Camellia West

Flood Assessment

August 2012

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1. Introduction and Background

Mott MacDonald has been engaged by Statewide Planning Pty Ltd to prepare this flood assessment in support of the proposed development works for the site identified as Camellia West, located at 181 James Ruse Drive, Camellia.

It is proposed that the site be redeveloped with an end use of mixed commercial and high-rise residential activities.

Based on the findings of a Flood Enquiry application submitted to Parramatta City Council, we understand previous flood studies have shown the subject site to be flood affected from the Parramatta River.

An assessment of the Parramatta City Council flood map has indicated the following levels are relevant to the subject site:

- The 20 year ARI flood level is RL 4.14m AHD;
- The 100 year ARI flood level is RL 4.75m AHD; and
- The PMF level is RL 8.99m AHD.

Parramatta's Local Floodplain Risk Management Policy divides land within the catchment into flood categories based on the level of potential flood risk. By incorporating the above mentioned flood levels and interpreting Council's flood risk map as well as accounting for the general location of the site, we can make the assumption that the site is categorised as a High Flood Risk Precinct. We note however, that portions of the site are not subject to high hydraulic hazard and appropriate evacuation systems can be incorporated for the premises in the case of a major flood event. It can therefore be argued that sections (namely residential areas) of the site be categorised as falling within the Medium Flood Risk Precinct.

Mott MacDonald has undertaken two-dimensional (2D) flood modelling to determine the effect the development will have on flood storage and flow conveyance through the subject site, as well as demonstrating that the proposed development will have no adverse impacts on upstream/downstream properties. This report will outline the methodology and findings of the study as well as demonstrate the developments compliance with the Floodplain Matrix controls outlined in Parramatta Council's Local Flood Risk Management Plan.

The aim of this report is to:

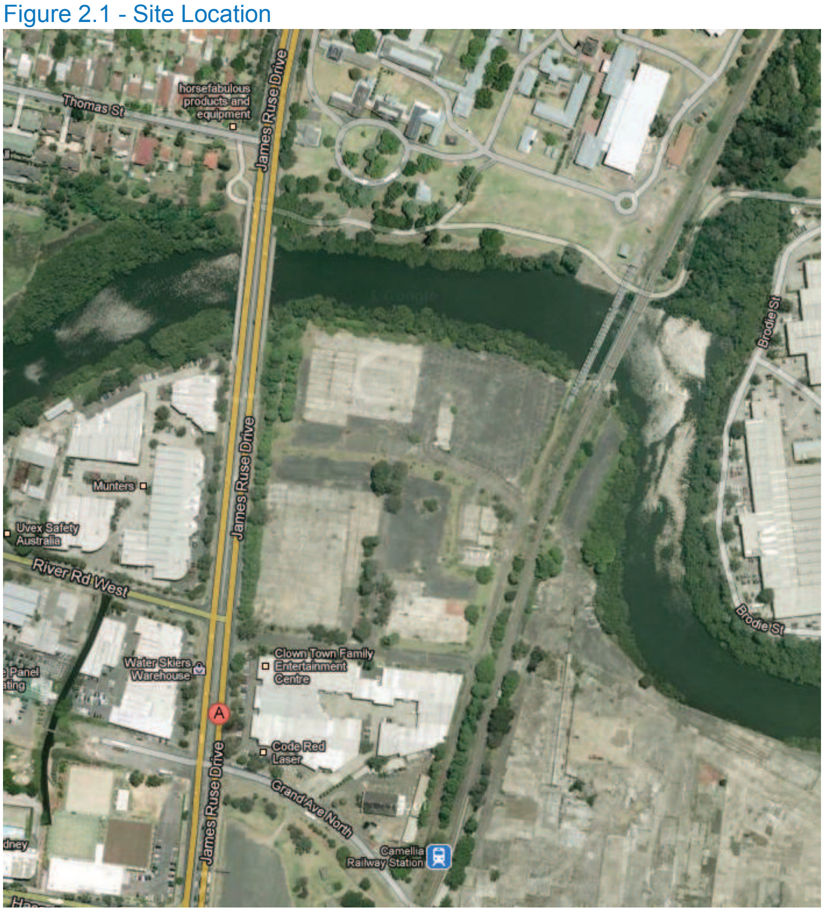
- compare the extent of flooding within the site in a pre-to-post scenario; and
- demonstrate that the necessary requirements regarding floodplain risk management have been identified and that the proposed development complies with these requirements.

2. Site Location

2.1 The Existing Site

The subject site is located at 181 James Ruse Drive, Camellia and is comprised of 35 individual lots. The site is bounded by the Parramatta River to the north, James Ruse Drive to the west, offices / industrial properties and Grand Avenue to the south and the Clyde to Carlingford railway line along the eastern boundary.

Figure 2.1 - Site Location



The existing site area of approximately 6.8Ha is predominantly vacant with areas of light vegetation, bitumen roads and concrete slabs on ground.

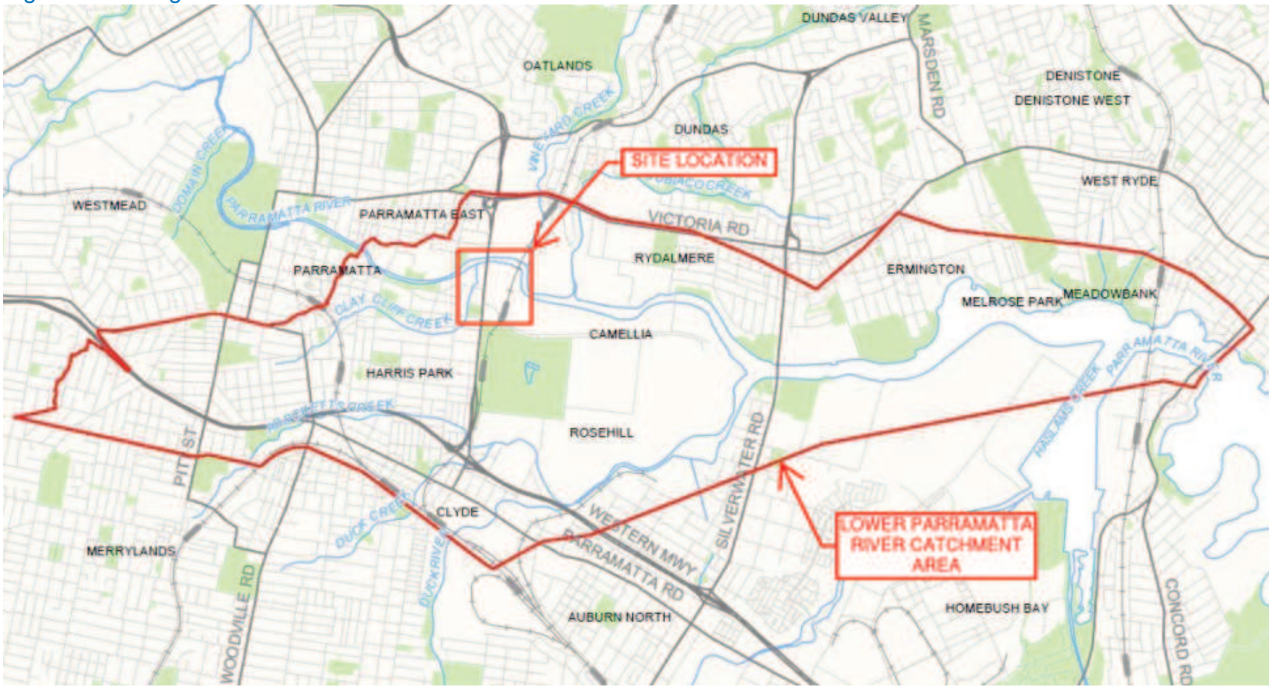
The site is relatively flat over the large paved areas and falls to a low point within the site located at the eastern boundary along the Carlingford Rail line. Existing drainage infrastructure has been ignored in this assessment.

Flows are conveyed past the subject site from the west along the Parramatta River with additional flows adjoining just downstream of the site from Vineyard Creek.

2.2 Regional Location

The existing site is shown in its regional stormwater catchment context in Figure 2.2 below. The regional stormwater catchment has been identified in Parramatta City Councils Floodplain Risk Management Study.

Figure 2.2 – Regional Stormwater Catchment



Source: Lower Parramatta River Floodplain Risk Management Study (SKM, 2005)

The catchment comprises the waterways, tributaries, foreshores and adjacent low-lying lands of the Lower Parramatta River from Charles Street weir to Ryde Bridge. The catchment is highly urbanised with development extending into the floodplain.

3. Flood Assessment

3.1 Introduction

TUFLOW, a two-dimensional (2D) hydraulic modelling program has been used to assess the existing (pre-development) and proposed (post-development) flooding scenario for the 1 in 100 year flood event within the subject site. The hydrological assessment has utilised existing results published in the Lower Parramatta River Flood Study, previously undertaken by SKM in 2005 and adopted by Parramatta City Council as part of their Floodplain Management policy. Hydraulic terrain flood modelling (2-dimensional) has been undertaken for the subject site using *TUFLOW*. A detailed description of the hydrological and hydraulic modelling assessment is provided in following sections of this report.

The objectives of the flood assessment are to determine the effect the proposed development will have on flood storage and flow conveyance through the subject site. This will be addressed by:
- assessing the impacts of contributing catchments to the existing development site;
- assessing overland flow paths and downstream system constraints;
- assessing the likely impact the proposed development has on flooding on adjacent sites; and
- Identifying flood hazard/flood risk for the proposed development.

This report will also demonstrate the proposed development's compliance with the Floodplain Matrix controls outlined in Parramatta City Council's Local Flood Risk Management Plan.

3.2 Hydrologic Data

Hydrologic data was obtained from the Lower Parramatta River Floodplain Risk Management Study, Flood Study Review (*LPR-FRMS*) undertaken by Sinclair Knight Merz (SKM) in 2005. Parramatta City Council (PCC) commissioned this study in 2001 as part of the process set out by the NSW Government's Floodplain Management Manual. The report describes the data collection and flood study aspects of the larger Floodplain Risk Management Study.

The following data was obtained from the above mentioned report and is shown attached in Appendix A;
- Cross-section locations along the Parramatta River;
- Cross-section data (Station vs. Elevation) of sections;
- Peak water levels associated with each of the utilised cross-sections;
- Peak flow rates associated with each of the utilised cross-sections.

The peak flow rates and water levels associated with these cross-sections correspond to the Flood Enquiry application data received for the development. The data has been used for the design and calibration of the model.

3.3 Hydraulic Model

3.3.1 TUFLOW Software Package

The subject site and the adjacent Parramatta River were modelled using the TUFLOW program.

TUFLOW computes flow paths by dividing the floodplain into a grid of individual cells. The flow of water between cells is then computed repeatedly at regular timesteps by solving two dimensional shallow water equations to estimate the flood spread and flow. As each cell contains information on water levels, flows are routed in the direction that will naturally follow the modelled topography.

3.3.1.1 Model Build

The *TUFLOW* model extents were selected to examine the area judged to be contributing to the flows affecting the site. This incorporated a number of sections from the *LPR-FRMS* Flood Study (as shown in Appendix A).

In order to simulate the flood events across the site, inflow boundary conditions in the form of peak flow rates (m^3/s) were inserted at key locations along the model extents. These locations were selected where existing cross sectional data was available that intersected with our *TUFLOW* model extents. The peak flows (extracted from the *LPR-FRMS*) associated with each upstream cross-section were applied at the low points across their respective boundaries (i.e. low points in the river channel) to simulate the floodwaters entering the river network.

The flood assessment was modelled using *TUFLOW* build 2012_05_AA_32.

3.3.1.2 Data Analysis

Subject to the data available to us, it was determined that the peak flows generated in the *LPR-FRMS* would be utilised as flow input for the model.

The following table (Table 3.1) shows the input at each of the upstream cross sections utilised in the model;

Table 3.1 - 100 year ARI Peak Storm Inputs

Cross-section	Peak Water Level (m AHD)	Peak Flows (m^3/s) applied to the model
PARRAMATTA_R_4065	5.01	855
VINEYARD_CK_3000	4.64	77

Source: *LPR-FRMS (SKM, 2005)*

This data was extracted from the *LPR-FRMS* Flood Study Review (SKM, 2005).

It is important to note that the peak flood level, flow and velocity at each cross section may not necessarily result from the same storm duration for the same flood event. We have adopted the maximums as a worst case scenario.

3.4 Pre Development Flood Assessment

3.4.1 Existing Flow Regimes

Based on our initial investigations, it was determined that flows from large storm events were entering the subject site along the northern boundary from the Parramatta River. Flows generally enter the site up the existing rail corridor in the north east corner of the site before overtopping the northern banks.

3.4.2 Pre Development 2D (*TUFLOW*) Modelling

A *TUFLOW* two dimensional (2D, surface terrain) flood model was prepared for the existing scenario.

3.4.2.1 Digital Elevation Model

A digital elevation model (DEM) was generated using LiDAR (Light Detection and Ranging) aerial survey obtained from AAM Group for the site and surrounding catchment area. The survey was undertaken in 2008.

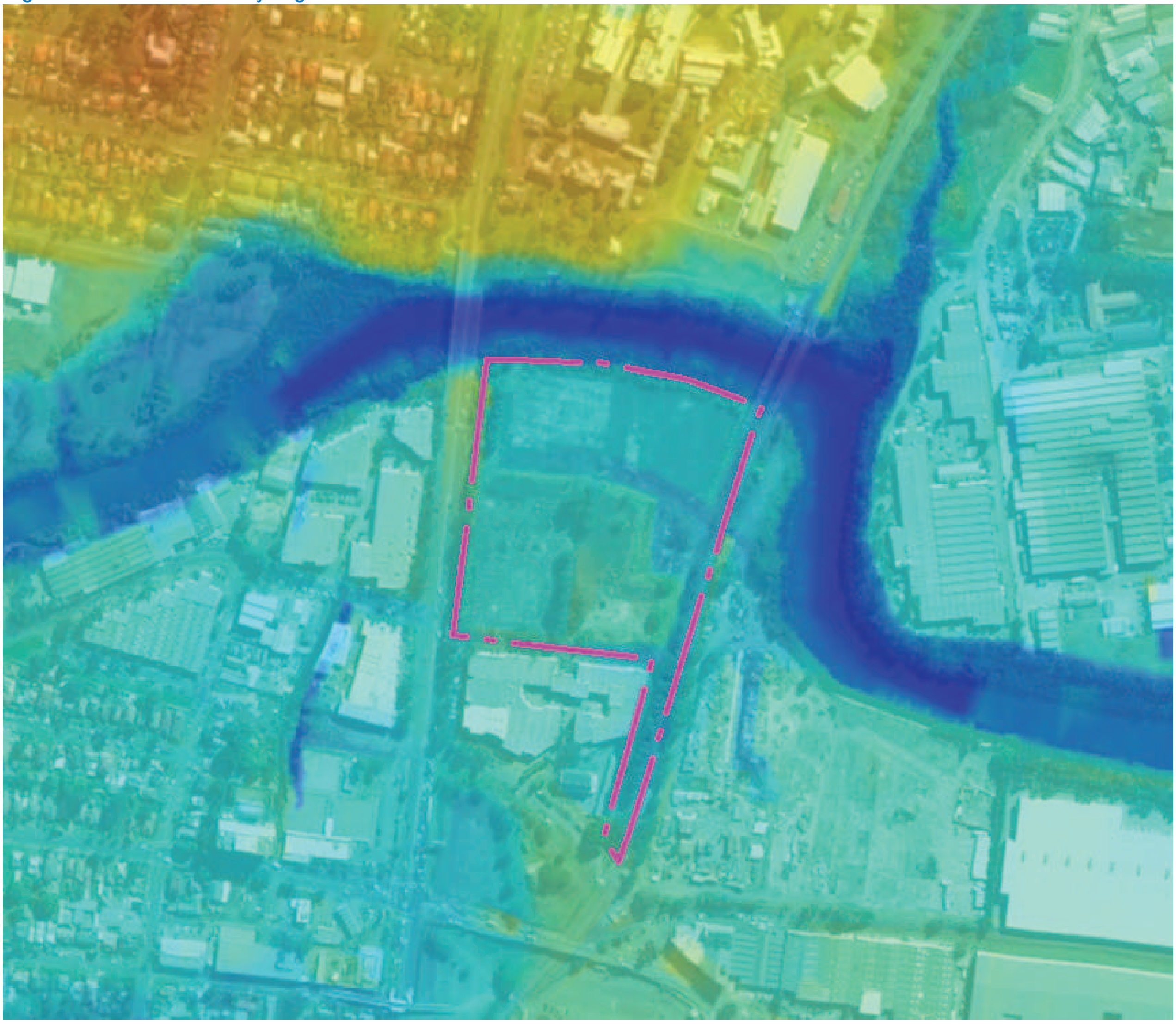
As the LiDAR survey is unable to accurately represent river bathymetry, existing cross-section data was combined with the LiDAR information to more accurately represent the river channel. River channel cross-section data obtained from SKM's MIKE11 model was used to represent the Parramatta River and adjoining tributaries. This data set was originally used in the *LPR-FRMS* and was obtained from Parramatta City Council for the purposes of this study.

These cross sections were integrated into the DEM through the use of the '12d' civil design program with the existing cross section data aligned with the channel banks from the LiDAR survey. The bed of the channel was then interpolated between the existing sections shown and a triangulation of the data points was performed to create the DEM representing the existing scenario.

A comparison of the LiDAR and detailed site survey was undertaken to determine the accuracy of the LiDAR information. LiDAR levels were generally within a -/+ 100mm tolerance of the detailed surveyed levels and therefore considered appropriate for use in this model.

Figure 3.1 below shows the LiDAR survey DEM colour gradient as a representation of the base elevations used in the model. This image was generated using MapInfo Software. Here the red colours indicate high elevations with the blue representing lower lying terrain.

Figure 3.1 – LiDAR Survey Digital Elevation Model



3.4.2.2 Model Extent and Grid Generation

A *TUFLOW* modelling grid was generated for the model extents. The finite element grid forms the basis for *TUFLOW* modelling and creates a readable network of squares that where each have applied characteristics such as elevation, slope, roughness etc.

