State Significant Development: Flood Study Report

Dicker Data Warehouse and Distribution Centre

Prepared for DCI Projects 26 February 2018 Revision A

171516 CAAB

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Contents

1.0 Introduction 4
1.1 Flood Impacts 4
2.0 Site Background 5
2.1 Existing Flood Conditions 5
2.2 Locality 5
2.3 Key Issues 6
3.0 Flood Modelling 7
3.1 Study Catchment Area 7
3.2 DRAINS Assumptions – 1% AEP 7
3.3 XP RAFTS Assumptions – PMP 9
3.4 TUFLOW Assumptions 10
3.5 Pre Development 1% AEP Results (S01) 12
3.6 Post Development 1% AEP Results (S02) 12
3.7 Post Development PMF Results (S03) 13
3.8 Post Development Sea Level Rise 1% AEP Results (S04_001) 14
3.9 Tidal Flooding + Sea Level Rise 15
3.10 Post Development Sea Level Rise PMF Results (S04_002) 16
3.11 1% AEP Design Storm Afflux Comparison (S02 vs S01) 16
3.12 Post Development 1% AEP (S02) Additional Flood Mapping 18
3.12.1 Post Development Velocity Gradients and Vectors 18
3.12.2 Post Development Hazard (Velocity Depth) Analysis 18
3.12.3 Post Development Hazard NSW Floodplain Manual Analysis 19
4.0 Flood Planning Levels 21
5.0 Emergency Evacuation Plan 22
5.1 Site Emergency Response Flood Plan 22
6.0 Recommendations: 23
7.0 Conclusions: 23
Appendix A 1
Appendix B i
Appendix C i

1.0 Introduction

This Flood Study has been prepared in accordance with Sutherland Shire Council's Development Control Plan and associated policies to support the development of an industrial warehouse in Kurnell.

The scope of this report includes a comprehensive assessment of the existing flow regimes before evaluating the effects of the proposed development on flood behaviour. Following the pre and post development comparison, recommended flood planning levels will be discussed as well as various other flood planning considerations.

A review of the following flood related documentation available at Sutherland Shire Council's website was undertaken in the preparation of this assessment:

- Secretary's Environmental Assessment Requirements (SEARs dated 18 Jan 2018)
- Concept civil engineering sketches by TTW;
- Concept Architectural Plans by WMK Architecture;
- Sutherland Shire Council Development Control Plan (2015);
- "Australian Rainfall and Runoff – A Guide to Flood Estimation", Institute of Engineers, Australia (2016);
- NSW Floodplain Development Manual (2005);
- Georges River Floodplain Risk Management Study and Plan (May 2004);
- Kurnell Township Flood Study (May 2009);
- Sutherland Shire Council Sea Level Rise Policy (November 2016)

The increase in impervious areas and alteration of the natural topography due to land development has the potential to increase and concentrate peak storm flows. This has the potential to impact on flood regimes and cause erosion of the downstream drainage network and associated waterways. To avoid any adverse impact on the downstream drainage systems, the site must be designed to ensure the safe conveyance of flows within the capacity of the downstream trunk drainage systems in a healthy environmental state for Ecological Sustainable Development.

1.1 Flood Impacts

This report indicates the flood management strategy to prevent adverse changes in the existing flow regimes for the development of the project. The measures outlined in this report extend beyond the traditional management measures to consider the overall impact of the development on the surrounding areas and wider catchment.

As outlined in this report, the flood management strategy will ensure the site and surrounding properties have limited change in overall flooding due to the proposed development and the proposed development is flood free in rare storm events.

2.0 Site Background

2.1 Existing Flood Conditions

Flooding on the site is currently limited to surface flow due to rain events. Due to the high hydraulic conductivity of the soils, it is expected that frequent storm events (50%, 20% AEP) are able to permeate into the ground without significant ponding or overland flow. During rare storm events (10%, 5%) combined with high seasonal (or tidal) water table some ponding including flooding will occur. Proximity to receiving waters and permeable soils will contribute to allowing flood heights to recede quickly (in comparison to rock, clay or other less permeable soils). Pre-development flood extents for the 1% AEP is shown in **Section 3.5.**

2.2 Locality

The site is located at 238-258 Captain Cook Drive, Kurnell which is within the Sutherland local government area (LGA). It is bound by a large warehouse to the north-east, Captain Cook Drive to the north-west, bushland to south-east and an unnamed gravel road to the south-west. The site currently exists as an industrial warehouse.

Figure 1 - Aerial photo of the proposed site (Source: https://maps.six.nsw.gov.au)

The proposed development includes the redevelopment of the site including construction of a new warehouse, carpark, stormwater infrastructure, earthworks including site filling, and associated utility services.

Figure 2 – Dicker Data Warehouse locality (Source: www.google.com.au/maps)

2.3 Key Issues

The key issue to be addressed in this report is:

- Flooding – New structures have the potential to alter existing flow paths and result in changes to flood extent, depth and velocity both upstream and downstream of the subject site. This can have the potential to cause damage and erosion to neighbouring properties. In addition to ensuring that upstream and downstream flow conditions are maintained, a freeboard requirement above flood levels will be implemented to ensure that habitable floor levels and basement crests are protected from potential flood events.

- TTW's has been engaged to evaluate the existing flood behaviour and the effects of the proposed development on flow regimes. The Australian Rainfall and Runoff 2016 guidelines and the Bureau of Meteorology 2016 Rainfall IFD data system were utilised to create a DRAINS hydrology model and TUFLOW two dimensional flood model of subject site. The model was created using a combination of LiDAR data, survey information, site inspection and interrogation of available online resources. Land use within this region of Kurnell is typically industrial development surrounded by densely vegetated brush. There are a number of natural open channels that exist at low points within the catchment which typically drain by a pressure head rather than gradient due to the flat nature of the area and close locality to Quibray Bay.

3.0 Flood Modelling

3.1 Study Catchment Area

The local catchment area for the development site was determined using a combination of LiDAR data, survey information, site inspection and interrogation of available contour maps.

The figure below indicates a conservative estimate of the 100 hectare catchment draining towards the low points within Captain Cook Drive. The catchment extents are shown by a dashed magenta line with the subject site outlined in a red polygon.

The catchment was conservatively estimated to be 50% pervious based on the combination of industrial development surrounded by dense vegetation. Overland flow across the subject site typically occurs in a South to North direction as sheet flow.

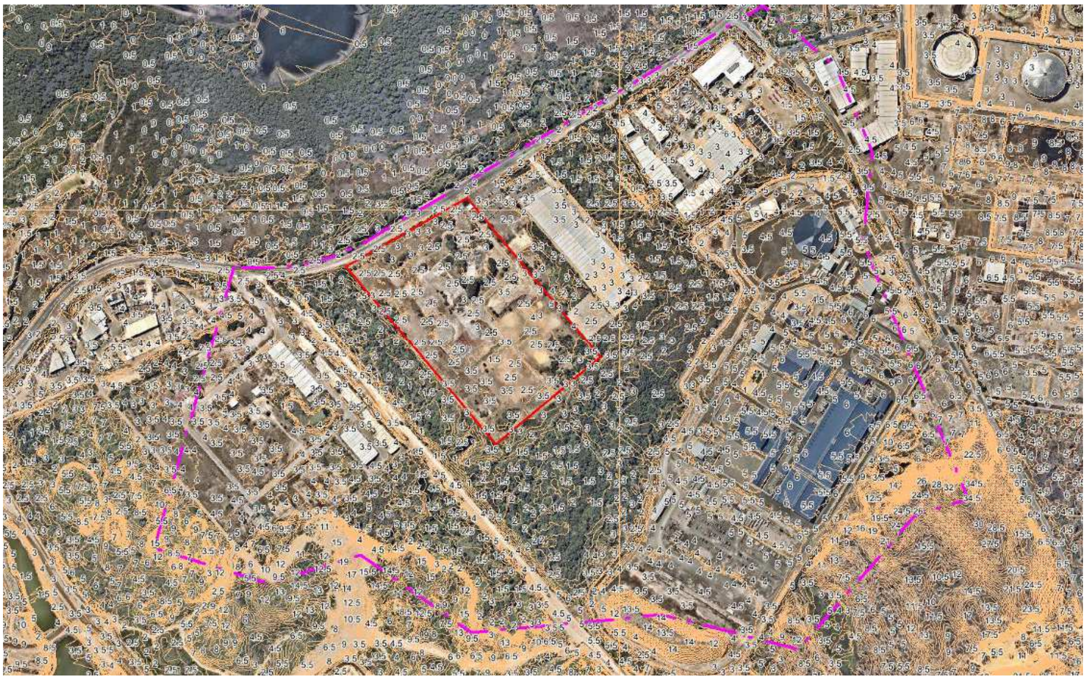

Figure 3 – Flood Study Catchment Area

3.2 DRAINS Assumptions – 1% AEP

A DRAINS model was used in determining the 1% Annual Exceedance Probability storm event using the following assumptions:

- Bureau of Meteorology's 2016 Intensity Frequency Duration data for rainfall run off rates and Australian Rainfall Runoff 2016 HUB initial/continuing loss modelling procedures and guidelines.
- A local catchment area of 100 hectares with an imperviousness ratio of 51%;
- Kinematic wave retardance factors of 0.016 for industrial impervious areas and 0.20 for pervious areas to reflect the densely vegetated shrub;
- Flow path length and slope calculated was based on the catchment area.

The above data was input into the model and run for all durations to determine the design storm for the 1% Annual Exceedance Probability event.

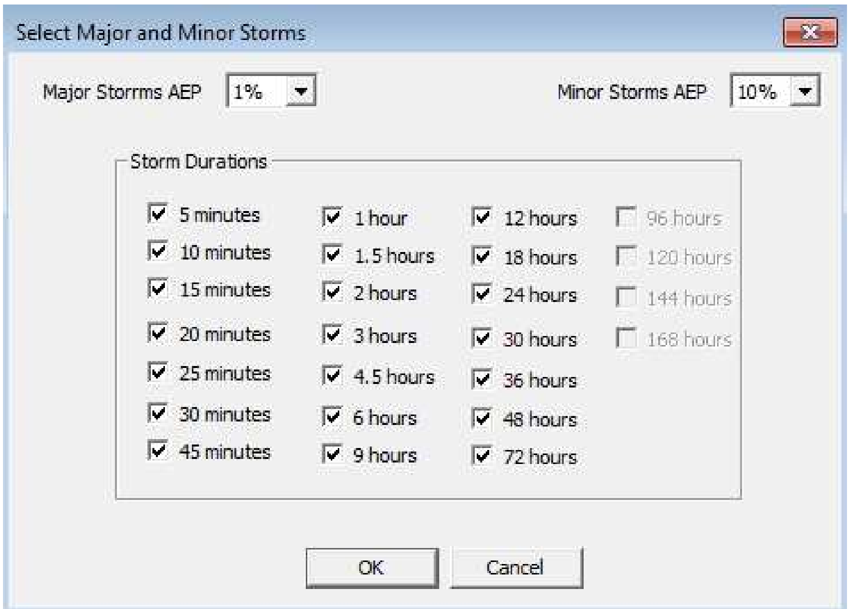

Figure 4 - Storm Durations Modelled in DRAINS

The critical storm based on the DRAINS modelling was found to be 23.951m^3/s in the 1% AEP, 15 minute burst, Storm 8. To evaluate the effects of volume rather than flow rate as well as accommodate for variances in catchment size, grade and flow path length two additional storms were considered for input into the TUFLOW model; 30 minute and 90 minute duration. Peak flood levels were found to occur in the 30 minute storm, indicating that a combination of tailwater level and volume of runoff are also contributing factors to flooding in Kurnell. The summary of the peak flows is attached to this report as Appendix A.

Storm	Peak Flow (cu.m/s)	
1% AEP, 15 min burst, Storm 1	23.956	
1% AEP, 15 min burst, Storm 2	23.945	
1% AEP, 15 min burst, Storm 3	23.939	
1% AEP, 15 min burst, Storm 4	23.939	
1% AEP, 15 min burst, Storm 5	23.950	
1% AEP, 15 min burst, Storm 6	23.945	
1% AEP, 15 min burst, Storm 7	23.957	
1% AEP, 15 min burst, Storm 8	23.951	Critical Storm for this AEP and Burst Duration
1% AEP, 15 min burst, Storm 9	23.968	
1% AEP, 15 min burst, Storm 10	23.962	
1% AEP, 30 min burst, Storm 1	23.419	
1% AEP, 30 min burst, Storm 2	18.131	
1% AEP, 30 min burst, Storm 3	20.618	
1% AEP, 30 min burst, Storm 4	21.629	
1% AEP, 30 min burst, Storm 5	20.066	
1% AEP, 30 min burst, Storm 6	17.819	
1% AEP, 30 min burst, Storm 7	23.492	
1% AEP, 30 min burst, Storm 8	18.486	
1% AEP, 30 min burst, Storm 9	21.438	Critical Storm for this AEP and Burst Duration
1% AEP, 30 min burst, Storm 10	22.575	
1% AEP, 1.5 hour burst, Storm 1	16.434	
1% AEP, 1.5 hour burst, Storm 2	17.231	
1% AEP, 1.5 hour burst, Storm 3	14.129	
1% AEP, 1.5 hour burst, Storm 4	12.324	
1% AEP, 1.5 hour burst, Storm 5	13.143	
1% AEP, 1.5 hour burst, Storm 6	19.075	
1% AEP, 1.5 hour burst, Storm 7	18.455	
1% AEP, 1.5 hour burst, Storm 8	16.230	Critical Storm for this AEP and Burst Duration
1% AEP, 1.5 hour burst, Storm 9	14.395	
1% AEP, 1.5 hour burst, Storm 10	13.886	

Figure 5 - Design Storms for TUFLOW

3.3 XP RAFTS Assumptions – PMP

XP RAFTS was utilised to estimate the PMP and peak flow hydrographs. The catchment characteristics were input into the model and ran for a range of durations ranging from 15 minutes to 6 hours which is the limit under the General Short Duration Method for calculating the Possible Maximum Precipitation (PMP). The peak flowrate based on the PMP for the given catchment area was found to be 124.729m^3/s in the 15 minute storm duration. To evaluate the effects of potential variance in catchment attributes and run off volume during the PMP event, the storms that provided the next highest peak flow rates were considered for input into the TUFLOW model; the 30 minute and 90 minute duration.

