Regional Jobs Precinct Flood Impact Assessment

Stage 4 Final Report

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Executive Summary

The Richmond Valley Regional Jobs Precinct (RJP) is one of four precincts in NSW identified by the NSW Government, where planning support is being provided to help fast-track approvals to drive growth, investment and development opportunities within regional NSW. The RJP is located in Casino and is made up of three investigation areas, namely Area 1, Area 2 and Area 3.

Council commissioned BMT to undertake a Flood & Risk Impact Assessment (FIA) for the RJP. This report documents the assessment.

The hydraulic flood model of the Richmond River catchment, developed for the Richmond Valley Flood Study Update (RVFSU) has been updated for the current assessment. The primary updates were made to improve (reduce) the model simulation time and to refine the model resolution across the RJP Area 3.

The updated model was used to simulate the baseline 2% Annual Exceedance Probability (AEP), 1% AEP, 1% AEP with climate change, 0.2% AEP and Probable Maximum Flood (PMF) flood events. The baseline assessment identified the key flooding and drainage constraints for RJP Area 1 and RJP Area 3 along with flood evacuation considerations and any critical infrastructure servicing these areas.

A desktop review of the hydrological assessment supporting the new Rail Freight Terminal at Namoona was also undertaken. This review was informed by the regional flood levels from the current assessment. Whilst some discrepancies in assumed catchment area were noted, the implications on the assessment outcomes are unlikely to be significant.

A review of existing flood planning controls along with consideration of the regional flood modelling results and flood behaviour allowed for recommendations to be made on appropriate:

- Flood planning levels
- Acceptable flood impact criteria

These recommendations were discussed with stakeholders including the Department of Planning and Environment (DPE) and the NSW SES at a project workshop.

Following the baseline assessment, a flood impact assessment (FIA) was undertaken for RJP Area 3 which took into account the stakeholder feedback on flood planning levels and acceptable impact criteria. For the FIA the model was updated to include allowance for development fill within RJP Area 3. The FIA identified the need for flood mitigation involving creating additional capacity for flow from west to east to the north of Area 3. Two mitigation solutions were shown to be viable when mitigating peak flood level impacts; one reinstating a flow path though the land currently occupied by the sewage treatment plant (STP) and the second creating a flow path in Crown Land north of Spring Grove Road. Extents of filling were then optimised to minimise any residual flood impacts remaining after the mitigation.

As part of the scope of works a stormwater quality assessment was undertaken which has evaluated three potential stormwater quality management strategies using a MUSIC model developed for the assessment. Of these strategies, bioretention systems were found to require less area than wetlands whilst still achieving stormwater quality performance targets. Indicative areas and locations of stormwater quality infrastructure have been proposed for consideration.

Contents

1 Introduction

The Richmond Valley Regional Jobs Precinct (RJP) is one of four precincts in NSW identified by the NSW Government, where planning support is being provided to help fast-track approvals to drive growth, investment and development opportunities within regional NSW. The RJP is located in Casino within the Richmond Valley Council (Council) Local Government Area (LGA) and is made up of three investigation areas, namely Area 1, Area 2 and Area 3.

A draft Master Plan is currently being prepared for the RJP which will establish a basis for changes to local planning provisions for the RJP. The draft Richmond Valley RJP, including the three Areas is shown in Figure 1.1.

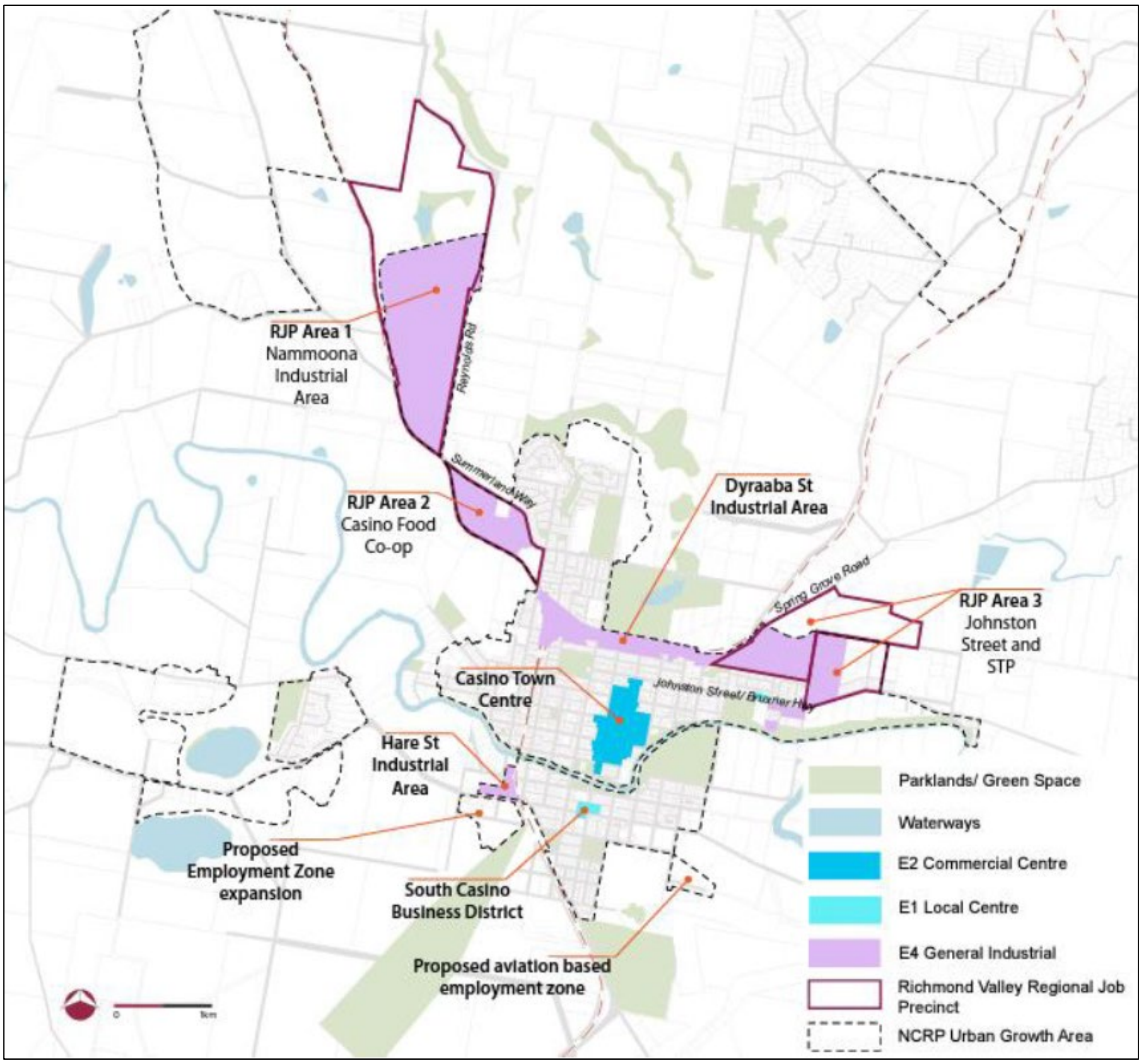


Figure 1.1 Draft Richmond Valley RJP Structure Plan (Feb 2023)

Council has commissioned BMT to undertake a Flood & Risk Impact Assessment (FIA) for the RJP. The key objective of Richmond Valley RJP FIA is to inform the RJP Master Plan, with a particular focus on the flood risk management of Area 3 and the northern part of Area 1.

The RJP is being conducted in five stages in accordance with the Project's Statement of Requirements (RVC, 2023). These five stages are as follows:

- Stage 1 – Inception Meeting
- Stage 2 – Baseline Analysis
- Stage 3 – Engagement and Review for Stage 2
- Stage 4 – Flood & Risk Impact Assessment and Report
- Stage 5 – Engagement and Review for Stage 4

This report documents the assessment up to and including Stage 4. It includes the Baseline Analysis and presents the Flood and Risk Impact Assessment. It includes the following key aspects:

- A summary of the state and local flood planning provisions and floodplain risk management plans regarding flooding, stormwater quality and integrated water management.
- Flood modelling of the 2% AEP, 1% AEP, 1% AEP with climate change (1%AEP+CC), 0.2% AEP and PMF flood events identifying flood and drainage constraints for Area 1 and Area 3.
- Nomination of recommended flood planning levels for the RJP Area 1 and Area 3.
- Analysis of any critical infrastructure servicing RJP Areas 1 and 3 which may have potential implications on flood evacuation should it be compromised during flood events.
- A review of flood assessments undertaken in support of the approved Casino Rail Freight Terminal in Area 1.
- A flood impact assessment for Area 3 which seeks to optimise fill extents in combination with mitigation to minimise the potential for flood impacts.
- An assessment of the constraints and opportunities in the stormwater quality management and integrated water cycle management.

2 Flooding and Drainage Assessment

2.1 Methodology

The Richmond Valley Flood Study Update (RVFSU) is currently being prepared by BMT. The RVFSU has involved the development of an URBS hydrologic model and a TUFLOW hydraulic model of the Richmond River catchment for the purposes of preparing flood inundation maps for regional flood events within the Richmond Valley LGA. The hydrologic and hydraulic models were calibrated against four historical flood events, namely the January 2008, May 2009, March/April 2017 and February/March 2022 events.

The TUFLOW hydraulic model utilised TUFLOW's 'Quadtree' functionality which allows the specification of different grid resolutions to different areas of the floodplain, thus enabling a finer grid representation where needed while optimising the simulation runtimes.

The hydrologic and hydraulic models developed as part of the RVFSU form the basis of the modelling for the RJP FIA. No modifications were made to the URBS hydrologic model, i.e. the inflow hydrographs applied to the RJP FIA hydraulic model are equivalent to those adopted in the RVFSU hydraulic model.

The TUFLOW hydraulic model was modified for the assessment in the following two key ways:

- The model was truncated to remove the lower portion of the model. The model was truncated at a location far enough downstream so as the results within Casino are unaffected by this change. This change reduces the model simulation time allowing for a higher turnover of simulations when optimising fill/mitigation scenarios.
- The model's Quadtree functionality was used to apply a higher model resolution across the RJP Area 3. RJP Area 3 and much of Casino is now modelled at a 5m grid resolution whereas Area 3 was previously represented by a 20m grid resolution.

Please refer to RVFSU for a detailed description of the setup and calibration of the RVFSU hydrologic and hydraulic models.

The updated model was simulated for the 2% AEP, 1% AEP, 0.2% AEP and PMF design flood events. These design events were derived in the RVFSU and are in accordance with the methodology outlined in 2019 Australian Rainfall & Runoff (ARR) guidelines.

A climate change scenario was also performed for the 1% AEP flood event in accordance with Richmond Valley Council's Scenario 3, which features an increase in rainfall intensity of 10%.

The critical storm durations and rainfall temporal patterns simulated in the hydraulic model were based on the critical duration assessment performed as part of RVFSU. A summary of the critical storms run in the hydraulic model for the RJP FIA is provided in Table 2.1.

Table 2.1 Summary of rainfall durations and temporal patterns run in the hydraulic model.

Design Flood Event	Critical Storm Duration	Critical Storm Temporal Pattern
2% AEP	24-hour	E8
1% AEP	24-hour	E7
1% AEP + Climate Change	24-hour	E7
0.2% AEP	24-hour	E5
PMF	36-hour	-

2.2 Flooding and Drainage Assessment

The results from the baseline model simulations are presented in Annex A (Area 1) and Annex B (Area 2). The result outputs are as follows:

- Peak flood level maps showing flood elevations with 0.25m interval contours
- Peak flood depth maps
- Peak flood velocity maps
- Peak flood hazard maps.

The flood hazard mapping is based on the flood hazard classification outlined by "*Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia*" (AIDR 2017). This categorises the hazard into 6 categories of increasing severity based on the flood hazard vulnerability curves shown in Figure 2.1.

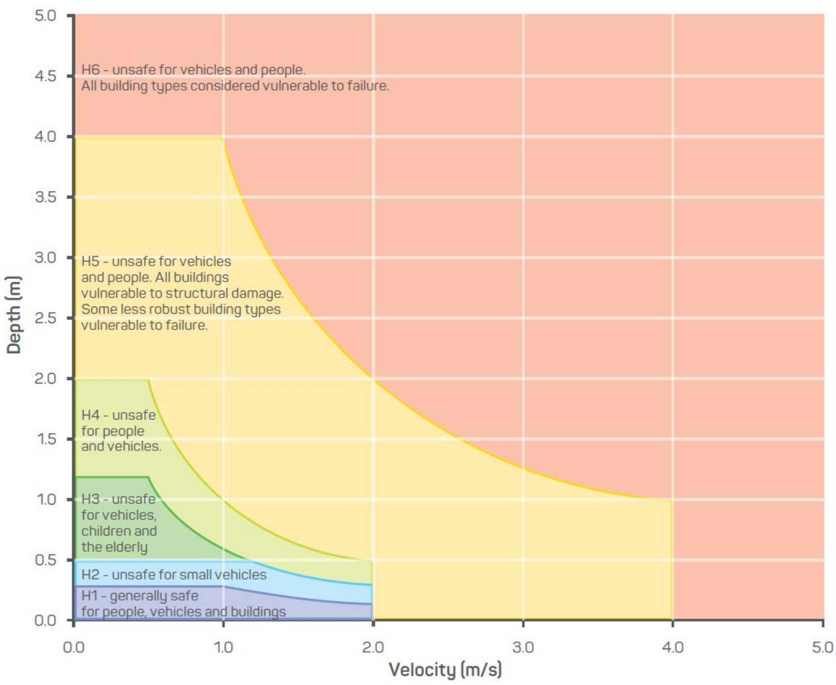


Figure 2.1 Flood hazard vulnerability curves (AIDR 2017).

RJP Area 1

Flood maps showing the peak flood level, depth, flow velocity and flood hazard of RJP Area 1 for the baseline conditions are provided in Annex A.

RJP Area 1 is bordered by the railway line on the southern and western boundaries, and by Reynolds Road on the eastern boundary. The southern portion of Area 1 is significantly higher than the adjacent Richmond River floodplain to the north, therefore, this southern portion of Area 1 is not affected by inundation from regional flood events up to and including the PMF event.

The northern portion of Area 1 includes low-lying wetland areas which form part of an overland flowpath draining in a north-south direction towards Reynolds Road. This northern portion of Area 1 is inundated in all the analysed flood events, however, the changes in flood extent between the 2% AEP and PMF flood events are minimal due to the relatively steep rise in elevation away from the low lying areas.

The assessment undertaken is based on simulations performed with the regional Richmond River flood model. This simulates design rainfall events which result in regional/catchment scale flood events and are characterised by critical rainfall durations longer than 24 hours. The upstream catchment area of the overland flowpath draining through the northern portion of Area 1 is small relative to that of the Richmond River catchment. As such, it will likely have a critical rainfall duration which is less than 24 hours. Therefore, the peak design flood levels estimated with the Richmond River flood model for the 24-hour rainfall duration may underestimate design flood levels in this portion of the floodplain given that shorter rainfall durations may produce higher peak flood levels. Given the small change in flood extent between events of different magnitudes, this limitation is unlikely to have any notable implications on development footprints, which should avoid those areas shown as being flood affected. It is however recommended to analyse the impacts of shorter rainfall durations in the simulations of future development scenarios for the northern portion of Area 1 at more detailed stages of the planning assessment.

RJP Area 3

Flood maps showing the peak flood level, depth, flow velocity and flood hazard of RJP Area 3 for the baseline conditions are provided in Annex B.

The flood inundation of RJP Area 3 during regional flood events mainly enters Area 3 from the west and south of the site. Figure 2.2 provides an overview of the ground elevations characterising Area 3 along with the flow velocity directions affecting the area during large flood events.

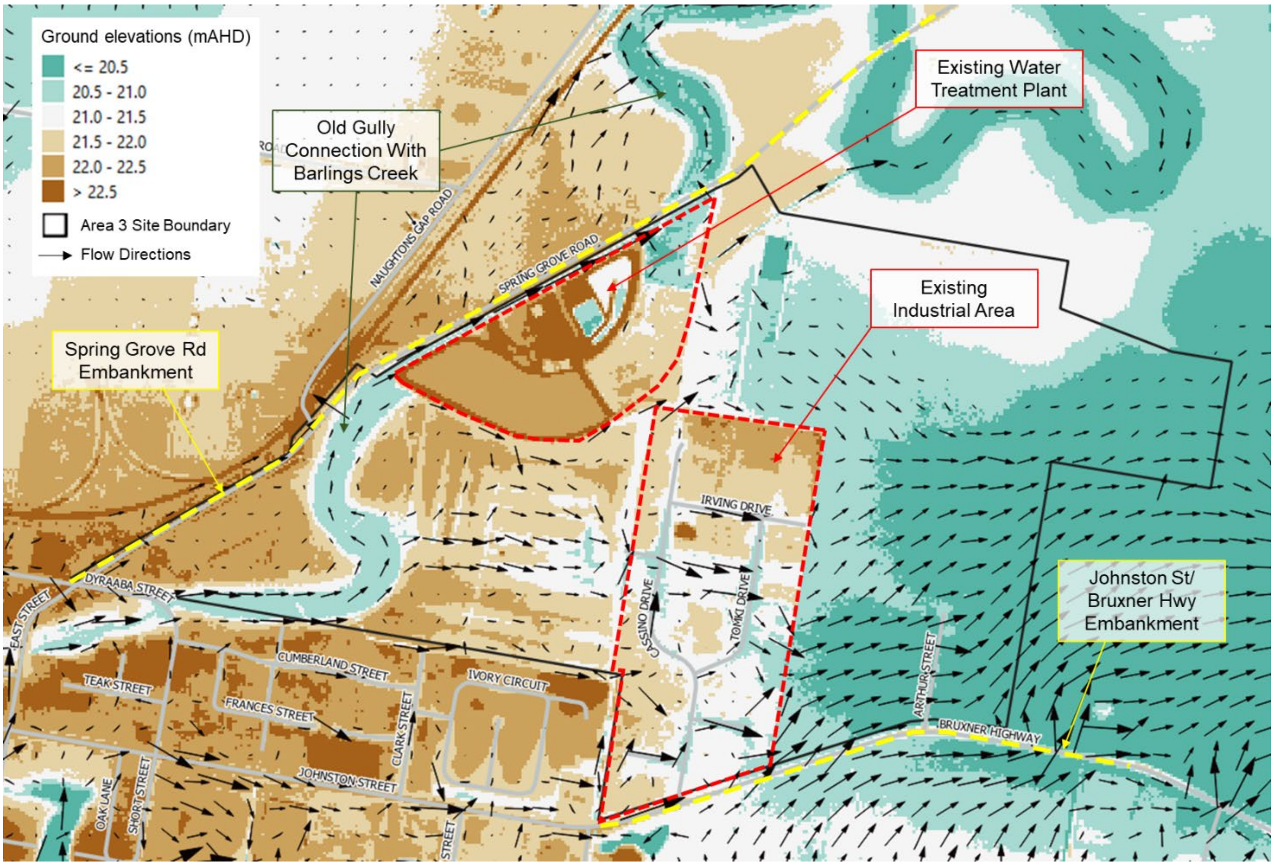


Figure 2.2 Topography and Flow Directions for Area 3 and Surrounds

On its western side, RJP Area 3 is crossed by a gully. During large flood events, breakout flow occurs from the Richmond River and passes through Casino, before connecting with Barlings Creek through this gully. The gully is significantly obstructed by the sewage treatment plant and associated treatment ponds, which limit the passage of flow towards Barlings Creek. This then redirects flow through the existing industrial area after which it spreads across the relatively flat land within the eastern portion of Area 3.

The flood inundation of RJP Area 3 is also due to the overtopping of the Bruxner Highway along the southern boundary of Area 3. In the 2% AEP flood event, roads within the existing industrial area and a portion of the rural area located on the eastern side of the industrial area are inundated by flood depths generally lower than 0.5 m, with an estimated maximum flood depth of 0.54m at the lowest point of Cassino Drive. The eastern, rural portion of Area 3 is completely inundated by floodwater during events rarer than and including the 1% AEP event. The flood model estimates a 1% AEP peak flood depth of approximately 0.9 m at the lowest point on Cassino Drive.