A 2m x 2m grid size was selected for the model and was considered appropriate for urban/industrial catchments. This grid size allows a finer and more accurate representation of the flows adjacent to our site than a more conventional 5m x 5m grid.

The model extent is shown in Figure 3.2 below.

Figure 3.2 - *TUFLOW* Model Extents

3.4.3 Key Assumptions

The following is a list of key assumptions used in development of the Camellia West *TUFLOW* model;

- All pipes and culvert structures within the site area and the local surrounds are assumed fully blocked.
- Initial and Continuing Losses are accounted for in the existing flood study. They have not been applied to the two dimensional (2D) model to avoid doubling up on the infiltration losses.

Assumptions have been assessed based on engineering design principles and industry standards. We consider these assumptions reasonable for the model development.

3.4.4 Roughness Coefficients

Manning's 'n' roughness coefficients were applied within the *TUFLOW* model to regions created in a *TUFLOW* Materials file. This file bounds regions within the model area and applies a bed resistance value, in this case, a Manning's 'n' value. *TUFLOW* adopts these values for each 2m x 2m cell within the specified regions. A plan of the *TUFLOW* Materials file regions can be found in Appendix B. Each of these regions has adopted the Manning's values set out below in Table 3.2.

Table 3.2 - Materials File Values

Material Regions	Manning's 'n'
Parramatta River	0.035
Buildings	0.2
Asphalt/Parking areas	0.013
Light vegetation	0.05
Dense vegetation	0.1
Residential Areas	0.125
Train Lines/Rail Corridor	0.015
Roads	0.013
Concrete Pavements (Default)	0.013

3.4.5 Boundary Conditions

The upstream boundary conditions shown in Figure 3.3 below (BC_US_PARRAMATTA_R_4065 and BC_US_VINEYARD_CK_3000) utilise a flow versus time relationship and apply a peak flow determined in the *LPR-FRMS* model to the Camellia West *TUFLOW* model. The boundary condition distributes flow in quantity and direction across the cells based on their topography, bed roughness and whether upstream or downstream conditions control the flow.

Table 3.3 below shows the association between the *TUFLOW* boundary conditions and their corresponding peak flow rates as specified in the SKM (2005) report. The following peak flows were applied as inflows at these locations.

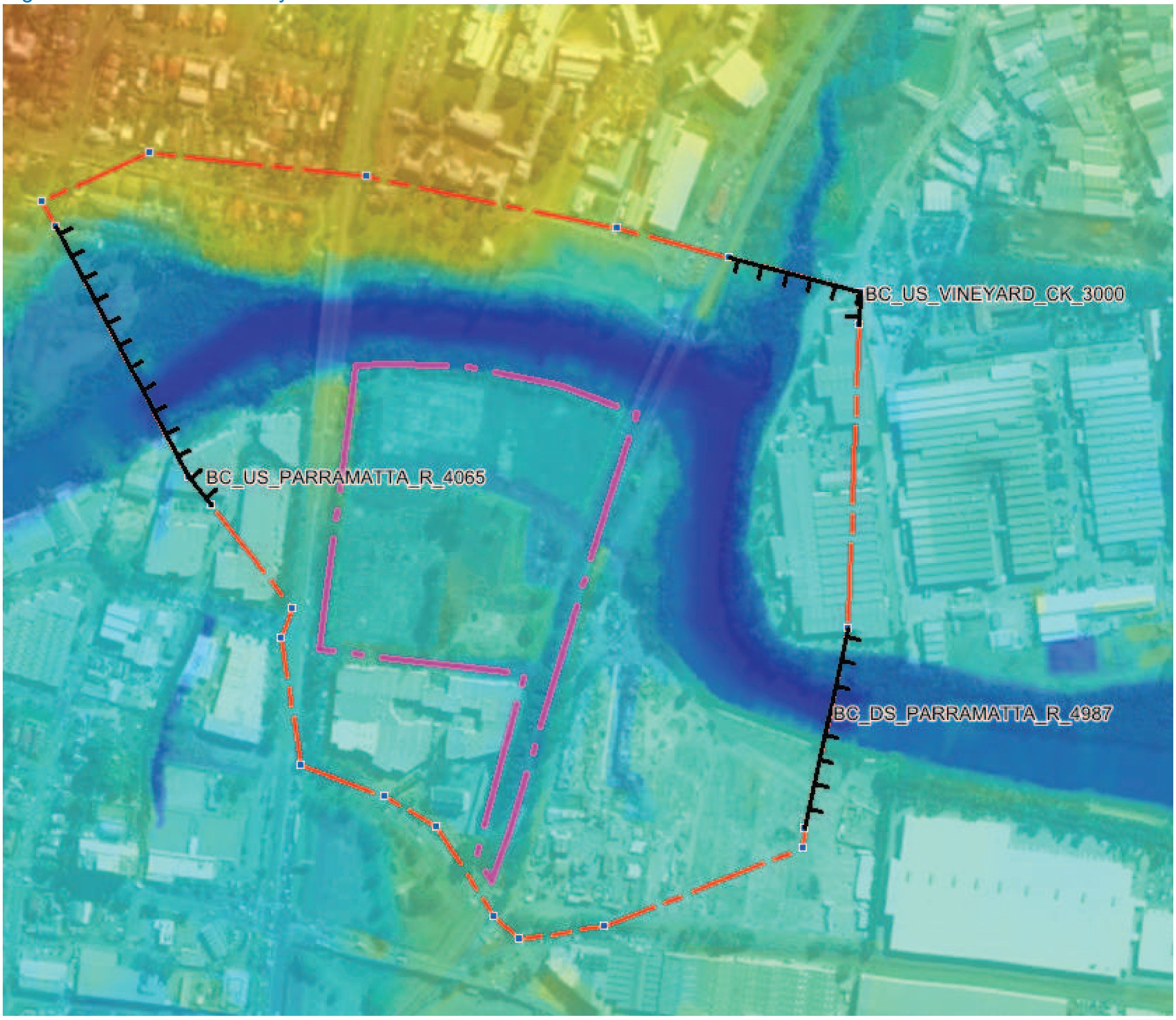
Table 3.3 - Upstream Boundary Conditions

Cross-section	Peak Flow (m^3/s)
BC_US_PARRAMATTA_R_4065	855
BC_US_VINEYARD_CK_3000	77

Source: *LPR-FRMS (SKM, 2005)*

Downstream boundary conditions were placed at the outlet of the *TUFLOW* model boundary extents as shown in Figure 3.4 below (BC_DS_PARRAMATTA_R_4987). The model assigns a water level to the cells based on a water level verses flow (stage discharge, HQ) curve. A slope is specified in the model data, and the *TUFLOW* program automatically generates the HQ curve, allowing flows to leave the model at the boundary extents without creating a dam like effect. The downstream boundary condition BC_DS_PARRAMATTA_R_4987 adopted a slope of 0.01% based on the existing survey data (slope of channel invert).

Figure 3.3 – Model Boundary Conditions



3.4.6 Floodplain

The underlying digital elevation model (DEM) for the 2D model was created from the latest LiDAR data with a 0.5m resolution. However, the 2D model covering the floodplain is based on a fixed grid with a cell size of 2m. Each grid cell is assigned with attributes including ground elevation which determines the topographic base for the 2D model. The 2m grid is generally accepted as an industry standard when modelling urban catchments. It was considered that such a model grid size would give a reasonable balance between the accuracy of the model and the model run time.

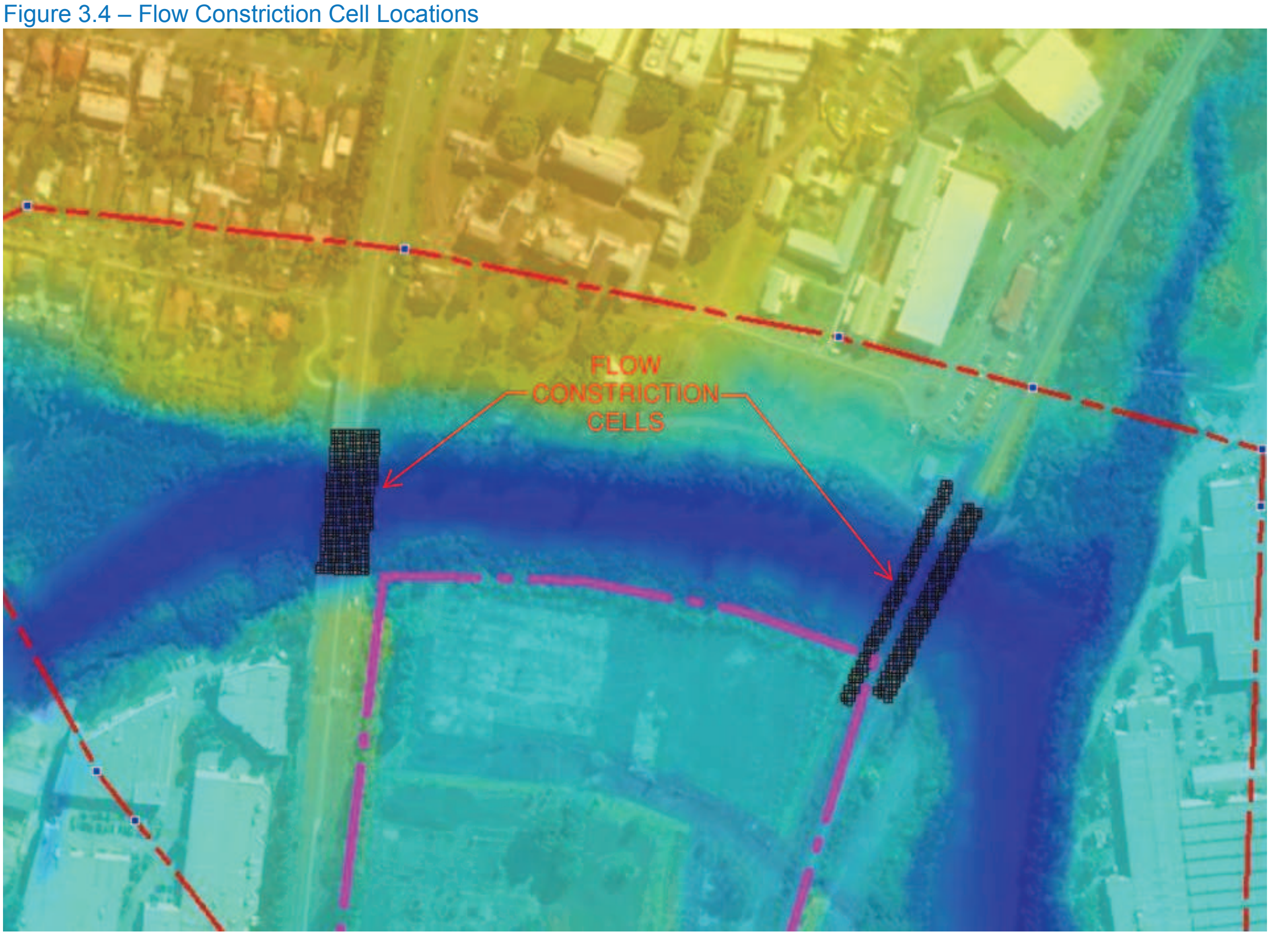
3.4.7 Flow Constrictions/Bridges

TUFLOW allows bridges, culverts and other structures that constrict flow to be modelled in 2D rather than using 1D elements. The 2D cells are able to be modified to account for additional losses associated with flows being interrupted by piers or flows reaching the underside of the deck. Additional form losses (energy head losses) can be specified.

Flow Constriction (FC) cells are used in TUFLOW to represent a constriction in the flow and fine-scale energy losses (e.g. from bridge piers). They are typically used for bridges and other structures that partially impede the water flow causing energy loss associated with the change in speed and direction of the water. However, 2D schemes do not model losses in the vertical or fine scale horizontal effects (such as around a bridge pier) and, therefore requires the introduction of additional form losses.

Three bridge structures we modelled using FC cells within the TUFLOW model. This included the river crossings at James Ruse Drive, the service structure at the north eastern corner of the site and the Carlingford Railway line. They are shown below in Figure 3.4.

Figure 3.4 – Flow Constriction Cell Locations



Additional losses were required to account for the bridge piers within the river network. 2m wide obstructions were modelled to account for losses at these points.

3.4.8 Initial Water Level

Initial water levels were set in the model based on the peak tide condition set out in the *LPR-FRMS* report. The *LPR-FRMS* report outlines that a 1% AEP tide level of 1.42m AHD was used as the downstream flood level in determining peak flood levels for the Lower Parramatta River. A constant water level of 1.42m AHD was set at the start of the simulation prior to peak flows being added to the model.

3.4.9 Model Controls

Within a *TUFLOW* model, simulation time commands are entered to control all time dependant data. For 2D models these controls include a Start Time, End Time and a Timestep. The starting time and finishing times specify the period in hours for which calculations are made. The timestep is the calculation interval in seconds, which is dependent on various conditions such as grid size and hydrograph inputs.

The model was run for a 1 hour period at a timestep of 0.1 seconds. This was a suitable period in order for the flows to reach a maximum extent of inundation before receding.

3.4.10 Model Calibration

The *TUFLOW* model was run utilising the peak flow rates extracted from the upstream cross-sections (BC_US_PARRAMATTA_R_4065 and BC_US_VINEYARD_CK_3000) extracted from the 2005 SKM report for a 100 year ARI storm event. The results were processed and Manning's values were then calibrated to achieve the flood levels similar to that found in the original flood study. The following table (Table 3.4) outlines the flood levels achieved within the model.

Table 3.4 - Water Levels – Extracted vs. Modelled

Cross Sections	Water Level (m AHD) extracted from *LPR-FRMS*	Modelled Water Level (m AHD)
PARRAMATTA_R_4065	5.01	5.02
PARRAMATTA_R_4185	4.96	4.95
PARRAMATTA_R_4268	4.75	4.78
PARRAMATTA_R_4452	4.70	4.69
VINEYARD_CK_3000	4.64	4.70
PARRAMATTA_R_4594	4.61	4.70
PARRAMATTA_R_4823	4.52	4.47
PARRAMATTA_R_4987	4.33	4.22

Source: *LPR-FRMS* (SKM, 2005)

The flood levels generated by the *TUFLOW* model are generally within +/- 100mm of the results produced in the *LPR-FRMS* report across the flood extents within the vicinity of the subject site. As our model utilises a more detailed survey, we would expect some differences in water levels across the flood extents. The minor variations from the levels produced in the SKM report indicate the *TUFLOW* model is a reasonable and acceptable representation of the existing scenario.

3.4.11 Model Runs and Results

The *TUFLOW* model was run for the 100 year ARI utilising peak flows extracted from the *LPR-FRMS*. The model was run for an event length of 1 hour to allow the flows to ‘fill’ the model and settle out before the peak extents were determined. Based on a review of the peak flood extents, flow velocities and depths it was determined that the 60 minute run duration was successful in producing the critical event affecting the subject site. The *TUFLOW* output results for the existing scenario have been attached in Appendix C.

3.5 Post Development Flood Assessment

3.5.1 Post Development Build

The post development flood model builds on the pre-development model that has been outlined in Section 3.4.

An additional DEM for the proposed scenario was developed (See Figure 3.5 below). This incorporated the proposed buildings, roads and open space areas that make up the proposed development layout.

This DEM was overlaid over the existing LiDAR data to create a model of the proposed scenario while still incorporating the existing surrounds. This enabled us to measure the effect the proposed development would have on adjacent properties and the local setting.

The revised DEM was then re-run in the *TUFLOW* model to determine the impact the development had on flooding within the subject site and the local surroundings.

The outcomes of this investigation have been documented in Appendix C and summarised below.

Figure 3.5 – Proposed Digital Elevation Model

3.6 Summary and Recommendations

Two dimensional modelling of the site and the adjacent river provides valuable information about the existing and proposed flow regimes at the site.

TUFLOW modelling indicated that during large storm events (i.e. 100 year ARI event) flows enter the subject site first at the low lying areas at the North East corner of the site adjacent to the Clyde-Carlingford Railway line. These flows extend towards the southern end of the site along the existing rail corridor. Flows eventually overtop the banks at the river and flow across the northern portion of the site until inundation of the site occurs to the extents shown in the attached sketches located in Appendix C.

A similar plan is proposed for the post-development scenario. Flows will enter the site at the north eastern corner and flow up the proposed road towards the south, as they did in the pre-development scenario. This ensures no major change to the localised flood regime is incurred and the proposed development has minimal effect on the flooding of surrounding properties. Additionally, localised re-grading of the river foreshore area is proposed to account for the loss in flood storage imposed by the development.

Flood map results are located in Appendix C and include the following;

- Flood Extent Maps (pre-development & post development);
- Proposed Flood Levels (100 year ARI);
- Flood depths;
- Flood depth differences between the existing and proposed scenarios (showing the change in flood levels between the pre-development and post-development scenarios); and
- Flood velocities (pre and post).

4. Floodplain Risk Management Controls

4.1 Council Requirements – Floodplain Planning Matrix

Parramatta City Council has indicated in the 'Local Floodplain Risk Management Policy' that floodplain risk management shall be addressed by the use of the *Planning Matrix* provided within the policy. The following issues have been addressed for a residential development within a medium flood risk precinct.

4.1.1 Floor Level

4.1.1.1 Habitable floor levels to be equal to or greater than the 100 year ARI flood level plus freeboard.

A minimum freeboard of 500mm is indicated in the policy. The proposed ground finished floor level for the commercial premises is RL 6.50m AHD which provides a freeboard greater than 500mm above the 100 year ARI flood level. This condition has been satisfied.

4.1.1.2 A restriction is to be placed on the title of the land, pursuant to S.88B of the Conveyancing Act, where the lowest habitable floor area is elevated more than 1.5m above finished ground level, confirming that the subfloor space is not to be enclosed.

Upon the completion of works a Deposited Plan will be registered and the required restriction will be placed by a registered surveyor.

