Costin Roe Consulting

PRECISION | COMMUNICATION | ACCOUNTABILITY

OVERLAND FLOW REPORT
STAGE 1

PROPOSED DEVELOPMENT:
MAMRE WEST PRECINCT
ORCHARD HILLS NSW

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1. INTRODUCTION

Costin Roe Consulting Pty Ltd has been commissioned by Altis Property Partners to undertake an overland flow assessment to accompany a planning application submission to amend the State Environmental Planning Policy (Western Sydney Employment Area) 2009 and rezone land IN1 General Industrial. Altis Property Partners are the Developer of 585-649 Mamre Road, Orchard Hills (Lot 2171 DP 1153854), a 48.35 hectare parcel of land ("Site") within what is known as the Mamre West Precinct ("Study Area").

The Study Area has been identified by Penrith City Council in their *Updated South Creek Flood Study (rp6033rg_crt150128-Updated South Creek Flood Study (FINAL – Volume 1)),* as being affected by overland flow associated with the adjacent South Creek. This report will be referred to as the South Creek Study from hereon.

Consultation with Penrith City Council has been undertaken to confirm the flood planning requirements for the rezoning. Meetings were held with the respective stakeholders, including the developer, Costin Roe (Civil Engineers), Hansen Yuncken (Project Manager), Department of Planning & Environment, council engineers and council planners, on 24 November 2014, 4 August 2015 and 24 August 2015, at Penrith City Council. During these meetings the scope of the development and the requirements for the required overland flow assessment, as it relates to the proposed rezoning, were discussed.

The scope and primary objectives of the overland flow assessment, as agreed with Council, are as follows:

- Determine the 1% Annual Exceedance Probability (AEP) Flood design flow generated by the contributing external catchment. Hydrology would be based on the flows completed in the South Creek Flood Study;
- Assess the pre-development overland flow path through the development site for a range of storms including the 1% AEP event;
- Assess the post-development overland flow path through the development site for the 100-year ARI event so that potential impacts on the development can be assessed and mitigated; and
- Confirm the flood planning level for the development and the hazard category in accordance with the adopted policy of the consent authority; and
- Confirmation of the Probable Maximum Flood (PMF) storm event (post construction) and discussion on flood evacuation from the development during a PMF event.

The modelling was to be undertaken in two stages, broadly speaking, as follows:

Stage 1 – Model Build and Validation

- Build of a 2D hydrodynamic flood model of South Creek in the vicinity of the proposed development area for the existing scenario;
- Modelling will be performed using the TUFLOW modelling engine with the main creek channel and overbank areas being modelled in 2D;
- Modelling of 5%, 2%, 1%, 0.5% AEP storms for the existing site with validation being completed against the modelling produced in the Council Flood Study;
- The Digital Terrain Model (DTM) used in the modelling will be based on a combination of detailed ground survey completed during later 2014, mid-2015 and LIDAR information;
- Reporting of Stage 1 modelling to be provided to Penrith City Council for a peer review to be undertaken by Worley Parsons, who compiled the South Creek Flood Study; and
- Reporting and modelling to be utilised in the Stage 2 Scenario Testing described below following peer review of the Stage 1 model results.

Stage 2 – Scenario Testing

- Scenario testing of pre and post construction configurations utilising the model build as defined in the Stage 1 report;
- Scenario testing will be undertaken for the range of AEP events defined in Stage 1 Report;
- Scenario testing is to include differences in flood levels, velocity and general hydraulics; and
- The scenario testing will be undertaken for the development of the The Site (48.5 Ha).

This report has been produced to present the Stage 1 component of the modelling. The report provides a summary of the modelling methodology, model parameters and model results for the existing conditions. The Stage 1 model is compiled to enable scenario testing to confirm the effect of development on the land within the study area. The Stage 1 TUFLOW model has not been produced to replicate the South Creek RMA model but has been completed and validated to be suitable for use in scenario testing of the effect of development on flooding.

The development site has been considered in the context of the Study Area (Mamre West Precinct) being proposed for rezoning in the State Environmental Planning Policy (Western Sydney Employment Area) 2009 and forming part of Precinct 11 "Broader Western Sydney Employment Area".

The information provided in this Report is intended to inform the relevant stakeholders including the landowner, surrounding property owners, council officers, planners and the property developer of the opportunities and constraints associated with the development in relation to overland flow and flooding within South Creek. The report will form part of a Precinct Planning Package to be exhibited and considered by the Department of Planning & Environment to inform them on the rezoning of the Study Area.

The Department of Planning and Environment are the consent authority for the rezoning in the State Environmental Planning Policy (Western Sydney Employment Area) 2009 and Penrith City Council are a key authority to be consulted; as such the guidelines for flood liable lands, as stipulated in Section C3.5 of Penrith City Council *Development Control Plan 2014,* apply. The planning application will be made through the NSW Department of Planning and Environment with Penrith City Council as a major stakeholder.

The current revision **(Revision B)** of this report contains updated modelling output to address the comments and suggestions contained in the peer review undertaken by Worley Parsons based on Revision A of this report (dated 22 September 2015). The peer review is included in a report by Worley Parsons, *Overland Flow Report Stage 1, Mamre West Precinct, Orchard Hills, NSW, Peer Review,* dated 27 October 2015. Reference to **Section 8** of this report should be made for clarification of how the Peer Review recommendations have been addressed.

2. DEVELOPMENT SITE

2.1. Site Description and Study Area

Mamre West Precinct (Study Area) is approximately 193ha with the subject site (Lot 2171, 585-649 Mamre Road) approximately 48ha, located on the western side of Mamre Road in the suburb of Orchard Hills as shown in **Figure 2.1**.

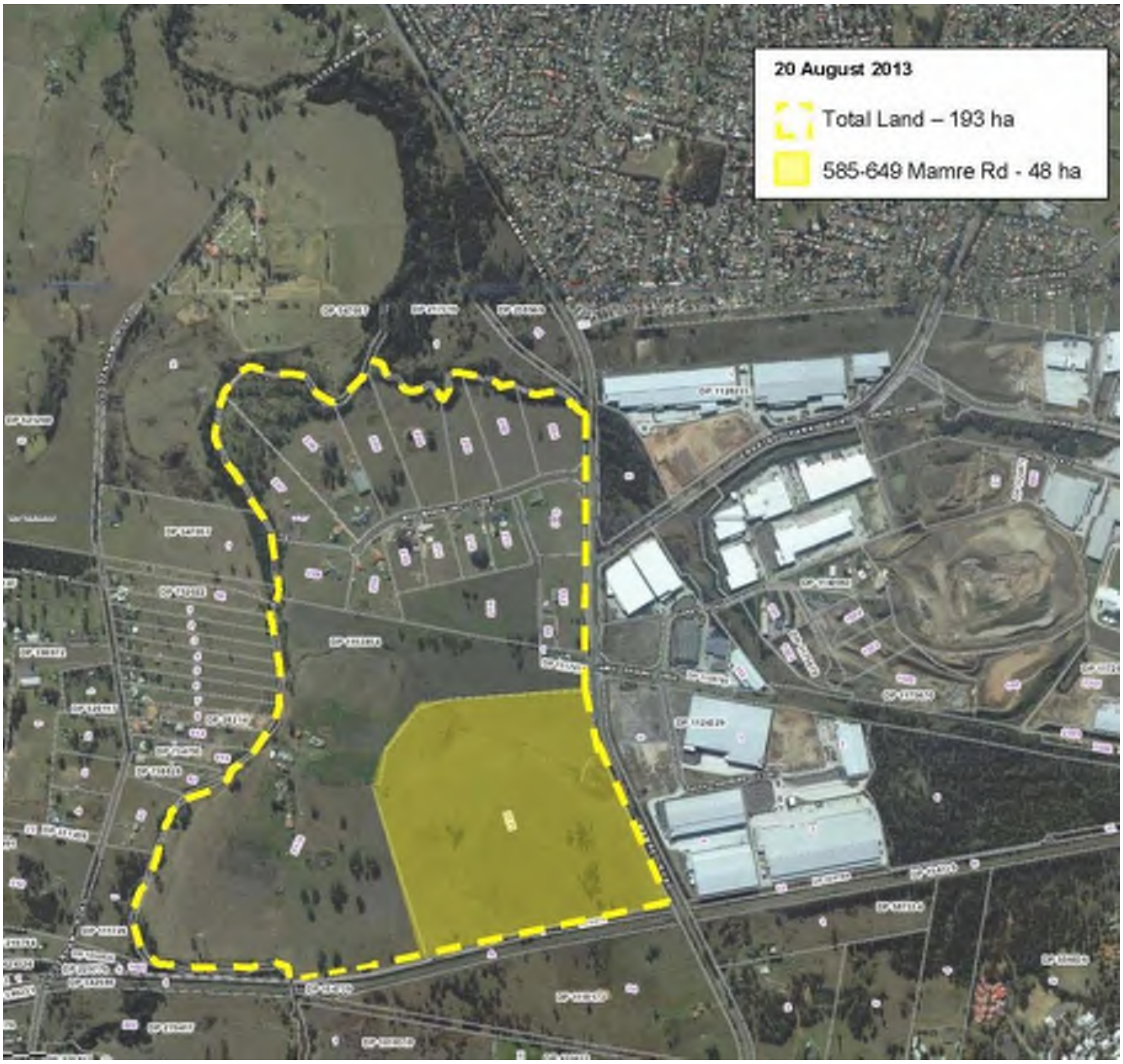


Figure 2.1 Locality Plan of 'The Site' and Study Area

Lot 2171 (hereby referred to as 'Site') is approximately 48Ha in area and generally rectangular in shape. The study area also comprises the properties which surround Mandalong Close on the northern side of the Site as represented by the dashed yellow perimeter in **Figure 2.1**.

The Site is bounded by rural residential development to the north, Mamre Road on the east, rural land to the south and rural land to the west. South Creek is located some 300m to the west of the development site boundary and a large diameter pipeline owned by Sydney Water is present on the southern boundary of the development site.

The land on the Eastern side of Mamre Road comprises industrial development known as the Erskine Park Employment Area.

Access to the site can be made via Mamre Road.

The land use on the site is currently rural residential. No formal drainage systems or development is present on the land. Review of the survey information shows that the land falls from the south and south-east to the west and north-west of the site. The grades over the site are low and in the order of 0.25% (1 in 400) to 0.5% (1 in 200). The highest level on the site, at RL 39.0m AHD, is located at the south-east corner of the site and the lowest level is RL 31.5m AHD at the north-west corner. The low point coincides with a natural low point or gully in the land which currently acts as overland flow path.

2.2. Proposed Development

The proposed development on the Site is for a subdivision of the land, infrastructure works and bulk earthworks and the construction of warehouse and logistics facilities to the Stage 1 Development.

The layout of the development will be confirmed as design progresses. The indicative master-planning for the site incorporates an access road which bisects the site and provides access to development lots within the site. Large development lots will flank either side of the access road. Development lots will vary in size, typically in the order of 2.5 Ha to 8 Ha. The final layout will be subject to market demands, access location from Mamre Road and the preferred architectural layout. Development lots will be sympathetic to the topography of the land and allowing for the minimum 500mm freeboard to the 1% AEP flood level of South Creek.

Access to all lots would be made via the new access road which intersects with Mamre Road. The new access road and associated intersection will be constructed to Penrith City Council requirements and ownership transferred to Penrith City Council.

3. STUDY METHODOLOGY & PLANNING OBJECTIVES

3.1. Study Methodology

The objectives of the Flood Study are to:

- Identify relevant flood-related data by searching all relevant data sources;
- Determine the likely extent and nature of flooding and identify potential hydraulic controls by carrying detailed site visits of the study area;
- Define existing catchment condition flood behaviours for mainstream flooding in the catchment with due consideration to upstream and downstream controls on the South Creek channel;
- Define design flood levels, velocities and flow distributions for the catchment.
- Define the extent of flooding for the 1% and 5% AEP floods and PMF for the catchment;
- Define differences in flood regime as it relates to the proposed development and upstream and downstream properties;
- Define Flood Planning Levels for the flood-affected areas; and
- Confirm flood planning requires for the development.

A numerical modelling tool was developed:

- A hydraulic model to convert runoff hydrographs into water levels and velocities throughout the study area. The model simulates the hydraulic behaviour of the water within the study area by accounting for flow in the major channels as well as the potential for overland flow paths, which develop when the capacity of the channel is exceeded. It relies on boundary conditions which include the runoff hydrographs and appropriate downstream boundary level.

Section 4 of the report discusses the content and source of relevant data which has been utilised in the study. This section describes relevant flood studies and available historical information and also provides details of the survey used to establish the DTM used in the analysis.

Section 5 discusses the catchment characteristics the hydrological information used in the study.

Section 6 discusses the development of the hydraulic model including establishment of the DTM, boundary conditions, validation, sensitivity analysis and subsequent use for design rainfall events and development scenarios.

