





ESQ1818 Development

Panthers Site

Flood Impact Assessment and Water Quality Management Report

05 April, 2016

SUSTAINABLE CERTIFICATION
ISO9001:2008
AS/NZS 4801:2001
ISO 14001:2004
Endorsed
Integrated Management System

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS

Document Control

Issue	Amendment	Author	Reviewer	Approved
A	First Draft	FL/RP	DC	DC
		17/03/2016	17/03/2016	18/03/2016
B	First Issue	FL	DC	DC
		24/03/2016	05/04/2016	05/04/2016
File Location	J:\110251 - Panthers North Precinct\02 - Flood Impact Assessment\SWE\SW Reports\110251_Rpt1B.docx			

PO Box 4366, PENRITH WESTFIELD, NSW 2750
77 Union Road, PENRITH, NSW 2750
P 02 4720 3300
W www.jwprince.com.au
E jwp@jwprince.com.au

Table of contents

LIST OF PLATES

LIST OF TABLES

LIST OF APPENDICIES

1 GLOSSARY

12D Model is a powerful terrain modelling, surveying and civil engineering software package used to develop the underlying surface for the 2D modelling.

Airborne Laser Survey (ALS) is a technique for obtaining a definition of the surface elevation (ground, buildings, power lines, trees, etc.) by pulsing a laser beam at the ground from an airborne vehicle (generally a plane) and measuring the time taken for the laser beam to return to a scanning device fixed to the plane. The time taken is a measure of the distance which, when ground truthed, is generally accurate to + 150mm.

Annual Exceedance Probability (AEP) is the probability that a given rainfall total accumulated over a given duration will be exceeded in any one year.

Average Recurrence Interval (ARI) means the average statistical interval (in years) between occurrences of floods, storms and flows of a particular magnitude.

Australian Rainfall and Runoff (AR&R) refers to the current edition of Australian Rainfall and Runoff published by the Institution of Engineers, Australia.

CatchmentSIM is a 3D-GIS application specifically tailored to hydrology based applications. CatchmentSIM is used to delineate a catchment, break it up into sub catchments, determine their areas and spatial topographic attributes and analyse each sub catchment's hydrologic characteristics to provide insight into the rainfall response of various catchments and the resultant assignment of hydrologic modelling parameters.

Council refers to Penrith City Council

Digital Terrain Model (DTM) is a spatially referenced three-dimensional (3D) representation of the ground surface represented as discrete point elevations where each cell in the grid represents an elevation above an established datum.

Floodplain Development Manual (FDM) and Guidelines (April 2005), the FDM is a document issued by DECCW that provides a strategic approach to floodplain management. The guidelines have been issued by the NSW DoP to clarify issues regarding the setting of FPL's.

Hydrograph is a graph that shows how the stormwater discharge changes with time at any particular location.

Hydrology The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.

J. Wyndham Prince Pty Ltd (JWP) Consultant Civil Infrastructure Engineers and Project Managers undertaking these investigations

Peak Discharge is the maximum stormwater runoff that occurs during a flood event3

Probable Maximum Flood (PMF) is the greatest depth of precipitation for a given duration meteorologically possible for a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends." largest flood that could be

Triangular Irregular Network (TIN) is a technique used in the created DTM by developing a mass of interconnected triangles. For each triangle, the ground level is defined at each of the three vertices, thereby defining a plane surface over the area of the triangle

TUFLOW is a computer program that provides two-dimensional (2D) and one-dimensional (1D) solutions of the free surface flow equations to simulate flood and tidal wave propagation. It is specifically beneficial where the hydrodynamic behaviour, estuaries, rivers, floodplains and urban drainage environments have complex 2D flow patterns that would be awkward to represent using traditional 1D network models.

XP-RAFTS runoff routing model that uses the Laurenson non-linear runoff routing procedure to develop a subcatchment stormwater runoff hydrograph from either an actual event (recorded rainfall time series) or a design storm utilising Intensity-Frequency-Duration data together with dimensionless storm temporal patterns as well as standard AR&R 1987 data.

2 INTRODUCTION

J. Wyndham Prince has been engaged to prepare a flood impact assessment and water quality management report to support the proposed ESQ1818 development of the northern portion of the Panthers site in Penrith. The site is bound by Mulgoa Road to the east, Jamison Road to the south, Showground Creek to the north and Peachtree Creek to the west. Plate 2-1 provides locality details of the proposed development within the Panthers site.

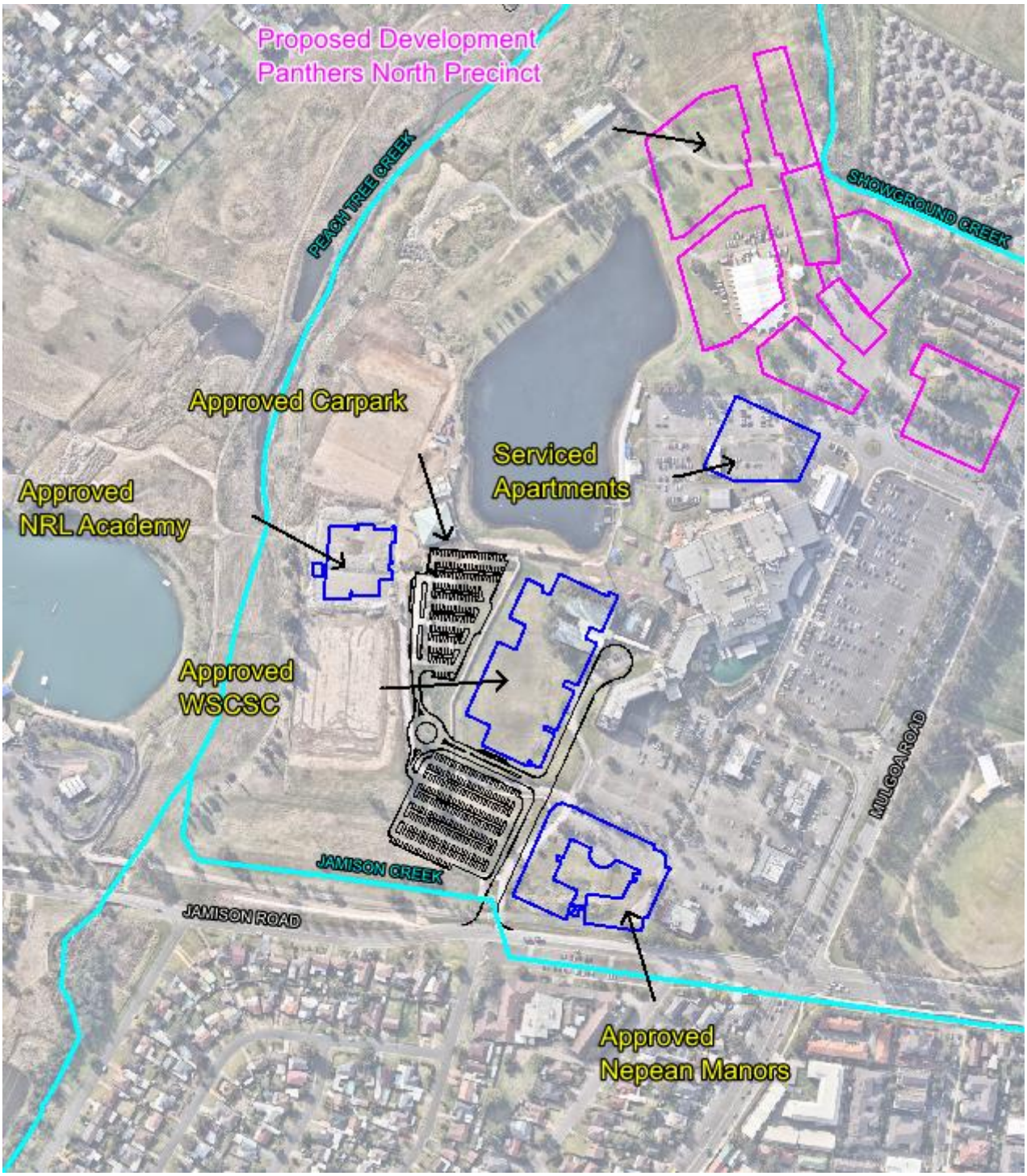


Plate 2-1 Panthers Site – ESQ1818 Locality Plan

The following section of the report provides an overview of the main features of the existing site focusing around the proposed ESQ1818 development.

2.1 Existing Site

The Panthers North Precinct where the proposed ESQ1818 development is to occur is approximately 6.7 ha in size. It currently supports an Exhibition Centre approximately 3,000 m^2 in size, an internal road and approximately 13,000 m^2 of carpark to support both the Exhibition centre and the broader Panthers site.

2.2 Proposed Development

The proposed ESQ1818 development consists of 11 residential apartment towers and 15 at grade retail outlets supported by basement car parking, internal roads and generous public space areas. Embellishments to Showground Creek will enhance the visual amenity of the local area and improve flow conveyance in what is currently a poorly defined, overgrown first order watercourse. Refer to Plate 2-2 below for an overview of the proposed development.

Plate 2-2 Proposed ESQ1818 development

Source Turner Architects

3 RELEVANT GUIDELINES AND POLICIES AND PREVIOUS REPORTS

The following section of the report provides an overview of the control documents and guidelines that have been used in the development of this report in order to gain an understanding of flooding and water quality management controls that have to be complied with.

3.1 Penrith Development Control Plan 2014

Section E13.10.1 of the Penrith Development Control Plan 2014 specifies the following controls relating to flooding and drainage that apply to proposed development within the Panthers Precinct:

- All applications are to address the relevant sub-sections of the Water Management Section of the DCP.
- A stormwater management strategy is to be prepared for the whole precinct and be submitted with the first major development application and should identify and address:
    - Impacts of stormwater generated both on and off the site;
    - Stormwater easements and overland flow paths;
    - Opportunities to maximise the re-use of stormwater runoff;
    - Means to reduce the demand on potable water supplies; and
    - Reductions in pollutants entering the water system.
    - It should be noted that the overall stormwater management strategy for the Panthers site has been submitted to Penrith City Council back in 2014.
- Any development west of the Club and within the flood flow conveyance corridor is to develop a strategy to ensure that the 200-year regional flood runner is maintained without causing adverse impact to adjoining lands in accordance with the principles of Scenario 4 modelling under Panthers Planning Proposal – Appendix H. The strategy will identify the timing, staging and detailing of necessary works to be undertaken.
- Development of a comprehensive flood evacuation and emergency response plan as part of the Infrastructure Masterplan.

Section C3.2 of the Penrith Development Control Plan 2014 specifies the following controls relating to water quality management that apply to proposed development within the Panthers Precinct:

- Water discharge from any development must not contain contaminants unless relevant licenses/approvals are obtained;
- Where there is potential to impact upon a water system, applications to Council must identify the relevant water systems in the catchment that may be affected and address how any potential impacts will be mitigated or avoided;
- A MUSIC model in accordance with Penrith City Council's WSUD policy and WSUD technical guidelines and using Penrith rainfall data will need to be utilised to demonstrate that the following pollutant reductions are achieved:
    - 90% Gross Pollutants
    - 85% Total Suspended Solids
    - 60% Total Phosphorous
    - 45% Total Nitrogen
    - 90% Free oils and grease with no visible discharge.
- The post development duration stream forming flows are to be no greater than 3.5 times the pre development duration stream forming flows.

3.2 Panthers Precinct Master Plan – Flood Assessment Report November 2014 (Rev E)

J. Wyndham Prince prepared *the* Flood Assessment Report in November 2014 documenting a hydrologic and flooding assessment for the Panthers Precinct based on the revised Panthers Masterplan.

The report concluded that:

- *The detailed flood assessment completed within the report demonstrated that the ultimate Master Plan development will result in minor increases in flood levels within the Precinct, which can be managed within the development. There are no increases in flood levels outside the precinct in the 1% AEP regional and local flood events. However, in the 0.5% AEP regional event, there is a minor flood level increase of less than 35mm outside the Precinct.*

- *This increase occurs in areas that are already significantly flooded during this event with flood depth of upwards of 4m experienced under existing conditions. Thus, this increase is considered minor and should not restrict development approval on the Panthers site.*

- *A separate flood impact assessment for the Panthers development has been undertaken by Worley Parsons in the regional RMA-2 model using the same land form and model parameters adopted in the TUFLOW model. The results of the RMA-2 modelling predicts very similar flood impacts to the TUFLOW modelling and demonstrate that the TUFLOW model is suitable for assessing the impacts of various development options proposed as part of the Panthers Master Plan.*

- *A number of staged development options have been assessed. The TUFLOW modelling indicates the majority of the proposed Panthers development is able to proceed without causing an adverse impact external to the Precinct. The proposed Factory Outlet Centre is a significant contributor to the external flood impacts. However, the external flood level impacts can be mitigated by either reducing the area of the northern ski lake extending into the floodplain or reducing the footprint of the outlet centre.*

The flood modelling used in the 2014 assessment has been augmented to support approval of the ESQ1818 development. Further details of the flood modelling history and amendments to support the ESQ1818 development are provided in Section 5 of this report.

4 STORMWATER MANAGEMENT

4.1 Water Quality Management

A Water Quality assessment has been undertaken using MUSIC modelling software, version 6.1.0 and in accordance with PCC's *Water Sensitive Urban Design (WSUD) Policy (2013) and WSUD Technical Guidelines (2015).*

The model provides a number of features relevant for the development:

- It is able to model the potential nutrient reduction benefits of gross pollutant traps, constructed wetlands, grass swales, bio-retention systems, sedimentation basins, infiltration systems, ponds and it incorporates mechanisms to model stormwater re-use as a treatment technique.
- It provides mechanisms to evaluate the attainment of water quality objectives.

The MUSIC modelling was undertaken to demonstrate that the stormwater management system proposed for the ESQ1818 development will result in reductions in overall post-development pollutant loads that comply with the designated target objectives.

Penrith City Council have established default parameters for use in MUSIC models to represent the generation of various pollutants by different land uses. A MUSIC model representing the proposed ESQ1818 development was prepared to demonstrate compliance with the required post development annual load reductions (PCC, 2013).

