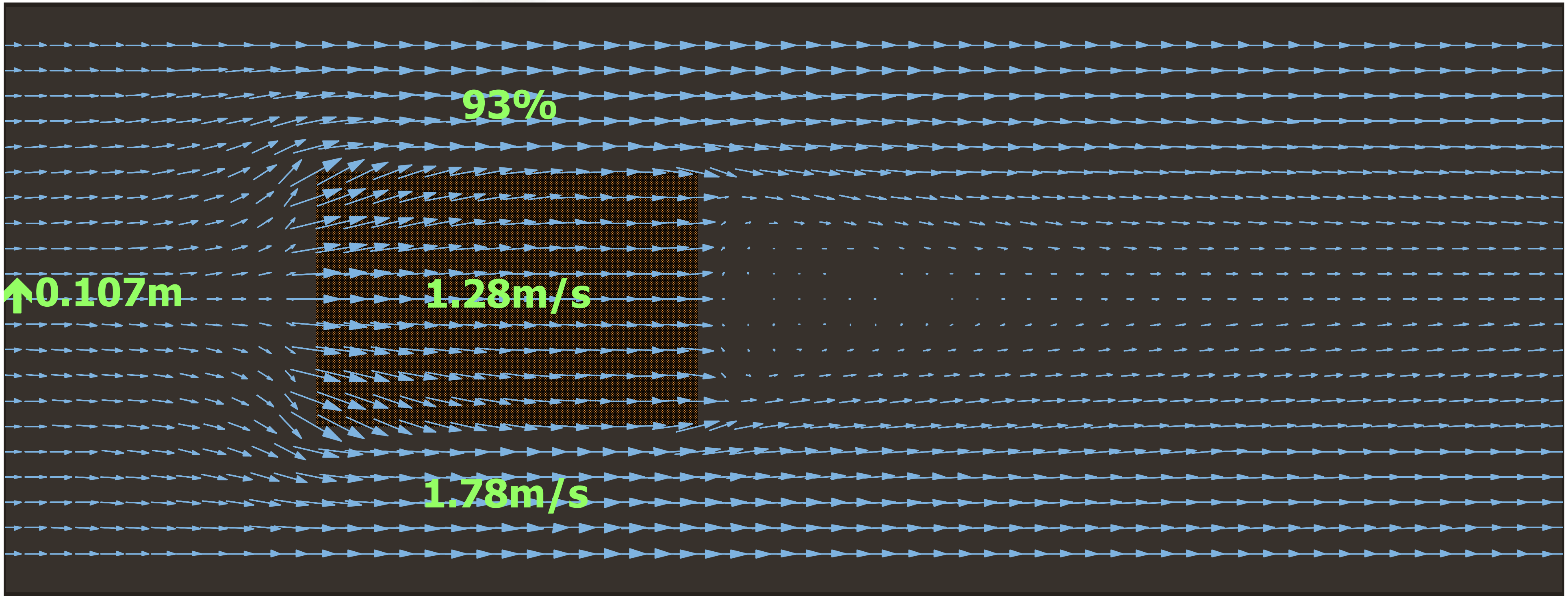


Modelling Building Roughened Up (n = 0.3)