Any filling within Area 3 will obstruct existing overland flows coming from the west and south, potentially causing an increase in flood levels to the west and south of Area 3 as well as in the existing industrial area located within RJP Area 3.

2.3 Flood Evacuation and Critical Infrastructure Analysis

The locations of identified critical infrastructure, in terms of flood evacuation considerations, are presented in Figure 2.3 and Figure 2.4 for RJP Areas 1 and 3, respectively. The 1% AEP classified flood hazard is also shown for context. In all cases the identified critical infrastructure are road crossings of drainage channels and which are subject to potential inundation and consequent road closure. The evacuation centre used in Casino is the Casino High School which is located on high ground to the north of the town centre. A summary of critical infrastructure locations and evacuation considerations is provided below for Areas 1 and 3 respectively.

RJP Area 1

The critical infrastructure servicing RJP Area 1 is shown in Figure 2.3.

The overland flowpath affecting the northern portion of RJP Area 1 crosses Reynolds Road at the north-east corner of Area 1. During a 1% AEP event, an approximate 710m section of Reynolds Road is inundated with a flood hazard category H3 (i.e., “unsafe for vehicles, children and the elderly”). Any potential blockage of the Reynolds Road bridge at this location can further exacerbate the flood issues by increasing the flood levels upstream of the bridge. This can cause overtopping of the bridge during all the analysed flood events.

The portion of Reynolds Road located south of the overland flowpath crossing is not affected by regional flooding in all the events up to the PMF event, therefore, the evacuation of RJP Area 1 can be safely performed to the south via Reynolds Road and Summerland Way. Access can then be made to the evacuation centre if required.

RJP Area 3

The critical infrastructure servicing RJP Area 3 is shown in Figure 2.4. A potential flood evacuation challenge for Area 3 is that roads heading west from Area 3 towards Casino and the evacuation centre are subject to high hazard flood conditions in the 1% AEP event.

As part of this assessment the SES were consulted. It was acknowledged that the site is for industrial use and so will not contain residents. It was also noted by DPE that Casino generally has good flood warning times as it forms part of the Bureau of Meteorology’s early warning network. The SES has advised that Area 3 would require evacuation before the Richmond River level reached 22m AHD (at the Casino Gauge) when access roads would become flooded. The preferred evacuation from Area 3 away from the floodplain is along Johnston Street B91 and West Street B91.

A level of 22mAHD at the Casino Gauge is between a 5% and a 2% AEP flood event based on the Draft Richmond Valley Flood Study. At this gauge level, the Richmond River is within bank through Casino. At a gauge level of approximately 22.5m there is some minor breakout of flow into Casino with more substantial flows occurring at 22.8mAHD. The February/March 2022 flood peaked at 22.9mAHD at the Casino Gauge and it is understood that there were no reported evacuation issues in relation to the existing Cassino Drive Industrial Estate which is within the RJP Area 3 site, during that event. Based on the rate of rise of the 2022 event, it took approximately 4 hours for the river level at the gauge to rise from 22mAHD (i.e. a level before which evacuation should occur) to 22.8mAHD (i.e a level at which substantial flow starts breaking out through Casino).

The requirement to evacuate the site before the Richmond River level reached 22m AHD means that the key evacuation routes remain flood free (except for any local drainage issues) and so evacuation to the evacuation centre is possible with the anticipated warning times. It is noted however that given this is an industrial area, people will likely prioritise going to their homes prior to making a journey to the flood evacuation centre.

Given sufficient warning time, evacuation to Casino should be possible. In the event of a late warning such that the roads towards Casino are inundated, evacuation of Area 3 would need to occur to the east towards Spring Grove. The critical infrastructure with implications for flood evacuation towards the east of Area 3 consist of drainage crossings on Spring Grove Road and Naughtons Gap Road. Both roads are mostly classified as flood hazard category H1 (i.e., “general safe for people, vehicles and buildings”) in the 1% AEP event for both existing and future climate scenarios. An approximate 280m section of Spring Grove Road located in proximity to the water treatment plant is affected by flood hazard category H3 (i.e., “unsafe for vehicles, children and the elderly”) in the 1% AEP event, however, this section of Spring Grove Road could be bypassed by taking Naughtons Gap Road instead.

A total of three bridges located at the Barlings Creek crossings of Naughtons Gap Road and Spring Grove Road are of key importance for the safe flood evacuation of Area 3. These crossings remain dry in the 1% AEP event although may be subject to inundation if any blockage at the structure should occur.

It is noted that most of the roads within the existing industrial area are affected by flood hazard category H3 (i.e., “unsafe for vehicles, children and the elderly”) in the 1% AEP event. These flooding issues are further exacerbated when considering the future climate scenario.

Project based engagement with the SES on the matter of Flood Emergency Management has occurred. Based on the information provided the SES have indicated that flood emergencies involving evacuation for the proposed RJP lands can be effectively managed. The SES has stated that documented strategies (as an output of this study) will be used to inform their intelligence database for future disaster management issues.

Figure 2.3 Critical infrastructure servicing RJP Area 1.

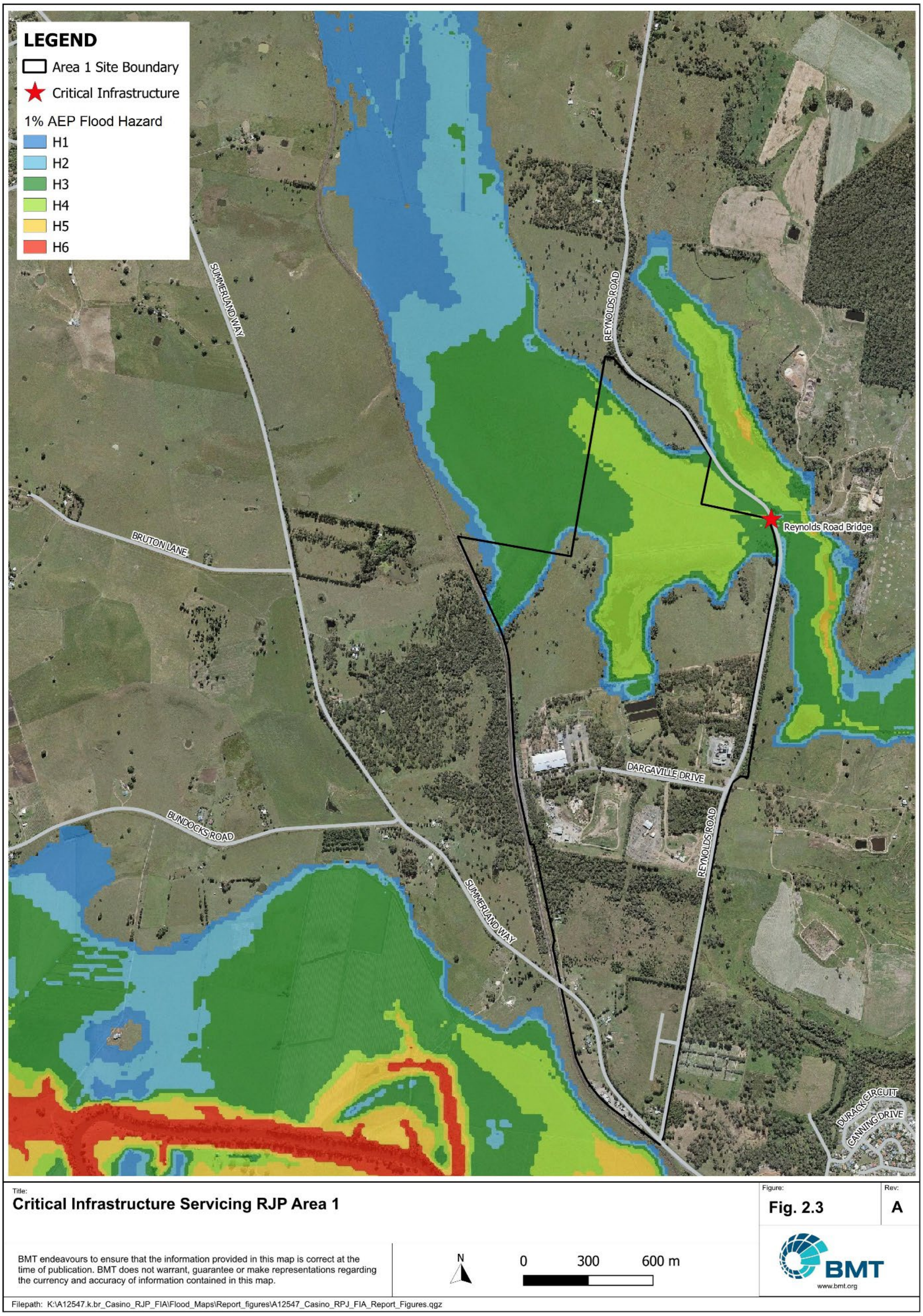
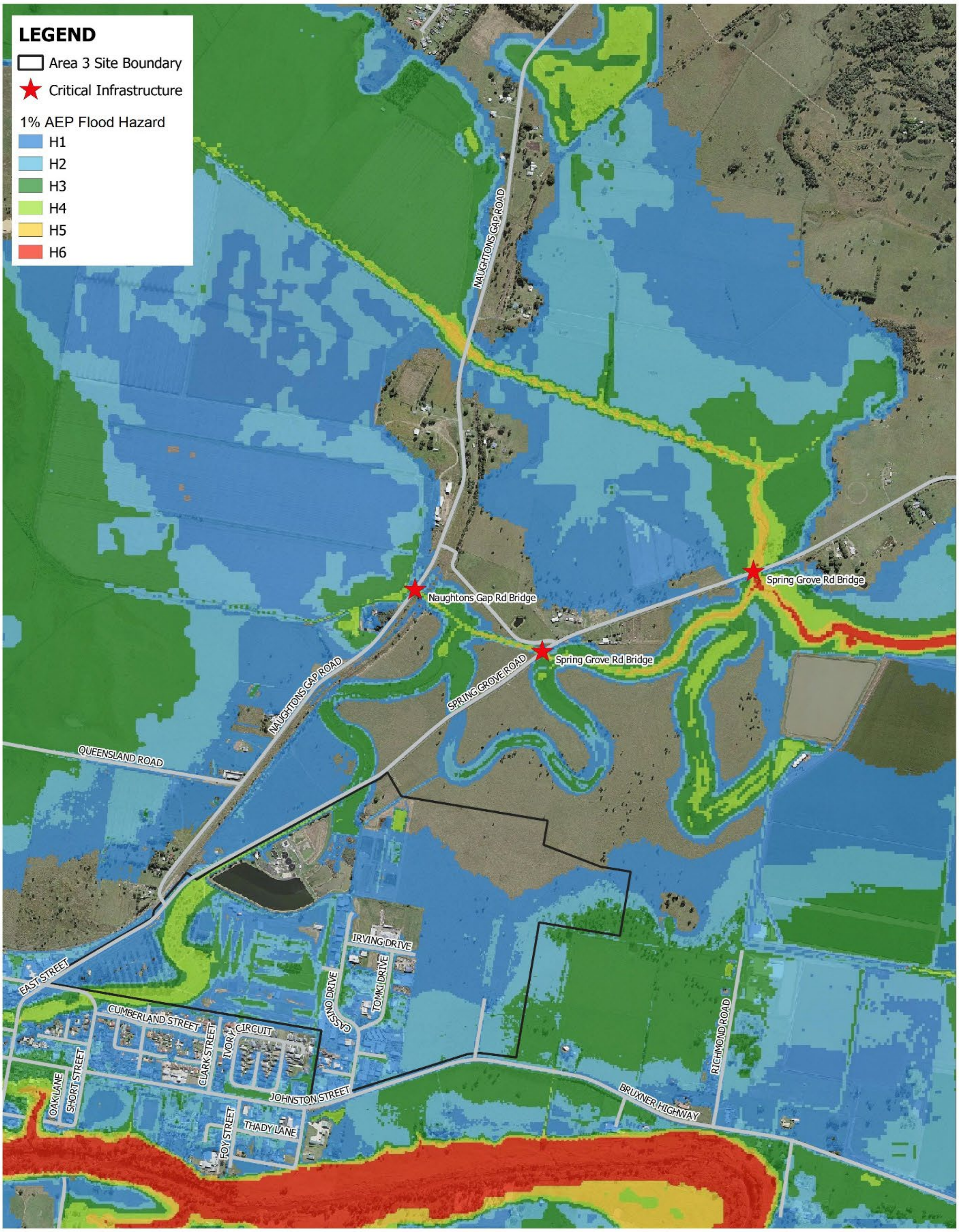


Figure 2.4 Critical infrastructure servicing RJP Area 3.



Title:
Critical Infrastructure Servicing RJP Area 3

Figure: **Fig. 2.4** Rev: **A**

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2.4 Summerdowns Rail Freight Terminal FIA

A desktop review of the "Stormwater Design and Flood Impact Assessment Report for Summerdowns Rail Freight Terminal" (Plateway, 2010) has been undertaken. The review has been undertaken in the context of the regional flood modelling results obtained for the RJP FIA. This section summarises the key outcomes of the review.

Development Overview

The proposed Summerdowns Rail Freight Terminal at Namoona includes the construction of a new freight terminal adjacent to the existing railway line and a new embankment crossing the floodplain in a west to east direction from the freight terminal to Reynolds Road (Figure 2.5). The new embankment is located within a low-lying portion of the floodplain which is inundated during the 1% AEP regional flood event, as well as during more frequent regional flood events.

The original assessment delineated three catchments which drain through the site as follows:

- Catchment 1 consists of a larger catchment draining in a north-south direction. The outlet of Catchment 1 is located at the bridge on Reynolds Road. The catchment was determined as having an area of 18.2km^2.

- Catchment 2 is a small catchment (0.13km^2) which includes the area occupied by the proposed office complex of the new freight terminal. Catchment 2 naturally drains into Catchment 1 under pre-development conditions. Under post-development conditions, the runoff generated by Catchment 2 will be directed toward a detention basin and then released into Catchment 1 in order to preserve the existing drainage pattern.

- Catchment 3 is the local catchment area which drains higher ground within Area 1 towards the north. It has an area of 1.3km^2 which includes the wetland located between the proposed freight terminal and Reynolds Road. In pre-development conditions, the runoff generated by Catchment 3 is collected by an existing drain and by the wetland which both direct the flows towards Catchment 1 and the bridge on Reynolds Road.

The proposed embankment will separate Catchment 1 from Catchment 3. The proposal includes a 2.5 x 3 m fauna/stock underpass and 5 x 600 mm culverts aimed at preserving the hydraulic connection between Catchment 1 and Catchment 3.

The proposed new embankment will also include 3 x 1.2 m box culverts which will be located at the north-east corner of the embankment. The key objective of these culverts is to preserve the drainage connection between the wetland in Catchment 3 and Catchment 1 and, hence, direct Catchment 3 runoff toward Catchment 1 outlet at Reynolds Road bridge.

The proposed minimum floor levels are set at 28.7 mAHD for the embankment and at 30 mAHD for the office complex of the freight terminal.

The hydrologic assessment was completed in 2010 in accordance with the methodology outlined in 1987 Australian Rainfall & Runoff (ARR) guidelines. The hydrologic assessment featured the application of the rational method in order to estimate the peak runoff generated by Catchments 1, 2 and 3, and to size the culverts connecting Catchment 1 and Catchment 3 for the new embankment. No flood modelling to establish flood levels was undertaken for the assessment.

Key review outcomes

As part of the current review, the proposed development layout and floor levels were compared against the regional design flood levels modelled as part of the RJP FIA. The proposed development is located within a tributary catchment of the Richmond River where the critical rainfall durations are likely to be shorter than those used to derive regional flood events. Therefore, rainfall durations shorter than 24 hours may produce higher local flood levels at the Summerdowns Rail Freight Terminal site than those discussed in the present assessment.

The regional flood model results show that there is negligible change in flood extent at the site when comparing the 1% AEP and 0.2% AEP flood events. Figure 2.5 shows the differences in flood levels and extents between these two events. The peak level increases by approximately 0.15m with a minimal change in flood extent.

The proposed freight terminal will be mostly built on high ground which is not affected by regional flooding. For this reason, the impacts of the freight terminal on the existing regional flood levels are expected to be minimal and contained within rural/grazing area. Given the significant height above regional flood levels it is unlikely therefore that the freight terminal would be inundated from local events from Catchment 1.

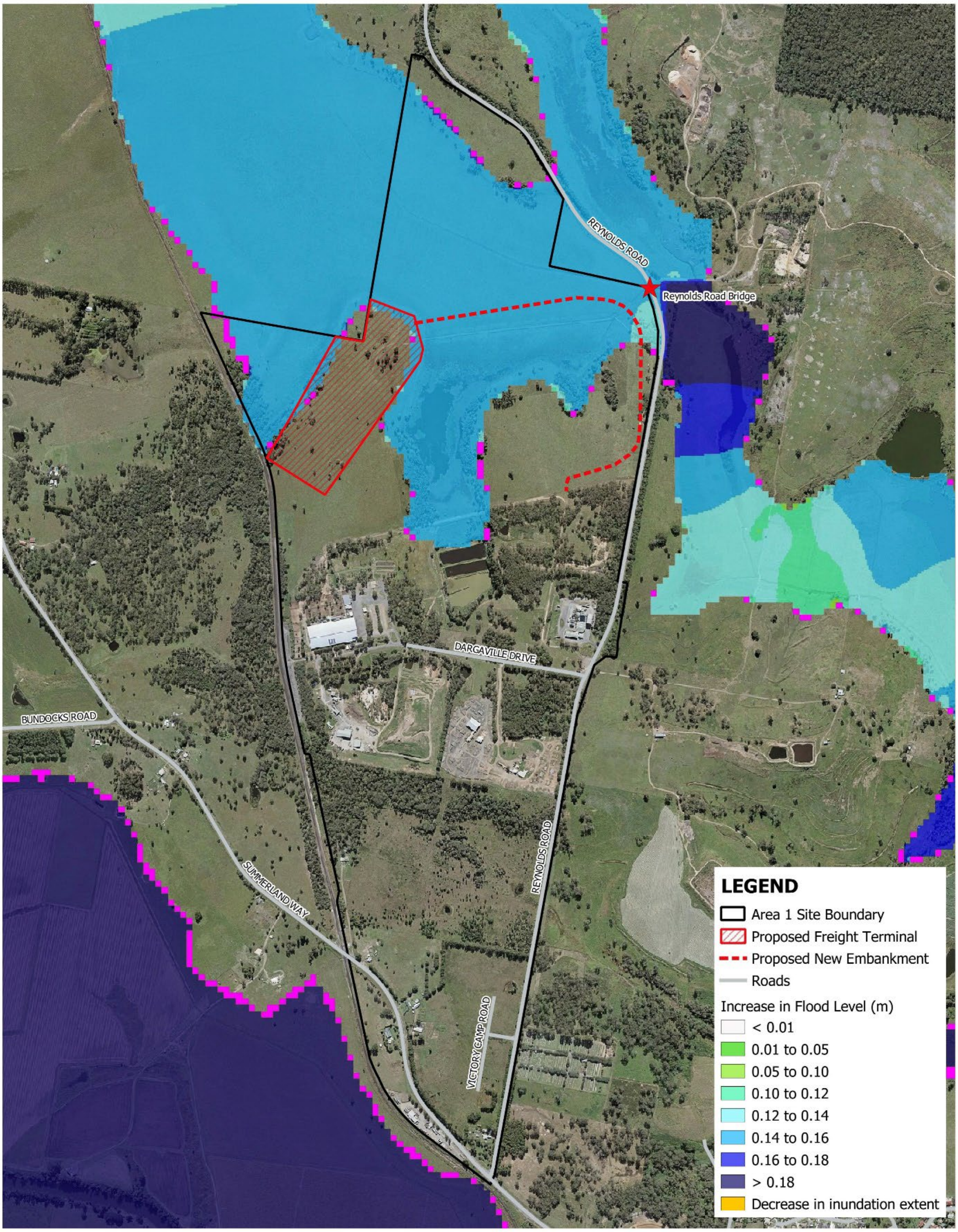
The proposed new embankment will divide the floodplain within a low-lying area affected by flooding in all the analysed flood events. The flood levels estimated by the regional flood model along the proposed new embankment are 26.1 mAHD for the 1% AEP, 26.2 mAHD for the 0.2% AEP and 26.9 mAHD for the PMF event. The top of the embankment is 1.8m higher than the regional PMF level.