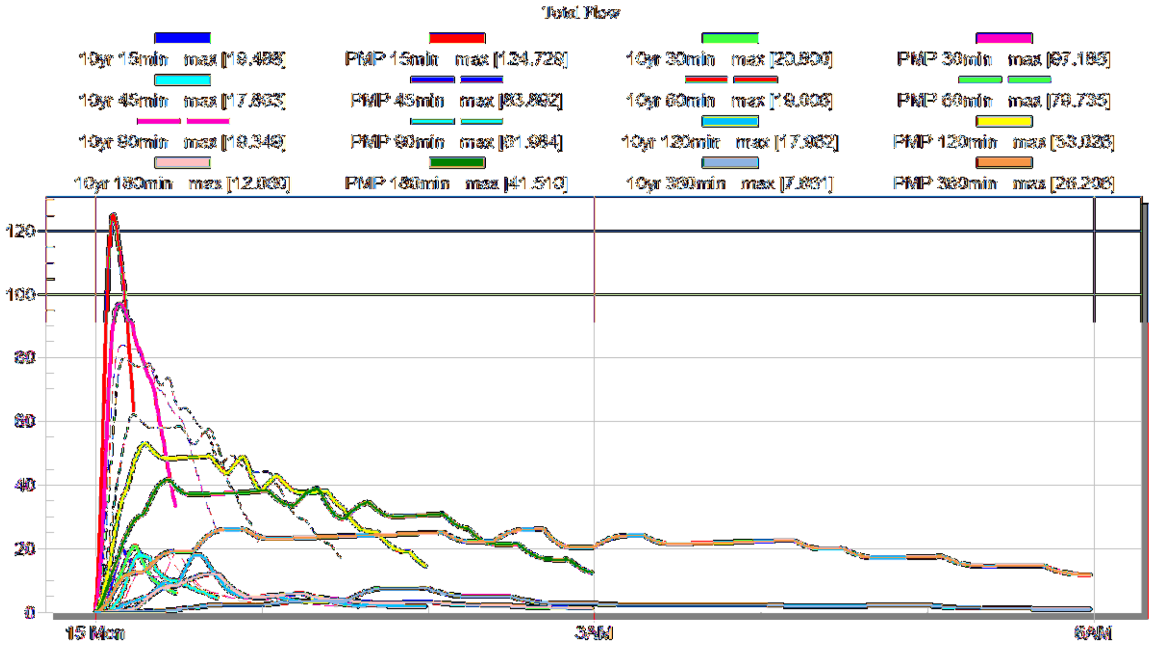

Figure 6 - XP RAFTS Results

3.4 TUFLOW Assumptions

The following design attributes were assumed for the purpose of a creating a pre development flood model:

- Roughness values applied to the external and site catchment are outlined in the ID table below and the figures attached to this report as Appendix B. The unshaded areas of the catchment were allocated a Manning's roughness of 0.025 to represent the sandy nature of Kurnell (ID5). The polygons shown in the post development breakdown were used to overwrite the cells in the pre development scenario.

Material ID	Manning's n	Infiltration Parameters	! Description
1	0.018	1.5, 0.0	!road carriageways
2	0.02	1.5, 0.0	!driveways and car parks
3	0.03, 0.02, 0.1, 3.00	0.0, 0.0	!buildings
4	0.04	5.0, 3.0	!open space & long grass
5	0.025	1.5, 0.0	!urban space & paved
6	0.06	2.5, 1.0	!residential blocks
7	0.04	1.5, 0.0	!industrial/commercial blocks
8	0.25	5.0, 3.0	!mangroves, wetlands & dense vegetation
9	0.03	1.5, 0.0	!water
10	0.03, 0.04, 0.1, 0.06	5.0, 3.0	!long grass pasture
11	0.07	5.0, 3.0	!channel; weedy reaches, deep pools
12	0.035	5.0, 3.0	!channel; grass swale
13	0.07	5.0, 3.0	!brush
14	0.04	2.5, 1.0	!railway embankments
15	0.08	0.0, 0.0	!special use
16	0.03, 0.10, 0.1, 0.04	5.0, 3.0	!lawns/grass/playingfields

Table 1 - Manning's Roughness Values

- Buildings within the catchment were modelled as areas with varying Manning's roughness value. For depths of flow less than 30mm the adopted Manning's was 0.02 to simulate the effects of roof sheet flow. For depths of flow in excess of 100mm the Manning's value was increased to 3 as a means of reflecting any existing freeboard provisions preventing the ingress of floodwater and storages in the model.

- A downstream boundary condition of 0.6m AHD was assumed as the tailwater level for the design storm. This level was deemed appropriate after consulting available information such as the Kurnell Township Flood Study 2009 by WMA as well as the Georges River Floodplain Risk Management Study and Plan 2004 by Bewsher.

- Rainfall losses for impervious areas were set to IL = 1.5, CL = 0 and losses for pervious areas were set to IL = 5.0, CL = 3.0. The values that were adopted in the TUFLOW model were considered conservative given rainfall losses provided by the ARR 2016 data hub for Tarren Point (the closest location to the site with available data) was a 32mm/hr continuing loss.

- To represent the sandy soils within Kurnell, infiltration losses were set to IL = 0, CL = 5.4mm/hr. This value matches the assumption in the Kurnell Township Flood Study 2009 by WMA. Note that this infiltration rate was not applied to developed areas or open bodies of water.

Figure 7 - External Catchment Breakdown

Figure 8 - Pre Development Catchment Breakdown

Figure 9 - Post Development Catchment Breakdown

3.5 Pre Development 1% AEP Results (S01)

The design storms were applied to the catchment in TUFLOW using the direct rainfall method and a time versus rainfall depth hyetograph.

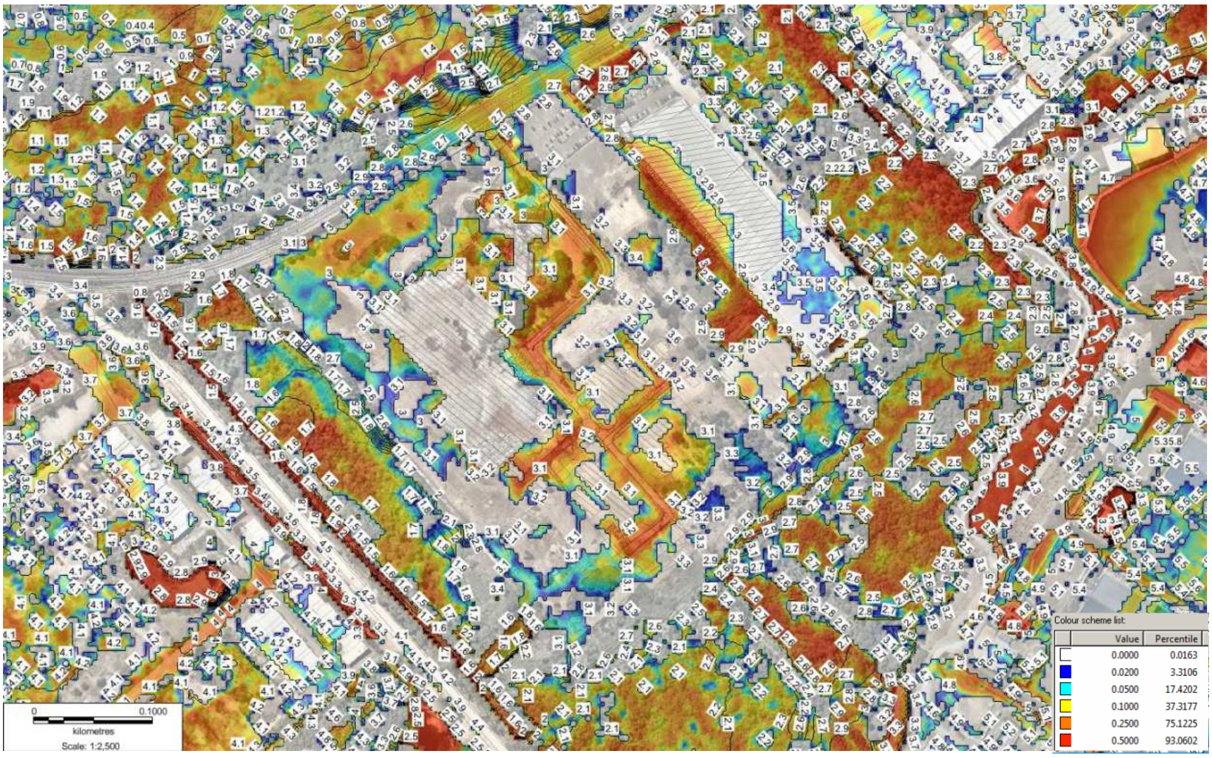

Figure 10 – Pre Development 1% AEP Depths & Flood Contours

3.6 Post Development 1% AEP Results (S02)

Modifications were made to reflect the new buildings and changes to pervious and impervious surfaces.

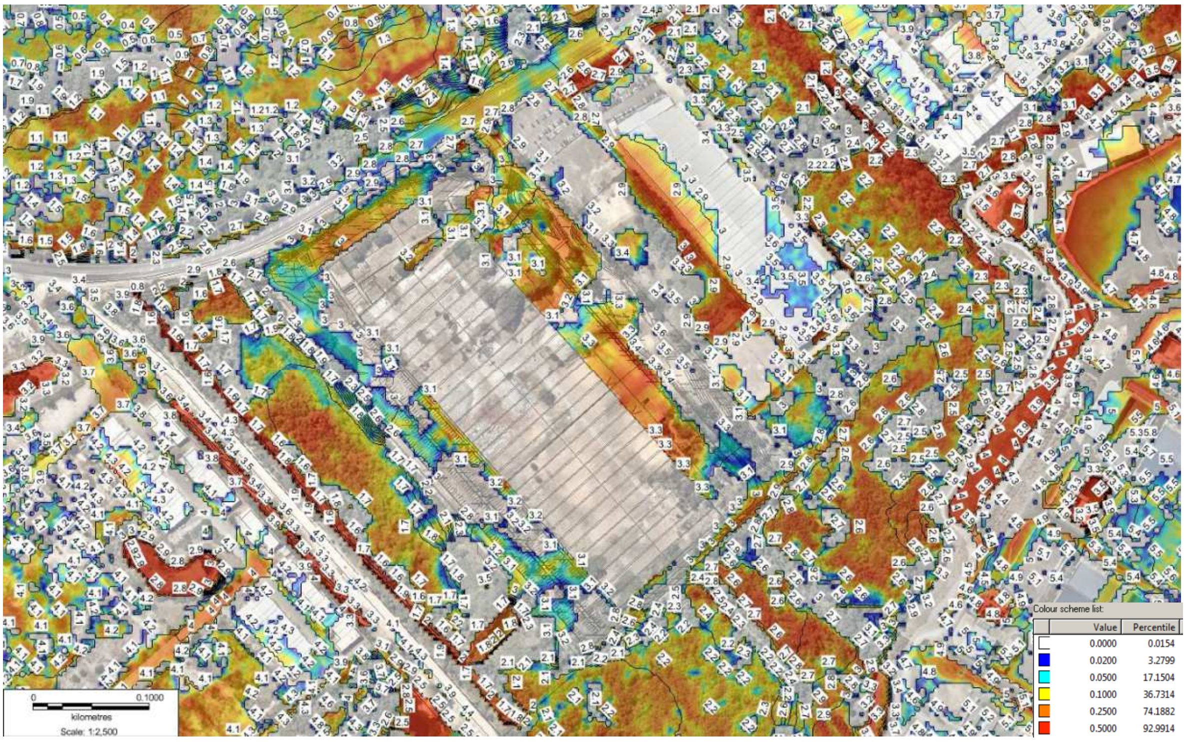

Figure 11 - Post Development 1% AEP Depths & Flood Contours

3.7 Post Development PMF Results (S03)

The 15, 30 and 90 minute storms were analysed to determine the effects of flowrate vs volume on peak flood levels. The 90 minute storm resulted in the highest peak flood levels.