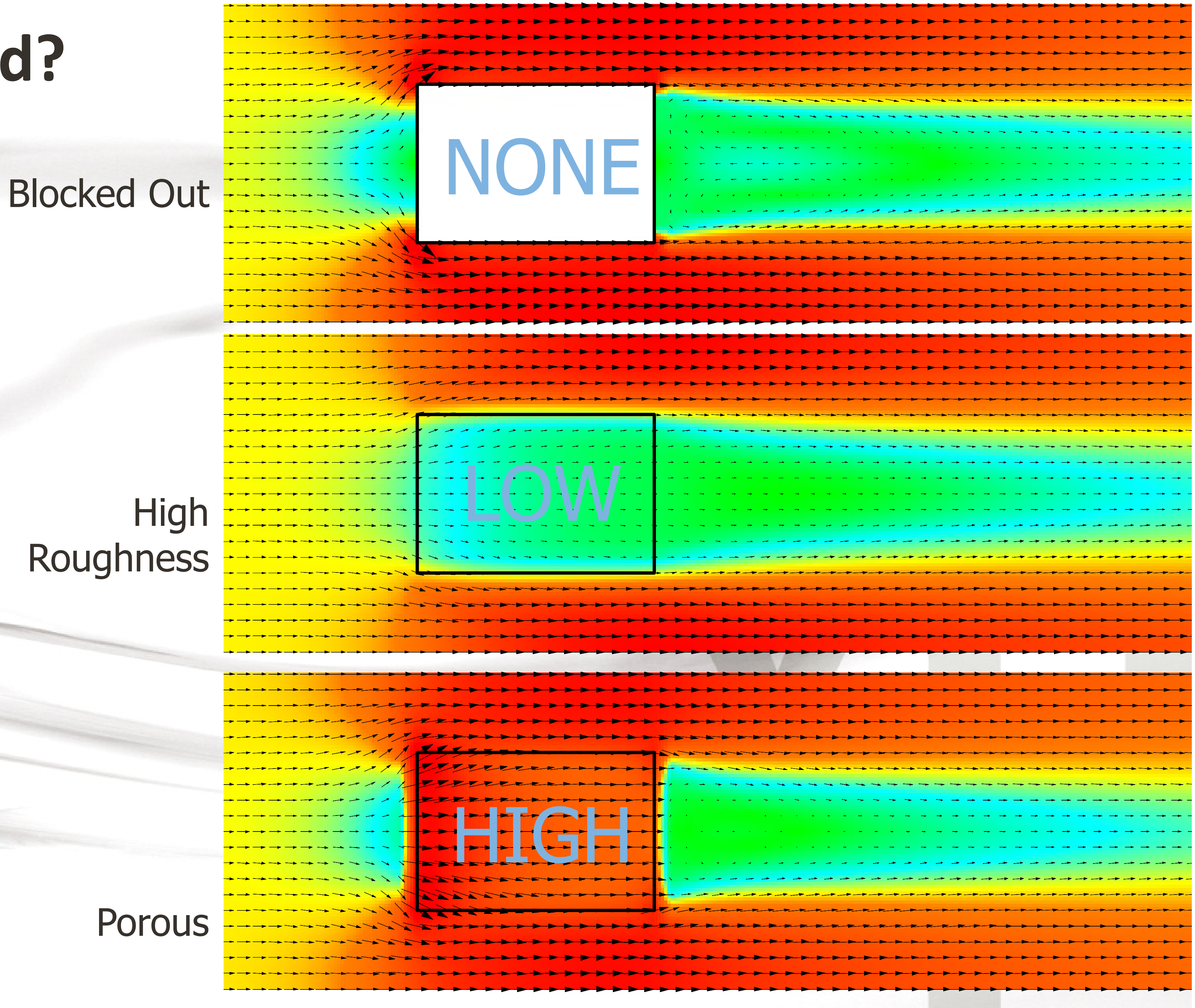


Modelling Building Porous (Blockage = 90%)

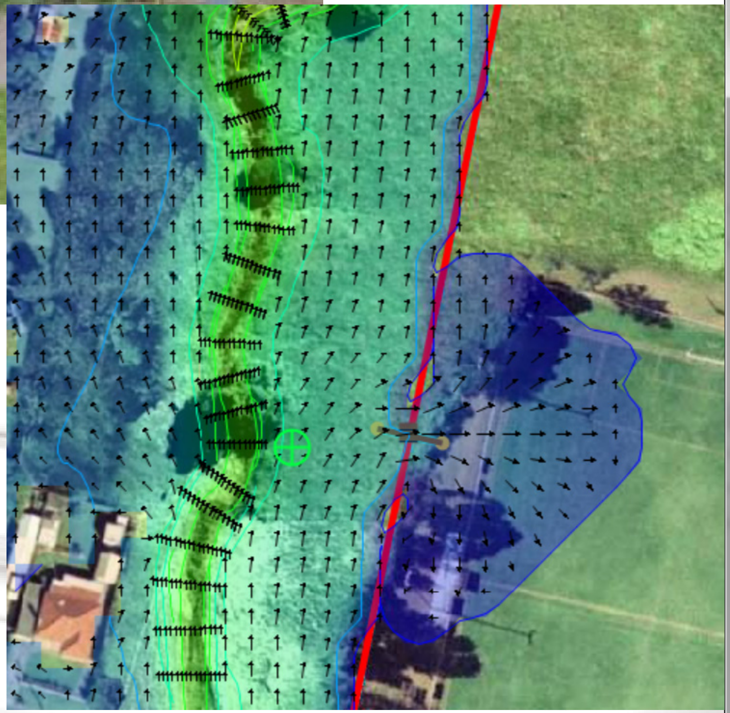
Energy Loss ($0.1*V^2/2g$)