4.1.2 Building Components & Method

4.1.2.1 All structures to have flood compatible building components below the 100 year ARI flood level plus freeboard

Compatible building components below the 100 year ARI flood level plus freeboard are to be confirmed by the project structural engineer during the detailed design stage of this development.

4.1.3 Structural Soundness

4.1.3.1 Engineers report to certify that the structure can withstand forces of floodwater, debris and buoyancy up to and including a 100 year ARI flood plus freeboard

This is to be certified by the project structural engineer during the detailed design stage of this development.

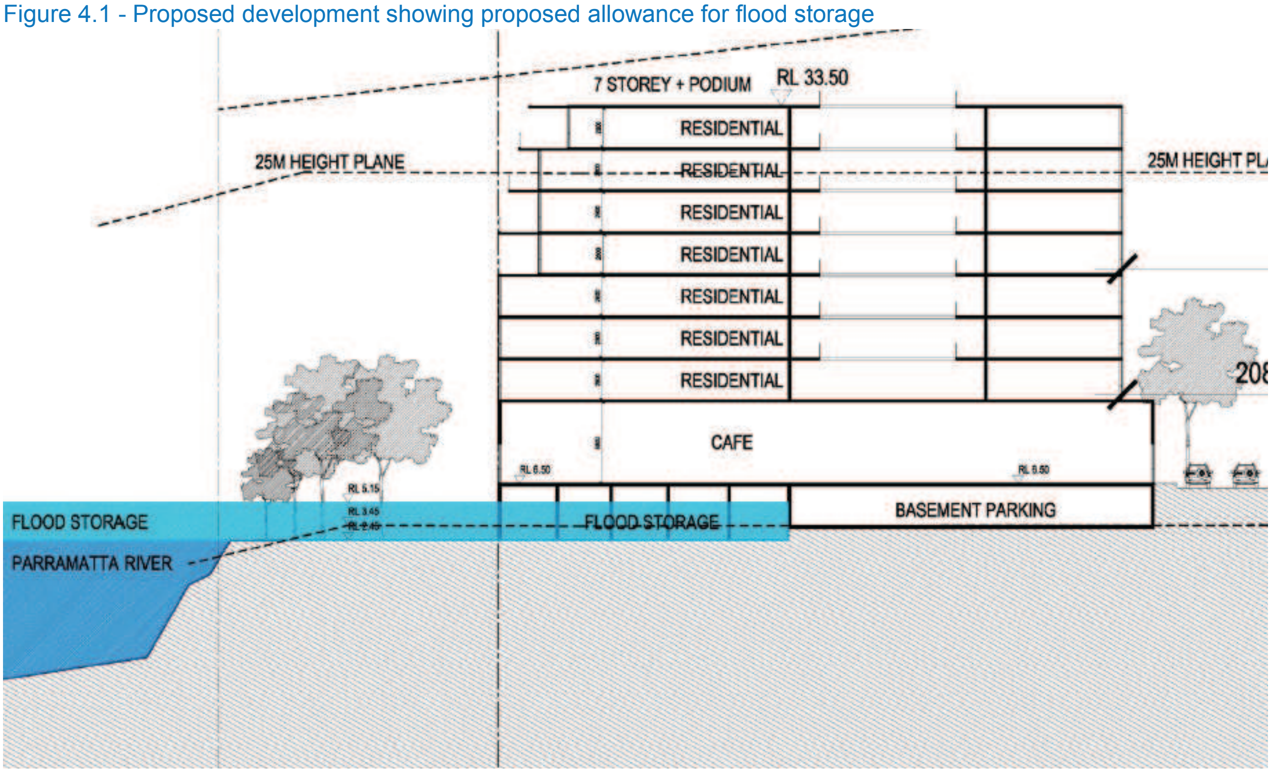
4.1.4 Flood Affectation

4.1.4.1 The impact of the development on flooding elsewhere to be considered having regard to the three factors: (i) loss of flood storage; (ii) changes in flood levels, flows and velocities caused by alterations to flood flows; and (iii) the cumulative impact of multiple potential developments in the vicinity.

With respect to the three factors the following observations have been made:

- There has been no net loss in flood storage due to the proposed development. Flood storage within the site has been accounted for through the implementation of a sub-floor void under the ground floor level of the proposed buildings adjacent to the river foreshore. This sub-floor flood storage zone (as shown in Figure 4.1) will cut into existing surface levels, while the ground floor level has been raised to accommodate the minimum 0.5m freeboard above the 100year ARI flood level. A net increase of approximately 2000m^3 of flood storage has been incorporated into the proposed design to account for the existing storage in the pre-development scenario.
- There are minimal changes in flood levels due to the proposed development. The sub-floor void and flowpath within the post-developed scenario are designed to maintain flood levels and the existing flows and velocities from the pre-developed scenario. As shown in the attached flood modelling sketches in Appendix C, changes in flood levels of approximately 20-30mm within the vicinity of the subject site are expected to have minimal impact on downstream properties.
- The development presents no cumulative impact on the flooding of other developments within the vicinity as the building footprints will not contribute to additional flooding elsewhere.

Figure 4.1 - Proposed development showing proposed allowance for flood storage



Source: *Tony Owen Partners* Camellia West Conceptual Design (April 2012)

Further to the above, we have undertaken a cursory review of the Probable Maximum Flood (PMF) flood impacts on site. Given the PMF flood level of RL 8.99m AHD, we believe that the building footprint in the extended PMF flood zone will have a negligible effect on flood behaviour in extreme events The proposed building footprint is deemed negligible over such a large PMF flood extent (the majority of the Parramatta CBD and its surrounds will be inundated in a PMF storm event).

4.1.5 Car Parking & Driveway Access

4.1.5.1 The minimum surface level of open spaces or carports shall be as high as practical, but no lower than 0.1m below the 100 year ARI flood level. In the case of garages, the minimum surface level shall be as high as practical, but no lower than the 100 year ARI flood level.

The proposed site incorporates below ground car parking to satisfy the parking requirements of the development. This condition is not applicable to this development.

4.1.5.2 Garages capable of accommodating more than 3 motor vehicles on land zones for urban purposes, or enclosed car parking, must be protected from inundation by floods equal to or greater than the 100 year ARI flood. Ramp levels to be no lower than 0.5m above the 100 year ARI flood level.

The proposed site incorporates below ground car parking to satisfy the parking requirements of the development. All basement carpark entrances are to be protected by a crest which is set at or above the 100 year flood level plus 0.5 metres freeboard.

4.1.5.3 The level of the driveway providing access between the road and parking spaces shall be no lower than 0.2m below the 100 year ARI flood level.

The proposed driveway entry between the road and parking spaces is above the 100 year ARI flood level. This condition has been satisfied.

4.1.5.4 Enclosed car parking and car parking areas accommodating more than 3 vehicles, with a floor below the 100 year ARI flood level, shall have adequate warning systems, signage, exits and evacuation routes.

Adequate warning systems will need to be provided to ensure the safety of residents and visitors within the belowground parking areas for flood events greater than the 100 year ARI event.

An evacuation strategy is outlined in the Flood Management Plan provided and attached to this report (refer to Appendix D).

Signage will be provided in the carparks alerting residents and visitors to the possible flood risk during storm events greater than the 100 year ARI and will direct people to safe exits and evacuation routes.

Signage will be included at ground floor and basement levels, namely:

- "Basement levels may flood during events greater than 1 in 100 years. In extreme events, evacuate the basement via marked exits and proceed to Level 1. See Site Flood Management Plan"

- Laminated copies of (a) Site Flood Management Plan; and (b) Evacuation Route are to be secured at each exit.

4.1.5.5 Restraints or vehicle barriers to be provided to prevent floating vehicles leaving a site during a 100 year ARI flood.

The basement carpark is protected from flooding in a 100 year event due to the crest level of access driveways being set at a minimum 0.5m above the 100 year flood level in accordance with Parramatta Councils Floodplain Risk Management Policy.

4.1.6 Evacuation

4.1.6.1 Reliable access for pedestrians and vehicles is required from the site to an area of refuge above the PMF level, either on-site (e.g. second storey) or off-site.

Safe points have been identified above the PMF which include:

- Level 1 of the building (RL 12.30m AHD) and all other levels above Level 1 of the development.

Stair access to Levels 1-16 (which are above the PMF) is provided on ground and basement levels.

An evacuation procedure is subsequently proposed for the safe and reliable access of residents and pedestrians above the PMF. This includes the following steps:

- Depth gauges shall be placed along the foreshore and near the carpark entrances of the proposed development.
- Residents and pedestrians may leave the premises safely either on foot or by vehicle until the depth of flood waters reaches 0.3m within the development's internal road network. After this time, the road network is considered unsafe for vehicles and pedestrians to leave the property (vehicles are deemed to be unstable in flood depths >= 300mm). It is recommended that residents do not attempt to exit the site via Tasman Street & James Ruse Drive as it is inundated during large events.
- After this depth has been reached the entrances to the basement carparks are no longer safe for access and egress and the residents should return to their place of residence or proceed to the higher levels of the development (Levels 1-16) until the flood subsides.
- Once the flood levels in the development site exceed a depth 0.3m below the driveway crest a siren will sound with flashing lights and the Security Entry Gate will close on the basement carpark. Vehicles will no longer be allowed to leave the development.
- An alarm will sound throughout the buildings emergency management system, alerting residents of the hazards and instructing them to evacuate the basement and proceed to higher levels.
- Residents and visitors are instructed by the Flood Management Plan to seek shelter within Level 1 of the building which is at RL 12.30m AHD and above the PMF level. Stair access is available for evacuation to Level 2 in the occurrence of extreme flood events until flooding alleviates.
- Residents and visitors are instructed by the Flood Management Plan not to evacuate the building at this time and wait until the flood recedes.

4.1.6.2 Applicant to demonstrate the development is consistent with any relevant flood evacuation strategy or similar plan.

An existing site specific flood evacuation plan in not available for the overall site. A site specific Flood Management Plan (FMP) is subsequently provided as part of this approval (See Appendix D). Here evacuation procedures are detailed above and within the attached Flood Management Plan.

4.1.6.3 Adequate flood warning is available to allow safe and orderly evacuation without increased reliance upon SES or other authorised emergency services personnel.

Refer attached Flood Management Plan for details.

4.1.7 Management and Design

4.1.7.1 Site Emergency Response Flood plan required where the site is affected by the 100 year ARI flood level, (except for single dwelling-houses).

A site specific "Flood Management Plan" has been prepared to be implemented within the site. This plan will be kept on site at all times and incorporated into the building safety management plan.

4.1.7.2 Applicant to demonstrate that area is available to store goods above the 100 year flood level plus freeboard.

All habitable floor levels in the proposed residential building are above the 100 year ARI flood level + freeboard (500mm).

4.1.7.3 No storage of materials below the 100 year ARI flood level.

Storage of materials and goods associated with the proposed offices will be on the above mentioned floors which are all situated above the 100year ARI flood level.

4.2 Conclusion

With reference to the 'Local Floodplain Risk Management Policy', the issues required to be addressed in order for sufficient floodplain risk management has been ascertained from the Planning Matrix. These requirements have been outlined within this report and in our opinion, compliance has been demonstrated for each item.

Appendices

Appendix A. Data from Council Flood Study

Lower Parramatta
Flood Inundation Maps

1% AEP Flood

Map 2 of 9

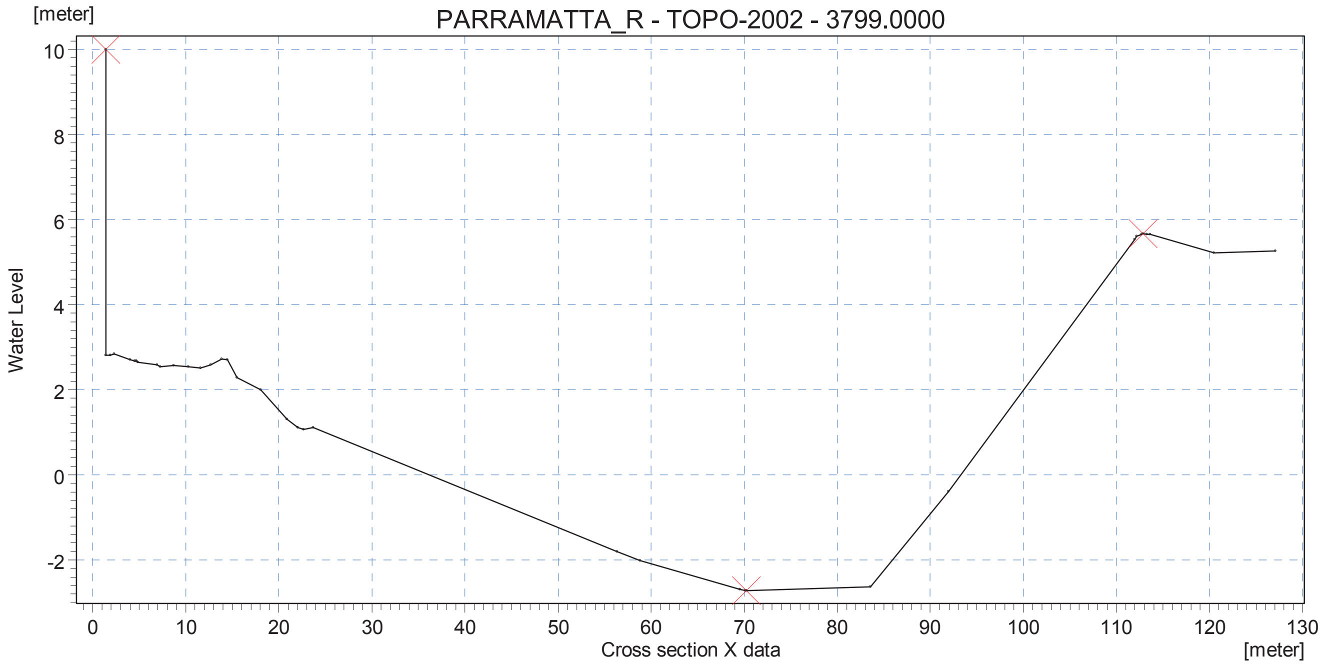
Legend

- Lower Parramatta Model Cross Sections
- 1% AEP Flood Inundation
- Cadastre Boundaries

0 25 50 100 150 200
Metres

Project: Lower Parramatta Flood Study
Projection: UTM, MGA Zone 56
Printed: February 2003