Section 7 provides the results of the design flood estimation for the catchment. Section 9 summarises the results of the assessment and provides discussion on the various aspects of the results while Section 9 provides concluding remarks to the overall study.

A number of figures are included to illustrate the study results.

3.2. Floodplain Management Considerations

1.1.1 Flood Planning Level

The introduction of a Flood Planning Level (FPL) is an important flood risk management measure. FPLs are derived from a combination of a designated flood event, which can either be a historic flood or a design flood of a certain recurrence interval, plus a nominated freeboard depth.

The Floodplain Development Manual, 2005 recommends that the FPL generally be based on the 100-year ARI event. It suggests that, whilst this event can be varied, it should only be done in exceptional circumstances. It is considered appropriate to adopt the 100-year ARI event for the proposed development.

The freeboard component of an FPL is the difference between the flood level that the level is based upon and the FPL itself. Freeboard is designed to provide reasonable certainty that the reduced risk exposure provided by the chosen FPL is warranted, taking into account factors such as:

- Uncertainties in the estimate of flood levels;
- Differences in water levels across the floodplain;
- Wave action resulting from wind and vehicular/marine traffic during the flood event;
- Changes in rainfall patterns due to climate change;
- The cumulative effect of subsequent infill development on existing zoned land.

The Floodplain Development Manual recommends a freeboard of 0.5m for most new industrial developments and it is considered appropriate that this recommended freeboard be for adopted for the proposed development.

1.1.2 Hydraulic and Hazard Categorisation

Floodwaters can vary significantly, both in time and place across the floodplain. They can flow fast and deep at some locations and slow and shallow at other locations. This can result in large variations to the personal danger and physical property damage resulting from the flood.

The Floodplain Development Manual recognises three hydraulic categories of flood prone land, these being floodway, flood storage and flood fringe. These are then further separated into two hazard categories, high hazard and low hazard.

Floodways

Floodways are those areas where a significant volume of water flows during floods and are often aligned with natural channels. They are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, which could adversely affect other areas. They can also be areas with deeper and higher velocity flow.

Flood Storage

Flood storage areas are the parts of the floodplain that provide temporary storage for floodwaters during the passage of a flood. If a reduction in the flood storage area is experienced due to the filling of land or construction of a levee bank, it can result in adverse effects on the flood levels and peak flow rates in other areas.

Flood Fringe

Flood fringe areas are the remaining area of land affected by flooding. The development of flood fringe land does not generally have any major impact on the pattern of flood flows and/or levels.

The preparation of a flood study is almost always required in the determination of hydraulic categories. This is so that peak depths, velocities and the extent of flooding can be determined across the catchment.

Hazard Categories

Flood hazard categories are broken down into high and low hazard for each hydraulic category. High hazard areas are defined as those where there is a possible danger to personal safety and the potential for significant structural damage. Able-bodied adults would have difficulty in wading to safety. With low hazard areas, should it be necessary, a truck could evacuate people and their possessions, and able-bodied adults would have little difficulty in wading to safety.

1.1.3 Flood Damages

Damage caused by floods is generally categorised as either tangible or intangible. Tangible damages are financial in nature and can be readily measured in monetary terms. They include direct damages such as damage or loss caused by floodwaters wetting goods and property, and indirect damages such as lost wages incurred during cleanup periods after the flood event. Intangible damage includes emotional stress and even mental and physical illness caused by the flood. It is difficult, if not impossible to quantify intangible damages in financial terms.

From a flood planning perspective, it is important to consider the following direct damage categories:

- Contents Damage – refers to damage to the contents of buildings, including carpets and furniture etc.;
- Structural Damage – refers to damage to the structural fabric of buildings, such as foundations, walls floors, windows, and built-in fittings; and
- External Damage – includes damage to all items external to buildings, including cars, landscaping etc.

As there is no way to prevent a flood from occurring, and it is unrealistic to exclude all development within flood-prone areas, the intent of establishing a FPL is to minimise the risk of direct damage when a flood occurs. By minimising the direct damage, there is a carry-on effect, whereby other associated indirect tangible damages and intangible damages are also minimised.

1.1.4 Emergency Response Planning

Flood planning refers to the preparation of a formal community-based plan of action to deal with the threat, onset and aftermath of flooding. It involves planning for an event equal to, or greater than the event used to derive the FPL.

The plan of action should include an on-site response plan that addresses what measures should be undertaken once the threat of a flood is determined to be imminent. A flood evacuation strategy should also be included so that all residents are familiar with what to do if a flood occurs.

4. REVIEW OF AVAILABLE DATA

Data has been obtained from a number of sources and includes information required for input to the numerical models, together with information required for validation of model results and the adequate representation and presentation of those results.

4.1. Survey

Survey is required to define the physical attributes of the floodplain topography including the creek cross sections and the associated floodplain levels.

The survey has been compiled based on a 5m LiDAR grid, combined with on-ground survey completed during November 2014 and July 2015. The on-ground survey information was completed in and around the creek to properly define the south creek cross section and features. This included definition of top and base of the creek bank and locally around overbanks areas.

This survey was used as the basis for the digital terrain model (DTM) used in the hydraulic modelling of the creek.

4.2. South Creek Flood Study

The *Updated South Creek Flood Study, Worley Parsons, 30 January 2015*, was obtained from Council for use in the study. Council has also made available a digital version of the model results including GIS output of the DTM used in their modelling, flood surface results, flood depth results, hydrology and model build information. This report is referenced from hereon as *The South Creek Study*.

The South Creek Study is a regional study commissioned by Penrith Council in-conjunction with Blacktown and Fairfield Councils. The study includes South Creek and associated tributaries, defining flood planning levels and hydraulic hazard zones along the creek and creek floodplain areas.

The South Creek Study includes hydrology and modelling of the 5% AEP event to the 0.5% AEP event and also the PMF event. The study shows the subject site approximately midway along the South Creek tributary and is affected by flooding during the 1% AEP event and also the 5% AEP event. The overbank flooding from South Creek extends partially within the property, comprising low hazard zones and a small area of high hazard.

The flood depths and flood surface levels predicted in the South Creek Study are nominated (Section 5.7: *Estimated RMA-2 Model Accuracy*) as being accurate to +/-200mm.

The South Creek has been used in the validation process for the TUFLOW modelling completed by Costin Roe Consulting. This validation process is discussed in more detail in following sections.

4.3. One-Dimensional Hec-Ras Modelling

A conservative 1-dimensional HEC_RAS hydraulic model was developed by Costin Roe Consulting in November 2014. This modelling was completed with the purpose of performing a suitable level of analysis to enable an understanding of the effect of the development on the existing flood scenario. This was used to assist in the master-planning of the development and for use in initial discussions with Penrith City Council held in November 2014.

The HEC-RAS model was produced with the following parameters:

- Q100 ARI flow of $1020m^3$;
- Detail survey information produced by Boxall Surveyors, completed during November 2014, based on traditional and aerial laser drone survey techniques;
- Manning's roughness (n) of 0.06 for the main channel and 0.04 for overbank areas;
- Cross sections at 50m centres;
- Upstream and downstream control based on normal conditions and a longitudinal slope of 0.005; and
- The developed scenario has been simulated by placing blockage through the developed portion of the site. No development has been modelled within the high hazard/ floodway zone as defined in the Council Flood Study.

The results of the HEC-RAS modelling for the Q100 ARI storm for pre and post development scenario are as follows:

- Water surface levels and flood extent for the pre-developed scenario generally agree with the 2D modelling completed in the Council Flood Report. Some differences in water surface level are noted however this is considered to be within the limitations of the modelling methods utilised;
- Change in water surface level between the pre and post development scenario is 50mm maximum and generally less than 30-40mm;
- Change in water surface level is confined to the bounds of the development site along South Creek; and
- Flood immunity to surrounding properties is not significantly affected.

Full details of the HEC-RAS modelling have been provided in Enclosure 5.

The HEC-RAS modelling was presented to Penrith City Council officers during a meeting on 19 November 2014. Mr Leo Chow, Councils catchment engineer, agreed that the results of the preliminary modelling would be acceptable in terms of filling of the flood storage and flood fringe areas and meeting the requirements of council policy. Council also confirmed that development within high hazard flood zones would not be acceptable and that the proposed layout which excludes this zone from development meets this requirement.

At this meeting it was confirmed that Council would require a 2D hydraulic analysis (TUFLOW or similar) to be undertaken as part of project development application documentation.

The proposed earthworks levels are to be set allowing for a minimum freeboard of 500mm to the Q100 ARI flood.

5. CATCHMENT INVESTIGATION & HYDROLOGY

5.1. Contributing Catchment Definition

The property is located approximately midway along the South Creek immediately downstream of the confluence of South Creek with Cosgrove Creek.

The contributing upstream catchment associated with South Creek is approximately 22,000 Ha (220km^2) with a mainstream length of 25 kM. The catchment generally comprises rural land which is interspersed with residential and industrial areas.

The smaller catchment associated with Cosgrove Creek is approximately 10% of the size of the larger South Creek catchment. The Cosgrove Creek catchment has an area of 2,150 Ha and a mainstream length of 9 kM. This catchment is also primarily rural residential land comprising large tracts of pervious areas.

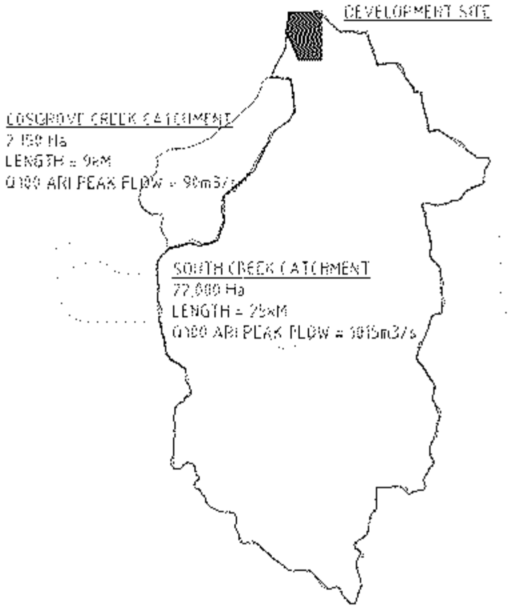


Figure 5.1. Contributing Catchments (Source: South Creek Study)

5.2. Hydrological Assessment of Existing Catchment

It was necessary to first assess the peak stormwater flow and flow hydrograph generated within the catchment, prior to estimating the levels required to traverse the subject site.

The hydrology for the TUFLOW modelling was based on the contributing catchments and peak flows described in the South Creek Study. Table H1 defines the 1% AEP flow of 1020m^3/s immediately downstream of the Sydney Water Supply Pipelines, a location which coincides with the southern extent of the study area. Table H1 also defines the 1% AEP peak flow upstream of the pipeline, at 1020m^3/s. Table H7 defines the Cosgrove Creek 1% AEP peak flow at 90m^3/s.

In order to undertake the TUFLOW modelling, the flood hydrograph for the different flood events were required to be confirmed. Utilising the peak flow defined in The South Creek Study, a basic two node rafts model was setup to establish the hydrographs for use in the TUFLOW model, these were further refined using the recommendations and peak flow values contained in the Worley Parsons Peer Review . Rainfall intensities and temporal patterns were derived from the Bureau of Meteorology online IFD tool and Australian Rainfall and Runoff (1987).

The assessment resulted in the following flood hydrograph's of the 1% AEP and 5% AEP, **Figures 5.2** and **Figures 5.3**, for Cosgrave Creek and South Creek being defined and used in the TUFLOW modelling. The combined peak flows are consistent with those contained in the Worley Parsons Peer Review. Hydrographs relating to the 5% AEP, 0.5% AEP and PMF storms are included in **Appendix C**.

Flow boundary locations were limited to the South Creek and Cosgrove Creeks channel. This is consistent with the South Creek Study which does not include any other flow entry points within the study area. We note that there are two flow entry points within the study extent from industrial areas to the east of Mamre Road which were not included to maintain consistency with the South Creek Study. The flows from these comparatively small catchments is a minor component of the overall hydrology of South Creek and inclusion is not expected to affect the flood results to any discernible degree.

We confirm the peak flow of 1020m^3/s for the 1% AEP and 735m^3/s for the 5% AEP storm matches that contained in Table 2 of the Worley Parson Peer Review Report. This peak flow occurs at 22 hours for both storms.