4.2 Catchments

Plate 4-1 below shows the general layout of the MUSIC model for the Panthers North development. The subject site has been split into three (3) sub-catchments (M1, M2 and M1 bypass) with each draining to the reconstructed channel bisecting the northern portion of the site.

For the purposes of this assessment, the study area is limited to the disturbed areas located within the Precinct boundary (up to the top of bank on the reconstructed channel) along with a portion of Retreat Drive.

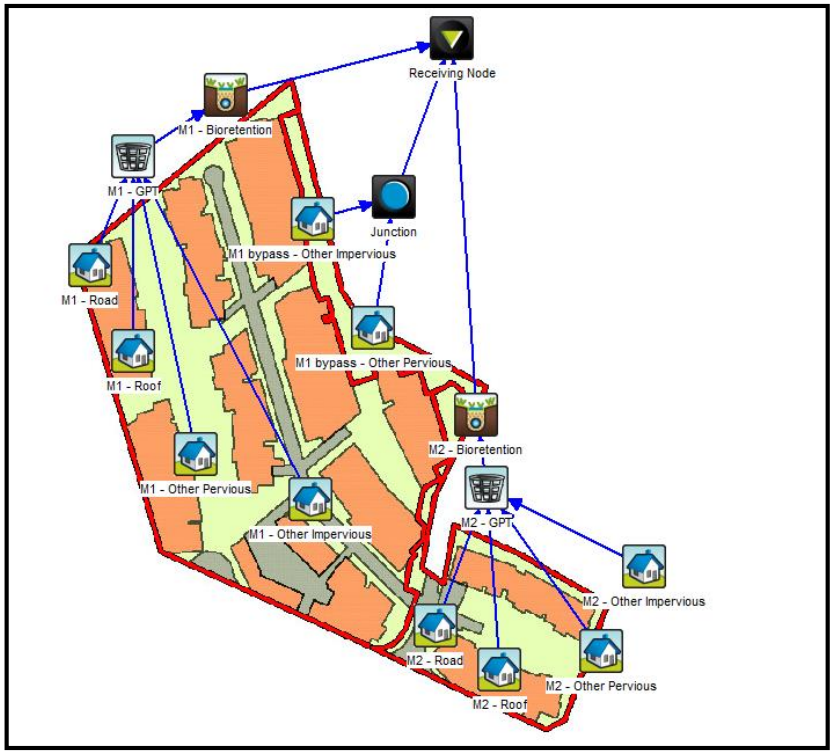


Plate 4-1 MUSIC Model Layout

(ref: 110251-Panthers North.sqz)

4.3 Modelling Inputs and Assumptions

The following assumptions and parameters have been adopted in the MUSIC modelling:

- In accordance with PCC's Water Sensitive Urban Design Technical Guidelines (2015), the target pollutant removal rates are 85% Suspended Solids (TSS), 60% Total Phosphorus (TP) and 45% Total Nitrogen (TN).
- Each sub-catchment has been split into "road" and "roof" areas based on the DA proposed layout. It is noted that the fraction impervious for the proposed layout is around 50 – 70%, however in accordance with Council standards an overall 90% fraction impervious has been adopted. Similarly a conservative 50% fraction impervious is also adopted for the bypass area.

  These remaining site areas are applied as "Other Pervious" and "Other Impervious". Refer to Table 4-1 for breakdown.

Table 4-1 – Summary of Area

	Area (Ha)					
Catchment	Total	Road	Building	Other Pervious	Other Impervious	% Imp
M1	4.32	0.48	2.30	0.43	1.11	90%
M1 bypass	0.34	0.00	0.00	0.17	0.17	50%
M2	1.09	0.12	0.41	0.11	0.45	90%
Total:	**5.75**	**0.61**	**2.70**	**0.71**	**1.72**	**87.7%**

- Bio-retention raingardens consist of a filtration bed with either gravel or sandy loam media and an extended detention zone of 300 mm deep designed to detain and treat first flush flows. The media bed of the raingardens is 500 mm deep. The location of the raingardens servicing the ESQ1818 development are shown on Figure 5-1 (refer Appendix A).
- Two (2) raingardens have been strategically located to receive flows from the proposed pipe networks before draining to the reconstructed Showground channel. Raingarden M1 will receive flows from proposed buildings and the pipe network along the central road. Whilst Raingarden M2 will receive flows via an offtake pipe from the proposed box culverts. Refer to Drawing 110251/DA09 and 110251/DA10.
- A portion of the site will bypass the two (2) raingardens and drain overland to the channel. The raingarden areas are subsequently sized to overcompensate for the M1 bypass catchment.
- It is assumed that trash and gross sediments will be effectively removed prior to entering the raingardens by the proposed GPT units. For the purposes of modelling, a generic style GPT has been adopted (no TSS, TP or TN removal).
- The surface area provided in raingardens for storage and filtration are approximately 1.6% of the catchment area they service. The approximate bed area of the raingardens are shown in Table 4-2 and on Figure 5-1 (refer Appendix A).

Table 4-2 – Summary of Raingarden Devices

Bioretention Location	Total Catchment Area (Ha)	Bioretention Raingarden Achieved (m^2)
M1 (plus bypass)	4.65	760
M2	1.09	150

4.4 Pollutant Load Estimates

Total annual pollutant load estimates were derived from the results of a MUSIC model based on a stochastic assessment of the developed site incorporating the proposed water quality treatment system. The estimated annual pollutant loads and reductions for TSS, TP, TN and Gross Pollutants for the Panthers North development are presented in Table 5-3.

Table 4-3 – Summary of Estimated Mean Annual Pollutant Loads & Reductions

Pollutant	Total Catchment Source Loads (kg/yr)	Minimum Reduction Required (kg/yr)	Total Residual Load (kg/yr)	Total Reduction Achieved (kg/yr)	Total Reduction Achieved (%)
TSS	6,240	5,304	931	5,309	85.1%
TP	10.0	6.5	3.1	6.9	69.3%
TN	67	30.3	30	37.7	55.9%
GP	835	752	40.4	795	95.2%

4.5 Stream Erosion Index

In accordance with Table 1 – Water Sensitive Urban Design Requirements of PCC's *Water Sensitive Urban Design Policy* (2013), we have undertaken a Stream Erosion Index (SEI) assessment to ensure that the duration of post-development stream forming flows are no greater than 3.5 times the duration of stream forming flows under existing conditions.

The methodology to determine the SEI complies with the Draft NSW MUSIC Modelling Guide (2010). The node used to represent the site under existing conditions was a forest node. The rainfall-runoff/soil parameters for the forest node are consistent with Table 4 – MUSIC Rainfall-Runoff Parameters from Penrith in PCC's Water Sensitive Urban Design Technical Guidelines (2013). Because this document does not provide the water quality parameters for a forest node, the stormwater quality parameters for storm and base flow were taken from the Draft NSW MUSIC Modelling Guide (2010).

The flow for the site was calculated using the Probabilistic Rational Method (PRM).

The SEI for the site was determined to be 2.5, which is less than the maximum 3.5 set out in PCC's guidelines. A summary table of the SEI assessment and results is provided in Table 4-4 – SEI Assessment and Results

below.

Table 4-4 – SEI Assessment and Results

Stream Index				50% - Comparison of 2 year ARI Results		
Assessment Location	Area (ha)	Pre Dev 2 yr ARI flow (m^3/s)	50% of 2yr ARI (m^3/s)	Pre Dev Outflow (ML/yr)	Post Dev Outflow (ML/yr)	SEI
Site Discharge Location	5.75	0.177	0.089	1.57	3.85	2.5

** Total flow in and out has been applied at SEI nodes based on 2yr existing results
**SEI nodes placed at site discharge location
** this has been applied to both the pre and post models
** comparison is then made between greenfield and the proposed scenario
(examining the total flow out of the system)
**approach is conservative given the existing site also includes pavillion and large carpark

4.6 Discussion of Water Quality Modelling Results

The performance of the proposed water quality management strategy and estimated annual pollutant load reductions for the ESQ1818 development, as determined through a stochastic MUSIC assessment demonstrates that the proposed strategy achieves the reduction targets specified by Penrith City Council. The assessment of the Stream Erosion Index also demonstrates that the development complies with statutory targets.

A copy of the MUSIC-Link report is included in Appendix C.

5 FLOOD IMPACT ASSESSMENT

As part of the Panthers Precinct masterplan, J. Wyndham Prince prepared a TUFLOW model to support this process and presented results of our investigation in a *Panthers Precinct Master Plan – Flood Assessment Report* (JWP 2014). This model was developed to determine localised flood impacts, as the broader RMA-2 regional flood model was agreed to be impractical to test development scenarios for the Panther site.

5.1 TUFLOW Modelling Background

Worley Parsons had undertaken regional flood modelling using RMA-2 for the Nepean River on behalf of Penrith City Council in 2008. Various development scenarios for the Panthers Precinct were incorporated into this regional model at planning proposal stage to establish that development of the land could occur without material flood impact for a range of events including the 0.5% AEP event. These impacts and the required flood level requirements were referred to as '*Appendix H of the Panthers Planning Proposal*' the in Penrith City Council's Development Control Plans 2010 and 2014, and is the current base for development on the Panthers site.

As part of the revised Panthers Precinct masterplan submitted to Penrith City Council back in 2014, J. Wyndham Prince prepared a TUFLOW model to support this process and presented results of our investigation in a detailed *Panthers Precinct Master Plan – Flood Assessment Report (*JWP, 2014). This model was developed to determine localised flood impacts, as Council agreed that the broader RMA-2 regional flood model was impractical to test development scenarios for the Panthers site.

At Council's request, Worley Parsons were engaged by Panthers to undertake an equivalent flood impact assessment of the proposed Master Plan in the regional RMA-2 model to endorse the results of the TUFLOW assessment detailed in J. Wyndham Prince's report. Whilst it would generally be expected that the two different modelling approaches would result in some differences, a major difference noted by Worley Parsons was the use of a fixed tail water condition in the J. Wyndham Prince assessment as opposed to a variable tail water used in the Worley Parsons assessment. It was also identified that Worley Parsons' RMA-2 model had adopted full blockouts for buildings throughout the Panthers site whilst J. Wyndham Prince's TUFLOW model had adopted a high roughness, which is considered a more realistic representation of the floodplain.

On information received from Worley Parsons, (email correspondence 19 August 2014) new inflow and tail water hydrographs for Peachtree Creek and the Nepean River were provided. J. Wyndham Prince TUFLOW model was then updated to incorporate the same variable 0.5% and 1% AEP tail water levels from the RMA-2 model and blocked-out each building footprint (in lieu of adopting a roughness coefficient). The inflow hydrographs for Jamison Creek (Bazooka Channel) and Showground Creek are as previously agreed with Council adopted from the Peachtree Creek Flood Study (PWD 1994):

- Jamison Creek peak flow 34.2 m^3/s and 48.32 m^3/s for the 20% and 1% AEP events respectively.
- Showground Creek peak flow 29.1 m^3/s and 39.2 m^3/s for the 20% and 1% AEP events respectively.

Worley Parsons subsequently reviewed the updated TUFLOW results and provided an addendum report which is included in Appendix B. Whilst they noted some differences in inflow distribution, velocity and roughness, the results of the RMA-2 and updated TUFLOW modelling were compared, and it was concluded that

> *'..they both predict equivalent flood impacts upstream, and thus the TUFLOW model can be confirmed as being suitable for assessing the impacts of various development options proposed as part of the Panthers Master Plan'* (WP October 2014).

The *Panthers Precinct Master Plan – Flood Assessment Report* was updated in November 2014 (Rev E) and documented modelling assumptions and parameters such as the digital terrain model, catchment roughness, inflow hydrographs and tail water conditions. It included a section detailing Worley Parsons' assessment and endorsement of the TUFLOW model's suitability to assess local flood impacts due to proposed development on the Panthers Site.

Subsequently this TUFLOW model has been utilised to support Development Approval for the following developments:

- The NRL Academy;
- The Western Sydney Community Sports Centre (WSCSC);
- The Multi-storey Carpark and Serviced Apartments (MSCSA); and
- The Nepean Manors (Seniors Living).

These individual flood assessments have considered cumulative impacts of all developments to date (i.e. the TUFLOW model developed to support the Nepean Manors development includes the NRL Academy, the WSCSC, and the MSCSA development) with all flood impacts compared to existing conditions results. This has ensured that the staged development of the Panthers site provides an accumulative assessment of the flood impact within the bound of the model.

Therefore, the modelling and report submitted to Council in November 2014 incorporated all recommendations and updated information from the Worley Parsons Review. Thus J. Wyndham Prince's TUFLOW model is a representative of the RMA-2 assessment and suitable to make flood assessments for the Panthers site and determine the need or otherwise for mitigation measures in order to support the development of the entire masterplan.

5.2 TUFLOW Model – ESQ1818 Development

The TUFLOW model utilised to support the proposed ESQ1818 development includes all development approved to date and incorporates the all local drainage within and adjacent to the Panthers. There has also been a series of model refinements since 2014 which have increase the model accuracy.

It is important to note that previously under the masterplan for the Panthers Site, a large solid block-out reflecting a Direct Factory Outlet (DFO) building. The proposed ESQ1818 development is significantly different in built form, whilst it may be similar in footprint, it consists of internal roads that provide flood conveyance through the proposed development both during the 1% and 0.5% AEP event. Additionally, it has been identified that the electricity substation, which was to be positioned adjacent to Peachtree Creek and within the main floodway, is no longer required to support development on the Panthers Site. See email correspondence forwarded to Penrith City Council on 15th March 2016.

The following elements/assumptions relating to the ESQ1818 development have been adopted in the TUFLOW modelling to confirm that there are no flood impacts outside the Panthers site due to the proposed works:

- All entry ramps to basement carparks are above required level (i.e. the regional 1% AEP flood level of 26.1 m AHD + 0.3 m freeboard).
- In a regional 0.5 % AEP flood event, the anticipated flood level is 27.25 m AHD. This will result in floodwater entering the basement car parks. However, from a modelling point of view, no storage in the carparks has been reflected and all buildings are 100% blocked out of the model.
- All podiums are reflected as solid blockouts to their respective design levels (i.e. varying from 26.5 m to 32.8 m AHD.