SKM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Cross section X data
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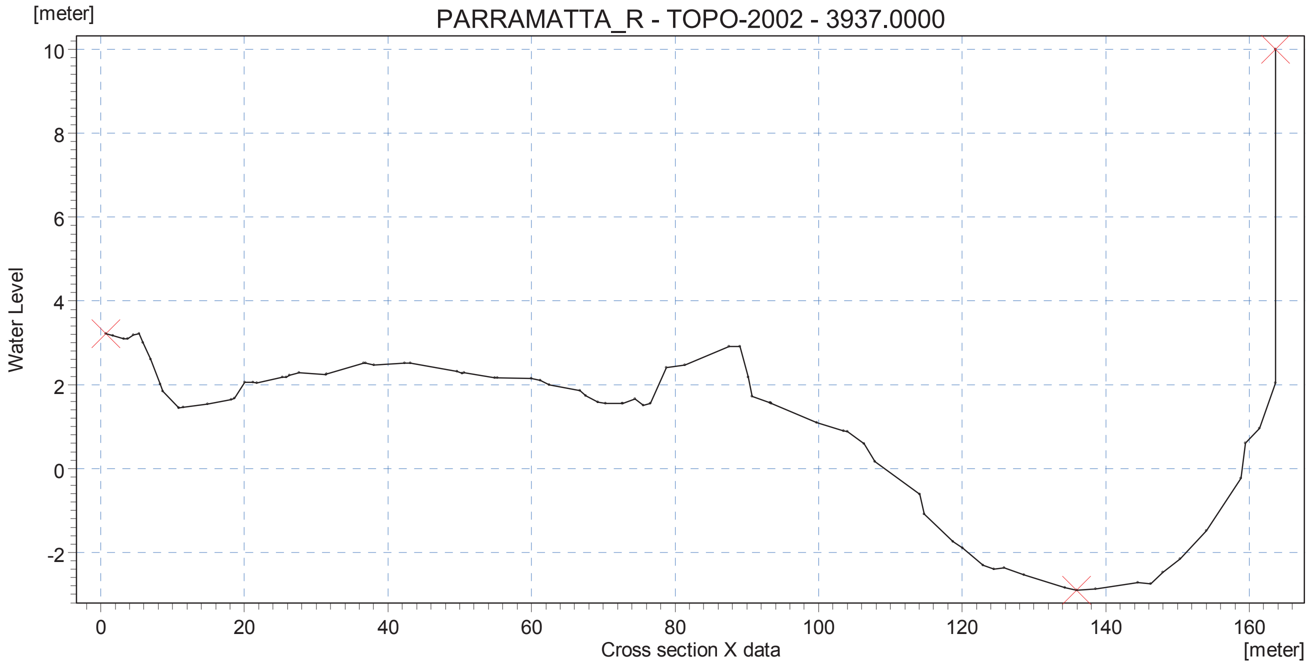
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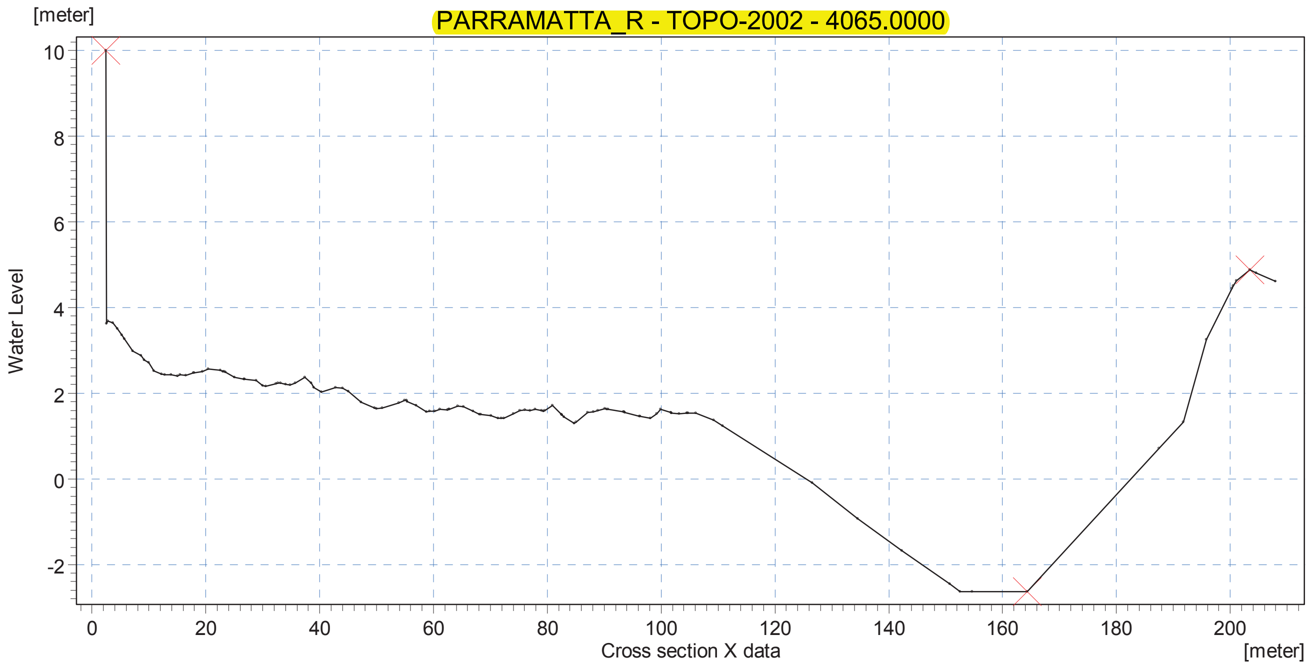
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Cross section X data
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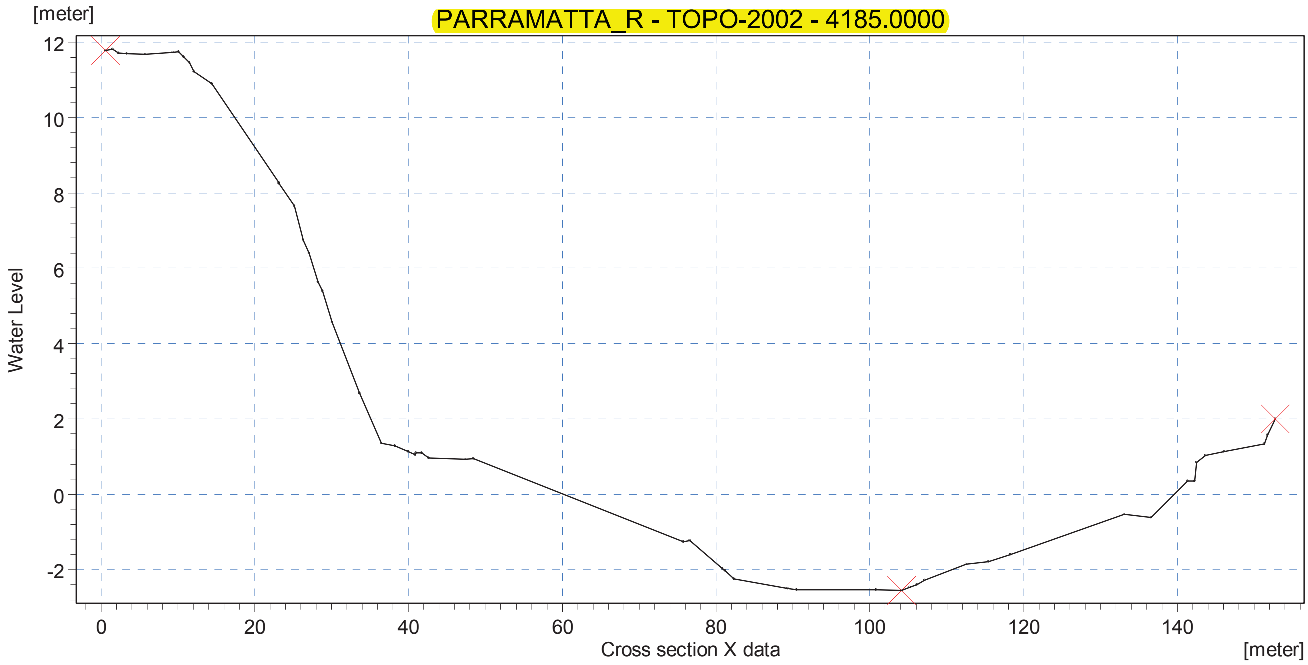
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-2
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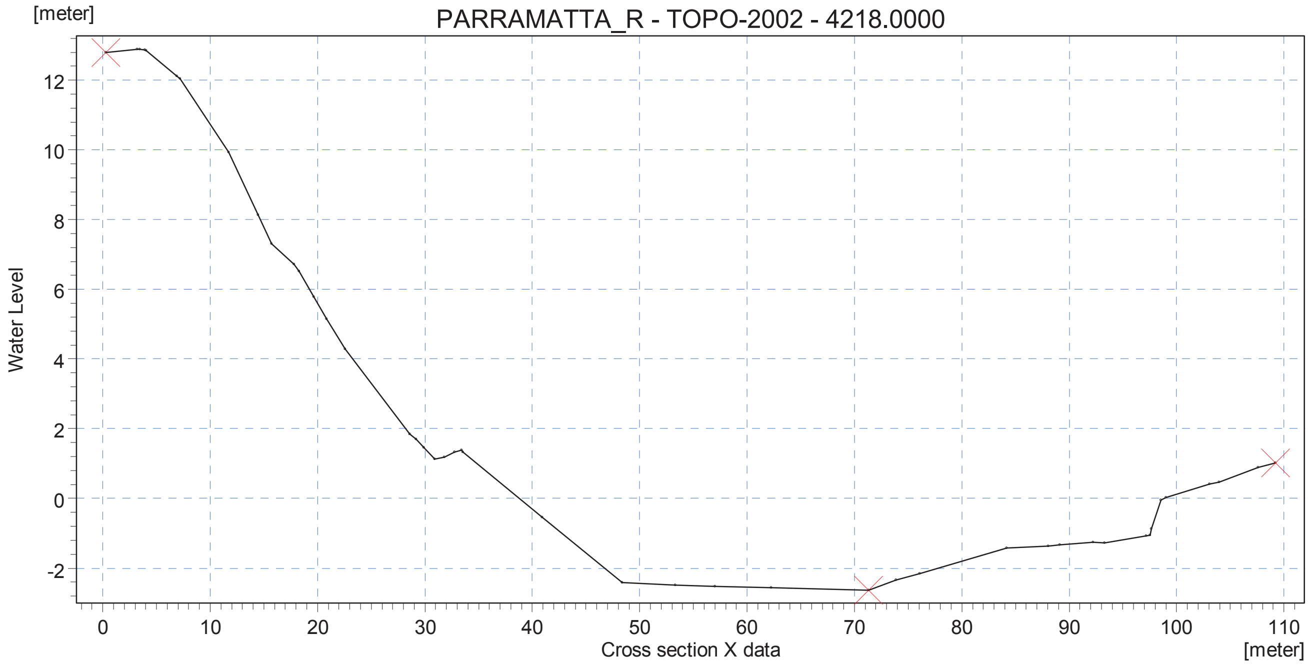
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100
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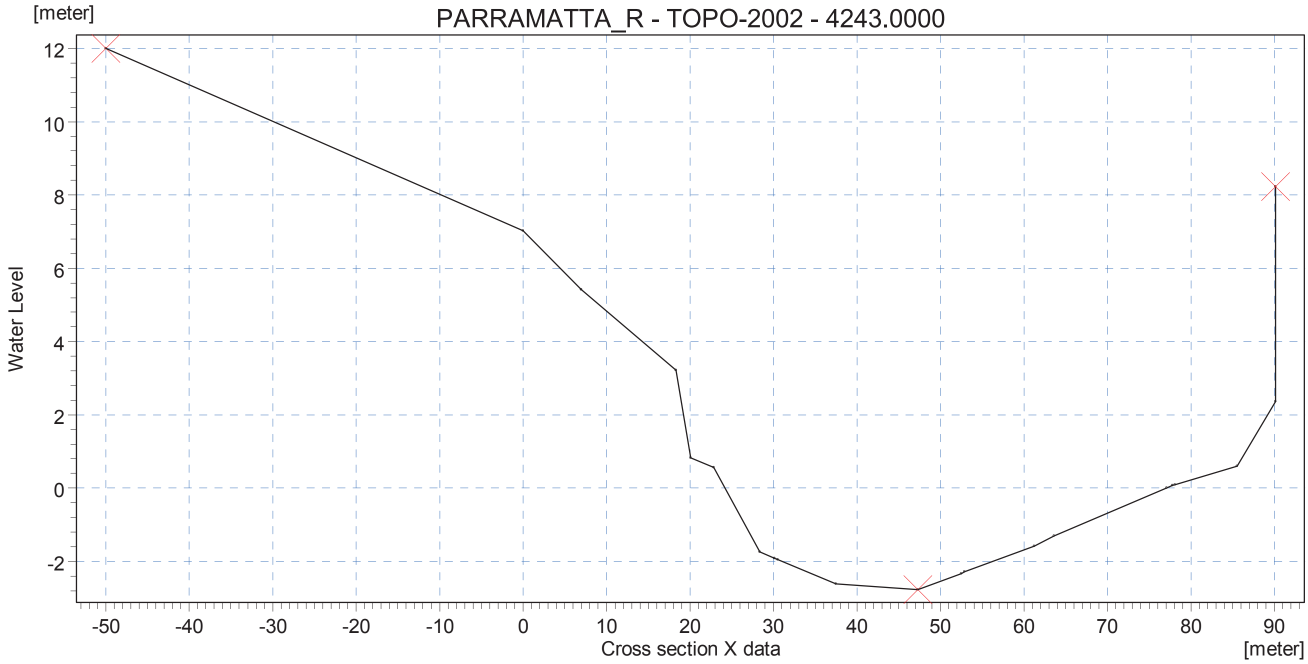
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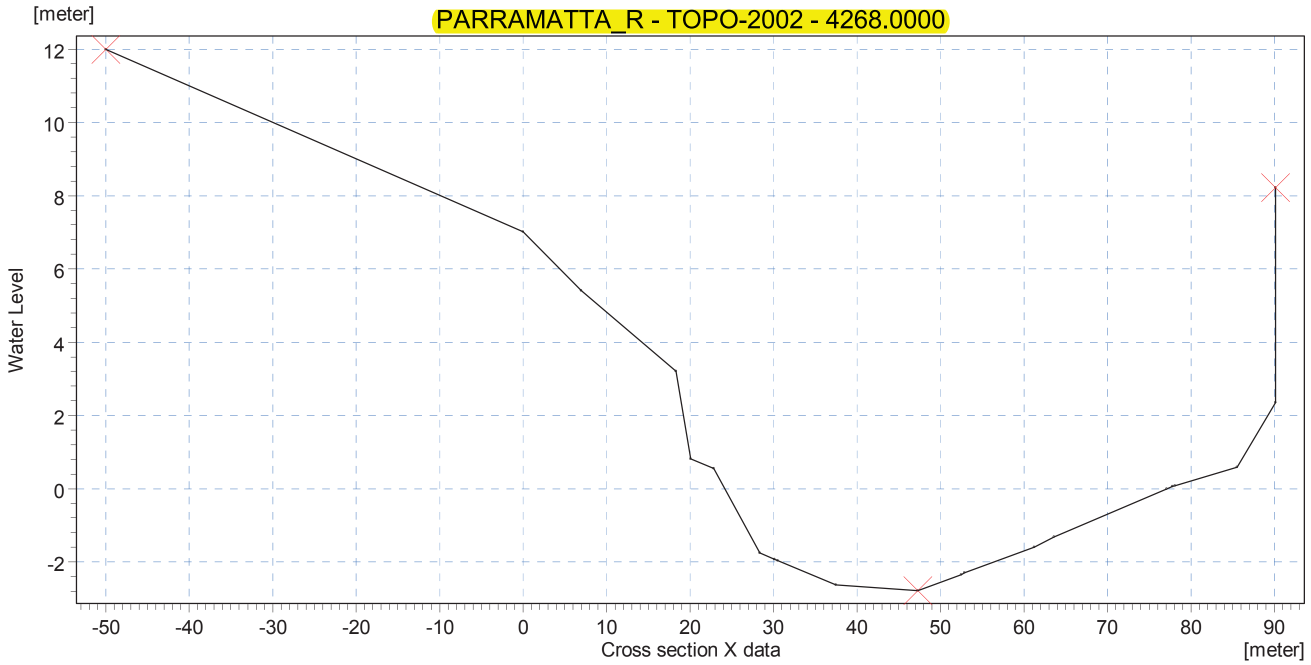

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-2
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-20
-10
0
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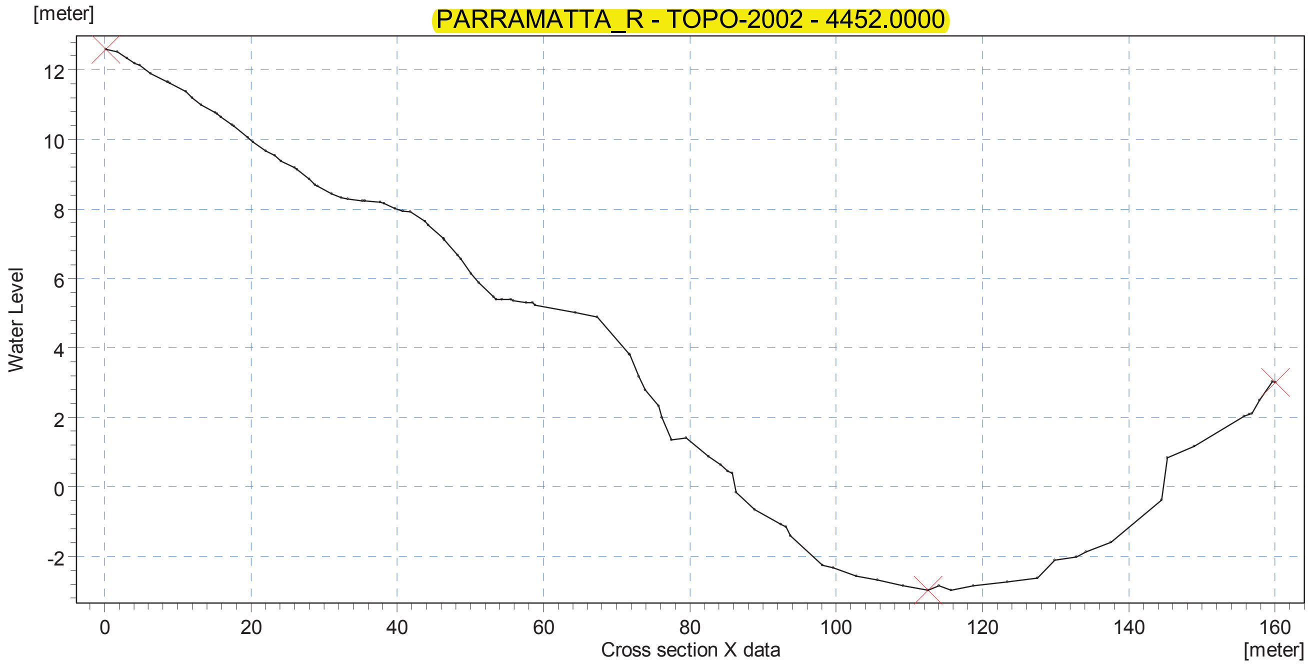
30
40
50
60
70
80
90
Cross section X data
[meter]



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-2
0
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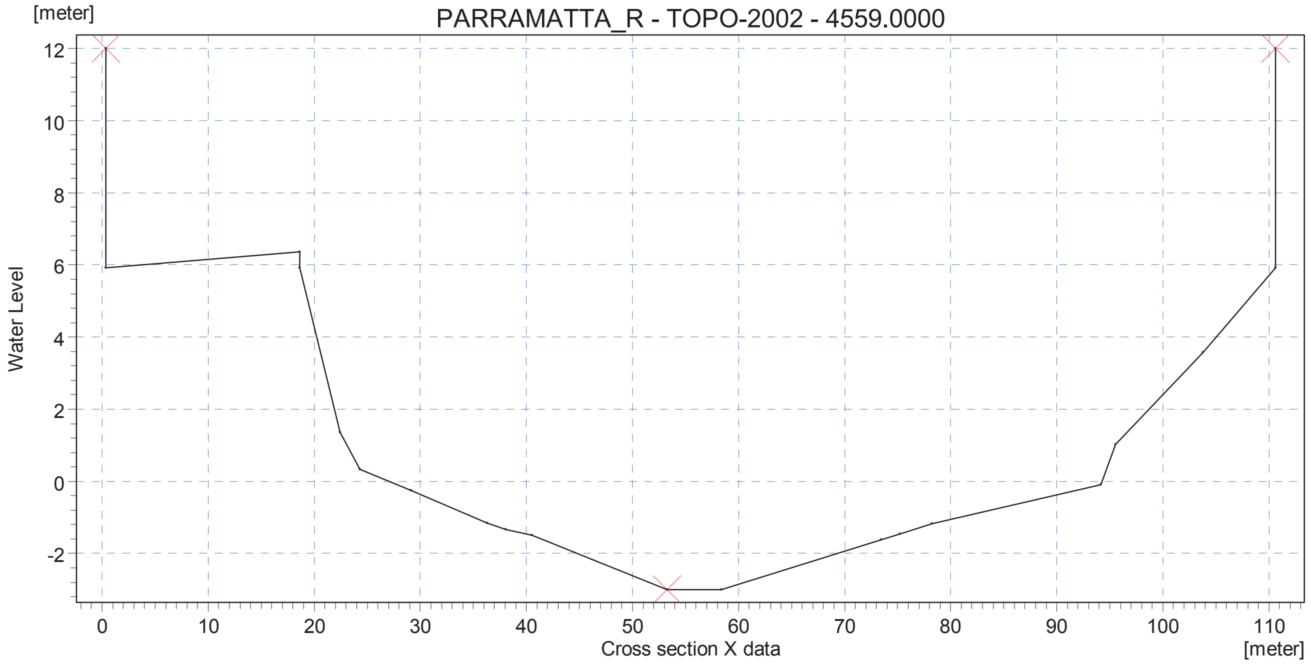
80
100
120
140
160
Cross section X data
[meter]