The volume occupied by the new embankment will promote a displacement of water volume during regional flood events with consequent increase in flood levels. However, the impacts of the new embankment construction on the existing flood levels are expected to be negligible given that the embankment volume is small when compared with the extent of the floodplain.

It is noted that the Catchment 1 area has been underestimated by roughly 20% when repeating the analysis using available LiDAR data. Therefore, Catchment 1 flows entering Catchment 3 through the new embankment may in turn be underestimated, resulting in higher flood levels on the northern side of the embankment (i.e., within Catchment 1) than on the southern side (i.e., within Catchment 3) and potentially affecting the flood immunity of the new embankment. However, considering that the proposed top of embankment is 1.8 m higher that the estimated PMF regional flood levels, the understatement of Catchment 1 runoff is expected to have negligible impacts on the flood immunity of the new embankment.

With regards to stormwater quality management of the proposed Summerdowns Rail Freight Terminal site, it is noted that there was no detailed consideration of stormwater quality runoff and the impacts on downstream receiving environments.

Figure 2.5 Differences in peak flood levels between the 0.2% AEP and 1% AEP flood events.



Title:
Differences in Peak Flood Levels | 0.2% AEP vs 1% AEP
Baseline Conditions

Figure: **Fig. 2.5**

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3 Flood Planning Levels & Impact Criteria

3.1 Review of Existing Flood Planning Controls

Introduction

Flooding can cause significant damage to property and risk to life. The Local Government Act 1993 (flooding) and NSW Flood Prone Lands Policy (2005) give responsibilities to councils to manage the impacts of flooding. The Policy incentivises councils to follow the principles of the Policy's Floodplain Development Manual which includes for councils to undertake flood studies to determine what land has the potential to be affected by flooding.

The flood studies usually determine Flood Planning Areas which are areas within which developments may be subject to flood related development controls. The development controls typically include the setting of a Flood Planning Level (FPL) which is a height used to set floor levels of property. The FPL is generally defined as the 1% AEP flood level plus an appropriate freeboard. The FPL can vary however, based on the type of development. For example, industrial land may be permitted with a lower FPL than a vulnerable land use such as a hospital.

Local Environment Plans (LEPs) are the main planning controls for councils as they set out objectives, zones and development controls. Councils are responsible for the preparation of LEPs and they usually specify the development permissible on any area of land and whether council consent is required.

Flood Planning Controls in Richmond LGA

The Richmond Valley LEP (2012) is the principal planning scheme for the Richmond Valley LGA. It includes the adoption of different land zones. Clause 5.21 of the LEP relates to flood planning and seeks to ensure that any development on land within the flood planning area is compatible with the flood function and behaviour on the land. The LEP states that the flood planning area has the same meaning as it has in the Floodplain Development Manual (2005) which is the area below the flood planning level. The flood planning levels for Casino are currently defined in the Casino Floodplain Risk Management Plan (2002). Other considerations within Clause 5.21 of the LEP include the need to consider the impact of proposed development on flood behaviour under future climate conditions.

The LEP is complemented with the Richmond Valley Development Control Plan (RV DCP) (2021) which includes development standards and assessment criteria. Part H-1 of the DCP sets out objectives and controls in relation to development of land below the FPL. It includes reference to Council's floodplain risk management plans, one of which is for Casino.

The Casino Floodplain Risk Management Plan (FRMP) was developed in 2002. It is based on flood modelling which occurred around that time. The FRMP used the 1% AEP design flood as a reference for flood planning purposes. More critical development is additionally assessed against its compatibility to flood hazard as set out in a Matrix of Development Type v Flood Hazard Category. The floodplain hazard categories were defined based on combination of depth and velocity. Both the 1% AEP flood level and the hazard categories are to be superseded by updated modelling undertaken for the Richmond Valley Flood Study Update. The hazard categories are now used as defined in AIDR (see section 2.1).

With regards to commercial and industrial development in Casino (for which the majority of the RJP will be), floor levels are currently required to be above the 1% AEP flood level (i.e., without the FPL freeboard). Part H-1.4 (3) (c) of the RV DCP notes that "A combination of design, flood level and freeboard will be used to determine the suitability of development through consultation of the Risk Plans."

Recommendations from Floods Inquiry

The NSW Floods Inquiry was commissioned following the significant flooding of March 2022 which affected large parts of NSW with the Northern Rivers region being one of the most affected areas. Part of the Inquiry considered the planning system as it relates to floods. The Inquiry was generally critical of the commonly adopted approach of simply adopting a 1% AEP flood level without further consideration given to the risk. Recommendation 18 of the Inquiry endorsed a risk based approach to determining the flood planning level. Whilst it was not specific about how this is undertaken it does flag that consideration should be given to the PMF, 1% AEP and 0.02% AEP.

Implications for RJP

The flood modelling undertaken for the Richmond Valley Flood Study Update maps the flood levels depths, velocities and flood hazard to a greater level of detail than previously available. Furthermore, the modelling is based on updated information for factors such as the terrain, existing development and model inflows. For the RJP assessment this modelling is therefore being used in place of the modelling previously undertaken for the Casino FRMP.

The current flood planning level for industrial zoned land within Casino is the 1% AEP flood level. Given Recommendation 18 of the NSW Flood Inquiry, it is considered warranted to investigate use of a risk based approach to determining the FPL for the RJP. Such an approach would include looking at the flood levels for large (rare) events and the difference in flood level between those events. For example, for those parts of the floodplain where the flood level increases significantly between a 1% AEP event and a rarer event, it may be prudent to adopt a higher level of freeboard than for those parts of the floodplain where the flood level increase is less. This is explored further in Section 3.2.

3.2 Recommended Flood Planning Levels

For the purposes of recommending flood planning levels within RJP Area 3, Area 3 was subdivided into three sub-areas (i.e., Area 3A, 3B and 3C). This allows for differences in flood levels and flood characteristics to be accounted for. The subdivision of Area 3 is shown in Figure 3.1, and the maximum peak flood levels estimated by the Richmond River flood model in each sub-area are summarised in Figure 3.2.

In general, various approaches can be adopted in the identification of flood planning levels. At a minimum the floor levels should be above the 1% AEP flood level. This view is also endorsed by the SES.

An FPL based on the following options was considered for this assessment:

- The 1% AEP flood level;
- The 1% AEP flood level with an allowance for climate change;
- The 1% AEP flood level with a nominal freeboard (NF), typically set at 0.5m based on the Floodplain Development Manual.
- The 1% AEP flood level with an allowance for climate change and a nominal freeboard;

- The 1% AEP in combination with a risk-based freeboard (RBF) flood level. In this case the RBF was considered to be the difference in peak level between the 0.2% AEP and 1% AEP events. The FPL therefore effectively becomes the 0.2% AEP flood level which incorporates a RBF; this RBF being is 0.4m for Area 3A, 0.3m for Area 3B and 0.4m for Area 3C.

A summary of the flood planning levels resulting from the approaches described above for each sub-area is provided in Figure 3.3.

Based on our review of existing planning controls and the modelling results, we recommend adopting the following flood planning levels for Casino RJP Area 3:

- A 1% AEP flood level for general commercial/industrial use;
- A 1% AEP + RBF flood level for commercial/industrial activities which includes storage of hazardous materials.
- Provision of sufficient readily accessible habitable areas above the PMF to cater for the safety of potential occupants, clients and visitors

Figure 3.1 Sub-division of Area 3 for estimation of flood planning levels.

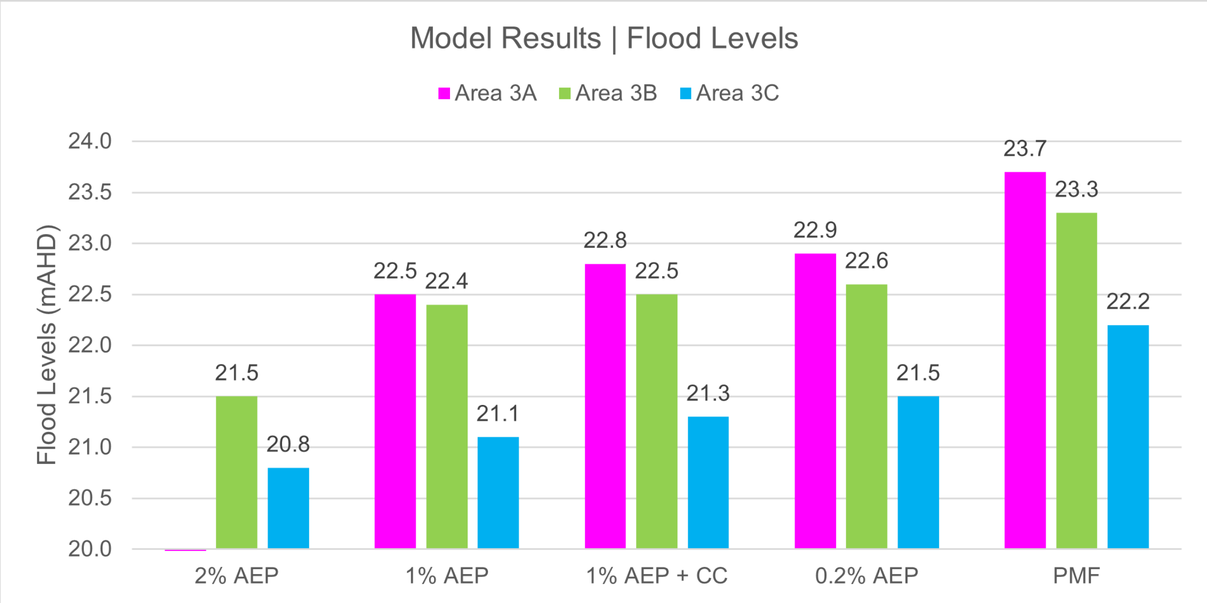
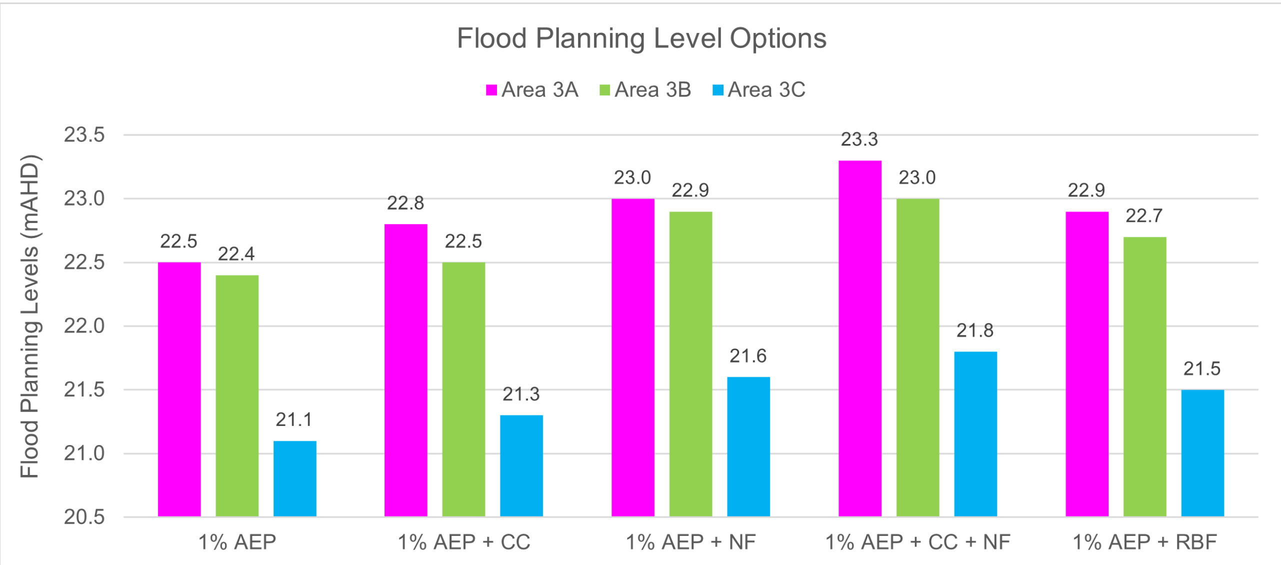


Figure 3.2 Maximum peak flood levels estimated by the Richmond River baseline flood model in Area 3A, 3B and 3C.



CC = climate change, RBF = Risk-based freeboard, NF = Nominal freeboard of 500mm

Nominated flood planning levels are provisional and should be revisited if development footprints change.

Figure 3.3 Summary of flood planning level options for Area 3A, 3B and 3C.

3.3 Adopted Flood Impact Criteria

Any new developments within flood affected areas can result in a loss of floodplain storage or obstruct floodplain conveyance. Both of these factors can result in changes to flood behaviour which includes changes in flood levels and extent, changes in flow velocity, and changes in duration of inundation to adjacent properties. These changes to flood behaviour as a result of a development are generally referred to as flood impacts.

Adverse flood impacts should be avoided where possible and an acceptable level of impact is typically defined by Councils, who also define the AEP events against which the flood impacts are investigated. In general, common flood impact criteria adopted by Councils focus on the changes in flood levels induced by the new development typically for events up to and including the 1% AEP flood event. The acceptable changes in flood levels are often defined based on the land use of affected land.

There is little to no published guidance on what an acceptable level of flood impact is as these are often dependent on many local factors. A recent guideline by Austroads (2023) outlines the acceptable flood impacts resulting from major transport infrastructure works. The flood impact criteria outlined by Austroads (2023) can be summarised as follows:

- Increase in flood levels must be lower than the values summarised in Table 3.1 depending on the land-use category of the properties.
- Increase in duration of inundation must be less than 10% of the existing duration of inundation, and in any case shorter than 1 hour for rainfall durations longer than 2 hours.
- Increase in inundation extent must be smaller than 10%.
- Increase in flow velocities must be such that the velocities are kept smaller than 1m/s. If the existing velocities are higher than 1m/s, than the increase in flow velocities must be smaller than 10%.
- The flood impacts should be assessed for the 1% AEP and 5% AEP events as a minimum. The 20% AEP or more frequent AEP events should also be assessed if the properties affected by flood impacts are classified as agricultural land.
- Sensitivity tests aiming at assessing the flood impacts in the 0.05% AEP and PMF should also be carried out to assess extreme changes in flood behaviour. However, these events should never be adopted for the assessment of acceptable impacts.

Table 3.1 Acceptable change in flood levels for major transport infrastructure (Austroads, 2023).

Land-use conditions	Acceptable changes in flood level (mm)
Residential buildings - general	25
Residential buildings – sensitive receivers including hospitals schools and critical infrastructure	10 - 20*
Residential yards	50
Industrial and commercial buildings	50
Industrial and commercial yards	100
Non-habitable structures (sheds)	100
Agricultural land	200 - 400**
Open space/forest	400***

*** If impacts less than or equal to 10mm can be achieved by the project then this is recommended as the acceptable impact. This is the practical limit to which models can predict impact.**

**** Dependent on the type of agriculture and its tolerance. Other criteria may be more important than peak level for example time of inundation.**

***** Conditional on no ecologically sensitive communities where flooding is an issue.**

Following discussions with project stakeholders during Stage 3 of this assessment and taking into account existing guidance, the following acceptable flood impact criteria for the development of Area 3 have been applied for this assessment:

- Increase in flood level no greater than 10mm in residential areas.
- Increase in flood level no greater than 20mm in commercial and industrial areas.
- Increase in flood level no greater than 200mm in agricultural areas.
- Increase in flood level no greater than 400mm in general rural open space
- Acceptable flood impacts to be assessed for the 2% and 1% AEP events. Sensitivity tests on flood impacts to be carried out for the 1% AEP + climate change flood event.
- Sensitivity tests for changes in extreme flood behaviour for the 0.2% AEP and PMF events.

4 Flood Impact Assessment

4.1 Introduction

The Baseline analysis (see Section 2) showed that Area 3 of the RJP is subject to a minor amount of inundation in the 2% AEP event and is affected by widespread inundation in the 1% AEP event. As such, any development within Area 3 has the potential to result in flood impacts in these, or rarer flood events. A flood impact assessment is therefore necessary to ensure that any development within Area 3 does not result in unacceptable flood impacts to surrounding property.

Two fill level scenarios are considered in the assessment:

- Filling to the 1% AEP flood level (1% AEP)
- Filling to the 1% AEP with climate change (1% AEP+CC) flood level.

The fill level scenarios are considered to be conservative as individual developments may not have a need to fill entire lots. Each fill level scenario is tested in the model using differing extents of fill. The remainder of this section documents the findings of the flood impact assessment of the RJP Area 3 site.

4.2 Unmitigated Development

Figure 4.1 presents peak flood level impacts in a 1% AEP+CC flood event when land within RJP Area 3 is filled to the 1% AEP+CC flood level. The fill extent is shown by the hatched areas and has sought to maximise the developable area of land whilst avoiding low lying land which provides an existing drainage function. Land which already contains development such as the Cassino Drive Industrial Estate and the existing Sewage Treatment Plant (STP) has not been modelled with any additional fill. The peak flood level impacts are derived by subtracting the baseline flood levels from the flood levels with the fill in place. The map therefore shows the change in peak flood levels due to the fill with positive values highlighting areas that now have higher flood levels and negative values highlighting areas with lower flood levels.

It can be seen from Figure 4.1 that flood levels are increased over an extensive area which includes existing residential property to the south and west of the RJP Area 3 site. These impacts are up to 0.2m on residential property and are considered unacceptable. The impacts are created by the fill obstructing the passage of flow from west to east and from south to north. As a consequence, floodwater backs up behind the fill in areas to the west and south resulting in higher flood levels compared to the baseline. A benefit, in the form of reduced flood levels, results primarily to rural land in the east.

The assessment demonstrates that such a fill scenario cannot proceed without some form of mitigation to address these impacts. Of note, in the 1% AEP+CC event, floodwater enters the RJP site from both the west and south. The south-eastern part of the RJP site is particularly constrained by floodwater and needs to maintain allowance for flow of floodwater coming from the west and south in order to avoid offsite flood impacts.

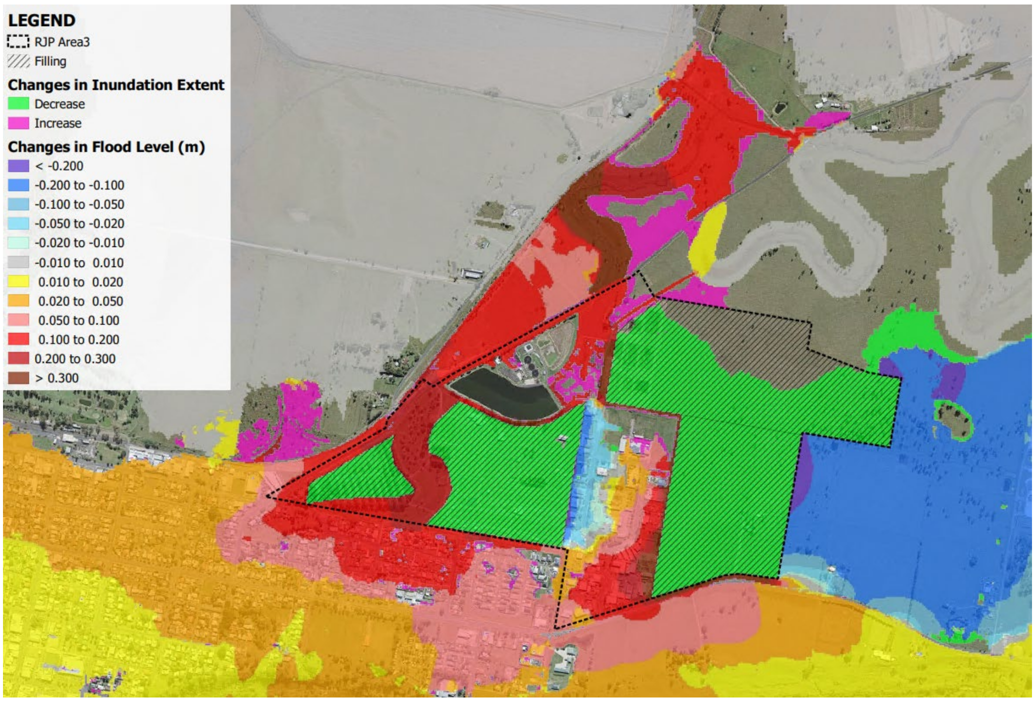


Figure 4.1 Peak Flood Level Impacts Resulting from Unmitigated Filling (1% AEP+CC)

4.3 Flood Mitigation

During early model simulations it became apparent that minimising flood impacts to within acceptable levels without providing flood mitigation was only possible by significantly reducing the extent of filling. This would likely result in the site not being economically viable from a development perspective. It was recognised therefore that additional flood mitigation would be required, and this, in turn, presented opportunities to create flood benefits which could extend to areas beyond the site. Mitigation options focused on reinstating flow paths from west to east which are currently obstructed by previous development, most notably the STP.

