Appendix G17
Flood Impact Assessment

Environmental Impact Statement

for Alterations and Additions to

St Philip's Christian College, Cessnock

St Philip's Christian College, 10 Lomas Lane, Nulkaba

Flood Impact Assessment

St Philip's Christian Education Foundation Ltd
Report
01
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Executive Summary

BMT Commercial Australia Pty Ltd (BMT) has prepared this flood impact assessment (FIA) report, on behalf of St Philip's Christian Education Foundation Ltd, to support a State Significant Development Application (SSDA) for alterations and additions to the existing school known as St Philip's Christian College (SPCC) Cessnock. The school is located on the corner of Lomas Lane and Wine Country Drive, Nulkaba. The site is bounded by Lomas Lane to the north, a rural property with large open space to the south, Wine Country Drive to the west and Black Creek to the east.

The proposed development, to be constructed in several stages, consists of seven (7) new buildings and additions/alterations to six (6) existing buildings. As part of the development certain existing prefabricated buildings will be removed to make way for new permanent buildings. The proposed development also incorporates infrastructure works external to the site associated with provision of a new intersection on Wine Country Drive providing direct access to the school at the southern end of the campus (immediately south of the proposed aquatic centre), and the upgrade of the intersection of Wine Country Drive and Lomas Lane to a roundabout. Widening of Lomas Lane on the eastern side will also be carried out to facilitate the provision of bus bays and a bus layover area. The SSDA application seeks approval for an increase in student numbers up to 1,732.

The school site is located within the Black Creek floodplain and affected by backwater flooding from the creek. It is therefore necessary to undertake a FIA to assess and ensure that the proposed development will not cause an adverse flood impact beyond the boundaries of the site. This report also included a high-level review and commentary on the flood emergency response plan (FERP) previously prepared by Worley Parsons as part of the 2009 Development Application (DA) submission in relation to the proposed 2021 masterplan.

The flood impact assessment herein utilised the XP-RAFTS hydrologic and TUFLOW hydraulic models of the local study area developed previously as part of the SPCC masterplan flood impact assessment undertaken in 2017 (BMT, 2017). Necessary modifications have been incorporated within the TUFLOW model to reflect the latest site information and the proposed development conditions as per the 2021 masterplan.

The detailed flood impact assessment herein includes or demonstrates the following flooding outcomes:

- The pre-development and post-development mainstream flood behaviour, such as peak flood level, depth and flood hazard have been defined for a range of design flood events, including the 20%, 10%, 5%, 2%, 1%, 0.5%, 0.2% AEP and Probable Maximum Flood (PMF) events.
- The existing elevated or developed part of the school (the north western quadrant block) is not inundated during events up to and including the 0.2% AEP (1 in 500 AEP). This part of the school nevertheless is subject to inundation in the PMF event, with a flood depth of up to 1.5m and flood hazard classification of "H4" to "H5" (i.e. unsafe flow conditions for people and vehicles).
- The existing main access point (easternmost access) from Lomas Lane is subject to inundation during the 1 in 5 AEP flood event. However, the central and western access points to the northern carpark from Lomas Lane are either flood-free or trafficable during flood events up to and including the 1 in 20 AEP events.

- Lomas Lane is subject to inundation and not trafficable during rare flood events up to and including the 1 in 50 AEP flood event. However, the northern carpark is elevated and flood-free for flood events up to and including the 1 in 200 AEP.
- The proposed internal road along Wine Country Drive (north-south alignment) leading to the new access point via Wine Country Drive on the southern side is predicted to be flood-free during flood events up to and including the 1 in 500 AEP.
- The proposed development will not result in an adverse increase in peak flood level beyond the boundaries of the site for events up to and including the 1 in 20 AEP (i.e., the afflux is within 20mm which is considered minor and acceptable). For events larger in magnitude than the 1 in 20 AEP, the proposed development has been predicted to result in increases in peak flood level greater than 20mm beyond the boundaries of the site. However, the exceedance above the 20mm threshold is marginal. During the PMF event, the proposed development is predicted to result in a maximum off-site afflux of 140mm predominately to the east of Black Creek. However, more importantly, the proposed development is not predicted to significantly alter the flood hazard level (classification) in the areas impacted. However, more importantly, the proposed development is not predicted to increase the flood hazard level in the areas impacted and surrounding roads. Hence, as the proposed development will not result in a change in the peak flood hazard level beyond the boundaries of the site, it is considered that the development does not significantly alter existing flood risks in the PMF event.
- A sensitivity testing has been conducted based on a 20% increase in the peak flows on the 1% AEP event, and this demonstrated that the 1% AEP peak flood levels would increase by 0.3m within the site.
- A review of Cessnock City Council's flood mapping indicates that Wine Country Drive leading to Cessnock is flood-free during the 1% AEP event, except at the intersection with Fleming Street. During the PMF event, Wine Country Drive is inundated for the section between SPCC and Cessnock.
- The FERP for the proposed development site consists of onsite refuge located above the PMF level based on the approved FERP prepared by Worley Parsons (2009).The review indicates that the FERP needs to be updated at a detailed design phase or prior to construction works to ensure that the plan is fit for the amended development masterplan.
- Overall, based on the flood impact assessment herein, the proposed development is not anticipated to cause adverse social and economic impacts associated with flooding.

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1 Introduction

1.1 Overview

BMT Commercial Australia Pty Ltd (BMT) has prepared this flood impact assessment (FIA) report, on behalf of St Philip's Christian Education Foundation Ltd, to support a State Significant Development Application (SSDA) for alterations and additions to the existing school known as St Philip's Christian College (SPCC) Cessnock. The school caters for students from Kindergarten to Year 12, and also incorporates an Early Education Centre and Preparation program as well as a special school for students requiring an alternate learning environment. The school has a current enrolment of approximately 1,470 students in total.

The school is located on the corner of Lomas Lane and Wine Country Drive, Nulkaba and its land holdings incorporate four large lots described as Lot 1 DP 126765, Lot 1 DP 744377, Lot 2 DP 600895 and Lot 518 DP 837571. The site is irregular in shape and has an overall area of 41.8 hectares. The northern boundary of the site has frontage to Lomas Lane of approximately 390 metres and its western boundary fronts Wine Country Drive with a length of approximately 1,030 metres. The eastern boundary of the site is bounded by Black Creek.

The school site is located within the Black Creek floodplain and affected by backwater flooding from the creek. It is therefore necessary to undertake a FIA to assess and ensure that the proposed development will not cause an adverse flood impact beyond the boundaries of the site.

1.2 Background

In 2009, Cessnock City Council ("Council") granted a development consent to develop the site as per the approved "SPCC Flood Impact Assessment" (Worley Parsons, 2009). It is understood that the cut and fill work as approved in the 2009 masterplan have been completed on the site, as such these works will form the baseline conditions at the site against which impacts of the proposed development will be assessed.

BMT subsequently completed the "St Philip's Christian College Cessnock Flood Impact Assessment" (BMT, 2017) to assess the flooding impacts of the revised 2017 masterplan design as part of a Development Application (DA) with Council. It is understood that the DA for the 2017 masterplan did not proceed.

A revised 2021 masterplan has now been completed for which an approval is being sought through the SSDA pathway. The SSDA requires an Environmental Impact Statements (EIS) that includes, amongst others, a flood impact assessment to address the Secretary's Environmental Assessment Requirements (SEARs).

1.3 SEARs and Scope of Assessment

This FIA will address Item 17 (Flooding) of the project SEARs (Application No. SSD-10360337). The specific requirements under Item 17 include the following:

- Identify any flood risk on-site in consultation with Council and having regard to the most recent flood studies for the project area and the potential effects of climate change, sea level rise and an increase in rainfall intensity.

- Assess the impacts of the development, including any changes to flood risk onsite or off-site, and detail design solutions to mitigate flood risk where required.

To address the above-stated SEARs, a detailed flood modelling has been undertaken in accordance with the NSW Floodplain Development Manual (DIPNR, 2005). The modelling and flood impact assessment herein utilised the hydrologic and hydraulic models developed as part of the BMT (2017) FIA. This report also included a high-level review and commentary on the flood emergency response plan (FERP) previously prepared by Worley Parsons as part of the 2009 DA submission in relation to the proposed 2021 masterplan.

1.4 Outline of Report

Section 2 provides description of the existing and development site conditions.

Section 3 describes the data collation process and review of available data.

Section 4 details the development and validation of the hydraulic model.

Section 5 provides the design flood modelling results, incorporating flood mapping.

Section 6 provides a high-level review and commentary on the FERP previously prepared as part of the 2009 DA submission.

Section 7 presents the conclusions of the study.

2 Description of Development Site

2.1 Existing Conditions

The locality of the site is shown in Figure 2.1. The site is situated between Black Creek and Wine Country Drive, on the southern side of Lomas Lane. The eastern boundary of the site is aligned with the Black Creek channel. The Lomas Lane forms the northern site boundary.

The Black Creek catchment area upstream of Lomas Lane is in the order of 84km^2 and the Creek is joined by Pokolbin Creek around 1km downstream of the site which provides an additional 35km^2 of contributing catchment area. Local topography in the vicinity of the site, as defined by the available topographic data, is shown in Figure 2.2. The floodplain slopes at a grade of approximately 0.4%, with typical elevations in the order of 56.0m AHD to 59.5m AHD. The Black Creek channel reach along the upstream, eastern site boundary has perched banks, elevated around 0.5m above the adjacent floodplain.

The existing development of the St Philip's campus largely sits within the north western quadrant of the block and is elevated out of the floodplain at over 58.0m AHD (as depicted in Figure 2.2). A landscaped earthen mound has been constructed on the western edge of the fill platform adjacent to the Wine Country Drive road reserve. Survey data available for the site shows that the crest of the mound ranges from around 60.3m AHD to 61.0m AHD. The floodplain between the fill platform and the Black Creek channel lies at around 57.2m AHD to 56.0m AHD.

The Black Creek floodplain in the vicinity of the site is relatively flat, containing several remnant channels and ponds – the most significant being a tight meander upstream of the site which has since been by-passed. A small bridge provides for the passage of Black Creek underneath Lomas Lane.

2.1.1 Existing Access Arrangement

The school has three access points via Lomas Lane (i.e. eastern, central, and western) as shown in Figure 2.3. The functions of the access points are described below.

- The easternmost access functions as a turning bay for buses; and access for service vehicles needing to access the northern part of the site and/or eastern service road.
- The central access currently functions as a vehicle entry point for cars accessing the northern carpark/kiss and drop areas.
- The western access functions as a vehicle-exit point.

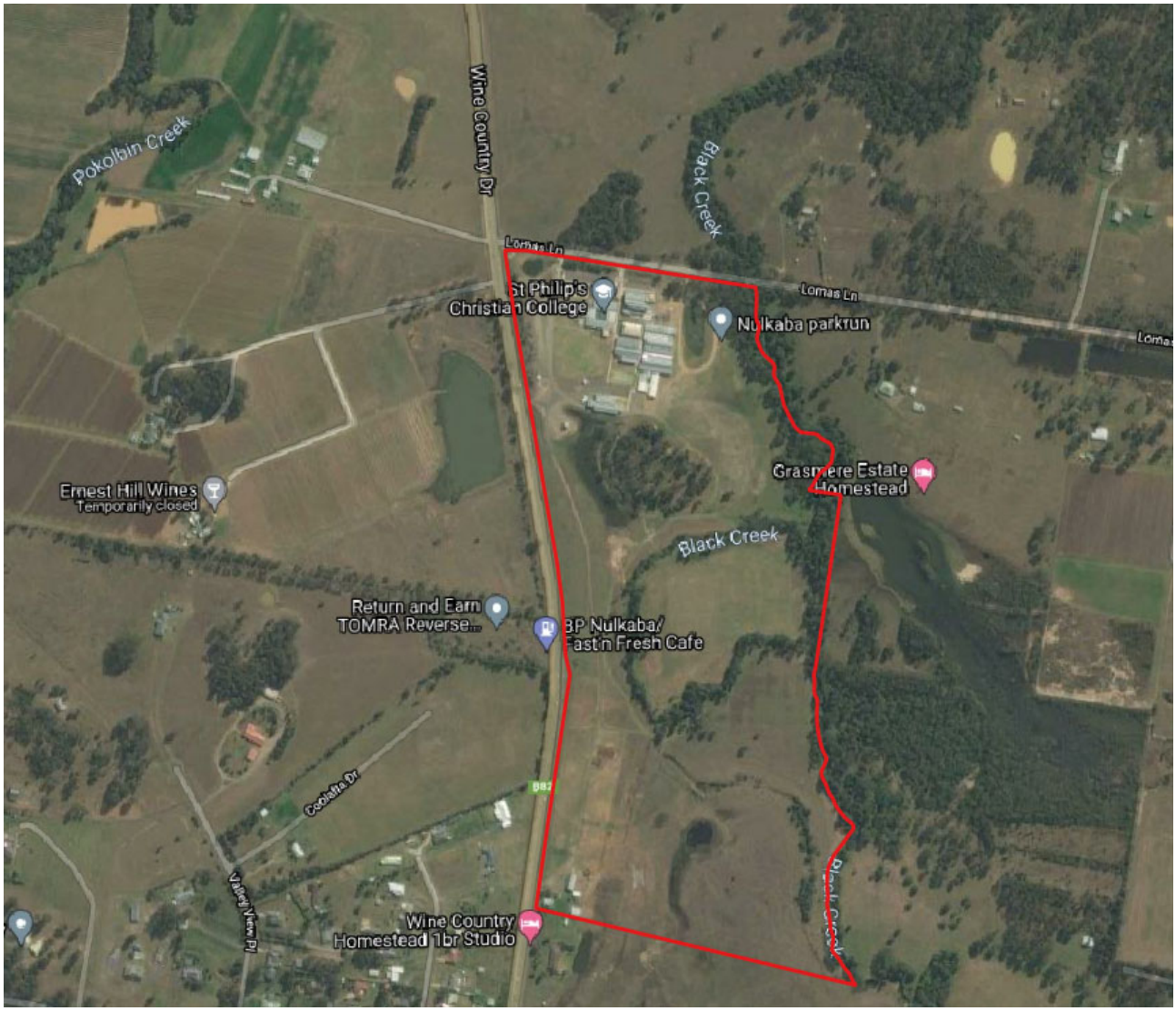


Figure 2.1 Site Locality Map

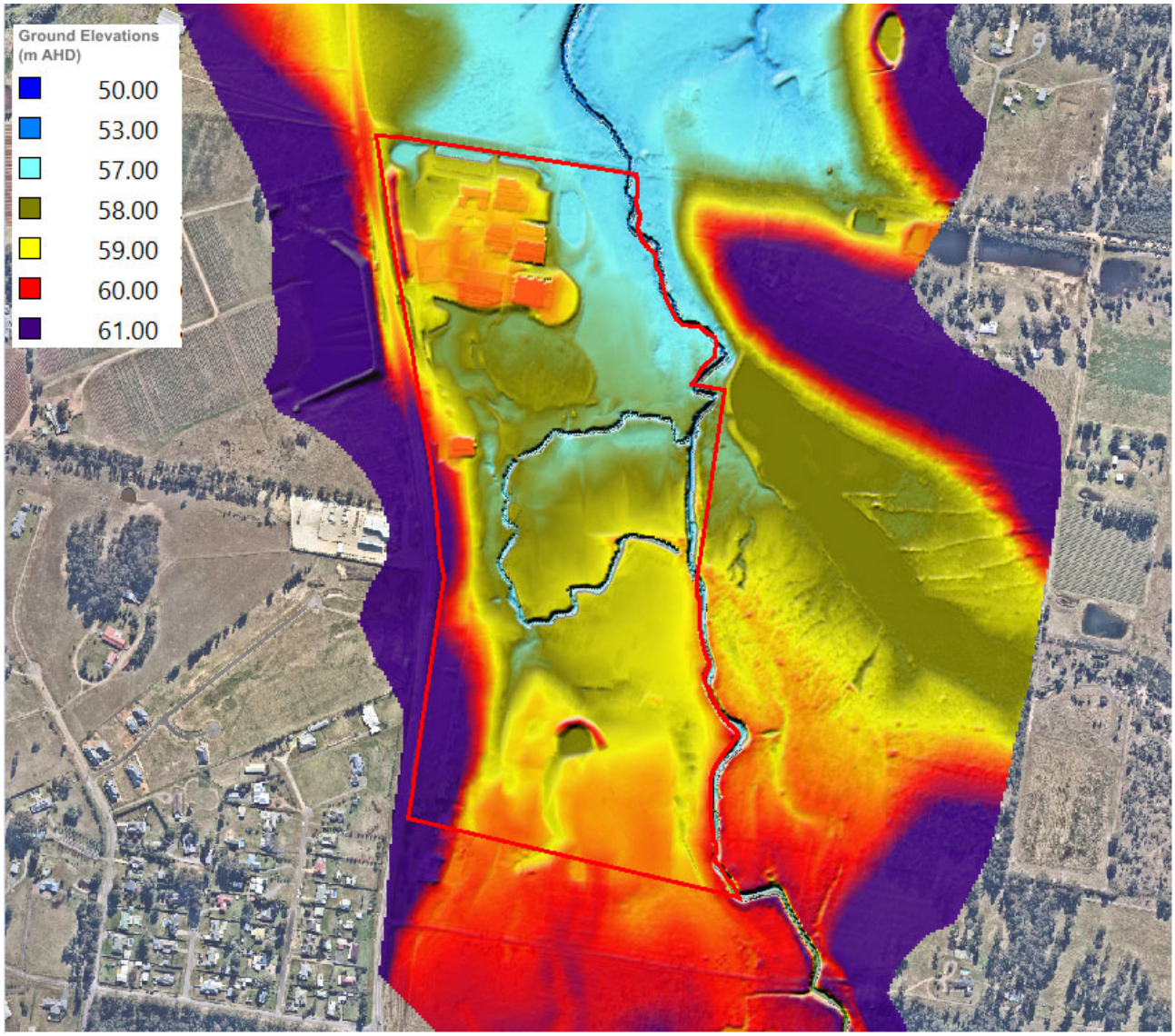


Figure 2.2 Existing Topography

Figure 2.3 Existing Access Points from Lomas Lane

2.2 Proposed Conditions

The proposed development, to be constructed in several stages, consists of seven (7) new buildings and additions/alterations to six (6) existing buildings. As part of the development certain existing prefabricated buildings will be removed to make way for new permanent buildings.

The proposed development also incorporates infrastructure works external to the site associated with provision of a new intersection on Wine Country Drive providing direct access to the school at the southern end of the campus (immediately south of the proposed aquatic centre), and the upgrade of the intersection of Wine Country Drive and Lomas Lane to a roundabout. Widening of Lomas Lane on the eastern side will also be carried out to facilitate the provision of bus bays and a bus layover area. The SSDA application seeks approval for an increase in student numbers by up to 1,732. Figure 2.4 shows the 2021 masterplan development layout. Annex A also contains the masterplan layout.

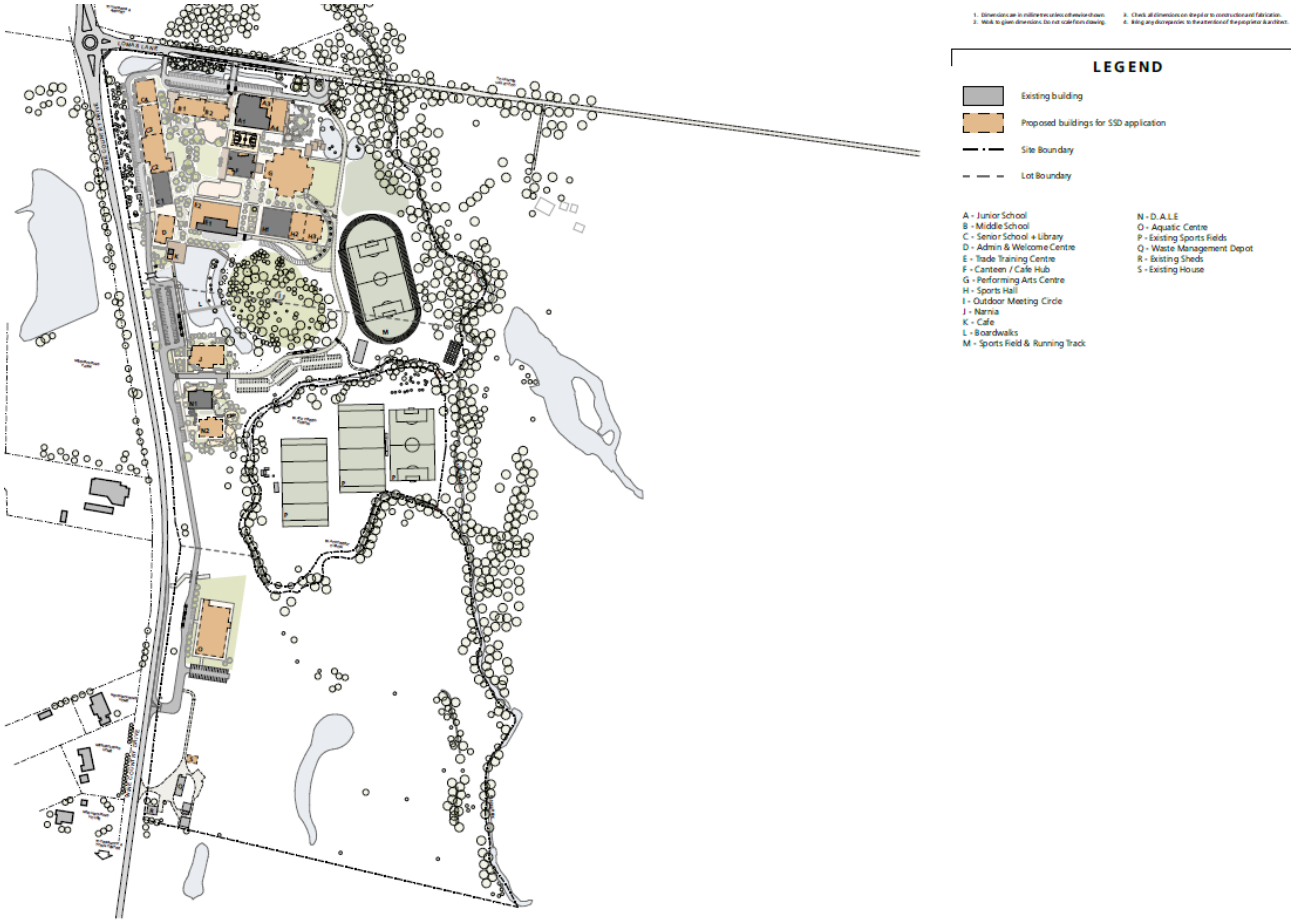


Figure 2.4 2021 Masterplan Development Layout

3 Review of Background Materials

This section provides a review of Cessnock City Council flood-related development controls and previous studies that have been considered and/or used in the preparation this flood impact assessment.

3.1 Council Development Control Plan

The Cessnock Development Control Plan (DCP) 2010 is Council's document used to guide and regulate developments. Chapter 9 of the DCP: Development on Flood Prone Land deals with developments within floodplains. The following sections provide a summary of the flooding aspects that have been considered in the preparation of this flood impact assessment. It is however noted that this is not an exhaustive review (nor a compliance assessment against the DCP), as the State Environmental Planning Policy (Educational Establishments and Childcare Centres) 2017 provides that a provision of a development control plan that specifies a requirement, standard or control in relation to development for the purpose of a school is of no effect, regardless of when the development control plan was made.

3.1.1 Objectives of the Chapter

The main objectives of Chapter 9 of the DCP include:

- Reduce risk to life and property resulting from floods by controlling development on flood prone land.
- Ensure that the impacts of the full range of flood sizes up to and including the Probable Maximum Flood (PMF) are considered when assessing development on flood prone land.
- Ensure that developers and the community are conscious of the potential flood hazard and consequent risk associated with the use and development of land within the floodplain.
- Ensure that all land uses, and essential services are appropriately sited and designed in recognition of all potential floods.
- Ensure that sensitive uses and facilities and critical infrastructure are not impacted by flood events.
- Ensure the future use of flood prone land does not cause undue stress to individuals or unduly increases potential flood liability to individuals or the community.
- Ensure that development on flood prone land does not place an unacceptable financial burden on landowners or the community.
- Ensure that development does not have a significant impact on flood behaviour, people's safety, surrounding properties and structures, and the natural environment.
- Protect the integrity of the flood plain, including riparian vegetation, fluvial geomorphologic environmental processes, and water quality.
- Ensure that the impact of climate change is considered when assessing development on flood prone land.

- Ensure that development on flood prone land is consistent with the NSW Flood Prone Land Policy and NSW Floodplain Development Manual 2005.

3.1.2 Council Flood Hazard and Risk Classification System

Hazard classification is to be based on the Australian Rainfall and Runoff Guidelines (ARR 2016) using the “H1” to “H6” classification system, with “H1” being the lowest hazard classification and “H6” being the highest. Based on Chapter 9 of the DCP, the hazard classification relates to the 1% AEP event except for critical infrastructure which is related to the PMF event. It notes that the following additional factors should be taken into consideration when locating and designing development:

- Isolation: are there safe evacuation routes to flood free land?
- Effective warning time: lack of effective warning times can increase the exposure of people to hazard.
- Rate of rise – a rapid rise in flood waters can lead to people evacuating being cut off from safe refugee or being overwhelmed.

3.2 Council Flood Mapping

Council has an online GIS database that contains different types of flood maps. The relevant flood inundation extents have been extracted for the 1% AEP and PMF events, hydraulic categorisation (flood function) for the 1% AEP event as well as the flood planning area (FPA). These are shown in Figure 3.1 to Figure 3.4.

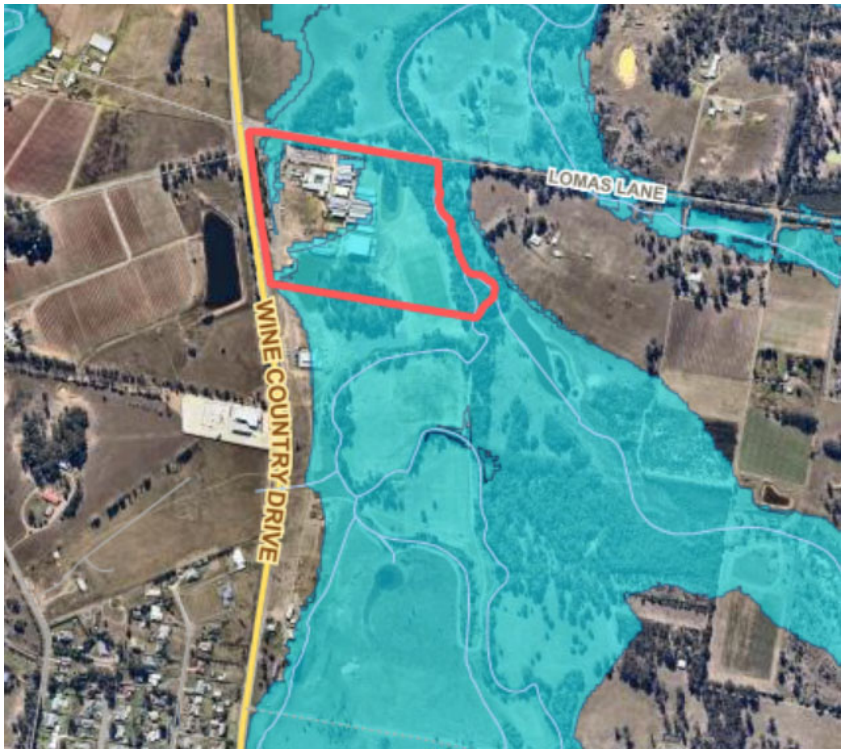


Figure 3.1 Council 1% AEP Inundation Extent

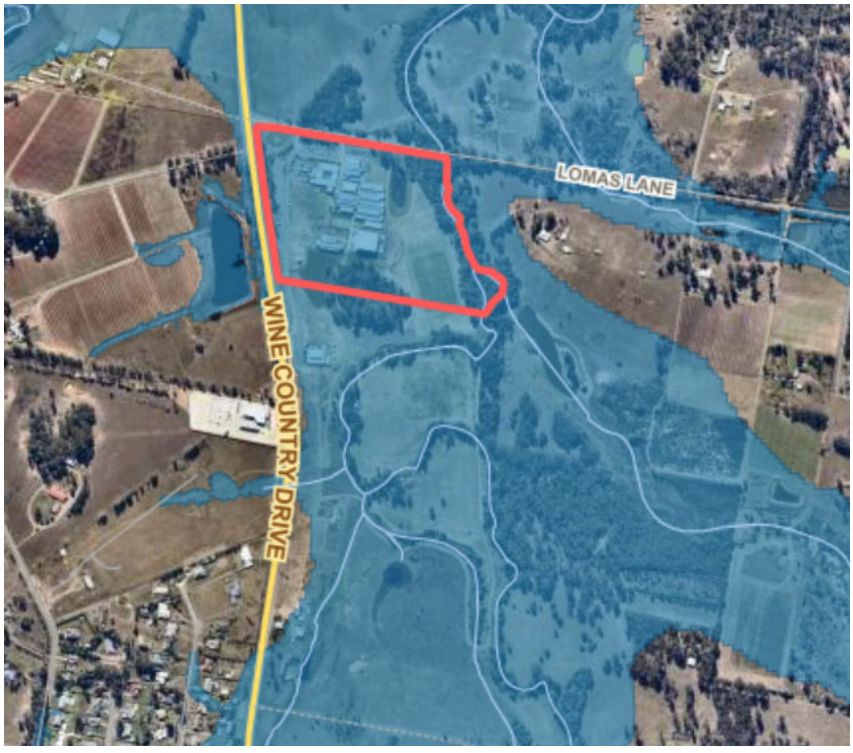


Figure 3.2 Council PMF Inundation Extent

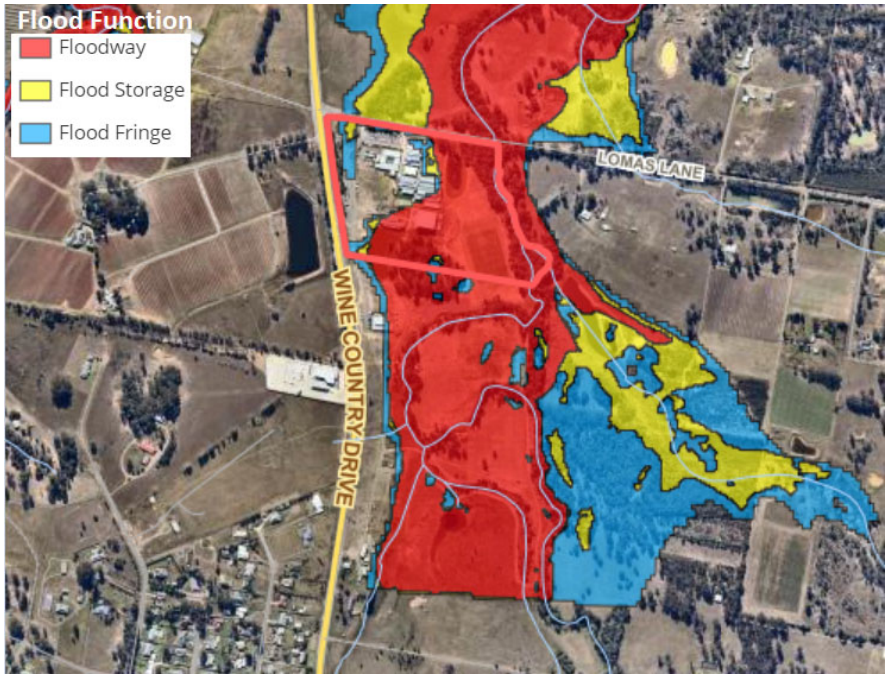


Figure 3.3 Council Black Creek Stage 2 1% AEP Flood Function

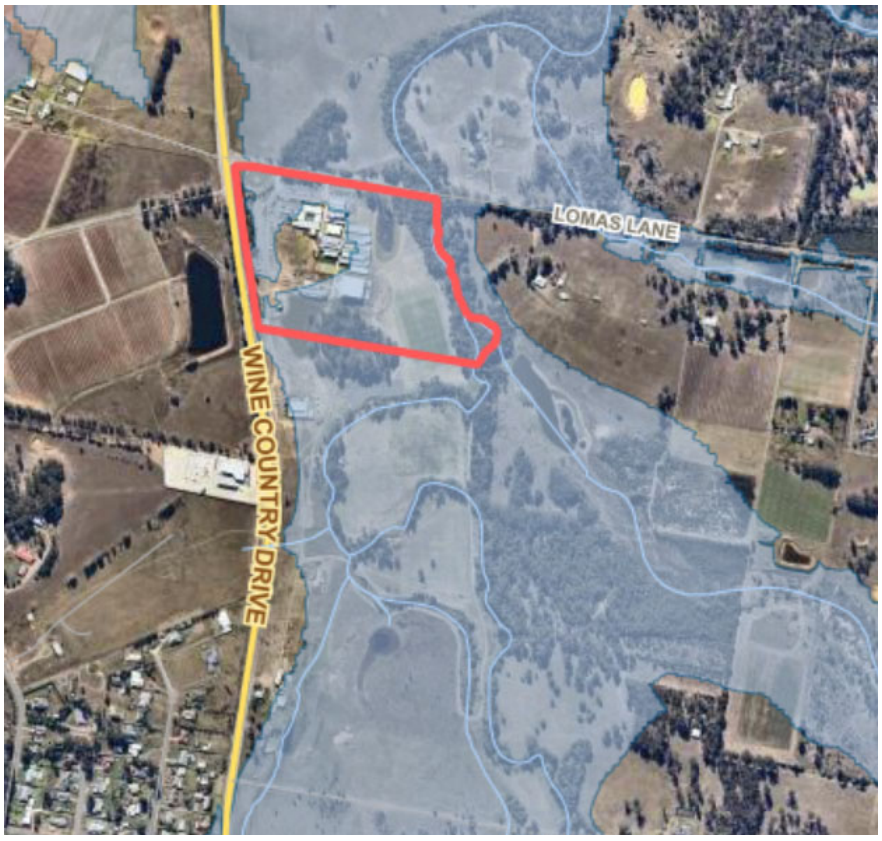


Figure 3.4 Council Flood Planning Area

3.3 Previous Studies

Several flood studies encompassing the study site have previously been undertaken and reviewed herein. Key model development details from each study are summarised as follows.