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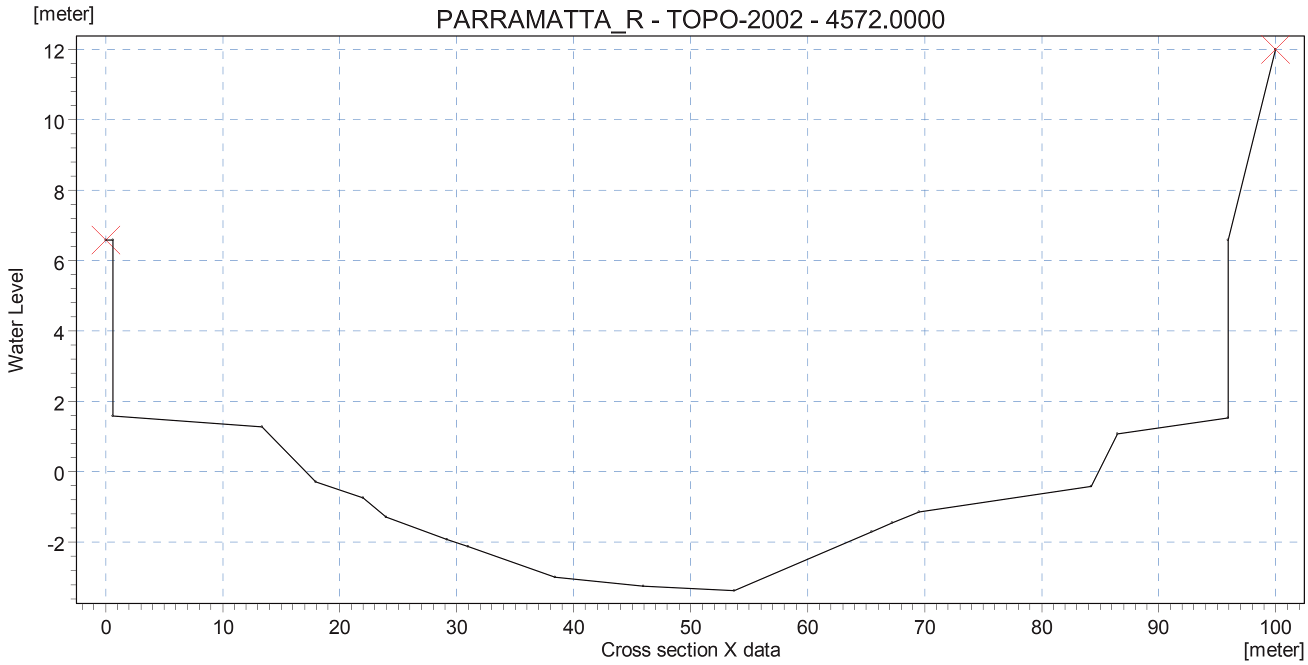
80
90
100
110
Cross section X data
[meter]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90
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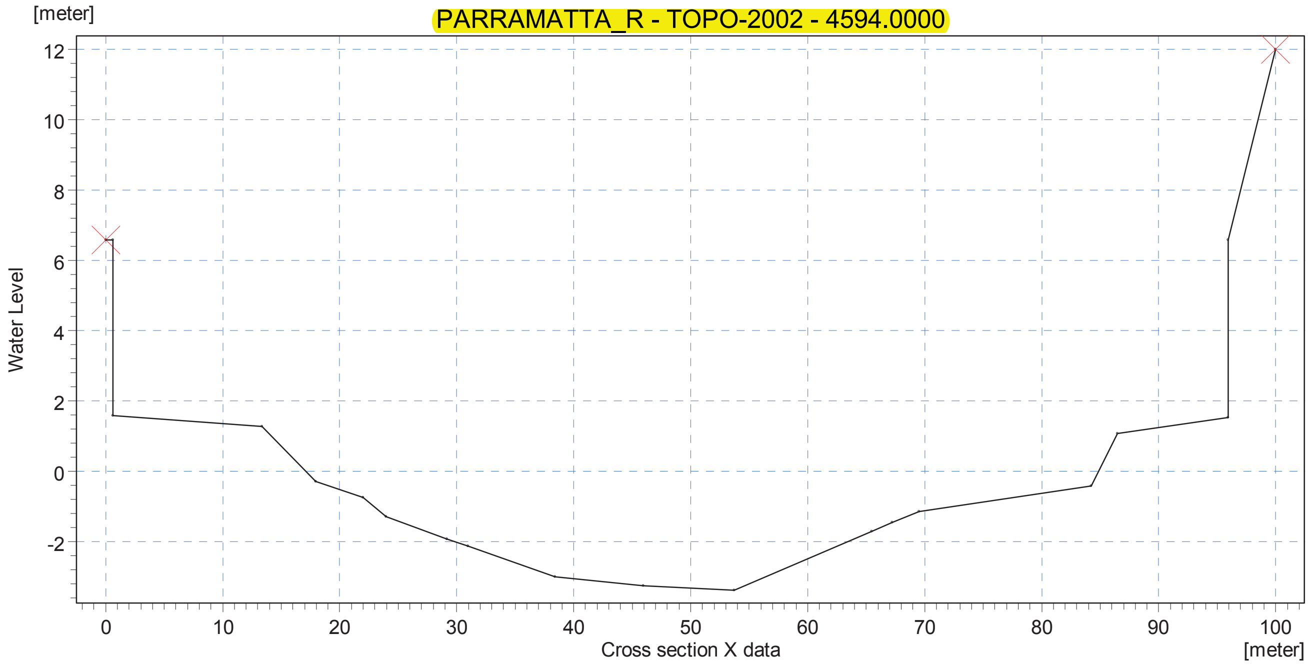
Cross section X data
[meter]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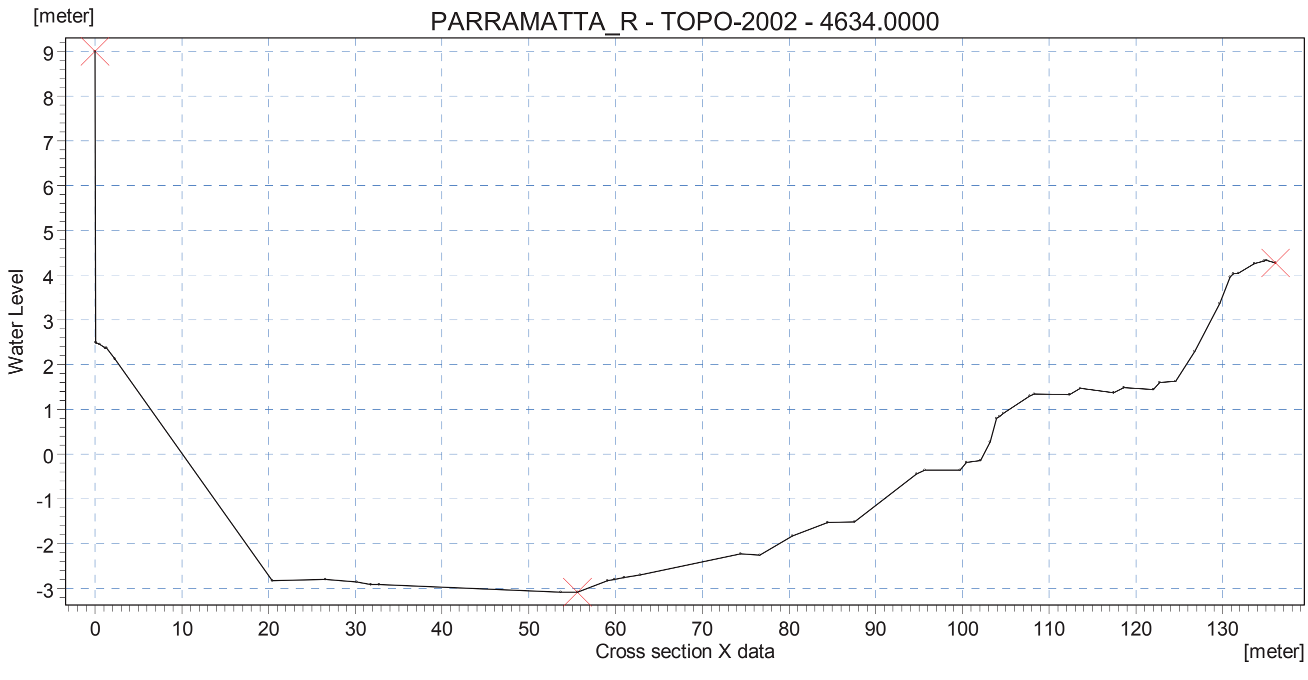
80
90
100
Cross section X data
[meter]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8
7
6
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4
3
2
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-1
-2
-3
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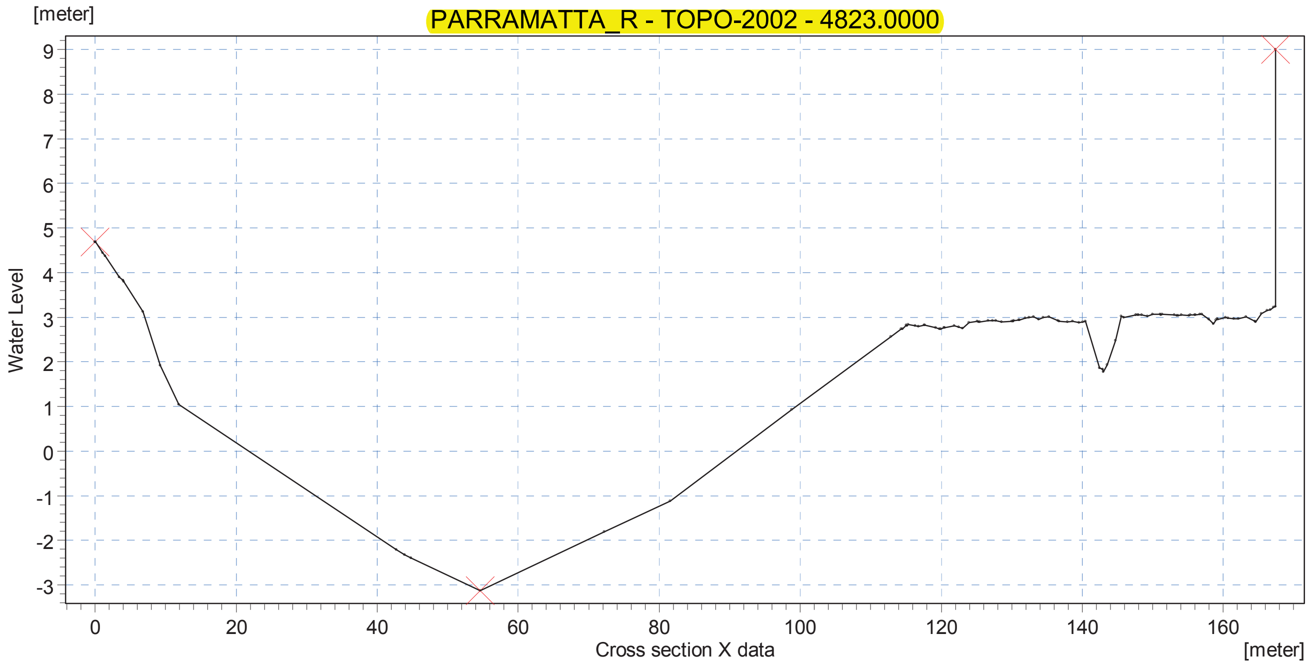
40
50
60
70
80
90
100
110
120
130
Cross section X data
[meter]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7
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100
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140
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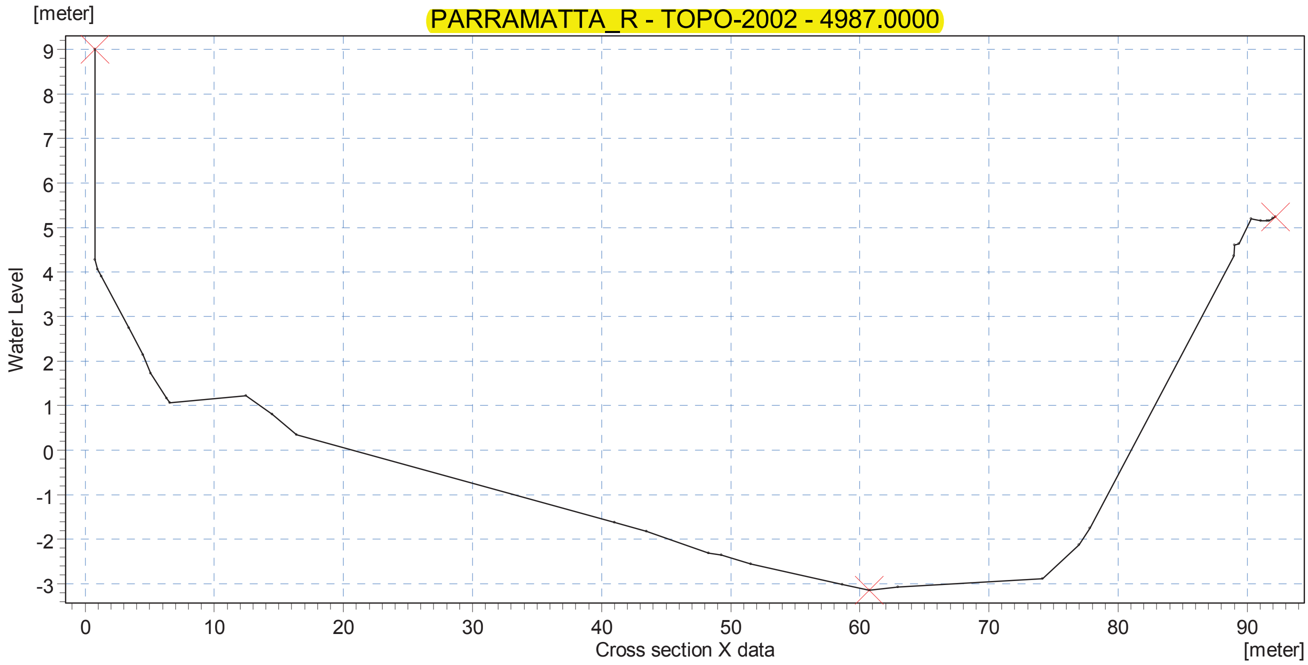
Cross section X data
[meter]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Cross section X data
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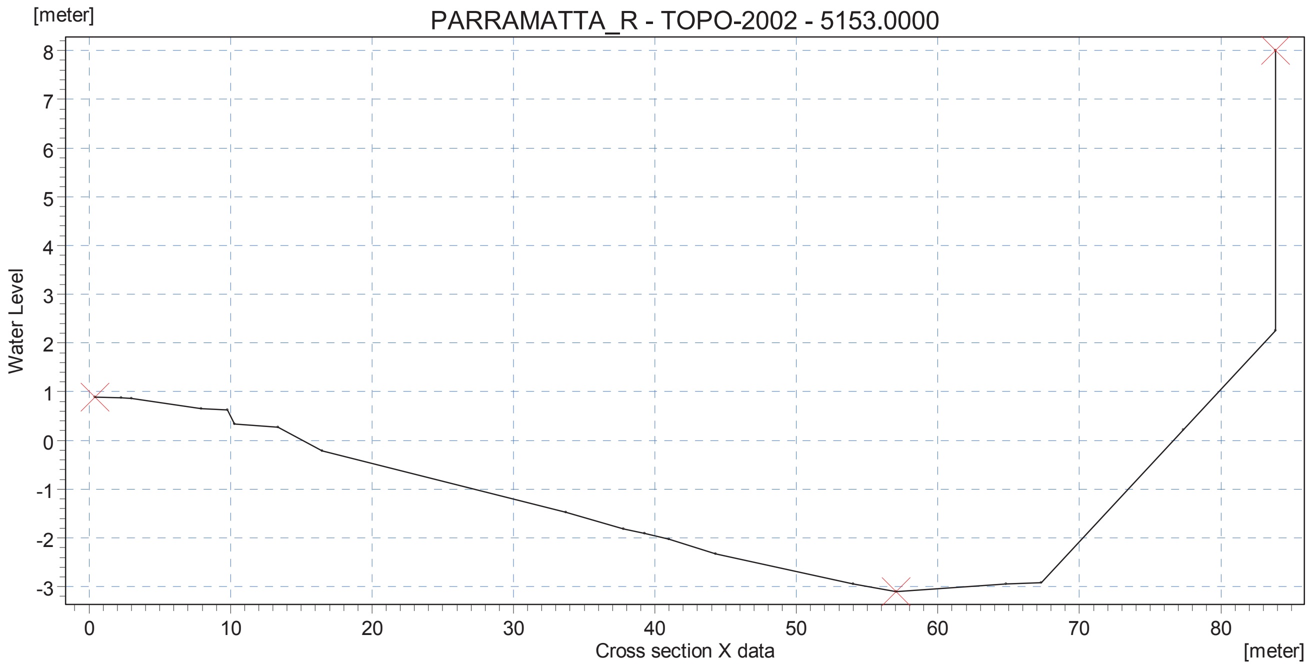
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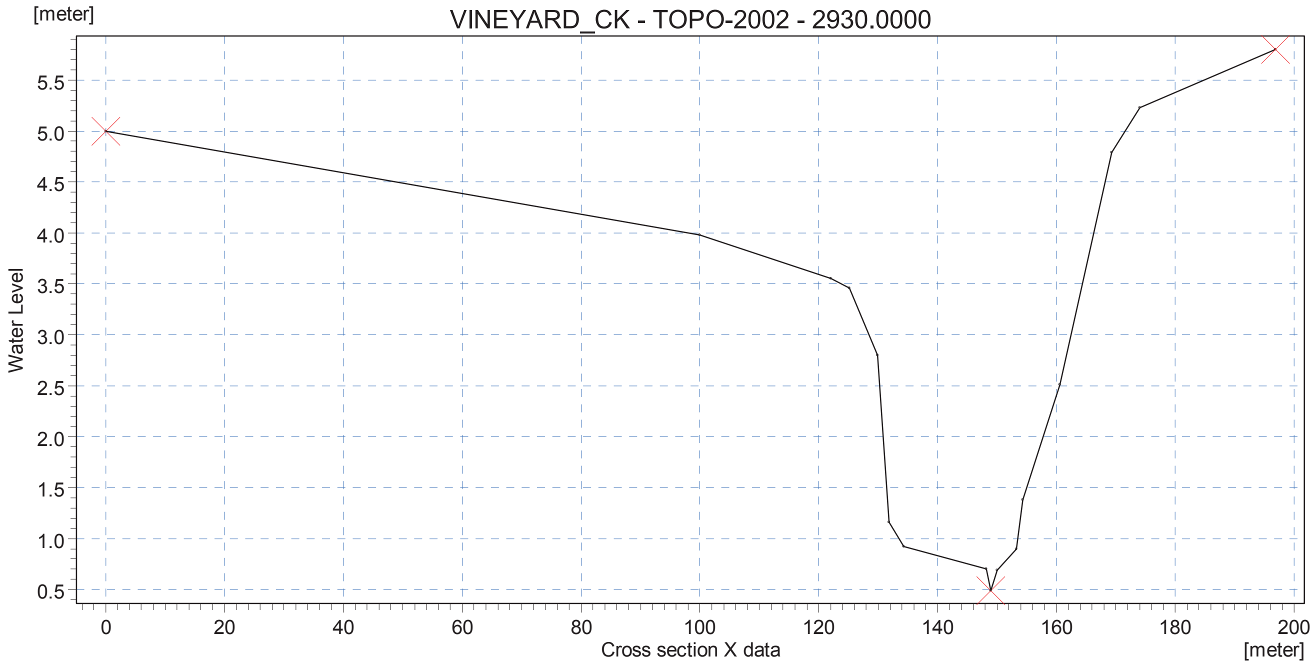
Cross section X data
[meter]