- All residential tower buildings above the podiums are reflected as solid block-outs up and out of the floodplain (i.e. an arbitrarily high value of RL 100 m AHD has been adopted).
- Materials roughness values are consistent with those adopted for the *Panthers Precinct Master Plan – Flood Assessment Report* (J. Wyndham Prince 2014).
- The orientation of the TUFLOW loc line has been slightly rotated in comparison to *Panthers Precinct Master Plan – Flood Assessment Report (*JWP, 2014). This slight rotation allowed a greater number of TUFLOW cell to represent the actual flow conveyance within Peachtree Creek together an improved alignment with the main features of the model (i.e. cells roughly parallel with Peachtree Creek rather than north-south orientation adopted in the previously modelling).
- The terrain at the location of the Peachtree Creek culverts under Jamison Road and the internal Panthers Ski Lake Road has been amended to remove the road surface as this infrastructure has now been modelled using a layered flow constrictions in TUFLOW.
- The future electricity sub-station that was to be located adjacent to Peachtree Creek in the northern portion of the site is no longer required to support development on the Panthers site, and has therefore been excluded from the modelling.
- The length of the 0.5 % AEP side-flow inflow boundary (reflecting mainstream breakout from the Nepean River in this event) has been increased from that used in the 2014 Panthers modelling to ensure that the peak water level at the inflow boundary (as provided by Worley Parsons) corresponds with the digital terrain model along this boundary.

The TUFLOW model was subsequently run for the following four (4) events:

- 1% AEP Regional Flood
- 0.5% AEP Regional Flood
- Combination 1% AEP Regional Flood + 5% AEP Local Flood
- Combination 1% AEP Local Flood + 5% AEP Regional Flood

Results for the assessment are provided on figure 5 – 8 with flood difference maps for these four (4) scenarios provide in figures 9 -12. Hazard maps for the two combination events are presented in Figures 13 and 14. Refer Appendix A.

5.3 Future Development Scenario

As requested by Penrith City Council, a future development scenario has been tested where all development approved to date (NRL Academy, MSCSA, WSCSC, Seniors Living), plus the ESQ1818 development together with the likely anticipated development within the remainder of the Panthers site.

This development scenario was also tested for the same four (4) storm events as completed for the ESQ1818 development. Results of the future development scenarios together with the associated flood difference maps are provide in Figures 15 – 22. Refer Appendix A.

5.3.1 Flood Impact Results

Flood modelling of the proposed ESQ1818 development was undertaken to determine the impact on flood behaviour within Peachtree Creek in the aforementioned scenarios. Flood level difference maps are included in Figures 10 – 12 (refer Appendix A) showing the impact of the proposed development in comparison to existing conditions.

The flood level difference mapping indicates wide spread flooding outside the Panthers site boundary no longer occur. The flood level differences for each Scenario are as follows:

- 1% AEP Regional Flood – Generally no changes (Figure 9);
- 0.5% AEP Regional Flood– Localised increases of generally less than 40 mm contained within the Panthers Precinct (Figure 10), and no widespread impacts outside the subject site;

- Combination 1% AEP Regional Flood + 5% AEP Local Flood – Localised increases of contained within the Panthers Precinct (Figure 11);and
- Combination 1% AEP Local Flood + 5% AEP Regional Flood – Localised increases are contained within the Panthers Precinct (Figure 12).

5.3.2 Floor Levels

The governing flood level for buildings A and B on the eastern portion of the site (refer Turner Architectural Plans) occurs in the Combination 1% AEP Local Flood + 5% AEP Regional Flood event, and is due to overland flooding between these buildings. This level is RL 26.84 m AHD. Therefore with the required 0.5 m freeboard, the minimum floor level of Buildings A and B will need to be 27.34 m AHD.

For the remainder of the proposed ESQ1818 development, the Combination 1% AEP Regional Flood + 5% AEP Local Flood event is the governing flood level. Based on the current modelling, the flood level in this event is 25.80 m AHD adjacent to Building E. It is noted however that Appendix H of the *Panthers Planning Proposal* indicates that the Regional 1% AEP flood level for planning purposes is approximately 26.10 m AHD for the Panthers site. Hence a minimum floor level of 26.60 m has been adopted to provide the required 0.5 m freeboard.

6 CONCLUSION

The Flooding and water quality assessment for the ESQ1818 development has been prepared to inform and support the a development approval of 11 residential apartment towers and 15 at grade retail outlets supported by basement car parking, internal roads and generous public space areas.

As part of the works associated with the project, embellishments of Showground Creek will enhance both the visual amenity of the local area and improve flow conveyance of what is currently a poorly defined, overgrown first order watercourse.

Furthermore, the strategy has been prepared to conform to the statutory requirements and relevant guidelines associated with flooding.

All approved developments to date within the Panthers site have been included in the ESQ1818 development flood assessment. The cumulative assessment of development within the Panthers site has then been compared back to the "existing conditions" assessment.

Four (4) different combinations of both regional and local flood events have form part of this assessment and it has concluded that the ESQ1818 development together and all other approved developments on the Panthers do not result in wide spread off site flood impacts.

The flood assessment also supports that fact that additional flood mitigation works which where anticipated as part of the *'Panthers Planning Proposal - Appendix H'* are not required to support either the ESQ1818 development or the full development of the Panthers site as outlined in the Panther 2014 masterplan.

This investigation therefore addresses Penrith City Council's requirements for assessing flood impacts. This comprehensive assessment provides Council with sufficient detail in order to support the current ESQ1818 development.

Yours faithfully

J. WYNDHAM PRINCE

[redacted]

DAVID CROMPTON

Manager – Stormwater & Environment

APPENDIX A – FIGURES

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au

LEGEND

- Panthers North Precinct Boundary
- MUSIC Catchment
- MUSIC - Road
- MUSIC - Roof
- MUSIC - Other Pervious / Impervious
- Proposed Raingarden
- Proposed GPT
- Proposed Pipe

N
W E
S

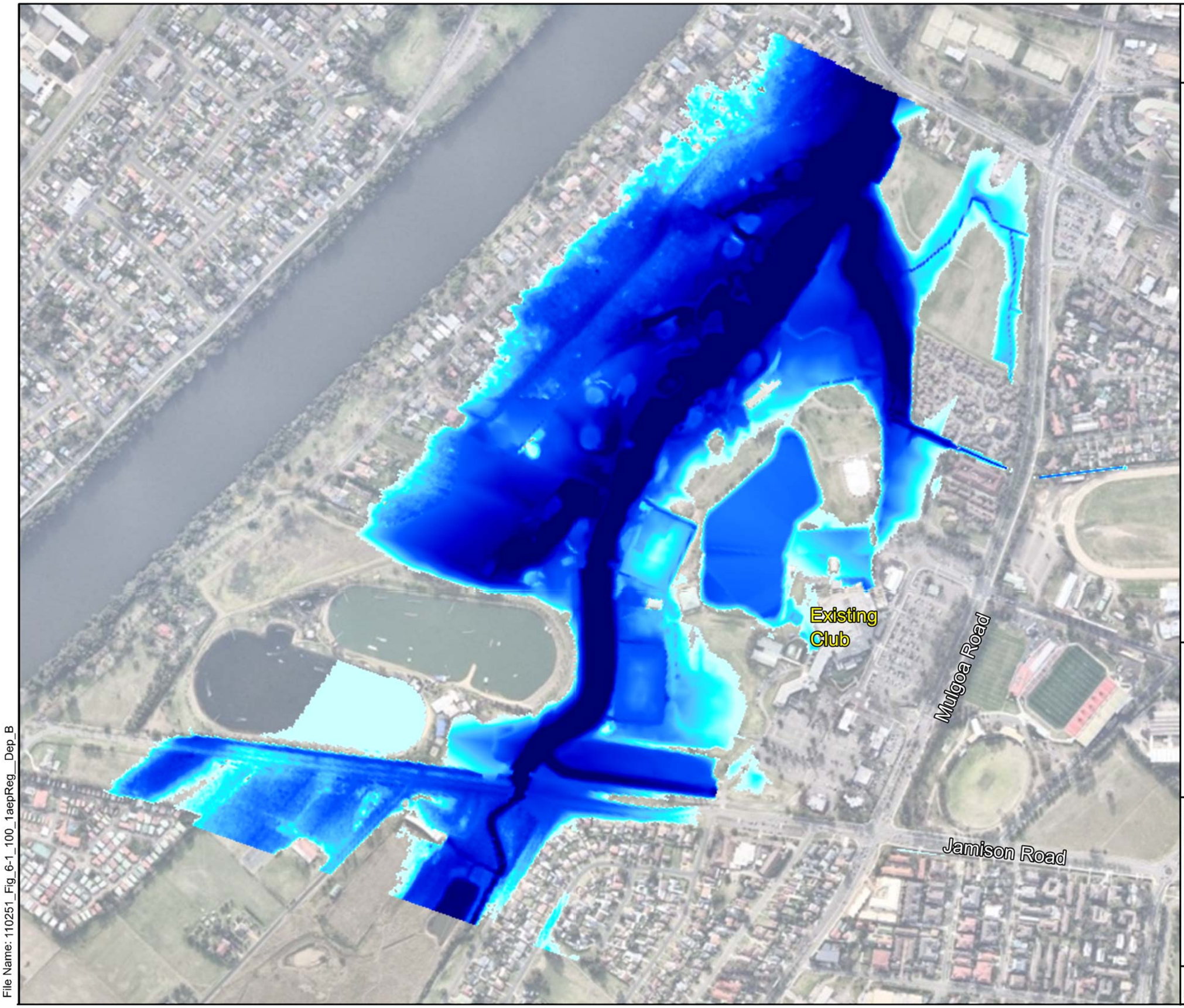
Figure 5.1
Panthers North Precinct Mixed Use Development

MUSIC Catchment Plan

Date : 06/04/2016 Issue : B

File Name: 110251_Fig_3_20_1aepReg+5aepLoc_ExLocDrain_Dep_A

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au



LEGEND

Depth (m)

- 0.0 to 0.2
- 0.2 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0 +

N
W E
S

Scale 1: 6,000 @ A3

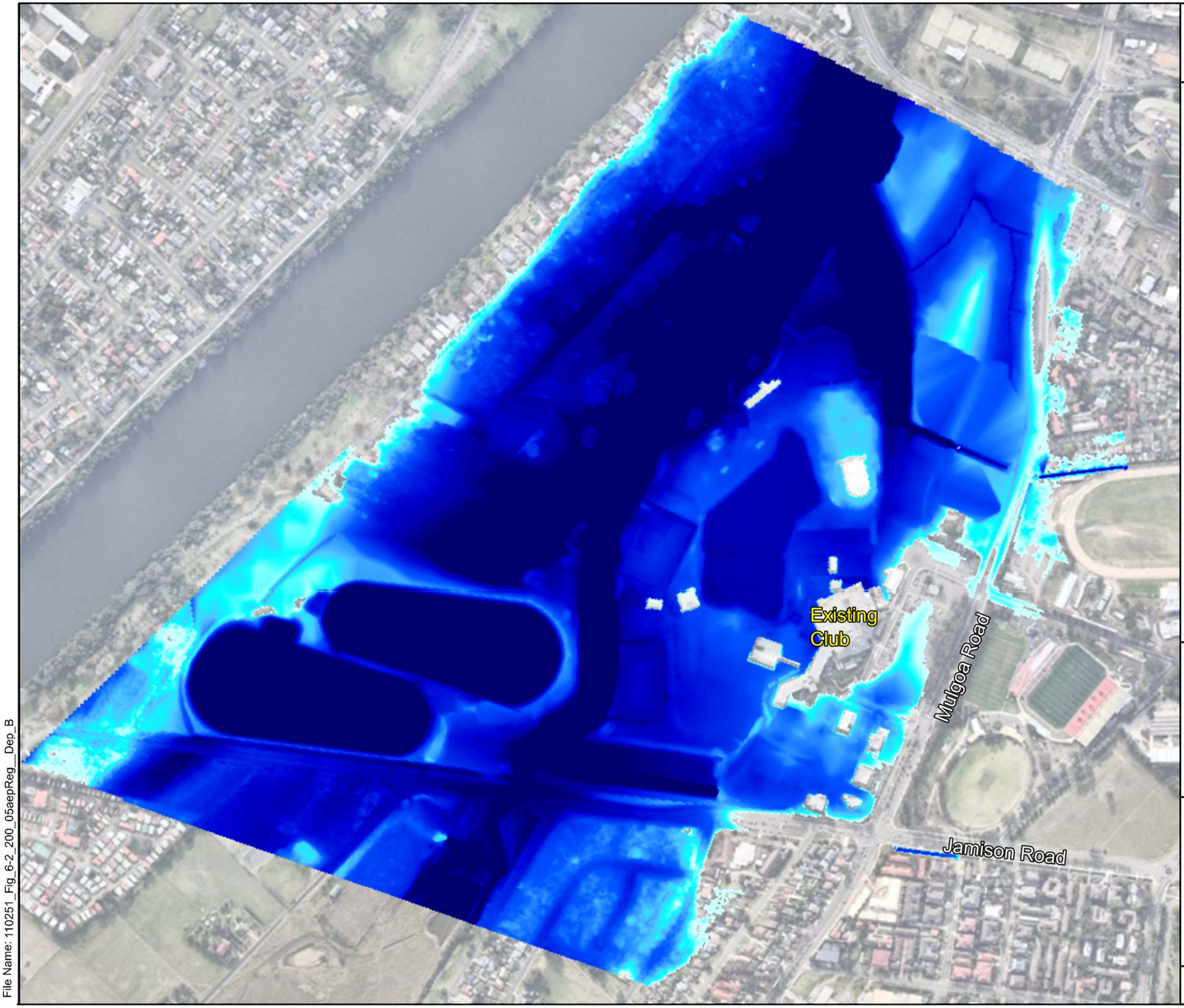
200 0 m

Figure 6-1
Panthers North Precinct Mixed Use Development
1% AEP Regional Existing Conditions Flood Depth Map