3.3.1 Black Creek Flood Study (DHI, 2010)

The “Black Creek Flood Study” (DHI, 2010) centres on the Cessnock CBD and covers the catchment area draining into Black Creek, upstream of Lovedale Road Bridge (Bancroft’s Bridge). The study developed an XP-RAFTS hydrologic model of the Black Creek catchment to Lomas Lane. The study found that the 9-hour storm was the critical duration for most of the area upstream of Fleming Street. The hydrologic model did not include Pokolbin Creek, as it is located outside of the study area.

The study utilised the MIKEFLOOD hydraulic modelling software package to define the flood behaviour for the upper Black Creek reaches. The MIKEFLOOD model couples MIKE-11 (1D (one-dimensional) representation of main channels) with MIKE-21 (2D (two-dimensional) overland flow modelling of the urban floodplain area of Cessnock). The area of interest for this study (i.e., between Fleming Street and Lovedale Road) was represented in the 1D model domain. The hydraulic model was calibrated to the June 2007 historical event, where the peak flood levels at Lomas Lane were predicted to be in the order of 58.8m AHD.

3.3.2 Black Creek Flood Study Stage 2 (WMAwater, 2015)

The “Black Creek Flood Study Stage 2” (WMAwater, 2015) focused on the reach of Black Creek downstream of Lomas Lane to Branxton. It included inflows from many tributaries including Pokolbin Creek. The study utilised the WBNM hydrologic modelling package to calculate inflows for the tributaries (including Pokolbin Creek) and the local Black Creek catchment within the study area as these were not available from the DHI (2010) study. The upstream model inflow at Lomas Lane was extracted from the DHI (2010) study.

The hydraulic model consisted of a fully 2D TUFLOW model of the entire study area. A 2D grid size of 10m was adopted. Modelled peak flood levels at Bancroft Bridge were 56.6m AHD for the 1% AEP and June 2007 historical event.

3.3.3 Black Creek FRMSP (Cardno, 2015)

The “Black Creek Floodplain Risk Management Study and Plan” (FRMSP) (Cardno, 2015) considers the same area included in the Black Creek Flood Study (DHI, 2010), i.e. the Black Creek catchment area upstream of Bancroft’s Bridge. The hydrologic model setup was as per the DHI (2010) study. The hydraulic model was similar to the DHI (2010) study, but the 2D area of the MIKEFLOOD model developed was extended to include LiDAR survey data captured in 2011. The updated model was validated against the June 2007 historical event to ensure consistency between the two models.

3.3.4 Approved SPCC Flood Impact Assessment (Worley Parsons, 2009)

The SPCC flood impact assessment undertaken by Worley Parsons (2009) was completed to support the DA for the original campus development proposal. This DA (including the flood impact assessment) has been approved by Council.

The study applied the flow hydrographs at Lomas Lane determined by DHI (2010) as the upstream model inflow boundary. A climate change assessment was included in the study which considered a

20% increase in flow rates. As the DHI (2010) XP-RAFTS model did not include Pokolbin Creek, an estimate of the 1% AEP peak flow rate at the Wine Country Drive Bridge was made based on relative catchment areas, providing an additional 120m^3/s at the confluence of Black and Pokolbin Creeks.

A 1D HEC-RAS hydraulic model was developed for the area, extending from Fleming Street to Bancroft's Bridge (Lovedale Road). Peak flood levels from the 1% AEP design event including climate change were recommended as the final 1% AEP levels to assist in planning at the site. Modelled 1% AEP design peak flood levels upstream of Lomas Lane were in the order of 58.3m AHD.

3.3.5 SPCC Flood Impact Assessment (BMT, 2017)

BMT previously completed the "St Philip's Christian College, Cessnock Flood Impact Assessment" (BMT, 2017). This FIA developed an XP-RAFTS hydrologic and TUFLOW hydraulic model of the Black Creek covering the area between Fleming Street (upstream model extent) and 275m downstream of Lovedale Road bridge (downstream model extent). The BMT (2017) assessment defined the baseline flood behaviour based on the 2009 approved development conditions.

For the study herein, the XP-RAFTS model from the BMT (2017) assessment has been used (without modifications), while the TUFLOW model has been modified to incorporate the latest site survey information (including drainage structures) and representation of the existing school buildings, as detailed in the following sections.

4 Development of Models

4.1 Hydrologic Model

A hydrologic model converts the gross rainfall (falling on a catchment) into effective rainfall, and then into runoff/streamflow and predicts the attenuation of the streamflow as it travels down the catchment. This hydrologic process is dependent on several factors, such as catchment area and level of urbanisation; rainfall intensity and its temporal pattern and spatial distribution; and antecedent conditions of the catchment (rainfall losses).

The hydrologic model of the study area has been developed as part of the BMT (2017) assessment using the XP-RAFTS software. The following sections describe the key model inputs and hydrologic parameters used in the XP-RAFTS model in accordance with the Australian Rainfall and Runoff 1987 (AR&R 87) guideline. It is noted that for the FIA herein, the XP-RAFTS model from the BMT (2017) assessment has been used without modifications.

4.1.1 Catchment Characteristics

The combined Black Creek and Pokolbin Creek catchment was delineated into thirty-five sub-catchments based on available digital elevation model (DEM) derived from LiDAR survey. Figure 4.1 shows the sub-catchment layout used in the XP-RAFTS model.

Each sub-catchment was modelled as two discrete areas (impervious and pervious) to reflect the level of urbanisation. Predominately urbanised sub-catchments were assumed to be 55% impervious and 45% pervious, while undeveloped sub-catchments were assumed to be 100% pervious (in other words, no impervious areas).

The sub-catchments were assigned with appropriate Manning's 'n' (PERN) values depending on the level of urbanisation, as listed in Table 4.1.

Table 4.1 PERN Values

Catchment Condition	PERN Value
Urban Areas	0.04
Cleared Land	0.06
Densely Vegetated	0.12

4.1.2 Rainfall Loss

The hydrologic analysis implemented the initial-continuing loss approach which is an accepted industry practice. The ARR1987 recommends an initial loss (IL) of 10mm and continuing loss (CL) of 2.5mm/hr for the NSW East Coast area, and hence these have been adopted.

4.1.3 Streamflow Routing

The sub-catchment inflows were routed through the next downstream sub-catchments in a cascading manner using the “Lag time” approach. The Lag times were calculated for each reach using an average velocity of 0.5m/s.

4.1.4 Rainfall Intensity and Temporal Pattern

Rainfall depths are usually determined from standard design rainfall intensity-frequency-duration (IFD) curve for a given locality or catchment for events up to and including the 0.2% AEP.Table 4.2 presents the relevant design rainfall intensities (mm/hr) for the study area for a range of annual exceedance probability (AEP) events.

In terms of temporal distribution of the rainfall, this study used the design temporal pattern Zone 1 for design events up to and including the 0.2% AEP.

For the Probable Maximum Flood (PMF) event, the rainfall depths and temporal pattern were defined in accordance with the Generalised Short Duration Method (GSDM) (Bureau of Meteorology, 2003).

Table 4.2 Average Rainfall Intensity

Durations	10% AEP	5% AEP	2% AEP	1% AEP
6	12.5	14.5	17.2	19.2
9	9.70	11.4	13.3	15.2
12	8.16	9.53	11.3	12.8
24	5.34	6.23	7.42	8.35
36	4.15	4.80	5.70	6.40
48	3.43	3.98	4.72	5.29

4.1.5 Critical Durations and Calculated Peak Flows

A range of storm durations were simulated with the XP-RAFTS software and it was found that the 36-hour rainfall event resulted in the critical flow condition at the site for events up to and including the 0.2% AEP events. For the PMF event, the 6-hour storm was found to be critical for the catchment.

The predicted peak discharge rates upstream of Lomas Lane, derived from the XP-RAFTS model, are presented in Table 4.3.

Table 4.3 Predicted Peak Discharge Rates Upstream of Lomas Lane

Peak Discharge Rates (m^3/s)							
20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
122	154	196	238	281	324	385	1780

4.1.6 Validation of Hydrologic Model Predictions

The predicted peak discharge rates herein have been compared to those adopted in previous studies, as presented in Table 4.4. With reference to these results, the 1% AEP flow rate calculated at Lomas lane in this current study is within 15% of that adopted by WMAwater (2105), verifying that the XP-RAFTS hydrological model developed for this study is broadly consistent with that adopted in the Council's flood study.

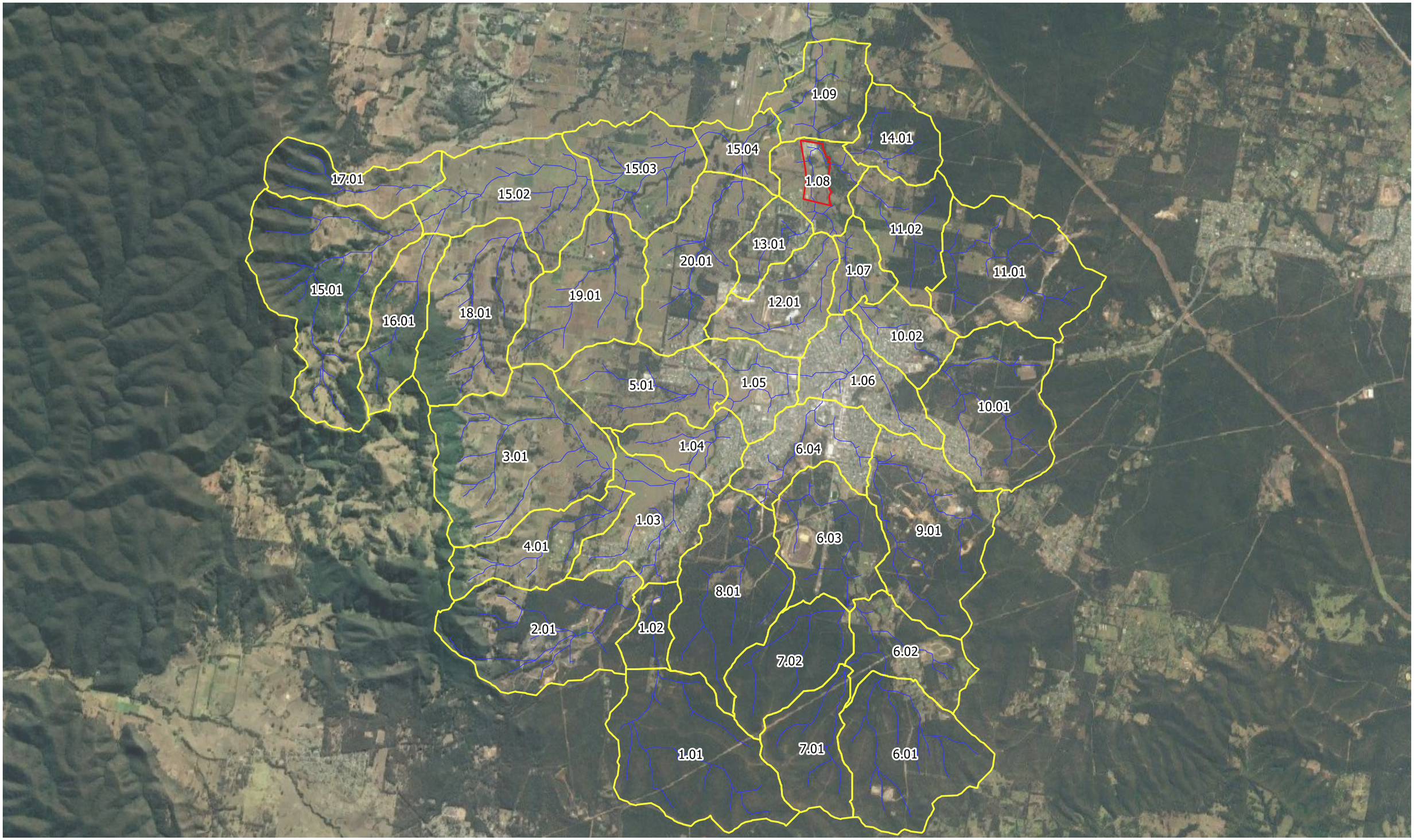
The peak PMF flow rates have also been compared between studies and are presented in Table 4.5. The PMF flow adopted for Worley Parsons (2009) was provided by DHI and is significantly lower than the flow determined by WMAwater (2015) and that derived for this current study. The PMF flow rate calculated for this study is within the range (and closer to the upper limit) of flows determined by the previous studies.

Table 4.4 Comparison of the 1% AEP Peak Discharge Rates at Lomas Lane

Study	Peak Flow (m^3/s)	Critical Duration (min)
DHI (2010)	318	9h
WMAwater (2015)	325	36h
Worley Parsons (2009)	382	9h
This Assessment	281	36h

Table 4.5 Comparison of PMF Peak Discharge Rates at Lomas Lane

Study	Peak Flow (m^3/s)	Critical Duration (min)
DHI (2010)	1180	6h
WMAwater (2015)	2130	6h
Worley Parsons (2009)	910	6h
This Assessment	1780	6h



Legend

- Site Boundary
- Sub-Catchment
- Streams

Title:

XP-RAFTS Sub-catchment Layout

Drawing: **4-1**

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BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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4.2 Hydraulic Model

A 2D model of Black Creek (containing the subject site) has been developed using the TUFLOW software package (Build 2018-03-AC-iSP) as per the BMT (2017) assessment. The key components of the hydraulic model setup are described in the following sections.

4.2.1 Model Extent and Topography

The 2D domain covers the area between Fleming Street (upstream model extent) and 275m downstream of Lovedale Road bridge (downstream model extent), as shown in Figure 4.2.

The 2D domain adopted a cell size of 4m to provide an accurate definition of the floodplain, including local topographical features. The underlying model DEM has been generated from a combination of a 1m resolution DEM derived from the 2011 LPI LiDAR elevation dataset and a more recent site survey completed by Marshall Scott Surveying and Land Development Consultants (Drawing Reference: 22972-DET.dwg, dated 23/07/2021).

4.2.2 Boundary Conditions

Upstream boundary conditions of the hydraulic model have been defined as inflows along Black Creek and Pokolbin Creek. Local sub-catchment inflows were also applied within the model domain within the subject site.

The downstream boundary was defined by a water level-discharge relationship, where discharge estimates for a range of water levels are determined based on the channel cross-section and geometry of the Lovedale Road bridge.

4.2.3 Structures

The model included the following structures:

- Existing bridges under Lomas Lane and Lovedale Road crossings of Black Creek and Wine Country Drive crossing of Pokolbin Creek. These were represented within the model as a 2D layered flow constriction.
- Existing cross drainages within the site and underneath Wine Country Drive on the western boundary of the site. These were represented as 1D structures embedded within the 2D domain with a dynamic linkage between the two (1D and 2D) domains.

4.2.4 Hydraulic Roughness Parameters

Another input required in the development of the TUFLOW model is the assignment of different hydraulic roughness zones to represent the variation in flow resistance. The Manning's 'n' roughness values adopted for this study are listed in Table 4.6.

Table 4.6 Adopted Hydraulic Roughness Parameters

Surface Condition	Manning's 'n' Value
Cleared Land	0.06
Creeks	0.08
Dense Vegetation	0.12
Road Reserve and Paved Areas	0.02
Existing Buildings within the Site	0.40
Well Maintained Grass	0.035

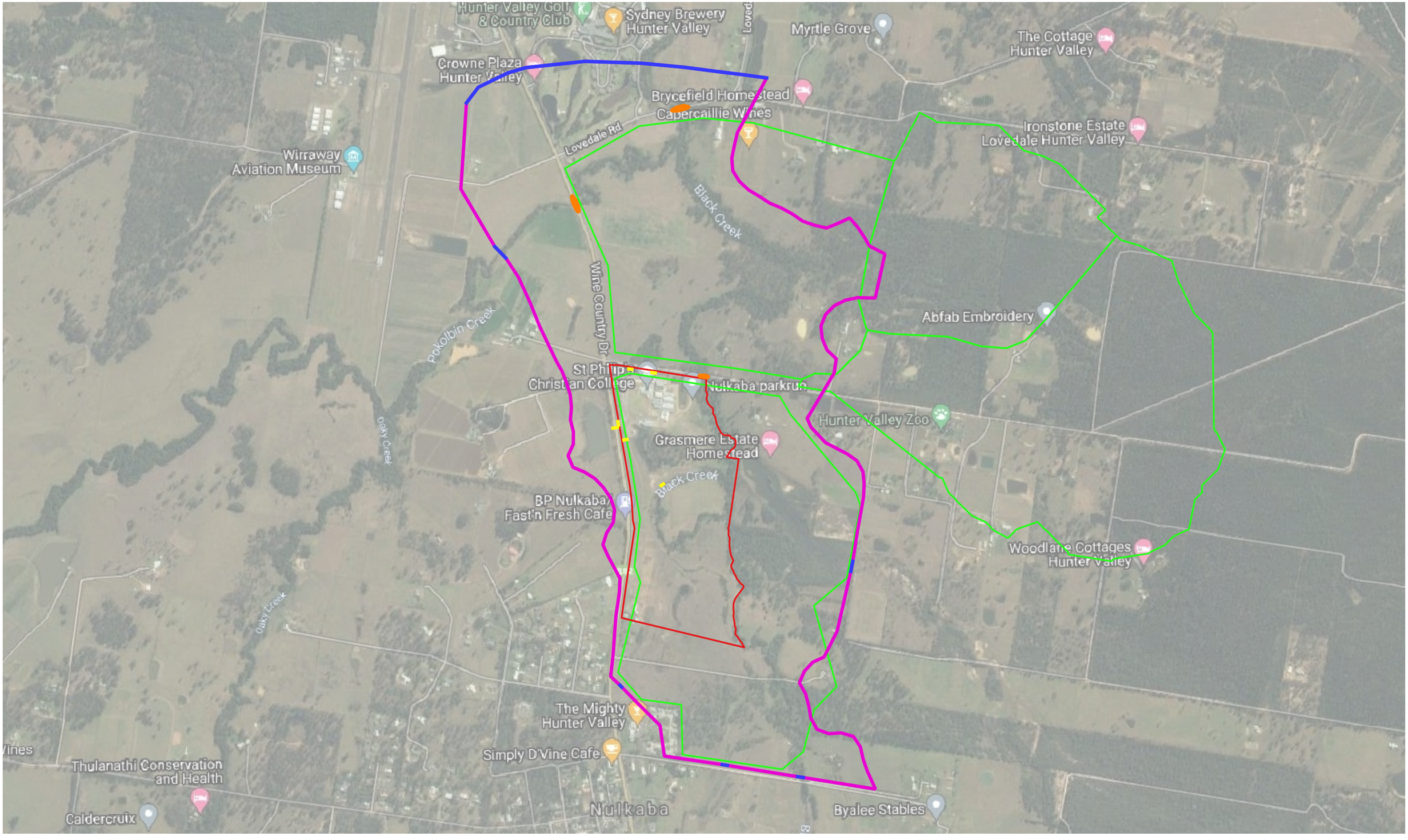
4.2.5 Validation of Base Case Hydraulic Model Performance

Peak flood levels at two locations, namely upstream of Lomas Lane (US LL) and upstream of Bancroft's Bridge (US BB) have been extracted and compared, as presented in Table 4.7. Evidently, there is a considerable discrepancy between the modelled peak flood levels between each of the studies, especially when considering the reduced upstream inflow adopted for this current study. The difference in peak flood levels is most likely a function of the different hydraulic models used and the adopted model parameters, such as Manning's roughness values. It is noted that this study did not involve calibration of the hydraulic model using the Manning's roughness values.

For some historical context, during the April 2015 event, a peak water level mark was recorded 300mm under the existing school building at the SPCC site, located on the eastern side of the fill platform. From available LiDAR information, this level is estimated to be around 58.0m AHD. The WMAwater (2015) study estimated that the 2015 historical event rainfall was in the order of 5% AEP to 2% AEP, when compared to the Bureau of Meteorology (BoM) IFD data. Under the existing scenario (i.e. the site topography in the model is representative of what is currently on the ground), peak flood levels modelled at the flood mark location in this study were 58.0m AHD and 58.2m AHD for the 5% AEP and 2% AEP, respectively. This demonstrates that the models developed for this study provide a reasonable consistency with the observed historical flood conditions at the site.

Table 4.7 Comparison of Base Case TUFLOW Model Performance

Study	1% AEP Event		PMF Event	
	US LL	US BB	US LS	US BB
DHI (2010)	-	-	-	-
WMAwater (2015)	57.6	56.6	60.3	59.0
Worley Parsons (2009)	58.3	57.5	59.4	58.8
This Assessment	58.3	57.0	60.8	59.7



Legend

- Existing Culvert
- Existing Bridge
- Site Boundary
- Boundary Conditions
- 2D Domain
- Local Inflows

Title: **Base Case TUFLOW Layout**

Drawing: **4-2**

Rev: **A**

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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4.2.6 Modelling of Proposed Development

The proposed development will involve filling associated with the proposed new buildings and alterations to existing buildings. It also involves filling associated with the proposed internal roads, including a new access from Wine Country Drive on southern end of the site (immediately south of the proposed aquatic centre). BMT iteratively optimised the proposed fill extent and levels within the TUFLOW model in coordination with Northrop Consulting Engineers (civil designers for the site). The design has been optimised to achieve the following design criteria:

- The building fill levels are based on the height of the 1% AEP peak flood level + 0.5m freeboard.
- The internal road levels are based on the height of the 1% AEP peak flood level.
- The fill extents do not result in an adverse flood impact beyond the boundaries of the site.

Northrop provided the design DEM (Reference: XP_NL167397_DESIGN_DTM.dwg) dated 26 October 2021. Figure 4.3 shows the extent and levels of the proposed site grading (fill). Figure 4.4 shows the topography difference (post-development minus pre-development) derived from the modelled DEM output check file.

To represent the flow-obstruction effects of the proposed new buildings during larger flood events (greater in magnitude than the 1% AEP events), a Manning's 'n' value of 0.4 was assigned to the buildings.

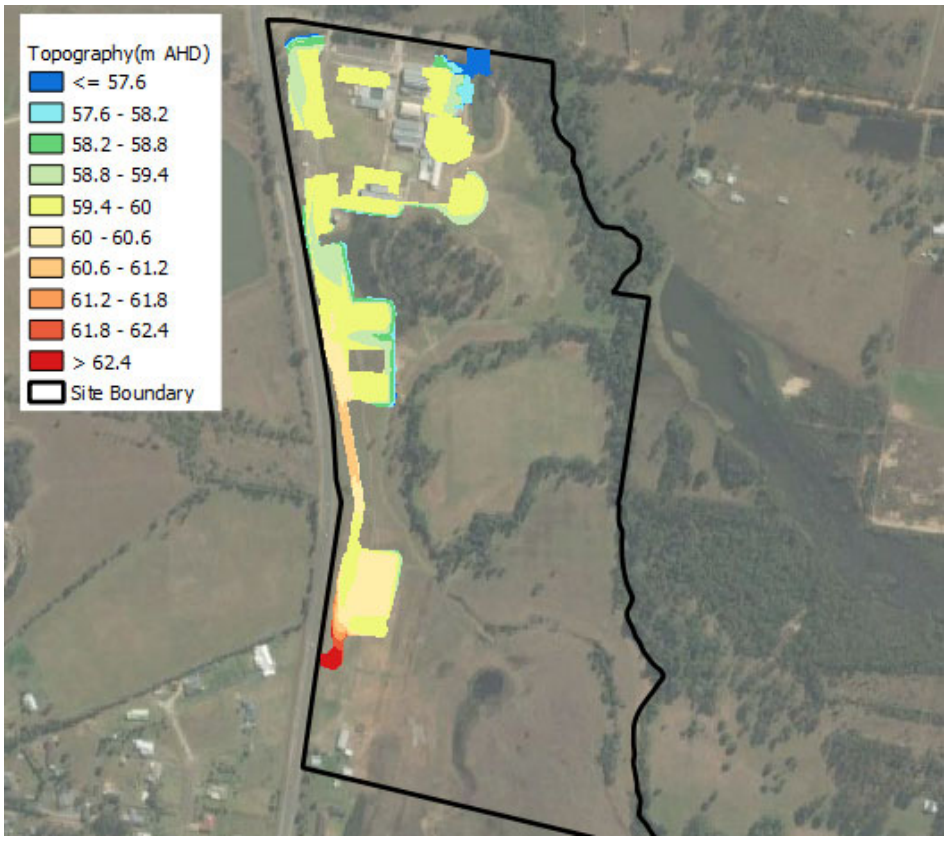


Figure 4.3 Proposed Site Grading Elevations

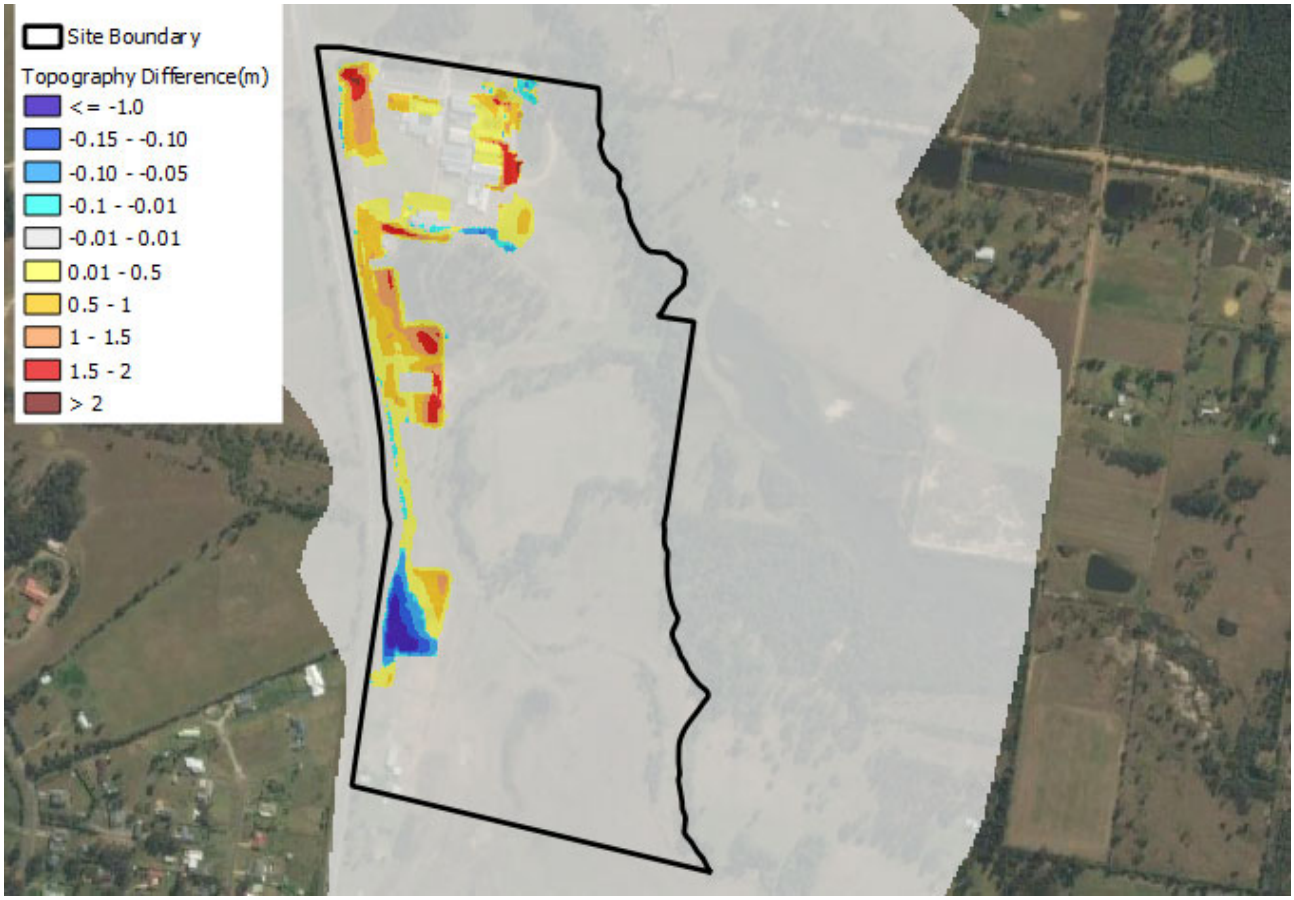


Figure 4.4 Topography Difference Between Post-Development and Pre-development Scenarios

5 Hydraulic Model Results

5.1 Pre-development Flood Behaviour

The predicted pre-development (baseline) flood behaviour, including peak flood level, flood depth and flood hazard classification) have been extracted from the TUFLOW model results and mapped for a range of flood including the 20%, 10%, 5%, 2%, 1%, 0.5% and 0.2% AEP and PMF events. These are contained in Annex B, as listed below.

- Figure B-1 to B-8 show the pre-development peak flood level maps.
- Figure B-9 to B-16 show the pre-development peak flood depth maps.
- Figure B-17 to B-24 show the pre-development peak flood hazard classification maps.

Based on the pre-development modelling results, the following key flooding conditions are observed in and around the subject site.

- The existing elevated or developed part of the school (the north western quadrant block) for the most part is not inundated during events up to and including the 0.2% AEP (1 in 500 AEP). This part of the school is subject to inundation in the PMF event, with a flood depth of up to 1.5m and flood hazard classification of “H4” to “H5”, i.e., unsafe flow conditions for people and vehicles. Figure 5.1 Refer to the Australian Institute of Disaster Resilience (AIDR) Hazard classification system.
- The existing main access point (easternmost access) from Lomas Lane is subject to inundation in the 20% AEP (1 in 5 AEP) event with a peak flood depth up to 0.4m, as shown in Figure 5.2. However, the central and western access points to the northern carpark from Lomas Lane are either flood-free or trafficable during flood events up to and including the 5% AEP (1 in 20 AEP) events.
- Lomas Lane is subject to inundation and not trafficable during rare flood events including the 2% AEP (1 in 50 AEP). However, the northern carpark is elevated and flood-free for flood events up to and including the 0.5% AEP (1 in 200 AEP).
- The road alignment of the proposed exit from the northern carpark to the southern part of the school (immediately south of the existing western dam) is subject to inundation (and not trafficable) during flood events including the 10% AEP (1 in 10 AEP). Figure 5.3 shows this proposed alignment overlaid on the 1% AEP peak flood depth map.