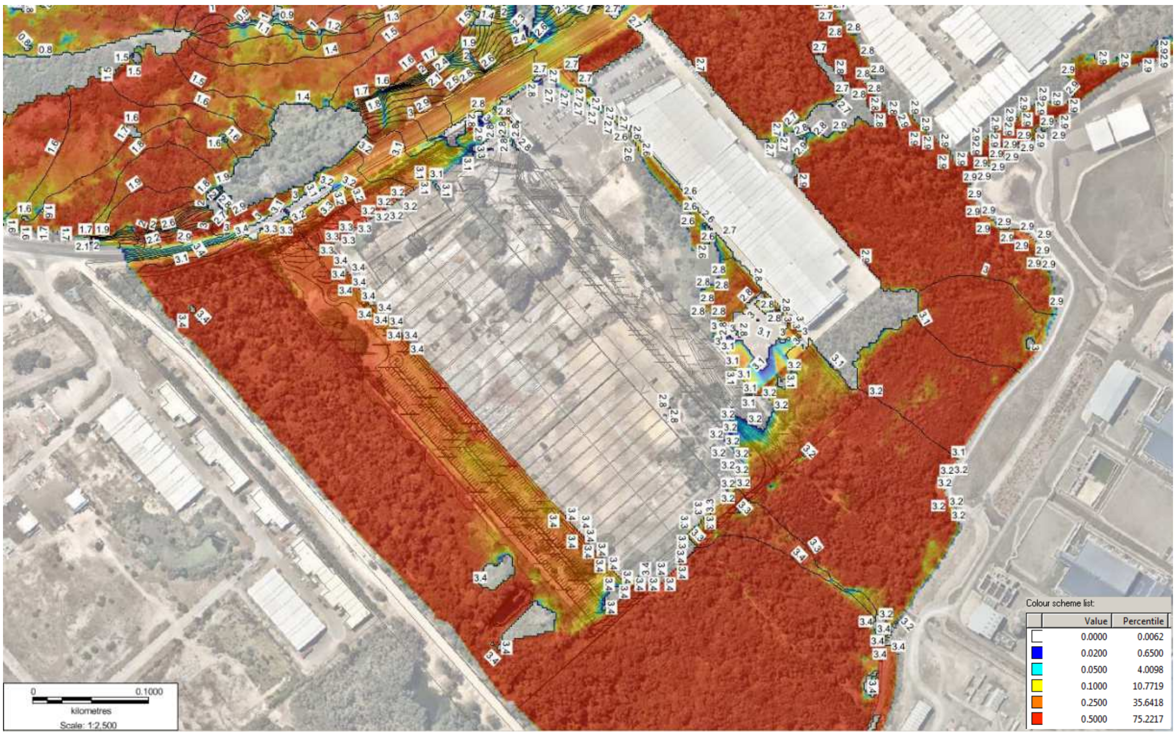

Figure 12 – Post Development PMF Indicative Depths of Inundation

3.8 Post Development Sea Level Rise 1% AEP Results (S04_001)

An additional sensitivity analysis scenario was evaluated whereby the tailwater level was increased to RL 1.32m AHD to consider the effects of a project 0.72m rise in water level above the design storm condition of a 0.6m high tide. Sutherland Shire Council's Sea Level Rise Policy (November 2016) includes a sea level rise projection of 0.72m by 2100. Map 46 of the document indicates that only a very small portion of the subject site is shown to be applicable under the policy. This area is well outside of the building envelope and is proposed to form part of the open space.

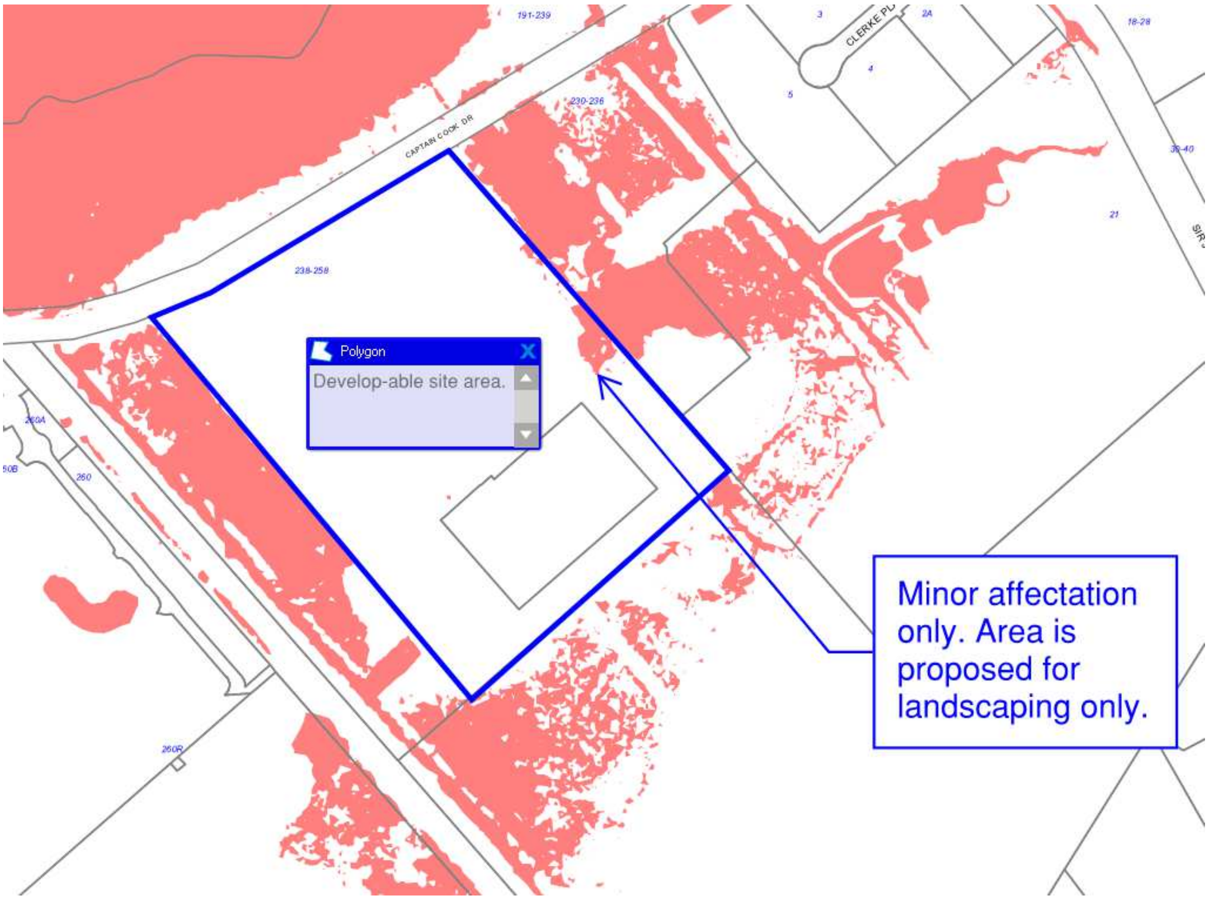

Figure 13 - Site areas to which Sea Level Rise Policy applies

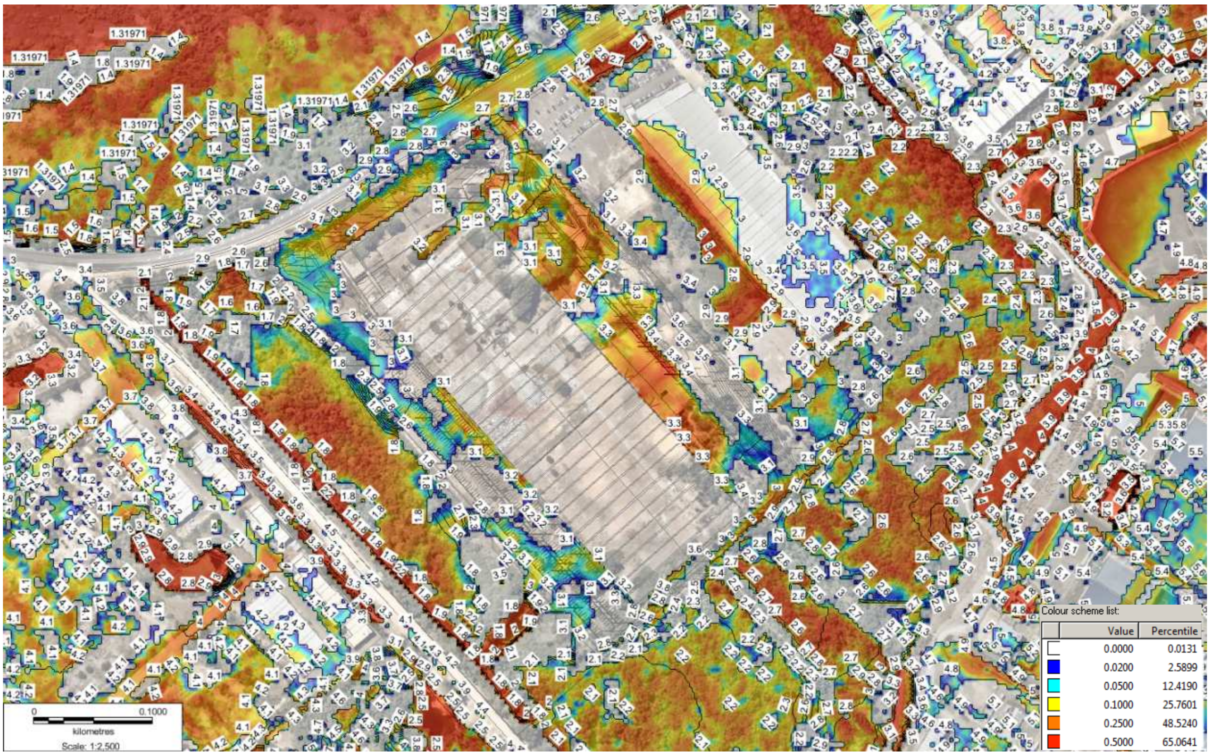

Figure 14 - Post Development 1% AEP + SLR Flood Depths & Contours

The downstream peak flood levels increased to RL 1.32m however as the existing site ground levels are around RL 2.80 or higher the increase to the tailwater condition due to sea level rise had minimal effects on the flood levels within the development. Minor fluctuations in flood levels occurred along the South East warehouse wall which can mitigated by the provision of flood proof walls.

Based on the flood modelling the peak flood level adjacent to the warehouse is RL 3.30m AHD. This is the level that will be used to set the Flood Planning Level in Section 4.0 of the report.

3.9 Tidal Flooding + Sea Level Rise

In addition to the above modelling the effects of tidal flooding and impact of sea level rise was considered. The design flood levels for tidal flooding taken from the Kurnell Township Flood Study (May 2009) Page 51 are listed to be RL 1.70m AHD for the 1% AEP event. With a projected sea level rise of RL 0.72m the estimated design flood level due to tidal flooding would be RL 2.42m AHD by 2100. The effects of sea level rise and tidal flooding are not expected to affect the development as the majority of the existing site levels are above this level. Furthermore, the finished floor level of the development is proposed to be RL 3.70m AHD as a result of the modelling and 500mm freeboard requirement.

3.10 Post Development Sea Level Rise PMF Results (S04_002)

The storm that created the peak flood levels for the PMF scenario (S03) was also run with a tailwater level of RL 1.32m AHD to ascertain the worst case scenario of high tide, sea level rise and Possible Maximum Precipitation (PMP).

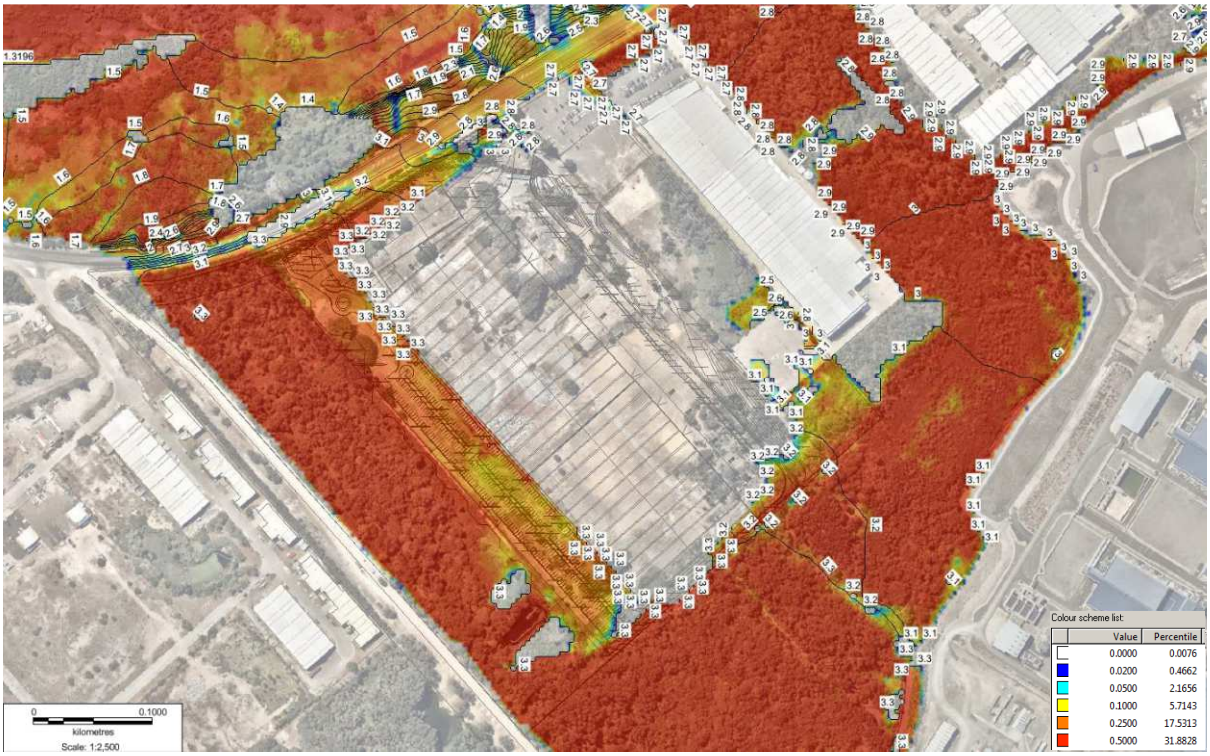

Figure 15 - Post Development PMF + SLR Flood Depths and Contours

It is to be noted that the 1% AEP flood level + 500mm freeboard requirement would result in the warehouse being above the PMF level.