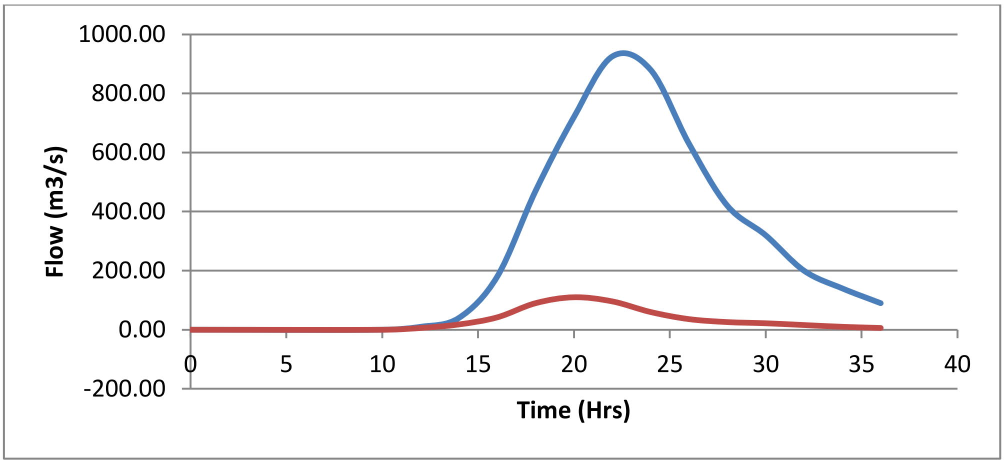


Figure 5.2 South Creek and Cosgrove Creek 1% AEP Hydrographs

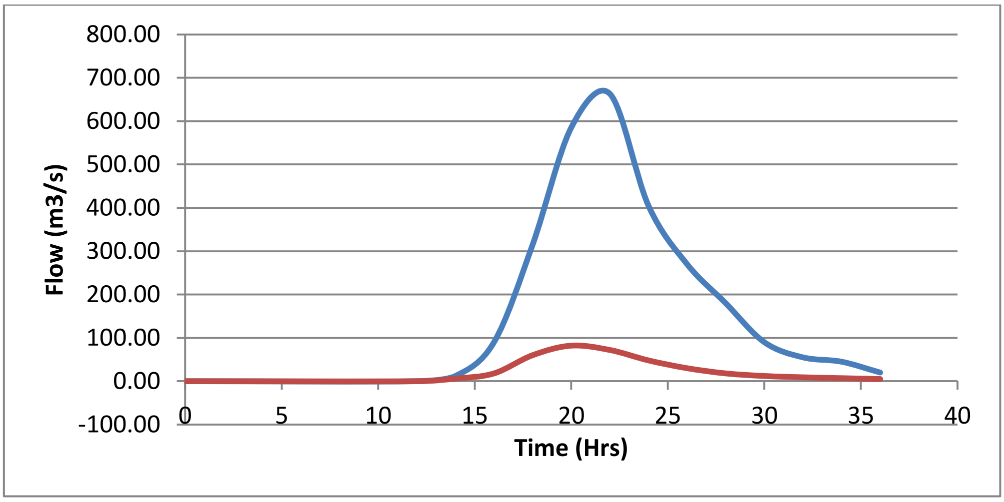


Figure 5.3 South Creek and Cosgrove Creek 5% AEP Hydrographs

6. HYDRODYNAMIC MODEL DEVELOPMENT

6.1. Extent and Topography

Hydraulic modelling for this study was undertaken using the TUFLOW engine via the XPStorm-2D Software Platform. The modelled system is based on a 2D approach for the existing cases. The DTM was developed based on LiDAR data and ground survey as discussed in Section 4 of this report.

The water levels and flows are resolved on a rectangular grid covering the area of interest. The TUFLOW model was set up with a 7m grid cell size, which is an appropriately small cell size to define overland flow behaviour, and more importantly, the difference in the behaviour between two modelled scenarios, through the area of interest.

The model extent is shown in **Figure 6.1**. Modelling has been completed along South Creek, beginning approximately 100m upstream of the Sydney Water Supply pipes and extending approximately 1100m to the north of the Mandalong Close Rural Residential Area.

The model extent has been chosen to encompass the study area, including the 48 Ha Industrial Site and extended development area through the existing rural residential area around Mandalong Close.

6.2. Boundary Conditions

Inflow Boundaries

Design inflow hydrographs of upstream boundaries of Cosgrove Creek and South Creek have been included in the locations noted in **Figure 6.1**. These are located approximately 400m upstream of the property boundary and inflows were based on hydrology as discussed in **Section 5** of this report.

A sensitivity analysis was performed to ensure that the upstream boundary was located sufficiently upstream of the property to ensure the extent of predicted impacts from the development would be covered. This was undertaken during both Stage 1 modelling (presented in this report) and Stage 2 modelling (presented in future report).

Modelling was performed with inflow hydrographs positioned at 350m and 300m from the property boundary to confirm the modelled boundary condition (400m from property) is appropriate. The sensitivity analysis found that a negligible difference is seen when at 350m and more substantial difference at 300m. The sensitivity analysis shows that the proposed location of the upstream boundary is located at a distance sufficiently upstream for Stage 2 Scenario Testing to be undertaken.

Downstream Water Level Boundaries

The model extent has been continued for a distance of approximately 1100m downstream of the study area to a point downstream of Luddenham Road crosses South Creek. The downstream water level boundary has been modelled using the boundary control levels recommend in the Worley Parsons Peer Review. The modelled downstream boundary levels are provided in the **Table 6.1**.

AEP (%)	Downstream Boundary Level (m)
5	29.2
1	29.75
0.5	30.0
PMF	31.8

Table 6.1. Downstream Boundary Water Surface Levels

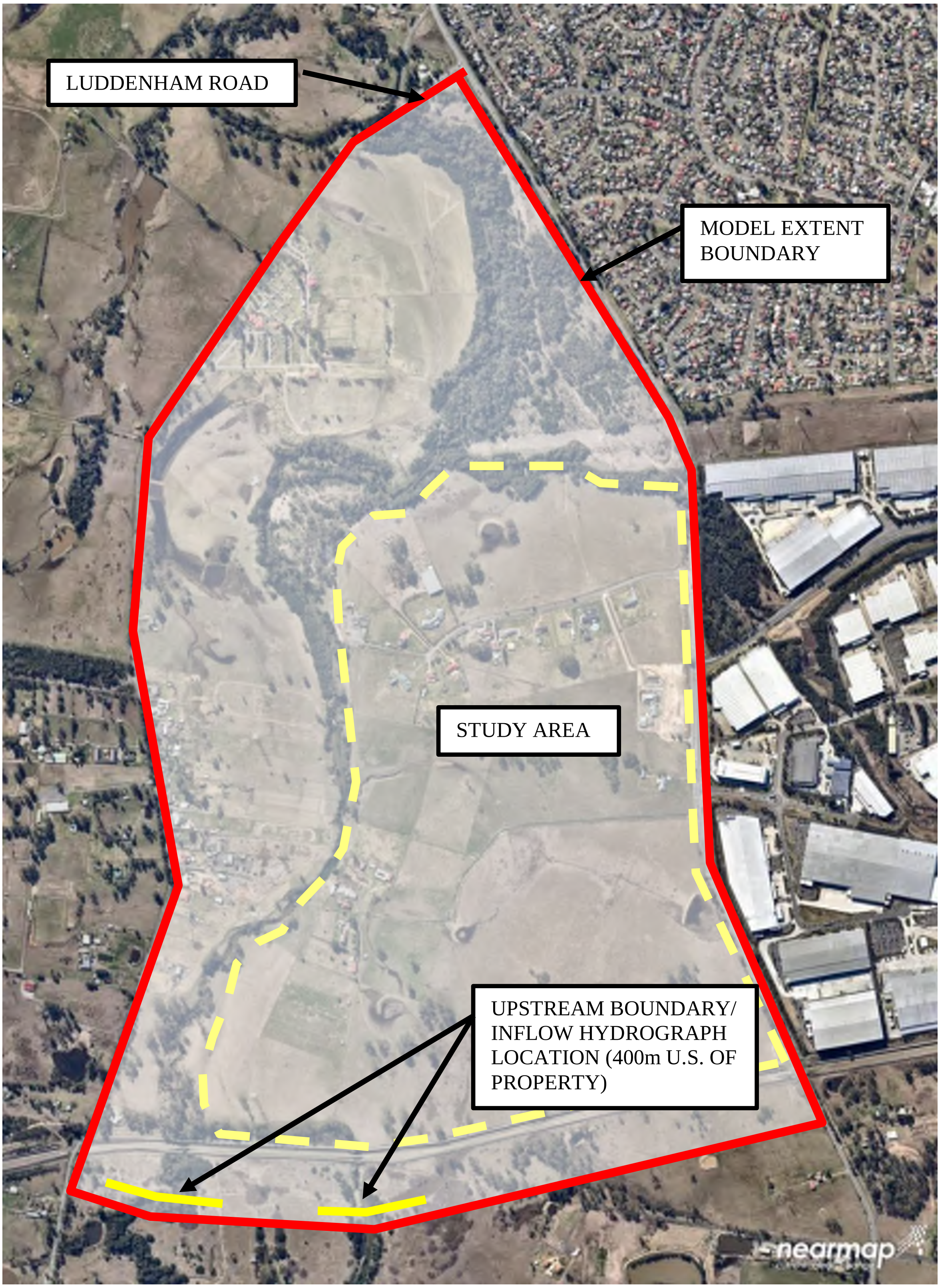


Figure 6.1. Model Extent and Model Boundary Locations

6.3. Channel and Floodplain Roughness

Roughness values adopted in the model are contained in **Table 6.2** below. These are generally consistent with those included in the Table 17 of the South Creek Study, except where adjusted to ensure validation of model results and achieving consistency with the results of the South Creek Study.

Table 6.2. Adopted TUFLOW Element Roughness Values

Model Element	Description	Roughness Parameter Value (South Creek Study)	Roughness Parameter Value (TUFLOW Study)
1	Moderately vegetated creek channel	0.10	**0.08**
2	Heavily vegetated creek channel	0.12	**0.12**
3	Grassed floodplain and sparse trees	0.05	**0.05**
4	Floodplain with moderate coverage of trees	0.08	**0.08**
5	Floodplain with dense trees	0.12	**0.12**
6	Urban Floodplain	0.04	**0.04**
7	Industrial Development	0.09	**0.09**
8	Roadways	0.015	**0.015**
9	Sydney Water Pipeline	NA	**0.08**

A figurative representation of where the above roughness values have been applied can be found in **Appendix F**.

6.4. Representation of Buildings and Hydraulic Structures

Structures modelled are consistent with those included in the South Creek Study.

Buildings within the extent of flooding are small, isolated residential dwellings. These dwellings provide a small footprint when compared to the overall flood plain and are were not included in the model as obstructions.

The South Creek Study did not include structures associated with the Sydney Water Supply Pipes located to the south of the subject land. The South Creek Study did not include the bridge structure associated with crossing at Luddenham Road. As recommended in the Worley Parsons Peer Review we have now included the Sydney Water Pipeline in the model as a hydraulic constraint. This constraint has been modelled with a high Manning's roughness value consistent with that of a floodplain with moderate tree coverage. No other major hydraulic structures are present within the limits of the modelling and no other structures have been included.

6.5. Model Validation

Model validation has been completed by comparing results of the TUFLOW modelling against the results contained in the South Creek Flood Study and adjusting as required to achieve good agreement between the two models. The process for the validation was as follows:

- Compare DTM's;
- Establish hydrology, peak flows and hydrograph for modelled events;
- Establish TUFLOW Model using defined parameters;
- Compare results of TUFLOW modelling with South Creek Study including flood depths, flood levels (taking into account the differences in DTM's), flood extents and hydraulics. The comparison is made at the peak of the predicted parameters;
- Adjust roughness factors to align TUFLOW flood depths and to within 100mm of South Creek Study Results.

Comparison of the DTM's show the surfaces generally agree however differences of 100mm and up to 150mm can be seen around the flood plain area. Larger differences in the DTM's can be seen to occur in and around the South Creek channel and creek banks. In some instances the creek banks are wider and do not align. This is likely due to the accuracy of ground survey and also the timing of the survey information. Changes to the creek banks resulting from flood events would be expected to affect the geometry of the creek banks. Reference to **Appendix D** shows a comparison between the two DTM's.

Hydrology and peak flows were established as described in Section 5 of this report. The hydrological information used in the TUFLOW model is consistent with those of the South Creek Study.

A number of trial models and iterations of the TUFLOW model were performed. Adjustment of roughness parameters were used to align the flood depths with those compiled in the South Creek Study. As there are differences in DTM's used in the TUFLOW and South Creek Study, flood depths were used for the comparison and adjustment of TUFLOW model parameters rather than flood heights. This provides a more transparent comparison between the two model results.

The comparison of the flood depth results shows good alignment of those produced in the TUFLOW model when compared with those of the South Creek Study. Flow depths were seen to have a difference less than 100mm and generally in the order of 50-100mm through the overbank/ floodplain areas. Higher differences can be seen in and around the main channel, particularly where ground survey has been undertaken. The predicted flood extent is consistent between the two models for the different flood events modelled.