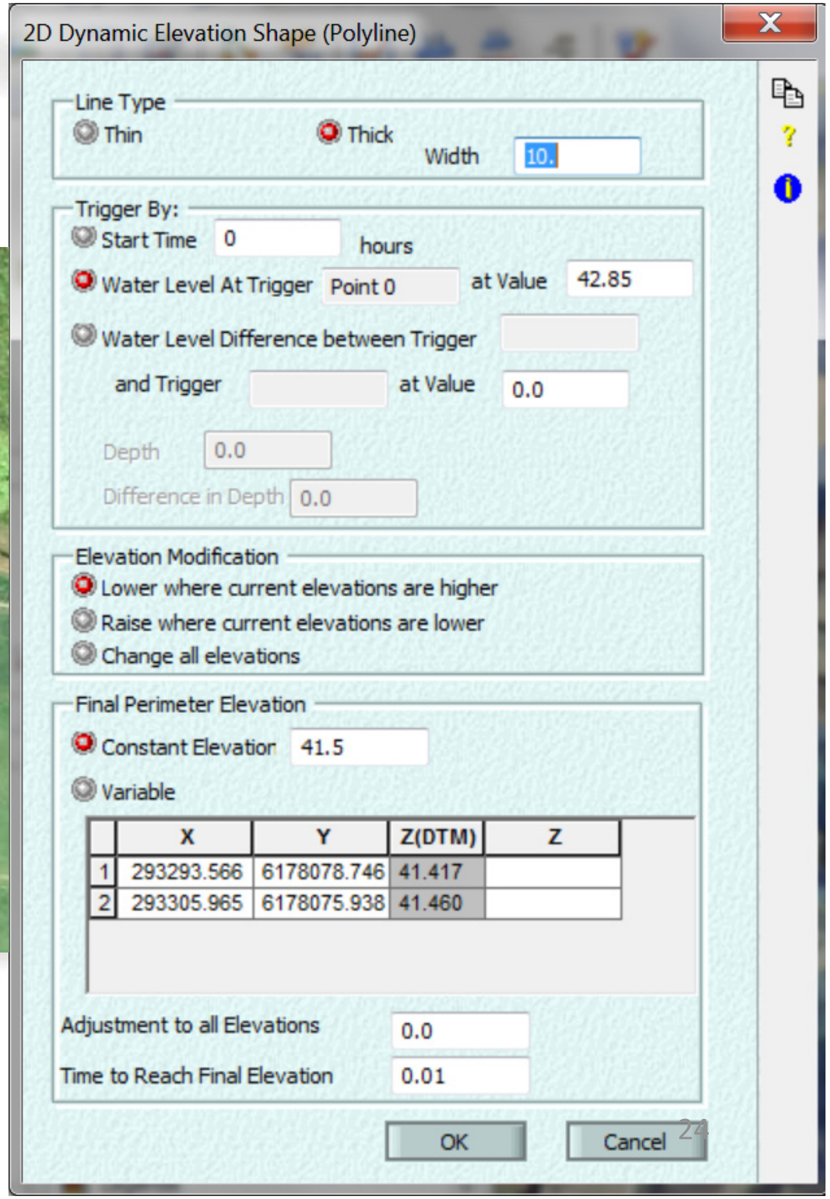


Hazard?