3.11 1% AEP Design Storm Afflux Comparison (S02 vs S01)

An afflux comparison map was plotted to compare the change in peak flood levels as a result of the development. The contours and thematic mapping indicate that there will be negligible changes to flood levels and flow regimes on the road and adjacent properties as the afflux was generally shown to be less than 20mm which is typically an industry acceptable level of variance. The bulk of afflux values are shown to occur within the subject site due to changes in building scale and location. A was dry (cyan) / now wet (red) plot is also attached indicating that the displacement of water is generally restricted to within the site.

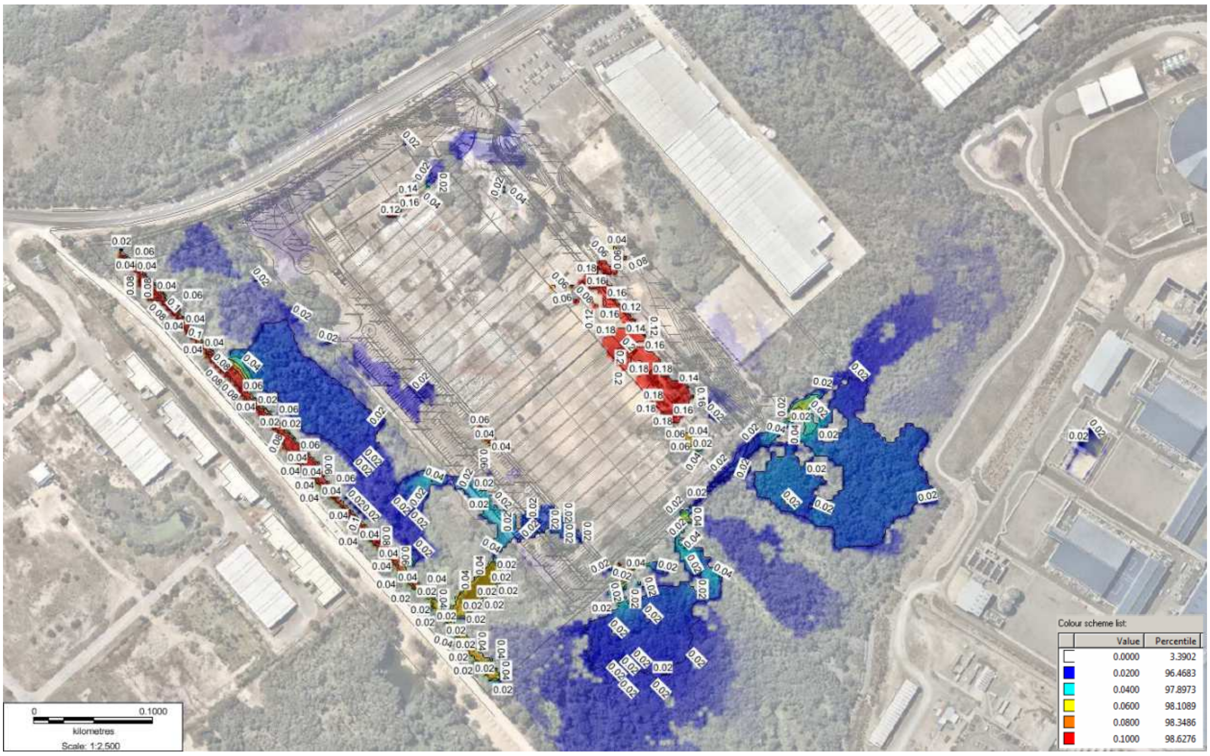

Figure 16 - Pre vs Post 1% AEP Afflux Comparison

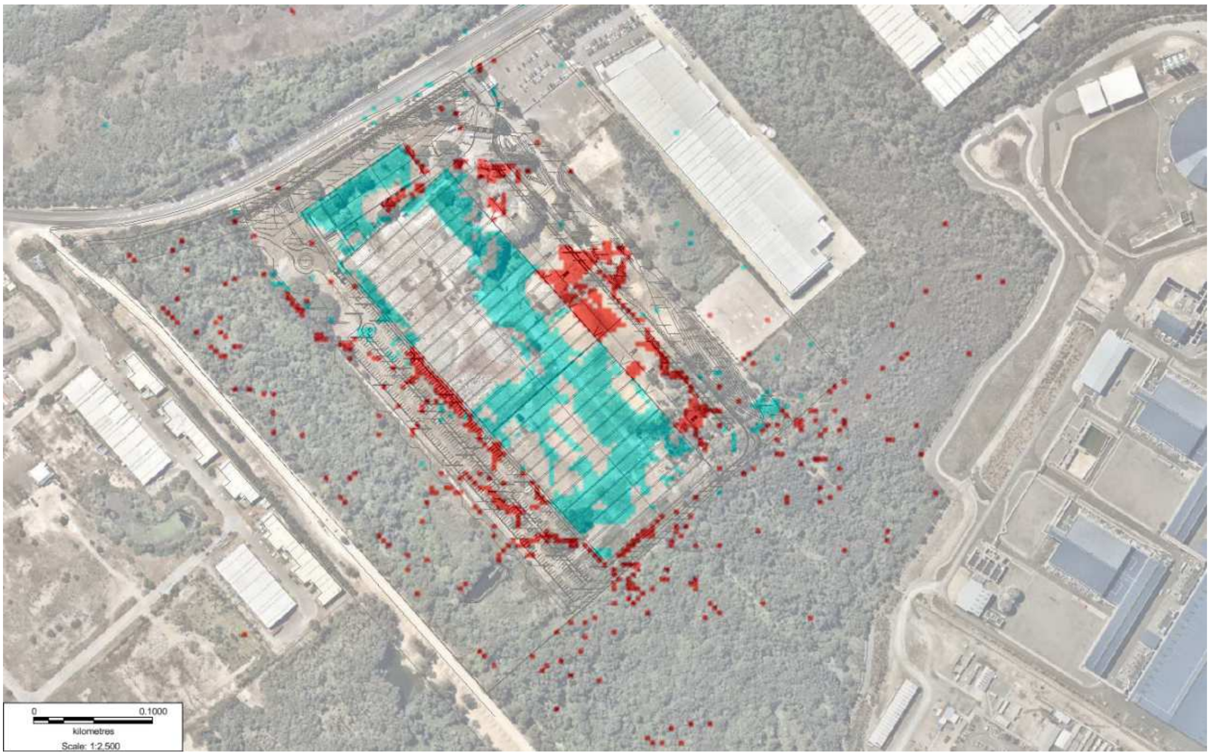

Figure 17 - Was Dry (Cyan) Now Wet (Red) Plot

3.12 Post Development 1% AEP (S02) Additional Flood Mapping

Although the changes to peak flood levels were negligible and as such the pre vs post development scenario would essentially remain unchanged, several additional flood mapping results have been provided for the 1% AEP post development design storm:

3.12.1 Post Development Velocity Gradients and Vectors

Due to the flat, low lying nature of the catchment, dense vegetation and flooding mechanism driven by volume and tide rather than peak flow rate, the velocity of overland flow remains low. Floodwaters would be expected to back up and pond rather than occur in a flash flood nature.

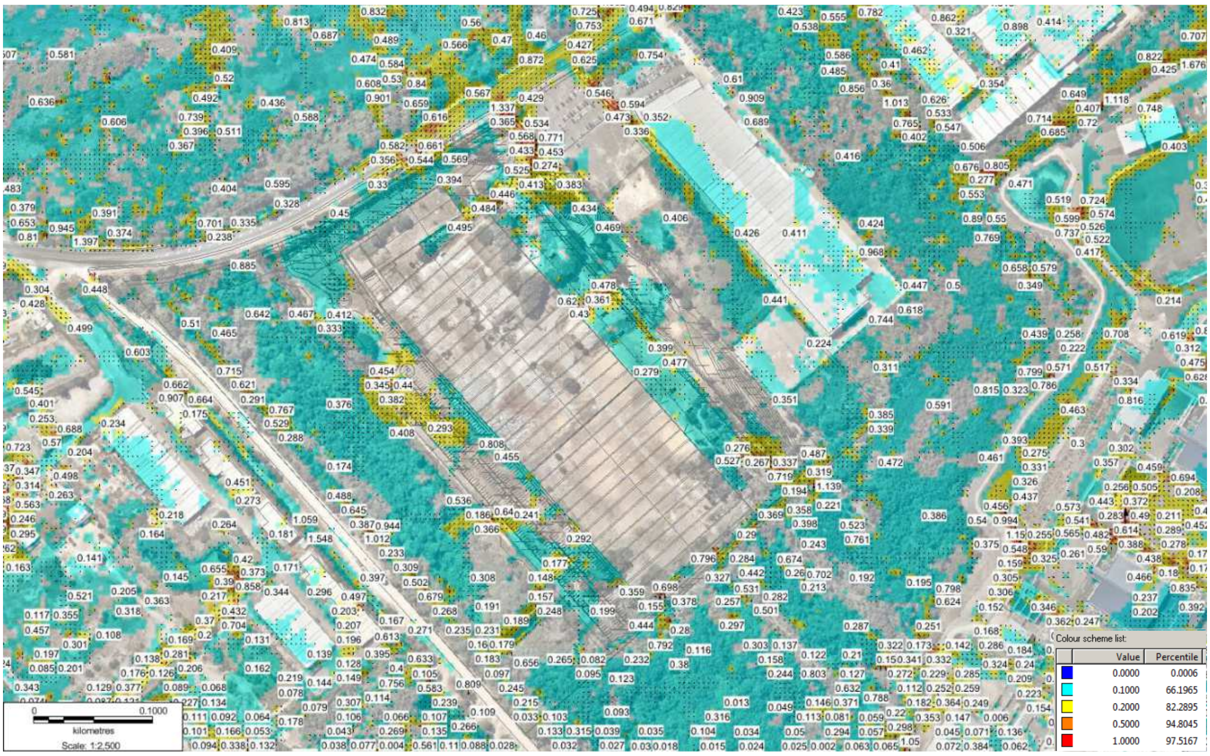

Figure 18 - Post Development 1% AEP Velocity Plot (ms^{-1})

3.12.2 Post Development Hazard (Velocity Depth) Analysis

Potential hazards to pedestrian and vehicle safety can be expressed as a product of velocity and depth, referred to as a VD product. Higher VD products indicate higher risk areas of deeper depth, higher velocity or combination of the two. Generally the limits for stability are:

- Able bodied pedestrian safety is a VD product of 0.3.
- The above figure can be increased up to a VD product of 0.4 in areas that are inaccessible for children and the elderly.
- Vehicles are able to remain stable up to a VD product of 0.6.

VD products shown on the mapping correlate with the relatively shallow depths of inundation and low flow velocity nature of the catchment, as 97% of the flood flows have a VD product less than the limit of pedestrian safety (0.3). It is noted that the flow hazard increases along the open channels traversing the catchment.