Given the differences in modelling techniques, parameters, predicted model accuracy (+/- 200mm) and model components these differences are considered acceptable for the base model and for continuation of the Stage 2 Scenario Modelling.

The comparison between the modelled results can be seen in **Appendix B** for the 1% AEP and 5% AEP flood events. Comparison of flood results at five key locations can also be observed in **Table 7.1**. Flood depths differences at these key locations can all be seen to be within the predicted flood accuracy of 0.2m.

7. FLOOD MODELLING RESULTS

The predicted peak flood levels, depth and velocities were extracted from the hydrodynamic modelling and were used to generate water surface profiles, depth profiles and velocity profiles for each of the design events.

The water surface profile for the 1% AEP event has been presented below in **Figure 7.1**. Reference to **Appendix A** should be made for water surface profiles, flood depth estimates and velocity output for the 5% AEP, 1% AEP, 0.5% AEP and PMF storm events.

Predicted 1% AEP flood levels and depths at key locations (defined in **Figure 7.1**) are also presented in **Table 7.1**.

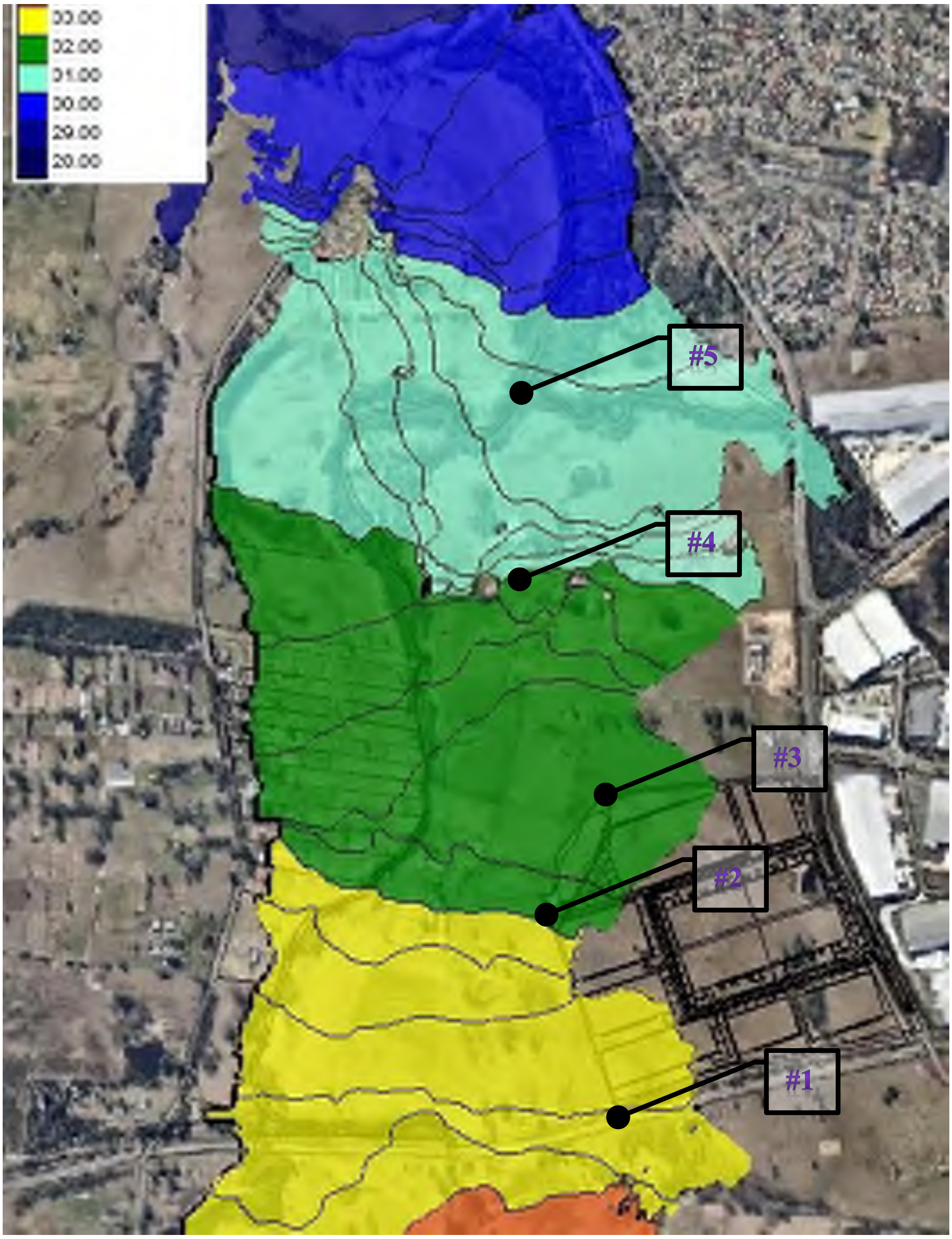


Figure 7.1. Predicted 1% AEP Peak Flood Level Profile

No.	TUFLOW			South Creek Study		
	Ground Level (m)	Flood Depth (m)	Flood Level (m)	Ground Level (m)	Flood Depth (m)	Flood Level (m)
1	33.11	0.48	33.59	33.09	0.44	33.53
2	31.94	0.99	32.93	32.03	0.81	32.84
3	31.66	1.03	32.69	31.49	1.08	32.57
4	31.44	0.68	32.12	31.40	0.55	31.95
5	29.54	1.72	31.26	29.71	1.74	31.45

Table 7.1. Predicted 1% AEP Peak Flood Parameters at Key Locations

Table 7.1 shows the predicted flood depths and levels in five key locations through the study area. The flood depths compare well with differences of 100mm or less at four of the five locations. Location 3 has a higher difference of 200mm however this is considered within the accuracy of the two models.

The predicted extent of flood inundation can be seen to extend across the floodplain for a considerable distance from the main channel of South Creek. This can be seen to comprise high and low hazard areas. The flood extent within The Site can be seen to be generally shallow and low velocity. The exception to this is at the north-west corner of the site where, although low velocity is present, depth of flow is in the order of 0.8-1.1m. This area has been categorised by Penrith Council in the South Creek Study as being high hazard zone.

Flood planning levels for future development will be based on the 1% AEP flood levels plus freeboard of 500mm, and any minor change in flood levels as a result of development, as defined in Section 3 of Penrith Councils Water Management DCP.

8. PEER REVIEW

As discussed in earlier sections of the report, the current revision **(Revision B)** of this report contains updated modelling output to address the comments and suggestions contained in the peer review undertaken by Worley Parsons based our initial, Revision A, version of this report (dated 22 September 2015). The peer review assessment is contained in a report by Worley Parsons, *Overland Flow Report Stage 1, Mamre West Precinct, Orchard Hills, NSW, Peer Review,* dated 27 October 2015. We provide the following discussion and confirmation of each of the items and recommendations contained in *Section 4. Overall Peer Review Findings* of the peer review report.

Item B1.a) *The downstream boundary levels are inappropriate and require review and update. It is recommended that peak flood levels from the RMA-2 flood model be adopted to ensure consistency. These peak flood levels are provided within Table 1.*

Response

Modeling has been updated to include the recommended downstream flow boundaries. Confirmation of the downstream boundary levels used has been included in **Section 6.2** of the report.

Item B1.b) *The upstream boundary should be located a sufficient distance upstream to cover the extent of predicted impacts from the proposed development. It is unclear if sensitivity analysis has been undertaken to ensure the current set-up is satisfactory.*

Response

A sensitivity analysis has been undertaken which confirms the upstream boundary, located 400m from the property boundary, is sufficiently located far enough from the property to enable appropriate scenario testing relating to the proposed development.

Please refer to **Section 6.2** and **Appendix E** of the report.

Item B1.c) *The model extents should extend to cover the PMF flood extent.*

Response

The completed model extent sufficiently covers the PMF event. The modeling comparison shows good agreement of flood surface levels with the RMA-2 modeling. The PMF model extents allow for a suitable level of information to enable emergency response planning for the development.

Item B1.d) *Hydrology should be based on the flows from the RMA-2 model. The basic two-node RAFTS model is not considered satisfactory for the definition of flows and has been shown to predict lower flows for most design events (refer Table 2).*

Response

Inflow hydrographs have been adjusted to match those recommended in Table 2 of Worley Parsons Peer Review Report. Refer to **Section 5.2** and **Appendix C** of the report.

Item B1.e) *Local tributaries should be incorporated into the TUFLOW model to ensure local catchment flooding through the site is taken into consideration in the design of the Precinct and during post-development modeling to be completed as Stage 2.*

Response

The local tributary from the upstream industrial catchment to the east of Mamre Road will be diverted and re-routed around the property via a piped system as part of the proposed infrastructure works for the development. Investigation and design regarding this conveyance would be completed as part of infrastructure works rather than part of the rezoning application.

The modeled arrangement is consistent with the agreed scope with council and South Creek Study with the South Creek Study, and also that as part of the future development, the diversion of the local tributary would made via a piped system designed in future detail phases of the development.

The exclusion of the minor tributaries described above was discussed and agreed between Mark Wilson from Costin Roe Consulting and Roy Golaszewski from Worley Parsons on 3 November 2015.

Item B1.f) *The Sydney Water supply pipeline should be incorporated into the TUFLOW model given its close proximity to the site and its potential to impact on the proposed development and modeling of post-development conditions.*

Response

The Sydney Water Supply Pipe has been included as a hydraulic constraint. Please refer to **Sections 6.3, 6.4** and **Appendix F** of the report.

Item B2 *The set-up of the existing condition model appears consistent with the available topographic data. A figure showing the spatial variation in adopted land use types should be incorporated within the Overland Flow Report.*

Response

Please refer to **Appendix D** of the report for DTM comparison.

Item B3 *The TUFLOW and RMA-2 results documented in the South Creek Flood Study (Final, 2015) should be compared based on peak flood levels and not depths. Any differences should be presented and discussed similar to Section 3.2.1 and Figure 3 to Figure 6.*

Response

Model comparison results have been adjusted to show differences in flood surface levels rather than flood depths. Please refer to **Appendix B** of the report.

Item B4 *A preliminary comparison of the TUFLOW and RMA-2 results has shown that both models are in general agreement (within 0.2 metres) across the extents of the primary development area. Significant differences to however occur downstream of the Precinct, which, may influence flood behavior upstream through the Precinct for existing and post-development conditions.*

Response

The differences in flood levels downstream of the precinct have been resolved with the inclusion of the downstream boundary conditions recommended in the Peer Review Report and confirmed in **Section 6.2** of this report.

9. CONCLUSION

This Overland Flow Report has been prepared in support of a development and rezoning of a parcel of land at 585-649 Mamre Road, Orchard Hills.

The Site has been identified by Penrith City Council as being affected by overland flows associated with South Creek. This report has been prepared in the Stage 1 modelling of the existing creek, within the zone of the development. This modelling has been undertaken to confirm the suitability of the model for future scenario relating to the development of the land and its effect on the flooding as a result of development. The development site has been considered in the context of an extended land area being proposed as the Subject Land for inclusion in the final structure plan for the Broader Western Sydney Employment Area and subsequent rezoning as part of the State Environmental Planning Policy (Western Sydney Employment Area) 2009 as appropriate.

A TUFLOW hydrodynamic flood model of South Creek was produced for the area surrounding the development for the purpose of future scenario testing. The current report provides a summary of the model build and results for the existing, pre-developed, condition over the land. The model has now been reviewed by Penrith City Councils consultants, Worley Parsons, prior to the Stage 2 Scenario Testing being undertaken.

The TUFLOW modelling included adjustment and validation using the South Creek Study. Results of the TUFLOW modelling show acceptable comparison with those of the South Creek Study with differences in flood depths of less than 100mm being achieved. Flood surface levels are also seen to be within 100mm of those produced in the South Creek Study and similar hydraulic conditions were also observed. The flood surface varies in level from RL 33.65m AHD at the upstream (south) end of the development site, RL 32.75m AHD at the downstream end of the site (north/ Mandalong Close Boundary) and RL 31.29m AHD at the downstream end of the Mandalong Close residential area.

We reiterate that the Stage 1 TUFLOW model has not been produced to replicate the South Creek RMA model but has been completed and validated to be suitable for use in scenario testing of the effect of development on flooding. The TUFLOW model is considered suitable for use in scenario testing to determine the effect of development on flooding upstream and downstream of the development site. We recommend the model is accepted for the ongoing scenario testing and look forward to discussing the outcome of the Worley Parsons Peer Review.

The information provided in this Report is intended to inform the relevant stakeholders including the surrounding property owners, Department of Planning and Environment, council engineers and planners, and the property developer of the opportunities and constraints associated with the development in relation to overland flow and flooding within South Creek.