Date : 23/03/2016 Issue : B

File Name: 110251_Fig_6-1_100_1aepReg__Dep_B

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au



LEGEND

Depth (m)

- 0.0 to 0.2
- 0.2 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0 +

N
W E
S

Scale 1: 6,000 @ A3

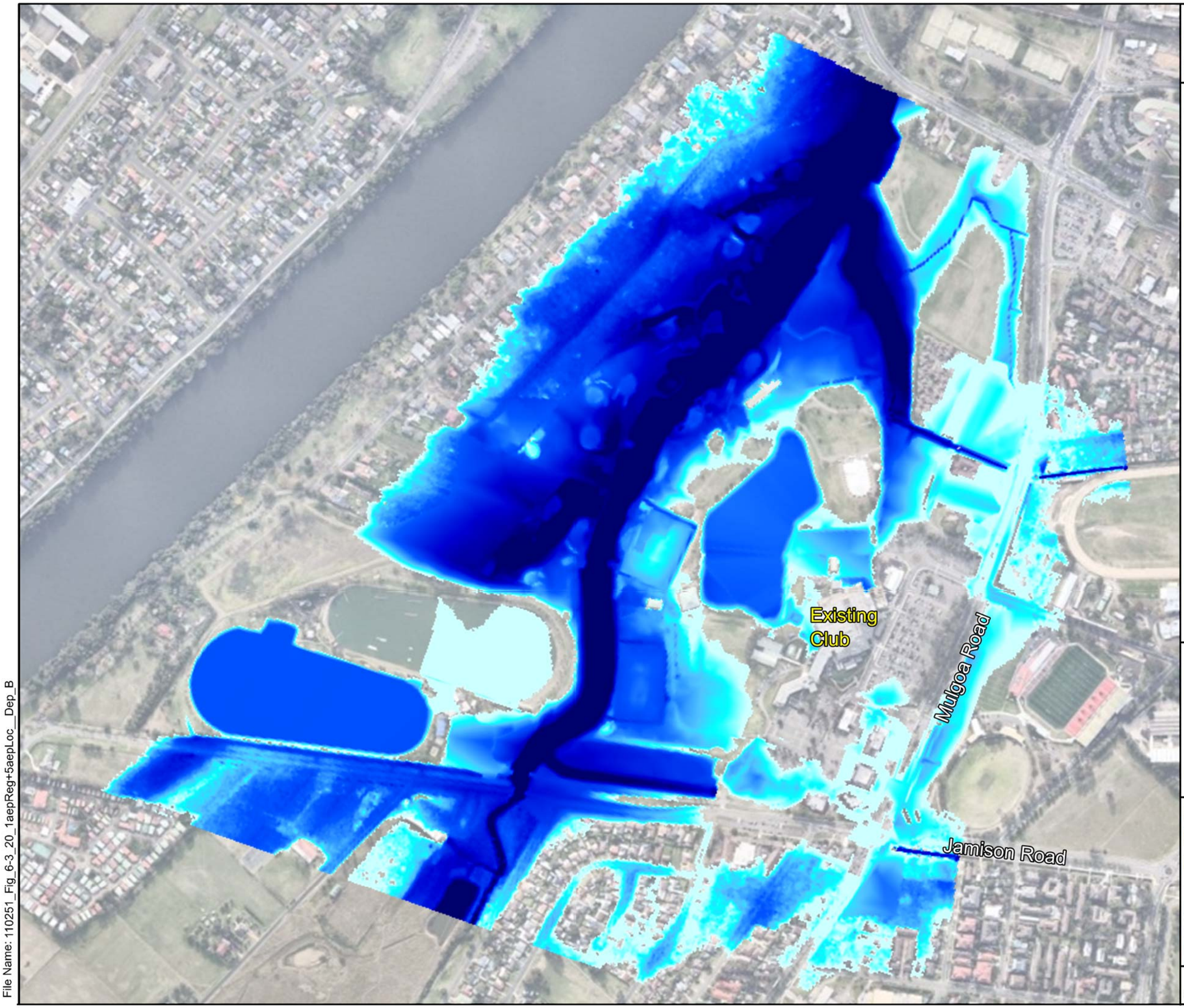
200 0 m

Figure 6-2
Panthers North Precinct Mixed Use Development
0.5% AEP Regional Existing Conditions Flood Depth Map

Date : 23/03/2016 Issue : B

File Name: 110251_Fig_6-2_200_05aepReg__Dep_B

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au



LEGEND

Depth (m)

- 0.0 to 0.2
- 0.2 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0 +

N
W E
S

Scale 1: 6,000 @ A3

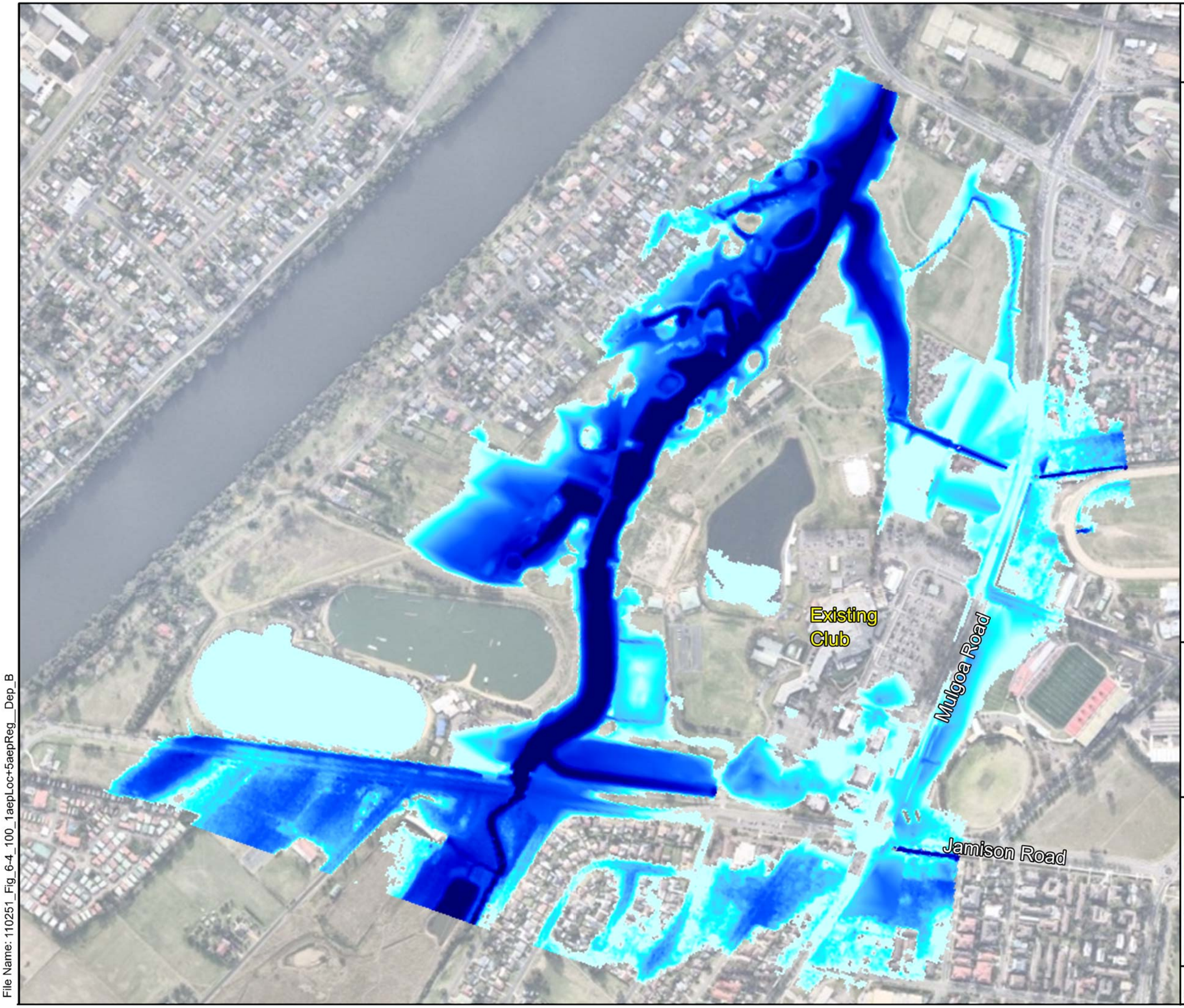
200 0 m

Figure 6-3
Panthers North Precinct Mixed Use Development
1% AEP Regional + 5% AEP Local Existing Conditions Flood Depth Map

Date : 23/03/2016 Issue : B

File Name: 110251_Fig_6-3_20_1aepReg+5aepLoc__Dep_B

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au



LEGEND

Depth (m)

- 0.0 to 0.2
- 0.2 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0 +

N
W E
S

Scale 1: 6,000 @ A3

200 0 m

Figure 6-4
Panthers North Precinct Mixed Use Development
1% AEP Local +
5% AEP Regional
Existing Conditions
Flood Depth Map

Date : 23/03/2016 Issue : B

File Name: 110251_Fig_6-4_100_1aepLoc+5aepReg__Dep_B

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au

Proposed Development
Panthers North Precinct

Approved Carpark

Serviced Apartments

Approved NRL Academy

Approved WSCSC

Approved Nepean Manors

Mulgoa Road

Jamison Road

LEGEND

Depth (m)

- 0.0 to 0.2
- 0.2 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0 +

N
W E
S

Scale 1: 6,000 @ A3

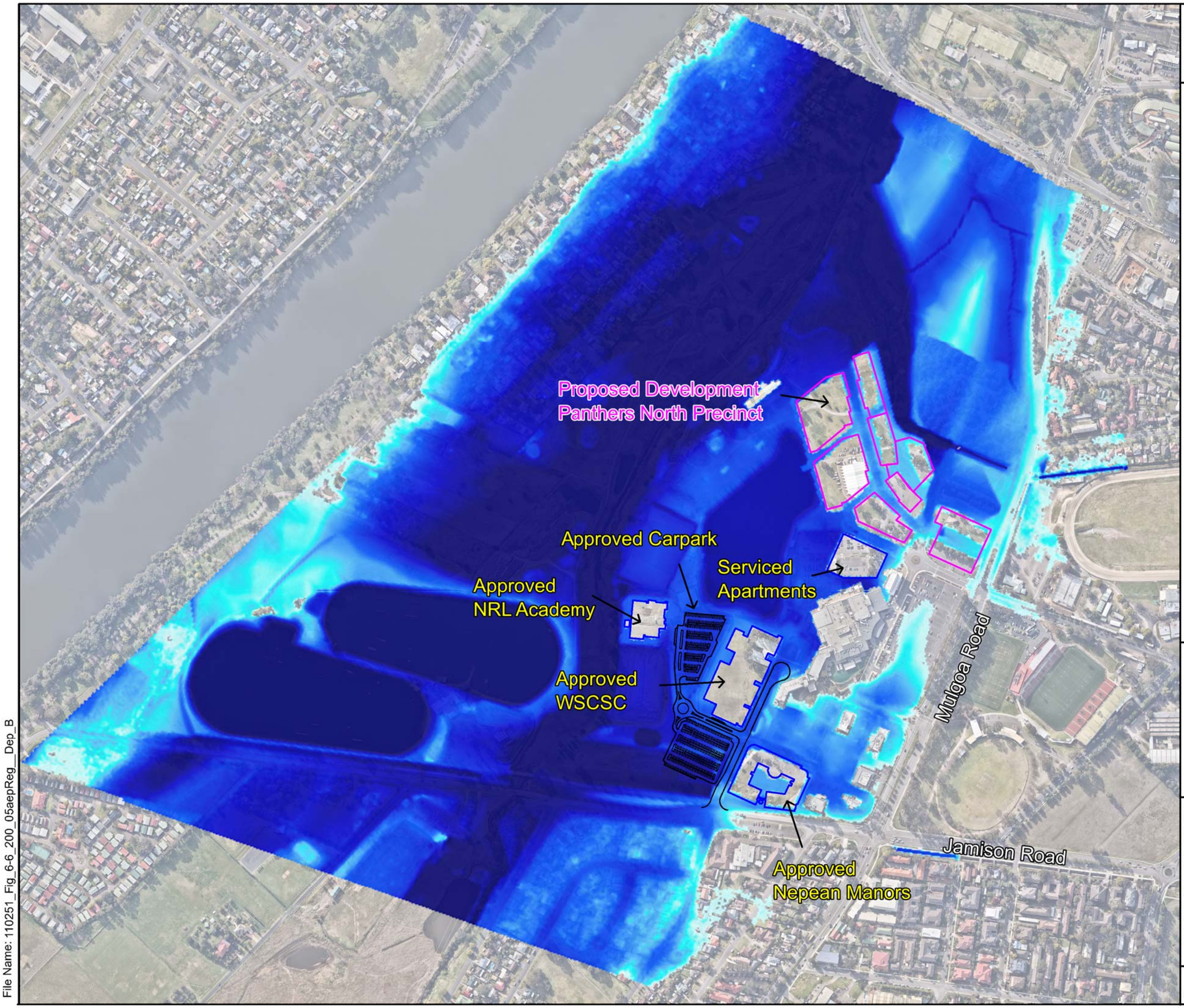
200 0 m

Figure 6-5
Panthers North Precinct Mixed Use Development
1% AEP Regional ESQ1818+Approved Flood Depth Map

Date : 6/04/2016 Issue : B

File Name: 110251_Fig_6-5_100_1aepReg__Dep_B

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au



LEGEND

Depth (m)

- 0.0 to 0.2
- 0.2 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0 +

N
W E
S

Scale 1: 6,000 @ A3

200 0 m

Figure 6-6
Panthers North Precinct Mixed Use Development
0.5% AEP Regional ESQ1818+Approved Flood Depth Map

Date : 6/04/2016 Issue : B

File Name: 110251_Fig_6-6_200_05aepReg__Dep_B

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au

LEGEND

Depth (m)

- 0.0 to 0.2
- 0.2 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0 +

Proposed Development
Panthers North Precinct

Approved Carpark

Serviced Apartments

Approved NRL Academy

Approved WSCSC

Approved Nepean Manors

Mulgoa Road

Jamison Road

N
W E
S

Scale 1: 6,000 @ A3

200 0 m

Figure 6-7
Panthers North Precinct Mixed Use Development
1% AEP Regional + 5% AEP Local ESQ1818+Approved Flood Depth Map