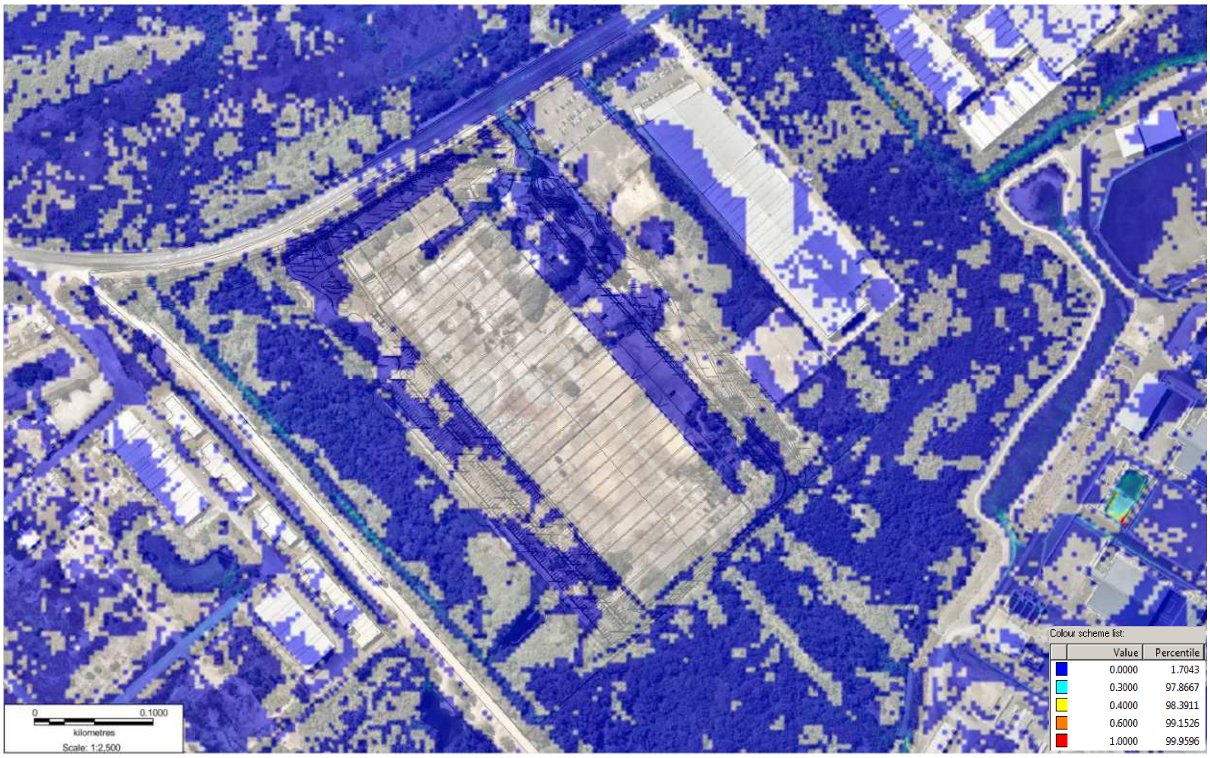

Figure 19 - Post Development 1% AEP VxD Plot

3.12.3 Post Development Hazard NSW Floodplain Manual Analysis

TUFLOW is able to output the hazard mapping results as an integer numbered 1 through to 3 depending on the hazard categorisations set out in the Australian NSW Floodplain Management Manual (2005). The majority of the site is shown to be low hazard with existing channels to the West and East shown to be areas of high hazard.

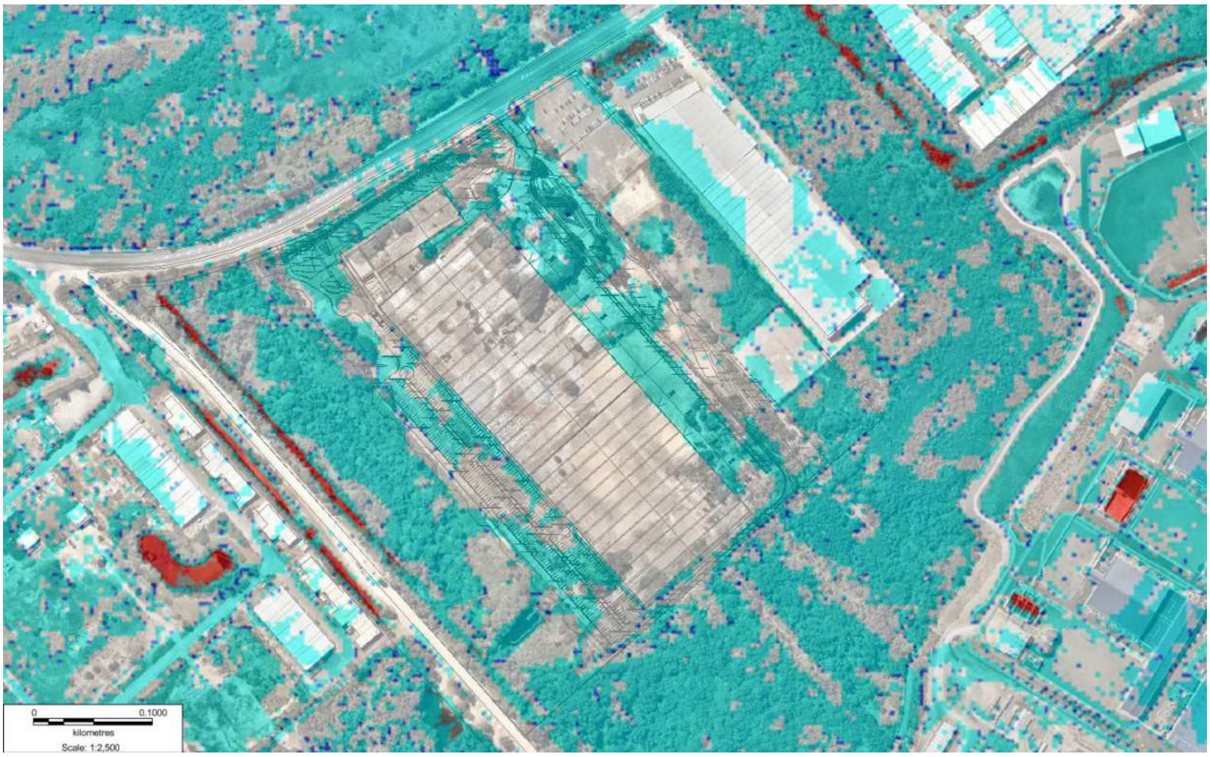

Figure 20 - Post Development 1% AEP NSW Floodplain Hazard

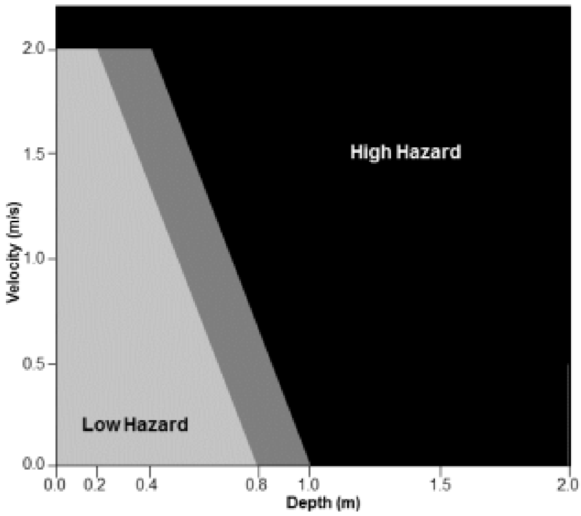

Figure 21 - NSW Floodplain Development Manual VD Chart

4.0 Flood Planning Levels

Based on the 1% AEP post development results, a peak flood level of RL 3.3m AHD is observed to occur along at the edge of the warehouse building envelope. The proposed floor level of the habitable areas and warehouse floor shall be set to RL 3.70m AHD in order to satisfy Council's freeboard requirement of 500mm above the 1% AEP storm event.

In accordance with Sutherland Shire Council's Stormwater Mangement 2009 Policy Clause 4.30, the driveways and car parking areas may be set to RL 3.00 m AHD to limit depths of ponding to 200mm. Flood levels and associated flood planning levels may be interpolated between contours in order to achieve site grading.

Proposed Use	**1 % AEP design storm flood level**	**Required Freeboard above 1% AEP**	**Minimum Level**
Habitable/ warehouse	RL 3.30m AHD	+500mm	RL 3.80m AHD
Driveway/ car park	RL 3.20m AHD	-200mm	RL 3.00m AHD

Table 2 - Flood Planning Levels

Note: In addition to the above table the proposed substation will be set on a plinth to achieve the 500mm freeboard requirement above the adjacent 1% AEP flood level.

5.0 Emergency Evacuation Plan

Due to the relatively short times of concentration and flooding nature of urban catchments it is likely that evacuation of properties will occur as a response to storm intensity rather than a preventative action in anticipation of approaching floodwater. Due to the hap hazard response to flooding and nature of the catchment being on a peninsula, it would be difficult to effectively organise the transportation of persons to areas outside of the flood affected zones.

The catchment characteristics result in flooding due to a combination of volume rather than flow rate, high tide levels and overland flow. As a result, changes to flood flows, depths and overland flow paths do not exponentially increase with the rarer storm events which is shown in the PMF scenario results. For this reason flood affectation in this catchment does not necessarily mean that properties need to be evacuated as a large majority of sites are not exposed to a high hazard nor would they be considered within the ‘floodway’ hydraulic category.

Although occupants may still able to escape either on foot or by vehicle along roadways in the 1% AEP even if evacuation is left late, due to the low lying nature of the catchment and flooding mechanism it is likely that most buildings will become flood islands in the PMF event. For these reasons it is recommended that occupants remain inside the building and take refuge as the finished floor level of the development would be above the probable maximum flood level.

5.1 Site Emergency Response Flood Plan

A site emergency response flood plan detailing the flood inundation and mitigation measures as well as the proposed relocation of people to a safe location should be implemented by operations and management. The staff employed at the new development will be required to be trained for typical emergency situations such as fires. In addition to this generalised training the management of a flood event can also be incorporated into the responsibility of staff members. It is recommended that a flood plan address the following items:

- The training and action required for the management of a flood event including the deployment of any flood mitigation measures and relocation of persons.
- Similarly to fire wardens, flood wardens can be appointed and made responsible for managing the evacuation procedures. Flood evacuation drills can also be scheduled to ensure all persons are aware of the correct procedure.
- The maintenance and operation schedules of any alarm and warning systems implemented. E.g. a ball float alarm system can in installed within the lower lying pits which would then sound and activate alarms and any flood mitigation measures.
- Locations of the appropriate flood warning signage.

6.0 Recommendations:

The key strategies to be adopted for the development include the following:

- Freeboard is to be provided through setting the flood planning levels as outlined in Table 2.
- The development shall incorporate the flood planning considerations outlined in Section 5 above.
- All flood proof walls shall be constructed from flood compatible materials and designed to withstand pressure and impacts from debris carried in floodwaters.
- The design shall also be certified by a structural engineer engaged on the development.
- An alarm warning system, flood warning and evacuation route signage is recommended to be incorporated as part of the development. Flood warning signage shall also be erected within the car park.

7.0 Conclusions:

The proposed development has the potential to lead to adverse changes in the existing flow regimes if a flood management strategy is not adopted during the design and development stage of the project. The measures outlined in this report extend beyond the traditional management measures to consider the overall impact of the development on the surrounding areas and wider catchment. Best practices must now encompass the effects of flooding to develop an appropriate water management strategy to ensure that development occurs in safe and sustainable way.

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Appendix A

DRAINS 1% AEP Results

Peak Flows for CAT_PRE

Storm	Peak Flow (cu.m/s)	
1% AEP, 5 min burst, Storm 1	13.394	Critical Storm for this AEP and Burst Duration
1% AEP, 10 min burst, Storm 1	20.282	
1% AEP, 10 min burst, Storm 2	20.282	
1% AEP, 10 min burst, Storm 3	20.288	Critical Storm for this AEP and Burst Duration
1% AEP, 10 min burst, Storm 4	20.288	
1% AEP, 10 min burst, Storm 5	20.294	
1% AEP, 10 min burst, Storm 6	20.282	
1% AEP, 10 min burst, Storm 7	20.288	
1% AEP, 10 min burst, Storm 8	20.282	
1% AEP, 10 min burst, Storm 9	20.294	
1% AEP, 10 min burst, Storm 10	20.294	
1% AEP, 15 min burst, Storm 1	23.956	
1% AEP, 15 min burst, Storm 2	23.945	
1% AEP, 15 min burst, Storm 3	23.939	
1% AEP, 15 min burst, Storm 4	23.939	
1% AEP, 15 min burst, Storm 5	23.95	
1% AEP, 15 min burst, Storm 6	23.945	
1% AEP, 15 min burst, Storm 7	23.957	
1% AEP, 15 min burst, Storm 8	23.951	Critical Storm for this AEP and Burst Duration
1% AEP, 15 min burst, Storm 9	23.968	
1% AEP, 15 min burst, Storm 10	23.962	
1% AEP, 20 min burst, Storm 1	24.187	
1% AEP, 20 min burst, Storm 2	23.08	
1% AEP, 20 min burst, Storm 3	19.996	
1% AEP, 20 min burst, Storm 4	23.839	
1% AEP, 20 min burst, Storm 5	20.814	
1% AEP, 20 min burst, Storm 6	22.445	
1% AEP, 20 min burst, Storm 7	23.903	
1% AEP, 20 min burst, Storm 8	22.079	
1% AEP, 20 min burst, Storm 9	21.785	
1% AEP, 20 min burst, Storm 10	22.94	Critical Storm for this AEP and Burst Duration
1% AEP, 25 min burst, Storm 1	21.276	Critical Storm for this AEP and Burst Duration
1% AEP, 25 min burst, Storm 2	20.282	
1% AEP, 25 min burst, Storm 3	22.186	
1% AEP, 25 min burst, Storm 4	21.111	
1% AEP, 25 min burst, Storm 5	21.918	
1% AEP, 25 min burst, Storm 6	20.797	
1% AEP, 25 min burst, Storm 7	23.267	
1% AEP, 25 min burst, Storm 8	20.174	
1% AEP, 25 min burst, Storm 9	20.584	
1% AEP, 25 min burst, Storm 10	23.917	