Revision B of this report contains updated modelling output to address the comments and suggestions contained in the peer review undertaken by Worley Parsons based our initial, **Revision A**, report (dated 22 September 2015). The peer review assessment is contained in a report, *Overland Flow Report Stage 1, Mamre West Precinct, Orchard Hills, NSW, Peer Review,* by Worley Parsons dated 27 October 2015. The TUFLOW output has been reproduced based on the recommendations of the Peer Review and a confirmation of each of the items and recommendations contained in the Peer Review has been provided as **Section 8** of this report.

APPENDIX A

TUFLOW MODEL RESULTS

(Figures represent predicted values at the peak of each event)

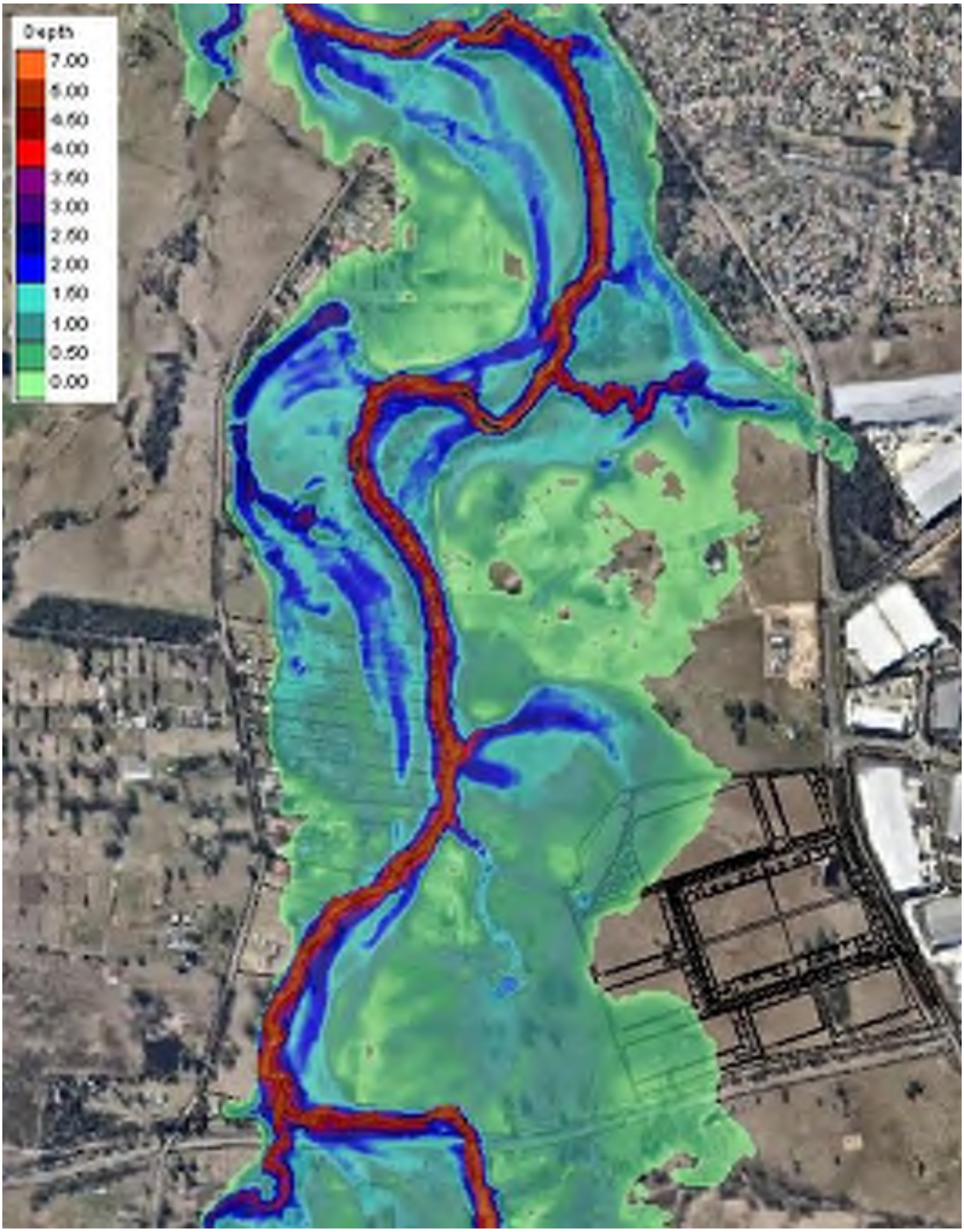


Figure A1 – 5% AEP Flood Depths

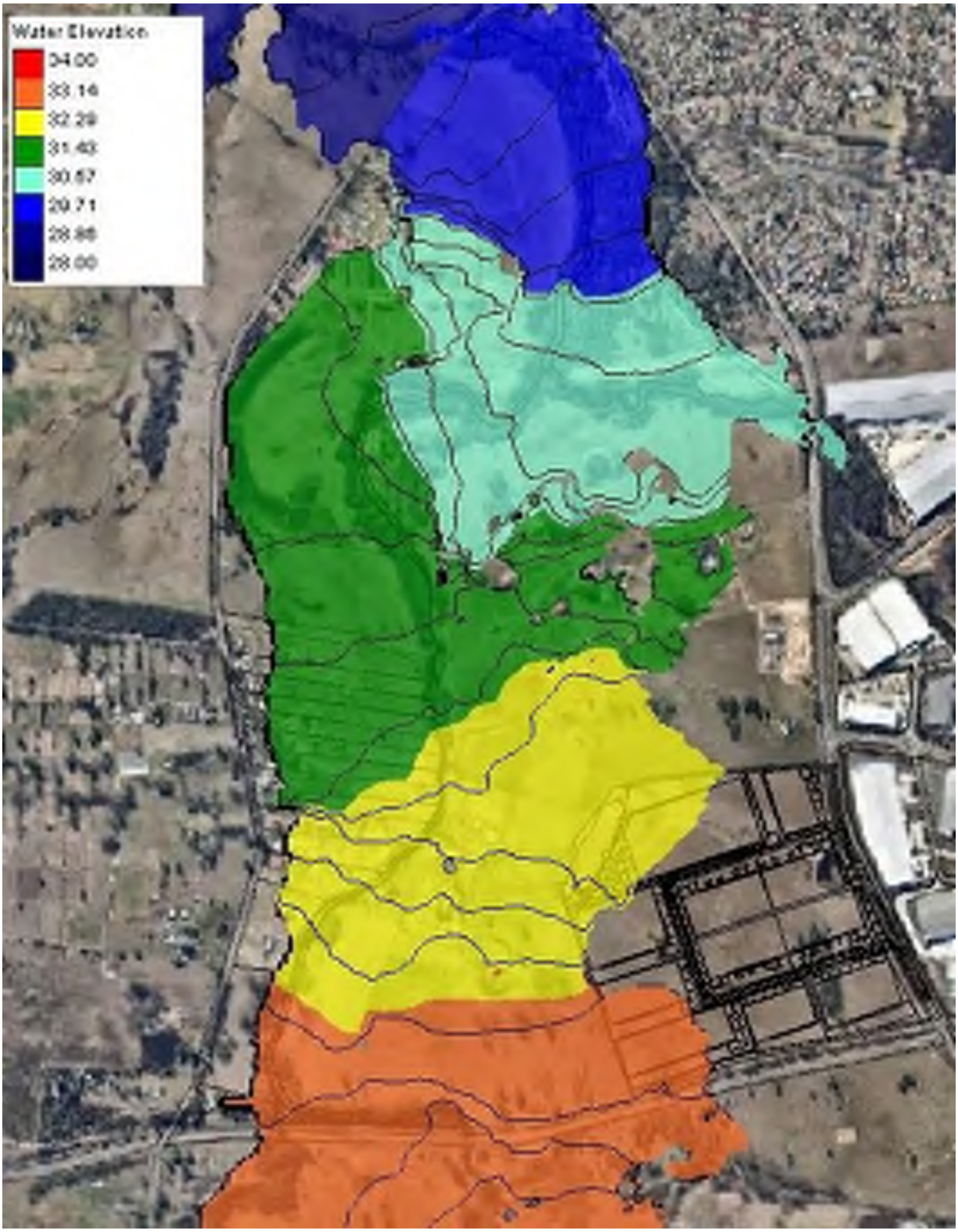


Figure A2 – 5% AEP Flood Levels

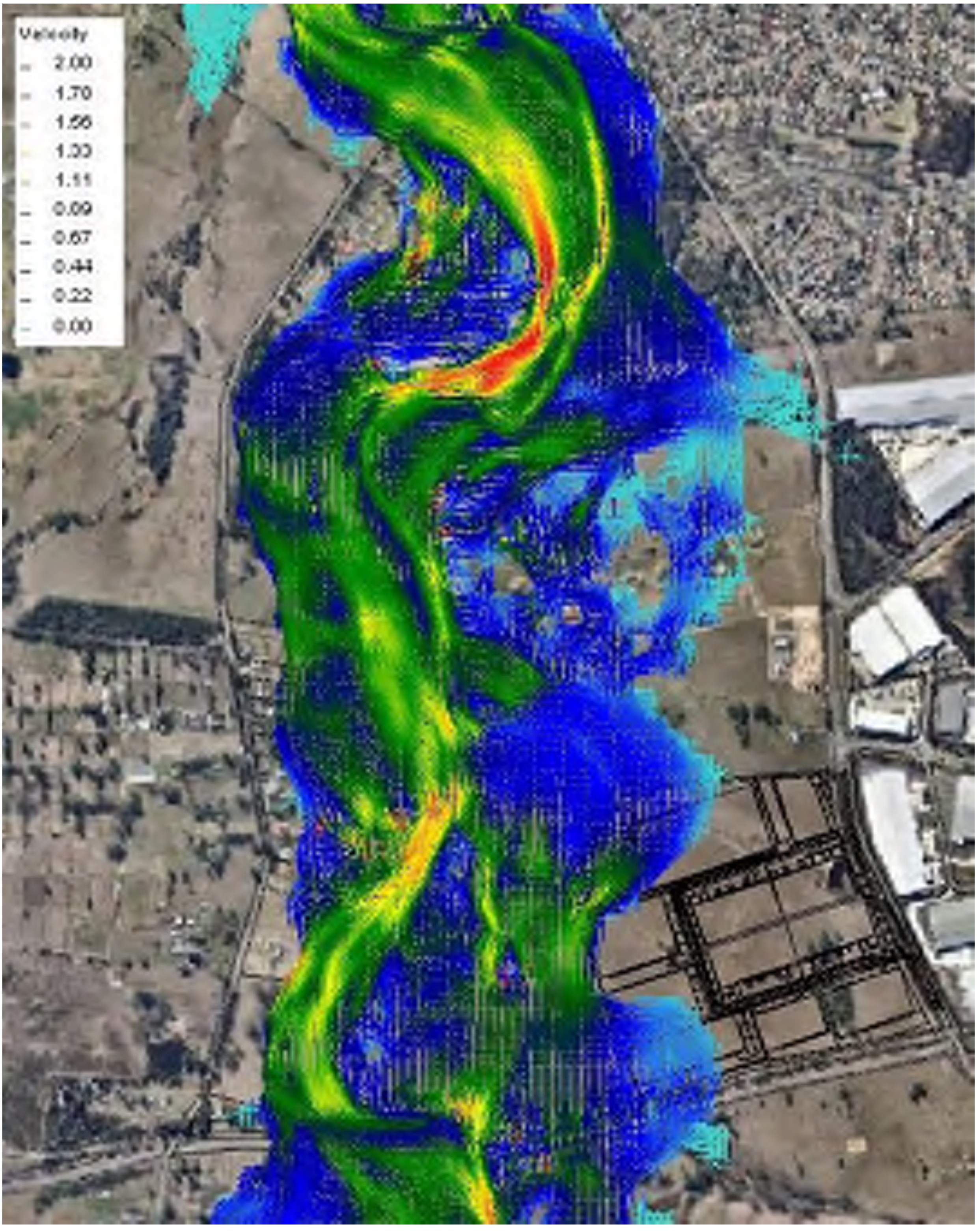


Figure A3 – 5% AEP Flood Velocity

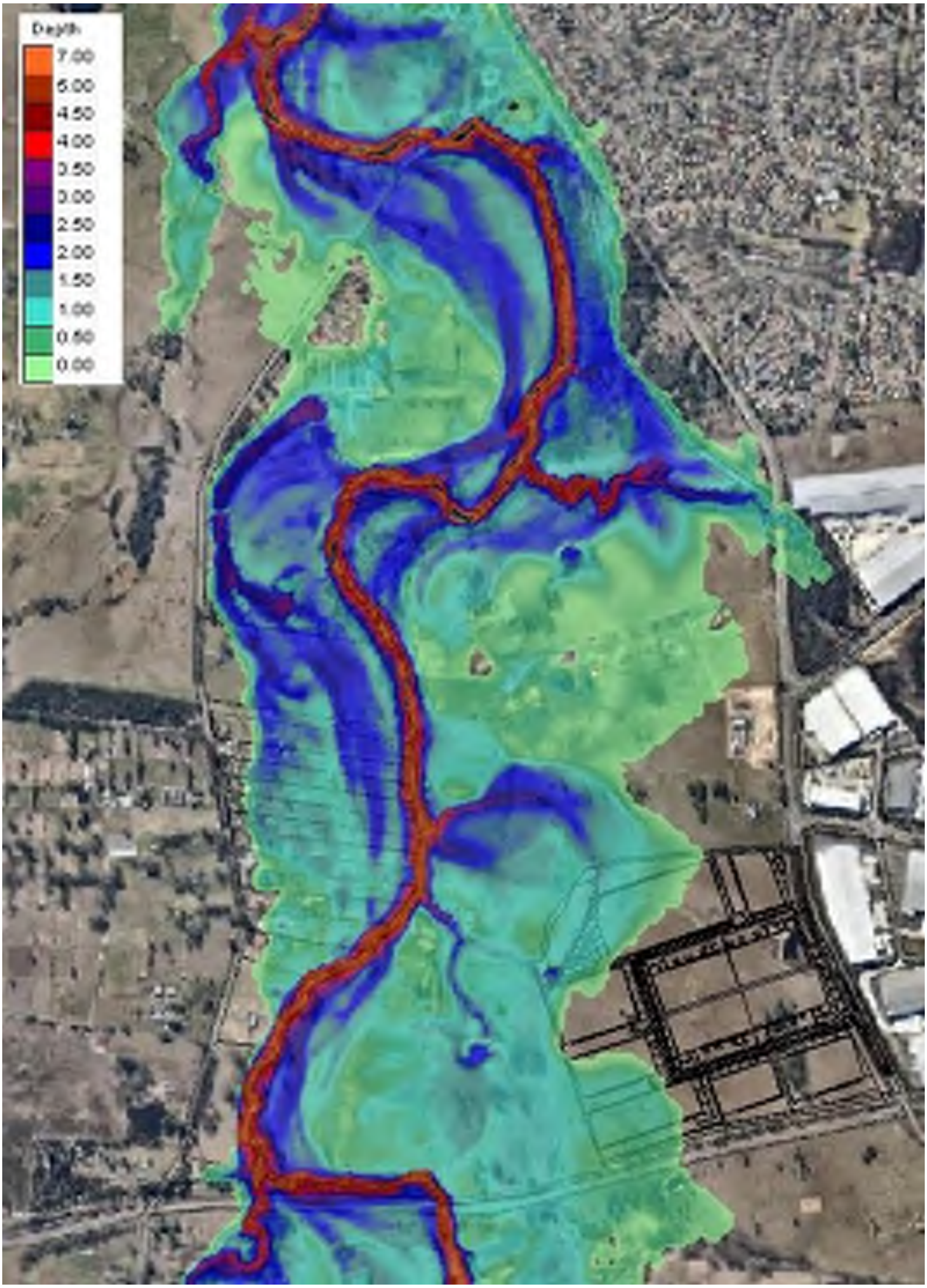


Figure A4 – 1% AEP Flood Depth