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3.0
2.5
2.0
1.5
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0.5
0
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40
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80
100
120
140
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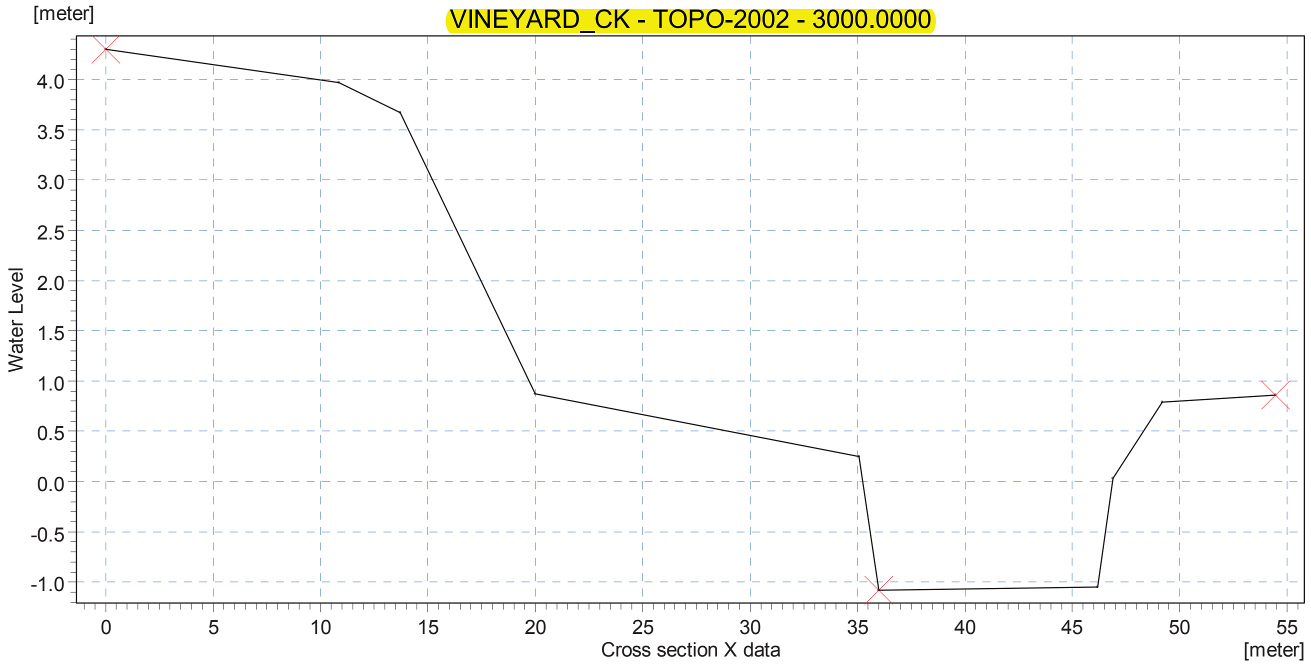
180
200
Cross section X data
[meter]



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0
5
10
15
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55
Cross section X data
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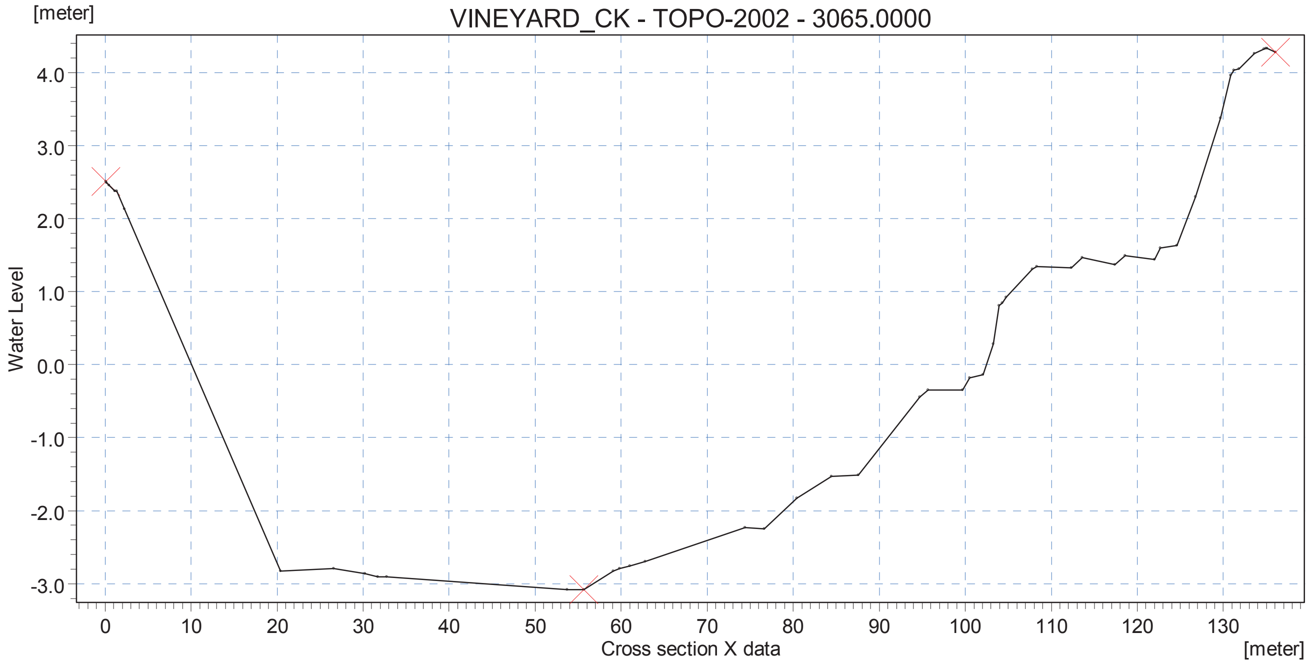

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-3.0
0
10
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30
40
50
60
70
80
90
100
110
120
130
Cross section X data
[meter]

Flowpath	Chainage	Peak water levels (m AHD)					Peak flows (m^3/s)					Peak velocities (m/s)				
	(m)	20% AEP	5% AEP	2% AEP	1% AEP	PMF	20% AEP	5% AEP	2% AEP	1% AEP	PMF	20% AEP	5% AEP	2% AEP	1% AEP	PMF
PARRAMATTA_R	3403	4.05	4.54	4.93	5.19	9.50	595	695	788	848	2195	1.1	1.5	1.2	1.3	1.7
PARRAMATTA_R	3538	4.02	4.51	4.90	5.16	9.50	594	694	785	849	2090	1.1	1.1	1.2	1.2	1.4
PARRAMATTA_R	3636	3.95	4.45	4.84	5.10	9.44	593	693	785	849	2084	1.5	1.4	1.5	1.5	1.7
PARRAMATTA_R	3799	3.89	4.38	4.76	5.02	9.32	592	692	786	851	2427	1.4	1.5	1.5	1.6	2.1
PARRAMATTA_R	3937	3.87	4.37	4.76	5.02	9.40	591	691	785	851	2429	1.2	1.7	1.2	1.3	1.8
PARRAMATTA_R	4065	3.86	4.36	4.75	5.01	9.42	591	691	787	855	2422	1.0	2.0	1.0	1.0	1.5
PARRAMATTA_R	4185	3.82	4.32	4.70	4.96	9.30	599	703	802	873	2418	1.1	1.6	1.2	1.3	2.0
PARRAMATTA_R	4218	3.77	4.26	4.63	4.88	9.14	599	703	802	873	2417	1.5	1.9	1.7	1.7	2.8
PARRAMATTA_R	4243	3.72	4.21	4.58	4.83	9.06	599	703	802	873	2417	1.7	1.8	1.9	2.0	3.1
PARRAMATTA_R	4268	3.66	4.14	4.51	4.75	8.99	599	703	802	873	2416	1.8	1.9	2.0	2.1	3.1
PARRAMATTA_R	4452	3.61	4.09	4.46	4.70	8.99	600	704	804	875	2416	1.5	1.6	1.7	1.8	2.6
PARRAMATTA_R	4559	3.56	4.04	4.41	4.65	8.89	606	712	814	885	2417	1.6	1.7	1.8	1.9	2.8
PARRAMATTA_R	4572	3.56	4.04	4.40	4.64	8.40	609	714	817	888	2417	1.4	1.8	1.6	1.7	2.7
PARRAMATTA_R	4594	3.54	4.01	4.37	4.61	8.33	605	711	813	884	2417	1.4	1.8	1.6	1.7	2.7
PARRAMATTA_R	4634	3.56	4.04	4.40	4.64	8.48	615	730	828	901	2430	1.0	1.5	1.1	1.2	1.9
PARRAMATTA_R	4823	3.44	3.92	4.29	4.52	8.36	614	728	827	900	2429	1.3	1.7	1.4	1.4	1.9
PARRAMATTA_R	4987	3.28	3.75	4.10	4.33	7.99	614	728	828	901	2430	1.7	1.8	1.9	2.0	3.1
PARRAMATTA_R	5153	3.19	3.66	4.00	4.22	7.80	614	728	829	901	2431	1.7	1.8	1.9	2.0	3.3
PARRAMATTA_R	5278	3.18	3.65	4.00	4.23	7.99	614	728	829	902	2431	1.4	1.5	1.5	1.6	2.1
PARRAMATTA_R	5353	3.14	3.61	3.95	4.18	7.89	660	793	901	974	2493	1.5	1.7	1.7	1.7	2.4
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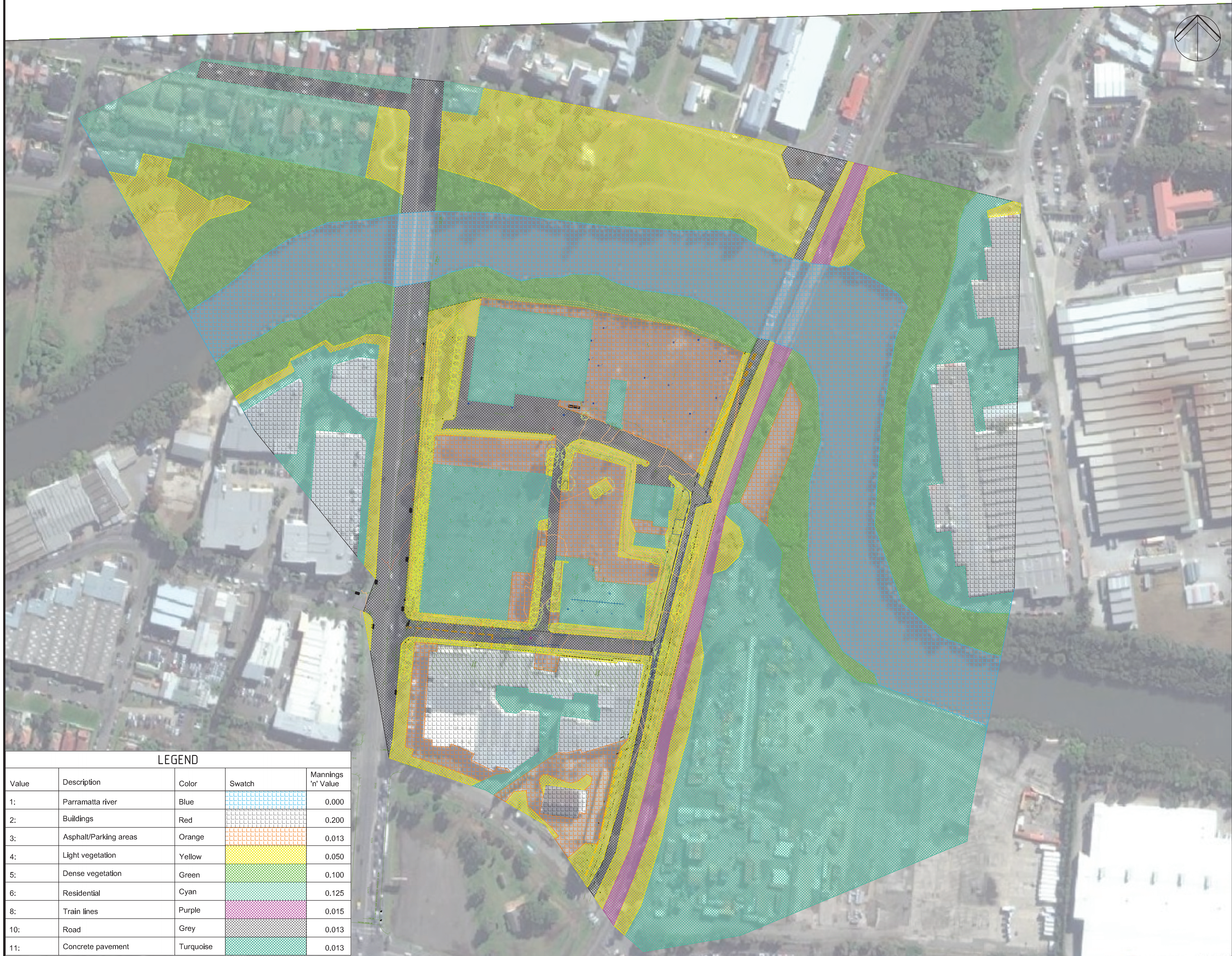
PARRAMATTA_R	5931	2.90	3.35	3.68	3.90	7.48	660	793	902	977	2492	1.6	1.7	1.8	1.9	2.9
PARRAMATTA_R	6167	2.78	3.24	3.57	3.78	7.40	660	793	903	978	2493	1.6	1.7	1.8	1.9	2.7
PARRAMATTA_R	6256	2.70	3.14	3.46	3.67	7.17	660	793	903	978	2504	1.8	2.0	2.1	2.2	3.3
PARRAMATTA_R	6304	2.71	3.16	3.48	3.70	7.30	660	793	903	979	2581	1.6	1.7	1.8	1.8	2.6
PARRAMATTA_R	6387	2.67	3.13	3.45	3.67	6.12	661	794	904	980	2550	1.5	1.6	1.7	1.7	2.6
PARRAMATTA_R	6598	2.59	3.04	3.36	3.57	6.00	661	794	904	981	2494	1.4	1.5	1.6	1.6	2.5
PARRAMATTA_R	6775	2.48	2.92	3.23	3.44	5.79	662	795	906	983	2496	1.6	1.7	1.8	1.8	2.8
PARRAMATTA_R	6960	2.37	2.81	3.12	3.33	5.65	662	796	907	984	2499	1.6	1.7	1.8	1.8	2.6
PARRAMATTA_R	7179	2.28	2.72	3.03	3.24	5.56	664	797	909	989	2506	1.3	1.8	1.4	1.4	2.1
PARRAMATTA_R	7352	2.27	2.71	3.01	3.23	5.61	665	798	911	992	2510	0.9	1.9	1.0	1.0	1.4
PARRAMATTA_R	7417	2.22	2.66	2.96	3.18	5.52	861	1068	1222	1341	3054	1.2	1.8	1.3	1.4	1.9
PARRAMATTA_R	7528	2.16	2.60	2.89	3.10	5.47	861	1069	1222	1342	3055	1.6	1.8	1.8	1.8	2.0
PARRAMATTA_R	7556	2.12	2.55	2.83	3.04	5.27	862	1069	1222	1342	3055	1.7	1.9	2.0	2.1	2.9
PARRAMATTA_R	7572	2.07	2.48	2.76	2.97	5.13	862	1069	1223	1342	3055	1.7	2.1	2.0	2.1	3.0
PARRAMATTA_R	7592	2.08	2.49	2.78	2.98	5.18	862	1069	1223	1343	3055	1.6	1.9	1.9	2.0	2.7
PARRAMATTA_R	7705	2.00	2.40	2.66	2.85	4.95	862	1070	1224	1344	3057	1.7	1.9	2.1	2.2	3.2
PARRAMATTA_R	7944	1.87	2.26	2.52	2.71	4.75	863	1071	1226	1346	3058	1.6	1.8	1.9	1.9	2.8
PARRAMATTA_R	8096	1.71	2.06	2.30	2.48	4.41	864	1073	1227	1348	3061	1.9	2.2	2.3	2.4	3.4
PARRAMATTA_R	8344	1.49	1.81	2.04	2.20	4.08	866	1074	1229	1350	3062	1.9	2.2	2.2	2.3	3.2
PARRAMATTA_R	8429	1.48	1.79	2.01	2.16	3.99	866	1075	1230	1351	3064	1.6	1.8	1.9	2.0	3.0
PARRAMATTA_R	8745	1.27	1.51	1.70	1.82	3.44	869	1078	1233	1354	3067	1.6	1.8	2.0	2.1	3.1
PARRAMATTA_R	9052	1.27	1.39	1.55	1.67	3.42	873	1082	1237	1358	3070	1.9	2.0	1.9	1.9	1.5
PARRAMATTA_R	9203	1.27	1.34	1.43	1.54	3.28	876	1086	1241	1362	3073	2.1	2.1	2.4	2.4	2.0
PARRAMATTA_R	9348	1.27	1.34	1.39	1.42	3.00	880	1090	1245	1367	3077	1.8	2.0	2.2	2.3	2.9
PARRAMATTA_R	9664	1.27	1.34	1.39	1.42	3.07	887	1097	1253	1375	3083	0.9	1.7	1.0	1.1	1.3
PARRAMATTA_R	9819	1.27	1.34	1.39	1.42	2.79	890	1101	1257	1379	3085	1.5	1.7	1.9	2.0	2.9
PARRAMATTA_R	10020	1.27	1.34	1.39	1.42	2.42	892	1103	1259	1381	3086	2.0	2.3	2.6	2.8	4.0
PARRAMATTA_R	10429	1.27	1.34	1.39	1.42	2.41	903	1116	1274	1396	3104	1.4	1.6	1.7	1.7	2.1
PARRAMATTA_R	10663	1.27	1.34	1.39	1.42	2.30	927	1147	1311	1438	3156	1.5	1.7	1.8	1.9	2.1
PARRAMATTA_R	10884	1.27	1.34	1.39	1.42	2.16	932	1152	1317	1443	3158	1.4	1.5	1.9	2.0	2.2
PARRAMATTA_R	11030	1.27	1.34	1.39	1.42	2.10	1201	1508	1715	1899	4038	1.0	1.6	1.3	1.4	2.3