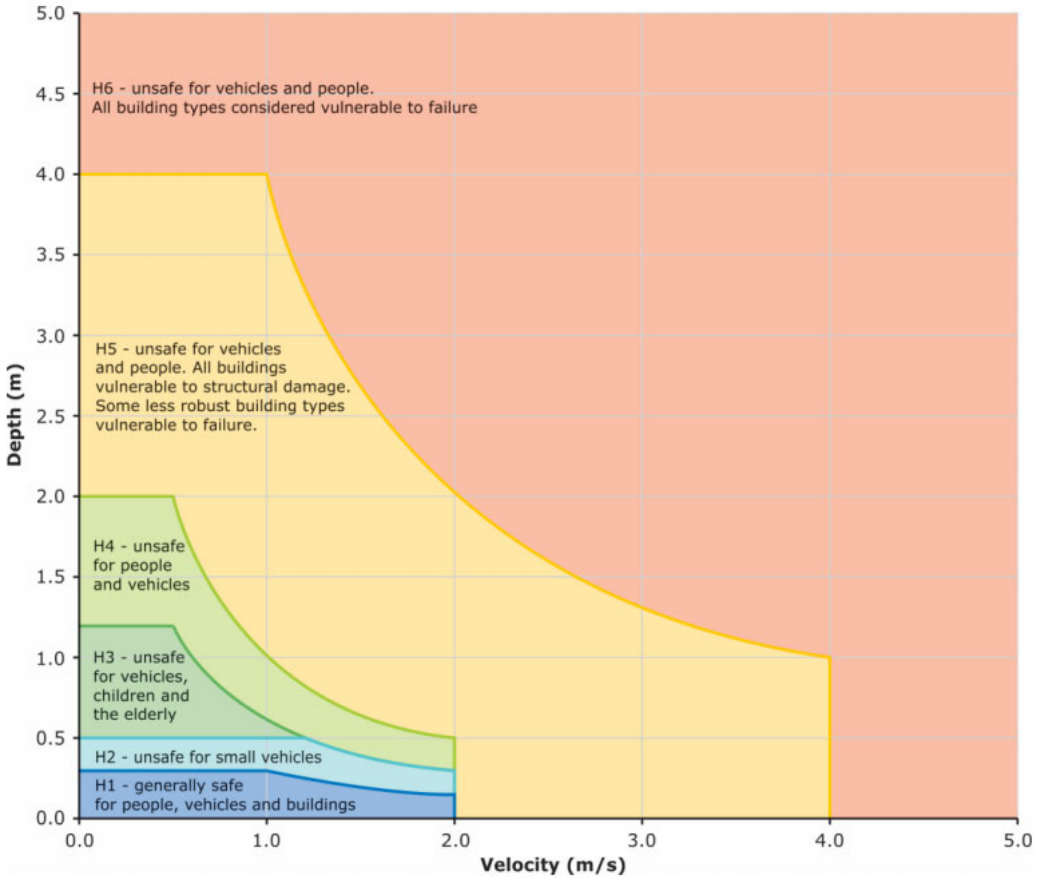


Figure 5.1 AIDR Flood Hazard Classification System

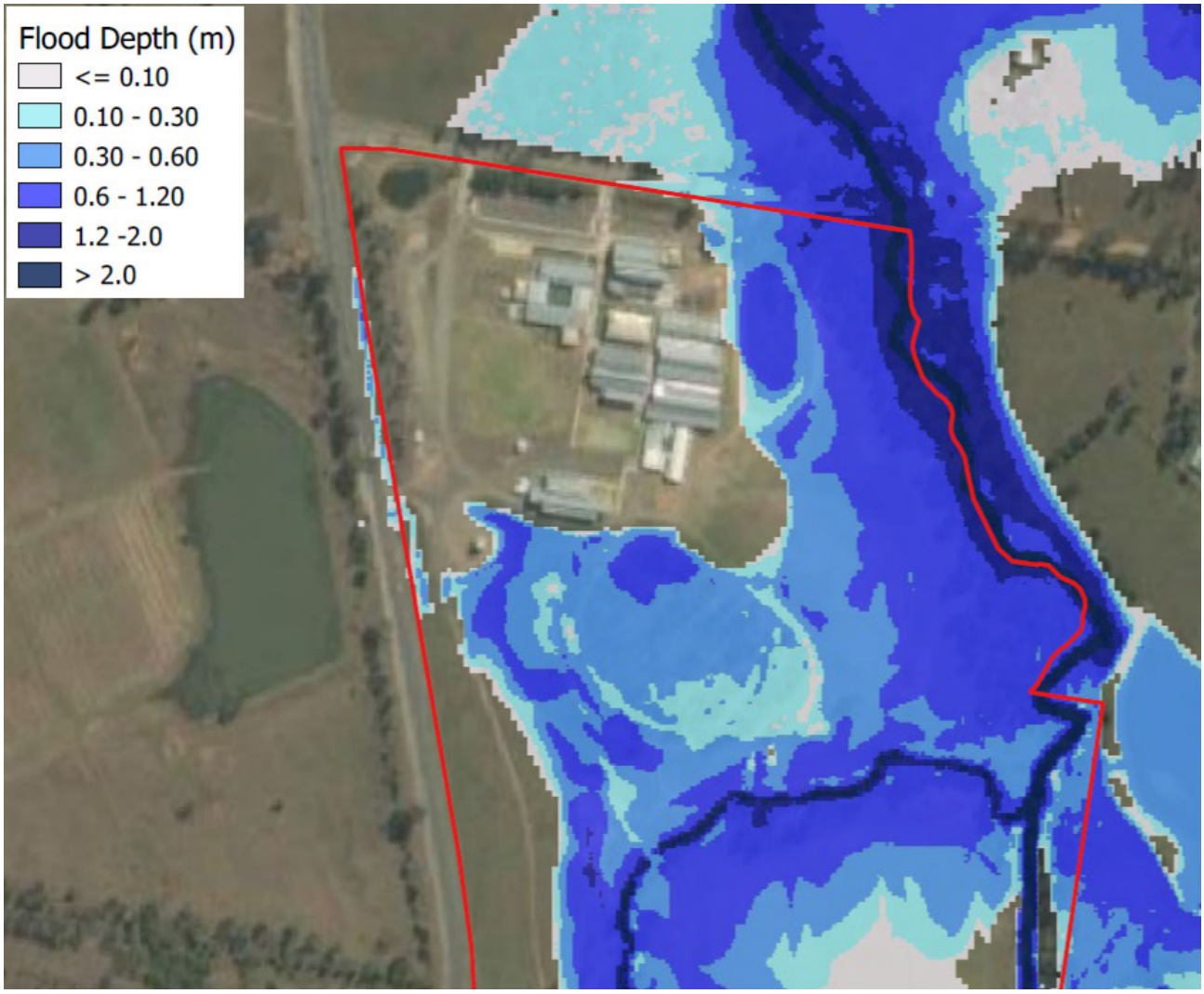


Figure 5.2 1 in 5 AEP Pre-development Peak Flood Depth at Existing Access Point

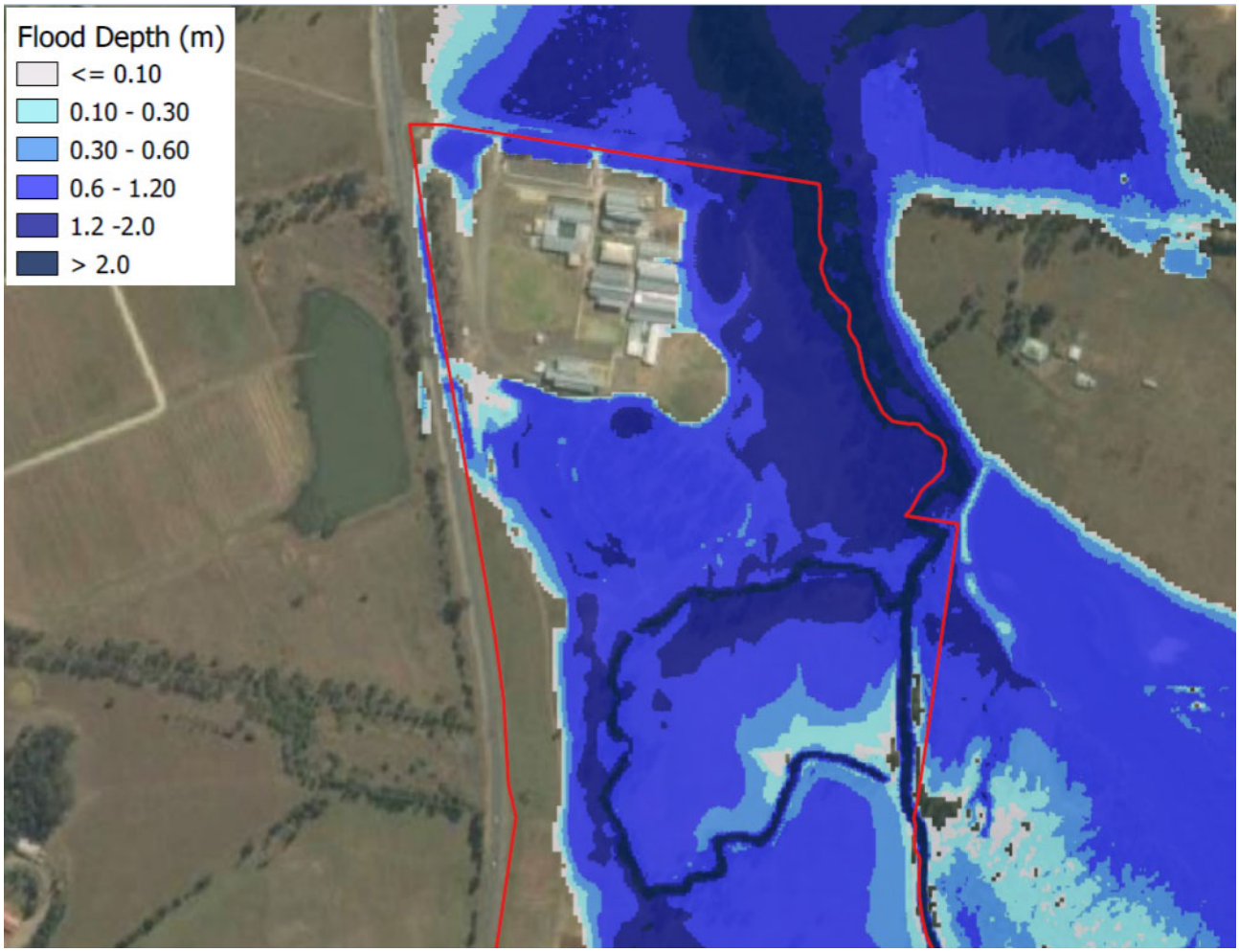


Figure 5.3 1 in 100 AEP Pre-development Peak Flood Depth

5.2 Post-development Flood Behaviour

The predicted post-development flood behaviour, including peak flood level, flood depth and flood hazard classification have been extracted from the TUFLOW model results and mapped for a range of flood including the 20%, 10%, 5%, 2%, 1%, 0.5% and 0.2% AEP and PMF events. These are contained in Annex C, as listed below.

- Figure C-1 to B-8 show the post-development peak flood level maps.
- Figure C-9 to C-16 show the post-development peak flood depth maps.
- Figure C-17 to C-24 show the post-development peak flood hazard classification maps.

Based on the post-development modelling results, the following key flooding conditions are observed in and around the subject site.

- The existing and proposed new school buildings will be flood-free during flood events up to and including the 0.2% AEP (1 in 500 AEP).

- The proposed internal road along Wine Country Drive (north-south alignment) leading up to the new access point via Wine Country Drive (immediately south of the proposed aquatic centre) is predicted to be flood-free during flood events up to and including the 1 in 500 AEP. For perspective, Figure 5.4 shows the 1 in 100 AEP peak flood depth map.
- The existing and new school buildings are inundated during the PMF event, with a flood hazard classification of “H4”, with the hazard increasing to “H5” in carparking and ground areas, as shown in Figure 5.5.

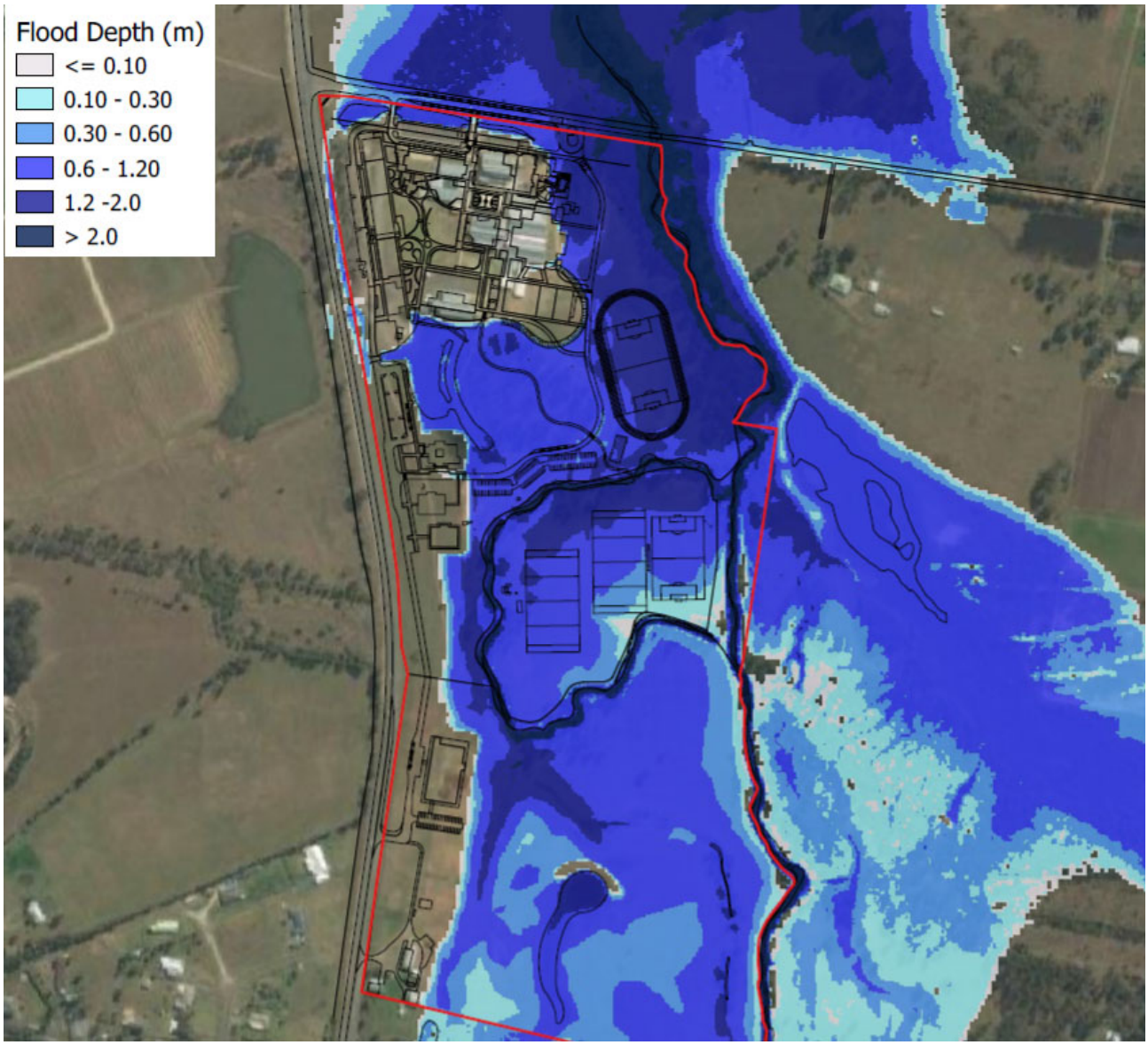


Figure 5.4 1 in 100 AEP Post-development Peak Flood Depth Map

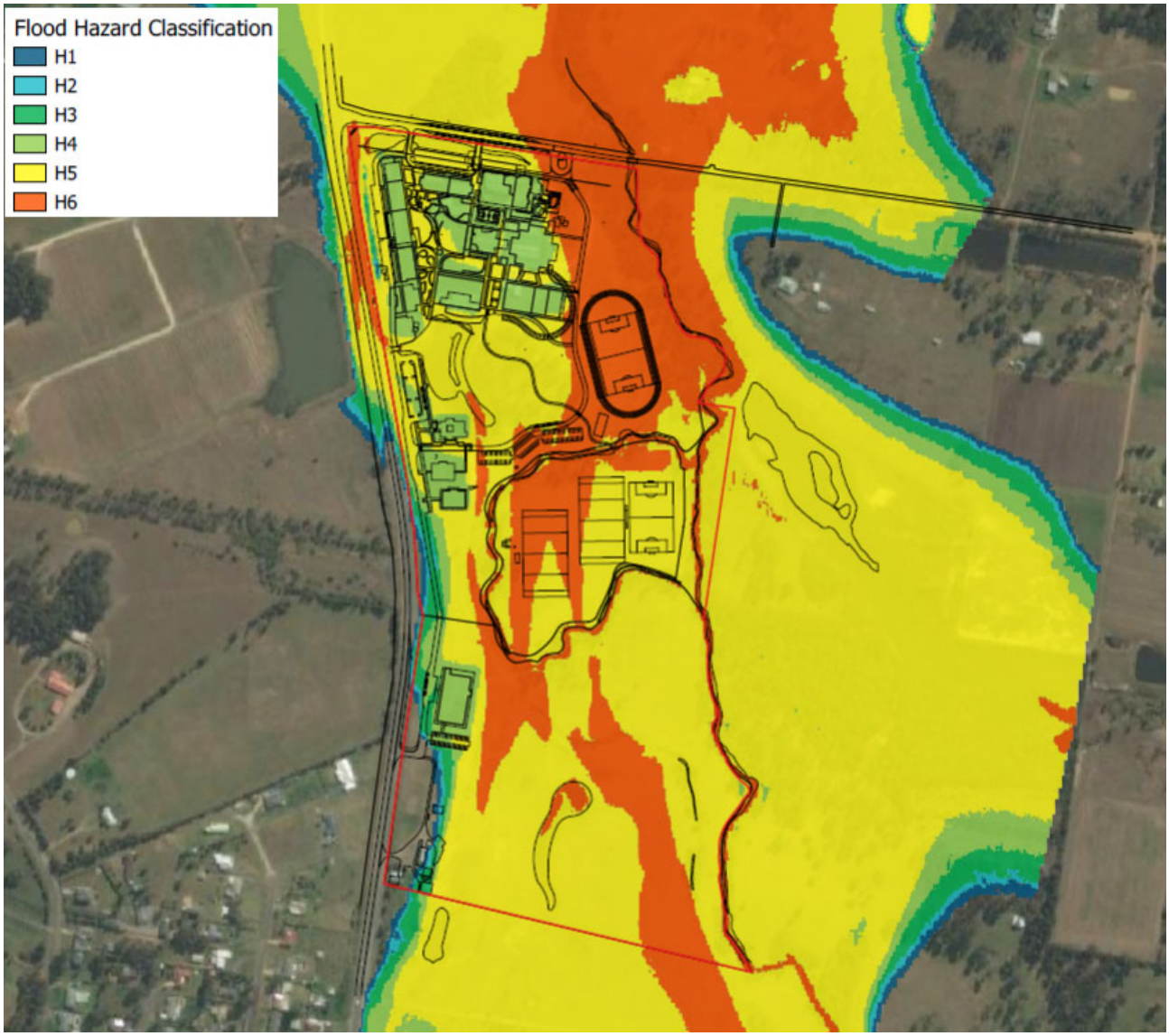


Figure 5.5 PMF Post-development Flood Hazard Classification

5.2.2 Off-site Flooding Impacts

The predicted increase in peak flood levels (afflux) have been determined and mapped for the 20%, 10%, 5%, 2%, 1%, 0.5% and 0.2% AEP and PMF. These are contained in Annex D of this report. The predicted afflux results are summarised as follows:

- The proposed development will not result in an adverse increase in peak flood level beyond the boundaries of the site for events up to and including the 1 in 20 AEP (i.e., the afflux is within 20mm which is considered minor and acceptable).
- For events larger in magnitude than the 1 in 20 AEP, the proposed development has been predicted to result in increases in peak flood level greater than 20mm beyond the boundaries of the site. Table 5.1 provides the predicted affluxes in the adjoining lot immediately east of Black Creek (See the reporting point in Figure 5.6 below) for a range of events up to and including the PMF. The

results indicate that the exceedance above the 20mm threshold is marginal for events up to and including the 1 in 500 AEP events.

- During the PMF event, the proposed development is predicted to result in a maximum off-site afflux of 140mm predominately to the east of Black Creek. However, more importantly, the proposed development is not predicted to significantly alter the flood hazard level (classification) in the areas impacted. It is noted that the PMF provides an upper limit of flooding and is mainly used for emergency response planning purposes to address the safety of people (NSW Floodplain Development Manual, 2005) and to ensure that no serious risk to life and property would occur. It is an improbable event with a notional AEP of 1 in 10,000,000 (BoM, 2003). Hence, as the proposed development will not result in a change in the peak flood hazard classification beyond the boundaries of the site, it is considered that the development does not significantly alter existing flood risks in the PMF event.

Table 5.1 Offsite Flood Impacts at Reporting Point East of Black Creek

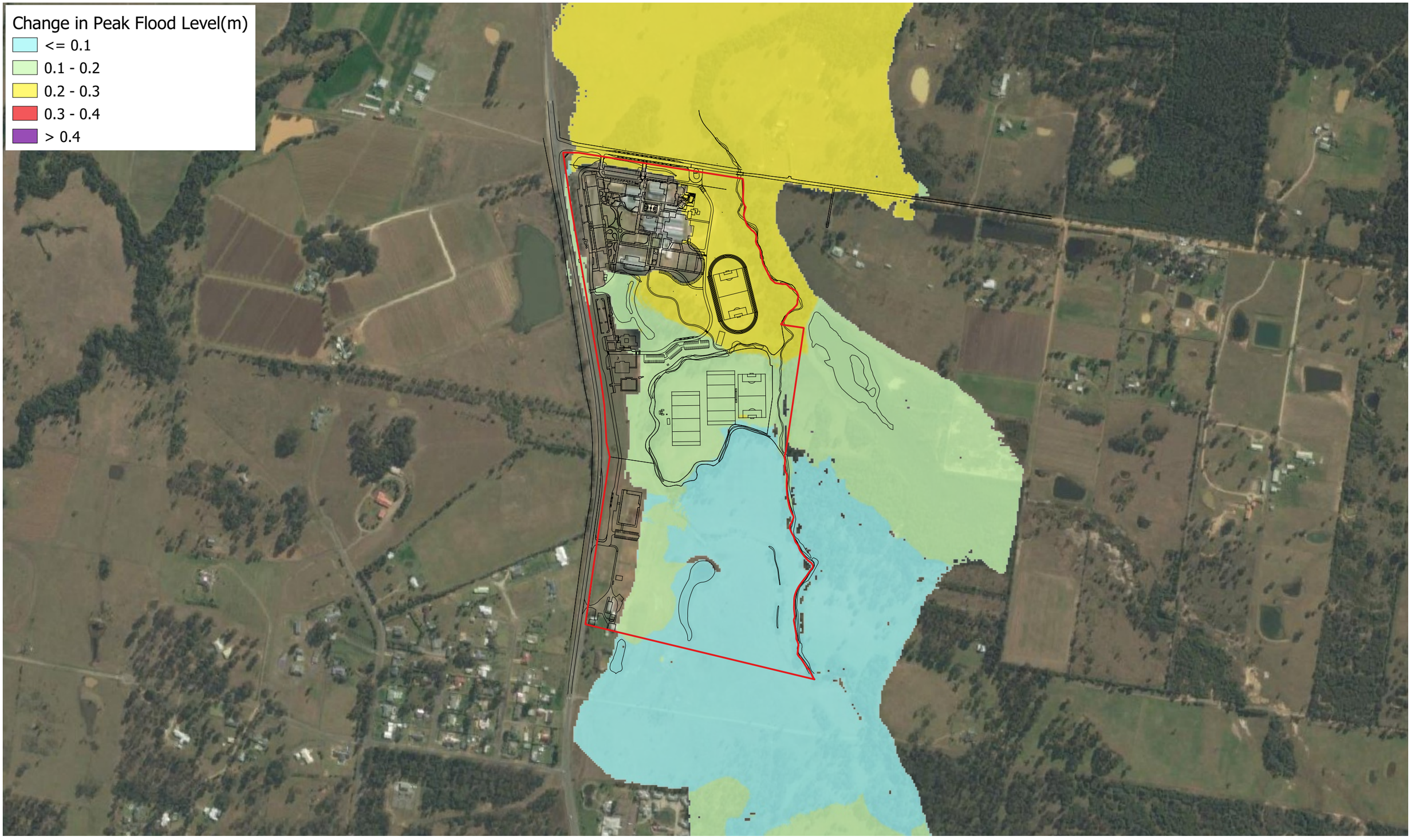
AEP	Afflux (mm)
1 in 5	3
1 in 10	9
1 in 20	14
1 in 50	22
1 in 100	25
1 in 200	27
1 in 500	32
PMF	110

Figure 5.6 1 in 100 AEP Zoomed-in Afflux Map

5.3 Climate Change Impact on Flooding

A climate change assessment has been undertaken based on a 20% increase in flow rates to mimic the influence of rainfall increase (due to climate change) on flooding. For the analysis, the 1% AEP event has been used wherein the inflow hydrographs were increased by 20% in the post-development TUFLOW model.

Figure 5.7 shows the predicted increases in the 1% AEP peak flood level. The modelling predicted a maximum flood level increase of 0.3m within the site. This indicates that school building floor levels (designed based on the height of the 1% AEP +0.5m freeboard) would remain higher than the 1% AEP peak flood levels under the climate change scenario.



Legend

- Site Boundary
- Development Layout

Title:

Climate Change Impact on the 1% AEP Flood Event

Drawing: 5-7

Rev: A

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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5.4 Social and Economic Impacts

As demonstrated in the preceding sections, the proposed development is not predicted to result in significant modifications of flood behaviour beyond the boundaries of the site (i.e., no significant increase in peak flood level during events up to and including the 1 in 500 AEP. For the PMF event, the proposed development will not significantly alter the flood hazard level in the surrounding properties and roads. This will ensure that any potential existing evacuation routes in the locality (emergency management arrangement) will not be adversely impacted.

Therefore, the proposed development is not anticipated to result in an adverse social and economic impact associated with flooding.

6 Review of Previous FERP

As part of this flood impact assessment, BMT undertook a high-level review of the preliminary flood emergency response plan (FERP) previously prepared by Worley Parsons (2009) as part of the approved DA, Council's flood mapping in conjunction with the flood modelling results documented herein. The outcomes of the review are summarised in the following sections.

6.1 Worley Parsons (2009) FERP

The Worley Parsons (2009) flood assessment report included a preliminary flood emergency response plan (FERP). The main flood emergency or evacuation issues and findings identified in the study are outlined below:

- Calculations undertaken by Worley Parsons estimated that the flood levels during a PMF would be expected to be above the 1% AEP flood level for approximately 6 hours.
- Given the problems associated with the evacuation of up to 1,500 students during adverse weather conditions associated with an extreme flood such as a PMF, the proposed evacuation strategy is to provide on-site flood refuge for all students and staff. This will effectively minimise the evacuation distances and therefore timeframes, and also the requirement for assistance from emergency services.
- Calculations undertaken by Worley Parsons estimated that the 4-hour duration storm as the governing storm duration and suggested that the effective warning time during a PMF event would be in the order of 1 to 1.5 hours. The proposed FERP must be able to be practically implemented in this short timeframe under the adverse weather conditions associated with a PMF. It is therefore recommended that the FERP is implemented if inundation of the school playing fields occurs following heavy rainfall and/or State Emergency Services (SES)/ BoM storm warnings.

Key components of the preliminary FERP proposed in the Worley Parsons (2009) flood assessment report are summarised as follows:

- Initially, the flood refuge point will be located in the Stage 1 specialist facilities building during the early years of school operation. The flood refuge will be relocated to the auditorium once it is constructed (potentially 5 to 10 years after the school opening). Both buildings will comprise a minimum floor level set at the predicted PMF level. As such, these flood refuge locations are considered flood free.
- Access to both of the flood refuge locations will be provided through the emergency access to Wine Country Drive, located to the west of the site. The minimum level of this access will be 59m AHD, which is 0.5 m above the 1% AEP peak flood level and up to 0.7m below the PMF level. This access road would be trafficable by 4WD or emergency vehicles during the peak of the PMF.
- The proposed site grading has been configured to provide continuously rising evacuation paths to the higher portion of the fill pad (designated by the 59m AHD contour) that is located in the western portion of the site. This higher area contains both flood refuge buildings as well as the emergency access.

Figure 6.1 shows an extract of the preliminary evacuation plan from the Worley Parsons (2009) report.

The Worley Parsons (2009) report also recommended that a detailed Flood Emergency Response Plan (FERP) will need to be developed in close coordination with the SES and Council. In addition, the following guidelines were recommended:

- As soon as a Black Creek flood warning is issued by the SES, or floodwater is sighted in the lower areas of the floodplain, the school will initiate their FERP. This plan will incorporate the following actions:
  - The school will contact the SES and brief them on their situation. SES will advise the school on the predicted severity of the flood and the appropriate action.
  - If the SES advises the implementation of the FERP, or if the school staff observes that the flood waters are a significant risk to the school, the school staff will evacuate all students and staff to the flood refuge location. Once at the flood refuge, a full roll call will be performed to confirm all students, staff and visitors/contractors on the site are present or to identify any missing persons. No staff, student or other member of the public will seek to exit the site via vehicle until advised by the SES.
  - The flood refuge should not be vacated at any time until instructed by the SES as floodwaters may still be rising upstream of the site.
- To maximise the flood preparedness, the Worley Parsons (2009) study recommended the following on-going measures:
  - The school will take a roll call every morning, including an inventory of all visitors/contractors on the premises to ensure an accurate head count can be undertaken if there is an emergency.
  - All staff at the school will be aware of the FERP and will have designated roles in the plan execution.
  - The school will maintain a SES approved radio communication device onsite at all times to ensure that communication with the SES and other authorities can be maintained in the event of power outage/phone lines being cut.
  - The school will restrict student access to the lower playing fields and courts during or following periods of heavy rainfall.

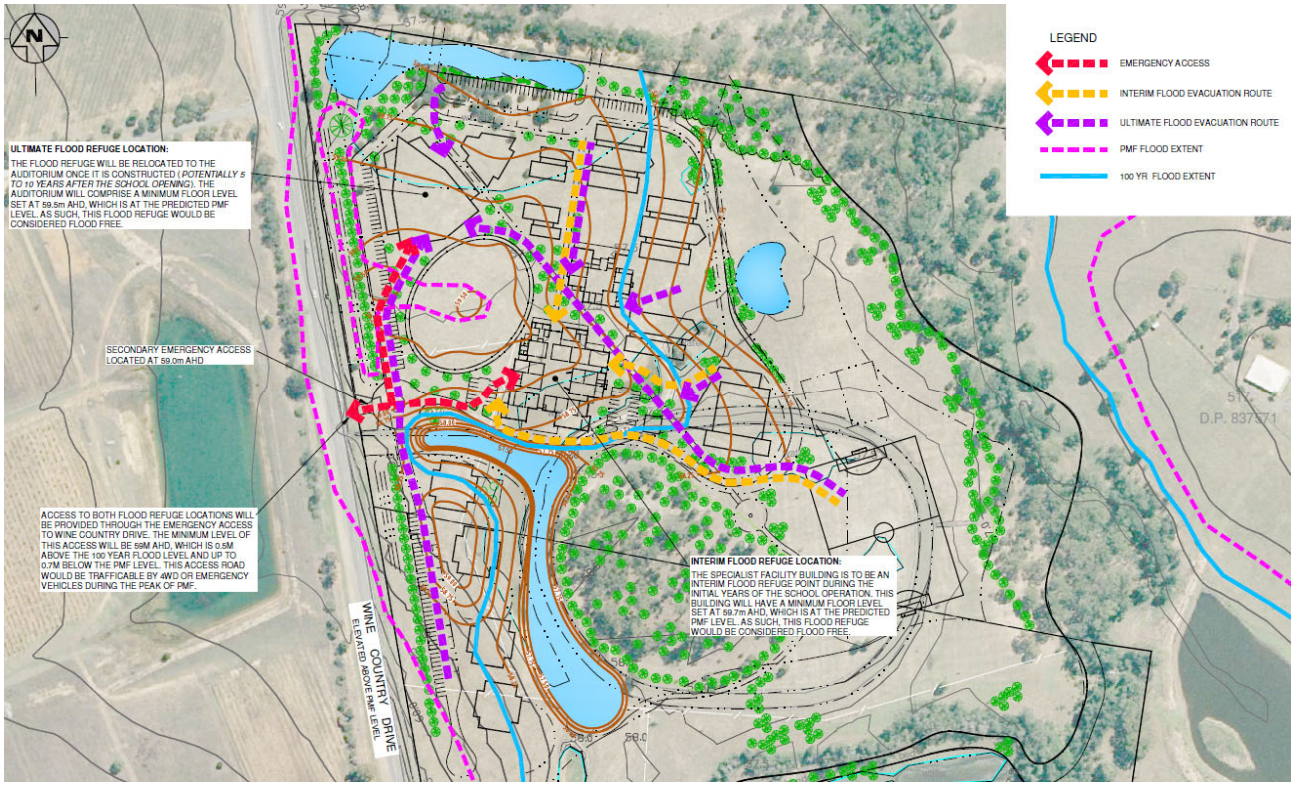

Figure 6.1 Worley Parsons (2009) Preliminary Flood Evacuation Plan

6.2 Commentary on the FERP

As part of this flood impact assessment, BMT also undertook a high-level review of the surrounding evacuation routes based on Council's flood mapping and the latest flood modelling results documented herein. Commentary on the FERP is given below:

- The new proposed access point from Wine Country Drive is situated further south of the old access point nominated in the Worley Parsons FERP. The Worley Parsons FERP claimed that the old access point (inundated by 0.7m in the PMF event) could be accessible by 4WD or emergency vehicles during such an event. This claim is not in line with current industry best practice.
- The proposed internal road along Wine Country Drive (north-south alignment) leading up to the new access point via Wine Country Drive (immediately south of the proposed aquatic centre) is predicted to be flood-free during flood events up to and including the 1 in 500 AEP.
- The existing and new school buildings are inundated during the PMF event, with a flood hazard classification of "H4", with the hazard increasing to "H5" in carparking and ground areas. Hence, the proposed onsite PMF refuge locations need to be designed commensurate with the predicted PMF flood hazard. The floor levels of the flood refuges need to be set at or above the PMF peak flood level.
- According to Council's flood mapping, Wine Country Drive leading to Cessnock is flood-free for the most part (during the 1 in 100 AEP event), except at the intersection with Fleming Street. However, the predicted flood hazard at this intersection is H1 and hence safe for people and vehicles in accordance with the AIDR flood hazard classification system.