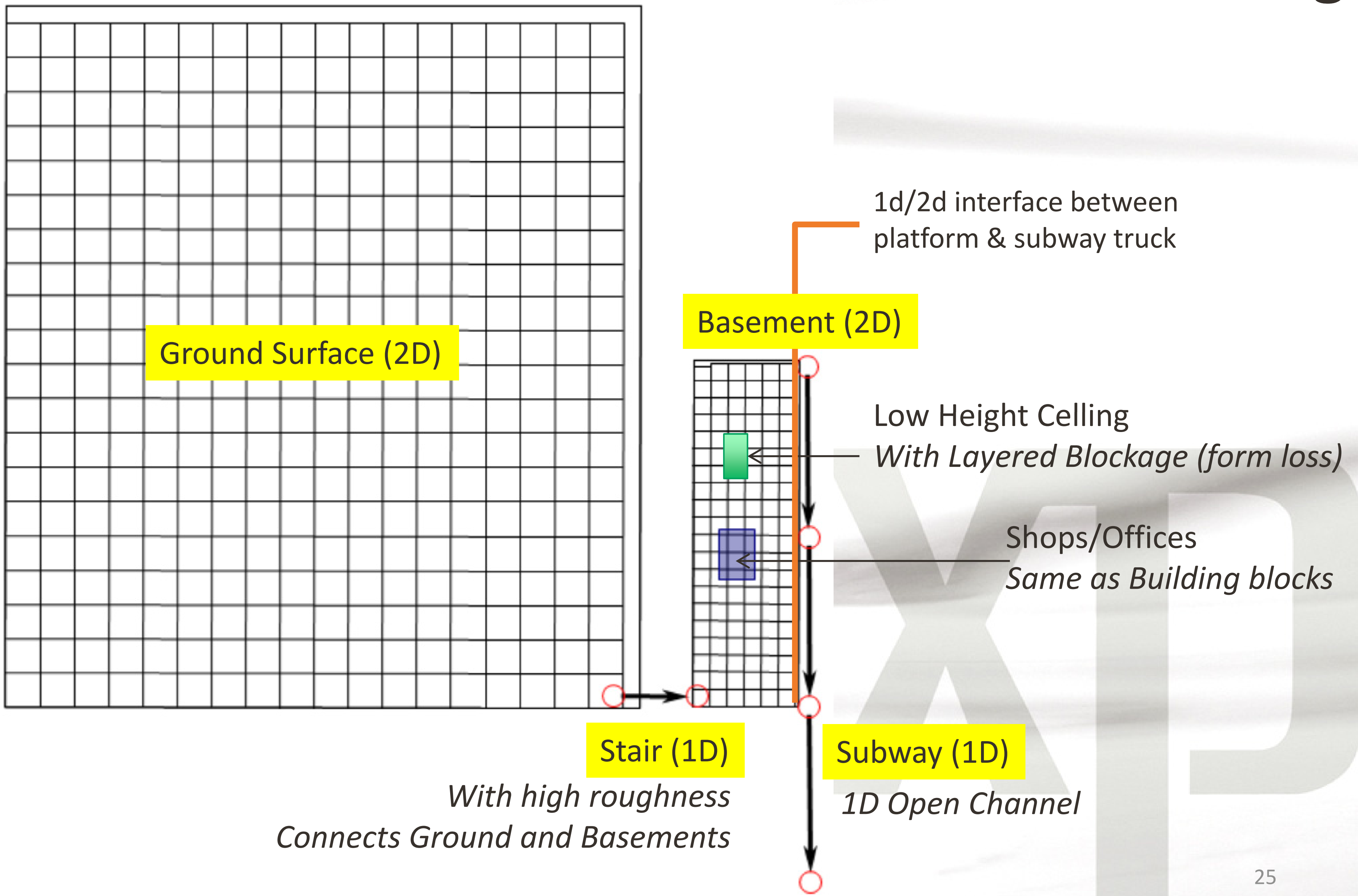
Levee/Dam/Fence Break





- Proper Breaking condition setting is essential

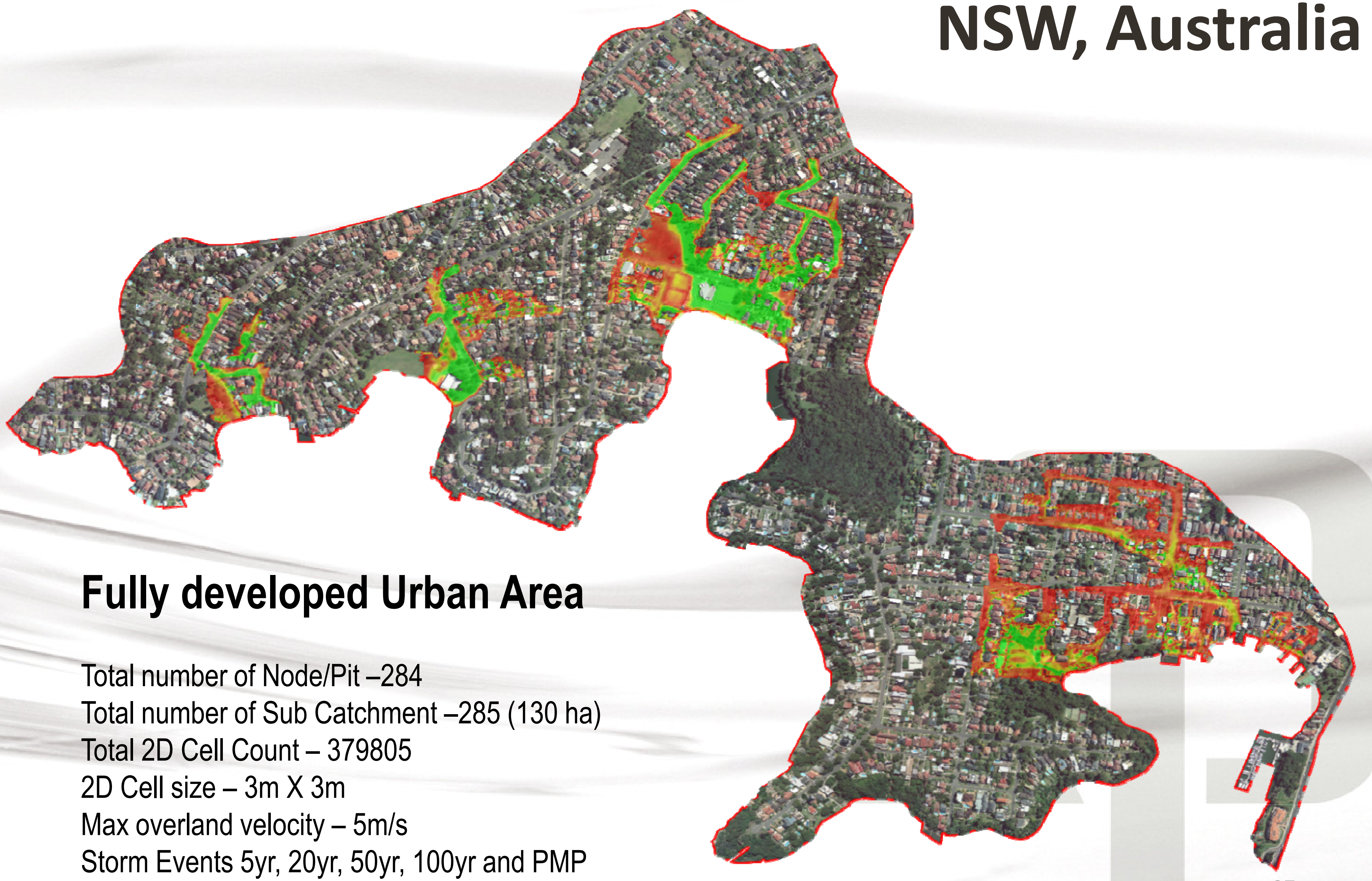
Basement Flooding



XP2D Application

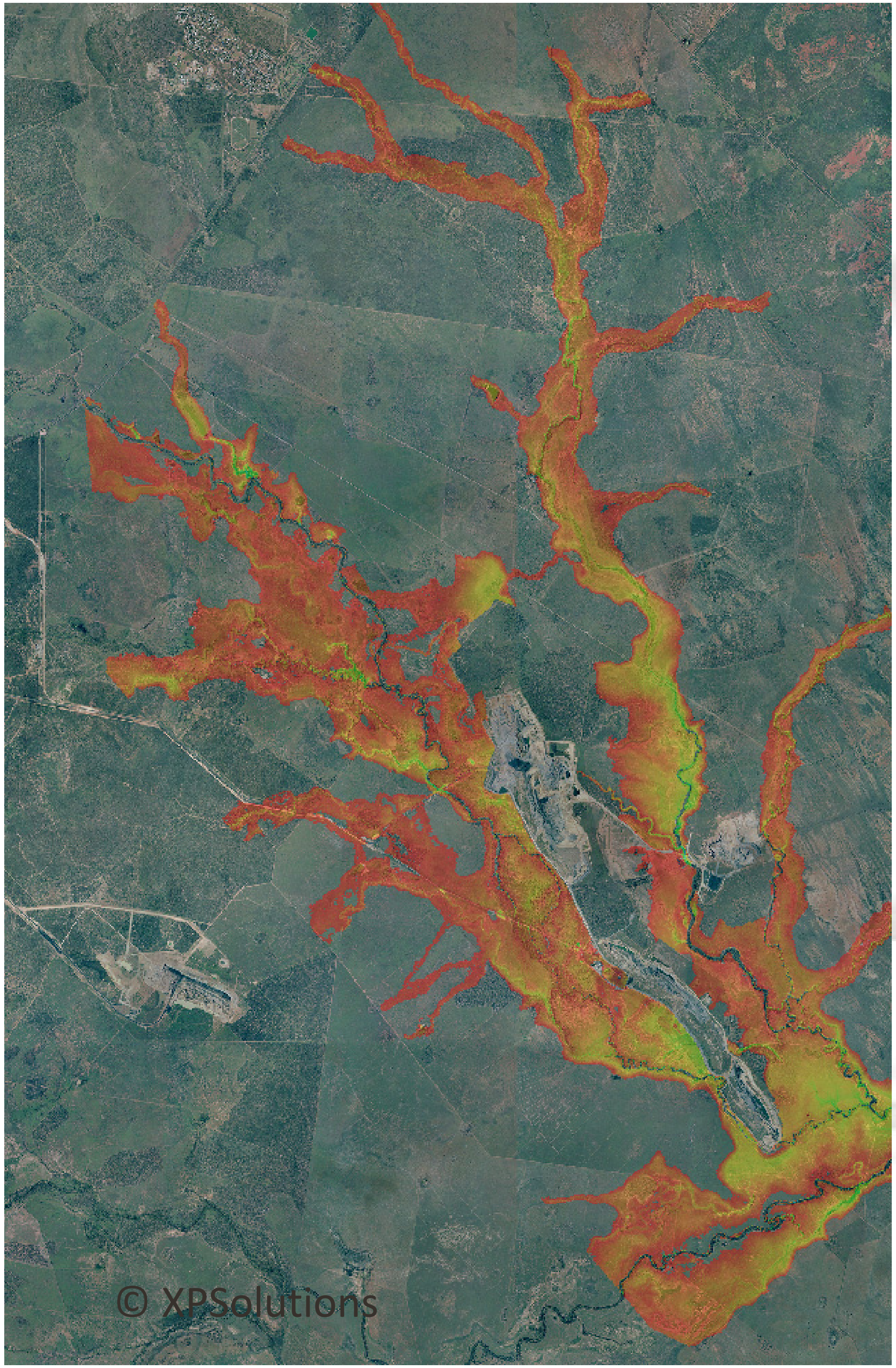
100s of Project Done

Case Study: NSW, Australia



Fully developed Urban Area

Total number of Node/Pit –284
Total number of Sub Catchment –285 (130 ha)
Total 2D Cell Count – 379805
2D Cell size – 3m X 3m
Max overland velocity – 5m/s
Storm Events 5yr, 20yr, 50yr, 100yr and PMP



Case Study: QLD, Australia

Rural Mining Area

Node –Total 300 (active)
Link – Culvert: 10, Channels: 202
Node with User Inflow– Total 95
2D Cell –Total 907481 (Cell size 20m)
2D Head Boundary – 1 (free outfall)
2D Flow Boundary - None

(Existing Condition for Q1000, 18hr event)

Costal Area – Tsunami Model
(East Japan Tsunami 2011)

Case Study: Sendai, Japan