Three general mitigation options (Options 1, 2 and 3) were identified. Options 1 and 2 include variants termed A and B. All mitigation options are described below.

Option 1A and 1B

Option 1 involves reinstating a broad flow path through a natural depression in the terrain which was blocked by the construction of the Sewage Treatment Plant (STP). The option requires removal of the tertiary treatment pond and other associated infrastructure along with increasing the drainage capacity under Spring Grove Road. The flow path mirrors the dimensions of the natural gully and is up to 80m in width. The bed level ties in with the upstream and downstream invert levels of the existing drain and slopes from an elevation of 20.6mAHD at its upstream end to 20.4mAHD at its downstream end. The 1% AEP and 1%AEP+CC peak flows conveyed through the flow path are 33m^3/s and 55m^3/s, respectively. Option 1A includes making further provision for additional drainage under Spring Grove Road at a second location further east, whereas Option 1B does not include additional drainage at this second location.

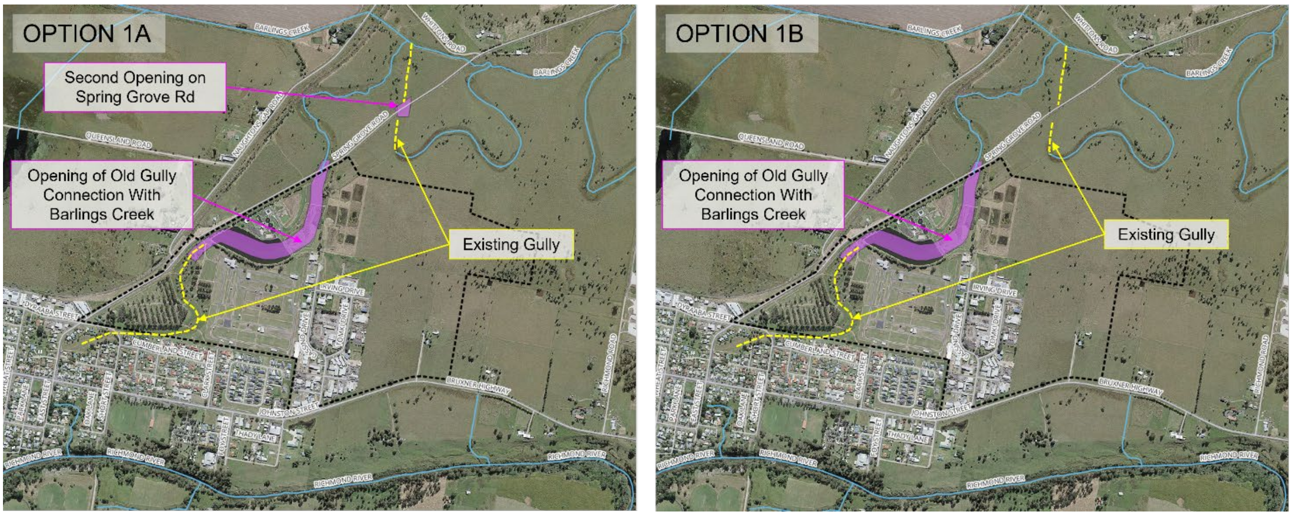


Figure 4.2 Mitigation Option 1A and 1B

Option 2A and 2B

Option 2 creates a new broad channel within Crown Land adjacent to Naughtons Gap Road to provide a link between two natural gullies and which bypasses the existing STP. The channel involves creating additional drainage under Spring Grove Road. The channel is approximately 60m wide and slopes from an elevation of 20.6mAHD at its upstream end to 20.4mAHD at its downstream end. The 1% AEP and 1%AEP+CC peak flows conveyed through the new channel are 32m^3/s and 50m^3/s, respectively. Option 2A includes making further provision for additional drainage under Spring Grove Road at a second location further east whereas Option 2B does not include additional drainage at this second location.

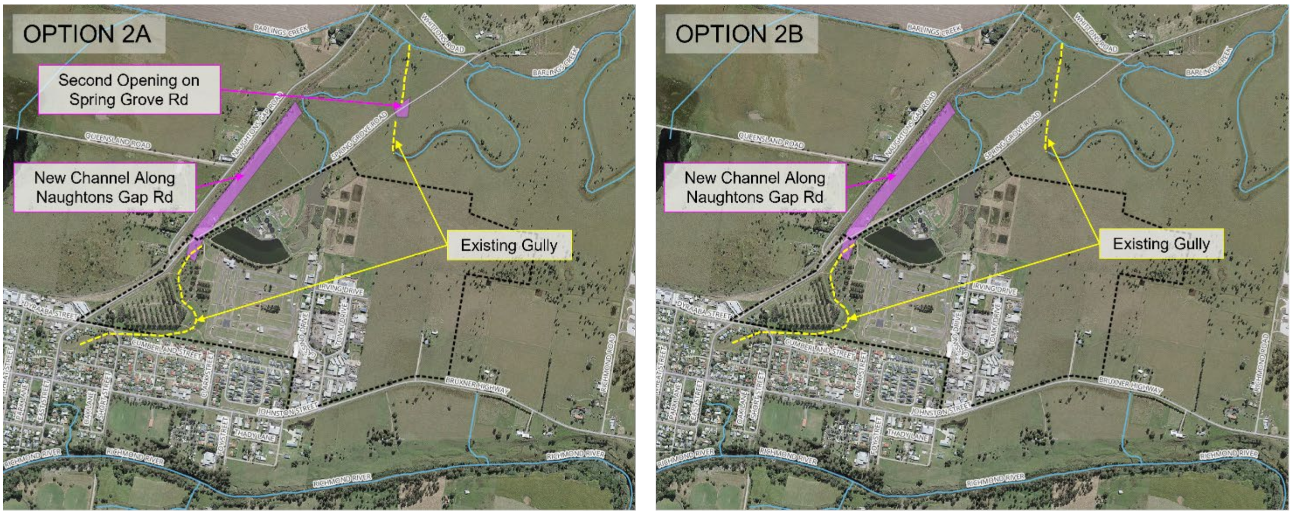


Figure 4.3 Mitigation Option 2A and 2B

Option 3

Option 3 widens and deepens an existing swale that runs along the southern boundary of Spring Grove Road. The swale is widened to approximately 10m and provides greater connectivity between the existing gully on either side of the STP.

Based on preliminary simulations of Option 3 it became apparent that the option would not be sufficient to convey the required flow in order to limit peak flood level impacts. This option was therefore not considered further in the assessment.

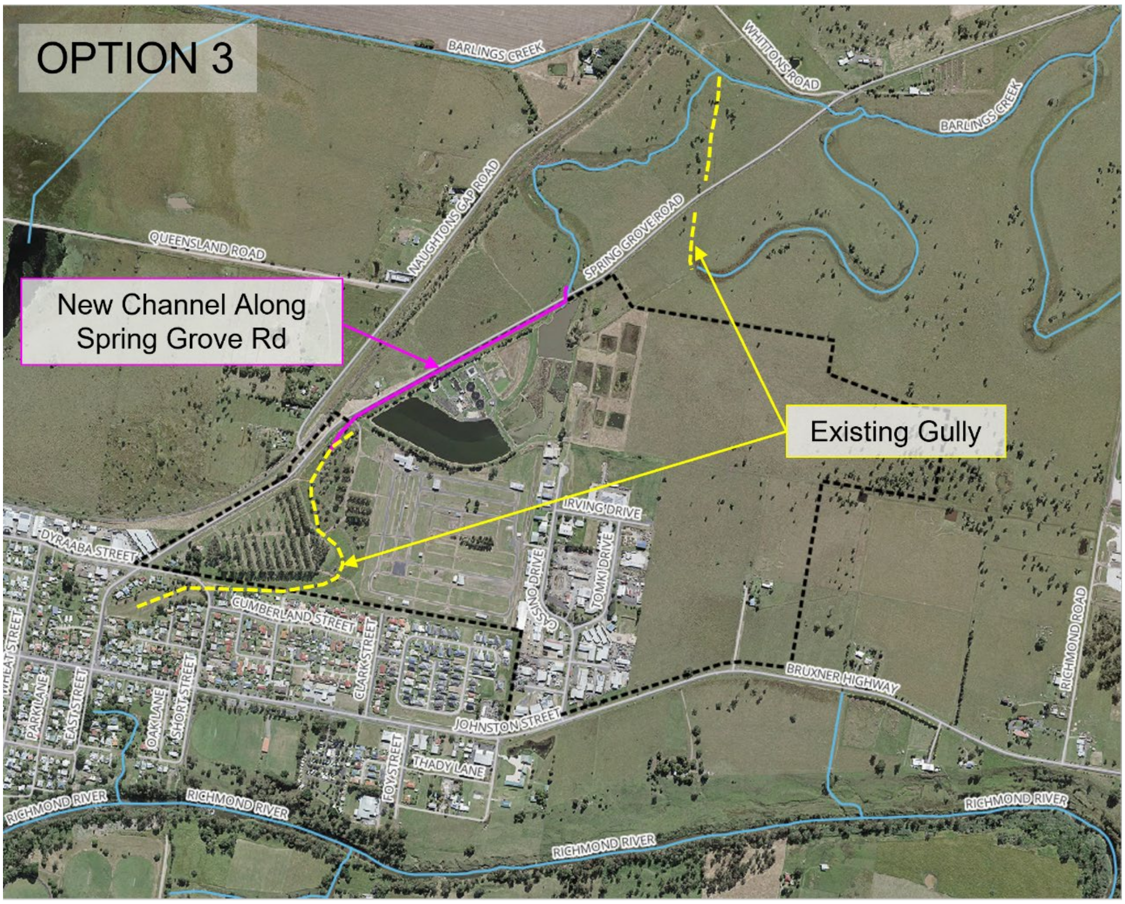


Figure 4.4 Mitigation Option 3

4.4 Optimised Fill Extent

The mitigation options were assessed in combination with different fill extents with the aim of maximising the fill extent whilst minimising the flood impacts. Fill extents were optimised for the 1% AEP+CC fill level scenario. Testing of extended fill extents at the lower 1% AEP fill level resulted in unacceptable peak flood level impacts for the 1 % AEP+CC event. Therefore, the optimised fill extent is the same whether the fill occurs to the 1% AEP flood level or the 1% AEP+CC flood level.

For the purposes of nominating preferred combinations of fill extents and mitigation options the following additional factors are noted:

- The widening of drainage infrastructure at a single location under Spring Grove Road for mitigation options 1B and 2B has taken preference over undertaking this at two locations under options 1A and 2A.
- Both mitigation options 1B and 2B provide similar outcomes i.e. the same optimised development fill extents and similar resulting flood impacts. Both have therefore been presented in this assessment allowing either to be taken forward for further assessment depending on other non-flood related development constraints.

Fill extents have been optimised for mitigation options 1B and 2B. Annex C presents the optimised fill extents and resulting flood impacts when filling is undertaken to the 1% AEP+CC flood levels (for both Option 1B and 2B). Annex D presents the flood impacts of filling an extended area to a lower 1% AEP fill level (for both Option 1B and 2B). In both Annex C and Annex D, the flood impacts are presented as changes in peak flood level for the 2% AEP, 1% AEP and 1% AEP+CC and as changes in flood hazard category for the 0.2% AEP and the PMF event. Annex F presents changes in flood duration (shown as percentage change), although noting that the model can only provide a general indication of flood duration. For example, minor drainage features not included in the model will not affect peak flood levels but may play a role in assisting an area to drain.

When optimising the fill extents it was found that some localised unacceptable flood impacts could be avoided through the placement of bunds. Two locations for bunds were identified; one near the existing STP connecting between two areas of fill and one east of Area 3 to reduce impacts to an existing residential property. The bunds are relatively low (less than 1m in height) and their locations are shown on mapping in Annex C and D.

The following key points are noted for the 1% AEP+CC fill level scenario (Annex C and Annex F):

- Minor offsite peak flood level increases (between 0.02 and 0.05m) are shown for the 2% AEP event within the Cassino Drive Industrial Estate and bordering residential land. These impacts appear to be contained within the road corridor (see Figure C1 and C6).
- The optimised fill with mitigation options 1B or 2B show widespread benefits in the form of reduced 1% AEP peak flood levels and extent to residential property and to the Cassino Drive Industrial Estate (see Figure C2 and C7).
- In the 1% AEP+CC event there is a minor benefit in the form of reduced peak flood levels to residential properties south of the RJP Area 3 site. There is also a notable benefit to the Cassino Drive Industrial Estate.
- In the 1% AEP event and rarer events, the mitigation and filling generally result in a reduction in peak flood levels east of Area 3 and an increase in peak flood levels north of Area 3. This is due to a combination of the fill obstructing flow to the east and the mitigation promoting flow to the north-east rural area. The increased peak flood levels in the north-east area are nearly all contained within existing rural open space land. Impacts within parts of the channel itself are up to 0.5m although these reduce to less than 0.01m a short distance downstream. No residential dwellings are shown to be impacted in all modelled events. In the 1% AEP+CC event an area of land in close proximity to a residential dwelling is shown to undergo an increase in flood extent. Close inspection of results shows that this impact is contained within land at a lower elevation than the dwelling and outbuildings and the depths are typically shallow (generally less than 0.1m).

- In the 0.2% AEP and PMF events, there is a general increase in flood hazard (see Section 2.2 for definitions) within the downstream channel and a decrease in flood hazard to the Cassino Drive Industrial Estate. There is no discernible change in hazard within residential areas of Casino.
- Increases in flood duration are typically located in close proximity to the existing gully which receives a greater concentration of water following the mitigation options. The increases occur across relatively localised areas and do not extend onto existing dwellings. There is a benefit in terms of a reduction in flood duration across existing residential areas within Casino and within the Cassino Drive industrial estate (see Figure F1 to F3).

In the 1% AEP fill level scenario (Annex D) the fill extents within the central (Primex) area and eastern area fronting Johnston Street have been increased from those optimised for the 1% AEP+CC fill scenario. The resulting flood impacts extend onto residential areas and would be considered unacceptable, for example in the 1% AEP+CC flood event (Figure D-3). It is likely that the extended fill within the Johnston Street site with a reduction in fill extent in the Primex site might result in acceptable impacts. However, the additional gain in fill extent at the Johnston Street site would be minimal when comparing the 1% AEP and 1% AEP+CC fill scenarios. This may be a consideration as the development planning progresses.

4.5 Alternative Fill Options

Annex E presents peak flood level impact maps for the 1% AEP+CC event in which some alternative fill extent and mitigation options were considered. These are included for reference purposes and include consideration of mitigation options 1A, 2A and 3.

4.6 Sequencing of Development

Development priorities for different parcels of land within RJP Area 3 are not known and it is beyond the scope of this assessment to provide a detailed staging plan. Any staging should be managed to avoid unacceptable flood impacts. The following points offer high level advice based on findings from the flood impact assessment:

- The north eastern portion of Area 3 (north of the Cassino Drive Industrial Estate and east of the existing STP) is an area where placement of fill would provide a lesser obstruction to flow than for other parts of Area 3. Model simulations were undertaken whereby this area was wholly filled and then only partially filled, both without mitigation. The results are shown as peak flood level impact maps in Annex G where the area filled is shown as hatched. Figure G.1 shows that filling the entire north eastern portion results in widespread impacts to the south which extend onto existing residential properties. Figure G.2 shows that by reducing this fill extent and avoiding placing fill in the area of greatest conveyance, the flood impacts are reduced to be within acceptable tolerances and extents. Therefore there is potential to place fill within the portion of Area 3 shown in Figure G.2 prior to implementing either of the main mitigation options.
- The key mitigation feature, that being either the channel reinstatement through the STP or the new channel in Crown Land north of Area 3 should occur prior to any substantial filling within any remaining portions of Area 3 outside of that shown in Figure G.2. This is to avoid unacceptable impacts on existing residential and commercial property.
- With the key mitigation in place there is flexibility over which parts of the development occur, although filling parts of the site will affect flood levels elsewhere within the site. For example, filling within the north eastern part of the site reduces flood levels to the south (Johnston Street site). If the Johnston Street site is to be subject to filling before filling of land to the north, then higher fill levels may be required to provide immunity for a flood of a given AEP.

It is recommended that a staging plan is assessed for flood impacts once details of site development priorities and layouts become available.

4.7 FIA Conclusions

The following key conclusions are drawn from the flood impact assessment:

- An optimised filling extent has been developed in combination with flood mitigation works which limits offsite flood impacts to within acceptable levels and provides an overall benefit to existing residential areas in Casino and to the Cassino Drive Industrial Estate.
- The flood mitigation works promote increased flow through or around the STP and reinstate a situation which was similar prior to the construction of the STP.
- Flood mitigation options 1B and 2B both result in similar outcomes in terms of flood impacts and are considered the preferred options. Options 1A and 2A also result in acceptable flood impact outcomes but require additional road works. Mitigation Option 3 was not sufficient to offset flood impacts.
- Fill extents have been optimised for a 1% AEP+CC fill level scenario. A lower 1% AEP fill level is shown to have limited benefit for extending fill extents as flood impacts remain a constraining factor in a 1% AEP+CC flood event. Therefore, the fill extents will be similar regardless of whether fill occurs to the 1% AEP of 1% AEP+CC flood level.

5 Stormwater Quality Assessment

5.1 Introduction

This section proves a conceptual stormwater quality assessment of the proposed RJP Area 1 and Area 3. This has been prepared so as to provide an indication of the size, potential location and performance characteristics of any proposed stormwater management strategy. This section explains how predicted stormwater pollutant loads from the proposed development will compare to stormwater performance targets.

5.2 Opportunities and Constraints

The development of the RJP presents a number of opportunities and constraints with respect to water quality management. These are outlined below.

Site Opportunities

There are a number of opportunities presented for the application of stormwater quality measures, including:

- **Site layout** – Depending on the stormwater quality measure selected, the layout of the site generally provides opportunity for the implementation of treatment without greatly encroaching on the proposed development.
- **Roof water reuse** – Runoff from roof areas within the industrial areas has the potential to be collected and utilised to supplement water demand where appropriate.

Site Constraints

The major constraints identified for the RJP with respect to stormwater quality controls include the following:

- **Topography** – The topography in Area 3 will need to be considered as part of further detailed design to ensure there is sufficient elevation from the surface of the system to the receiving drainage system. This is particularly the case for bioretention systems to ensure the filter media does not remain waterlogged.
- **Site layout** – For stormwater treatment systems that require a larger footprint relative to the contributing catchment area, a percentage of the developable area may need to be allocated to facilitate the incorporation of the stormwater treatment measure.
- **Existing Land Use** – It is noted that some area identified as potential industrial land has existing uses. For the purposes of this preliminary study to identify indicative treatment areas it was assumed that these are all converted to high impervious industrial land uses.

5.3 Relevant local and state planning provisions

A review of the relevant local and state planning provisions with regards to stormwater was undertaken. This identified that the key planning requirements related to stormwater quality management for the site are outlined in the *Richmond Valley Development Control Plan* (RVC 2021) (RV DCP). The key items addressed in the DCP include:

1. Riparian areas, wetland buffers, littoral rainforest buffer and habitat corridors
2. Water quality performance targets
3. Stormwater generation performance targets

Riparian areas, habitat corridors, vegetation and landform

Riparian corridor management is identified in the *Richmond Valley Development Control Plan* (RVC 2021) (RV DCP). A review of the requirements in the RV DCP highlighted that there were differences between the requirements in the RV DCP and the requirements for 'controlled activities' as regulated by the *Water Management Act 2000* (WM Act), however the intent of both planning documents is similar. As a result, the guidelines provided by the Department of Planning and Environment (DPE) in support of the WM Act have been used for the purposes of this project. This was done in consultation with RVC (T McAteer 2023, pers. comm., 19 April).