- According to Council's flood mapping Wine Country Drive leading to Cessnock is subject to flood inundation during the PMF event for the section between the site and Cessnock.
- The Worley Parsons (2009) flood assessment considered up to 1,500 students, while the current approval seeks approval for an increase in student numbers up to 1,732. Hence, the FERP for the site needs to cater for the increased school occupancy.

In conclusion, the above review indicates that the FERP needs to be updated at a detailed design phase or prior to construction works to ensure that the plan is fit for the amended development masterplan.

Figure 6.2 Council's 1% AEP Inundation at Wine Country Drive and Fleming Street Intersection

7 Conclusions

BMT has prepared this flood impact assessment (FIA) report, on behalf of St Philip's Christian Education Foundation Ltd, to support a State Significant Development Application (SSDA) for alterations and additions to the existing school known as St Philip's Christian College (SPCC) Cessnock.

The school site is located within the Black Creek floodplain and affected by backwater flooding from the creek. It is therefore necessary to undertake a FIA to assess and ensure that the proposed development will not cause an adverse flood impact beyond the boundaries of the site. The flood impact assessment utilised the XP-RAFTS hydrologic and TUFLOW hydraulic models of the local study area. The detailed flood impact assessment has demonstrated the following flooding outcomes:

- The pre-development and post-development mainstream flood behaviour, such as peak flood level, depth and flood hazard have been defined for a range of design flood events, including the 20%, 10%, 5%, 2%, 1%, 0.5%, 0.2% AEP and PMF events.
- The existing elevated or developed part of the school (the north western quadrant block) is not inundated during events up to and including the 0.2% AEP (1 in 500 AEP). This part of the school, however, is subject to inundation in the PMF event, with a flood depth of up to 1.5m and flood hazard classification of "H4" to "H5" (i.e. unsafe flow conditions for people and vehicles).
- The existing main access point (easternmost access) from Lomas Lane is subject to inundation during the 1 in 5 AEP flood event. However, the central and western access points to the northern carpark from Lomas Lane are either flood-free or trafficable during flood events up to and including the 1 in 20 AEP events.
- Lomas Lane is subject to inundation and not trafficable during rare flood events including the 1 in 50 AEP flood event. However, the northern carpark is elevated and flood-free for flood events up to and including the 1 in 200 AEP.
- The proposed internal road along Wine Country Drive (north-south alignment) leading to the new access point via Wine Country Drive on the southern side is predicted to be flood-free during flood events up to and including the 1 in 500 AEP.
- The proposed development will not result in an adverse increase in peak flood level beyond the boundaries of the site for events up to and including the 1 in 20 AEP (i.e., the afflux is within 20mm which is considered minor and acceptable). For events larger in magnitude than the 1 in 20 AEP, the proposed development has been predicted to result in increases in peak flood level greater than 20mm beyond the boundaries of the site. However, the exceedance above the 20mm threshold is marginal. During the PMF event, the proposed development is predicted to result in a maximum off-site afflux of 140mm predominately to the east of Black Creek. However, more importantly, the proposed development is not predicted to significantly alter the flood hazard level (classification) in the areas impacted. However, more importantly, the proposed development is not predicted to increase the flood hazard level in the areas impacted and surrounding roads. Hence, as the proposed development will not result in a change in the peak flood hazard level beyond the boundaries of the site, it is considered that the development does not significantly alter existing flood risks in the PMF event.

- A sensitivity testing has been conducted based on a 20% increase in the peak flows on the 1% AEP event, and this demonstrated that the 1% AEP peak flood levels would increase by 0.3m within the site.
- A review of Council's flood mapping indicates that Wine Country Drive leading to Cessnock is flood-free during the 1% AEP event, except at the intersection with Fleming Street. During the PMF event, the road section between the school and Cessnock is inundated.
- Based on review of the preliminary flood emergency response plan previously prepared by Worley Parsons (2009), the main FERP consists of onsite PMF refuge located above the PMF flood level. The review indicates that the FERP needs to be updated at a detailed design phase or prior to construction works to ensure that the plan is fit for the amended development masterplan.
- Overall, based on the flood impact assessment herein, the proposed development is not anticipated to cause adverse social and economic impacts associated with flooding.

Annex A: Development Layout

For Information

1. Dimensions are in millimetres unless otherwise shown.
2. Work to given dimensions. Do not scale from drawing.
3. Check all dimensions on site prior to construction and fabrication.
4. Bring any discrepancies to the attention of the proprietor & architect.

LEGEND

- Existing building
- Proposed buildings for SSD application
- Site Boundary
- Lot Boundary

A - Junior School
B - Middle School
C - Senior School + Library
D - Admin & Welcome Centre
E - Trade Training Centre
F - Canteen / Cafe Hub
G - Performing Arts Centre
H - Sports Hall
I - Outdoor Meeting Circle
J - Narnia
K - Cafe
L - Boardwalks
M - Sports Field & Running Track
N - D.A.L.E
O - Aquatic Centre
P - Existing Sports Fields
Q - Waste Management Depot
R - Existing Sheds
S - Existing House

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RevB - WIP 03.12.21

Proposed Site Plan - Overall

St Philip's Christian College Cessnock
10 Lomas Lane, Nulkaba

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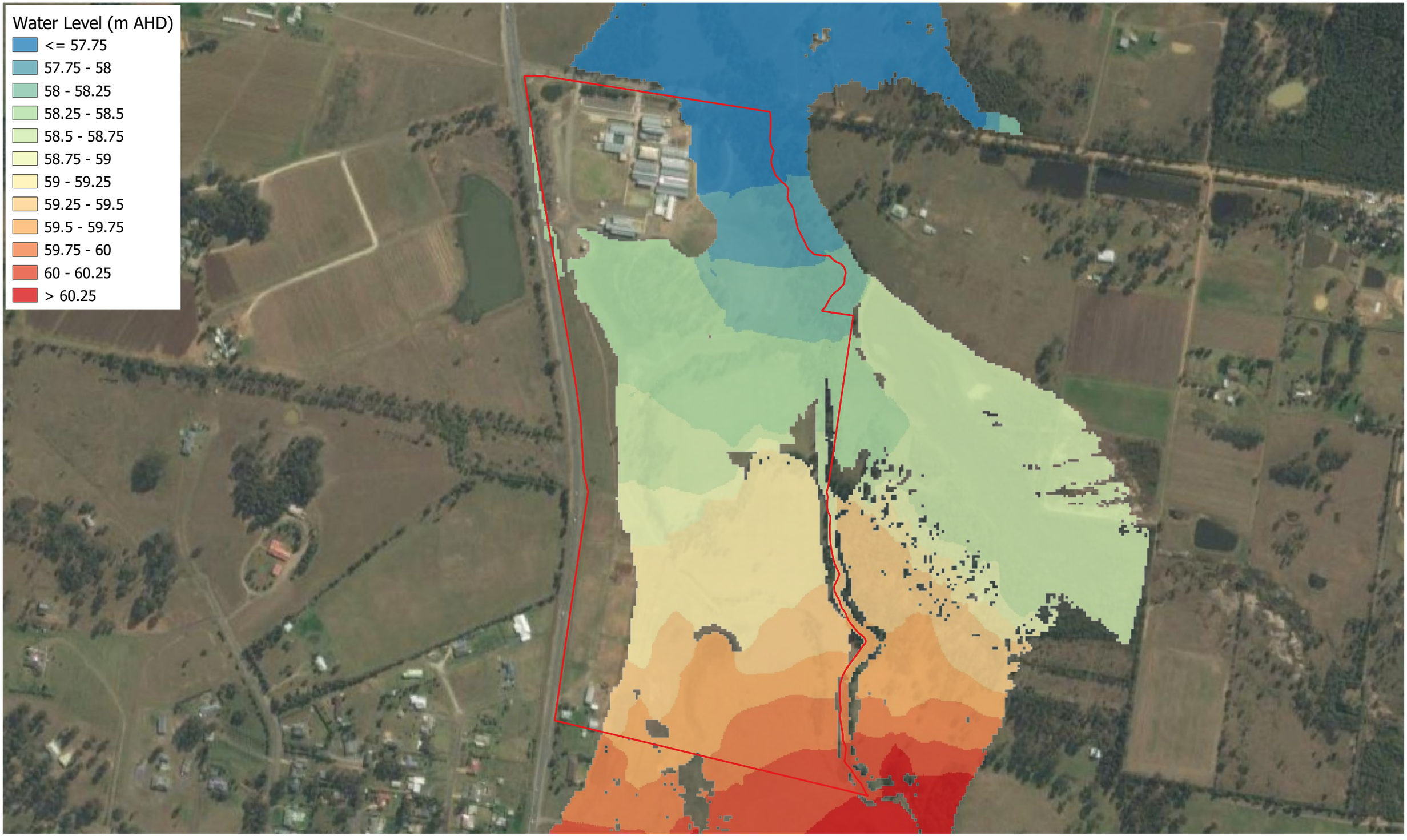
SHAC

Nominated Architect Justin Hamilton (6160) | ABN 32 131 584 846

Annex B: Pre-development Flood Maps



Legend

Site Boundary

Title:

20% AEP Pre-development Peak Flood Level

Drawing: B-1

Rev: A

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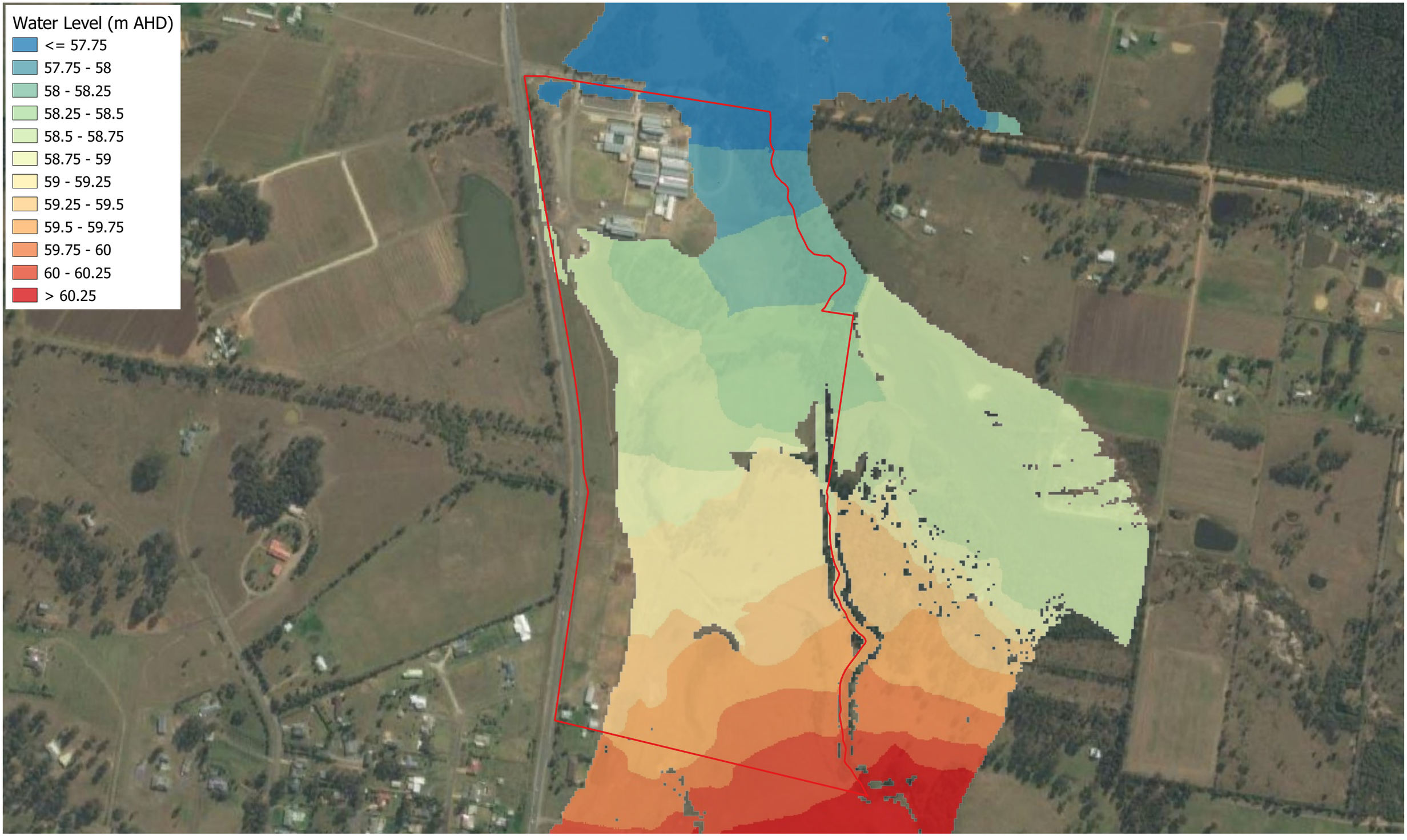

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Site Boundary

Title:

10% AEP Pre-development Peak Flood Level

Drawing: B-2

Rev: A

0 100 200 m

BMT
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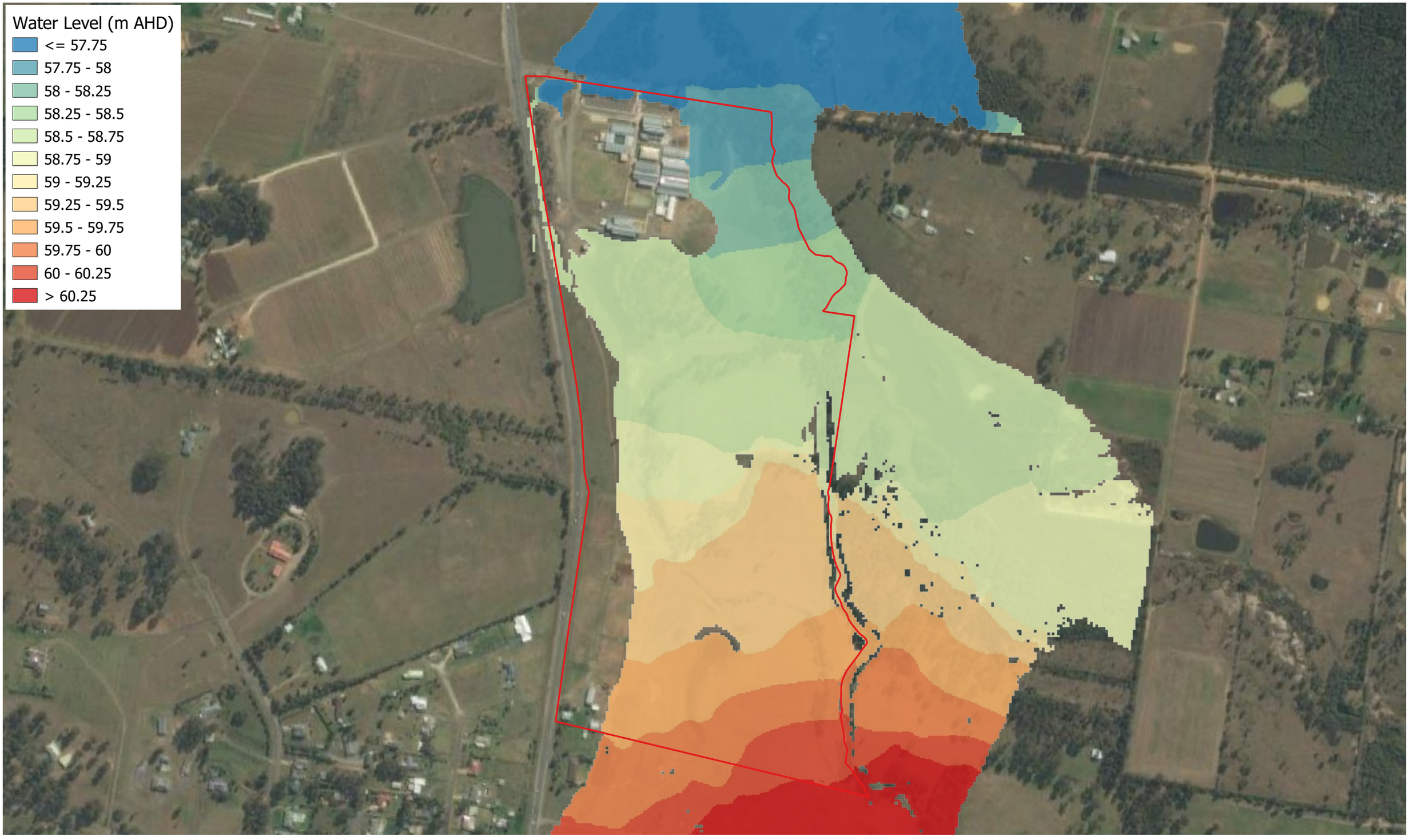
Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexB\AnnexB.qgz



Legend

Site Boundary

Title:

5% AEP Pre-development Peak Flood Level

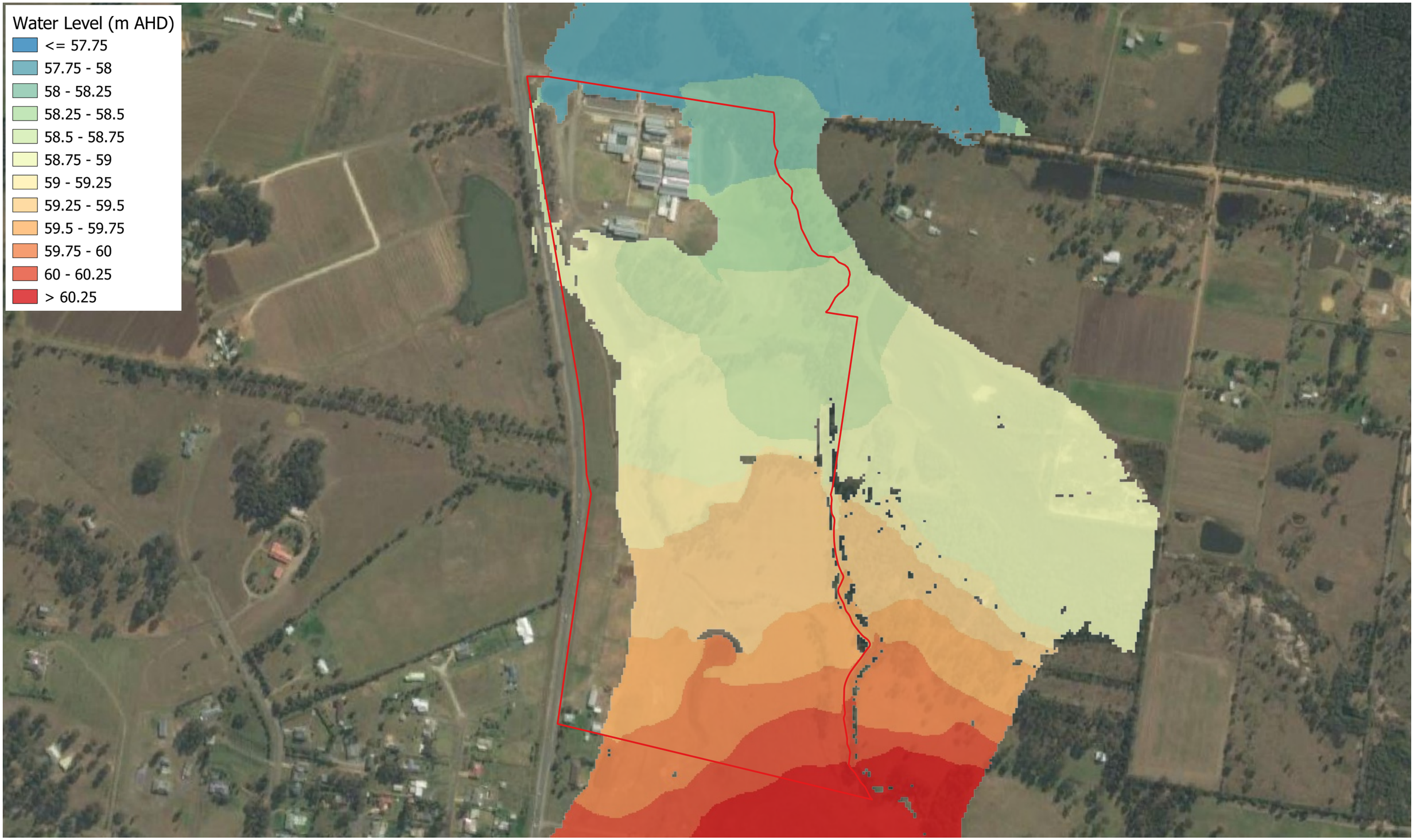
Drawing: B-3

Rev: A

0 100 200 m

BMT
www.bmt.org

Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexB\AnnexB.qgz



Legend

Site Boundary

Title:

2% AEP Pre-development Peak Flood Level

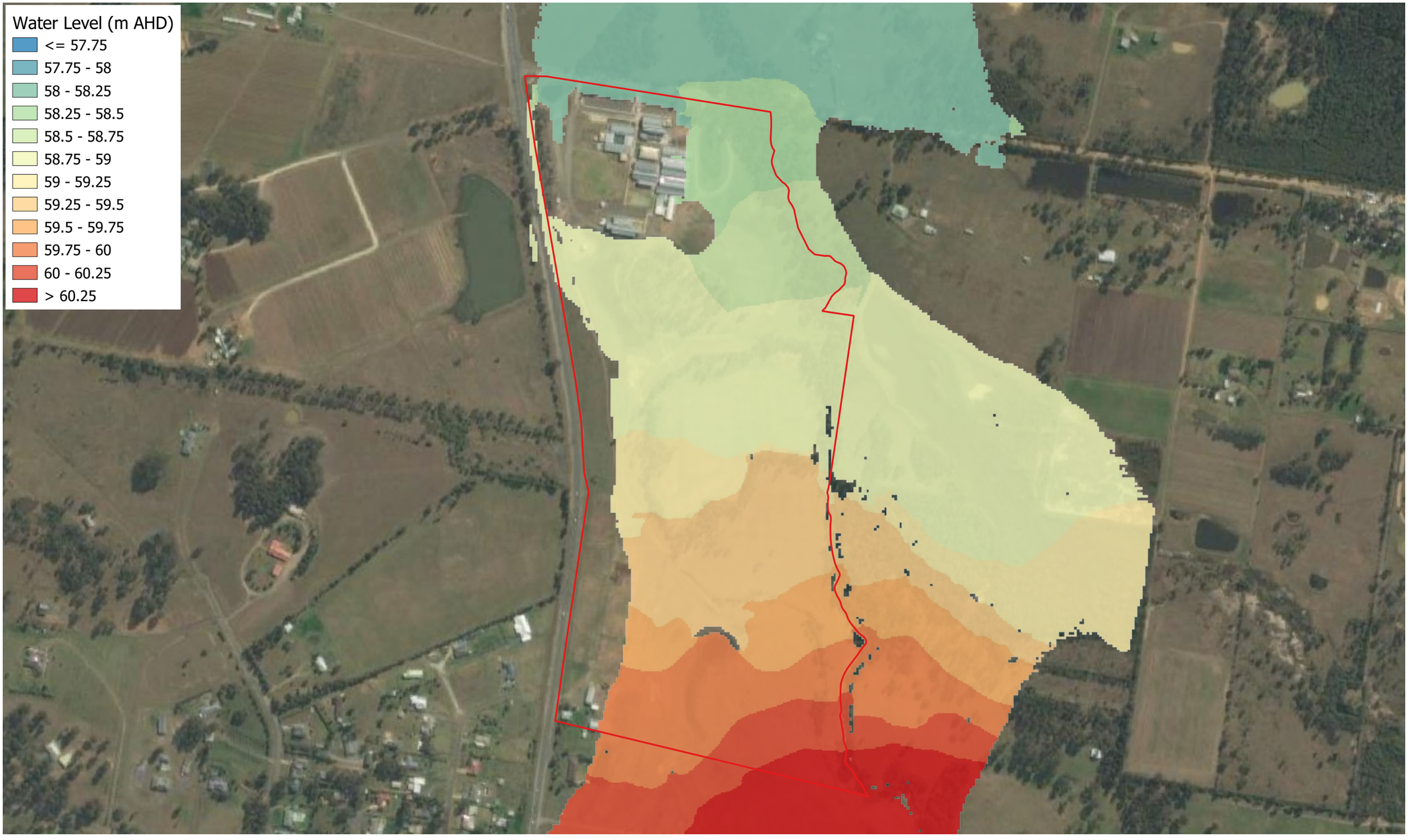
Drawing: B-4

Rev: A

0 100 200 m

BMT
www.bmt.org

Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexB\AnnexB.qgz



Legend

Site Boundary

Title:

1% AEP Pre-development Peak Flood Level

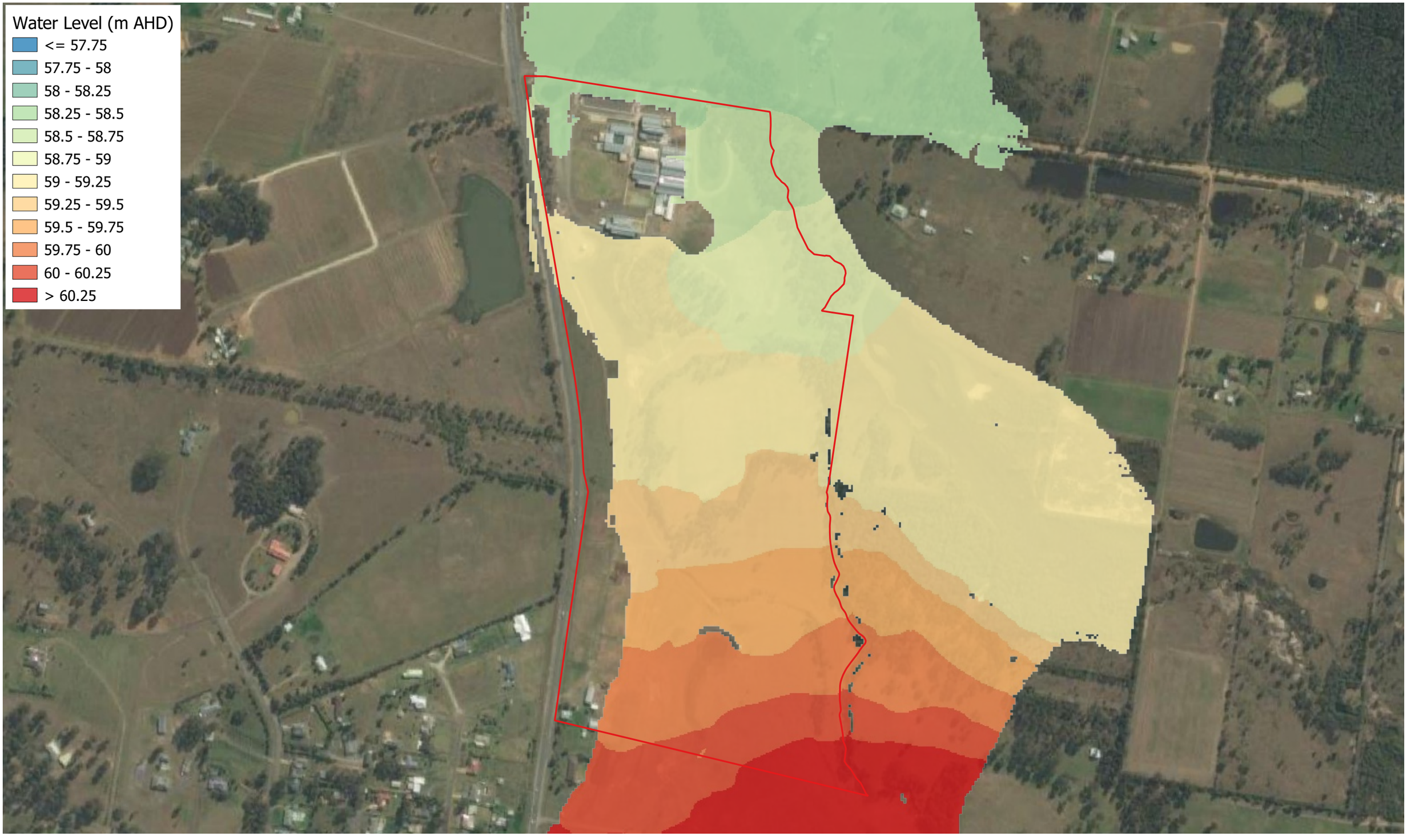
Drawing: B-5

Rev: A

0 100 200 m

BMT
www.bmt.org

Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexB\AnnexB.qgz



Legend

Site Boundary

Title:

0.5% AEP Pre-development Peak Flood Level

Drawing: B-6

Rev: A

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0 100 200 m

BMT
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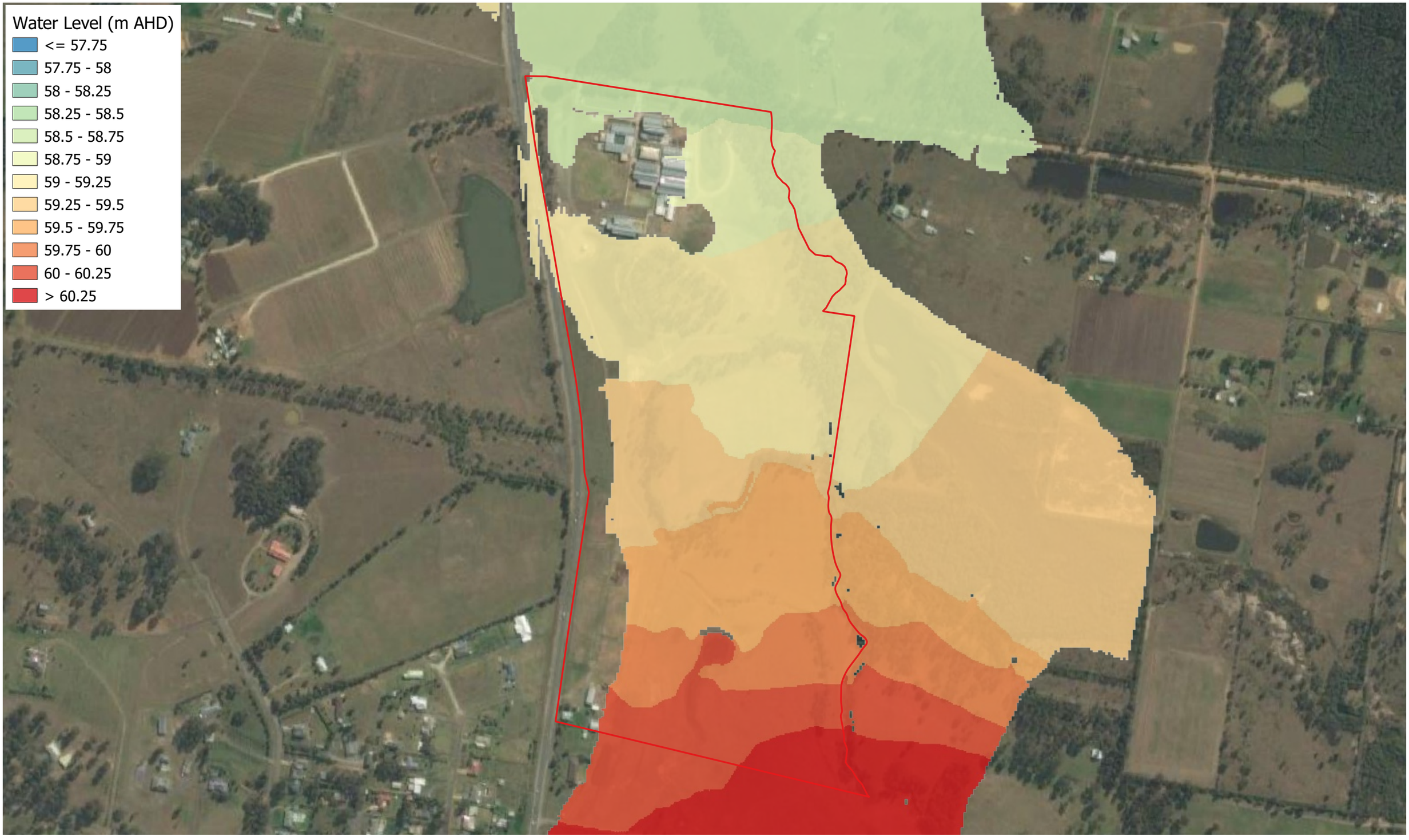
Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexB\AnnexB.qgz



Legend

Site Boundary

Title:

0.2% AEP Pre-development Peak Flood Level

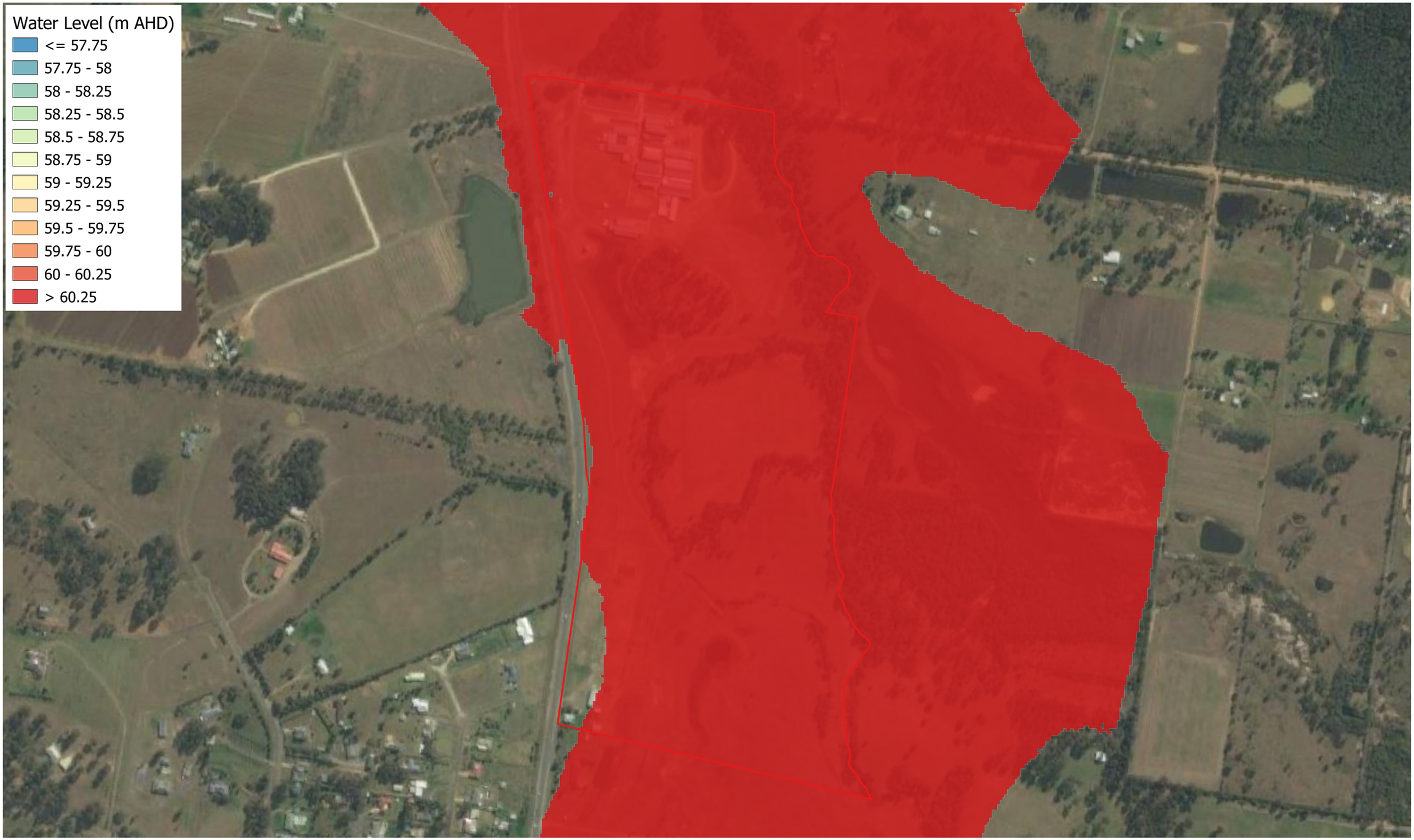
Drawing: B-7

Rev: A

0 100 200 m

BMT
www.bmt.org

Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexB\AnnexB.qgz



Legend

Site Boundary

Title:

PMF Pre-development Peak Flood Level

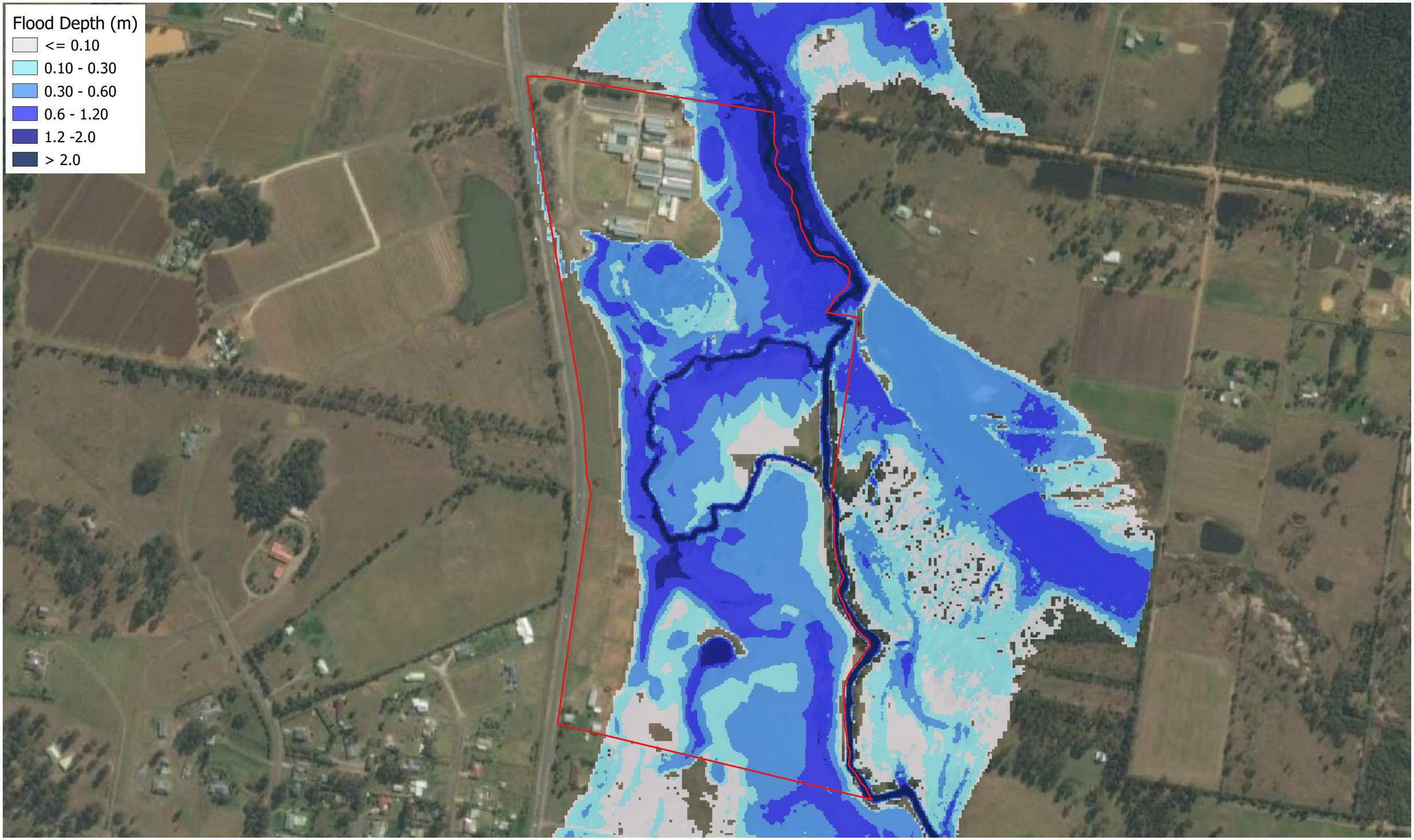
Drawing: **B-8**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexB\AnnexB.qgz



Legend

Site Boundary

Title:
20% AEP Pre-development Peak Flood Depth

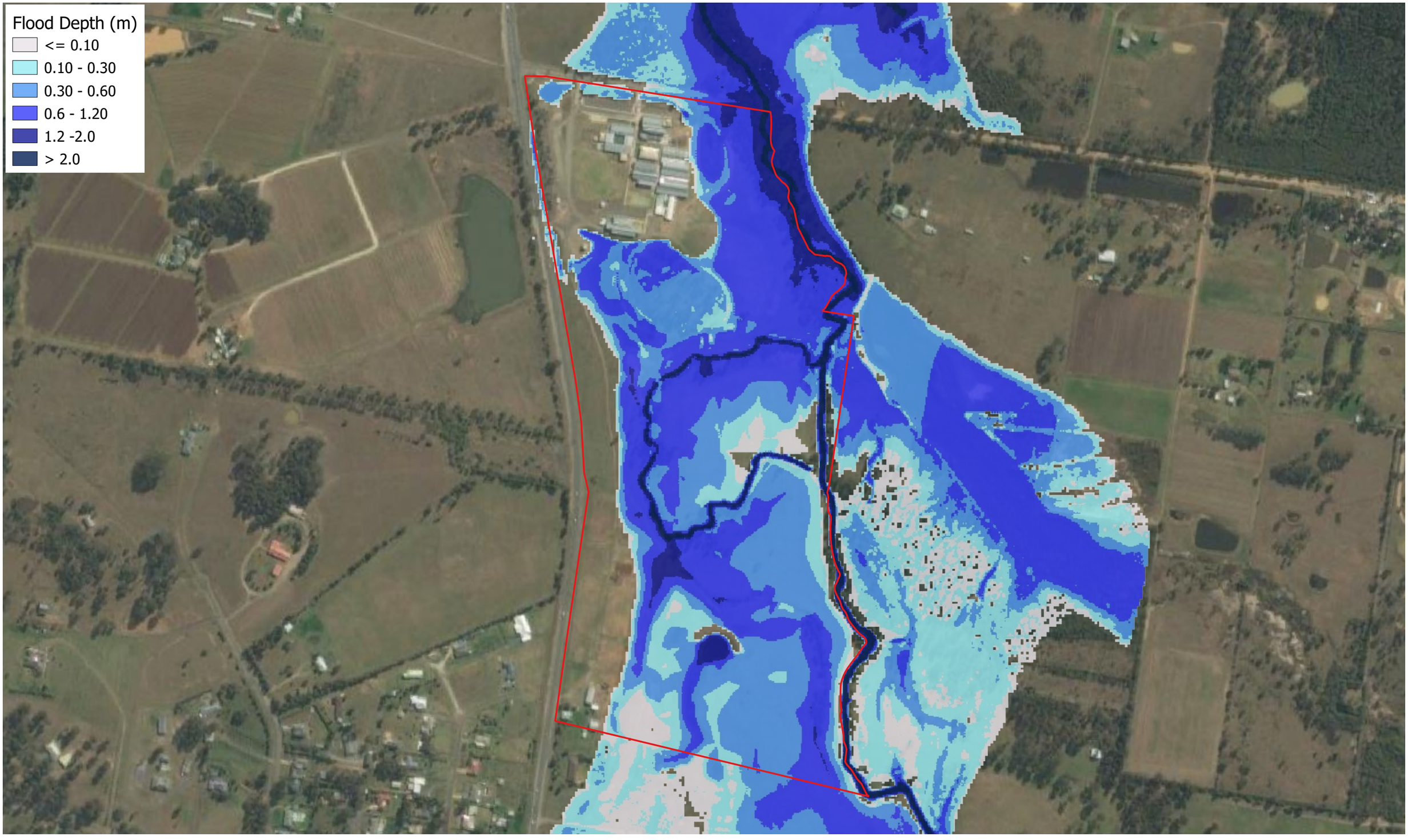
Drawing: **B-9**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexB\AnnexB.qgz



Legend

Site Boundary

Title: 10% AEP Pre-development Peak Flood Depth

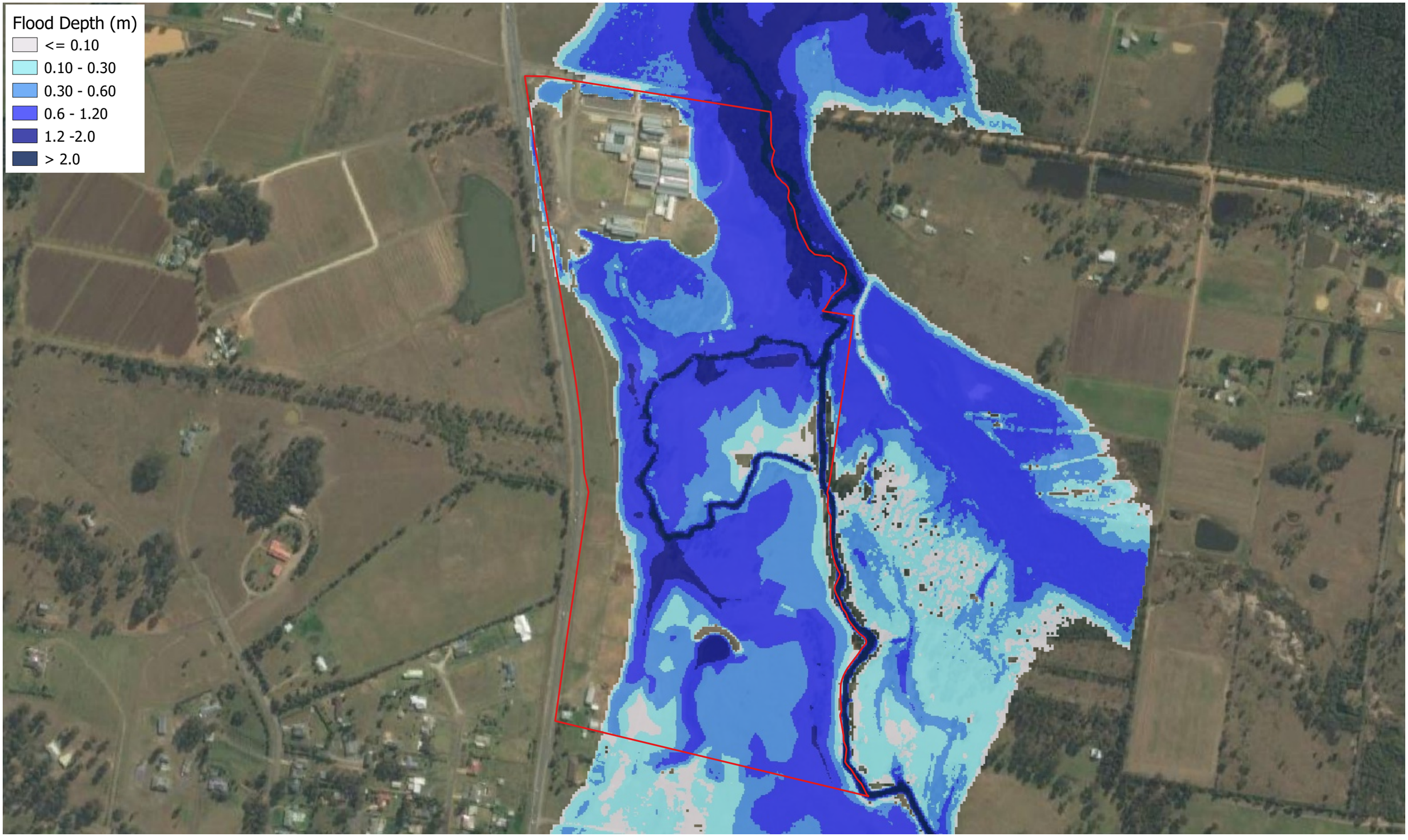
Drawing: B-10

Rev: A

0 100 200 m

BMT
www.bmt.org

Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexB\AnnexB.qgz



Legend

Site Boundary

Title: 5% AEP Pre-development Peak Flood Depth

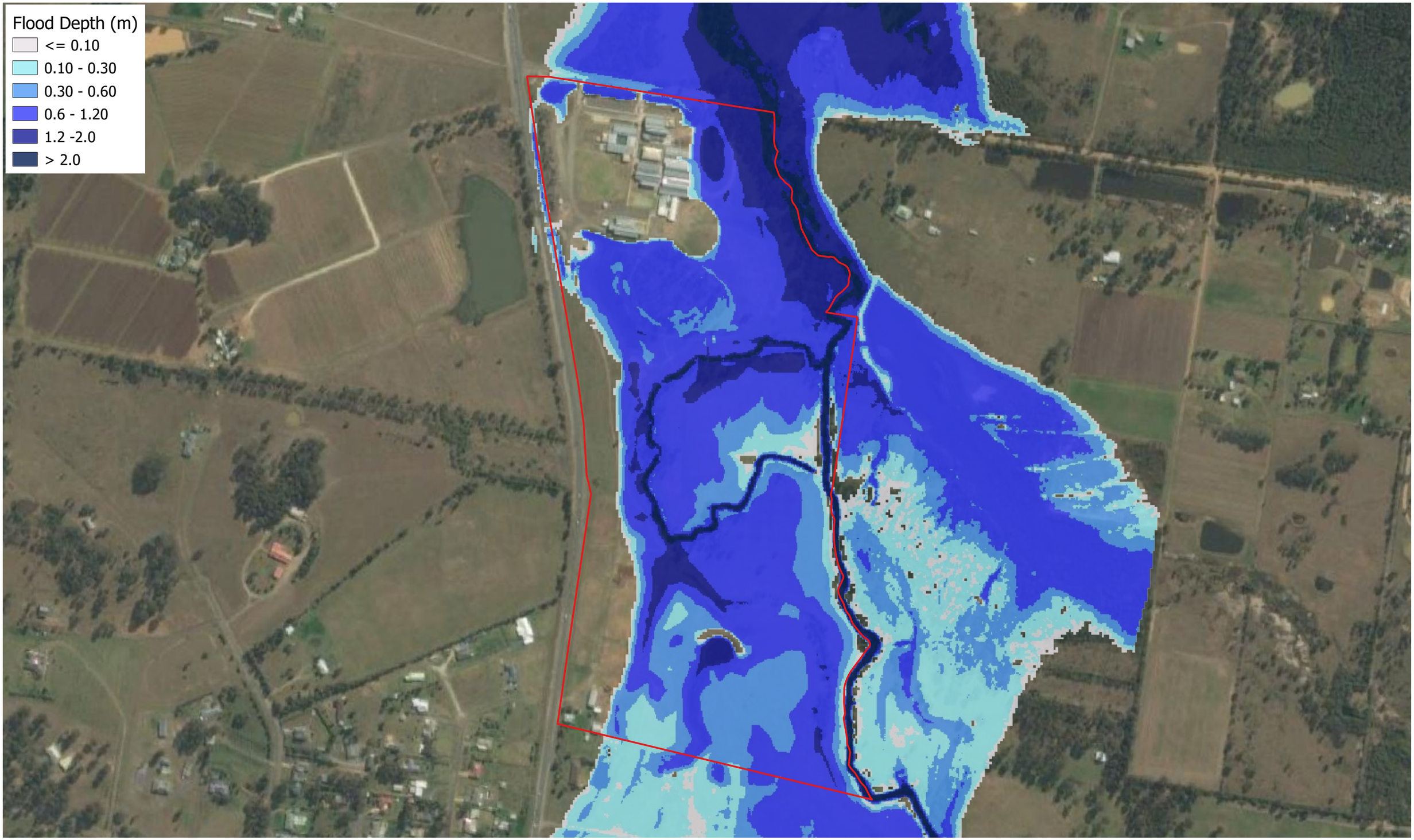
Drawing: B-11

Rev: A

0 100 200 m

BMT
www.bmt.org

Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexB\AnnexB.qgz



Legend

Site Boundary

Title:

2% AEP Pre-development Peak Flood Depth

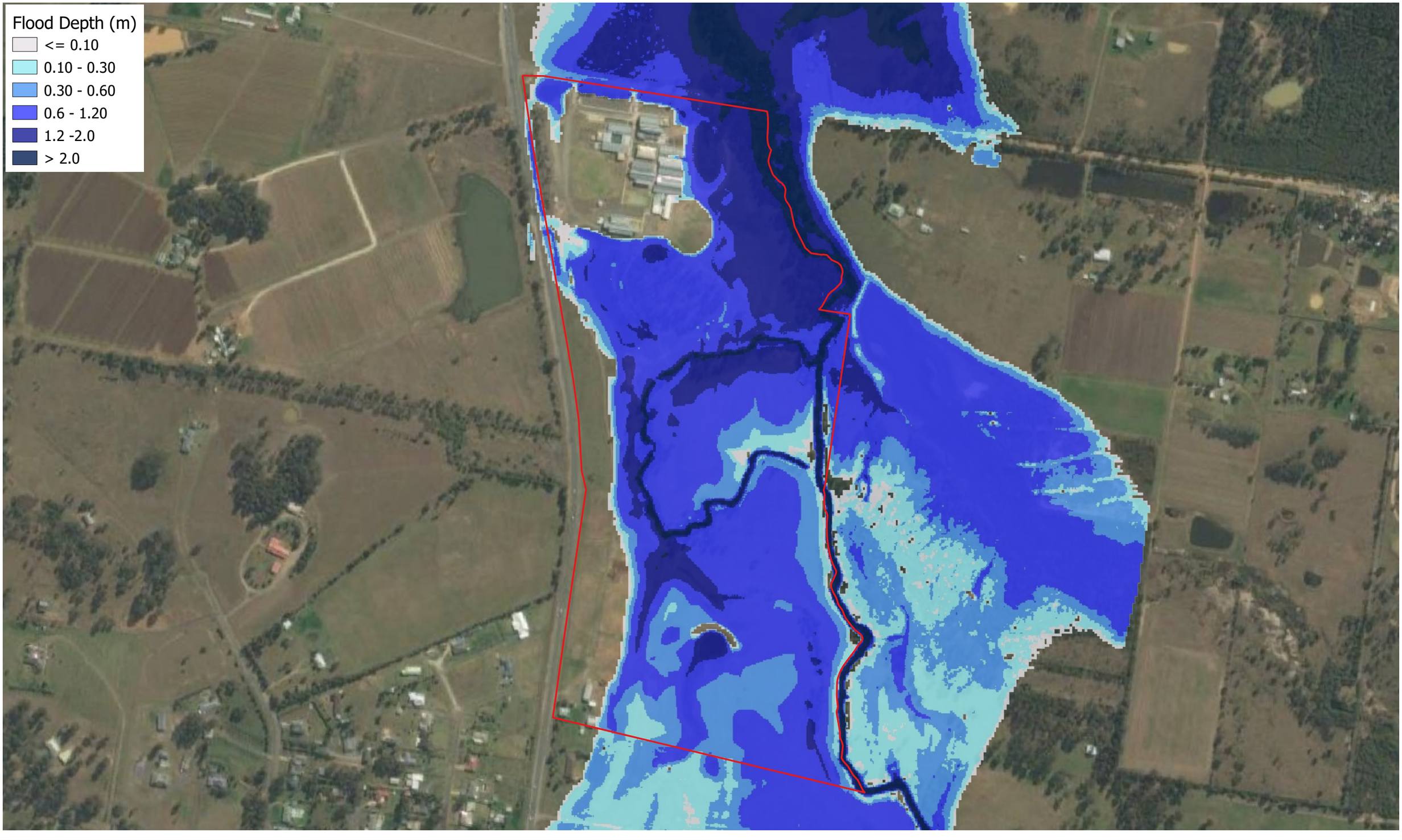
Drawing: B-12

Rev: A

0 100 200 m

BMT
www.bmt.org

Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexB\AnnexB.qgz



Legend

Site Boundary

Title:

1% AEP Pre-development Peak Flood Depth

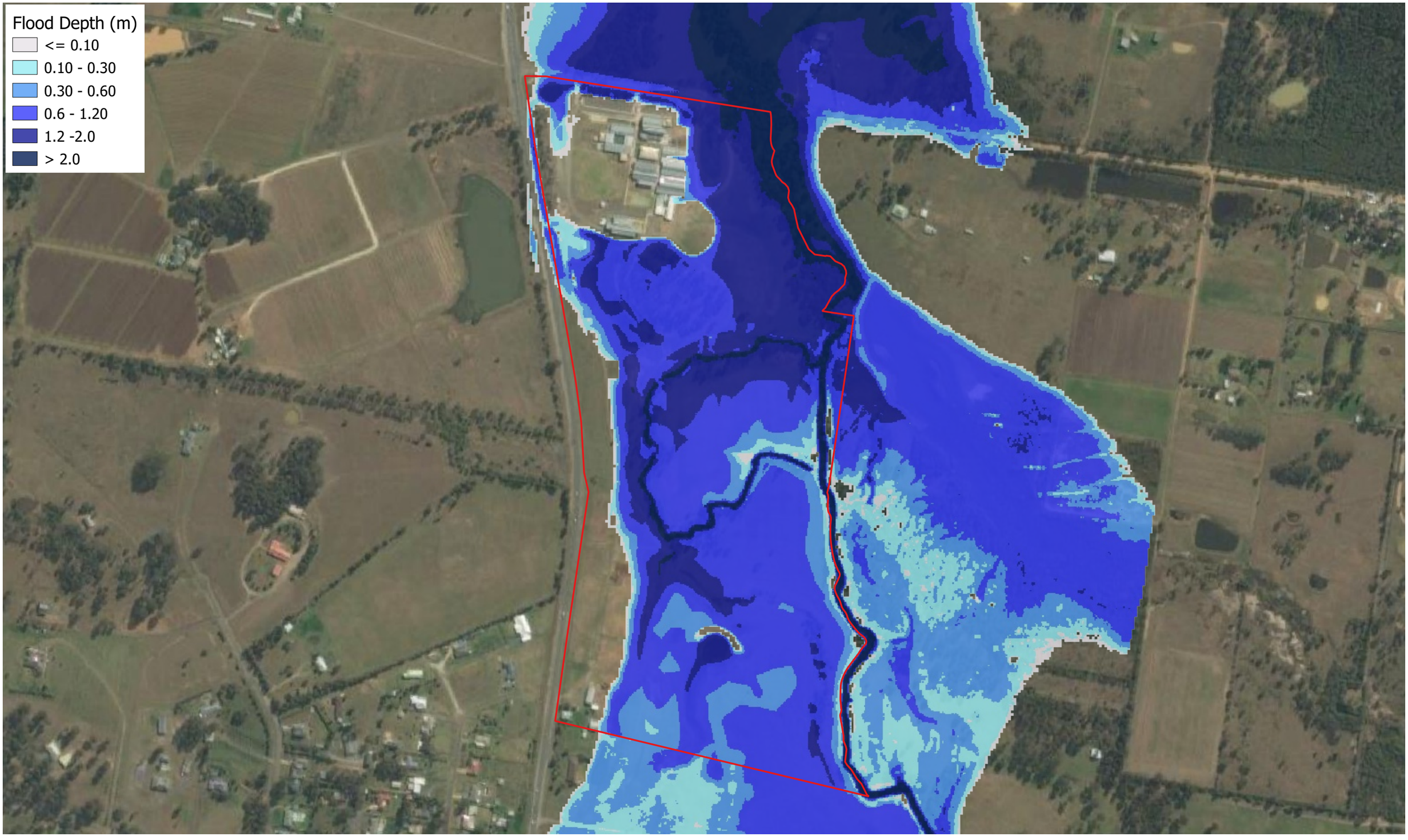
Drawing: B-13

Rev: A

0 100 200 m

BMT
www.bmt.org

Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexB\AnnexB.qgz



Legend

Site Boundary

Title:

0.5% AEP Pre-development Peak Flood Depth

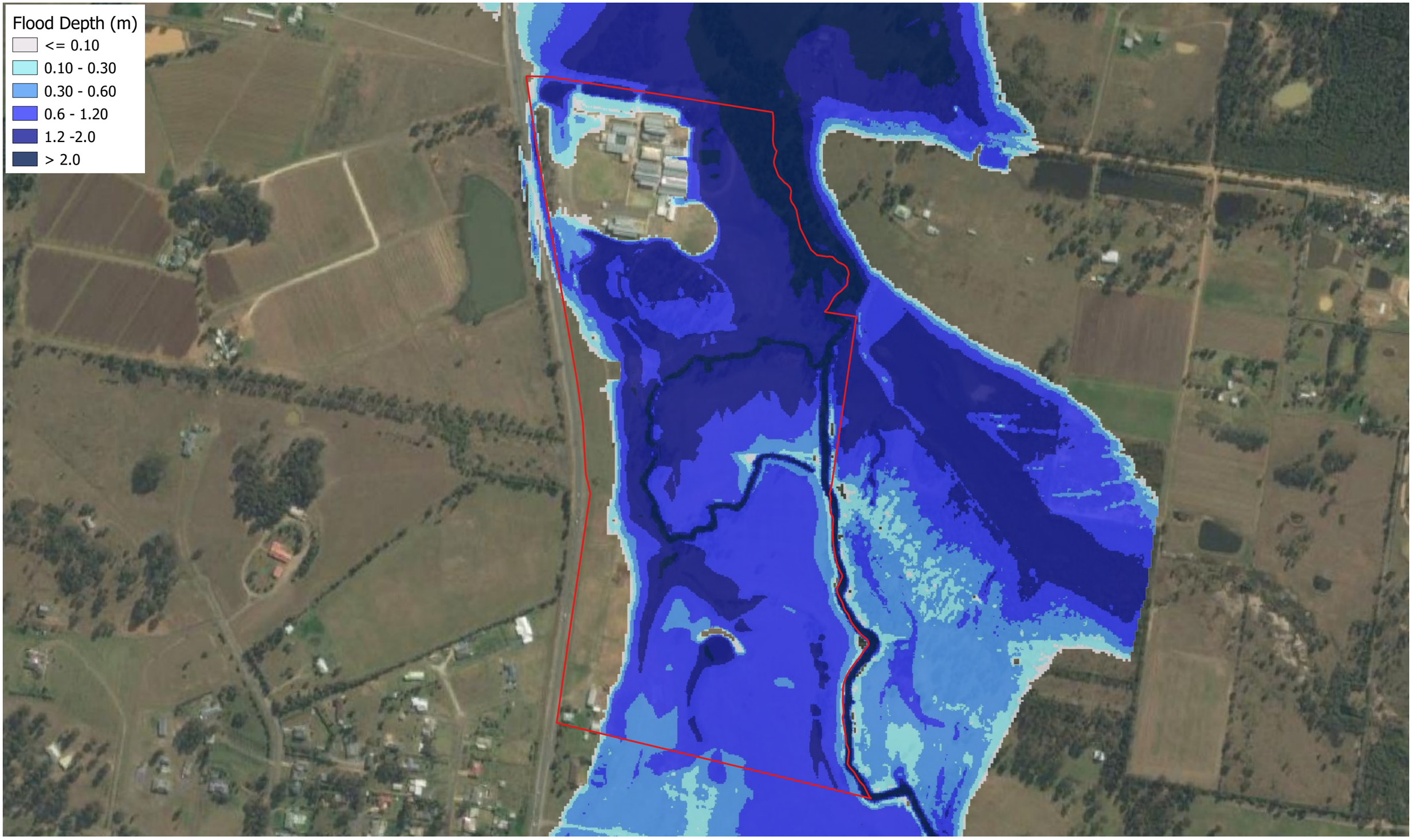
Drawing: **B-14**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexB\AnnexB.qgz



Legend

Site Boundary

Title:

0.2% AEP Pre-development Peak Flood Depth

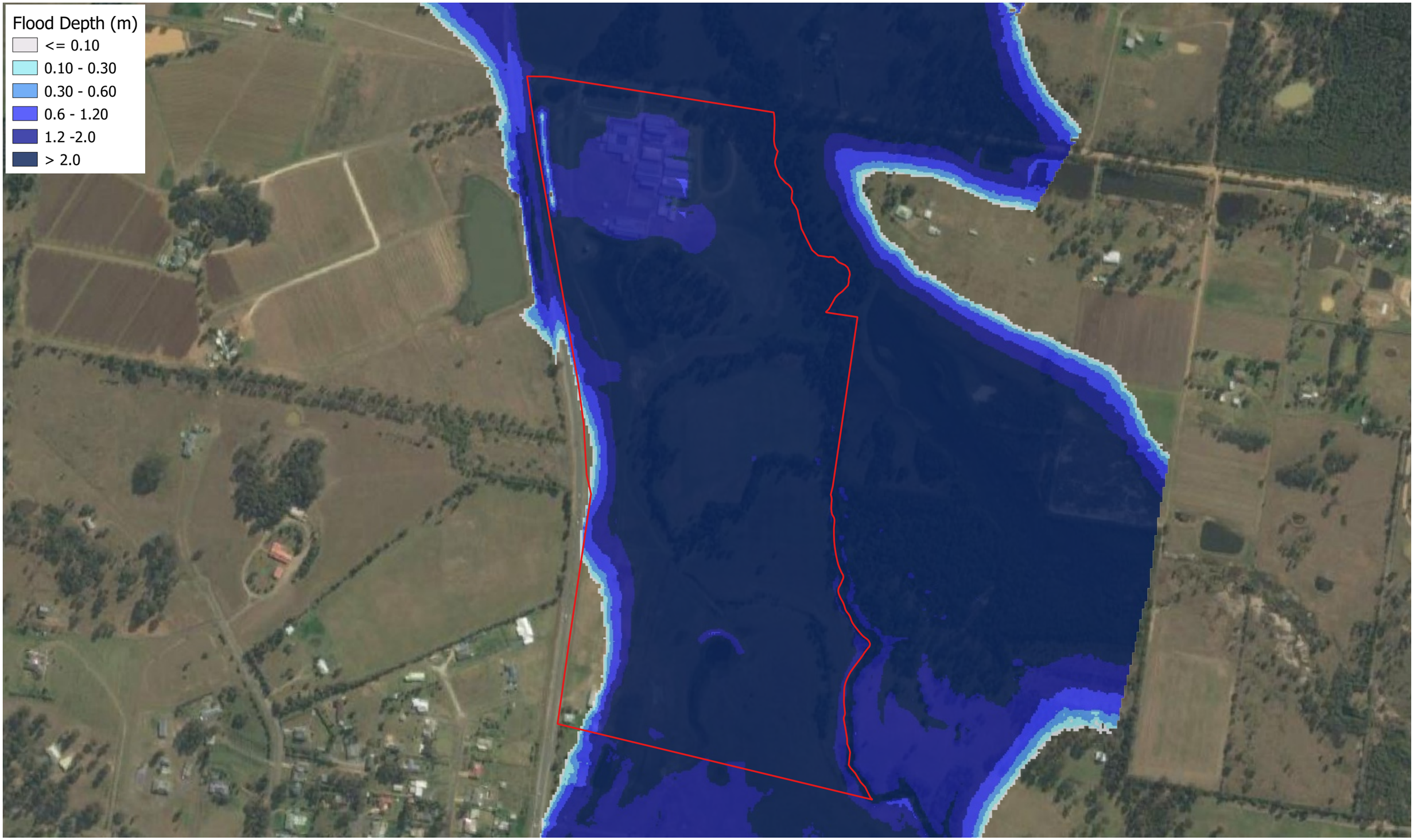
Drawing: **B-15**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexB\AnnexB.qgz