1% AEP, 30 min burst, Storm 1	23.419	
1% AEP, 30 min burst, Storm 2	18.131	
1% AEP, 30 min burst, Storm 3	20.618	
1% AEP, 30 min burst, Storm 4	21.629	
1% AEP, 30 min burst, Storm 5	20.066	
1% AEP, 30 min burst, Storm 6	17.819	
1% AEP, 30 min burst, Storm 7	23.492	
1% AEP, 30 min burst, Storm 8	18.486	
1% AEP, 30 min burst, Storm 9	21.438	Critical Storm for this AEP and Burst Duration
1% AEP, 30 min burst, Storm 10	22.575	
1% AEP, 45 min burst, Storm 1	20.576	
1% AEP, 45 min burst, Storm 2	19.942	
1% AEP, 45 min burst, Storm 3	20.487	
1% AEP, 45 min burst, Storm 4	18.899	
1% AEP, 45 min burst, Storm 5	18.76	
1% AEP, 45 min burst, Storm 6	18.601	
1% AEP, 45 min burst, Storm 7	16.497	
1% AEP, 45 min burst, Storm 8	17.261	
1% AEP, 45 min burst, Storm 9	19.352	Critical Storm for this AEP and Burst Duration
1% AEP, 45 min burst, Storm 10	20.632	
1% AEP, 1 hour burst, Storm 1	22.774	
1% AEP, 1 hour burst, Storm 2	15.666	
1% AEP, 1 hour burst, Storm 3	19.642	
1% AEP, 1 hour burst, Storm 4	15.343	
1% AEP, 1 hour burst, Storm 5	17.964	Critical Storm for this AEP and Burst Duration
1% AEP, 1 hour burst, Storm 6	19.074	
1% AEP, 1 hour burst, Storm 7	15.051	
1% AEP, 1 hour burst, Storm 8	16.894	
1% AEP, 1 hour burst, Storm 9	14.22	
1% AEP, 1 hour burst, Storm 10	20.378	
1% AEP, 1.5 hour burst, Storm 1	16.434	
1% AEP, 1.5 hour burst, Storm 2	17.231	
1% AEP, 1.5 hour burst, Storm 3	14.129	
1% AEP, 1.5 hour burst, Storm 4	12.324	
1% AEP, 1.5 hour burst, Storm 5	13.143	
1% AEP, 1.5 hour burst, Storm 6	19.075	
1% AEP, 1.5 hour burst, Storm 7	18.455	
1% AEP, 1.5 hour burst, Storm 8	16.23	Critical Storm for this AEP and Burst Duration
1% AEP, 1.5 hour burst, Storm 9	14.395	
1% AEP, 1.5 hour burst, Storm 10	13.886	
1% AEP, 2 hour burst, Storm 1	16.739	Critical Storm for this AEP and Burst Duration
1% AEP, 2 hour burst, Storm 2	17.373	
1% AEP, 2 hour burst, Storm 3	11.259	
1% AEP, 2 hour burst, Storm 4	19.629	
1% AEP, 2 hour burst, Storm 5	15.763	
1% AEP, 2 hour burst, Storm 6	17.749	

1% AEP, 2 hour burst, Storm 7	11.906	
1% AEP, 2 hour burst, Storm 8	16.946	
1% AEP, 2 hour burst, Storm 9	13.986	
1% AEP, 2 hour burst, Storm 10	16.293	
1% AEP, 3 hour burst, Storm 1	12.036	
1% AEP, 3 hour burst, Storm 2	15.136	
1% AEP, 3 hour burst, Storm 3	15.686	
1% AEP, 3 hour burst, Storm 4	16.432	
1% AEP, 3 hour burst, Storm 5	10.458	
1% AEP, 3 hour burst, Storm 6	12.517	
1% AEP, 3 hour burst, Storm 7	13.959	Critical Storm for this AEP and Burst Duration
1% AEP, 3 hour burst, Storm 8	12.842	
1% AEP, 3 hour burst, Storm 9	12.272	
1% AEP, 3 hour burst, Storm 10	14.993	
1% AEP, 4.5 hour burst, Storm 1	9.625	
1% AEP, 4.5 hour burst, Storm 2	13.874	
1% AEP, 4.5 hour burst, Storm 3	10.634	
1% AEP, 4.5 hour burst, Storm 4	14.371	
1% AEP, 4.5 hour burst, Storm 5	12.536	
1% AEP, 4.5 hour burst, Storm 6	13.725	
1% AEP, 4.5 hour burst, Storm 7	9.335	
1% AEP, 4.5 hour burst, Storm 8	11.769	
1% AEP, 4.5 hour burst, Storm 9	15.598	
1% AEP, 4.5 hour burst, Storm 10	12.68	Critical Storm for this AEP and Burst Duration
1% AEP, 6 hour burst, Storm 1	11.93	
1% AEP, 6 hour burst, Storm 2	12.871	
1% AEP, 6 hour burst, Storm 3	11.964	
1% AEP, 6 hour burst, Storm 4	8.806	
1% AEP, 6 hour burst, Storm 5	12.231	Critical Storm for this AEP and Burst Duration
1% AEP, 6 hour burst, Storm 6	14.016	
1% AEP, 6 hour burst, Storm 7	11.483	
1% AEP, 6 hour burst, Storm 8	10.13	
1% AEP, 6 hour burst, Storm 9	13.774	
1% AEP, 6 hour burst, Storm 10	14.094	
1% AEP, 9 hour burst, Storm 1	12.294	
1% AEP, 9 hour burst, Storm 2	11.313	
1% AEP, 9 hour burst, Storm 3	7.925	
1% AEP, 9 hour burst, Storm 4	11.983	
1% AEP, 9 hour burst, Storm 5	10.139	Critical Storm for this AEP and Burst Duration
1% AEP, 9 hour burst, Storm 6	7.722	
1% AEP, 9 hour burst, Storm 7	8.517	
1% AEP, 9 hour burst, Storm 8	7.953	
1% AEP, 9 hour burst, Storm 9	13.847	
1% AEP, 9 hour burst, Storm 10	8.78	
1% AEP, 12 hour burst, Storm 1	11.206	Critical Storm for this AEP and Burst Duration

1% AEP, 12 hour burst, Storm 2	10.15	
1% AEP, 12 hour burst, Storm 3	13.404	
1% AEP, 12 hour burst, Storm 4	7.598	
1% AEP, 12 hour burst, Storm 5	14.829	
1% AEP, 12 hour burst, Storm 6	14.643	
1% AEP, 12 hour burst, Storm 7	7.64	
1% AEP, 12 hour burst, Storm 8	10.519	
1% AEP, 12 hour burst, Storm 9	14.251	
1% AEP, 12 hour burst, Storm 10	8.457	
1% AEP, 18 hour burst, Storm 1	8.869	
1% AEP, 18 hour burst, Storm 2	6.898	
1% AEP, 18 hour burst, Storm 3	7.475	Critical Storm for this AEP and Burst Duration
1% AEP, 18 hour burst, Storm 4	5.57	
1% AEP, 18 hour burst, Storm 5	7.65	
1% AEP, 18 hour burst, Storm 6	9.857	
1% AEP, 18 hour burst, Storm 7	7.43	
1% AEP, 18 hour burst, Storm 8	4.683	
1% AEP, 18 hour burst, Storm 9	9.175	
1% AEP, 18 hour burst, Storm 10	5.834	
1% AEP, 24 hour burst, Storm 1	8.632	
1% AEP, 24 hour burst, Storm 2	10.638	
1% AEP, 24 hour burst, Storm 3	6.609	Critical Storm for this AEP and Burst Duration
1% AEP, 24 hour burst, Storm 4	7.402	
1% AEP, 24 hour burst, Storm 5	5.646	
1% AEP, 24 hour burst, Storm 6	6.977	
1% AEP, 24 hour burst, Storm 7	5.994	
1% AEP, 24 hour burst, Storm 8	6.519	
1% AEP, 24 hour burst, Storm 9	6.175	
1% AEP, 24 hour burst, Storm 10	5.332	
1% AEP, 30 hour burst, Storm 1	4.394	
1% AEP, 30 hour burst, Storm 2	8.62	
1% AEP, 30 hour burst, Storm 3	5.555	
1% AEP, 30 hour burst, Storm 4	7.055	
1% AEP, 30 hour burst, Storm 5	4.591	
1% AEP, 30 hour burst, Storm 6	4.509	
1% AEP, 30 hour burst, Storm 7	7.479	
1% AEP, 30 hour burst, Storm 8	5.189	Critical Storm for this AEP and Burst Duration
1% AEP, 30 hour burst, Storm 9	4.809	
1% AEP, 30 hour burst, Storm 10	3.373	
1% AEP, 36 hour burst, Storm 1	4.035	
1% AEP, 36 hour burst, Storm 2	7.073	
1% AEP, 36 hour burst, Storm 3	4.504	
1% AEP, 36 hour burst, Storm 4	6.685	
1% AEP, 36 hour burst, Storm 5	6.736	Critical Storm for this AEP and Burst Duration
1% AEP, 36 hour burst, Storm 6	5.5	
1% AEP, 36 hour burst, Storm 7	3.23	

1% AEP, 36 hour burst, Storm 8	7.543	
1% AEP, 36 hour burst, Storm 9	8.588	
1% AEP, 36 hour burst, Storm 10	6.812	
1% AEP, 48 hour burst, Storm 1	4.11	
1% AEP, 48 hour burst, Storm 2	5.109	Critical Storm for this AEP and Burst Duration
1% AEP, 48 hour burst, Storm 3	3.901	
1% AEP, 48 hour burst, Storm 4	6.45	
1% AEP, 48 hour burst, Storm 5	4.088	
1% AEP, 48 hour burst, Storm 6	6.379	
1% AEP, 48 hour burst, Storm 7	4.865	
1% AEP, 48 hour burst, Storm 8	2.838	
1% AEP, 48 hour burst, Storm 9	6.696	
1% AEP, 48 hour burst, Storm 10	6.674	
1% AEP, 72 hour burst, Storm 1	3.795	
1% AEP, 72 hour burst, Storm 2	2.662	
1% AEP, 72 hour burst, Storm 3	6.008	
1% AEP, 72 hour burst, Storm 4	3.792	
1% AEP, 72 hour burst, Storm 5	3.205	
1% AEP, 72 hour burst, Storm 6	4.74	Critical Storm for this AEP and Burst Duration
1% AEP, 72 hour burst, Storm 7	5.906	
1% AEP, 72 hour burst, Storm 8	4.402	
1% AEP, 72 hour burst, Storm 9	5.176	
1% AEP, 72 hour burst, Storm 10	4.946	

Appendix B

Catchment Manning's Roughness Breakdown

PRE DEVELOPMENT:
EXTERNAL CATCHMENT
MANNINGS ROUGHNESS

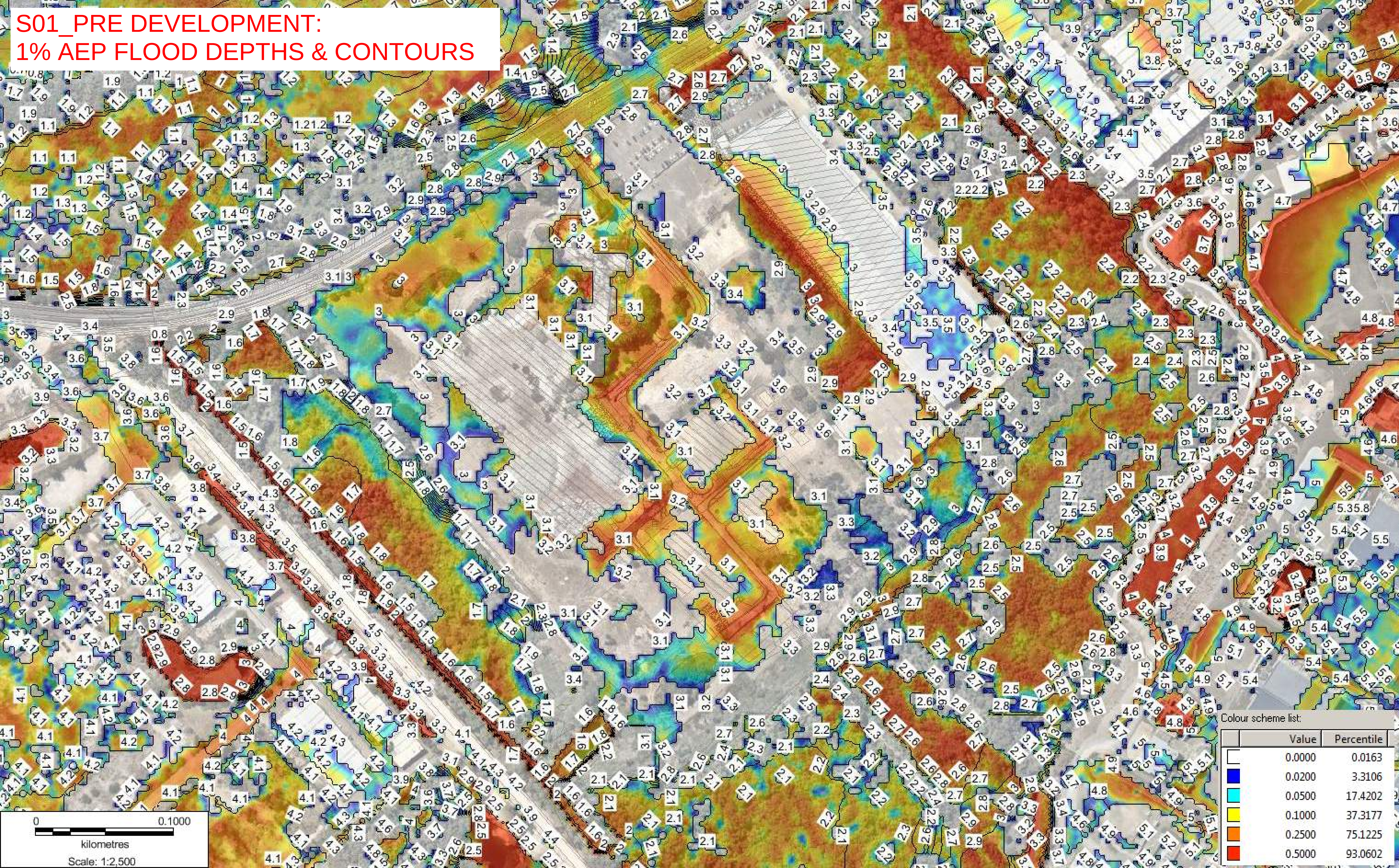
PRE DEVELOPMENT: SITE CATCHMENT MANNINGS ROUGHNESS