Controlled activities carried out in, on or under waterfront land are regulated by the WM Act. DPE administers the WM Act and is required to assess the impact of any proposed controlled activity to ensure that no more than minimal harm will be done to waterfront land as a consequence of carrying out the controlled activity.

Waterfront land includes the bed and bank of any river, lake or estuary and all land within 40 metres of the highest bank of the river, lake or estuary.

Waterfront land is identified based on consideration of three factors:

1. The presence of defined bed and banks
2. Evidence of flow and geomorphic features (whether water is present or not)
3. The presence of aquatic/ riparian vegetation.

It is noted that where a watercourse does not exhibit the features of a defined channel with bed and banks, the department may determine that the watercourse is not waterfront land for the purposes of the WM Act.

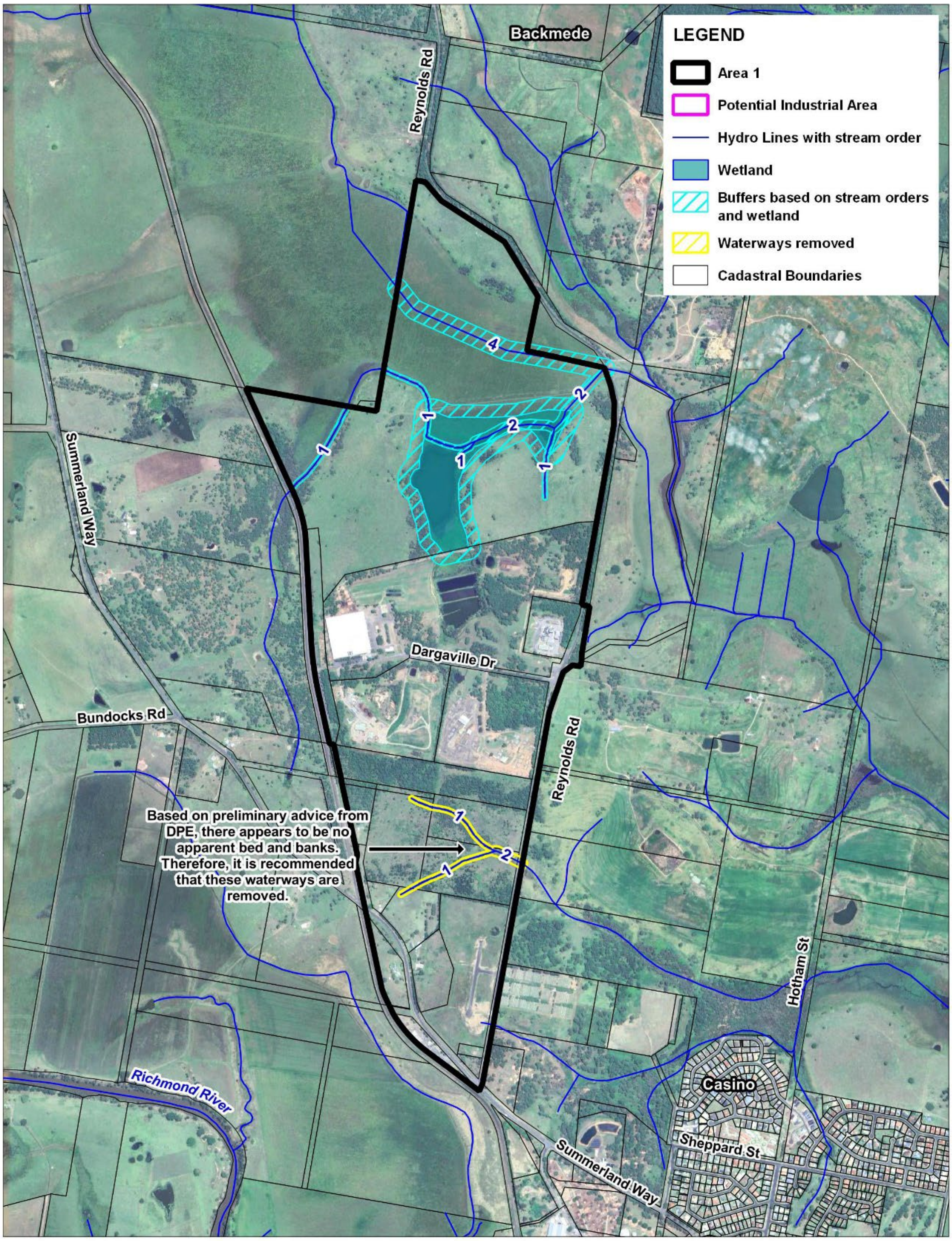
The recommended riparian corridor widths for waterfront land as outlined in the 'Controlled activities – Guidelines for riparian corridors on waterfront land fact sheet' (DPE 2022) are provided below in Table 5.1.

Table 5.1 Recommended riparian corridor widths (DPE 2022)

Watercourse type	VRZ width	Total RD width
1st order	10 metres	20 m + channel width
2nd order	20 meters	40 m + channel width
3rd order	30 metres	60 m + channel width
4th order and greater (includes estuaries, wetlands and any parts of rivers influenced by tidal waters)	40 metres	80 m + channel width

A desktop review of the available relevant data was undertaken and assessed against the definition of waterfront land. The data available includes the NSW Hydro Line dataset which is the dataset of mapped watercourses and waterbodies in NSW and provided by the State Government. Mapping of the Hydro Line spatial data for Area 1 and Area 3 is provided in Figure 5.1 and Figure 5.2.

Figure 5.1 RJP – Area 1 Potential Riparian Areas



Title: **RJP – Area 1 Potential Riparian Areas**

Figure: **5.1**

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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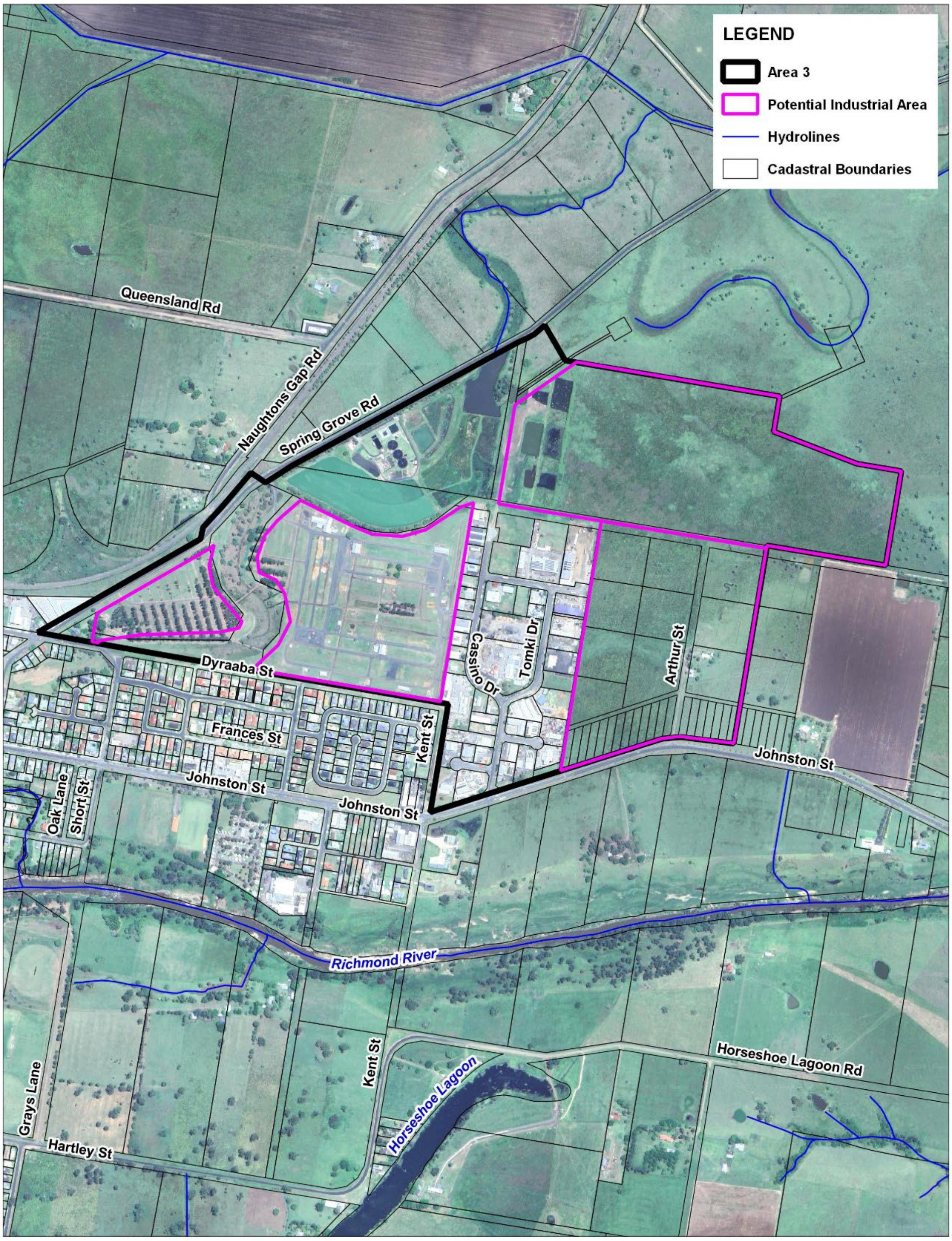
Figure 5.2 RJP – Area 3 Potential Riparian Areas



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RJP – Area 3 Potential Riparian Areas	**5.2**	**A**

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- **Area 1**: Figure 5.1 shows several watercourses identified within Area 1. A review of aerial images of the site indicates that:
    - The Hydro Lines in the south do not exhibit the presence of defined bed and banks or riparian vegetation. Therefore, it is recommended that these are removed in consultation with DPE.
    - The Hydro Lines in the north of Area 1 do exhibit characteristics of a 'river' as defined in the WM Act. Therefore, it is recommended that these are reviewed in greater detail. Based on the stream orders, an estimate of the required riparian corridor widths has been provided. It is noted that this area has a development approval for a rail terminal. It is recommended that as part of further design of the rail terminal an on-ground assessment of the watercourses is undertaken and riparian buffer corridors included in the design, if required. The assessment would consider what is on site against the three key considerations of the definition of waterfront land as outlined above.
- **Area 3**: Figure 5.2 shows that there are no Hydro Lines mapped within Area 3, therefore no further consideration of riparian corridors is required.

Data provided by RVC was used to identify wetlands within the RJP Area 1 and Area 3. A wetland is mapped in the northern area of Area 1. This is shown in Figure 5.1 and is outside the area highlighted for potential industrial development. A key consideration of the development will be to ensure that the wetland is not negatively impacted by changes in hydrology resulting from the proposed development. As outlined in the RV DCP, particular attention must be given to ensure the existing moisture levels to which the flora and fauna are accustomed are maintained.

A review of the available environmental spatial datasets provided by RVC highlighted that there were no identified habitat corridors or littoral rainforest within Area 1 or 3.

Water Quality Performance Targets

Part I-9 of the RV DCP (*Water Sensitive Urban Design)*, includes performance targets for stormwater quality. These are set out in Table 5.2 below. The RV DCP also specifies that at least 80% of the total impermeable area of a site must be treated to the targets specified.

Table 5.2 Stormwater Quality Targets (Reproduced from Table I-9.1 of RV DCP)

Contaminant	Target
Coarse sediment (0.1 to 0.5 mm)	80% mean annual reduction from baseline
Fine particles (<0.1 mm)	50% mean annual reduction from baseline
Total Phosphorus	45% mean annual reduction from baseline
Total Nitrogen	45% mean annual reduction from baseline
Litter	70% mean annual reduction from baseline
Hydrocarbons, motor fuels, oils and greases	90% mean annual reduction from baseline

Stormwater Generation Performance Targets

Part I-9 of the RV DCP (*Water Sensitive Urban Design)*, includes objectives and performance targets for stormwater generation.

The objectives of the stormwater generation performance targets are to:

1. To maintain the site's mean stormwater volumes, peak flow rates, and runoff event frequency as near as reasonable to sites original characteristics.
2. To reduce flooding, property damage, and risk to public safety to downstream areas as a result of increased imperviousness, increased runoff volume and changes to drainage line upstream.
3. To protect receiving environments from the impacts of changes to stormwater characteristics.

The performance targets for stormwater volumes and drainage are provided in Table 5.3 below.

Table 5.3 Stormwater Generation Performance Targets (Reproduced from Table I-9.3 RV DCP)

Element	Target
Peak flowrates (m^3/s)	The following targets apply: • Flowrates at any point are not to increase during storms for the 2- and 5-year ARI event; or • As specified within specific drainage sub-catchment policy recognised by Council; or • As specified within Council standards.
Mean annual stormwater post development volumes (ML/yr)	The following targets apply: • Mean annual stormwater volumes reduced by at least 10% from baseline; or • As specified within specific drainage sub-catchment policy recognised by Council; or • As specified within Council standards.

It is noted that at this early stage of the development the mean annual stormwater post development volumes can be assessed. However, to undertake a review of the peak flowrates a hydrological model of the proposed development is required. It is recommended that this is undertaken at a later stage of the planning process once a conceptual site design has been developed.

5.4 Modelling Approach

MUSIC modelling has been undertaken to evaluate three potential stormwater quality management options (detailed in Section 5.5) to demonstrate how the proposed development of RJP Area 1 and Area 3 can meet the required performance targets. The modelling is also used to provide an indication of the treatment area required for each of the three options. This section provides a summary of how the MUSIC modelling was undertaken.

Software

The performance of possible stormwater treatment strategies in managing stormwater pollutants has been assessed using the MUSIC X software package (Version 1.0.0) developed by the CRC for Catchment Hydrology and now supported by the eWater CRC. MUSIC is well suited to the assessments required for the site, i.e. prediction of annual discharge loads of total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS) and gross pollutants (GP). The software has been specifically designed to allow comparisons to be made between different stormwater management systems and thereby functions as a decision support tool.

Meteorological Data

There is no specific meteorological data specified by Richmond Valley Council for MUSIC modelling. Therefore, an assessment of the pluviograph rainfall gauges surrounding Casino was undertaken to determine the most suitable rainfall data for MUSIC modelling based on the available information. The gauges assessed are have their locations shown in Figure 5.3 and are listed in Table 5.4.

Table 5.4 Pluviograph Rainfall Gauge Assessment

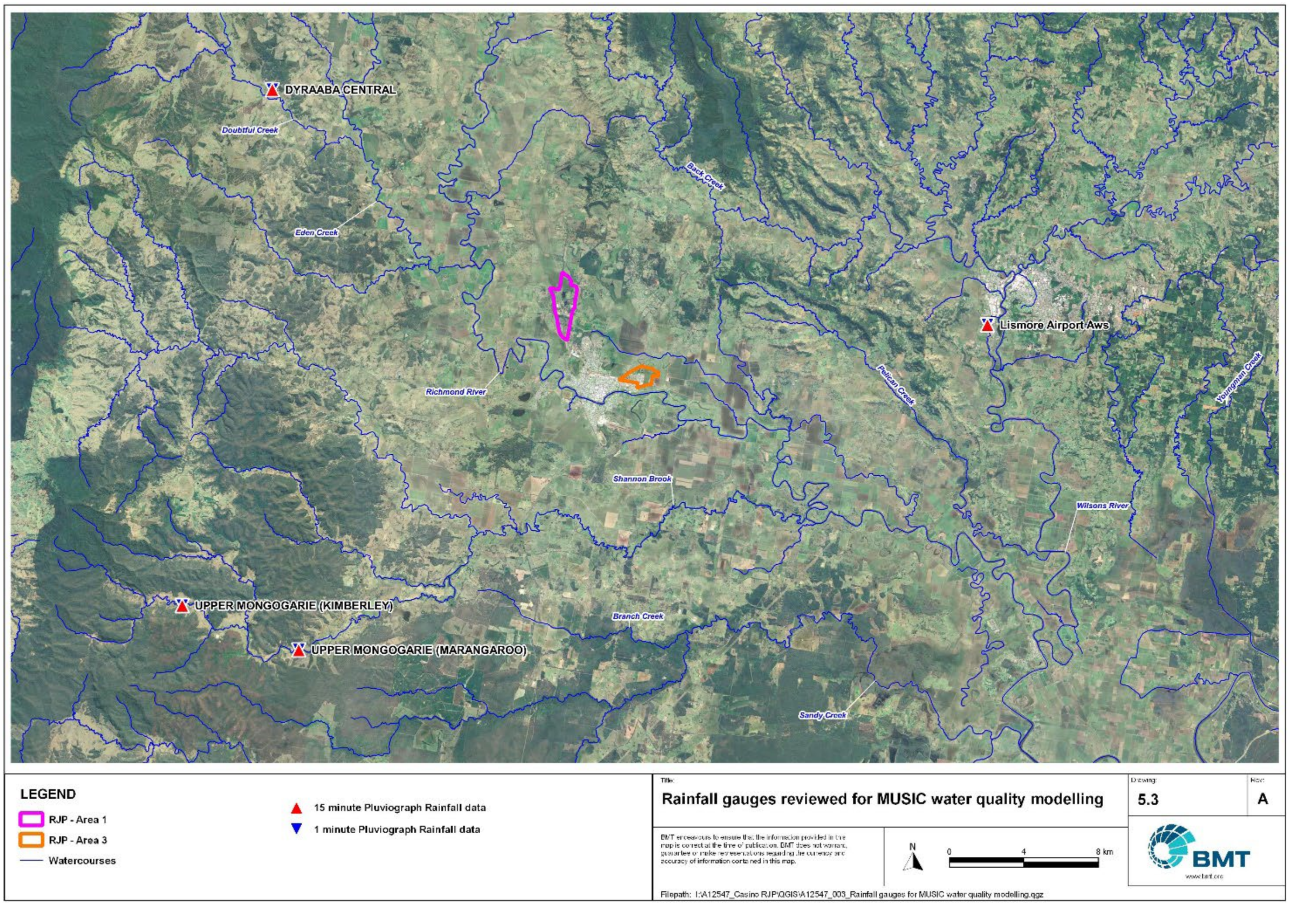
Rainfall Gauge	Timestep	Timeframe	% Complete
Lismore Airport (58214)	1 minute	1963 – 2015	42%
Upper Mongogarie (Marangaroo) (58192)	1 minute	1963 – 2016	79%
Dryaaba Central (58132)	1 minute	1963 – 1977	88%
Upper Mongogarie (Kimberley) (58081)	1 minute	1963 – 1984	71%
Shannon Brook at Yorklea (203041)	15 minute	2001 – 2023	>90%
Eden Ck at Doubtful (203034)	15 minute	2001 - 2023	NA

The preferred requirements for the selection of rainfall data when used as input to MUSIC models are provided below:

- Data is representative of the long-term annual average of rainfall at the site
- Timestep of 6 minutes
- Continuous period of data to allow a 10 year modelling period
- Minimal missing data
- Daily distribution is representative of long term conditions at the site.

The two gauges that were identified as potentially being suitable based on the above criteria were Shannon Brook and Upper Mongogarie (Marangaroo). A review of the data highlighted that although the timestep of Upper Mongogarie (Marangaroo) was preferable, the long-term average of the available data was not as suitable as Shannon Brook. Therefore, for the purposes of this study Shannon Brook was selected for the rainfall data input. The time period of 2012 to 2021, inclusive was used as it is noted that the rainfall within 2022 was generally not typical of long term conditions. Daily potential evapotranspiration (PET) data was sourced from SILO for Casino and a monthly average was used in the modelling.

Figure 5.3 Rainfall gauges reviewed for MUSIC water quality modelling



Modelling Scenarios

The modelling scenarios considered for this assessment were:

- The proposed future development areas *without* stormwater treatment. It is noted that the details of the development footprint have not been confirmed. Therefore, for the purposes of this modelling assessment a near maximum developed area has been assumed.
- The proposed future development areas *with* stormwater treatment.