Legend

Site Boundary

Title:

PMF Pre-development Peak Flood Depth

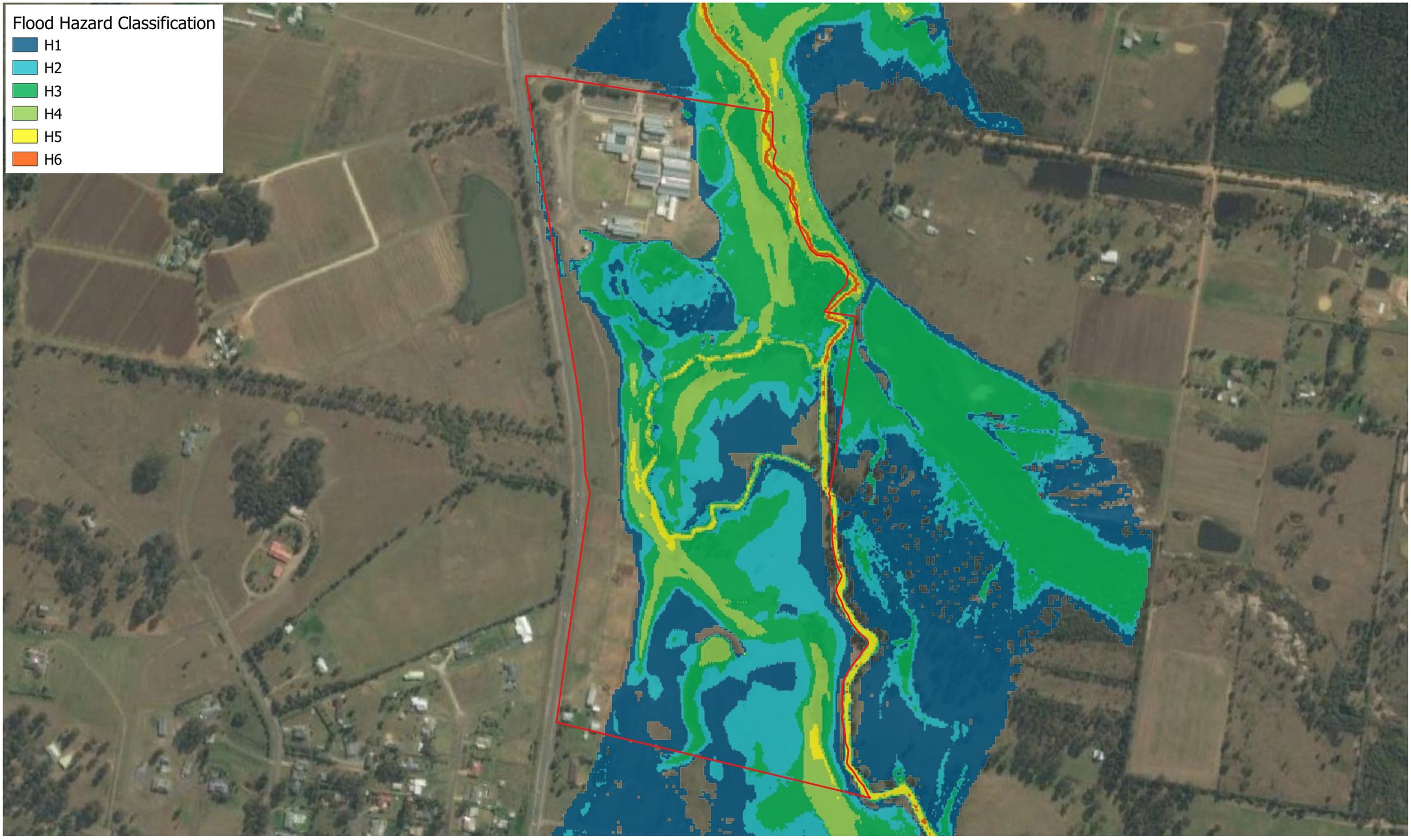
Drawing: B-16

Rev: A

0 100 200 m

BMT
www.bmt.org

Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexB\AnnexB.qgz



Legend

Site Boundary

Title:

20% AEP Pre-development Peak Flood Hazard

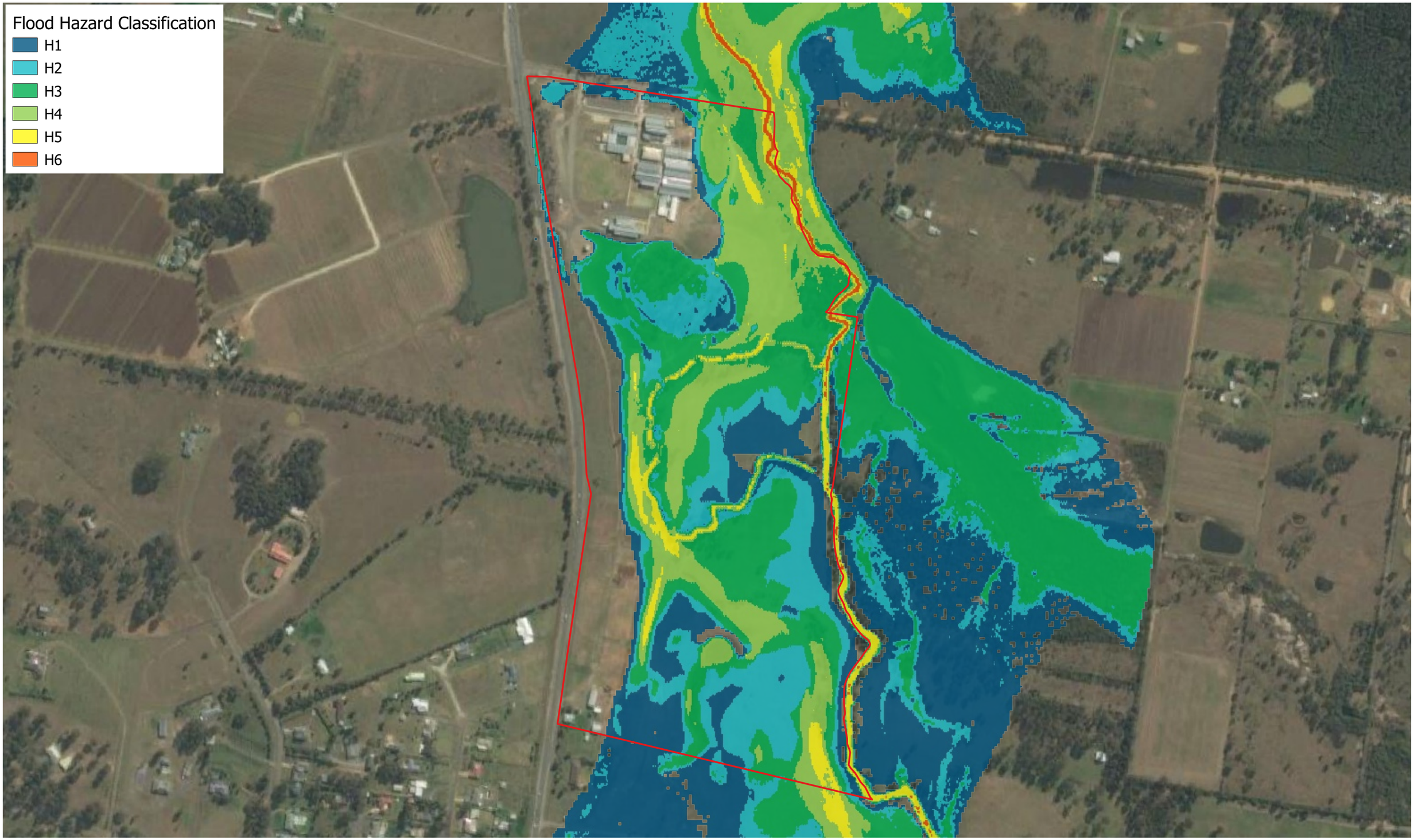
Drawing: **B-17**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexB\AnnexB.qgz



Legend

Site Boundary

Title:

10% AEP Pre-development Peak Flood Hazard

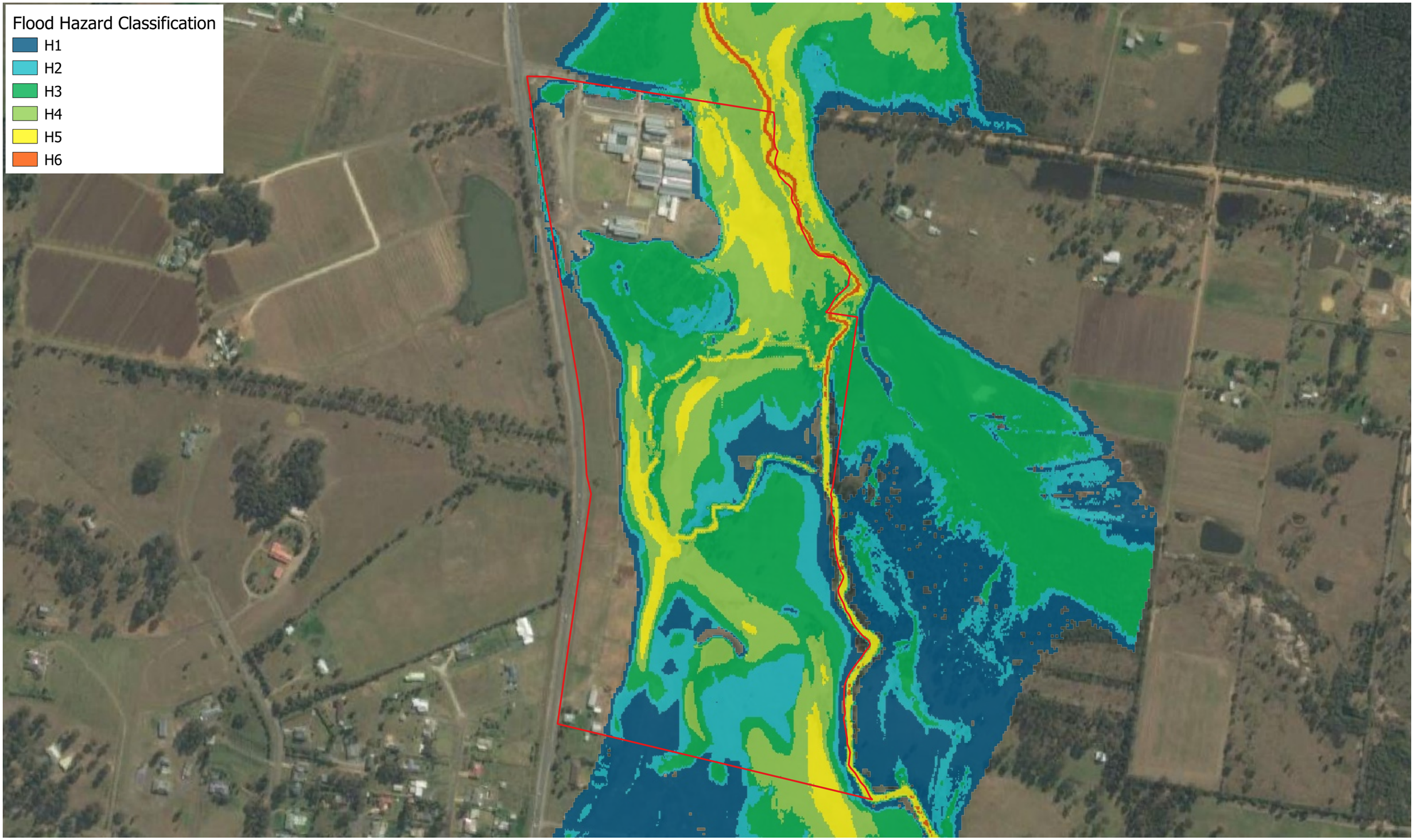
Drawing: **B-18**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexB\AnnexB.qgz



Legend

Site Boundary

Title:

5% AEP Pre-development Peak Flood Hazard

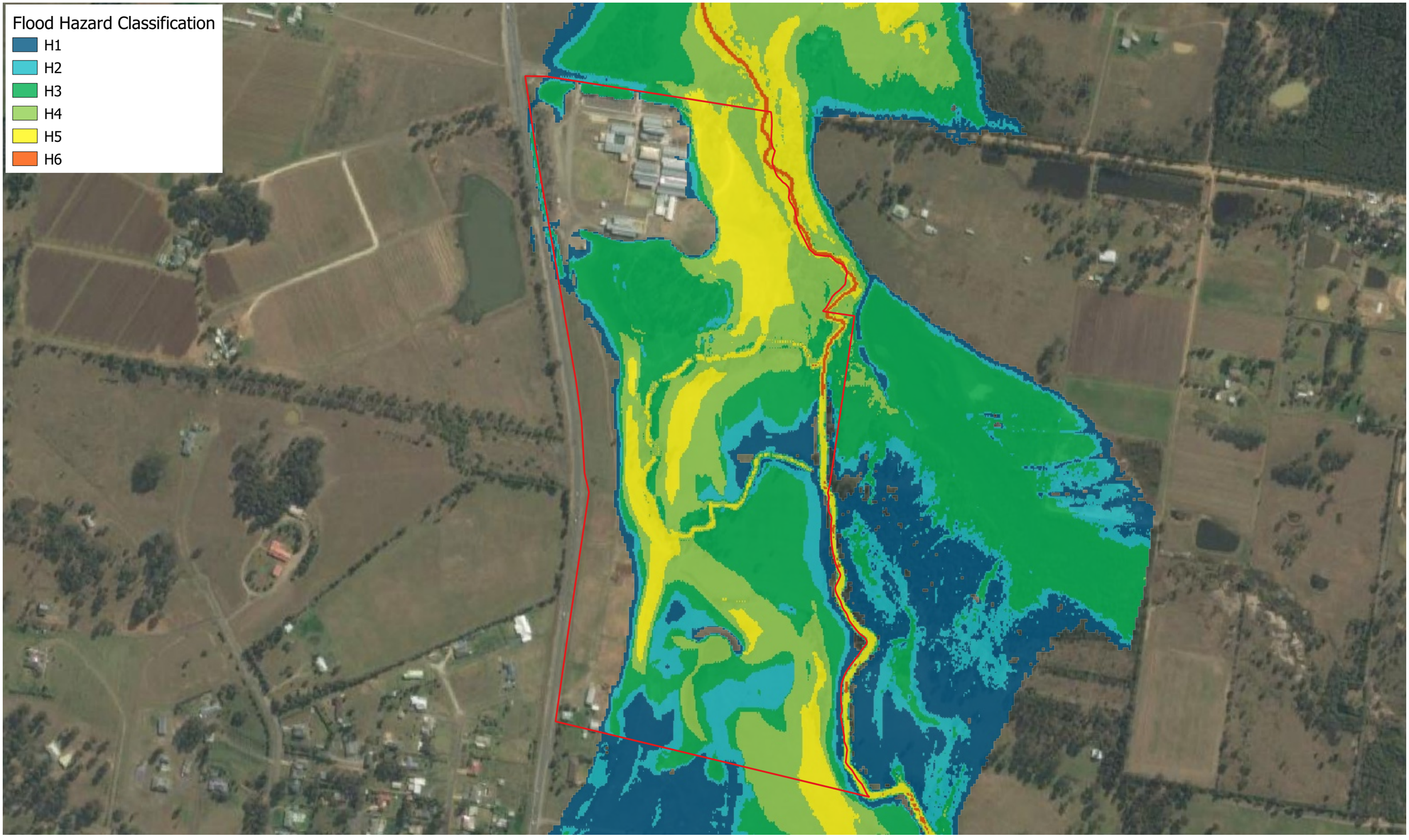
Drawing: B-19

Rev: A

0 100 200 m

BMT
www.bmt.org

Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexB\AnnexB.qgz



Legend

Site Boundary

Title:

2% AEP Pre-development Peak Flood Hazard

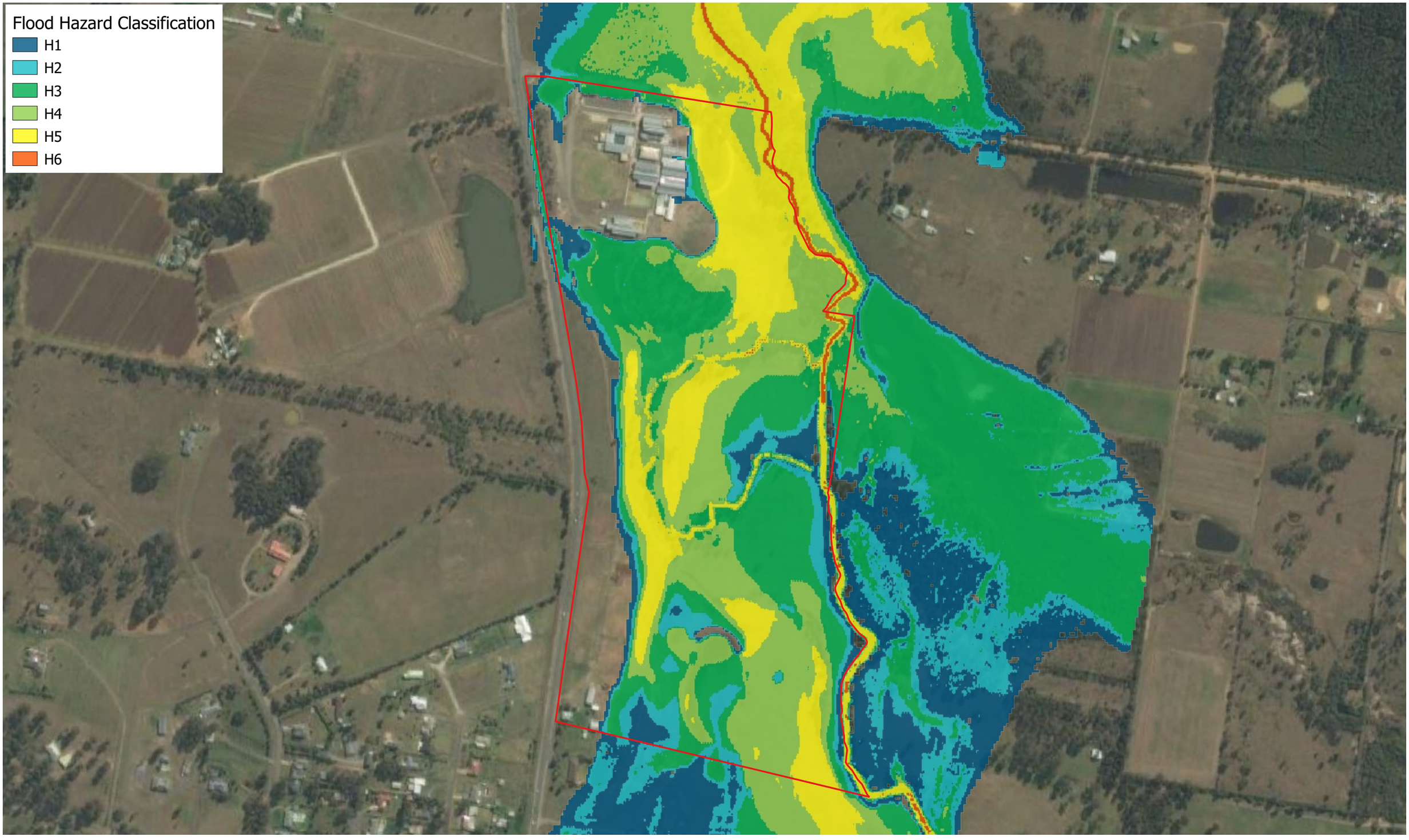
Drawing: B-20

Rev: A

0 100 200 m

BMT
www.bmt.org

Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexB\AnnexB.qgz



Legend

Site Boundary

Title:

1% AEP Pre-development Peak Flood Hazard

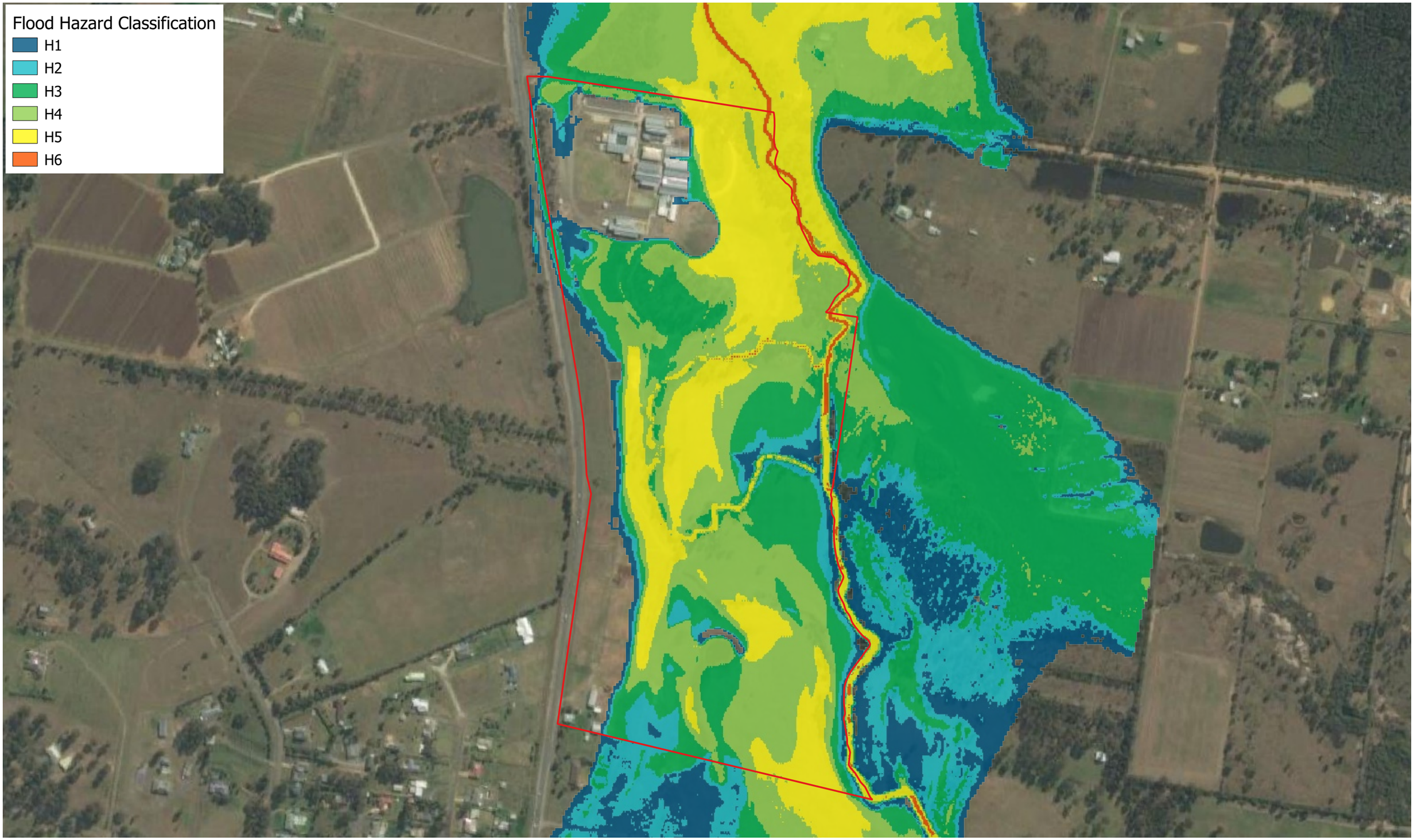
Drawing: **B-21**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexB\AnnexB.qgz



Legend

Site Boundary

Title:

0.5% AEP Pre-development Peak Flood Hazard

Drawing: B-22

Rev: A

0 100 200 m

BMT
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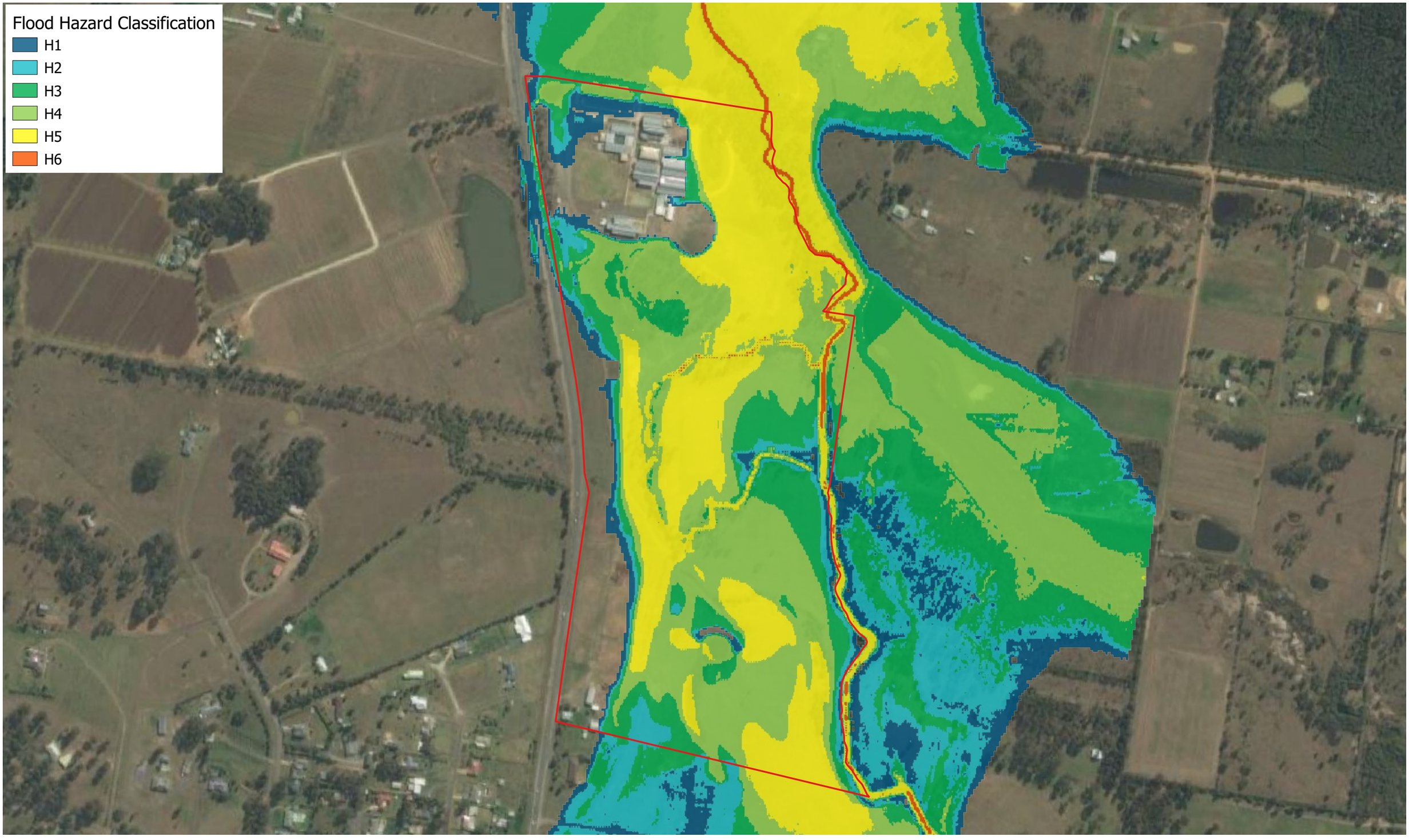
Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexB\AnnexB.qgz



Legend

Site Boundary

Title:

0.2% AEP Pre-development Peak Flood Hazard

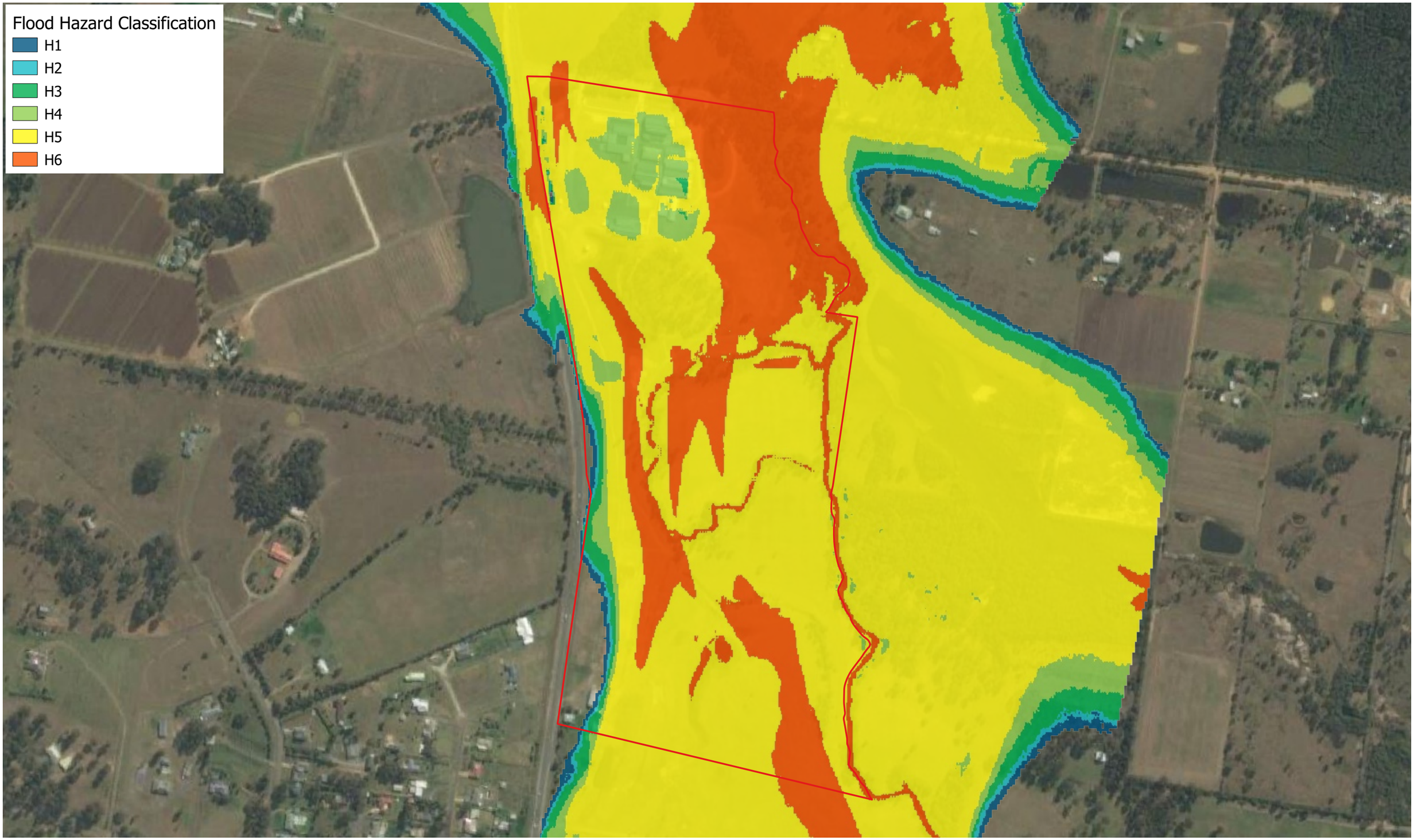
Drawing: B-23

Rev: A

0 100 200 m

BMT
www.bmt.org

Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexB\AnnexB.qgz



Legend

Site Boundary

Title:

PMF Pre-development Peak Flood Hazard

Drawing: B-24

Rev: A

0 100 200 m

BMT
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Annex C: Post-development Flood Maps

Water Level (m AHD)
- <= 57.75
- 57.75 - 58
- 58 - 58.25
- 58.25 - 58.5
- 58.5 - 58.75
- 58.75 - 59
- 59 - 59.25
- 59.25 - 59.5
- 59.5 - 59.75
- 59.75 - 60
- 60 - 60.25
- > 60.25