Date : 6/04/2016 Issue : B

File Name: 110251_Fig_6-7_20_1aepReg+5aepLoc__Dep_B

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au

Proposed Development
Panthers North Precinct

Approved Carpark

Serviced Apartments

Approved NRL Academy

Approved WSCSC

Approved Nepean Manors

Mulgoa Road

Jamison Road

LEGEND

Depth (m)

- 0.0 to 0.2
- 0.2 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0 +

N
W E
S

Scale 1: 6,000 @ A3

200 0 m

Figure 6-8
Panthers North Precinct Mixed Use Development
1% AEP Local +
5% AEP Regional
ESQ1818+Approved
Flood Depth Map

Date : 6/04/2016 Issue : B

File Name: 110251_Fig_6-8_100_1aepLoc+5aepReg__Dep_B

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au

Proposed Development
Panthers North Precinct

Approved Carpark

Serviced Apartments

Approved NRL Academy

Approved WSCSC

Approved Nepean Manors

Mulgoa Road

Jamison Road

LEGEND

INCREASE IN FLOOD LEVELS (m)

- -0.2+
- -0.18
- -0.16
- -0.14
- -0.12
- -0.10
- -0.08
- -0.06
- -0.04
- -0.02
- -0.02 to 0.02
- 0.02
- 0.04
- 0.06
- 0.08
- 0.10
- 0.12
- 0.14
- 0.16
- 0.18
- 0.2+
- **AREA FLOOD FREE IN MODELLED EVENT**
- **AREA FLOOD AFFECTED IN MODELLED EVENT**

N
W E
S

Scale 1: 6,000 @ A3

200 0 m

Figure 6-9
Panthers North Precinct Mixed Use Development
1% AEP Regional ESQ1818 & Approved - Ex Flood Difference Map

Date : 6/04/2016 Issue : B

File Name: 110251_Fig_6-9_100_1aepReg__FDM_B

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au

LEGEND

INCREASE IN FLOOD LEVELS (m)

- -0.2+
- -0.18
- -0.16
- -0.14
- -0.12
- -0.10
- -0.08
- -0.06
- -0.04
- -0.02
- -0.02 to 0.02
- 0.02
- 0.04
- 0.06
- 0.08
- 0.10
- 0.12
- 0.14
- 0.16
- 0.18
- 0.2+
- **AREA FLOOD FREE IN MODELLED EVENT**
- **AREA FLOOD AFFECTED IN MODELLED EVENT**

N
W E
S

Scale 1: 6,000 @ A3

200 0 m

Figure 6-10
Panthers North Precinct Mixed Use Development
0.5% AEP Regional ESQ1818 & Approved - Ex Flood Difference Map

Date : 6/04/2016 Issue : B

File Name: 110251_Fig_6-10_200_05aepReg__FDM_B

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au

Proposed Development
Panthers North Precinct

Approved Carpark

Serviced Apartments

Approved NRL Academy

Approved WSCSC

Approved Nepean Manors

Mulgoa Road

Jamison Road

LEGEND

INCREASE IN FLOOD LEVELS (m)

- -0.2+
- -0.18
- -0.16
- -0.14
- -0.12
- -0.10
- -0.08
- -0.06
- -0.04
- -0.02
- -0.02 to 0.02
- 0.02
- 0.04
- 0.06
- 0.08
- 0.10
- 0.12
- 0.14
- 0.16
- 0.18
- 0.2+
- **AREA FLOOD FREE IN MODELLED EVENT**
- **AREA FLOOD AFFECTED IN MODELLED EVENT**

N
W E
S

Scale 1: 6,000 @ A3

200 0 m

Figure 6-11
Panthers North Precinct Mixed Use Development
1% AEP Regional +
5% AEP Local
ESQ1818 & Approved - Ex
Flood Difference Map

Date : 6/04/2016 Issue : B

File Name: 110251_Fig_6-11_20_1aepReg+5aepLoc__FDM_B

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au

Proposed Development
Panthers North Precinct

Approved Carpark

Serviced Apartments

Approved NRL Academy

Approved WSCSC

Approved Nepean Manors

Mulgoa Road

Jamison Road

LEGEND

INCREASE IN FLOOD LEVELS (m)

- -0.2+
- -0.18
- -0.16
- -0.14
- -0.12
- -0.10
- -0.08
- -0.06
- -0.04
- -0.02
- -0.02 to 0.02
- 0.02
- 0.04
- 0.06
- 0.08
- 0.10
- 0.12
- 0.14
- 0.16
- 0.18
- 0.2+
- **AREA FLOOD FREE IN MODELLED EVENT**
- **AREA FLOOD AFFECTED IN MODELLED EVENT**

N
W E
S

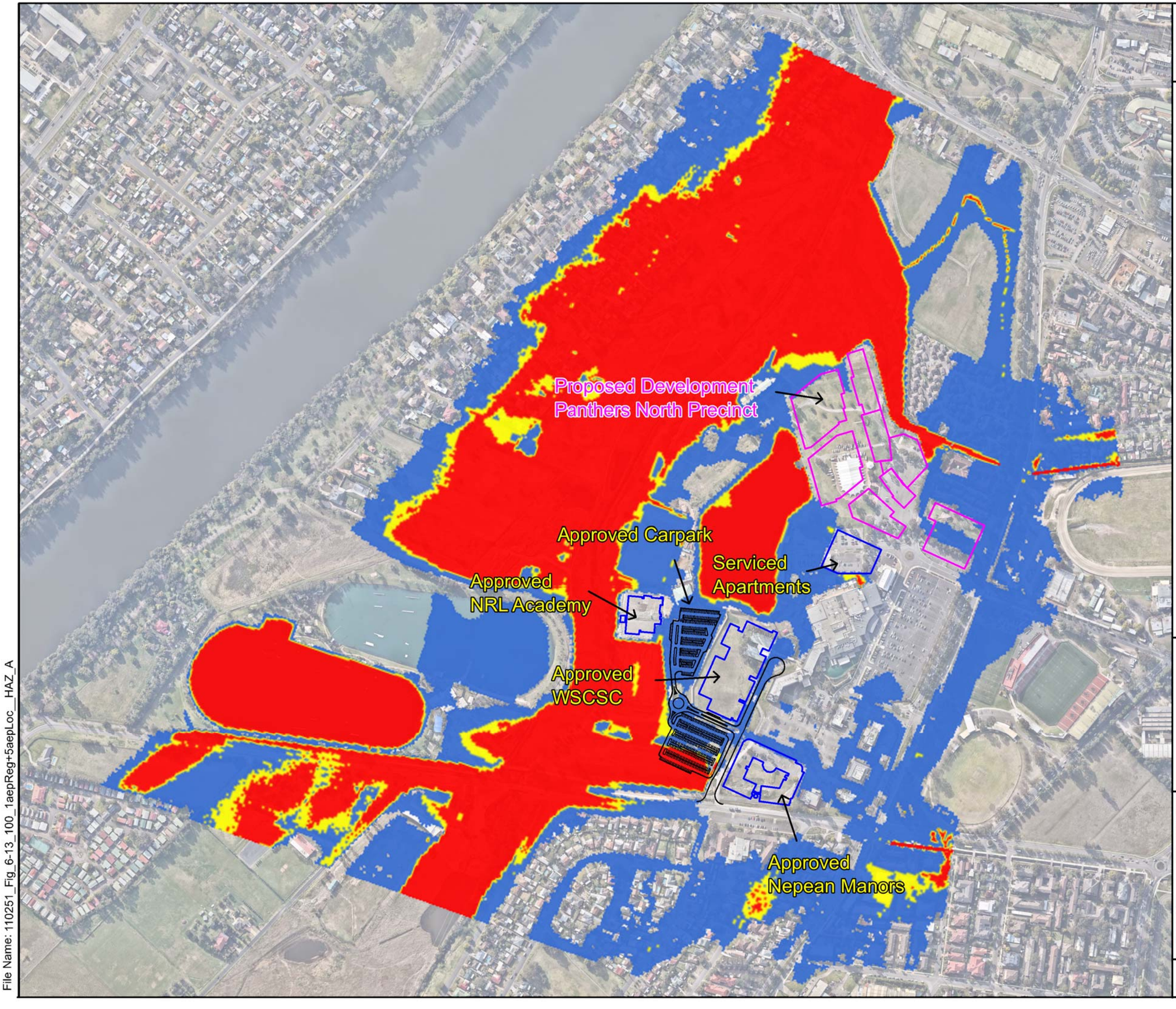
Scale 1: 6,000 @ A3

200 0 m

Figure 6-12
Panthers North Precinct Mixed Use Development
1% AEP Local +
5% AEP Regional
ESQ1818 & Approved - Ex
Flood Difference Map

Date : 6/04/2016 Issue : B

File Name: 110251_Fig_6-12_100_1aepLoc+5aepReg__FDM_B



J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au

LEGEND

Hazard Categorisation

- LOW HAZARD
- TRANSITION HAZARD
- HIGH HAZARD

N
W E
S

Scale 1: 6,000 @ A3

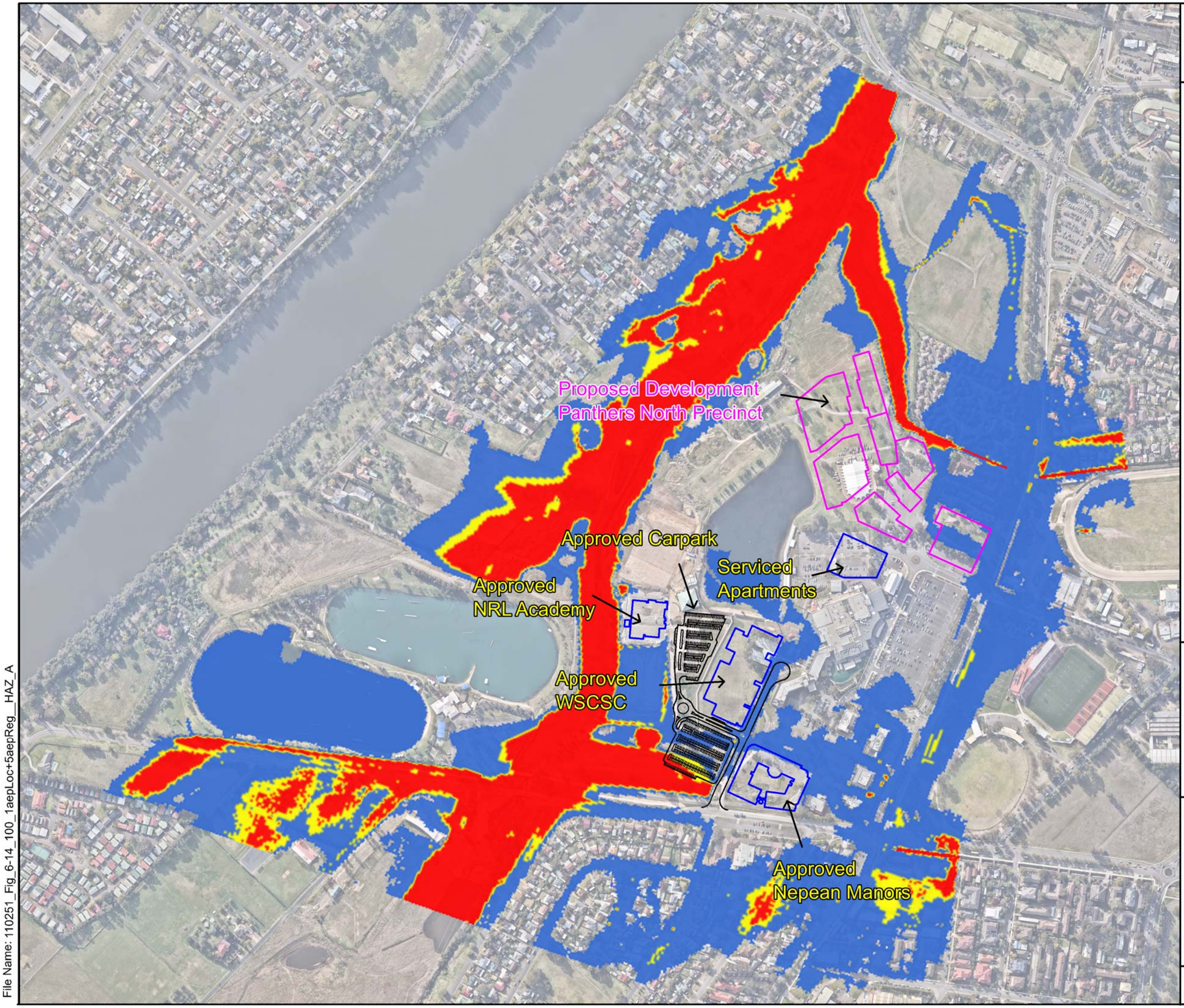
200 0 m

Figure 6-13
Panthers North Precinct Mixed Use Development
1% AEP Regional + 5% AEP Local ESQ1818+Approved Hazard Map