POST DEVELOPMENT:
SITE CATCHMENT
MANNINGS ROUGHNESS

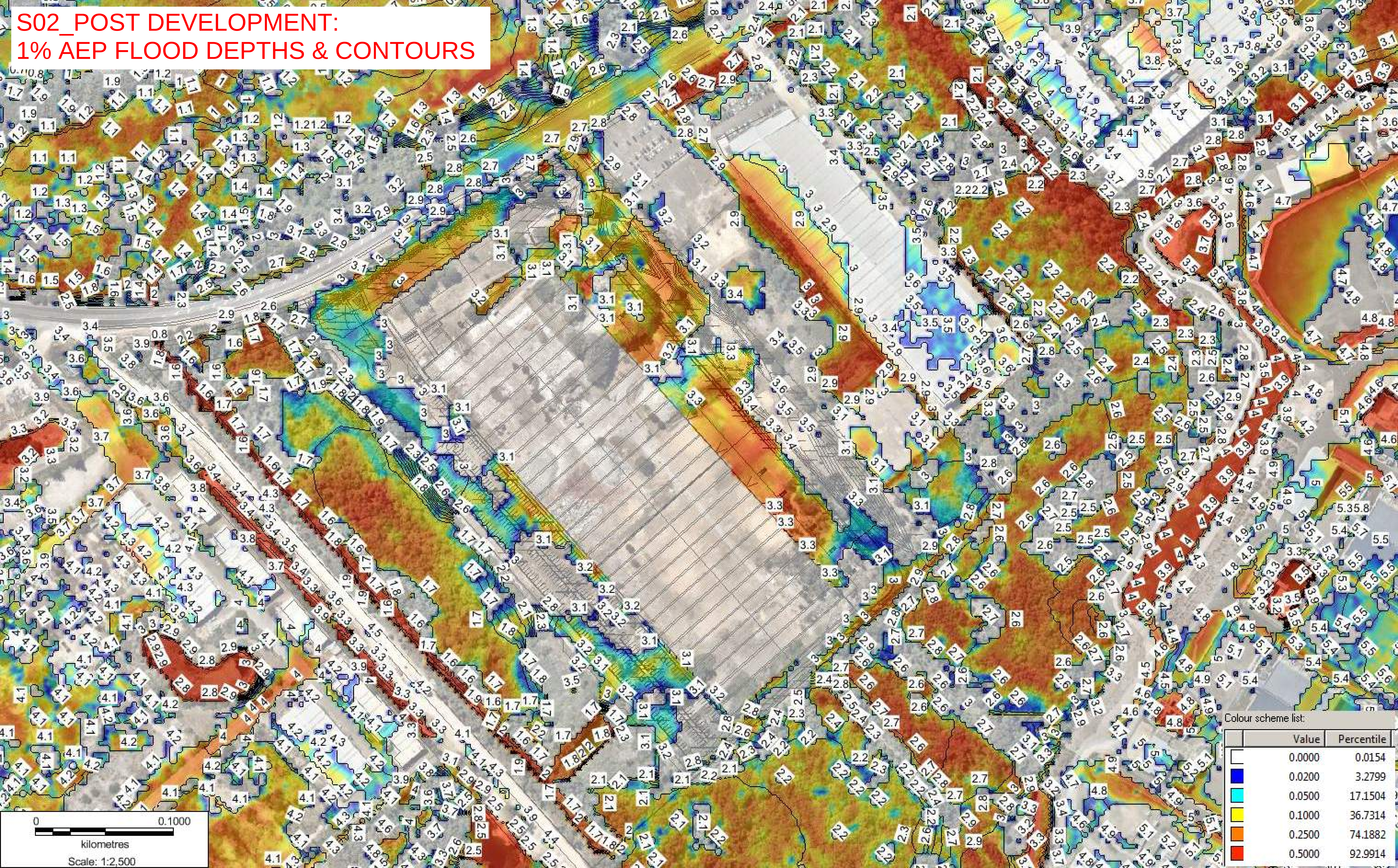
Appendix C

Compiled Flood Mapping Results

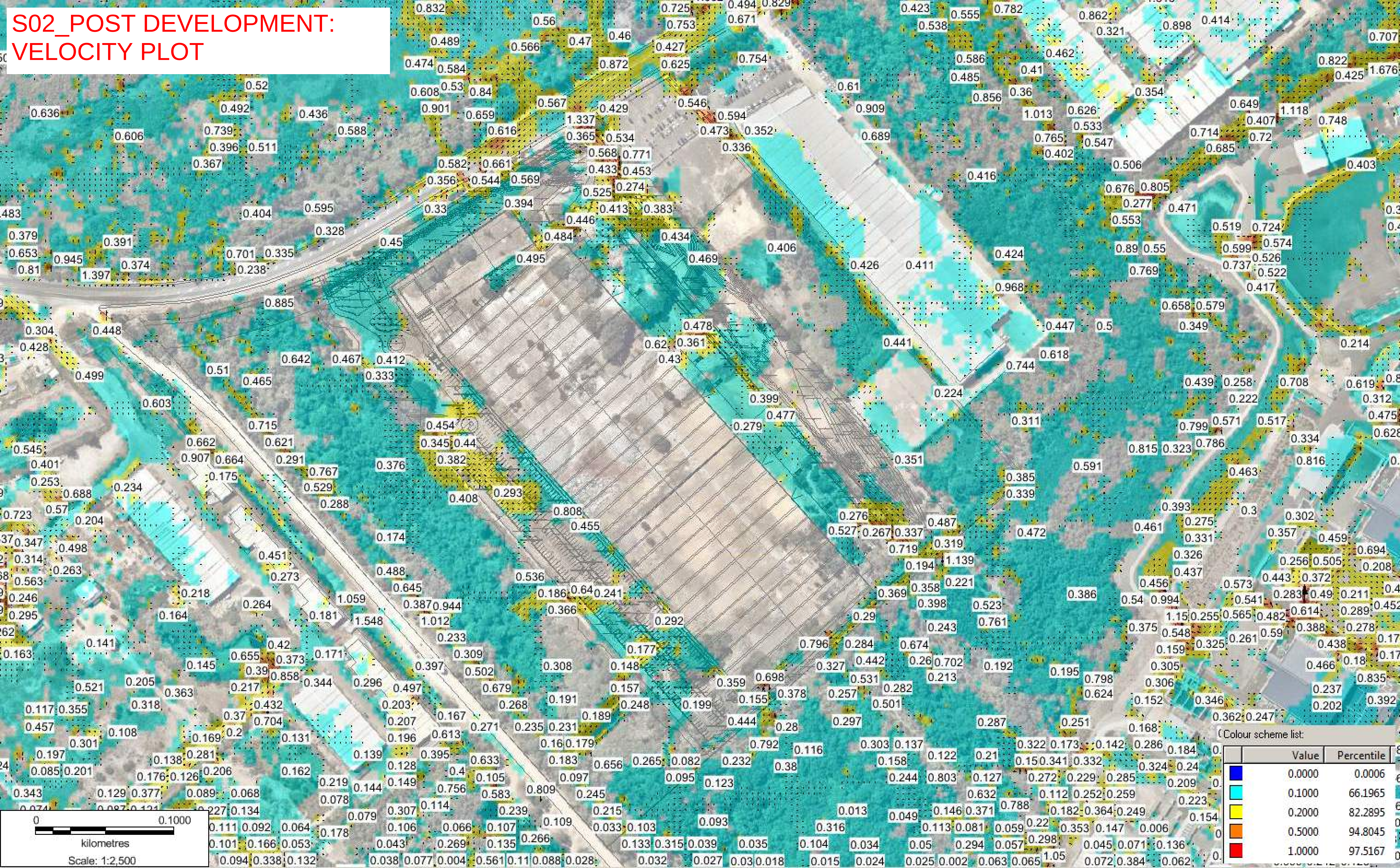
S01_PRE DEVELOPMENT: 1% AEP FLOOD DEPTHS & CONTOURS