Legend

- Site Boundary
- Development Layout

Title:

20% AEP Post-development Peak Flood Level

Drawing: C-1

Rev: A

0 150 300 m

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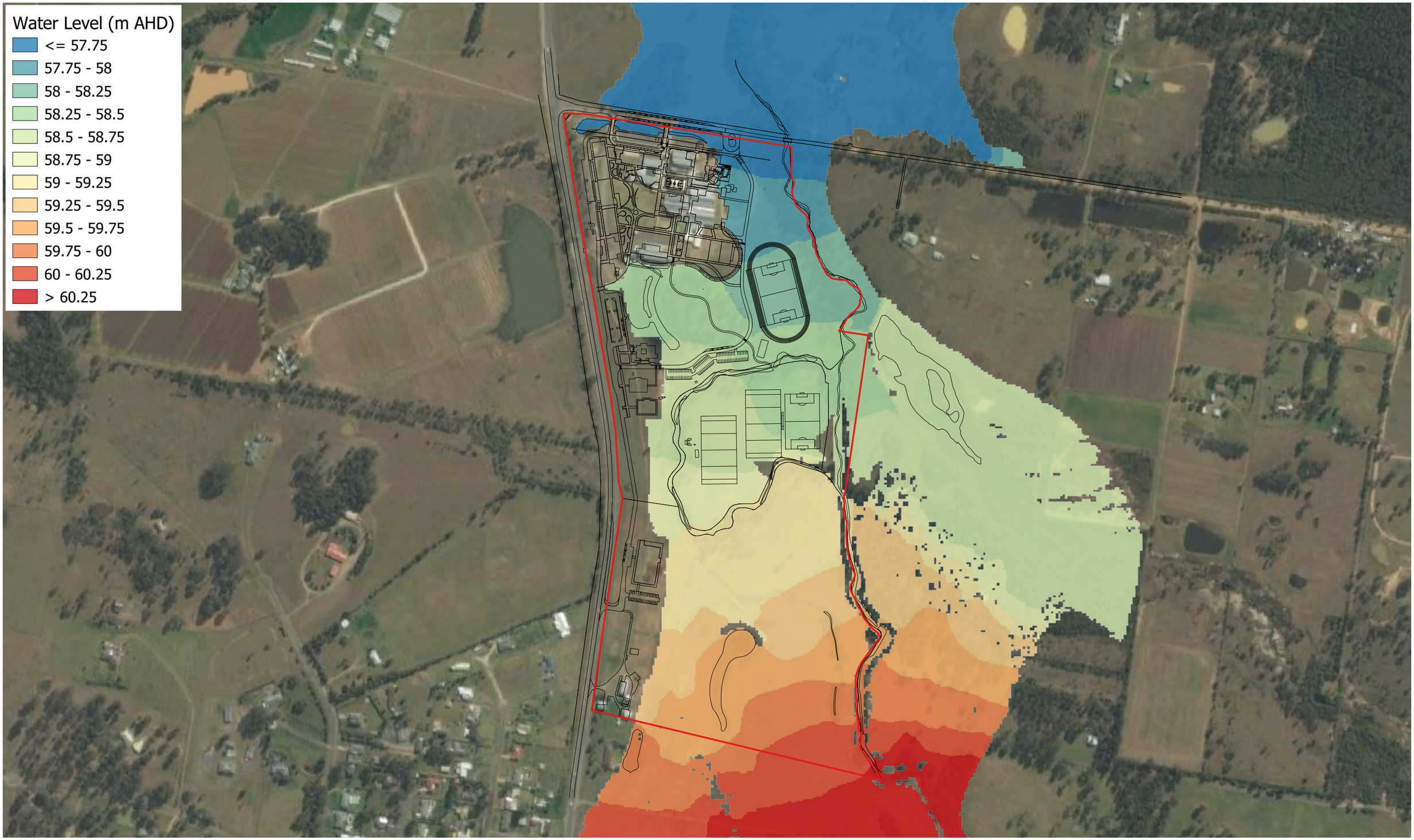
Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexC\AnnexC.qgz



Legend

- Site Boundary
- Development Layout

Title:

10% AEP Post-development Peak Flood Level

Drawing: C-2

Rev: A

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0 150 300 m

BMT
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Water Level (m AHD)
- <= 57.75
- 57.75 - 58
- 58 - 58.25
- 58.25 - 58.5
- 58.5 - 58.75
- 58.75 - 59
- 59 - 59.25
- 59.25 - 59.5
- 59.5 - 59.75
- 59.75 - 60
- 60 - 60.25
- > 60.25

Legend

- Site Boundary
- Development Layout

Title:

5% AEP Post-development Peak Flood Level

Drawing: C-3

Rev: A

0 150 300 m

BMT
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Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexC\AnnexC.qgz

Water Level (m AHD)
- <= 57.75
- 57.75 - 58
- 58 - 58.25
- 58.25 - 58.5
- 58.5 - 58.75
- 58.75 - 59
- 59 - 59.25
- 59.25 - 59.5
- 59.5 - 59.75
- 59.75 - 60
- 60 - 60.25
- > 60.25

Legend

- Site Boundary
- Development Layout

Title:

2% AEP Post-development Peak Flood Level

Drawing: C-4

Rev: A

0 150 300 m

BMT
www.bmt.org

Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexC\AnnexC.qgz

Water Level (m AHD)
- <= 57.75
- 57.75 - 58
- 58 - 58.25
- 58.25 - 58.5
- 58.5 - 58.75
- 58.75 - 59
- 59 - 59.25
- 59.25 - 59.5
- 59.5 - 59.75
- 59.75 - 60
- 60 - 60.25
- > 60.25

Legend

- Site Boundary
- Development Layout

Title:

1% AEP Post-development Peak Flood Level

Drawing: C-5

Rev: A

0 150 300 m

BMT
www.bmt.org

Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexC\AnnexC.qgz

Water Level (m AHD)
- <= 57.75
- 57.75 - 58
- 58 - 58.25
- 58.25 - 58.5
- 58.5 - 58.75
- 58.75 - 59
- 59 - 59.25
- 59.25 - 59.5
- 59.5 - 59.75
- 59.75 - 60
- 60 - 60.25
- > 60.25

Legend

- Site Boundary
- Development Layout

Title:

0.5% AEP Post-development Peak Flood Level

Drawing: C-6

Rev: A

0 150 300 m

BMT
www.bmt.org

Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexC\AnnexC.qgz

Water Level (m AHD)
- <= 57.75
- 57.75 - 58
- 58 - 58.25
- 58.25 - 58.5
- 58.5 - 58.75
- 58.75 - 59
- 59 - 59.25
- 59.25 - 59.5
- 59.5 - 59.75
- 59.75 - 60
- 60 - 60.25
- > 60.25

Legend

- Site Boundary
- Development Layout

Title:

0.2% AEP Post-development Peak Flood Level

Drawing: C-7

Rev: A

0 150 300 m

BMT
www.bmt.org

Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexC\AnnexC.qgz

Water Level (m AHD)
- <= 57.75
- 57.75 - 58
- 58 - 58.25
- 58.25 - 58.5
- 58.5 - 58.75
- 58.75 - 59
- 59 - 59.25
- 59.25 - 59.5
- 59.5 - 59.75
- 59.75 - 60
- 60 - 60.25
- > 60.25

Legend

- Site Boundary
- Development Layout

Title:

PMF Post-development Peak Flood Level

Drawing: C-8

Rev: A

0 150 300 m

BMT
www.bmt.org

Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexC\AnnexC.qgz

Flood Depth (m)
- <= 0.10
- 0.10 - 0.30
- 0.30 - 0.60
- 0.6 - 1.20
- 1.2 -2.0
- > 2.0

Legend

- Site Boundary
- Development Layout

Title:
20% AEP Post-development Peak Flood Depth

Drawing: C-9

Rev: A

0 150 300 m

BMT
www.bmt.org

Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexC\AnnexC.qgz

Flood Depth (m)
- <= 0.10
- 0.10 - 0.30
- 0.30 - 0.60
- 0.6 - 1.20
- 1.2 -2.0
- > 2.0

Legend

- Site Boundary
- Development Layout

Title:

10% AEP Post-development Peak Flood Depth

Drawing: C-10

Rev: A

0 150 300 m

BMT
www.bmt.org

Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexC\AnnexC.qgz

Flood Depth (m)
- <= 0.10
- 0.10 - 0.30
- 0.30 - 0.60
- 0.6 - 1.20
- 1.2 -2.0
- > 2.0

Legend

- Site Boundary
- Development Layout

Title:

5% AEP Post-development Peak Flood Depth

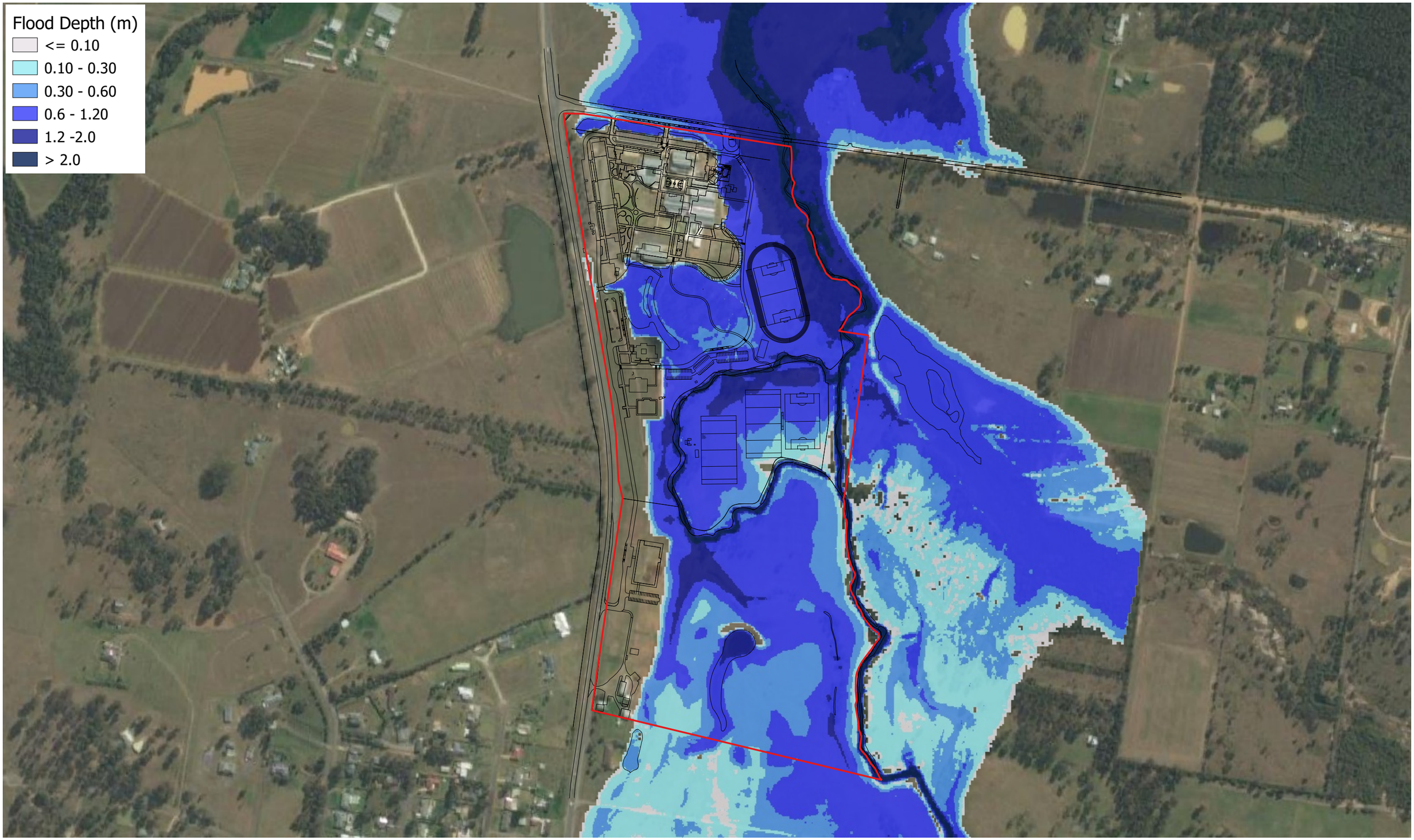
Drawing: C-11

Rev: A

0 150 300 m

BMT
www.bmt.org

Filepath: \\bmt-syd-fs01\wbmsyd\WATER\PROJECTS\A11230_StPhilipsCC_Cessnock_FIA\MapInfo\AnnexC\AnnexC.qgz



Legend

- Site Boundary
- Development Layout

Title:

2% AEP Post-development Peak Flood Depth

Drawing: C-12

Rev: A

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0 150 300 m

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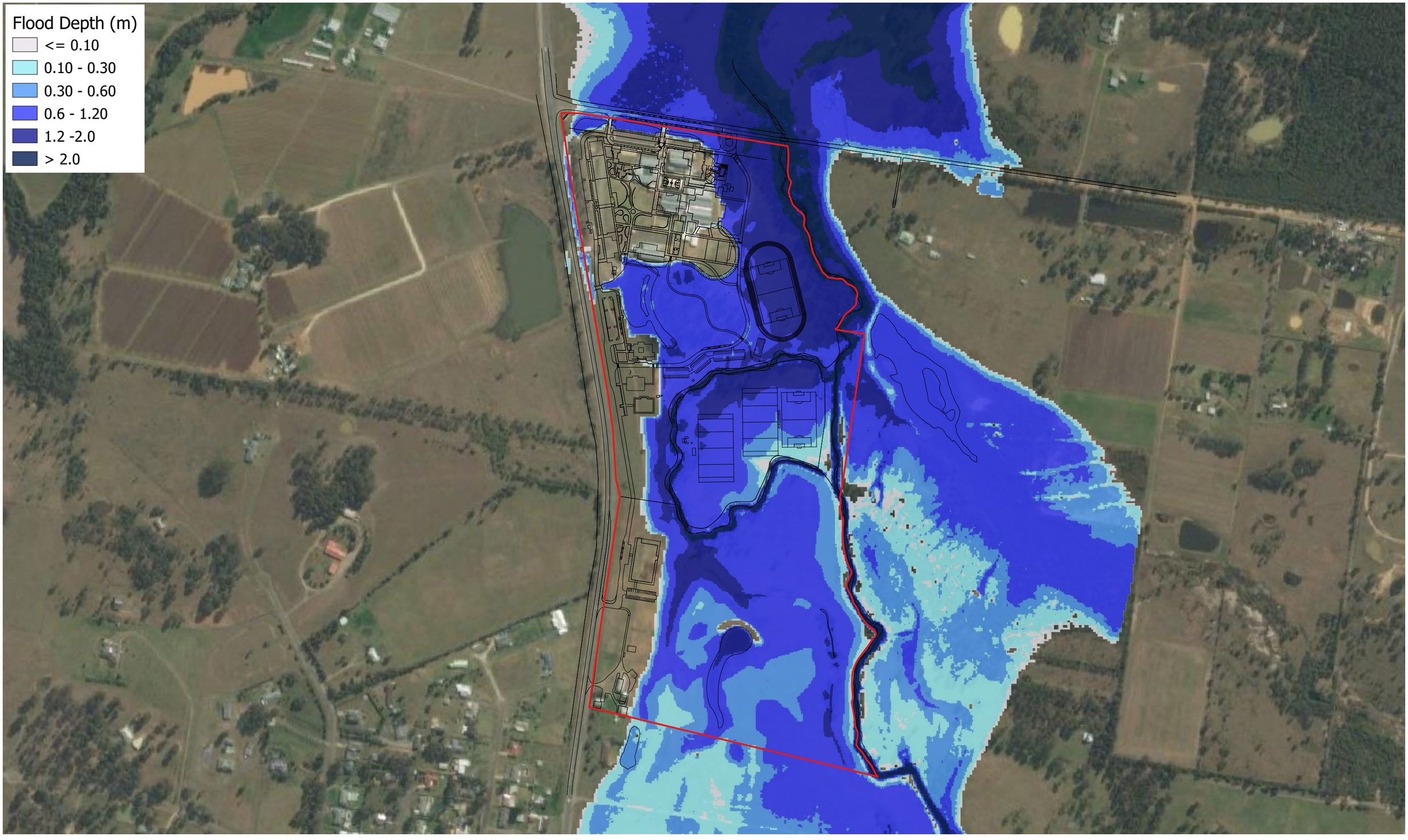

Legend

- Site Boundary
- Development Layout

Title:

1% AEP Post-development Peak Flood Depth

Drawing: C-13

Rev: A

0 150 300 m

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Flood Depth (m)
- <= 0.10
- 0.10 - 0.30
- 0.30 - 0.60
- 0.6 - 1.20
- 1.2 -2.0
- > 2.0

Legend

- Site Boundary
- Development Layout

Title:

0.5% AEP Post-development Peak Flood Depth

Drawing: C-14

Rev: A

0 150 300 m

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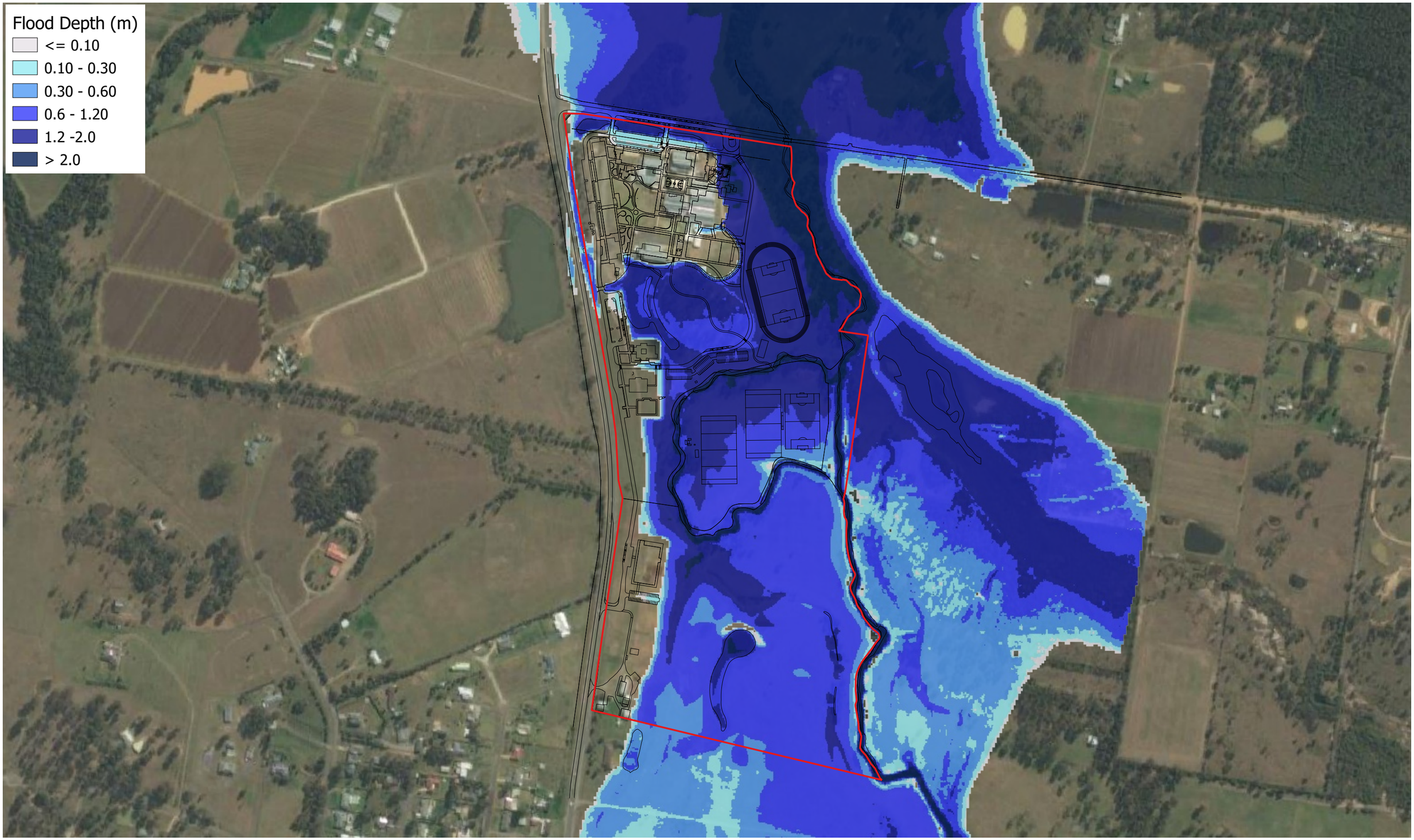

Legend

- Site Boundary
- Development Layout

Title:

0.2% AEP Post-development Peak Flood Depth

Drawing: C-15

Rev: A

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0 150 300 m

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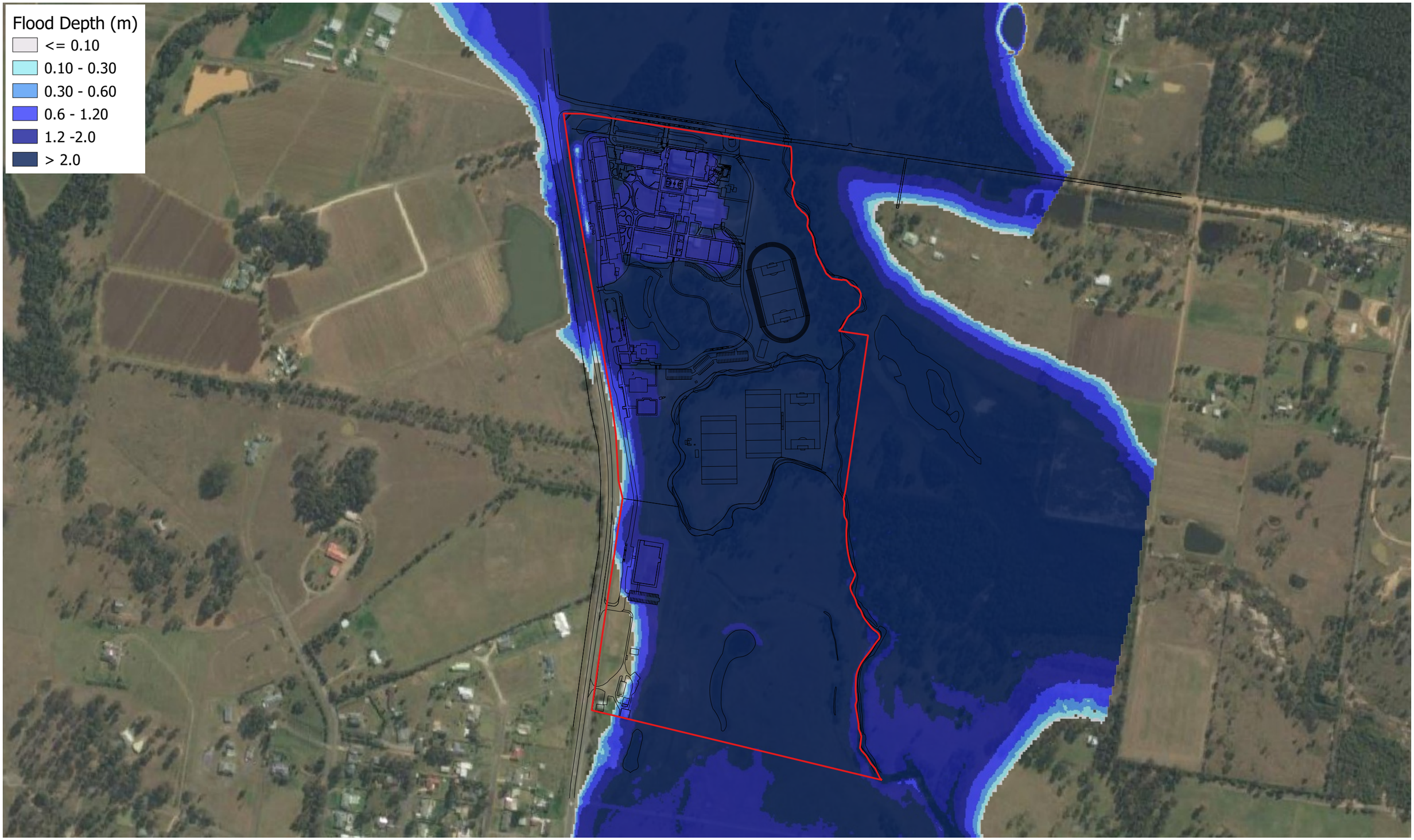

Legend

- Site Boundary
- Development Layout

Title:

PMF Post-development Peak Flood Depth

Drawing: C-16

Rev: A

0 150 300 m

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Flood Hazard Classification
- H1
- H2
- H3
- H4
- H5
- H6

Legend

- Site Boundary
- Development Layout

Title:
20% AEP Post-development Peak Flood Hazard

Drawing: C-17

Rev: A

0 150 300 m

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Flood Hazard Classification
- H1
- H2
- H3
- H4
- H5
- H6

Legend

- Site Boundary
- Development Layout

Title:

10% AEP Post-development Peak Flood Hazard

Drawing: C-18

Rev: A

0 150 300 m

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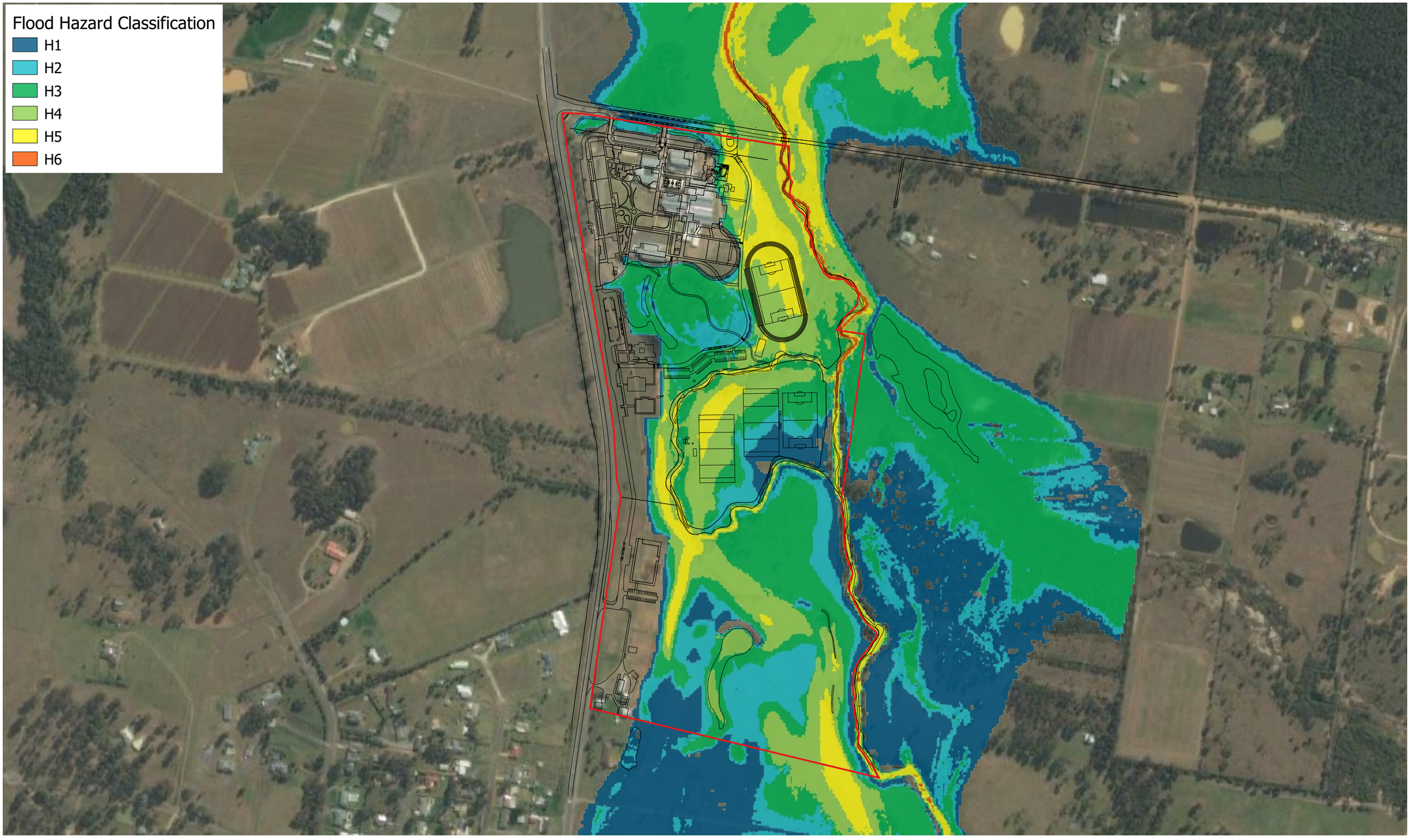

Legend

- Site Boundary
- Development Layout

Title:

5% AEP Post-development Peak Flood Hazard

Drawing: C-19

Rev: A

0 150 300 m

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Flood Hazard Classification
- H1
- H2
- H3
- H4
- H5
- H6

Legend

- Site Boundary
- Development Layout

Title:
2% AEP Post-development Peak Flood Hazard

Drawing: C-20

Rev: A

0 150 300 m

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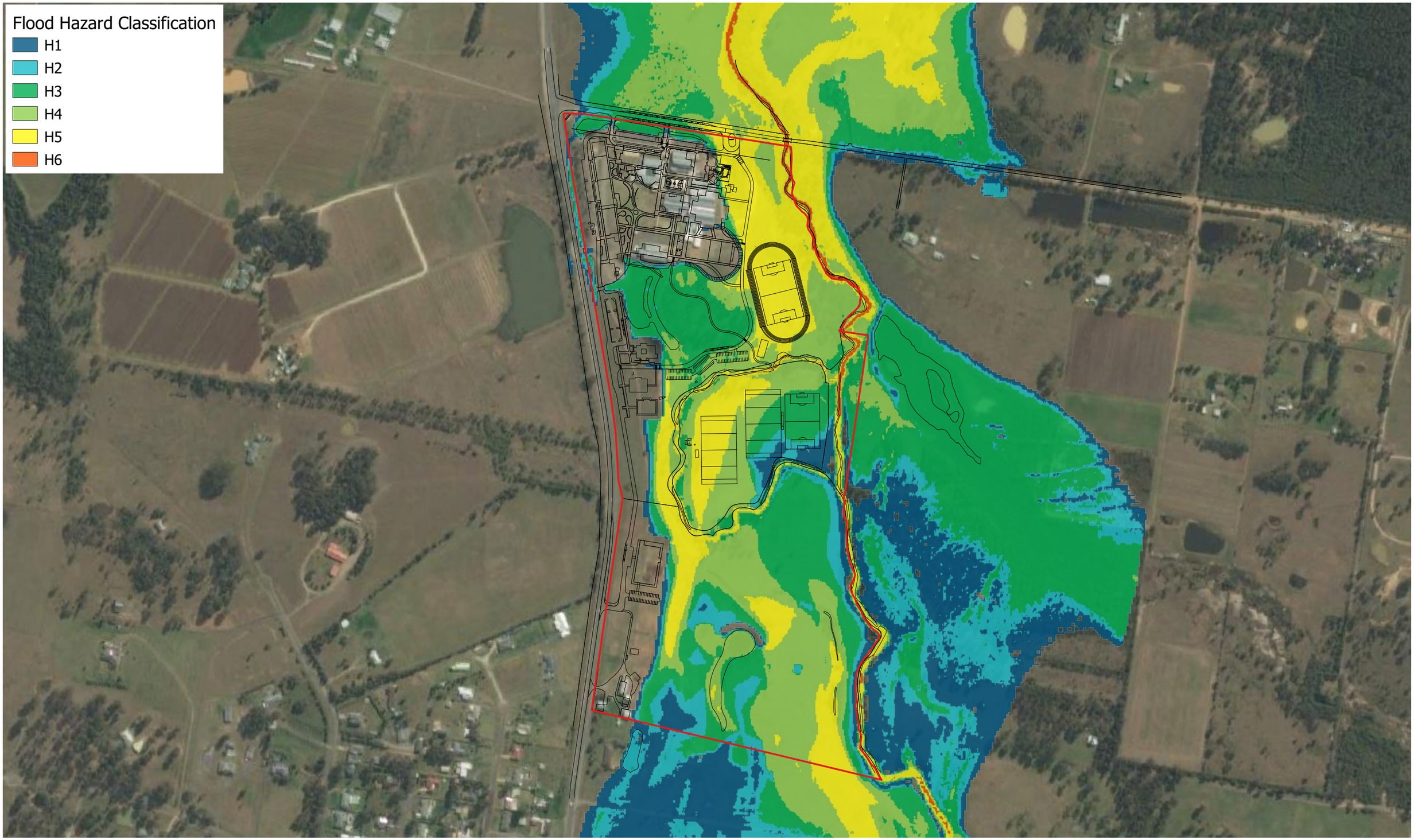

Legend

- Site Boundary
- Development Layout

Title:

1% AEP Post-development Peak Flood Hazard

Drawing: C-21

Rev: A

0 150 300 m

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Flood Hazard Classification
- H1
- H2
- H3
- H4
- H5
- H6