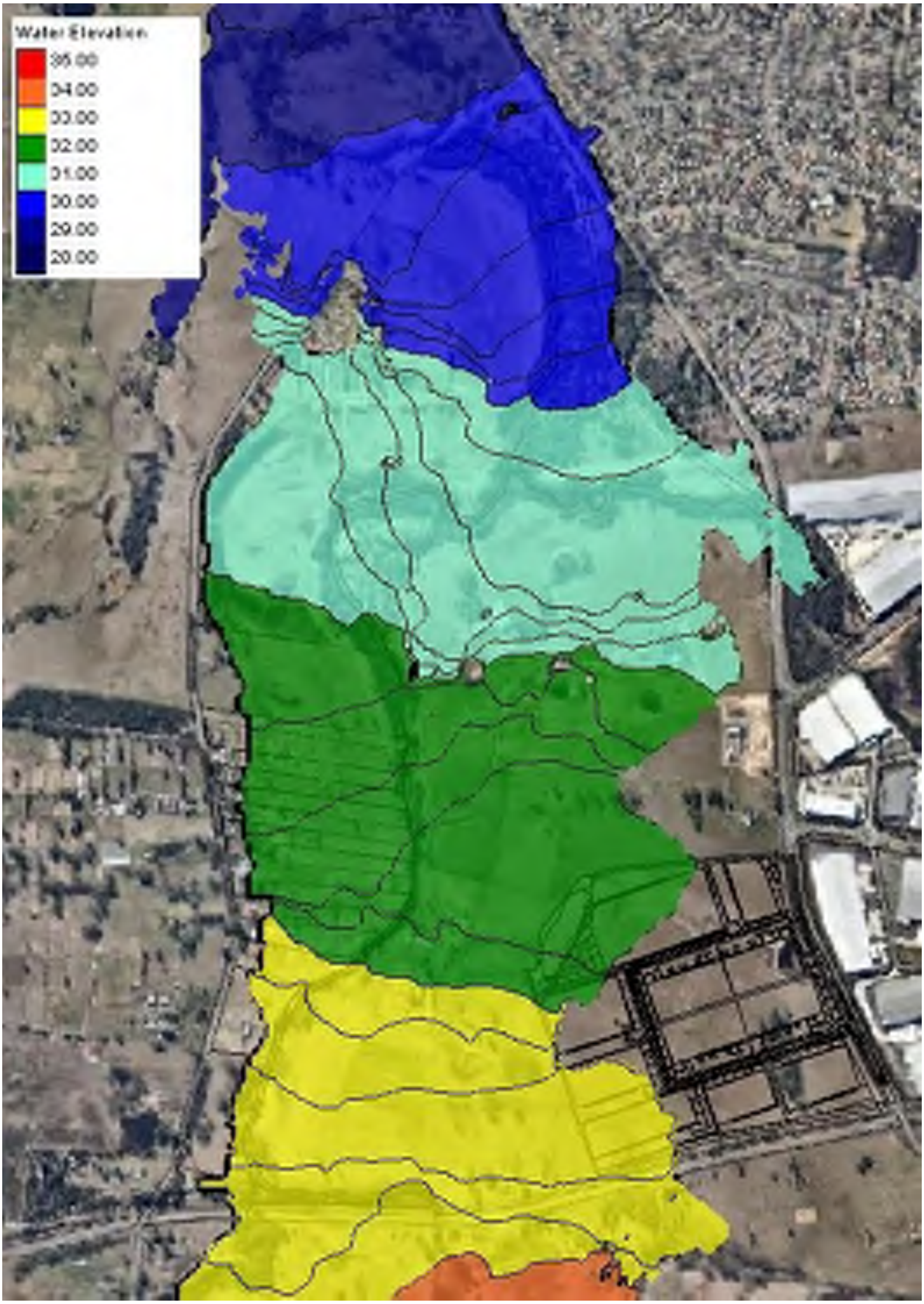


Figure A5 – 1% AEP Flood Levels

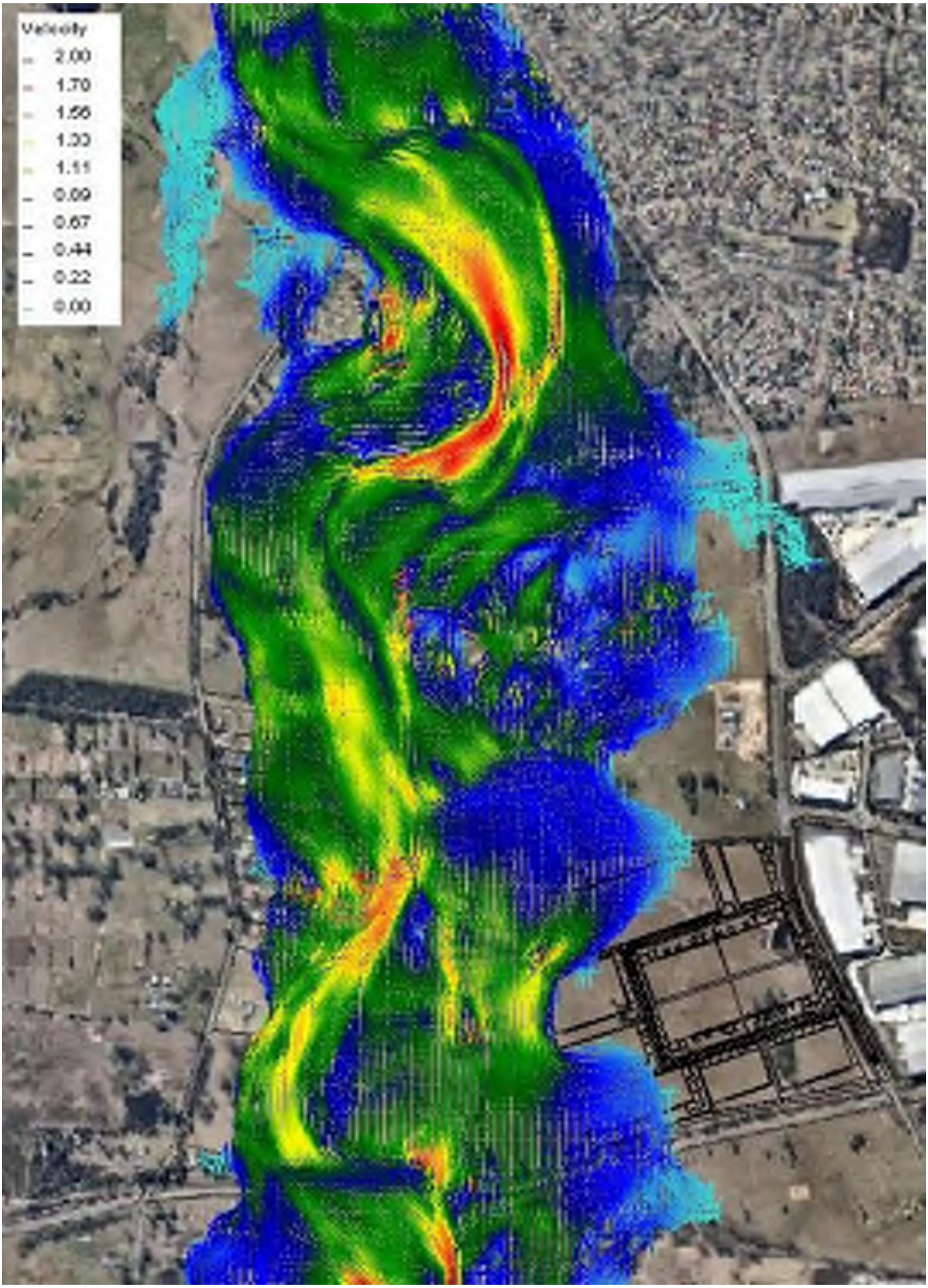


Figure A6 – 1% AEP Flood Velocity

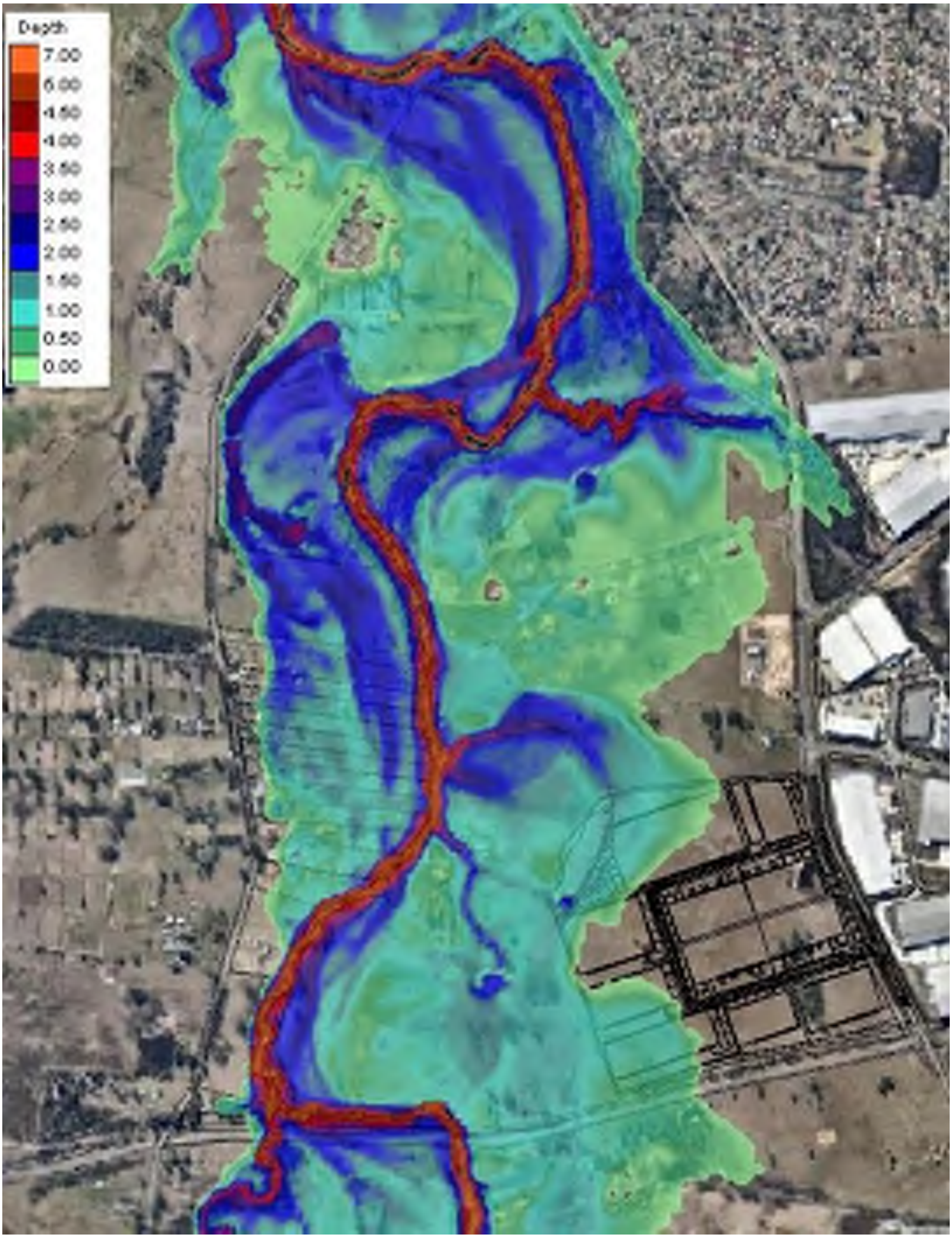


Figure A7 – 0.5% AEP Flood Depth

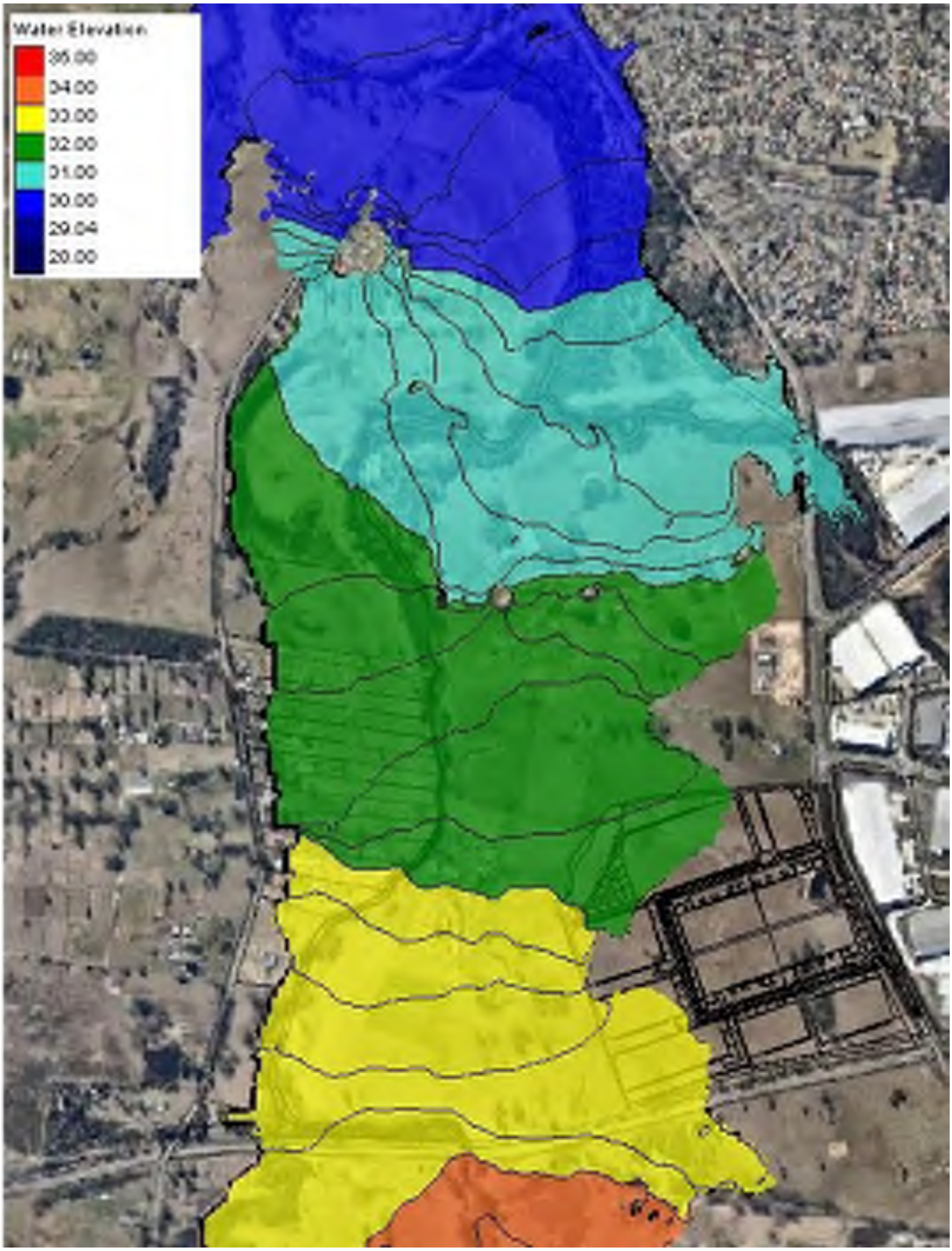


Figure A8 – 0.5% AEP Flood Levels

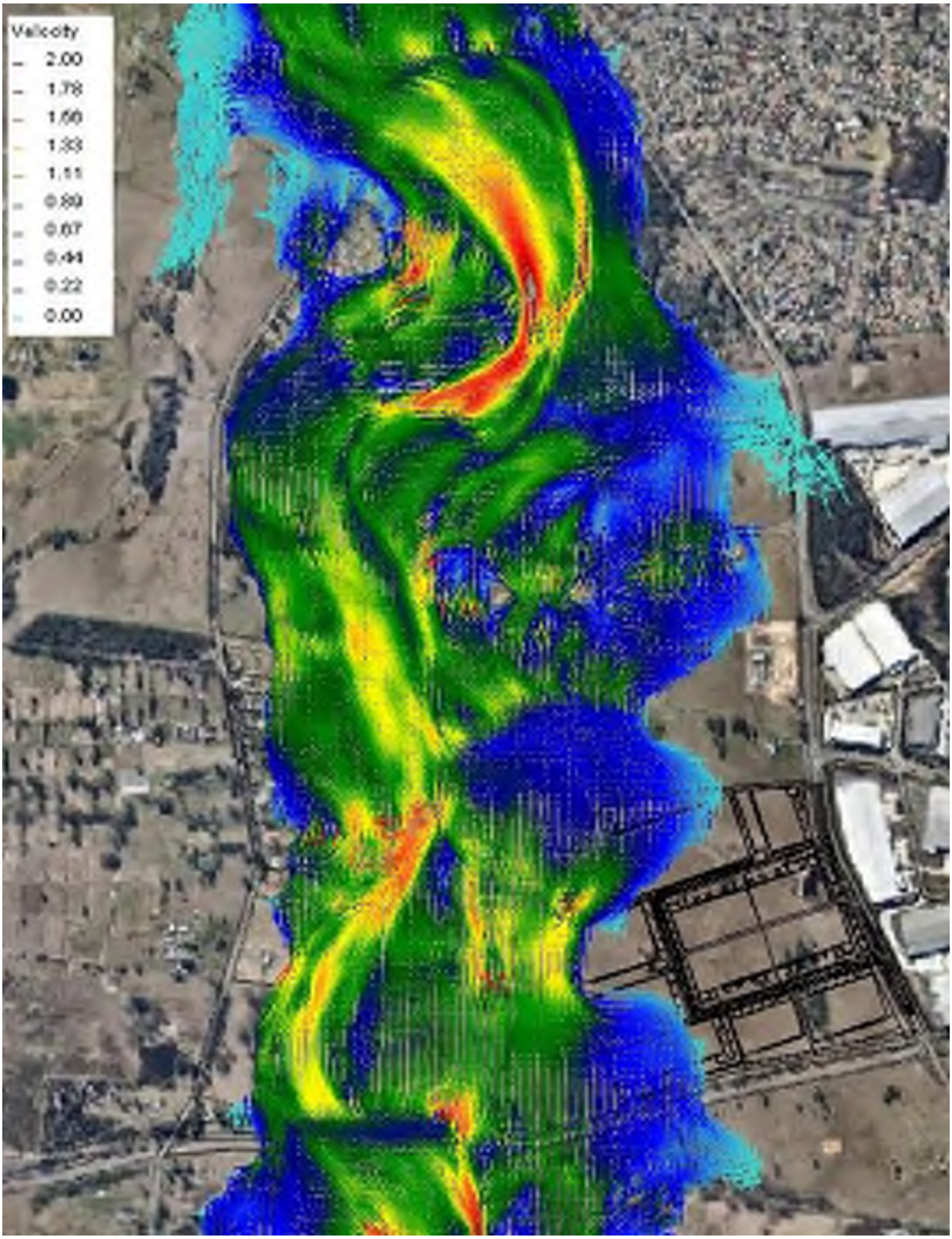


Figure A9 – 0.5% AEP Flood Velocity

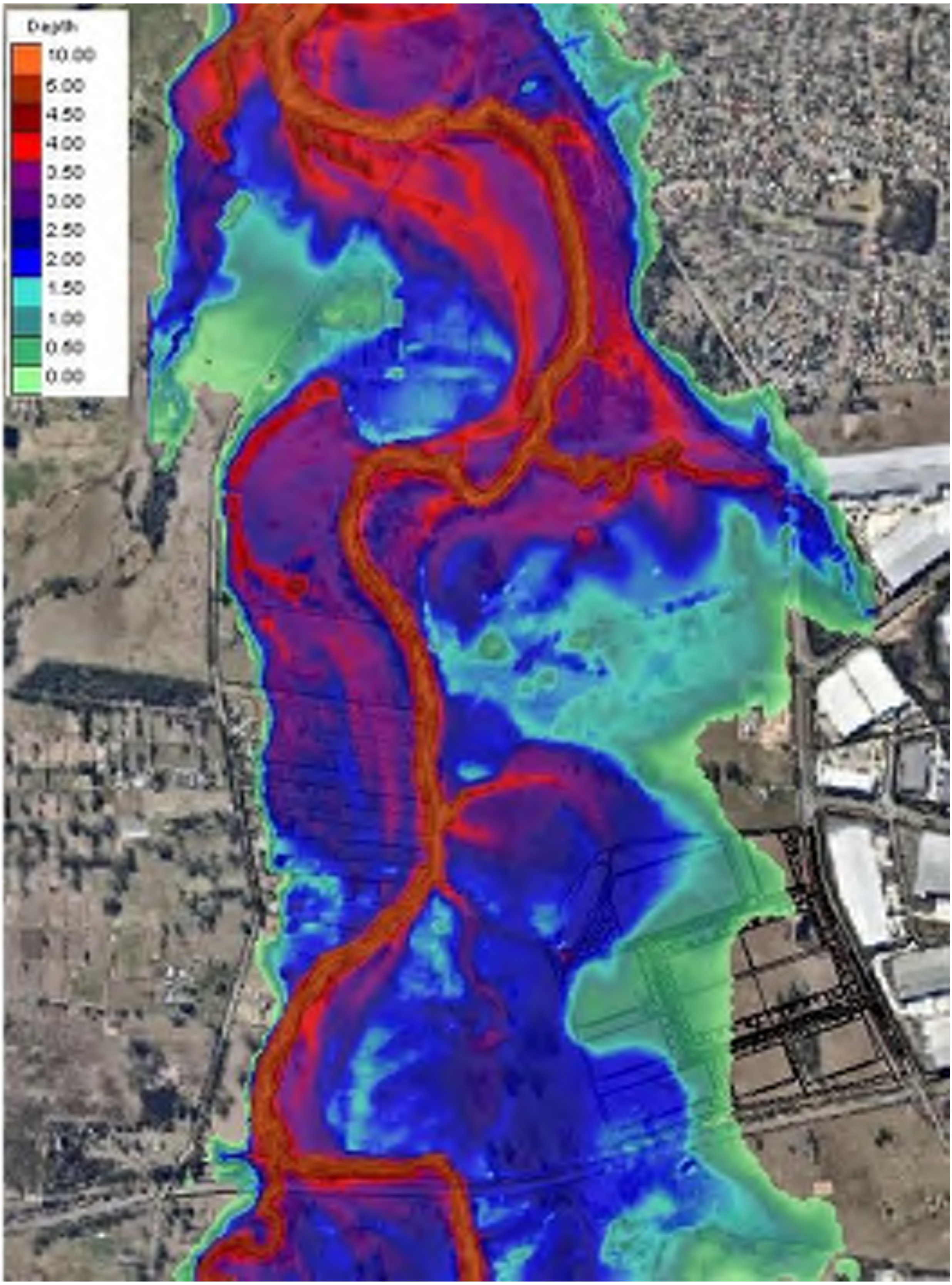


Figure A10 – PMF Flood Depth

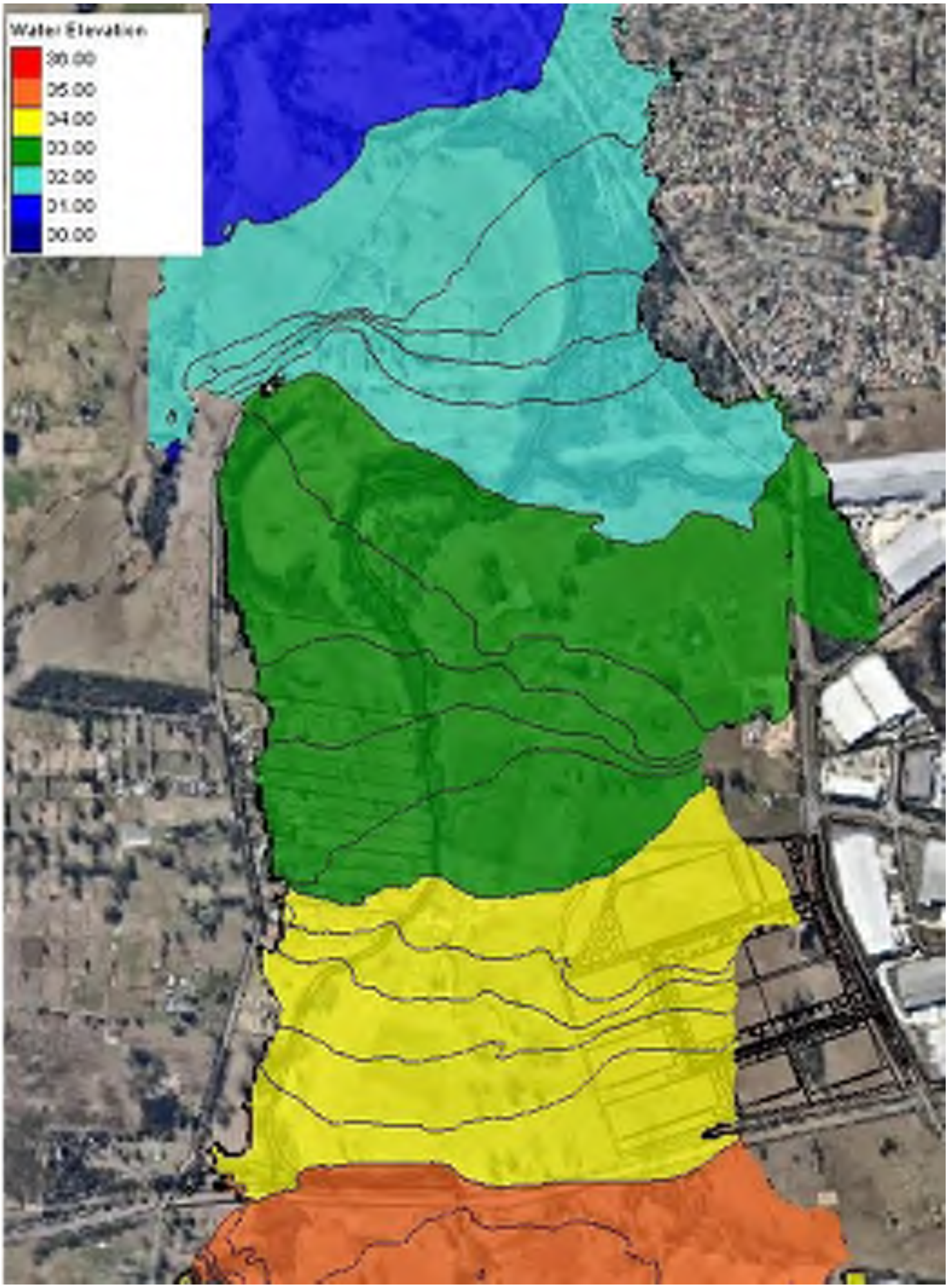