Date : 6/04/2016 Issue : A

File Name: 110251_Fig_6-13_100_1aepReg+5aepLoc__HAZ_A

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au



LEGEND

Hazard Categorisation

- LOW HAZARD
- TRANSITION HAZARD
- HIGH HAZARD

N
W E
S

Scale 1: 6,000 @ A3

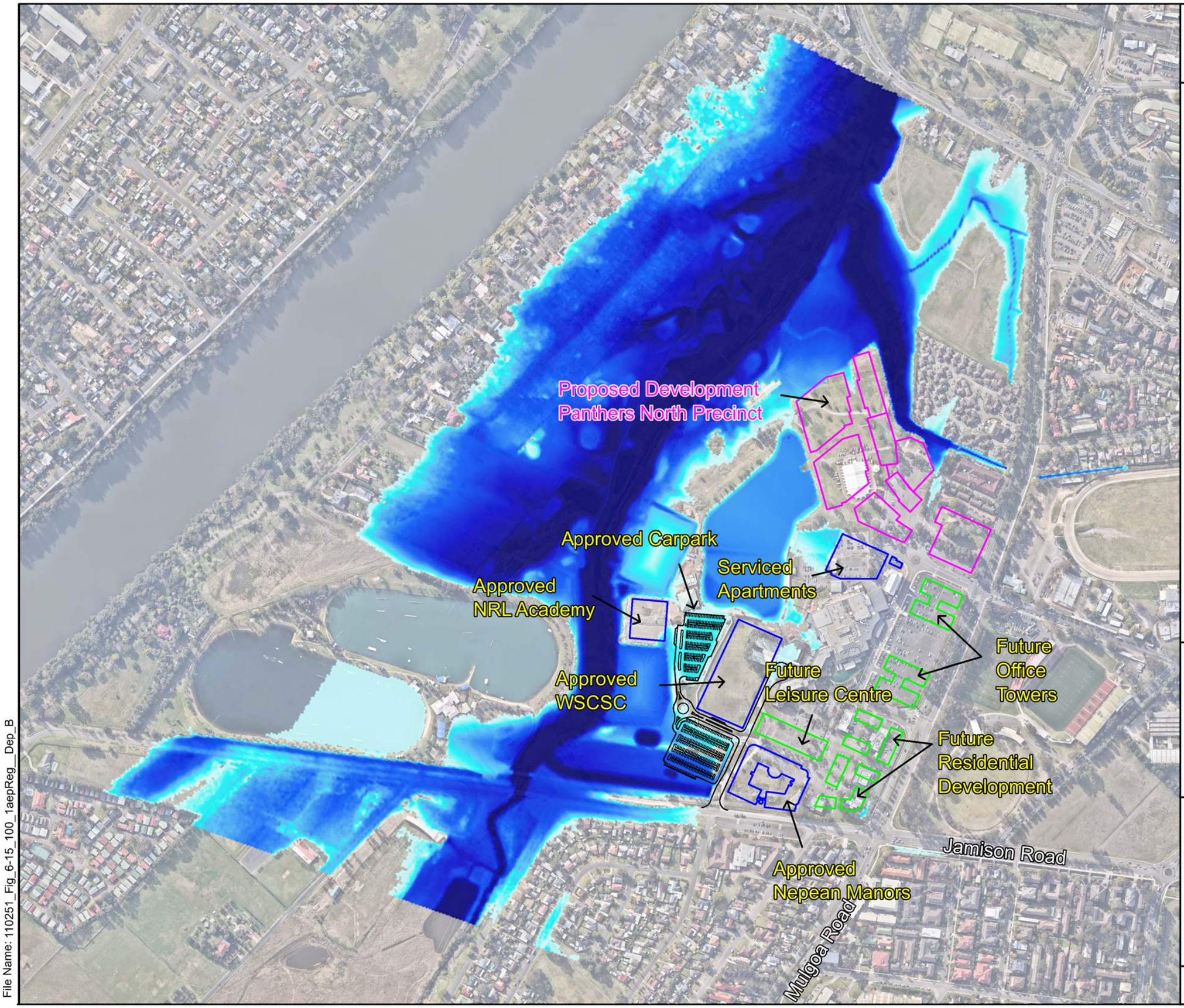
200 0 m

Figure 6-14
Panthers North Precinct Mixed Use Development
1% AEP Local + 5% AEP Regional ESQ1818+Approved Hazard Map

Date : 6/04/2016 Issue : A

File Name: 110251_Fig_6-14_100_1aepLoc+5aepReg__HAZ_A

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au



LEGEND

Depth (m)

- 0.0 to 0.2
- 0.2 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0 +

N
W E
S

Scale 1: 6,000 @ A3

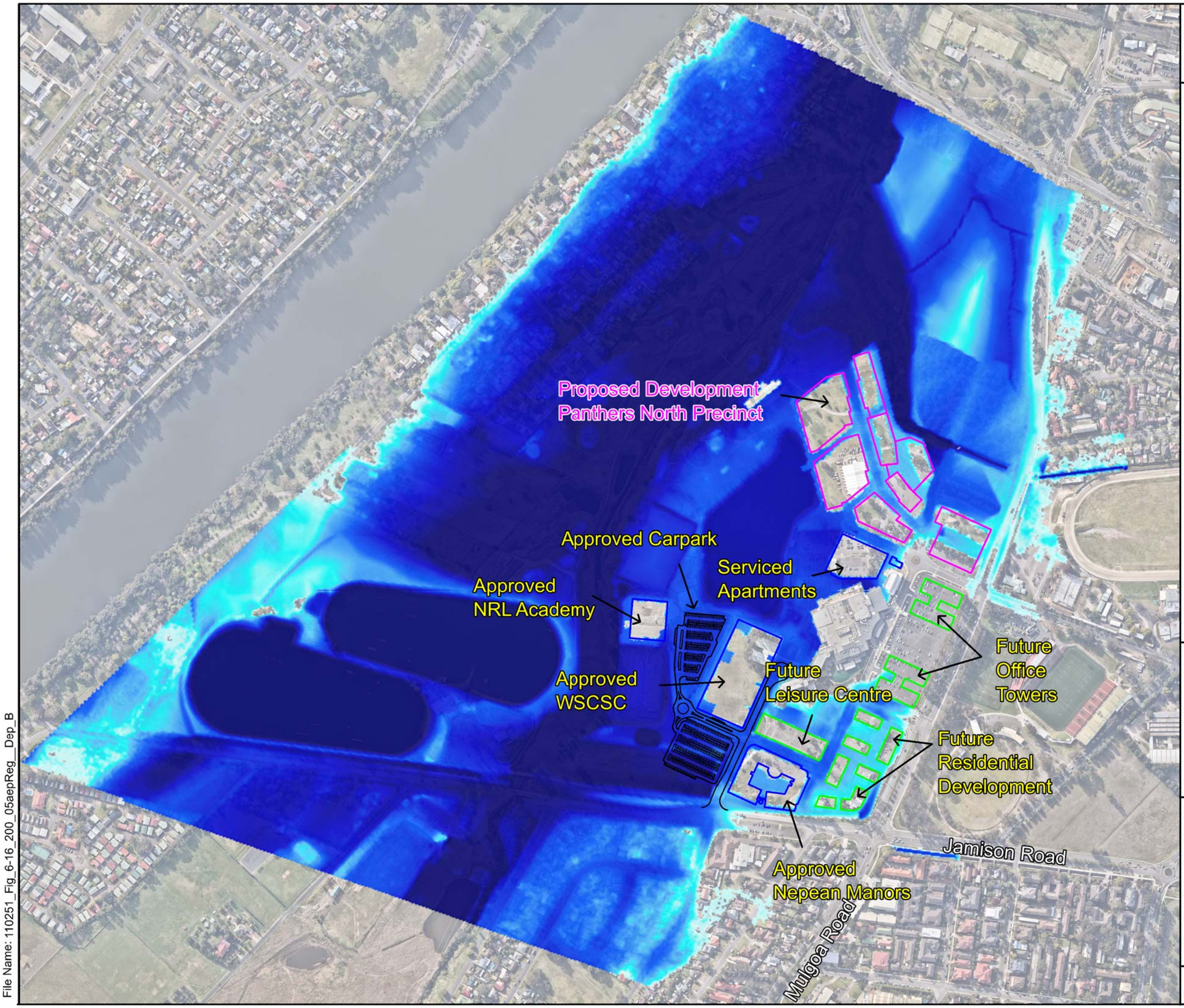
200 0 m

Figure 6-15
Panthers North Precinct Mixed Use Development
1% AEP Regional ESQ1818+Approved+Future Flood Depth Map

Date : 6/04/2016 Issue : B

File Name: 110251_Fig_6-15_100_1aepReg__Dep_B

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au



LEGEND

Depth (m)

- 0.0 to 0.2
- 0.2 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0 +

N
W E
S

Scale 1: 6,000 @ A3

200 0 m

Figure 6-16
Panthers North Precinct Mixed Use Development
0.5% AEP Regional ESQ1818+Approved+Future Flood Depth Map

Date : 6/04/2016 Issue : B

File Name: 110251_Fig_6-16_200_05aepReg__Dep_B

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au

LEGEND

Depth (m)

- 0.0 to 0.2
- 0.2 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0 +

Proposed Development
Panthers North Precinct

Approved Carpark

Serviced Apartments

Approved NRL Academy

Approved WSCSC

Future Leisure Centre

Future Office Towers

Future Residential Development

Approved Nepean Manors

Jamison Road

Mulgoa Road

N
W E
S

Scale 1: 6,000 @ A3

200 0 m

Figure 6-17
Panthers North Precinct Mixed Use Development
1% AEP Regional +
5% AEP Local
ESQ1818+Approved+Future
Flood Depth Map

Date : 6/04/2016 Issue : B

File Name: 110251_Fig_6-17_20_1aepReg+5aepLoc__Dep_B

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au

LEGEND

Depth (m)

- 0.0 to 0.2
- 0.2 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0 +

Proposed Development
Panthers North Precinct

Approved Carpark
Serviced Apartments
Approved NRL Academy
Approved WSCSC
Future Leisure Centre
Future Office Towers
Future Residential Development
Approved Nepean Manors
Jamison Road
Mulgoa Road

N
W E
S

Scale 1: 6,000 @ A3

200 0 m

Figure 6-18
Panthers North Precinct Mixed Use Development
1% AEP Local +
5% AEP Regional
ESQ1818+Approved+Future
Flood Depth Map

Date : 6/04/2016 Issue : B

File Name: 110251_Fig_6-18_100_1aepLoc+5aepReg__Dep_B

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au

Proposed Development
Panthers North Precinct

Approved Carpark
Serviced Apartments
Approved NRL Academy
Approved WSCSC
Future Leisure Centre
Future Office Towers
Future Residential Development
Approved Nepean Manors
Jamison Road
Mulgoa Road

LEGEND

INCREASE IN FLOOD LEVELS (m)

- -0.2+
- -0.18
- -0.16
- -0.14
- -0.12
- -0.10
- -0.08
- -0.06
- -0.04
- -0.02
- -0.02 to 0.02
- 0.02
- 0.04
- 0.06
- 0.08
- 0.10
- 0.12
- 0.14
- 0.16
- 0.18
- 0.2+
- **AREA FLOOD FREE IN MODELLED EVENT**
- **AREA FLOOD AFFECTED IN MODELLED EVENT**

N
W E
S

Scale 1: 6,000 @ A3

200 0 m

Figure 6-19
Panthers North Precinct Mixed Use Development
1% AEP Regional
Future - Existing
Flood Difference Map

Date : 6/04/2016 Issue : B

File Name: 110251_Fig_6-19_100_1aepReg__FDM_B

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au

Proposed Development
Panthers North Precinct

Approved Carpark

Serviced Apartments

Approved NRL Academy

Approved WSCSC

Future Leisure Centre

Future Office Towers

Future Residential Development

Approved Nepean Manors

Jamison Road

Mulgoa Road

LEGEND

INCREASE IN FLOOD LEVELS (m)

- -0.2+
- -0.18
- -0.16
- -0.14
- -0.12
- -0.10
- -0.08
- -0.06
- -0.04
- -0.02
- -0.02 to 0.02
- 0.02
- 0.04
- 0.06
- 0.08
- 0.10
- 0.12
- 0.14
- 0.16
- 0.18
- 0.2+
- **AREA FLOOD FREE IN MODELLED EVENT**
- **AREA FLOOD AFFECTED IN MODELLED EVENT**

N
W E
S

Scale 1: 6,000 @ A3

200 0 m

Figure 6-20
Panthers North Precinct Mixed Use Development
0.5% AEP Regional
Future - Existing
Flood Difference Map

Date : 6/04/2016 Issue : B

File Name: 110251_Fig_6-20_200_05aepReg__FDM_B

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au

Proposed Development
Panthers North Precinct

Approved Carpark

Serviced Apartments

Approved NRL Academy

Approved WSCSC

Future Leisure Centre

Future Office Towers

Future Residential Development

Approved Nepean Manors

Jamison Road

Mulgoa Road

LEGEND

INCREASE IN FLOOD LEVELS (m)

- -0.2+
- -0.18
- -0.16
- -0.14
- -0.12
- -0.10
- -0.08
- -0.06
- -0.04
- -0.02
- -0.02 to 0.02
- 0.02
- 0.04
- 0.06
- 0.08
- 0.10
- 0.12
- 0.14
- 0.16
- 0.18
- 0.2+
- **AREA FLOOD FREE IN MODELLED EVENT**
- **AREA FLOOD AFFECTED IN MODELLED EVENT**

N
W E
S

Scale 1: 6,000 @ A3

200 0 m

Figure 6-21
Panthers North Precinct Mixed Use Development
1% AEP Regional +
5% AEP Local
Future - Existing
Flood Difference Map

Date : 6/04/2016 Issue : B

File Name: 110251_Fig_6-21_20_1aepReg+5aepLoc__FDM_B

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au

LEGEND

INCREASE IN FLOOD LEVELS (m)

- -0.2+
- -0.18
- -0.16
- -0.14
- -0.12
- -0.10
- -0.08
- -0.06
- -0.04
- -0.02
- -0.02 to 0.02
- 0.02
- 0.04
- 0.06
- 0.08
- 0.10
- 0.12
- 0.14
- 0.16
- 0.18
- 0.2+
- **AREA FLOOD FREE IN MODELLED EVENT**
- **AREA FLOOD AFFECTED IN MODELLED EVENT**

Proposed Development
Panthers North Precinct

Approved Carpark

Serviced Apartments

Approved NRL Academy

Approved WSCSC

Future Leisure Centre

Future Office Towers

Future Residential Development

Approved Nepean Manors

Jamison Road

Mulgoa Road

N
W E
S

Scale 1: 6,000 @ A3

200 0 m

Figure 6-22
Panthers North Precinct Mixed Use Development
1% AEP Local +
5% AEP Regional
Future - Existing
Flood Difference Map

Date : 6/04/2016 Issue : B

File Name: 110251_Fig_6-22_100_1aepLoc+5aepReg__FDM_B

APPENDIX B – WORLEY PARSONS REPORT

WorleyParsons
resources & energy

Infrastructure & Environment
Level 12, 141 Walker Street
North Sydney NSW 2060
Australia
Telephone: +61 2 8923 6866
Facsimile: +61 2 8923 6877
www.worleyparsons.com
ABN 61 001 279 812

16 October 2014

Ref: 301015-03536
File: Penrith Panthers MasterPlan Flooding-Addendum.docx

Penrith Rugby League Club Ltd
123 Mulgoa Road
Penrith, NSW 2750

ATT: Ben Bacon

RE: PENRITH PANTHERS MASTER PLAN (PPMP) – FLOOD IMPACT ASSESSMENT - ADDENDUM

Dear Ben,

We are pleased to provide this addendum to our previous letter report on the investigation into determining the flood impacts associated with the proposed Penrith Panthers development site.