Legend

- Site Boundary
- Development Layout

Title:

0.5% AEP Post-development Peak Flood Hazard

Drawing: C-22

Rev: A

0 150 300 m

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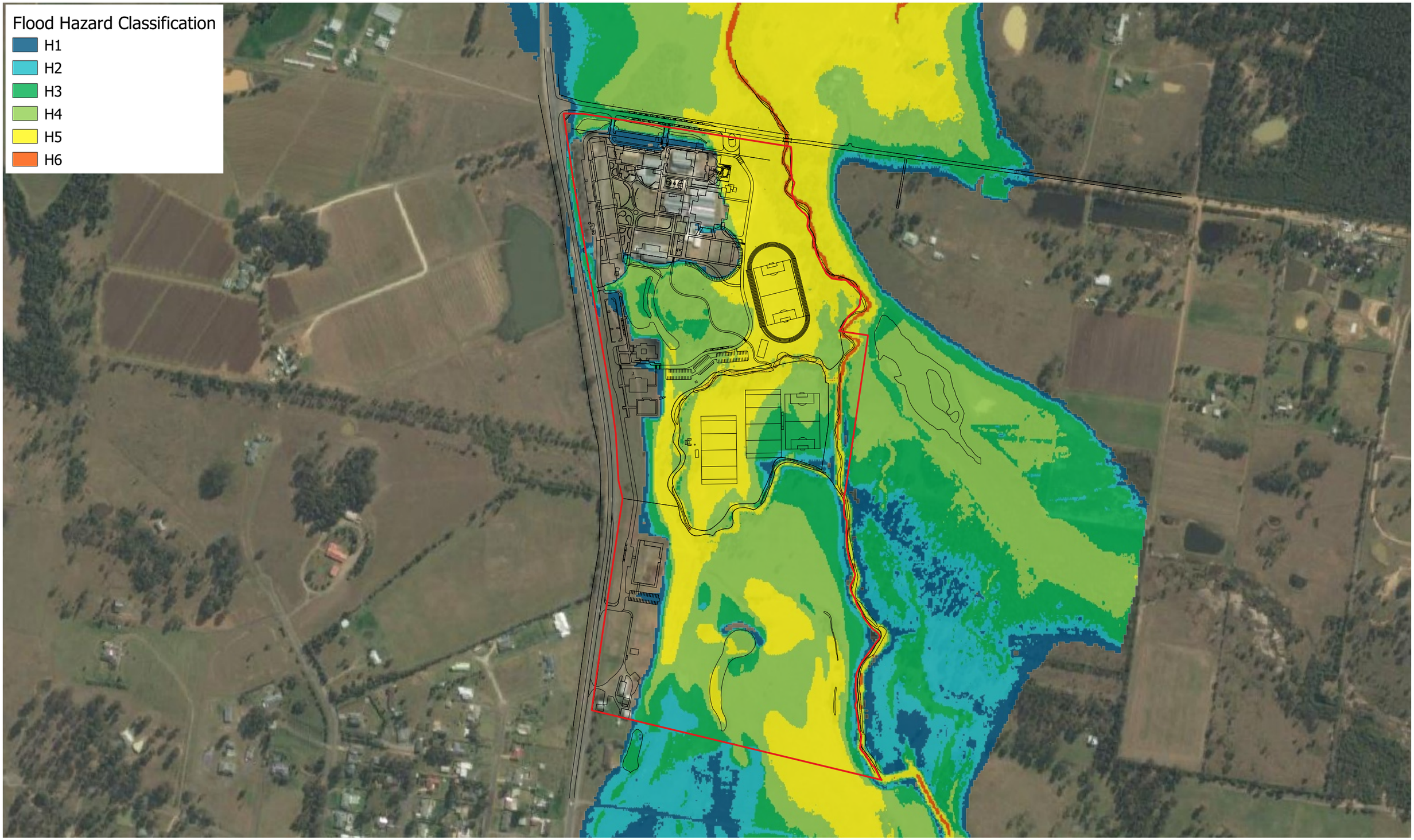

Legend

- Site Boundary
- Development Layout

Title:

0.2% AEP Post-development Peak Flood Hazard

Drawing: C-23

Rev: A

0 150 300 m

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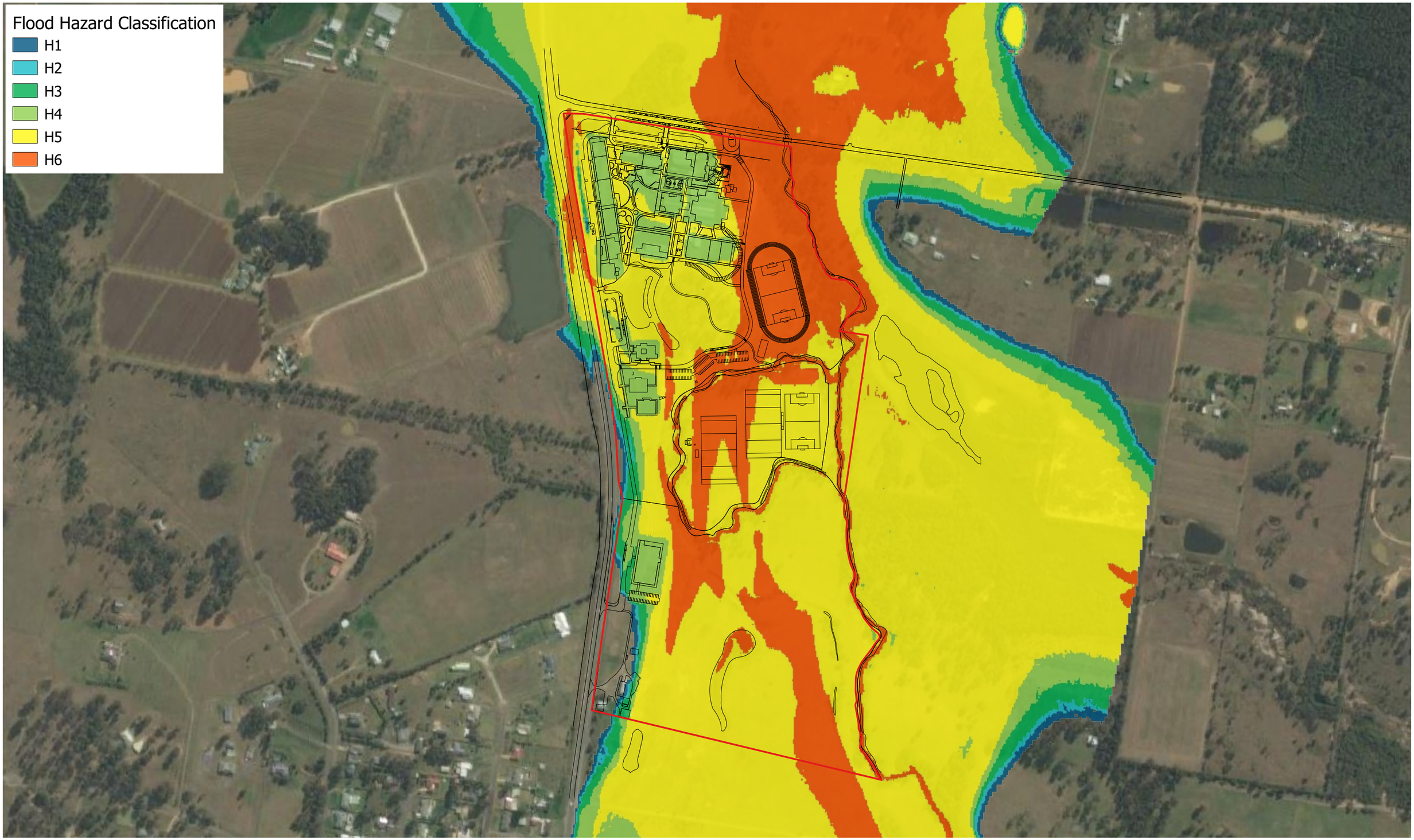

Legend

- Site Boundary
- Development Layout

Title:

PMF Post-development Peak Flood Hazard

Drawing: C-24

Rev: A

0 150 300 m

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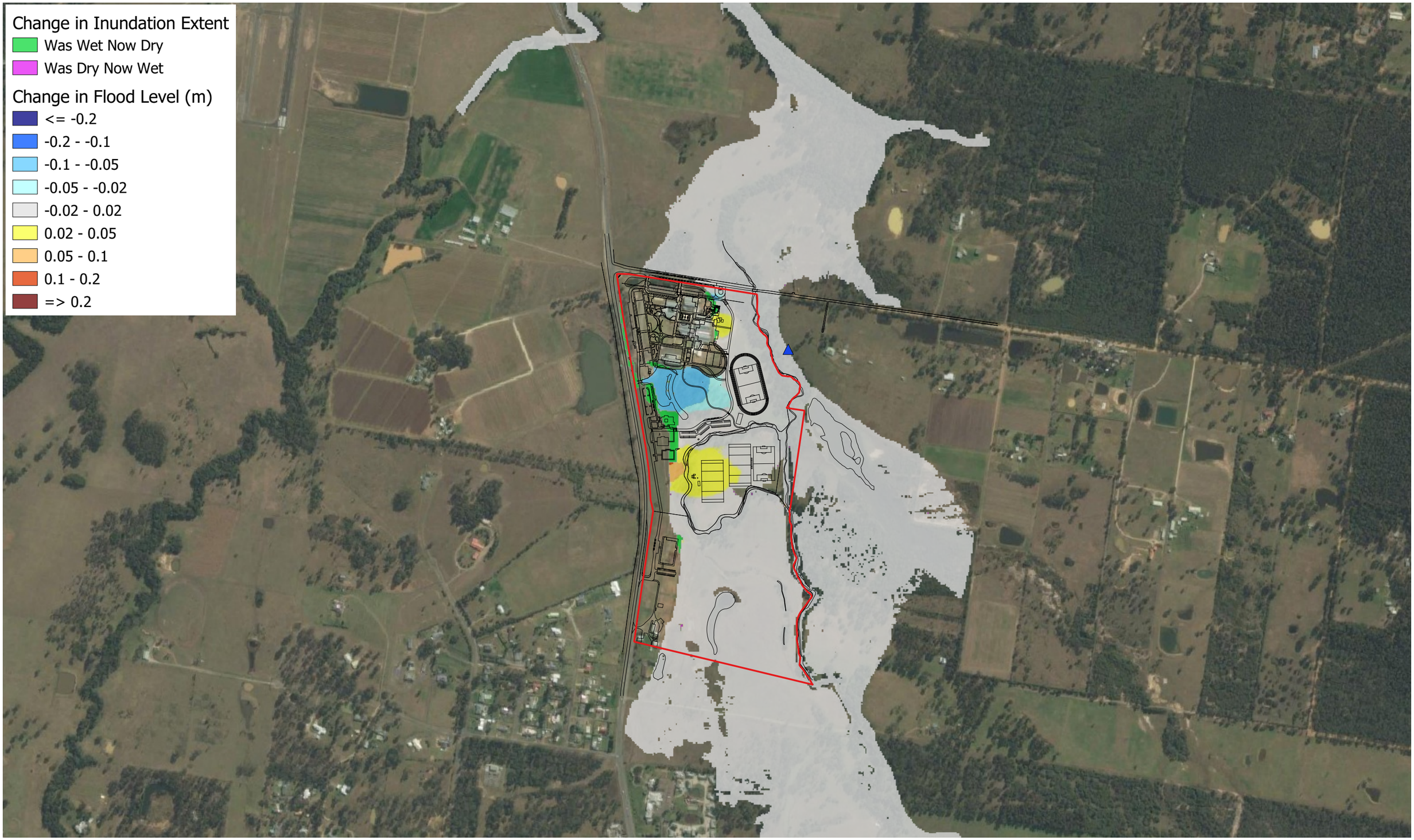
Annex D: Peak Flood Level Impact Maps



Legend

- Reporting Point
- Site Boundary
- Development Layout

Title:

20% AEP Post-development Afflux

Drawing: D-1

Rev: A

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0 200 400 m

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Change in Inundation Extent
- Was Wet Now Dry
- Was Dry Now Wet

Change in Flood Level (m)
- <= -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.02
- -0.02 - 0.02
- 0.02 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- => 0.2

Legend

- Reporting Point
- Site Boundary
- Development Layout

Title:
10% AEP Post-development Afflux

Drawing: D-2

Rev: A

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0 200 400 m

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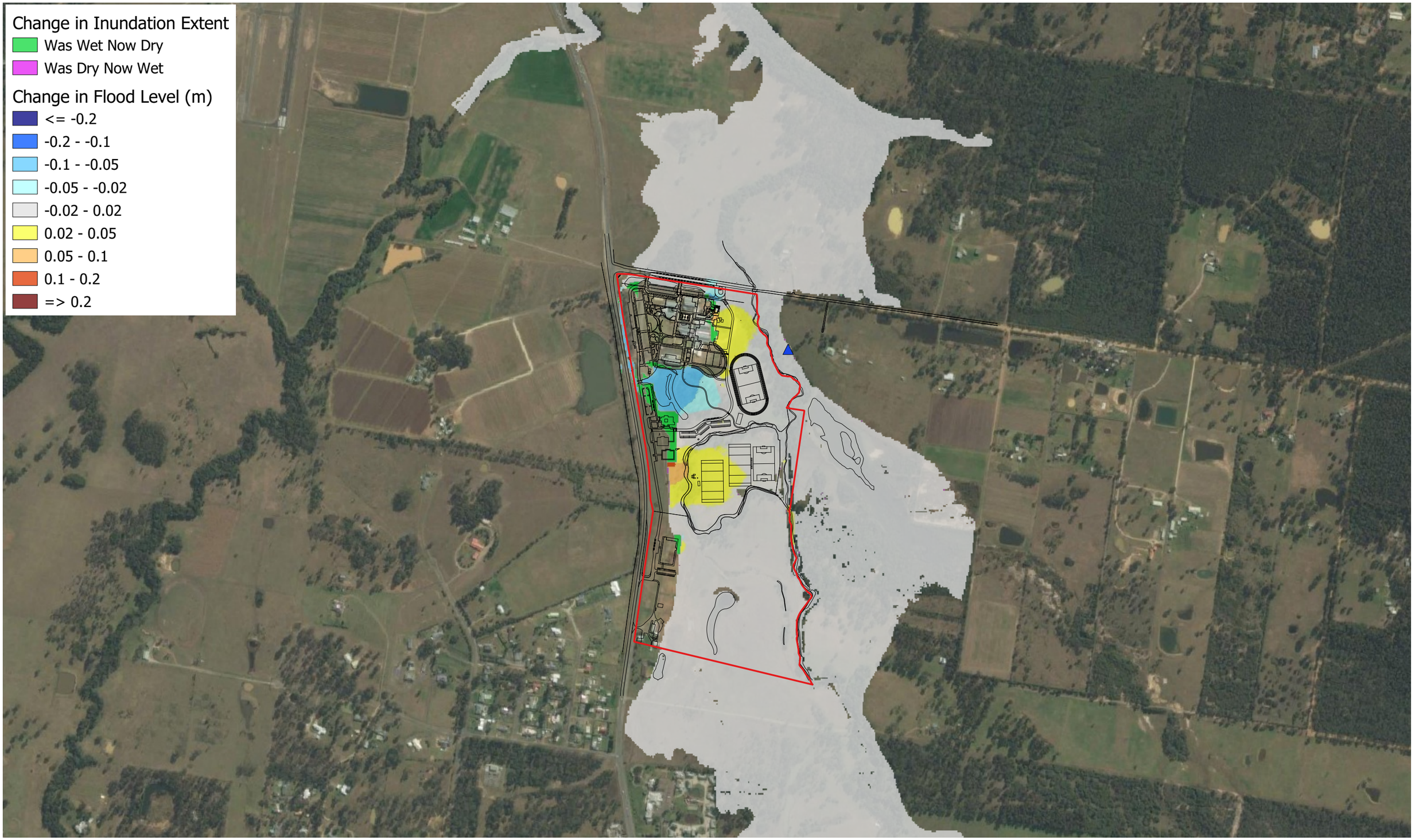

Legend

- Reporting Point
- Site Boundary
- Development Layout

Title:

5% AEP Post-development Afflux

Drawing: D-3

Rev: A

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0 200 400 m

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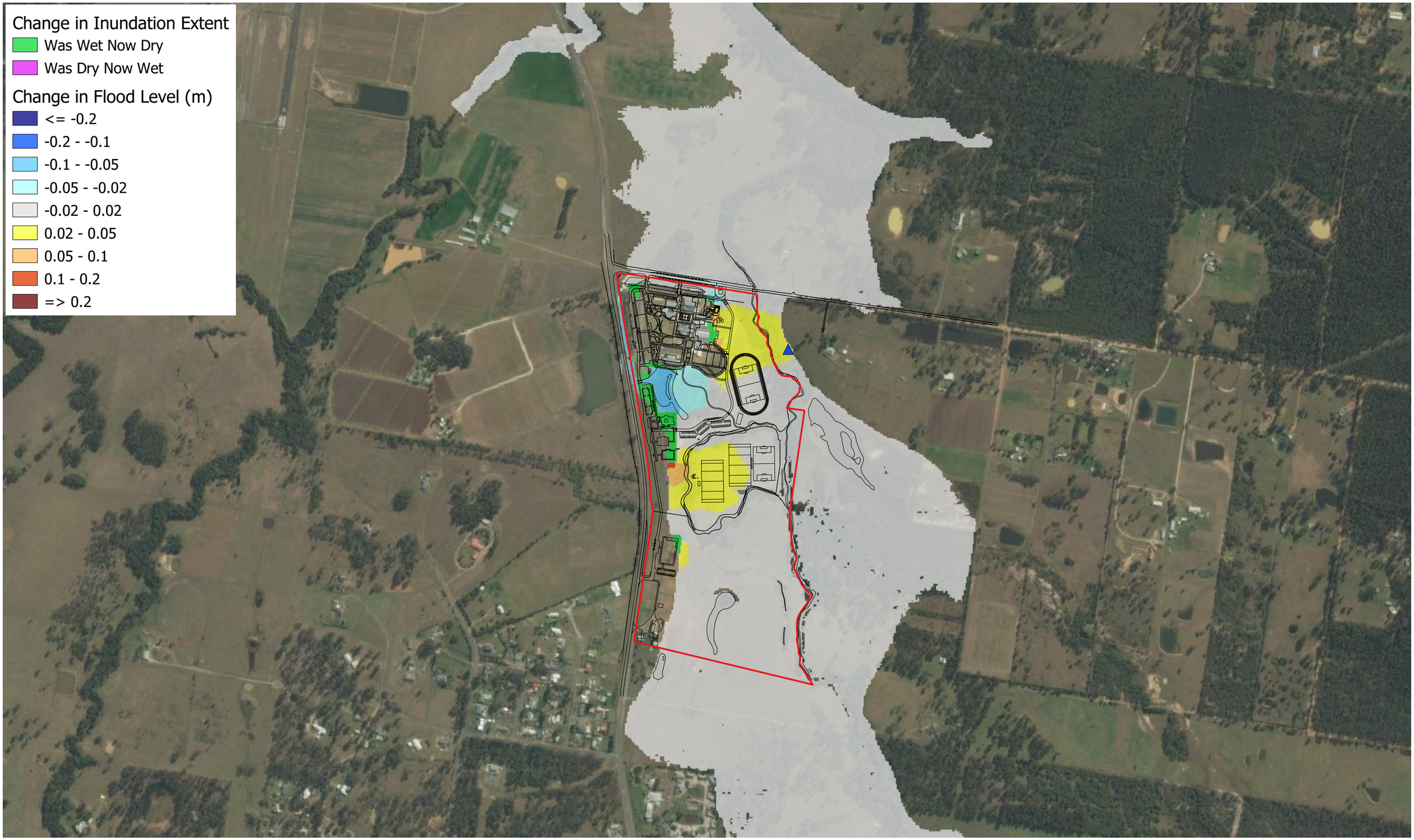

Legend

- Reporting Point
- Site Boundary
- Development Layout

Title:

2% AEP Post-development Afflux

Drawing: **D-4**

Rev: **A**

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0 200 400 m

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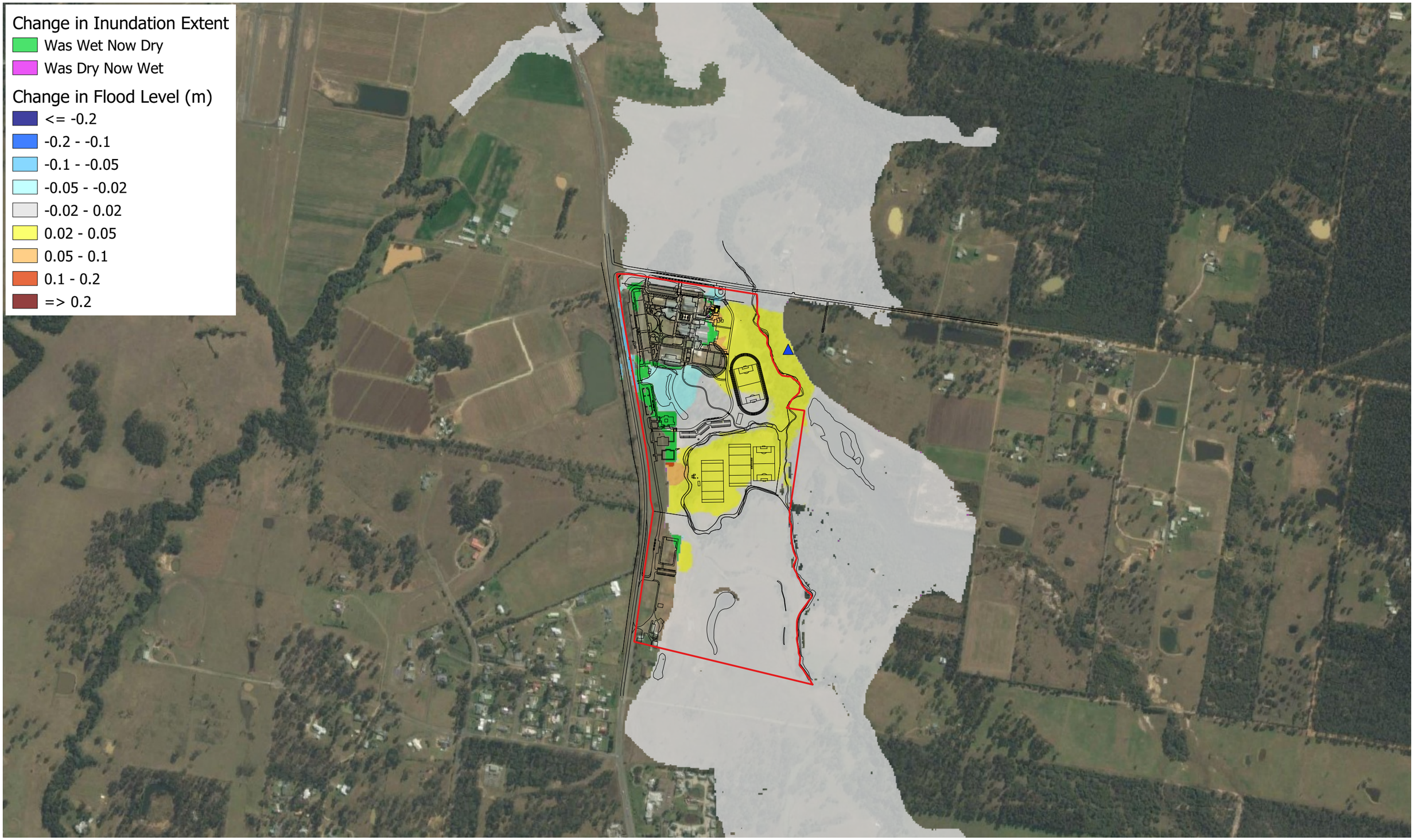

Legend

- Reporting Point
- Site Boundary
- Development Layout

Title:

1% AEP Post-development Afflux

Drawing: **D-5**

Rev: **A**

0 200 400 m

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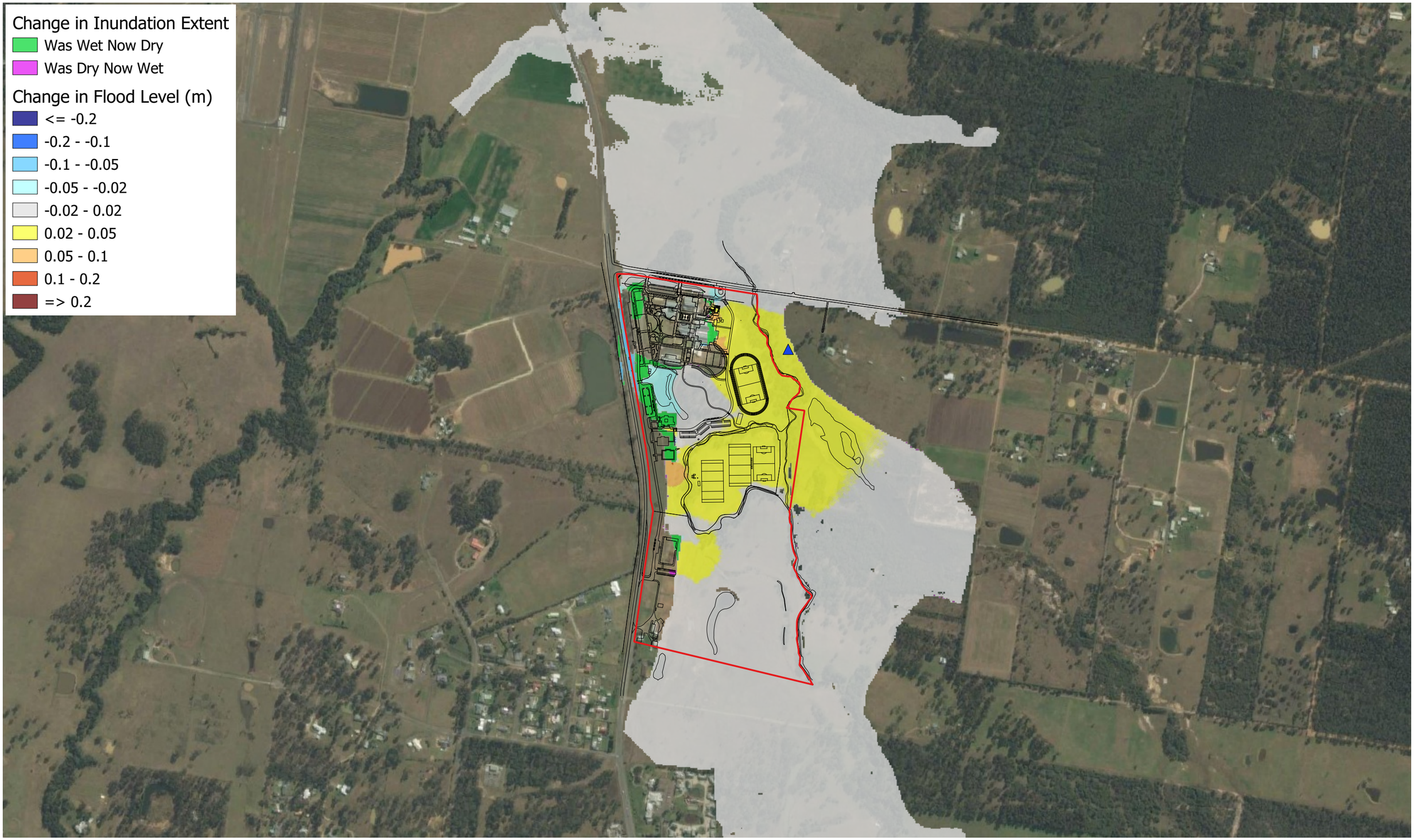

Legend

- Reporting Point
- Site Boundary
- Development Layout

Title:

0.5% AEP Post-development Afflux

Drawing: **D-6**

Rev: **A**

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0 200 400 m

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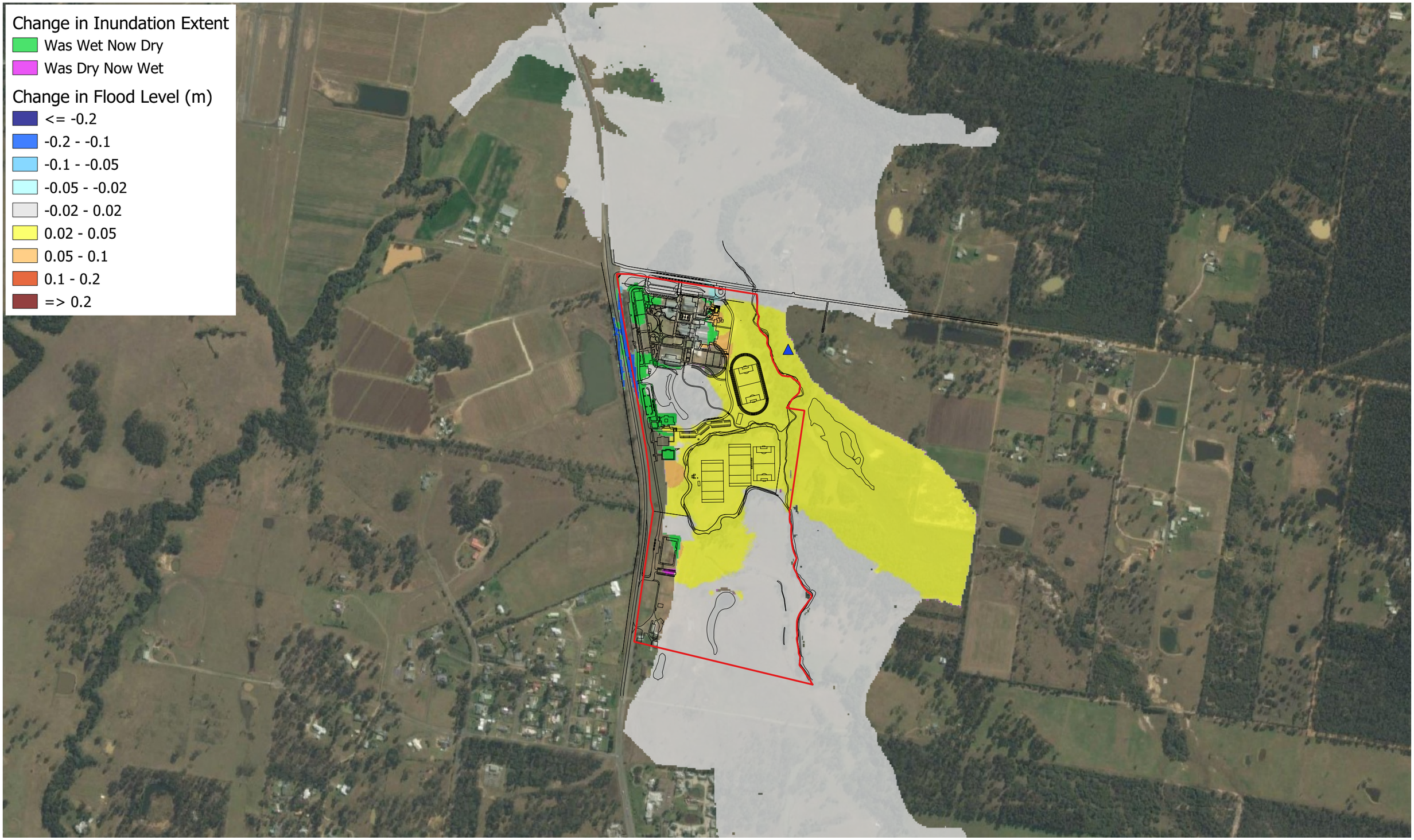

Legend

- Reporting Point
- Site Boundary
- Development Layout

Title:

0.2% AEP Post-development Afflux

Drawing: D-7

Rev: A

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0 200 400 m

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Change in Inundation Extent
- Was Wet Now Dry
- Was Dry Now Wet

Change in Flood Level (m)
- <= -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.02
- -0.02 - 0.02
- 0.02 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- => 0.2

Legend
- Reporting Point
- Site Boundary
- Development Layout

Title:
PMF Post-development Afflux

Drawing: **D-8**

Rev: **A**

0 200 400 m

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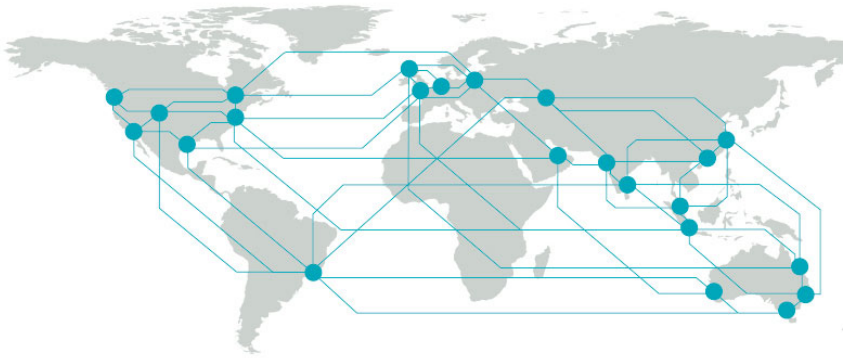

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