Source Nodes

Within MUSIC, the different land-usage classifications (and hence pollutant generating properties) of the study site are represented by source nodes. For this project, the properties of the source nodes were determined using the *NSW MUSIC Modelling Guidelines* (2015).

The *NSW MUSIC Modelling Guidelines* (2015) recommends that the rainfall runoff parameters are determined based on a combination of set values along with parameters determined based on the predominant soil type. The dominant soil types were determined from the Australian Soil Classification (ASC) soil type map of Australia (https://datasets.seed.nsw.gov.au/dataset/australian-soil-classification-asc-soil-type-map-of-nsweaa10). The dominant soil types were determined to be:

- *Area 1*: Nammoona (9540na) – loamy sand
- *Area 3*: Leycester (9540le) – light clay.

Based on the above, the rainfall-runoff parameters were determined and are outlined in Table 5.5. The pollutant concentration parameters were obtained from the *NSW MUSIC Modelling Guidelines* (2015) and are provided in Table 5.5. It is noted that only industrial land use was modelled.

Table 5.5 Rainfall-Runoff Parameters Determined for Input to MUSIC Model

Parameter	Area 1	Area 3
Rainfall threshold (mm)	1	1
SSC (mm)	139	98
FC (mm)	69	73
Inf “a” (mm/day)	360	135
Inf “b”	0.5	4.0
DRR (%)	100%	10%
DBR (%)	50%	10%
DDSR (%)	0%	0%

Table 5.6 Pollutant Concentration Parameters

Parameter		Industrial
Base Flow		
TSS	Mean	1.20
	Std dev	0.17
TP	Mean	-0.85
	Std dev	0.19
TN	Mean	0.11
	Std dev	0.12

Parameter		Industrial
Storm Flow		
TSS	Mean	2.15
	Std dev	0.32
TP	Mean	-0.60
	Std dev	0.25
TN	Mean	0.30
	Std dev	0.19

5.5 Proposed Stormwater Management Strategy

In the development of this report, a range of stormwater management options have been assessed.

Three treatment strategies have been modelled for the purposes of this report:

1. Wetlands
2. Bioretention Basins
3. Streetscape Bioretention

The following sections provide a description of these devices (and their potential application to this project), along with parameter values applied in the modelling of these devices for this project.

These three strategies have been designed to achieve the water quality objectives given in Table 5.2. It should, however, be noted that alternative stormwater management options could be integrated within the site instead of (or in addition to) the treatment devices outlined above. These options include (but are not limited to):

- **Best practice erosion and sediment control**: Whilst the focus of this report is on the operational phase of the site, best practice erosion and sediment control will be critical to protecting the health of waterways during the construction phase(s) of the site.

- **Self-watering landscaped areas**: In addition to (or in combination with) other stormwater management options, landscaped areas (e.g. street trees) could be 'self-watering', with runoff from impervious areas (e.g. roads) directed to these areas. These could be identical to the streetscape bioretention systems (described below) or a reduced cost alternative (e.g. bioretention with no under-drainage). This option would have the benefit of providing a stormwater treatment function, but also improving site amenity (through passively watered landscaping).

- **Stormwater harvesting and reuse**: This option could include utilising open water storage areas (e.g. wetlands) to harvest stormwater runoff to supplement water demands (e.g. irrigation).

Wetlands

Wetland systems are extensively vegetated, shallow water bodies that use enhanced sedimentation, fine filtration and biological uptake processes to remove pollutants from stormwater (Water by Design, 2006). In addition to enhancing water quality, wetlands also provide improved habitat and amenity values.

Examples of ‘typical’ stormwater wetlands are provided in Figure 5.4.

The modelling properties of the wetlands used in this study have been based *NSW MUSIC Modelling Guidelines* (2015), and are presented in Table 5.7.

Table 5.7 Wetland Modelling Properties

Parameter	Value
Inlet Pond Depth	1.5 m
Inlet Pond Area	5% of the Wetland Surface Area
Extended Detention Depth	0.5 m
Exfiltration Rate	0.0 mm/hour
Evaporative Loss as % PET	125%
Overflow Weir Width	10% of the Wetland Surface Area
Notional Detention Time	48 hours

Figure 5.4 Examples of Typical Constructed Wetlands

Bioretention Basins

A bioretention basin is a soil and plant-based stormwater management measure. A typical basin consists of a porous medium such as sandy loam. Vegetation is also established within the bioretention basin to promote evapotranspiration, maintain soil porosity, encourage biological activity, and promote uptake of some pollutants.

Examples of bioretention basins are provided in Figure 5.5. Figure 5.6 provides a conceptual cross section of a bioretention system, illustrating the modelling properties applied for this project.

The modelling properties of bioretention systems used in this study have been based on the *NSW MUSIC Modelling Guidelines* (2015) and are presented in Table 5.8.

Table 5.8 Assumed Properties for the Bioretention System

Parameter	Value
Extended Detention Depth	Bioretention Basins = 0.3 m Raingardens = 0.1 m
Saturated Hydraulic Conductivity	100 mm/hour
Filter Depth	0.4 m
Submerged Zone Depth	0.0 m
Surface Area/ Filter Area Ratio	1.0
TN Content of Filter Media	400 mg/kg
Orthophosphate Content of Filter Media	40 mg/kg
Vegetation properties	Effective Vegetation with Nutrient Removal Plants
Exfiltration Rate	0.00 mm/hour

Figure 5.5 Bioretention Basin Examples

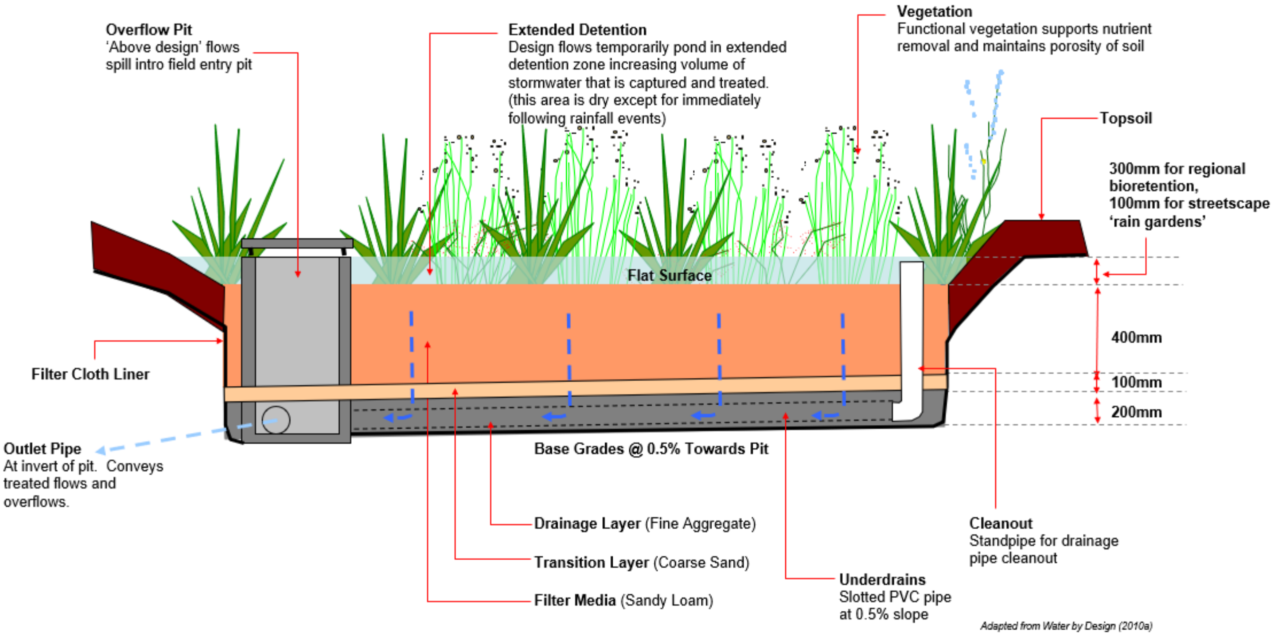


Figure 5.6 Conceptual Cross Section of Assumed Bioretention Properties

Streetscape Bioretention

A streetscape bioretention system (also referred to as a biopod or rain garden) is an 'at source' soil and plant-based stormwater management measure. A typical system consists of a porous medium such as sandy loam. Vegetation is also established within the system to promote evapotranspiration, maintain soil porosity, encourage biological activity, and promote uptake of some pollutants. Runoff is directed into the system and infiltrates through the plant/mulch/soil environment. Figure 5.7 provides examples of rain gardens (or similar streetscape/'ground level' bioretention systems).

Figure 5.7 Examples of Streetscape Bioretention Systems

5.6 Modelling Results

This section provides results from modelling the assumed future development areas with three different stormwater management strategies – each designed to achieve the water quality objectives outlined in Table 5.2.

For each strategy, the treatment area required (as a percentage of upstream development area) is illustrated in Figure 5.8. The estimated treatment area required for RJP Area 1 and Area 3 for each of the three stormwater management strategies is provided in Table 5.9.

It is worth noting that these treatment area requirements do not include additional area required for the management measures that do not contribute to the 'treatment' of stormwater flows – such as batters and maintenance access. It is also noted that the rainfall-runoff parameters for the two different areas did not make a significant difference to the modelling results. This is because the industrial area has been assumed to be 90% impervious and therefore there is minimal infiltration into the soils.

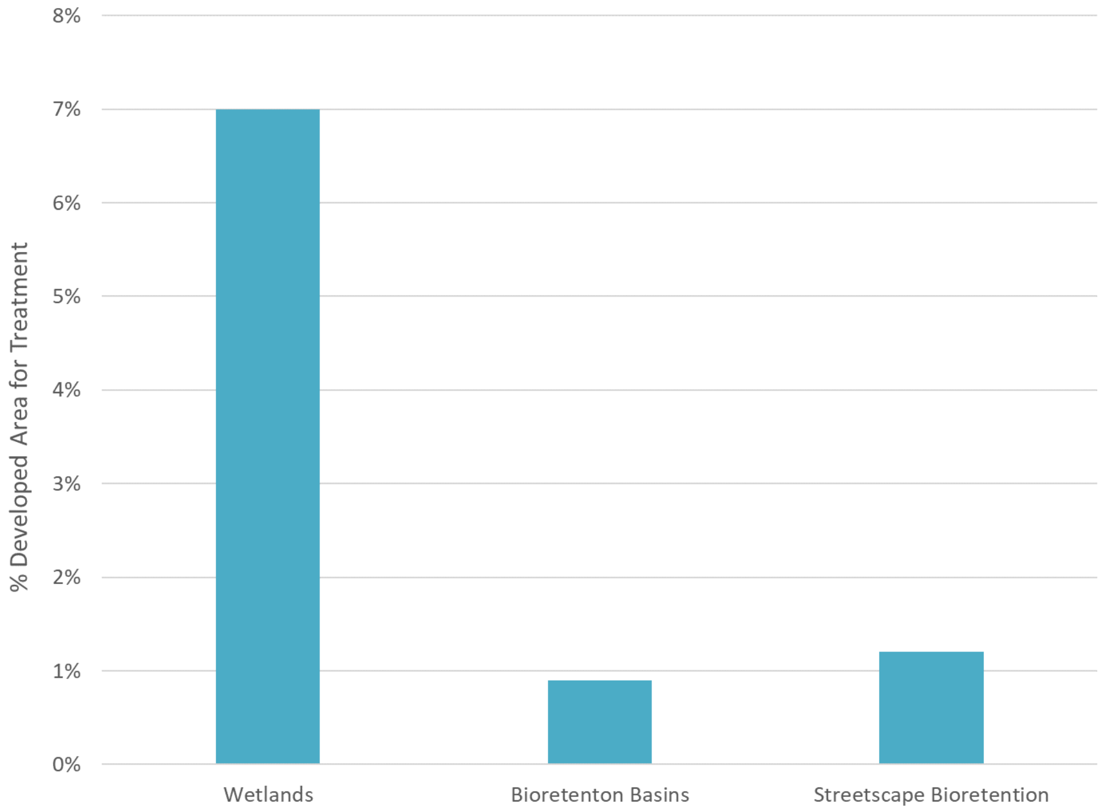


Figure 5.8 Treatment Area Requirements for Area 1 and Area 3

Table 5.9 Indicative Treatment Area Required for Stormwater Quality Management

Management Measure	Indicative Treatment Area Required (ha): RJP Area 1	Indicative Treatment Area Required (ha): RJP Area 3
Wetlands	10.1	4.9
Bioretention Basins	1.3	0.63
Streetscape Bioretention	1.7	0.84

The predicted annual pollutant loads *per hectare* of industrial development and the reduction with each of the treatment strategies is provided in Table 5.10.

Table 5.10 Predicted Annual Pollutant Loads (per 1 hectare) for the Developed Areas for Area 1 and Area 3

Parameter	1 hectare developed area without treatment	7% Wetlands		0.9% Bioretention Basis		1.2% Streetscape Bioretention	
		Flow & Loads	% Removal	Flow & Loads	% Removal	Flow & Loads	% Removal
Flow (ML/yr)	8.1	6.6	19	6.3	23	6.2	24
TSS (kg/yr)	1490	257	84	275	82	267	82
TP (kg/yr)	2.56	0.75	70	0.9	66	0.85	64
TN (kg/yr)	18.8	8.90	48	8.7	54	8.7	50
Gross Pollutants (kg/yr)	206	0.0	100	0.0	100	0.0	100

It is noted that due to the stochastic nature of the model and the summarised nature of these results the % removal presented are not exact.

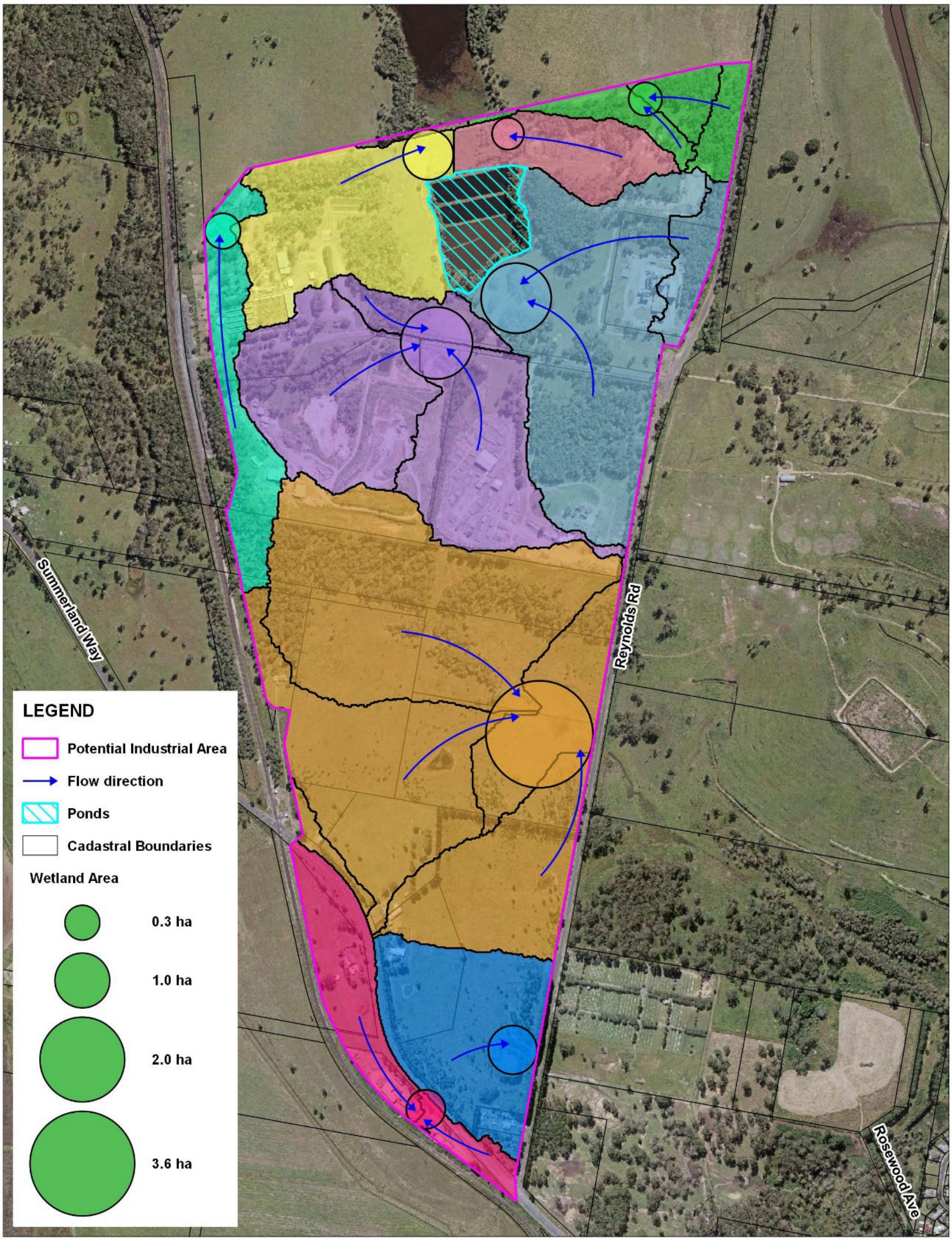
Key findings of the modelling include:

- The implementation of bioretention systems will require significantly less area relative to wetlands.
- All of the treatment strategies meet the 10% reduction in mean annual stormwater volumes when compared to the baseline volume generated by the industrial land use (refer to Table 5.3).

The final treatment strategy for the sites may utilise a combination of each of the proposed treatment measures. Figure 5.9 to Figure 5.12 provide indicative locations and sizing where wetlands and bioretention basins may be utilised. Streetscape bioretention systems would be incorporated throughout the development layout once the street layout has been determined.

It should be noted that there are areas within Area 1 that have existing treatment systems (e.g. , Namoona Landfill and Northern Rivers Livestock Exchange). Indicative treatment locations and sizing for these areas have been included to provide a conceptual model of the area if the entire area was to be redeveloped.