The addendum has been prepared in response to some refinements to the TUFLOW model that were identified in the previous letter report. The changes related to more correctly representing boundary conditions for tailwater hydrographs and inflow hydrographs.

The purpose of this brief review is to confirm the suitability of the TUFLOW model in assessing options for the proposed Panthers Master Plan.

Review of Boundary Conditions

Water level hydrographs were extracted from the updated TUFLOW results in waterRIDE™ and reviewed. The shapes of the 100yr and 200yr ARI hydrographs match the data that was provided to JWP on August 19, 2014. However there is a small difference of 2cm in the peak 100yr level with the TUFLOW model being lower. The 200yr results have equivalent peak tailwater levels.

The very flat water gradients through Peachtree Creek would likely see any small change in tailwater levels reflected across the floodplain surface within the TUFLOW model extents, and given that options assessment will be based on relative changes, this issue should not have any influence on outcomes.

Considering the accuracy of extracting flows from 2D model results, the correct magnitudes for the peak flows at the upstream and western lateral boundary (*200yr only*) agree with the data provided in August. However it is noted that the upstream boundary flows are concentrated within Peachtree Creek, rather than being distributed across the floodplain boundary. This leads to increased velocities within the TUFLOW model.

Review and Comparison of Results

200yr ARI Design Flood

The 200yr ARI design flood results from the RMA and TUFLOW models have been compared using a common profile along Peachtree Creek, **Figure 1** and the following points can be noted:

- Firstly, a comparison between the original (*previous*) TUFLOW results and the recently updated results for the proposed case, clearly shows the effect of the adjusted tailwater conditions. The tailwater was lowered by 0.24m and this difference is reflected throughout the profile within a centimetre or two (*average of 0.2403m*).

- Secondly, the two TUFLOW Original profiles (*existing and proposed*), show the influence of the proposed development with a slight increase in the water surface gradient leading to the 3cm difference outlined in the previous letter. This difference is likewise reflected in the two RMA profiles (*existing and proposed*), with an equivalent increase in water level at Jamison Road.

- Finally, a comparison between the TUFLOW Updated model and the RMA model results for the proposed case shows the equivalent tailwater level with a steeper backwater gradient leading to higher absolute flood levels at Jamison Road. Since the flow magnitudes are equivalent for both models, the increased backwater slope can only be explained through velocity, roughness and terrain differences.

  The majority of the landscape along the main flow corridor through the creek is grass and has been represented with a Manning's 'n' roughness of 0.030 and 0.035 in the RMA model. The TUFLOW model has a higher roughness of 0.06 which would explain the steeper gradient.

  The terrain for both models is based on Council's LiDAR data, however the TUFLOW model has a finer mesh capable of capturing more detail. A review of 6 cross-sections normal to the flow (*200yr ARI*), from Jamison Road downstream to just past the sub-station, **Table 1**, shows the increased conveyance area in the TUFLOW model moderated by some variation in the terrain. The reduced terrain capacity at the downstream end and in the middle reach for the TUFLOW model may be influencing the increased backwater gradient.

  As indicated in the boundary condition discussion above, the TUFLOW model has increased velocities resulting from the confined distribution of upstream boundary inflows. A velocity profile along the creek, **Figure 2**, clearly shows the significant increase in velocity in the TUFLOW model down to the vicinity of the ski lake, and then a smaller increase along the remainder of the profile down to the Great Western Highway. Since water surface slope is proportional to the square of velocity, these increased velocities in the TUFLOW model may explain or partly explain the backwater differences, along with the differences in roughness.

Table 1- Comparison of TUFLOW conveyance and terrain capacity with RMA

Cross-section	Chainage	Conveyance Area (TUFLOW – RMA)	Area Above Bed (TUFLOW - RMA)
Across Jamison Road	160m	+8%	0%
Downstream of ski lakes	430m	+12%	+4%
Middle of Panthers lake	690m	+3%	-8%
Downstream end of Panthers lake	840m	+2%	-6%
Downstream of Sub-station	1140m	+6%	-1%
Downstream end of TUFLOW model	1430m	-3%	-13%

100yr ARI Combined Design Flood

The 100yr ARI design flood results from the RMA and TUFLOW models have also been compared using a common profile along Peachtree Creek, **Figure 3** and the following points can be noted:

- Firstly, a comparison between the original (*previous*) TUFLOW results and the recently updated results for the proposed case, clearly shows the effect of the adjusted tailwater conditions. The tailwater was lowered by 0.09m and this difference is reflected throughout the profile within a centimetre (*average of 0.092m*).

- Secondly, a comparison between the TUFLOW Updated model and the RMA model results for the proposed case shows the equivalent tailwater level with a steeper backwater gradient upstream of the NRL Academy, leading to higher absolute flood levels at Jamison Road. Similar to the 200yr results, the increased backwater slope can only be explained through velocity, roughness and terrain differences.

  The 100yr velocity comparison, **Figure 4**, also shows some increased velocities in the TUFLOW results upstream of the NRL Academy, although not as dramatic as the 200yr differences where the total flow is much greater. The ratio of water surface slopes is proportional to the square of the ratio of the roughness values, and the increased slope of the TUFLOW results upstream of the NRL Academy can readily be explained by the difference in roughnesses.

- Finally, notwithstanding the increased absolute levels upstream of the NRL Academy in the TUFLOW model, the increases resulting from the proposed development are equivalent for both models and vary between 0 and 2 cm, **Figure 3**

TUFLOW Confirmation

The updated TUFLOW model with the corrected boundary conditions provides a closer agreement with the RMA model. Further corrections to the distribution of inflows across the upstream TUFLOW model boundary together with adjustments to roughness values would alleviate any issues related to the velocity differences and may see even closer agreement. The refined mesh of the TUFLOW model may well be related to some of the backwater slope differences and thus be providing a more realistic outcome for the local area covered by the TUFLOW model.

Notwithstanding these differences between the two models, they both predict equivalent impacts upstream, and thus the TUFLOW model can be confirmed as being suitable for assessing the impacts of the various options being proposed as part of the Panthers Master Plan.

We trust that this report addresses your requirements

Yours faithfully
WorleyParsons

[redacted]