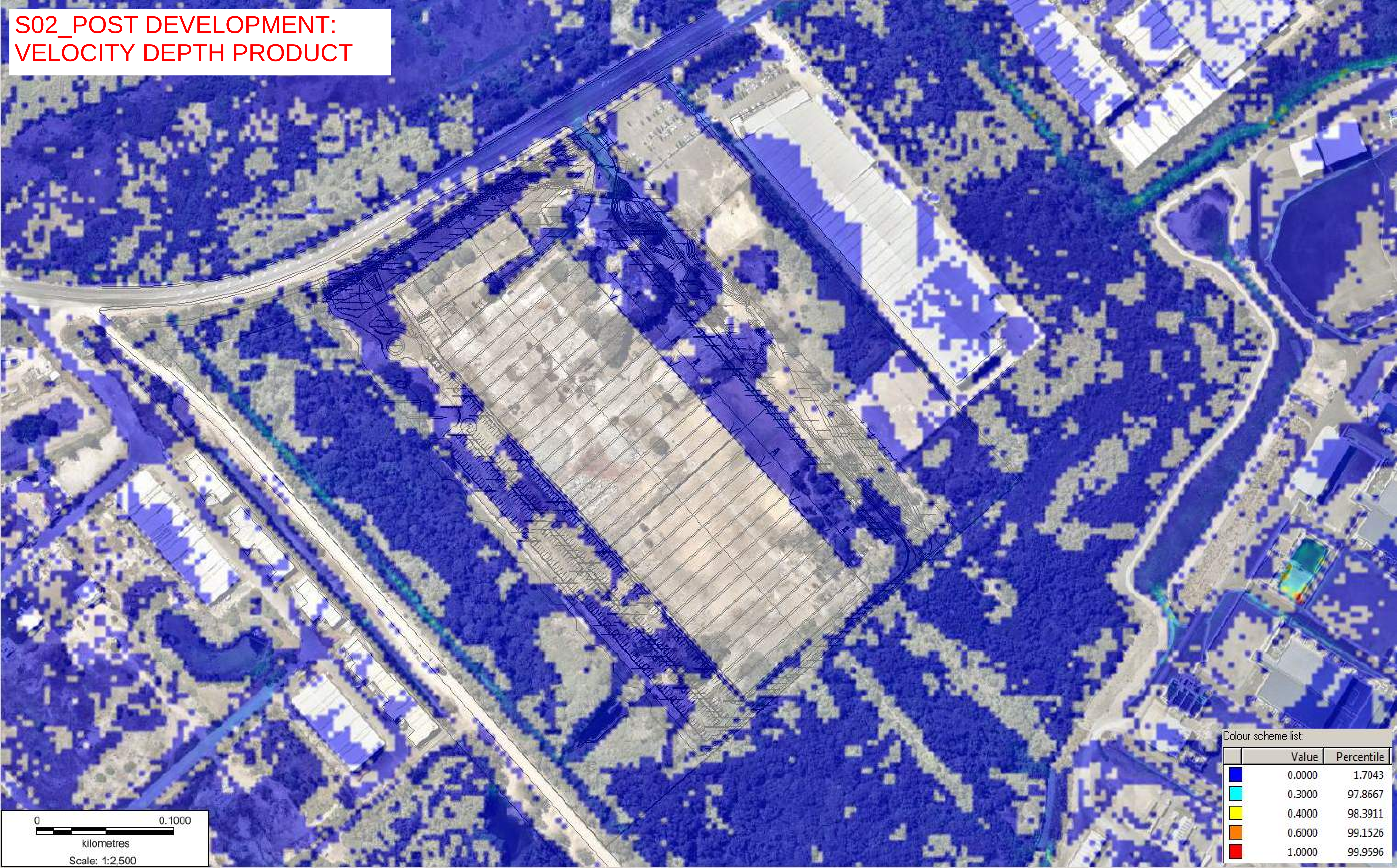


S02_POST DEVELOPMENT:
1% AEP FLOOD DEPTHS & CONTOURS

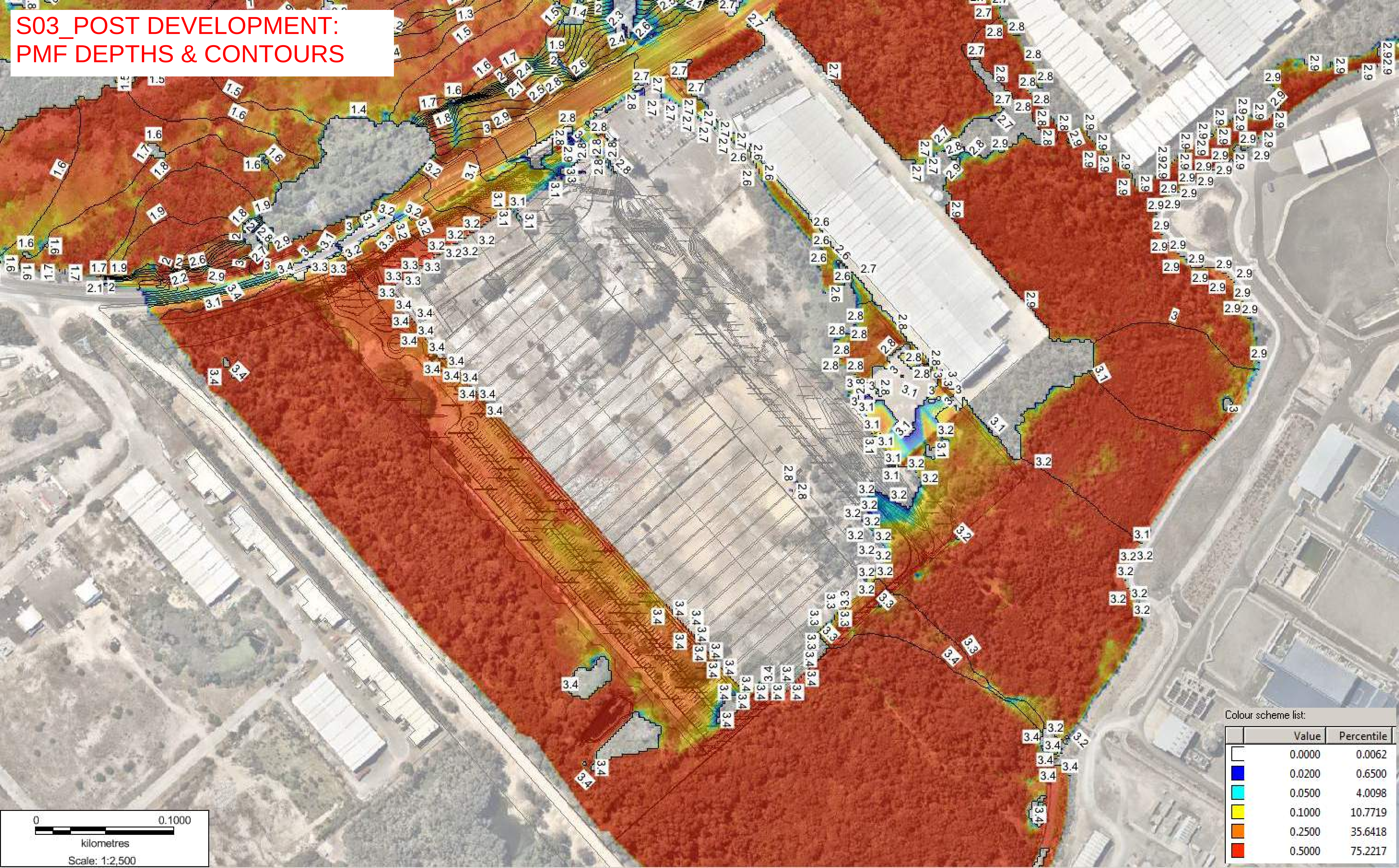


S02_POST DEVELOPMENT: VELOCITY PLOT

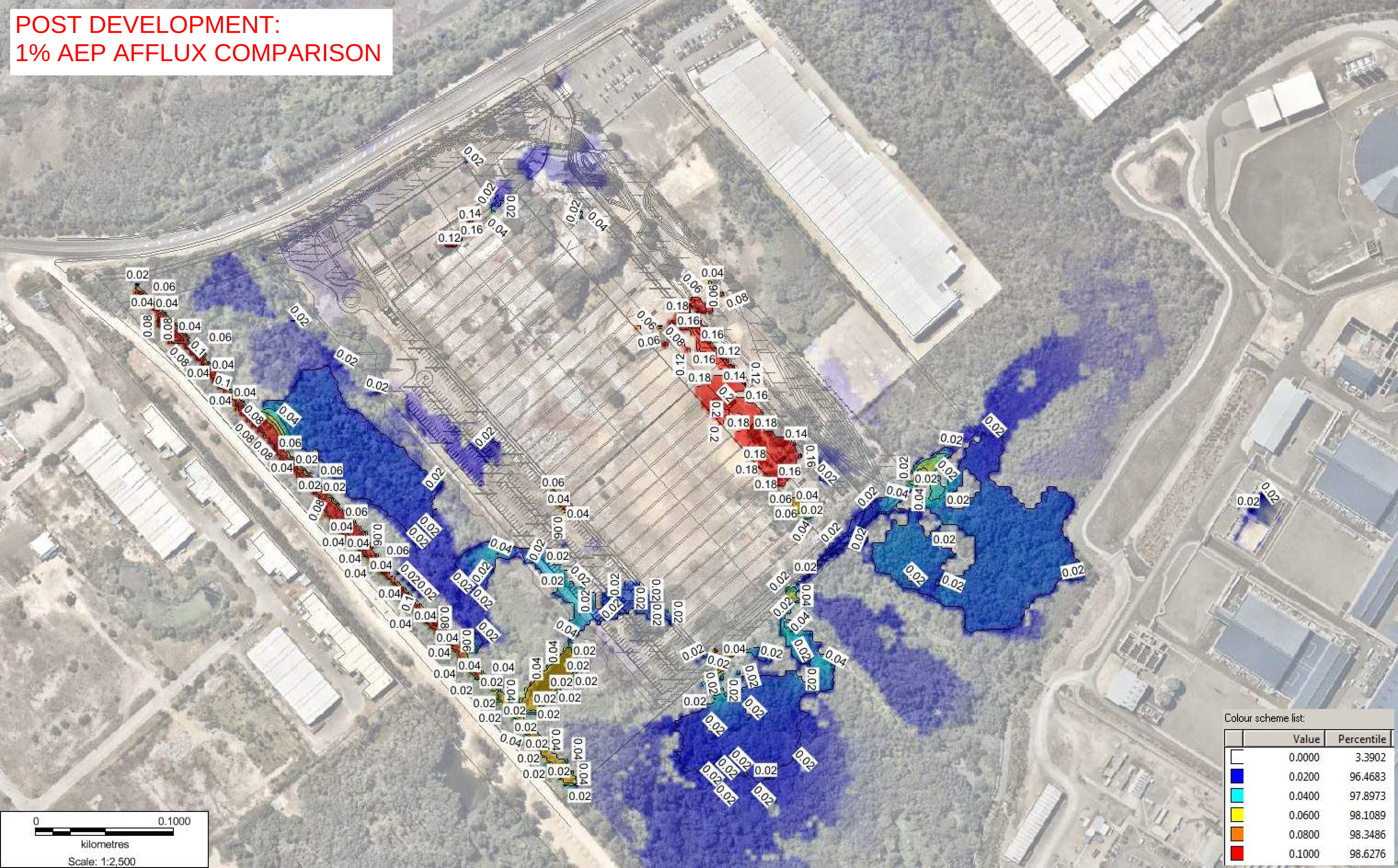



S02_POST DEVELOPMENT:
VELOCITY DEPTH PRODUCT
Colour scheme list:
Value Percentile
0.0000 1.7043
0.3000 97.8667
0.4000 98.3911
0.6000 99.1526
1.0000 99.9596
0 0.1000
kilometres
Scale: 1:2,500

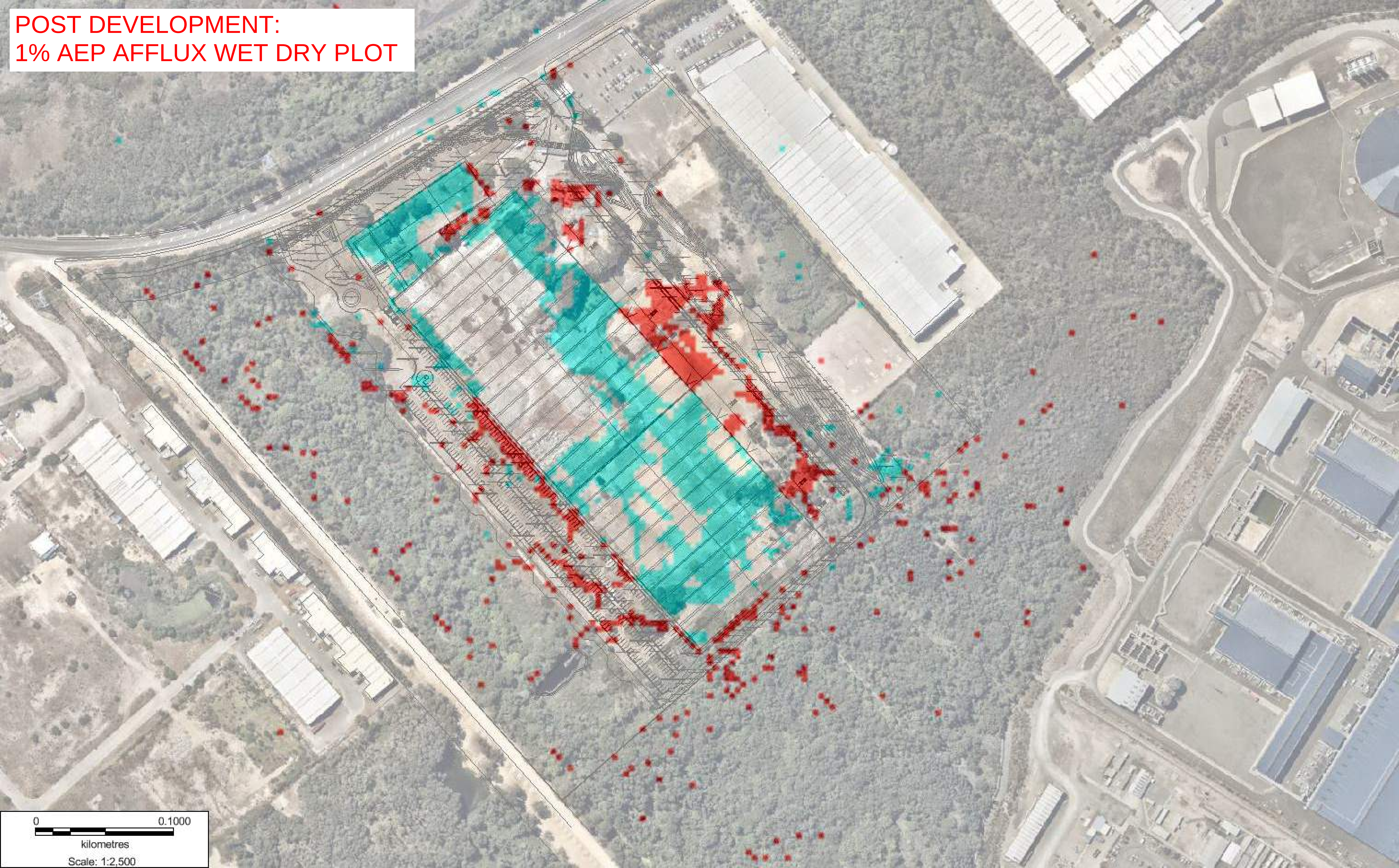
S02_POST DEVELOPMENT: NSW FLOODPLAIN MANUAL


S03_POST DEVELOPMENT:
PMF DEPTHS & CONTOURS
Colour scheme list:
Value Percentile
0.0000 0.0062
0.0200 0.6500
0.0500 4.0098
0.1000 10.7719
0.2500 35.6418
0.5000 75.2217
0 0.1000
kilometres
Scale: 1:2,500

POST DEVELOPMENT: 1% AEP AFFLUX COMPARISON



POST DEVELOPMENT:
1% AEP AFFLUX WET DRY PLOT



S04_001_POST DEVELOPMENT: 1% AEP + SLR FLOOD DEPTHS & CONTOURS

S04_002_POST DEVELOPMENT: PMF + SLR FLOOD DEPTHS & CONTOURS