Figure A11 – PMF Flood Levels

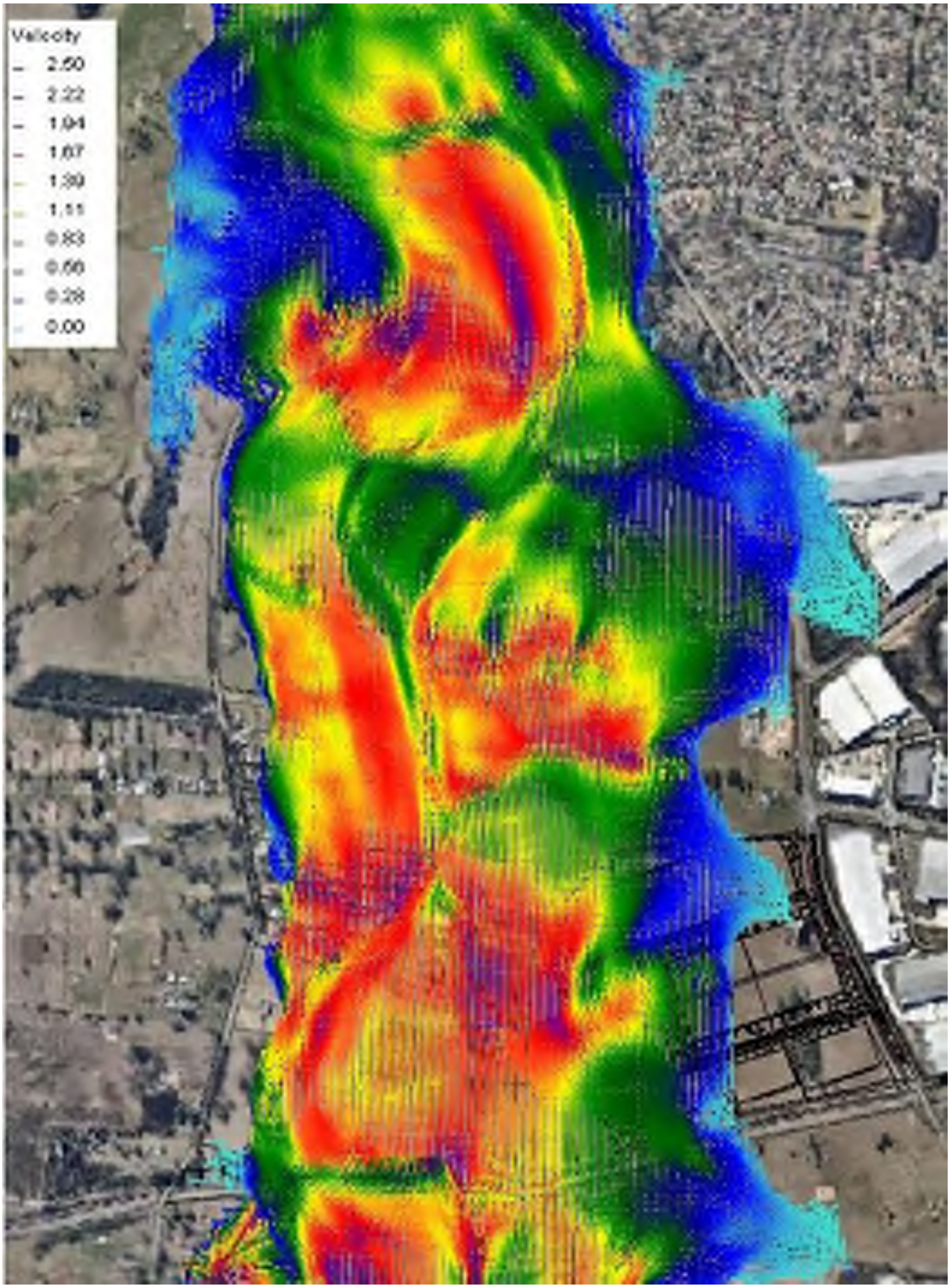
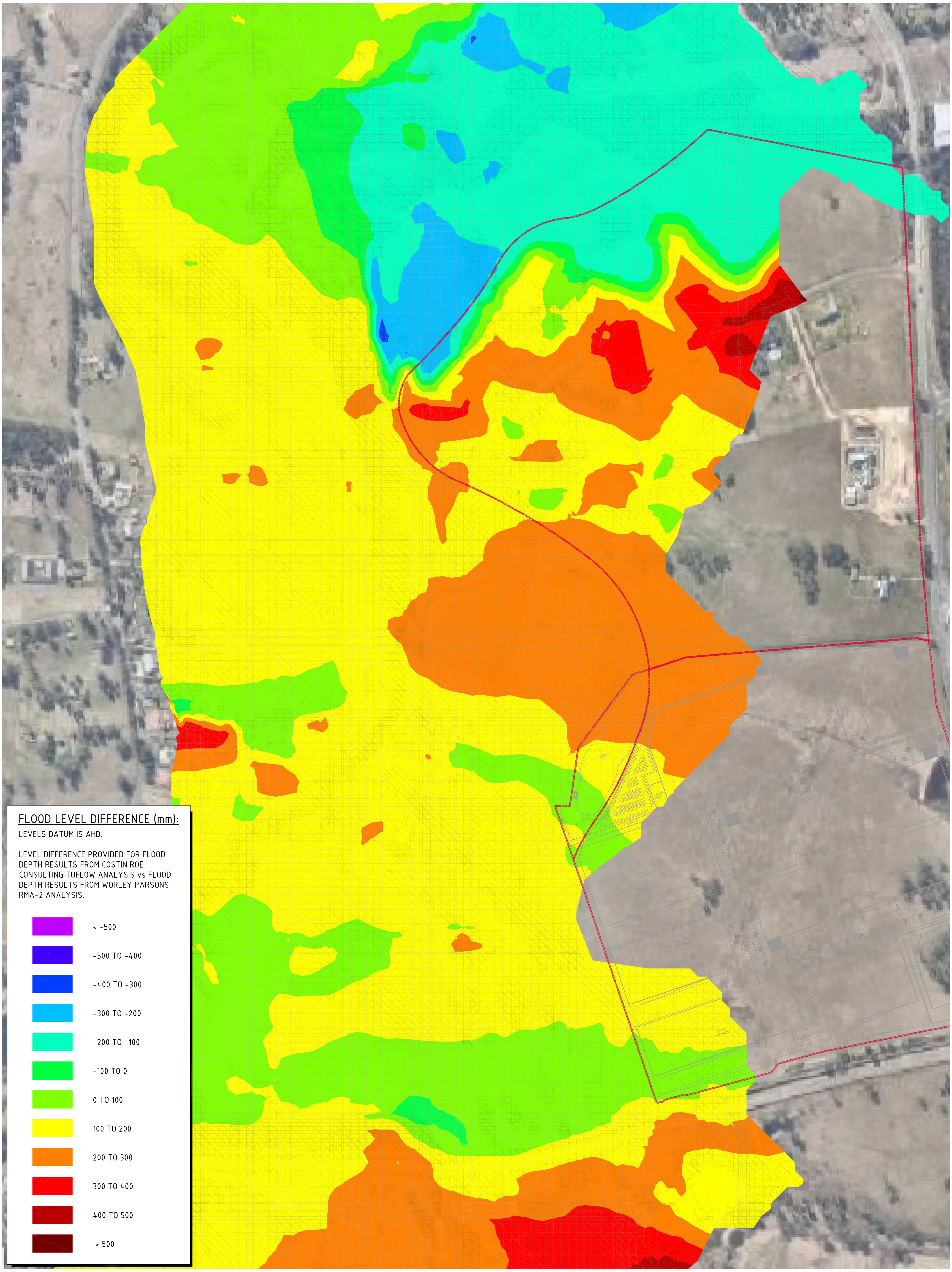


Figure A12 – PMF Flood Velocity

APPENDIX B

TUFLOW AND RMA-2 MODEL COMPARISON


FLOOD LEVEL DIFFERENCE (mm):
LEVELS DATUM IS AHD.
LEVEL DIFFERENCE PROVIDED FOR FLOOD DEPTH RESULTS FROM COSTIN ROE CONSULTING TUFLOW ANALYSIS vs FLOOD DEPTH RESULTS FROM WORLEY PARSONS RMA-2 ANALYSIS.
< -500
-500 TO -400
-400 TO -300
-300 TO -200
-200 TO -100
-100 TO 0
0 TO 100
100 TO 200
200 TO 300
300 TO 400
400 TO 500
> 500