David McConnell
Principal Consultant

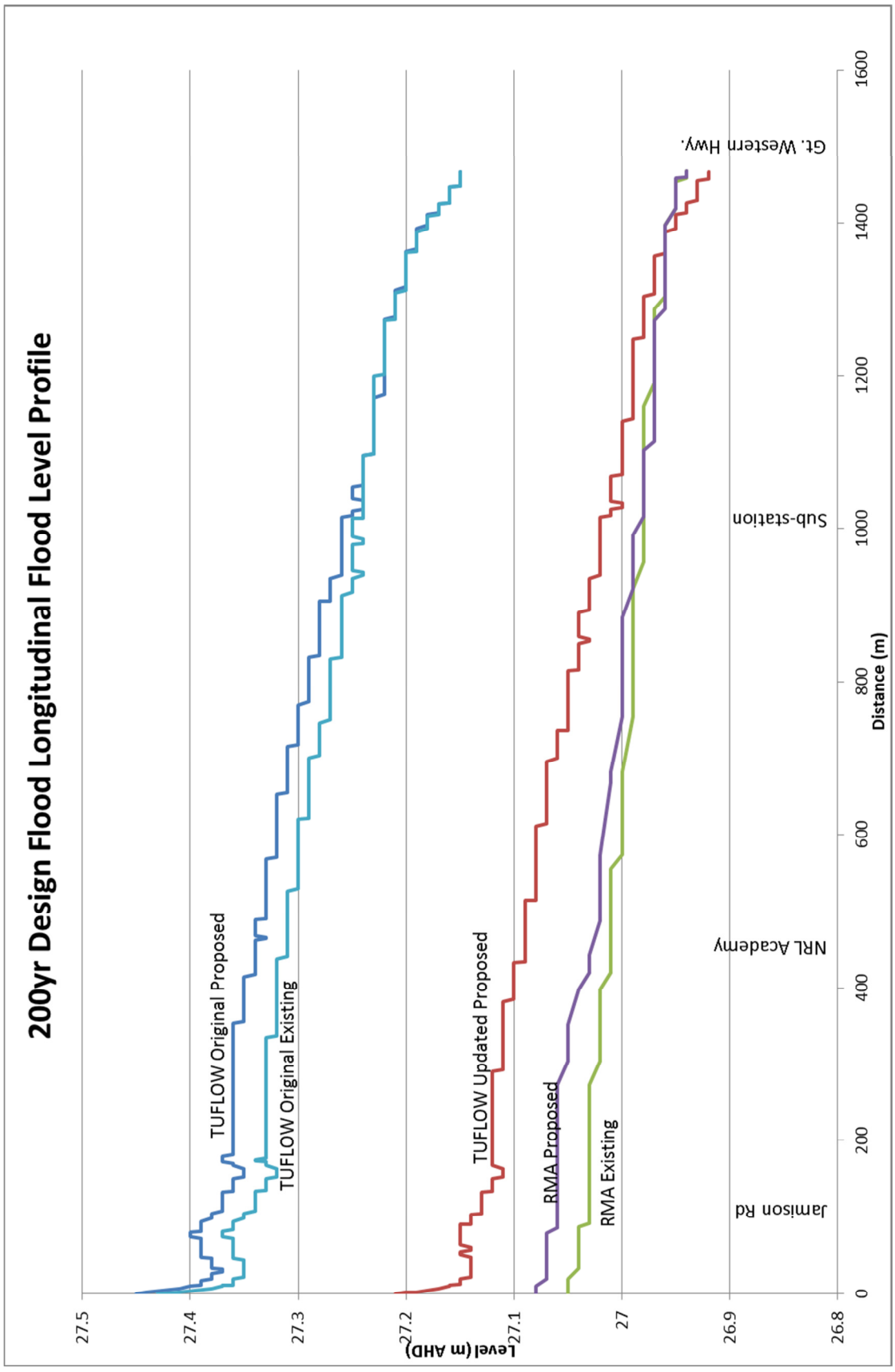


Figure 1: 200yr ARI flood profiles along Peachtree Creek

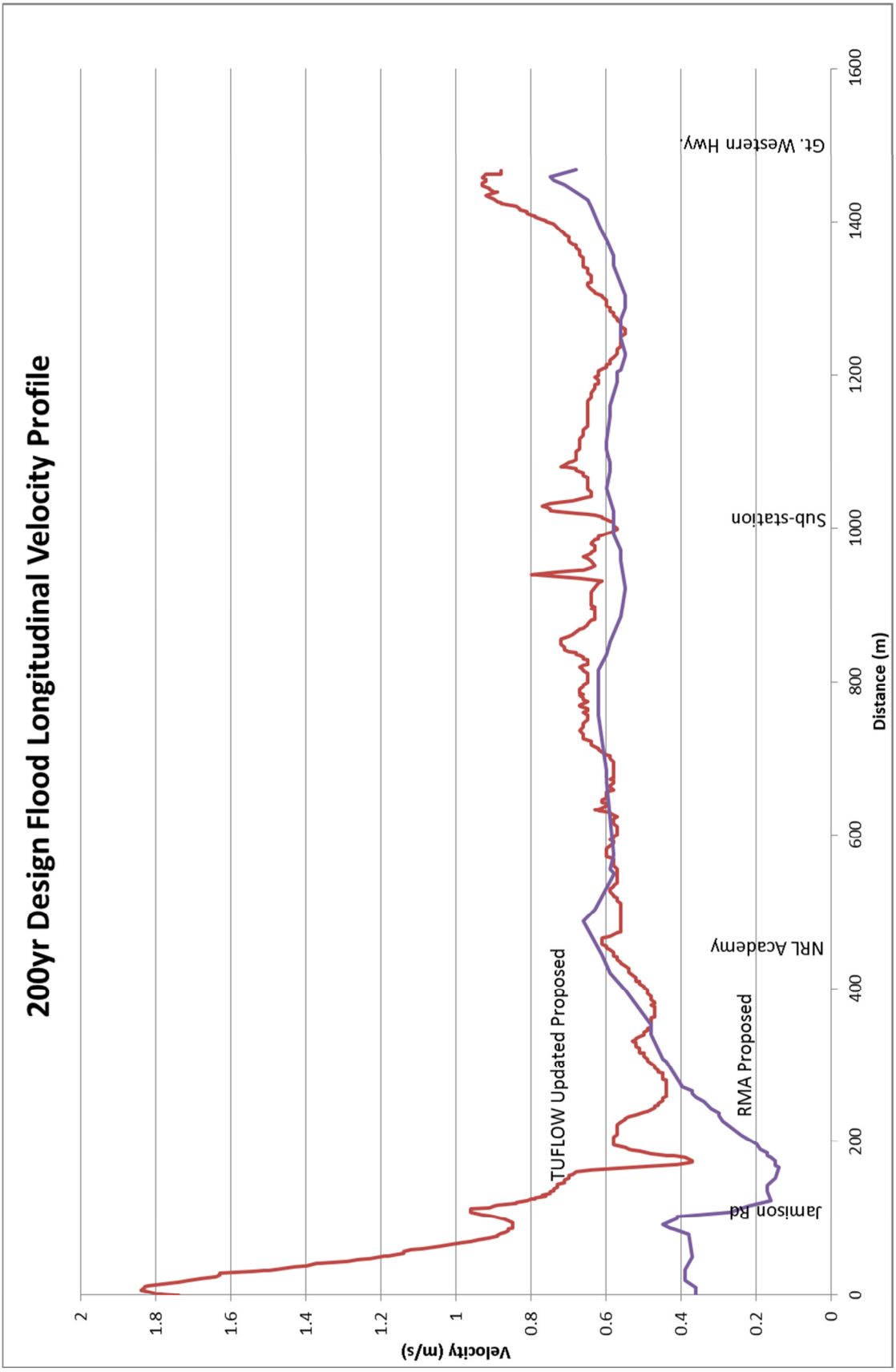


Figure 2 - 200yr ARI velocity profiles along Peachtree Creek

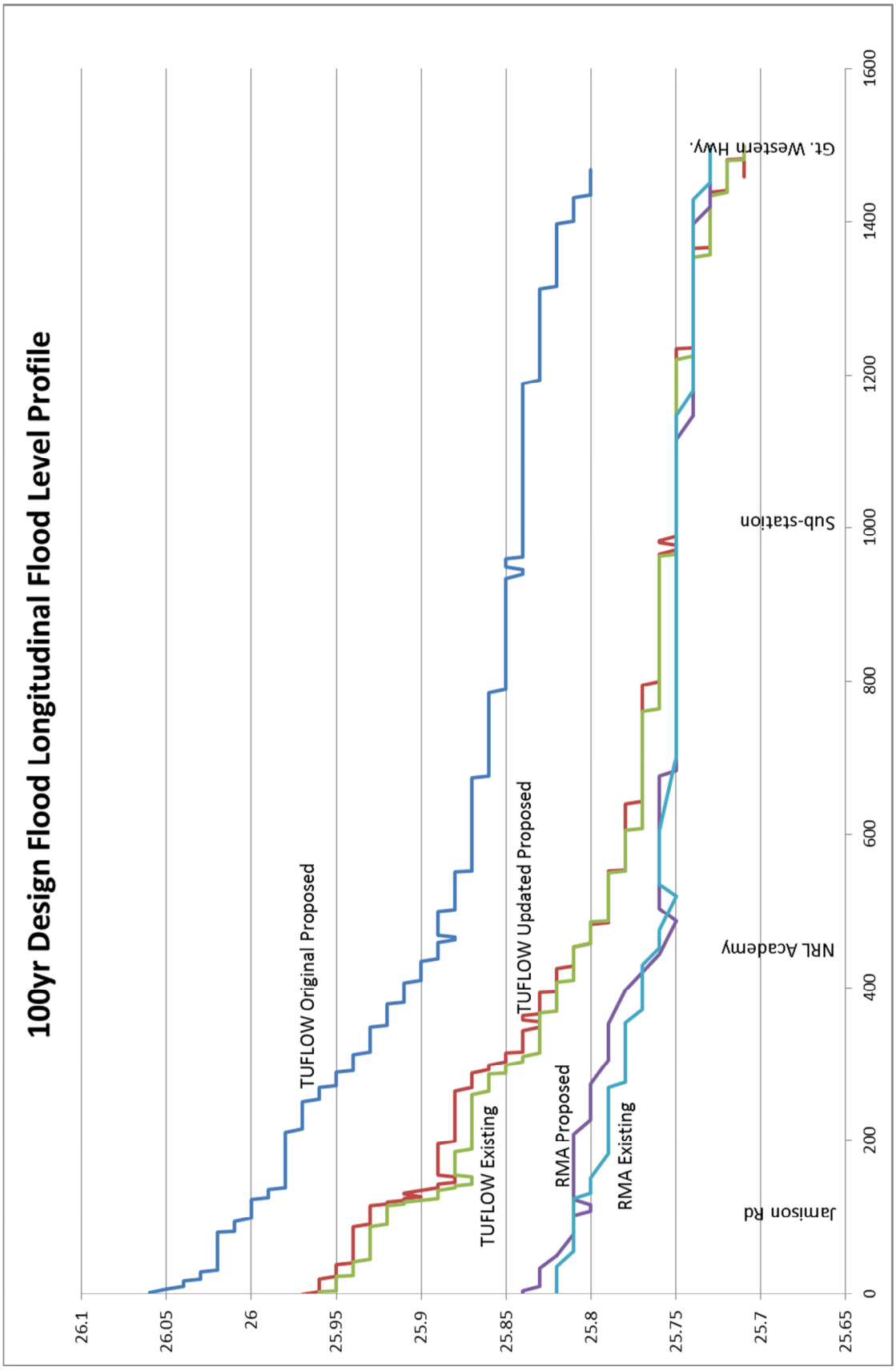


Figure 3 - 100yr ARI flood profiles along Peachtree Creek

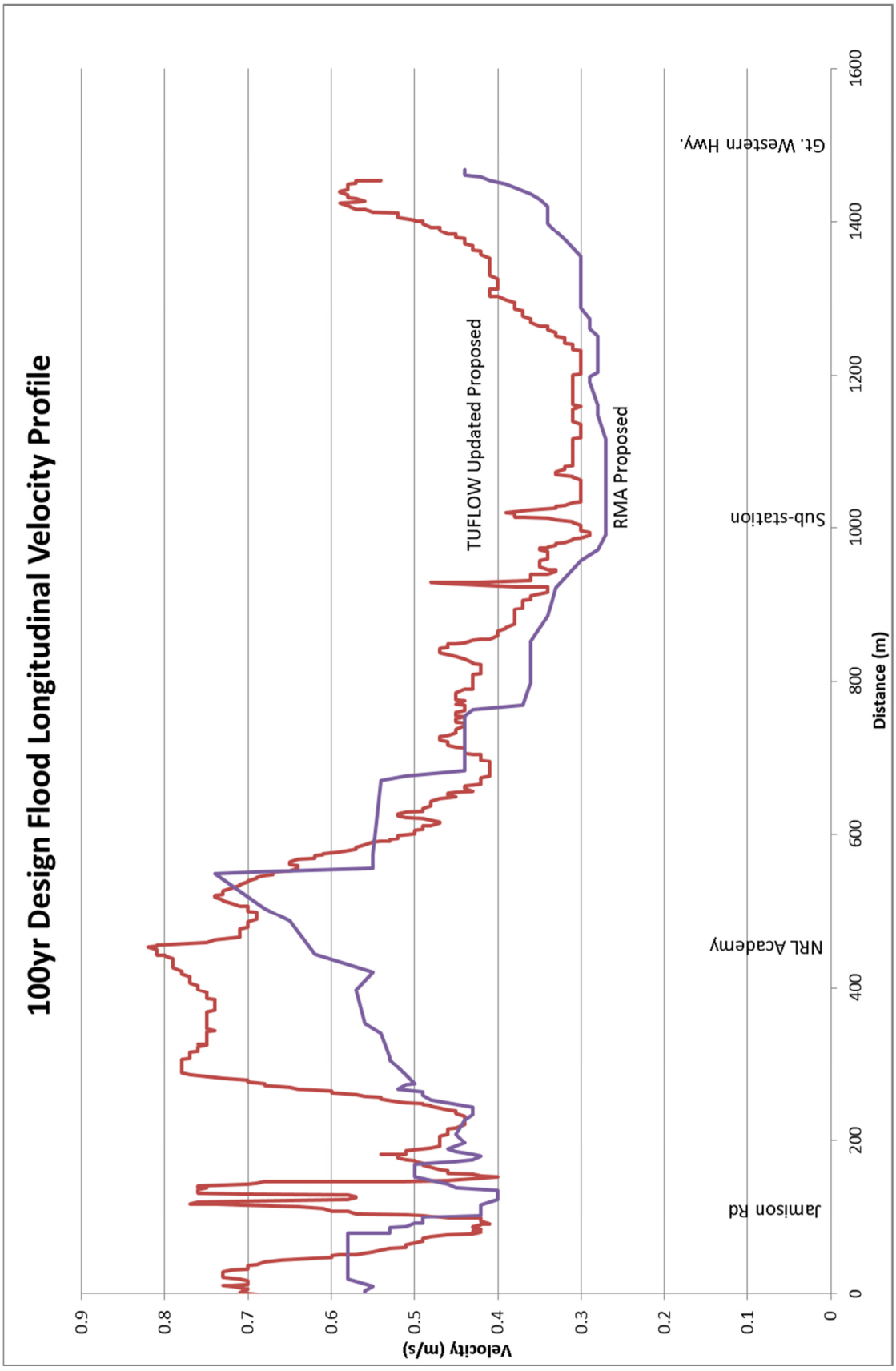


Figure 4 - 100yr ARI velocity profiles along Peachtree Creek

APPENDIX C – MUSIC LINK REPORT

PENRITH CITY COUNCIL

music@link

MUSIC-*link* Report

Project Details		Company Details	
Project:	Panthers North	**Company:**	J. Wyndham Prince
Report Export Date:	18/03/2016	**Contact:**	Chris Randall
Catchment Name:	110251 Panthers North	**Address:**	580 High Street, Penrith
Catchment Area:	5.75ha	**Phone:**	47203342
Impervious Area*:	87.65%	**Email:**	crandall@jwprince.com.au
Rainfall Station:	67113 PENRITH		
Modelling Time-step:	6 Minutes		
Modelling Period:	1/01/1999 - 31/12/2008 11:54:00 PM		
Mean Annual Rainfall:	691mm		
Evapotranspiration:	1158mm		
MUSIC Version:	6.1.0		
MUSIC-link data Version:	6.0		
Study Area:	Penrith		
Scenario:	Penrith Development		

* takes into account area from all source nodes that link to the chosen reporting node, excluding Import Data Nodes

Treatment Train Effectiveness		Treatment Nodes		Source Nodes	
Node: Receiving Node	**Reduction**	**Node Type**	**Number**	**Node Type**	**Number**
Flow	5.59%	Bio Retention Node	2	Urban Source Node	10
TSS	85%	GPT Node	2		
TP	69.3%				
TN	55.5%				
GP	95.2%				

Comments

Generic GPT nodes adopted.

PENRITH CITY COUNCIL

music@link

Passing Parameters

Node Type	Node Name	Parameter	Min	Max	Actual
Bio	M1 - Bioretention	Hi-flow bypass rate (cum/sec)	None	99	0.28
Bio	M1 - Bioretention	PET Scaling Factor	2.1	2.1	2.1
Bio	M2 - Bioretention	Hi-flow bypass rate (cum/sec)	None	99	0.07
Bio	M2 - Bioretention	PET Scaling Factor	2.1	2.1	2.1
GPT	M1 - GPT	Hi-flow bypass rate (cum/sec)	None	99	0.28
GPT	M2 - GPT	Hi-flow bypass rate (cum/sec)	None	99	0.07
Receiving	Receiving Node	% Load Reduction	None	None	5.59
Receiving	Receiving Node	GP % Load Reduction	90	None	95.2
Receiving	Receiving Node	TN % Load Reduction	45	None	55.5
Receiving	Receiving Node	TP % Load Reduction	60	None	69.3
Receiving	Receiving Node	TSS % Load Reduction	85	None	85
Urban	M1 - Other Impervious	Area Impervious (ha)	None	None	1.11
Urban	M1 - Other Impervious	Area Pervious (ha)	None	None	0
Urban	M1 - Other Impervious	Total Area (ha)	None	None	1.11
Urban	M1 - Other Pervious	Area Impervious (ha)	None	None	0
Urban	M1 - Other Pervious	Area Pervious (ha)	None	None	0.43
Urban	M1 - Other Pervious	Total Area (ha)	None	None	0.43
Urban	M1 - Road	Area Impervious (ha)	None	None	0.48
Urban	M1 - Road	Area Pervious (ha)	None	None	0
Urban	M1 - Road	Total Area (ha)	None	None	0.48
Urban	M1 - Roof	Area Impervious (ha)	None	None	2.3
Urban	M1 - Roof	Area Pervious (ha)	None	None	0
Urban	M1 - Roof	Total Area (ha)	None	None	2.3
Urban	M1 bypass - Other Impervious	Area Impervious (ha)	None	None	0.17
Urban	M1 bypass - Other Impervious	Area Pervious (ha)	None	None	0
Urban	M1 bypass - Other Impervious	Total Area (ha)	None	None	0.17
Urban	M1 bypass - Other Pervious	Area Impervious (ha)	None	None	0
Urban	M1 bypass - Other Pervious	Area Pervious (ha)	None	None	0.17
Urban	M1 bypass - Other Pervious	Total Area (ha)	None	None	0.17
Urban	M2 - Other Impervious	Area Impervious (ha)	None	None	0.45
Urban	M2 - Other Impervious	Area Pervious (ha)	None	None	0
Urban	M2 - Other Impervious	Total Area (ha)	None	None	0.45
Urban	M2 - Other Pervious	Area Impervious (ha)	None	None	0
Urban	M2 - Other Pervious	Area Pervious (ha)	None	None	0.11
Urban	M2 - Other Pervious	Total Area (ha)	None	None	0.11
Urban	M2 - Road	Area Impervious (ha)	None	None	0.12
Urban	M2 - Road	Area Pervious (ha)	None	None	0
Urban	M2 - Road	Total Area (ha)	None	None	0.12
Urban	M2 - Roof	Area Impervious (ha)	None	None	0.41
Urban	M2 - Roof	Area Pervious (ha)	None	None	0

Only certain parameters are reported when they pass validation

PENRITH CITY COUNCIL

music@link

Node Type	Node Name	Parameter	Min	Max	Actual
Urban	M2 - Roof	Total Area (ha)	None	None	0.41

Only certain parameters are reported when they pass validation

PENRITH CITY COUNCIL

music e link

Failing Parameters

Node Type	Node Name	Parameter	Min	Max	Actual
GPT	M1 - GPT	TN % Load Reduction	0	0	-0.00
GPT	M1 - GPT	TP % Load Reduction	0	0	-0.00
GPT	M1 - GPT	TSS % Load Reduction	0	0	-7.17
GPT	M2 - GPT	TN % Load Reduction	0	0	-0.00
GPT	M2 - GPT	TP % Load Reduction	0	0	-9.86
GPT	M2 - GPT	TSS % Load Reduction	0	0	4.753

Only certain parameters are reported when they pass validation