



Figure 1. Steady vs. unsteady 1D water surface elevation profiles





Figure 2. 1D vs. 2D water surface elevation profile without structure





Figure 3. Grid size sensitivity for 0.5-metre, 1-metre, 2-metre, 5-metre, 10-metre, and 20-metre computational grid vs. 1D results, high flow scenario





Figure 4. Wetting front for 0.1 second, 0.5 second, 1 second, and 2 second time steps using 2-metre computational mesh





Figure 5. Maximum water surface elevation for 0.1 second, 0.5 second, 1 second, and 2 second time steps





Figure 6. Grid size and time step sensitivity with culvert in place







Figure 7. Blocked flow assessment





Figure 8. 2D water surface elevation profiles for gate vs. culvert





Figure 9. Diffusion wave vs full momentum for standard 2D culverts





Figure 10. Diffusion wave vs full momentum for wormhole culverts





Figure 11. Weir flow vs. terrain for wormhole culvert





Figure 12. 1D vs. coupled 1D/2D water surface elevation results



## Water Surface Elevation on 'Profile' - 1D Culvert Sub OC 'Open' 13 -- 1D Culvert Sub Pr 'Pressure' - 1D Culvert Sub Wr 'Weir' - 2D\_Internal\_Culv\_OC 'Max' 2D\_Internal\_Culv\_Pr 'Max' - 2D\_Internal\_Culv\_FM\_Mx\_Wr 'Max' - 2D\_Wormhole\_OC'Max' 12 -- 2D\_Wormhole\_Pr'Max' 2D\_Wormhole\_FM\_Mix\_2DTerrain 'Max' - 'Sydney\_Harbour\_Merged\_Blocked\_Channel' Profile 11 -10 -Value [meters] م 0 20 40 100 120 140 160 180 200 220 240 260 280 300 320 340 360 420 440 460 480 500 60 80 380 Station [meters]

Figure 13. 1D vs. 2D standard weir with culvert vs. 2D wormhole culvert water surface elevation profiles