Figure 5.9 RJP Area 1: Indicative Location and Sizing of Wetlands



Title:
RJP Area 1: Indicative Location and Sizing of Wetlands

Figure: 5.9

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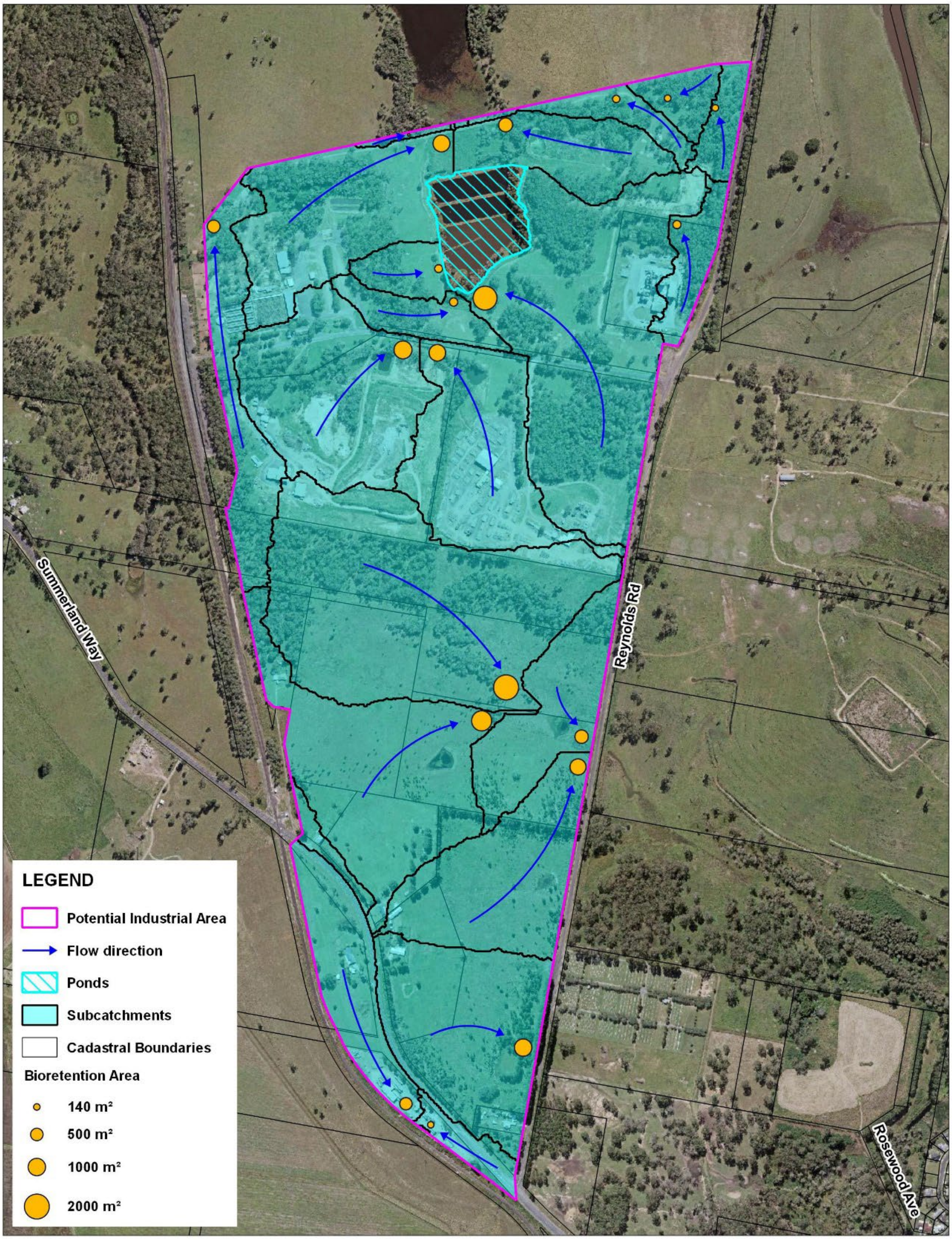
Figure 5.10 RJP Area 1: Indicative Location and Sizing of Bioretention Basins



Title: RJP Area 1: Indicative Location and Sizing of Bioretention Basins	Figure: 5.10	Rev: B

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Figure 5.11 RJP Area 3: Indicative Location and Sizing of Wetlands

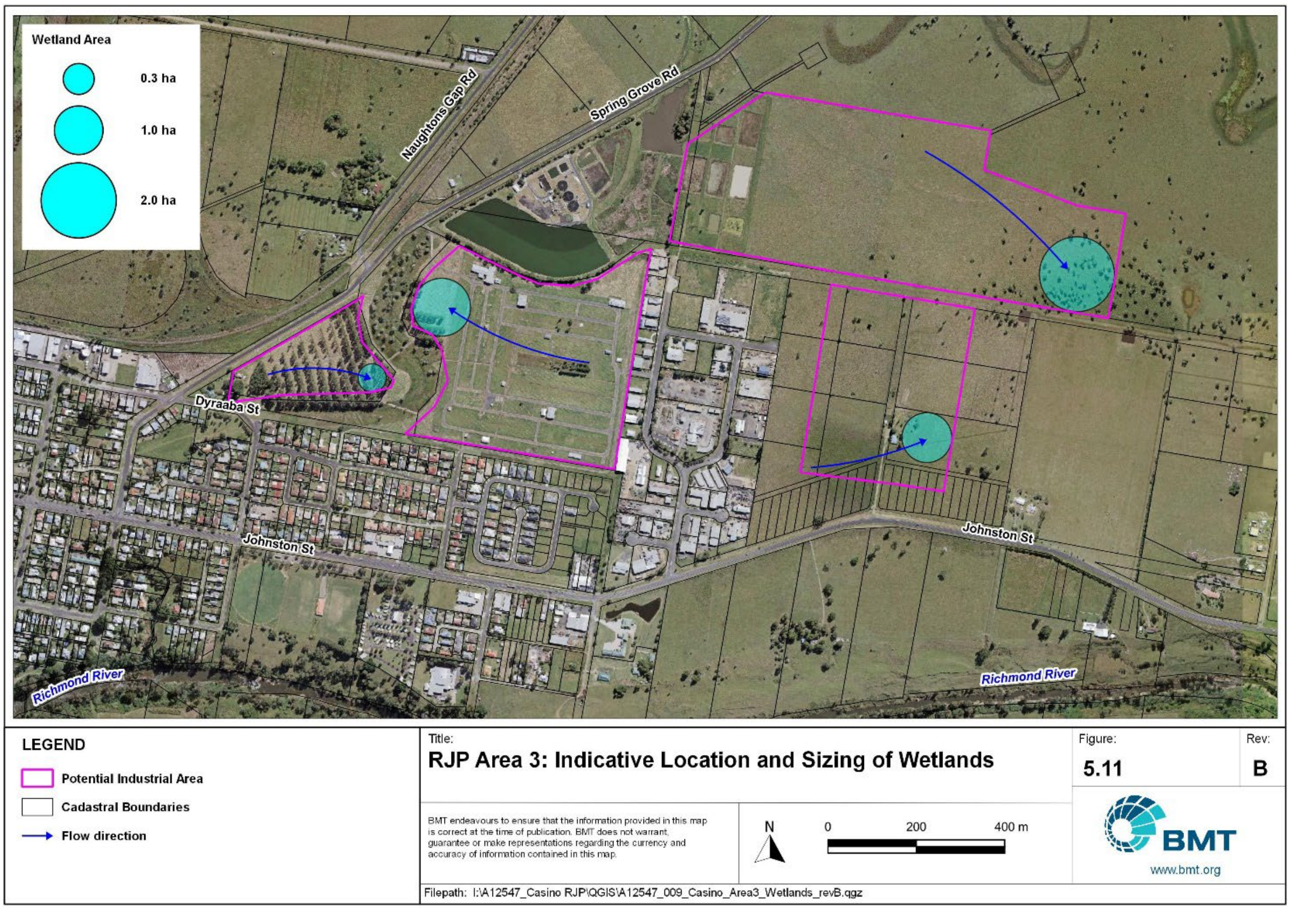
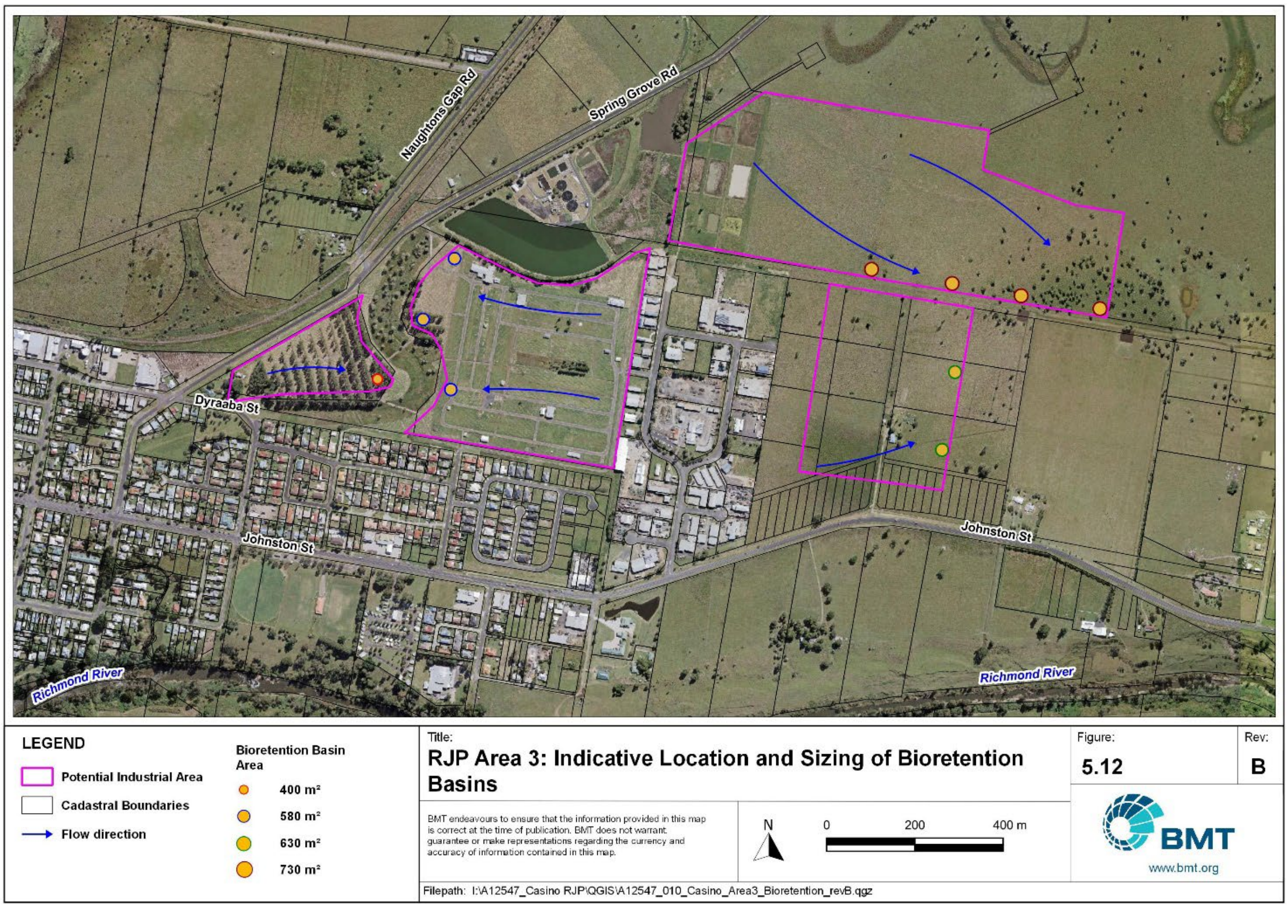


Figure 5.12 RJP Area 3: Indicative Location and Sizing of Bioretention Basins



5.7 Indicative Stormwater Quality Infrastructure Costs

A cost analysis has been performed on the three stormwater quality management options. The methodology used in the cost analysis is provided in Annex H.

Given the preliminary planning stage of the proposal, costings have been based on high-level data and are indicative only. For planning purposes, it is also recommended that a 30% contingency is added to these costs.

Capital expenditure and operational costs per hectare of developed area have been developed for each stormwater management option. These costs have been used to calculate the Net Present Value (NPV) of each solution over a planning period of 20 years. The NPV has been calculated assuming there is no requirement to purchase the land.

The total NPV for RJP Area 1 and Area 3 has been calculated assuming the development of 143 ha and 70 ha of industrial land, respectively. The total NPV of each stormwater management option is presented in Table 5.11.

Table 5.11 NPV for each stormwater treatment option

Treatment Option	Total Net Present Value ($NPV): RJP Area 1	Total Net Present Value ($NPV): RJP Area 3
Assumed industrial land area	*145 ha*	*70 ha*
7.0% Wetlands	$32,017000	$15,457,000
0.9% Bioretention Basins	$8,676,000	$4,189,000
1.2% Streetscape Bioretention	$28,487,000	$13,753,000

These costs include capital and operation expenses for a 20 year period

From the results presented in Table 5.11 the lowest cost option is bioretention basins followed by streetscape bioretention and wetlands.

The estimated costs have been further broken down into four (4) sub-components of the lifecycle of the treatment devices. A definition of each sub-component is provided below with further details of how they are calculated included in Annex H.

1. Design and construction: includes the cost of defining the need for the treatment measure, all design costs and construction costs.
2. Establishment: includes the first two years after construction and includes the cost required to ensure that the treatment device/ measure is properly established.
3. Maintenance: annual maintenance commences after the establishment period and includes typical, frequent maintenance activities.
4. Renewal and adaptation: includes the cost of unusual and/ or infrequent restoration activities (sometimes called ‘corrective maintenance’).

The breakdown of the lifecycle costs for the three treatment strategies for Area 1 and Area 3 are provided below in Table 5.12 and Table 5.13, respectively.

Table 5.12 Area 1 Breakdown of Lifecycle Costs

Lifecycle Cost Component	Wetlands	Bioretention basins	Streetscape bioretention
Design and construction	$24,106,000	$5,351,000	$24,917,000
Establishment	$1,936,000	$556,000	$556,000
Maintenance	$4,383,000	$1,259,000	$1,259,000
Renewal and adaptation	$1,592,000	$1,510,000	$1,755,000
Total	$32,017,000	$8,676,000	$28,487,000

Table 5.13 Area 3 Breakdown of Lifecycle Costs

Lifecycle Cost Component	Wetlands	Bioretention basins	Streetscape bioretention
Design and construction	$11,638,000	$2,583,000	$12,029,000
Establishment	$935,000	$269,000	$269,000
Maintenance	$2,116,000	$608,000	$608,000
Renewal and adaptation	$768,000	$729,000	$847,000
Total	$15,457,000	$4,189,000	$13,753,000

6 Conclusions & Recommendations

A baseline analysis and flood impact assessment for the RJP has been undertaken. The analysis included a flood and drainage assessment and a stormwater quality assessment of the RJP precinct, with a particular focus on RJP Area 3 and the northern portion of RJP Area 1.

The flood and drainage assessment was informed by the results from the regional Richmond River flood model. Simulations of the 2% AEP, 1% AEP, 1% AEP + climate change, 0.2% AEP and PMF flood events were carried out to identify flood and drainage constraints. The analysis included consideration of flood evacuation and an assessment of critical infrastructure with regards to flood evacuation for RJP Area 1 and Area 3.

The key outcomes of the baseline flood and drainage assessment can be summarised as follows:

- The northern part of Area 1 is affected by an overland flowpath which crosses Reynolds Road to flow into Barlings Creek. There is minimal change in regional inundation extent between the 2% AEP and 0.2% AEP flood events within for Area 1. Our recommendation for Area 1 is to develop outside of the area shown as inundated for all events.
- A review of the hydrological assessment for the proposed Rail Freight Terminal highlighted that the upstream catchment area (Catchment 1) is underestimated by approximately 20% and, hence, any Catchment 1 flows which enter Catchment 3 through the proposed embankment may in turn be underestimated. This has the potential to result in higher flood levels on the northern side of the embankment (i.e., within Catchment 1) than on the southern side (i.e., within Catchment 3). This issue is unlikely to affect the flood immunity of the proposed embankment, as the top of embankment is 1.8 m higher that the estimated PMF regional flood level.
- The inundation of Area 3 during regional flood events is due to water entering the site from the west and south. Any proposed filling of Area 3 would obstruct overland flow paths and would likely produce unacceptable flood impacts. These flood impacts can potentially be mitigated by reinstating original flow paths in the vicinity of the sewage treatment plant.
- Following a review of the existing planning controls and the modelling results, BMT recommends adopting the following flood planning levels for the RJP Area 3:
  - A 1% AEP flood level for general commercial/industrial use.
  - A 1% AEP + Risk-Based Freeboard (RBF) flood level for commercial/industrial activities which include storage of hazardous materials.
- Following discussions with project stakeholders during Stage 3 of this assessment and taking into account existing guidance, the following acceptable flood impact criteria for the development of Area 3 have been applied for this assessment:
  - Increase in flood level no greater than 10mm in residential areas.
  - Increase in flood level no greater than 20mm in commercial and industrial areas.
  - Increase in flood level no greater than 200mm in agricultural areas.
  - Increase in flood level no greater than 400mm in general rural open space
  - Acceptable flood impacts to be assessed for the 2% and 1% AEP events. Sensitivity tests on flood impacts to be carried out for the 1% AEP + climate change flood event.
  - Sensitivity tests for changes in extreme flood behaviour for the 0.2% AEP and PMF events.

The key outcomes from the flood impact assessment for RJP Area 3 are as follows:

- An optimised filling extent has been developed in combination with flood mitigation works which limits offsite flood impacts to within acceptable levels and provides an overall benefit to existing residential areas in Casino and to the Cassino Drive Industrial Estate.
- The flood mitigation works promote increased flow through or around the STP and reinstate a situation which was similar prior to the construction of the STP.
- Flood mitigation options 1B and 2B both result in similar outcomes in terms of flood impacts and are considered the preferred options. Options 1A and 2A also result in acceptable flood impact outcomes but require additional road works. Mitigation Option 3 was not sufficient to offset flood impacts.
- Except for some limited filling within the north east portion of Area 3, flood mitigation should occur prior to the placement of any substantial quantities of fill within Area 3.
- The SES has been engaged at key project stages in consideration of flood emergency management for the RJP lands. Overall the SES has indicated that flood evacuation of these lands would be possible and the assessment is consistent with their current recommendations.

The key outcomes from the stormwater quality assessment are as follows:

- Riparian corridor widths have been identified within Area 1 with no riparian corridors identified within Area 3.
- Water quality performance and stormwater generation performance targets have been identified.
- MUSIC modelling has been undertaken to evaluate three potential stormwater quality management strategies as follows:
  - Wetlands
  - Bioretention Basins
  - Streetscape Bioretention.
- The MUSIC modelling has assumed the three stormwater quality management strategies will meet the water quality performance targets and for each strategy the treatment area is identified along with indicative locations of the stormwater management features.
- Key findings from the MUSIC modelling are:
  - The implementation of bioretention systems will require significantly less area relative to wetlands.
  - All of the treatment strategies meet the 10% reduction in mean annual stormwater volumes when compared to the baseline volume generated by the industrial land use.

Overall, it is recommended that the information presented in the baseline analysis is now used to inform the flood impact assessment of the RJP. This includes the optimisation of fill extents and any associated flood mitigation.