Flowpath	Chainage	Peak water levels (m AHD)					Peak flows (m^3/s)					Peak velocities (m/s)				
	(m)	20% AEP	5% AEP	2% AEP	1% AEP	PMF	20% AEP	5% AEP	2% AEP	1% AEP	PMF	20% AEP	5% AEP	2% AEP	1% AEP	PMF
THOMAS_PURCHASE	51	5.17	5.41	5.58	5.72	9.47	0	0	0	0	64	0.0	0.0	0.0	0.0	4.5
THOMAS_PURCHASE	102	5.08	5.19	5.28	5.46	9.46	0	0	0	0	64	0.0	0.0	0.0	0.0	4.5
THOMAS_PURCHASE	150	4.60	4.87	5.21	5.36	9.46	0	0	0	0	65	0.0	0.0	0.0	0.0	2.6
THOMAS1	0	5.18	5.47	5.64	5.74	9.41	0	0	0	0	-101	0.0	0.0	0.0	0.0	1.8
THOMAS1	39	4.95	5.31	5.44	5.60	9.42	0	0	0	0	-100	0.0	0.0	0.0	0.0	1.2
THOMAS1	62	4.50	5.20	5.33	5.49	9.42	0	0	0	0	-99	0.0	0.0	0.0	0.0	3.2
THOMAS1	90	4.04	4.52	4.91	5.16	9.43	0	0	0	0	-98	0.0	0.0	0.0	0.0	6.1
THOMAS2	0	5.18	5.47	5.64	5.74	9.41	0	0	0	0	-194	0.0	0.0	0.0	0.0	2.5
THOMAS2	81	3.89	4.37	4.84	5.15	9.49	0	0	0	0	-193	0.0	0.0	0.0	0.0	3.1
THOMAS2	147	4.05	4.54	4.93	5.19	9.50	0	0	0	0	-192	0.0	0.0	0.0	0.0	6.1
VINEYARD_CK	3000	3.56	4.04	4.40	4.64	8.48	39	59	67	77	192	0.7	1.2	1.0	1.1	1.3
VINEYARD_CK	3065	3.56	4.04	4.40	4.64	8.48	37	57	64	74	197	0.1	1.1	0.1	0.2	0.3
WIGRAM	0	7.57	8.02	8.18	8.30	9.61	0	3	9	14	168	0.0	0.8	1.0	1.3	4.9
WIGRAM	45	7.45	7.94	8.08	8.17	9.43	0	3	8	13	154	0.0	0.8	1.1	1.2	4.9
WIGRAM	115	6.00	7.90	8.00	8.06	9.42	0	3	8	13	154	0.0	1.2	1.5	1.7	5.4

Notes:

Peak flows at modelled cross sections were extracted from MIKE-11 model results (ie. Minimum and Maximum flows at H points)
- ve indicates the direction of flow opposite to that assigned in the MIKE-11 model set up
Peak flood level, flow and velocity at a cross section may not necssarily result from the same storm duration for the same flood event.

Appendix B. TUFLOW Materials File Regions



LEGEND

Value	Description	Color	Swatch	Mannings 'n' Value
1:	Parramatta river	Blue		0.000
2:	Buildings	Red		0.200
3:	Asphalt/Parking areas	Orange		0.013
4:	Light vegetation	Yellow		0.050
5:	Dense vegetation	Green		0.100
6:	Residential	Cyan		0.125
8:	Train lines	Purple		0.015
10:	Road	Grey		0.013
11:	Concrete pavement	Turquoise		0.013

P:\Parramatta\Projects\30xxxx\308388\8.0 Drawings\7.1 Internally Produced\Technical Software Files\SKETCHES\MMD-308388-C-SK-00-XX-0001.dwg Aug 13, 2012 - 11:06AM pac55913

Notes

Key to symbols

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd

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Client
STATEWIDE PLANNING PTY LTD

Title
CAMELLIA WEST
MANNINGS VALUES

Designed	GC	Eng check	AH
Drawn	AMP	Coordination	AH
Dwg check	GC	Approved	X
Scale at A1: 1:100	Status: PRE	Rev: P1	

Drawing Number
MMD-308388-C-SK-00-XX-0001

Appendix C. TUFLOW Modelling Results

ISSUE	DRAWN BY	CHECKED	AUTHORISED
A	AH	GL	CA

Note: This drawing may have been prepared using colour and may be incomplete if copied to black and white.

308388-CIV-FL-SK-001
CAMELLIA WEST FLOOD MODELLING
PRE-DEVELOPMENT
100 YEAR ARI FLOOD EXTENTS

Mott MacDonald

ISSUE	DRAWN BY	CHECKED	AUTHORISED
B	AH	GL	CA

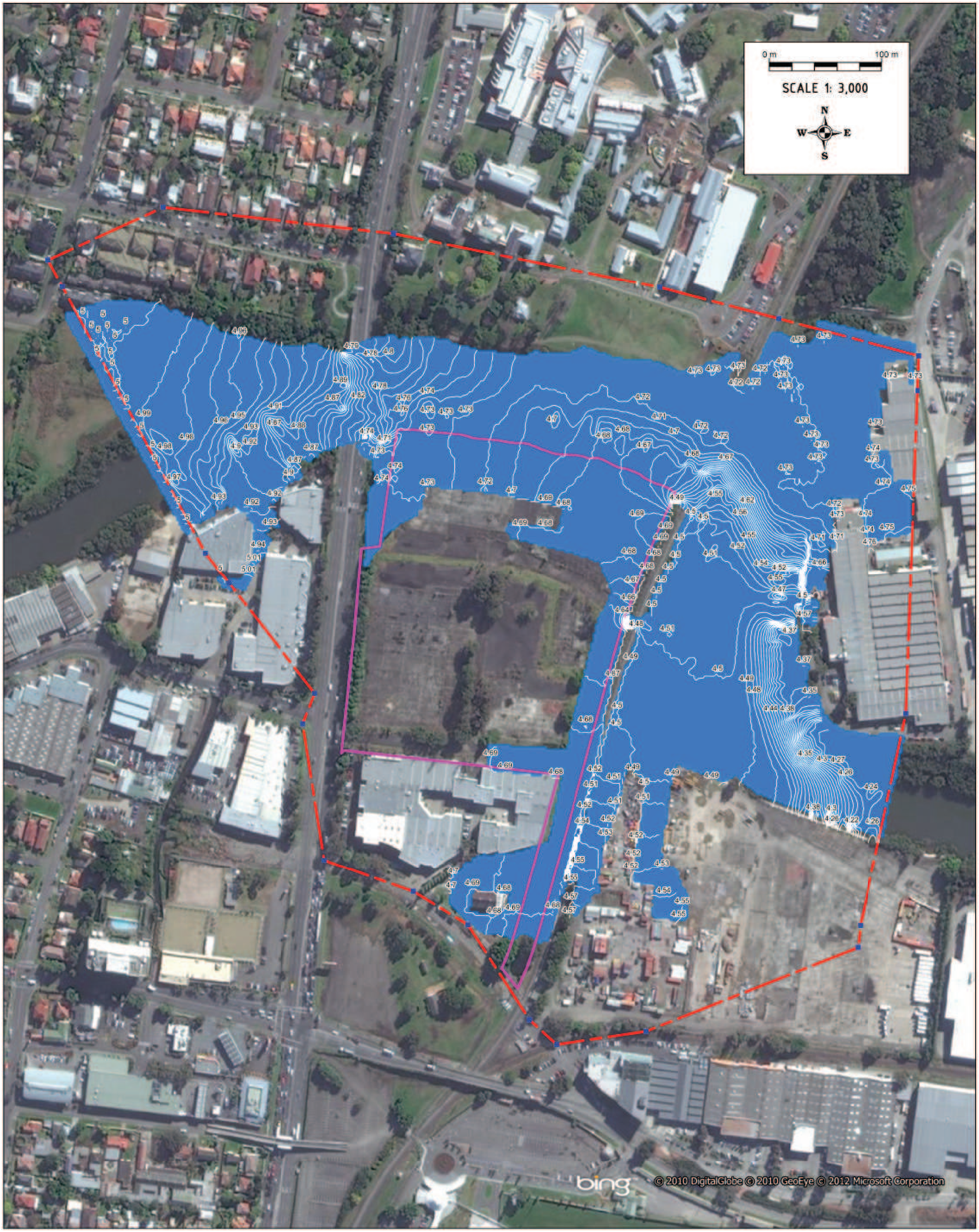
308388-CIV-FL-SK-002

CAMELLIA WEST FLOOD MODELLING

POST-DEVELOPMENT

100 YEAR ARI FLOOD EXTENTS

Mott MacDonald



ISSUE	DRAWN BY	CHECKED	AUTHORISED
B	AH	GL	CA

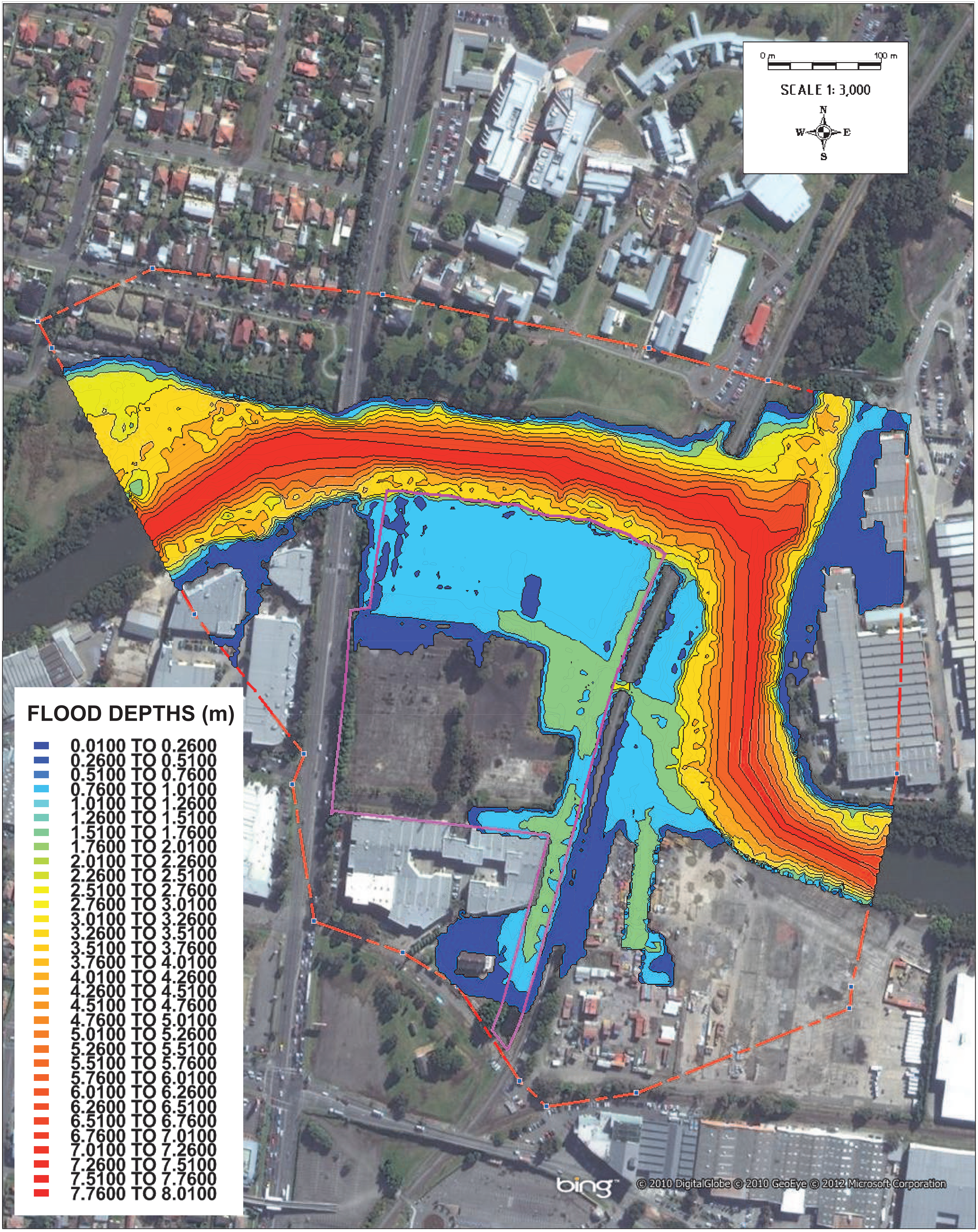
308388-CIV-FL-SK-003

CAMELLIA WEST FLOOD MODELLING

POST-DEVELOPMENT

100 YEAR ARI FLOOD LEVELS

Mott MacDonald



ISSUE	DRAWN BY	CHECKED	AUTHORISED
A	AH	GL	CA

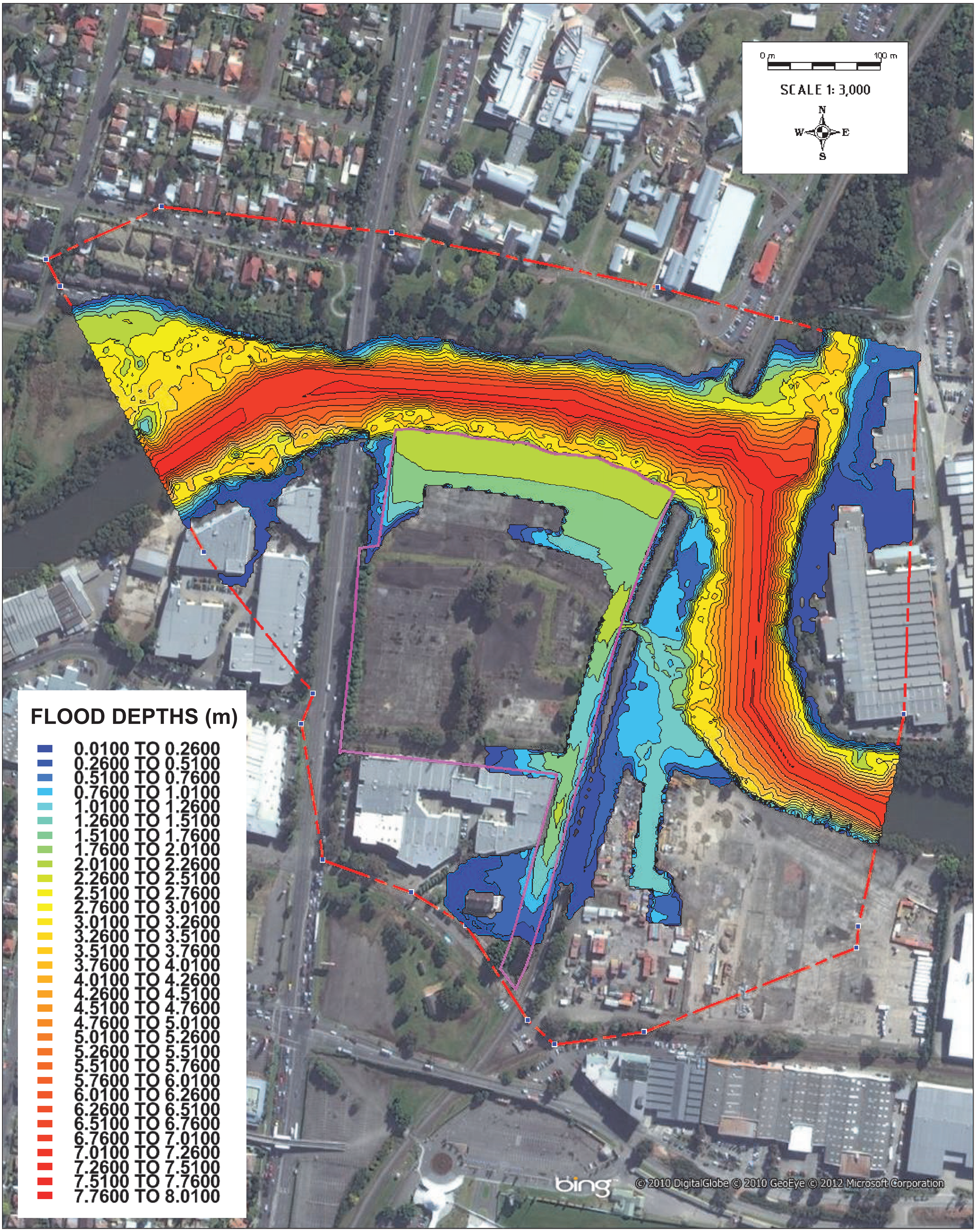
308388-CIV-FL-SK-004

CAMELLIA WEST FLOOD MODELLING

PRE-DEVELOPMENT

100 YEAR ARI FLOOD DEPTHS

Mott MacDonald



ISSUE	DRAWN BY	CHECKED	AUTHORISED
B	AH	GL	CA

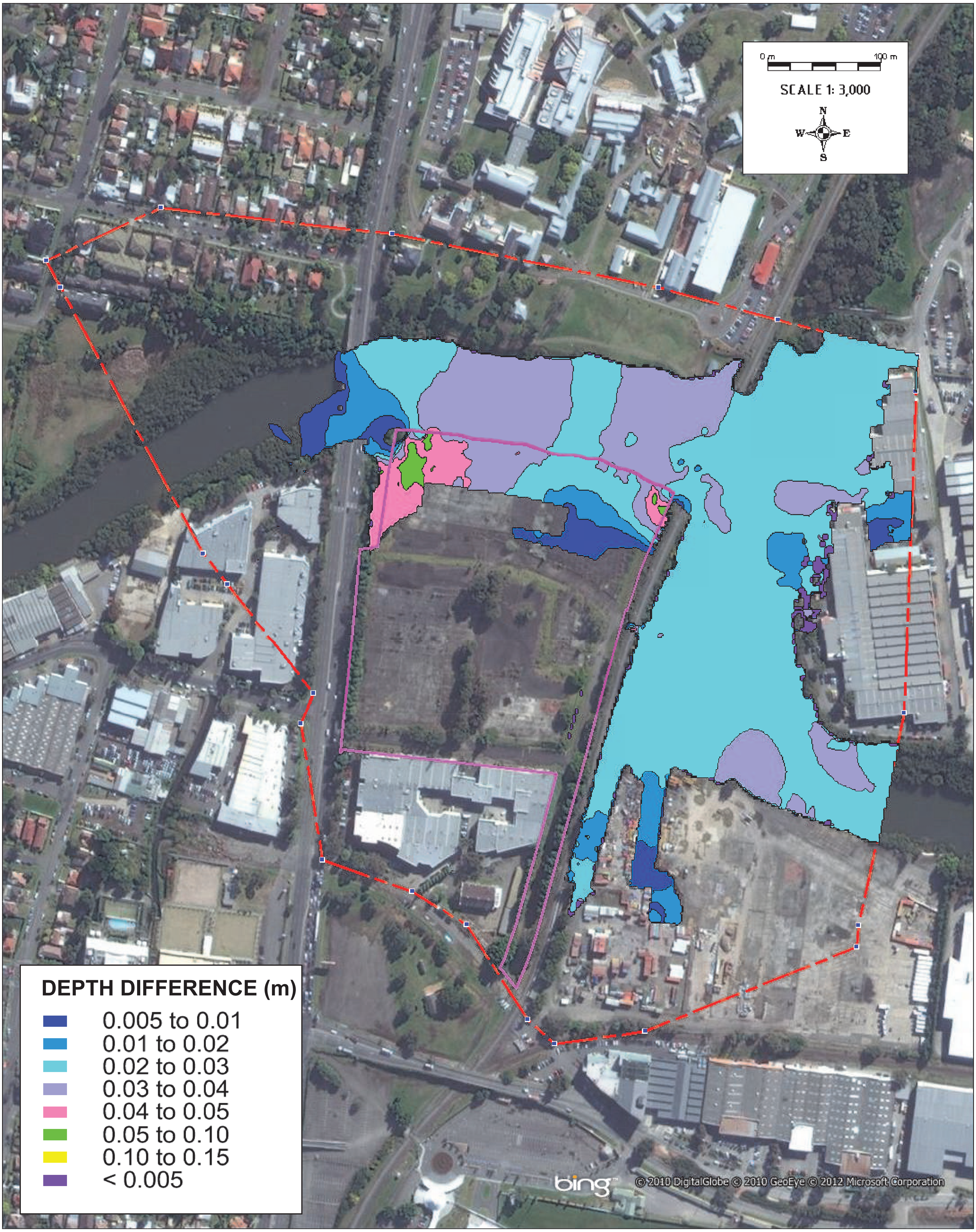
308388-CIV-FL-SK-005

CAMELLIA WEST FLOOD MODELLING

POST-DEVELOPMENT

100 YEAR ARI FLOOD DEPTHS

Mott MacDonald



ISSUE	DRAWN BY	CHECKED	AUTHORISED
B	AH	GL	CA

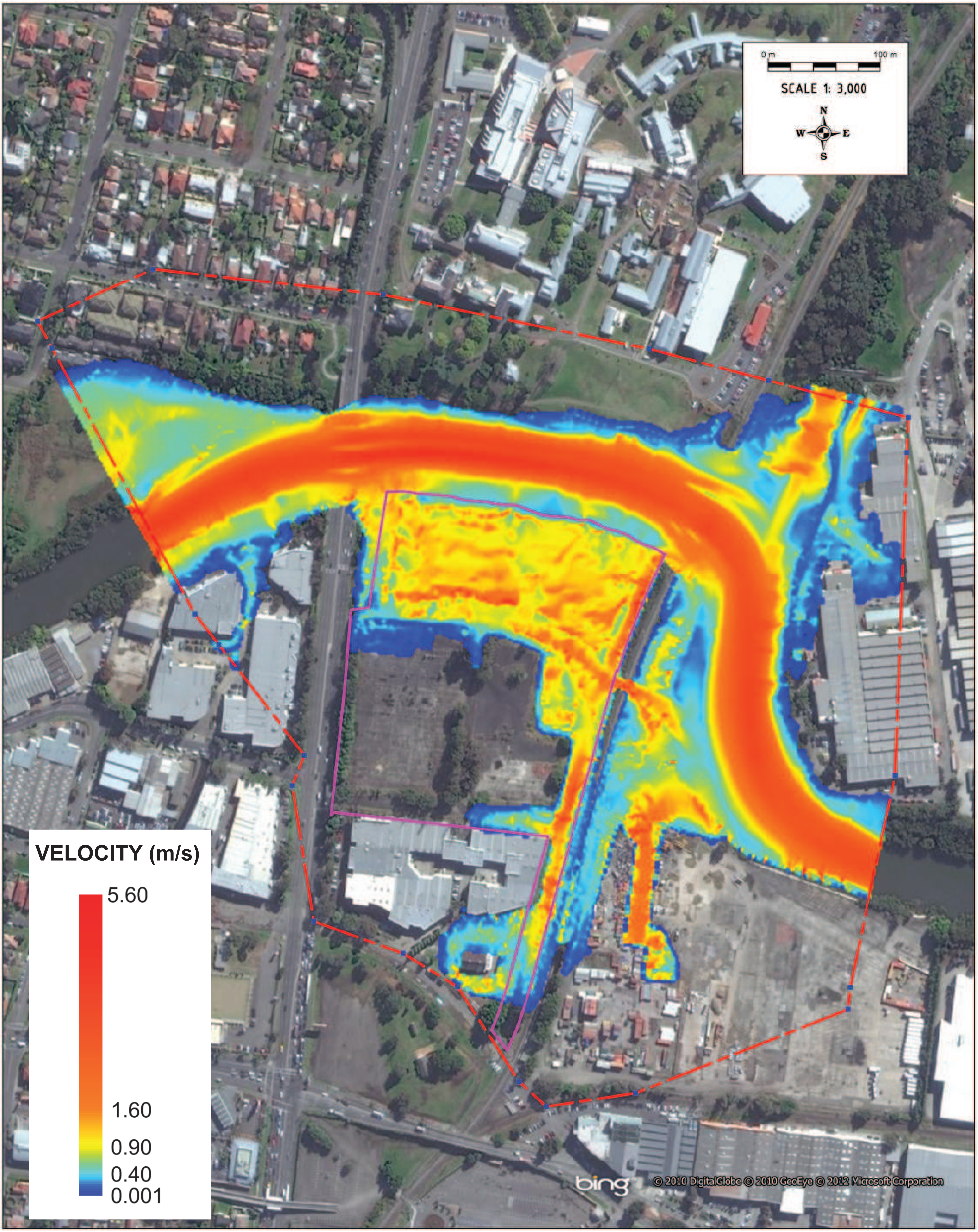
308388-CIV-FL-SK-006

CAMELLIA WEST FLOOD MODELLING

POST-DEVELOPMENT

100 YEAR ARI DEPTH DIFFERENCE

Mott MacDonald



ISSUE	DRAWN BY	CHECKED	AUTHORISED
A	AH	GL	CA

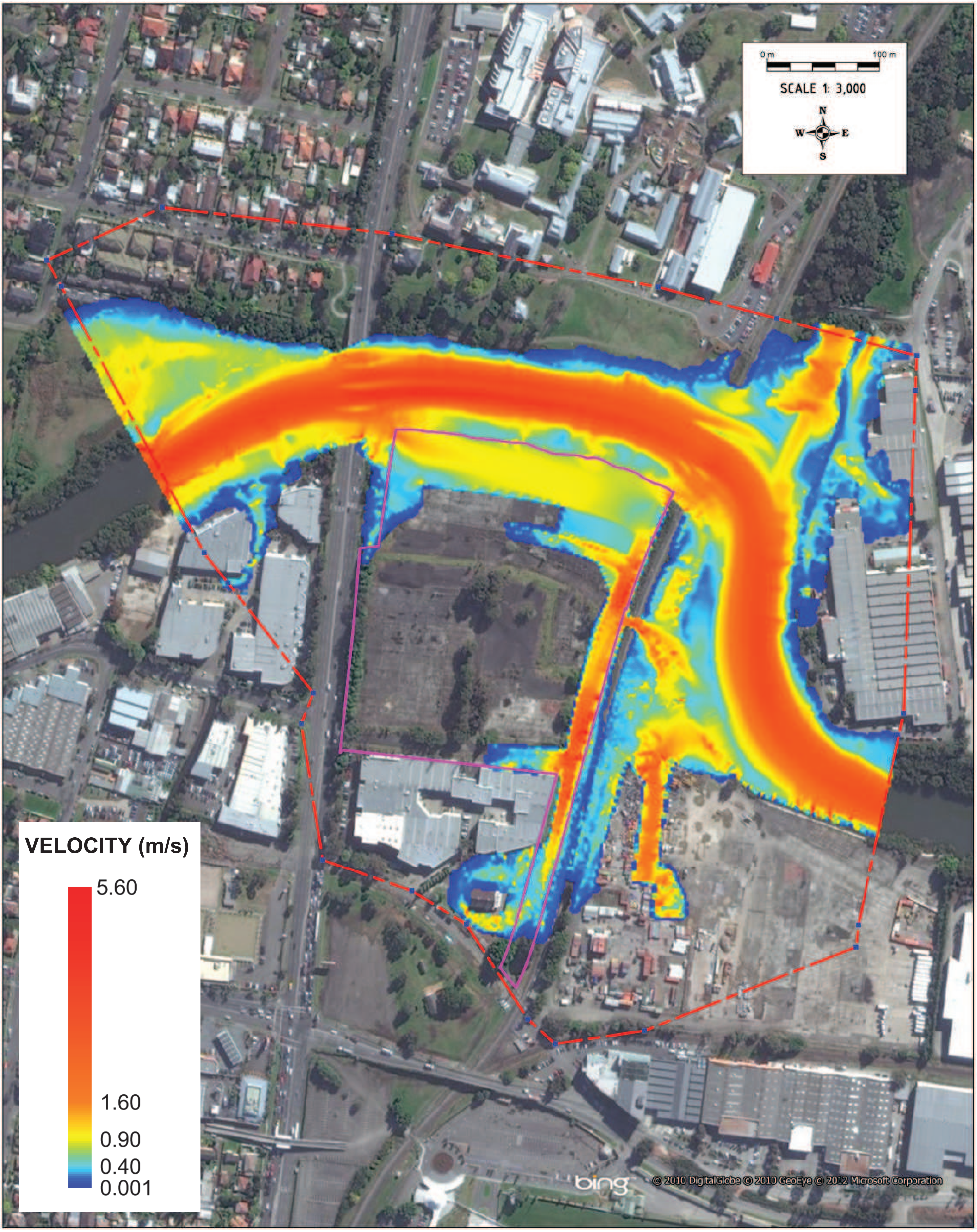
308388-CIV-FL-SK-007

CAMELLIA WEST FLOOD MODELLING

PRE-DEVELOPMENT

100 YEAR ARI VELOCITY

Mott MacDonald



ISSUE	DRAWN BY	CHECKED	AUTHORISED
B	AH	GL	CA

308388-CIV-FL-SK-008

CAMELLIA WEST FLOOD MODELLING

POST-DEVELOPMENT

100 YEAR ARI VELOCITY

Mott MacDonald

Appendix D. Flood Management Plan

FLOOD MANAGEMENT PLAN –
181 JAMES RUSE DRIVE, CAMELLIA WEST

Background

Council has advised that this property is subject to flooding in a 1% Annual Exceedance Probability (AEP) (1 in 100 year ARI) storm event. The Probable Maximum Flood (PMF) is the highest flood level that is ever likely to occur, however it is extremely rare. Relevant levels are:

- 5% AEP Flood Level = 4.14 m AHD
- 1% AEP Flood Level = 4.75 m AHD
- Probable Maximum Flood = 8.99 m AHD

Building
- Ground Floor Level = 6.50 m AHD
- Level 1 = approx 12.50 m AHD

The above levels give an indication of how the various floods will impact this property. A Flood Evacuation procedure is provided below and shall be implemented in the event of an extreme flood event in order to provide sufficient time for evacuation to a suitable safe point.

General Information
- The development is situated flood prone land and is affected by flood waters which overtop the banks of the Parramatta River during large events.
- During a 5% AEP flood event (1 in 20 years), the development will be affected by flooding. Traveling through floodwaters on foot or in a vehicle can be very dangerous as obstructions can be hidden under the floodwaters, or you could be swept away, even in a car. **All residents and visitors are advised to follow instructions from the Flood Management Plan for directions to evacuation points and safe areas.**
- If there is time prior to evacuation gather medicines, food, mobile phones, first aid kit, special papers and any small valuables into a bag in one location,
- Level 1 is the primary evacuation point in the event of major flooding. Residents should evacuate up to higher levels of the building using the stairs.
- It is important to note that in events larger than 1% AEP (1 in 100 years) the basement carpark may flood. When flood waters reach unsafe depths for evacuation at the front of the property (0.3m in depth), alarms will sound and security gates at the entrance to the carpark will be shut, locking the entrance/exit to the basement carpark prior to the basement flooding. Residents within the basement at this time are urged to proceed to higher levels through use of the stairs. Early detection is subsequently essential in order to allow sufficient time for the evacuation of the basement carpark areas.
- Flood depth markers and signage are provided along the foreshore and at the entrance of the basement carparks which may become flooded in large storm events.

- In the event that the road networks becomes inundated to a depth of 0.3m (i.e. via ponding) then it is deemed untrafficable and no longer safe to travel in a vehicle. At this time, residents and visitors should relocate to Level 1 of the building.
- Do not evacuate the building at this time and wait until the flood recedes. Remember floodwaters are much deeper and run much faster outside.

- In the case of a medical or other life threatening emergency ring 000 as normal, but explain the flooding situation.
- A laminated copy of this flood plan should be permanently attached (glued) adjacent to the exits on all Basement levels, the Ground floor, Level 1 and Level 2 of the building.

Procedure

The following evacuation procedure shall be implemented for the safe evacuation of pedestrians above the PMF.

Safe points above the PMF are available and include:

- Level 1 and above within the building,

Stair access to Levels 1-8 (which are above the PMF) is provided on ground and basement levels.

Evacuation procedures to these safe points include the following steps:

- Depth gauges shall be placed along the foreshore and near the carpark entrances of the proposed development.
- Residents and pedestrians may leave the premises safely either on foot or by vehicle until the depth of flood waters reaches 0.3m within the development's internal road network. After this time, the road network is considered unsafe for vehicles and pedestrians to leave the property (vehicles are deemed to be unstable in flood depths >= 300mm). It is recommended that residents do not attempt to exit the site via Tasman Street & James Ruse Drive as it is inundated during large events.
- After this depth has been reached the entrances to the basement carparks are no longer safe for access and egress and the residents should return to their place of residence or proceed to the higher levels of the development (Levels 1-16) until the flood subsides.
- Once the flood levels in the development site exceed a depth 0.3m below the driveway crest a siren will sound with flashing lights and the Security Entry Gate will close on the basement carpark. Vehicles will no longer be allowed to leave the development.
- An alarm will sound throughout the buildings emergency management system, alerting residents of the hazards and instructing them to evacuate the basement and proceed to higher levels.
- Residents and visitors are instructed by the Flood Management Plan to seek shelter within Level 1 of the building which is at RL 12.30m AHD and above the PMF level. Stair access is available for evacuation to Level 2 in the occurrence of extreme flood events until flooding alleviates.
- Residents and visitors are instructed by the Flood Management Plan not to evacuate the building at this time and wait until the flood recedes.