7 References

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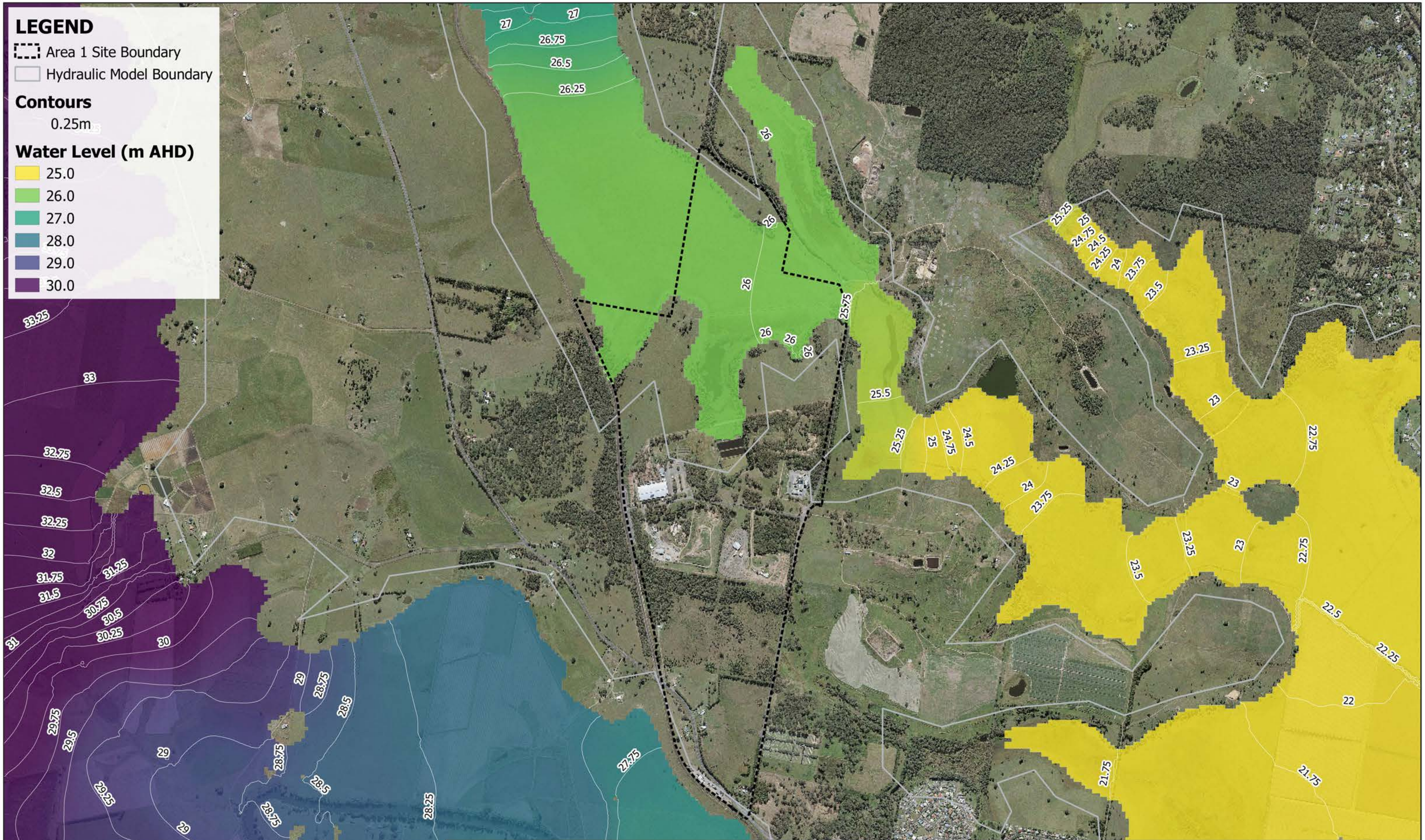
Annex A: Flood Maps | Baseline Conditions | Area 1



Title:
2% AEP Peak Flood Level | Baseline Conditions | Area 1

Figure: **A-1**

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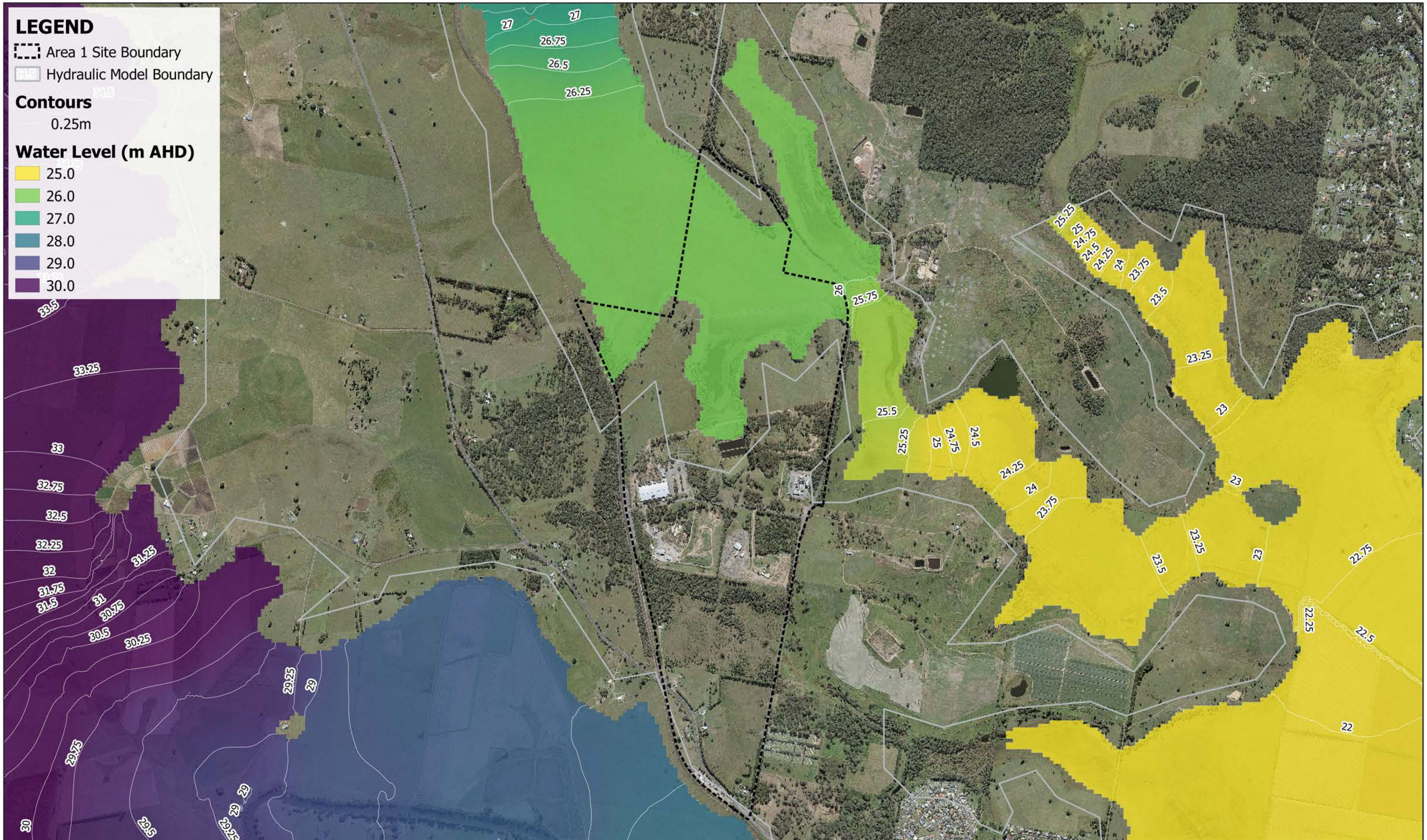

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1% AEP Peak Flood Level | Baseline Conditions | Area 1

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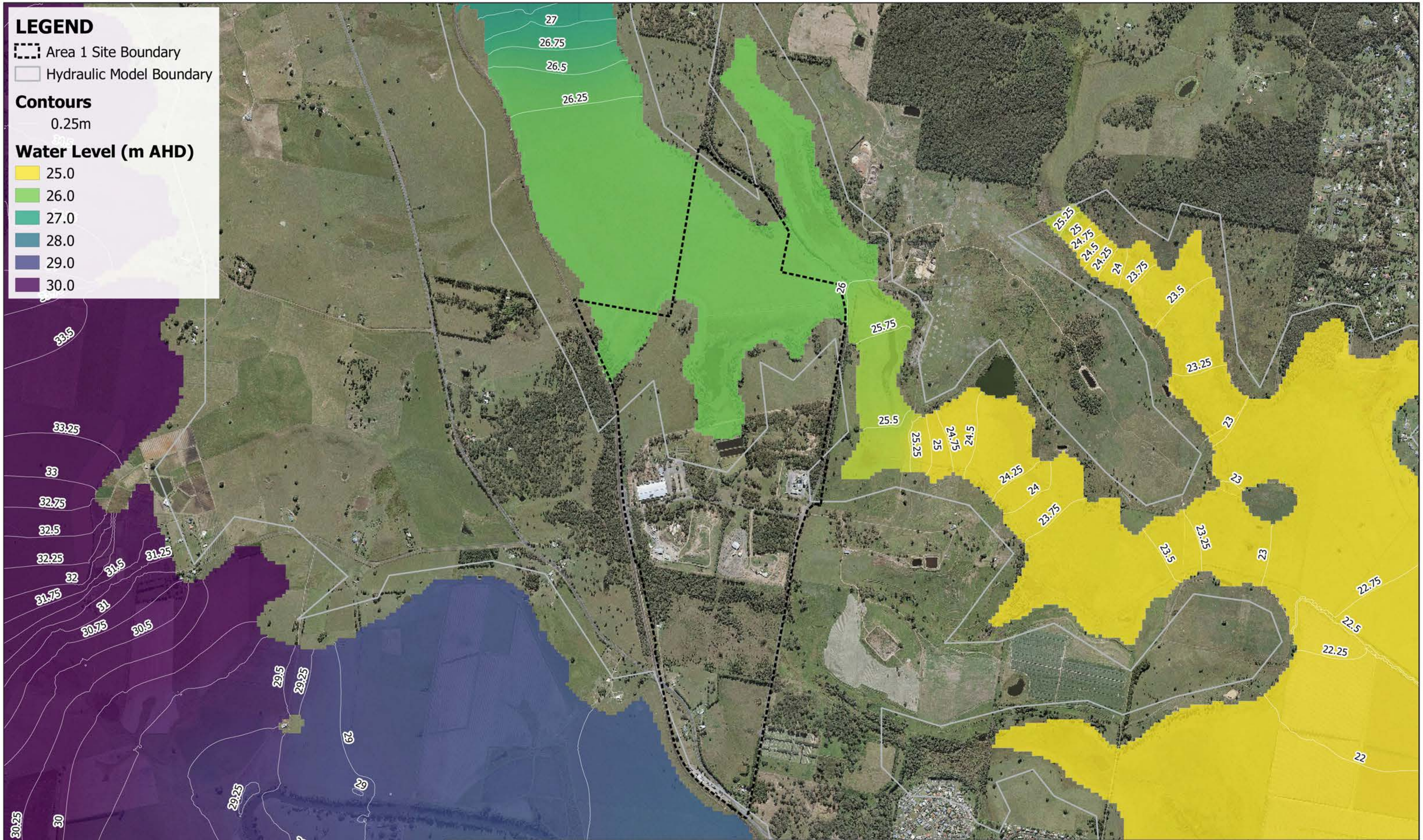

Title:
1% AEP + Climate Change Peak Flood Level | Baseline Conditions | Area 1

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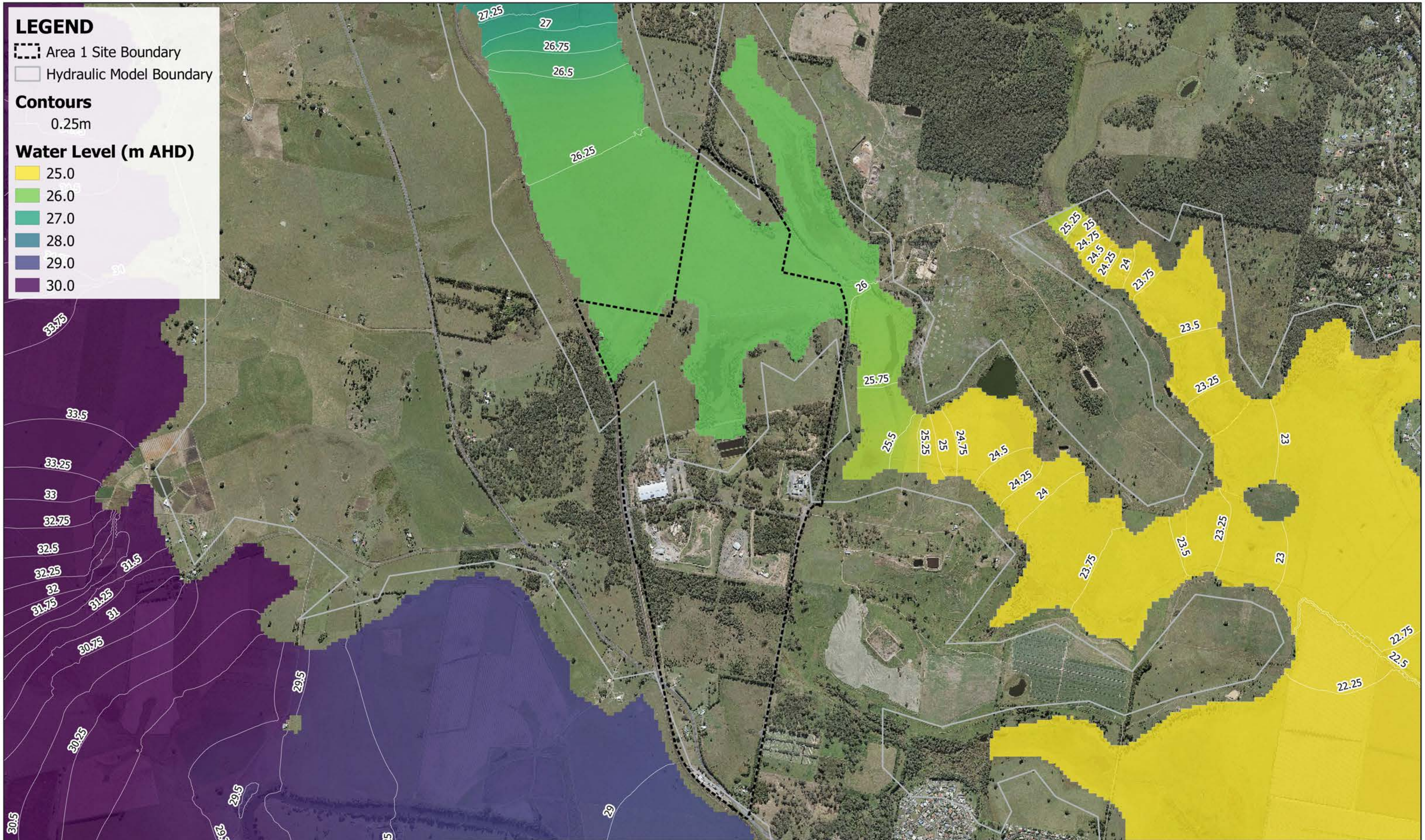

Title:

0.2% AEP Peak Flood Level | Baseline Conditions | Area 1

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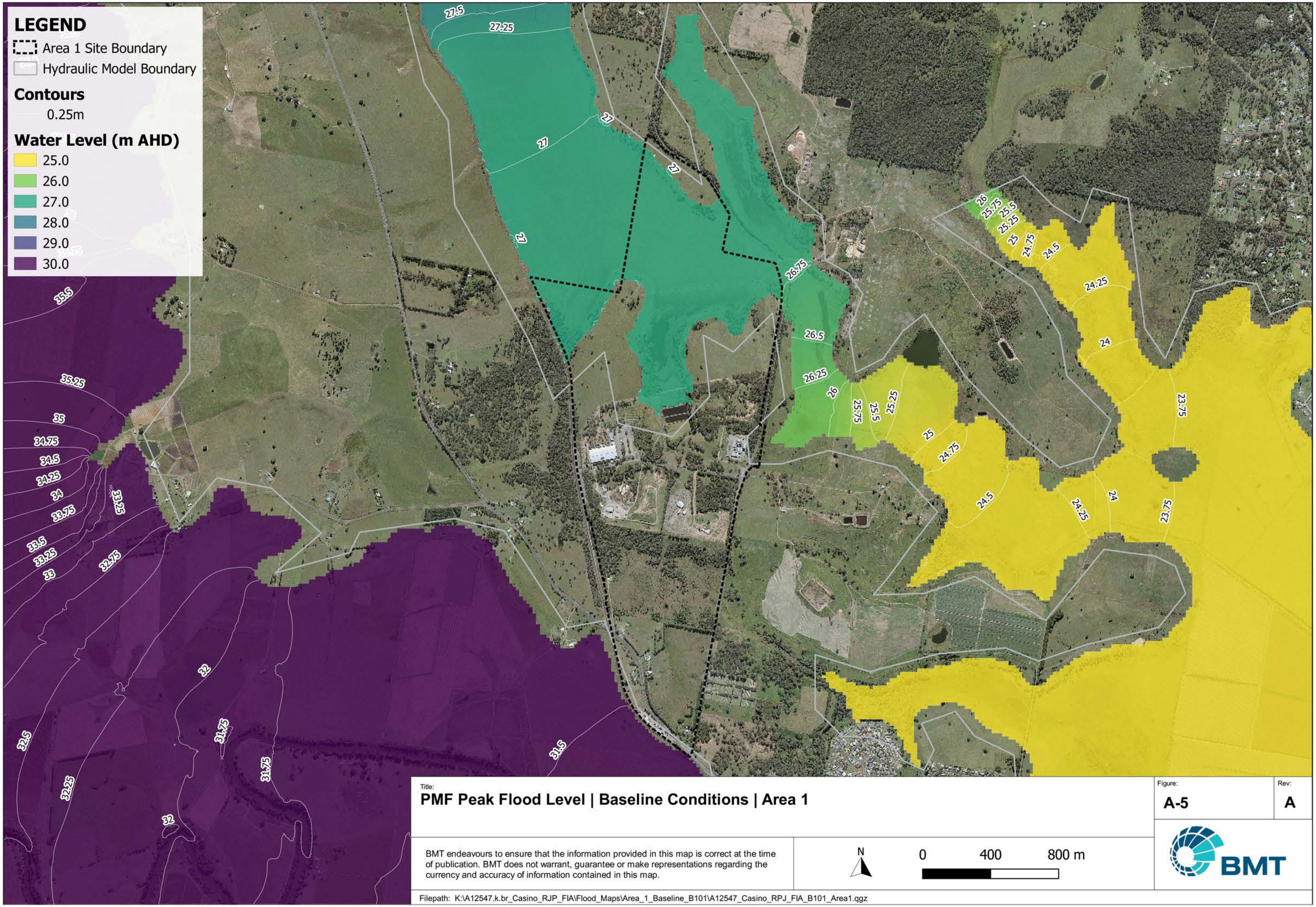

Title:
PMF Peak Flood Level | Baseline Conditions | Area 1

Figure: A-5

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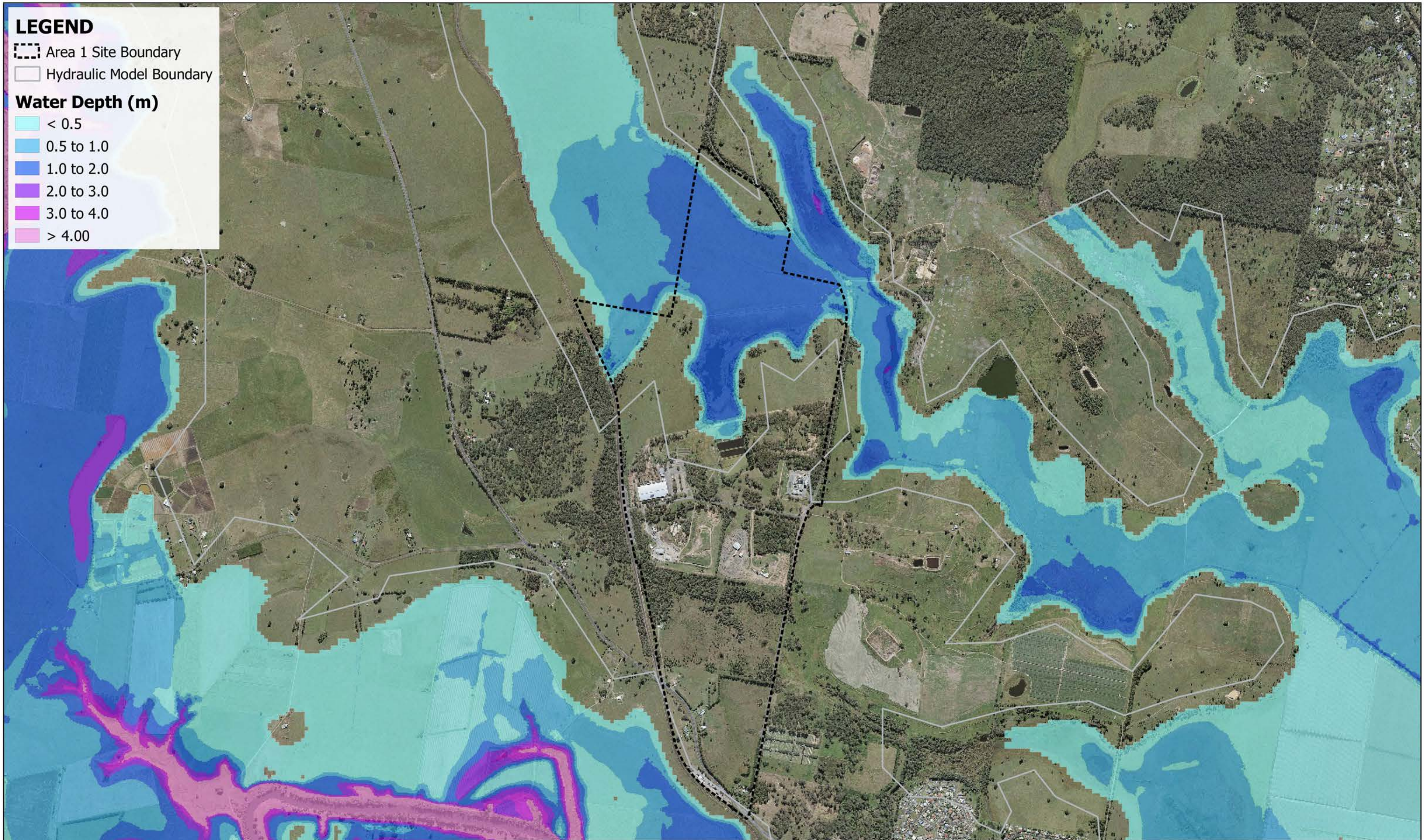

Title:

2% AEP Peak Flood Depth | Baseline Conditions | Area 1

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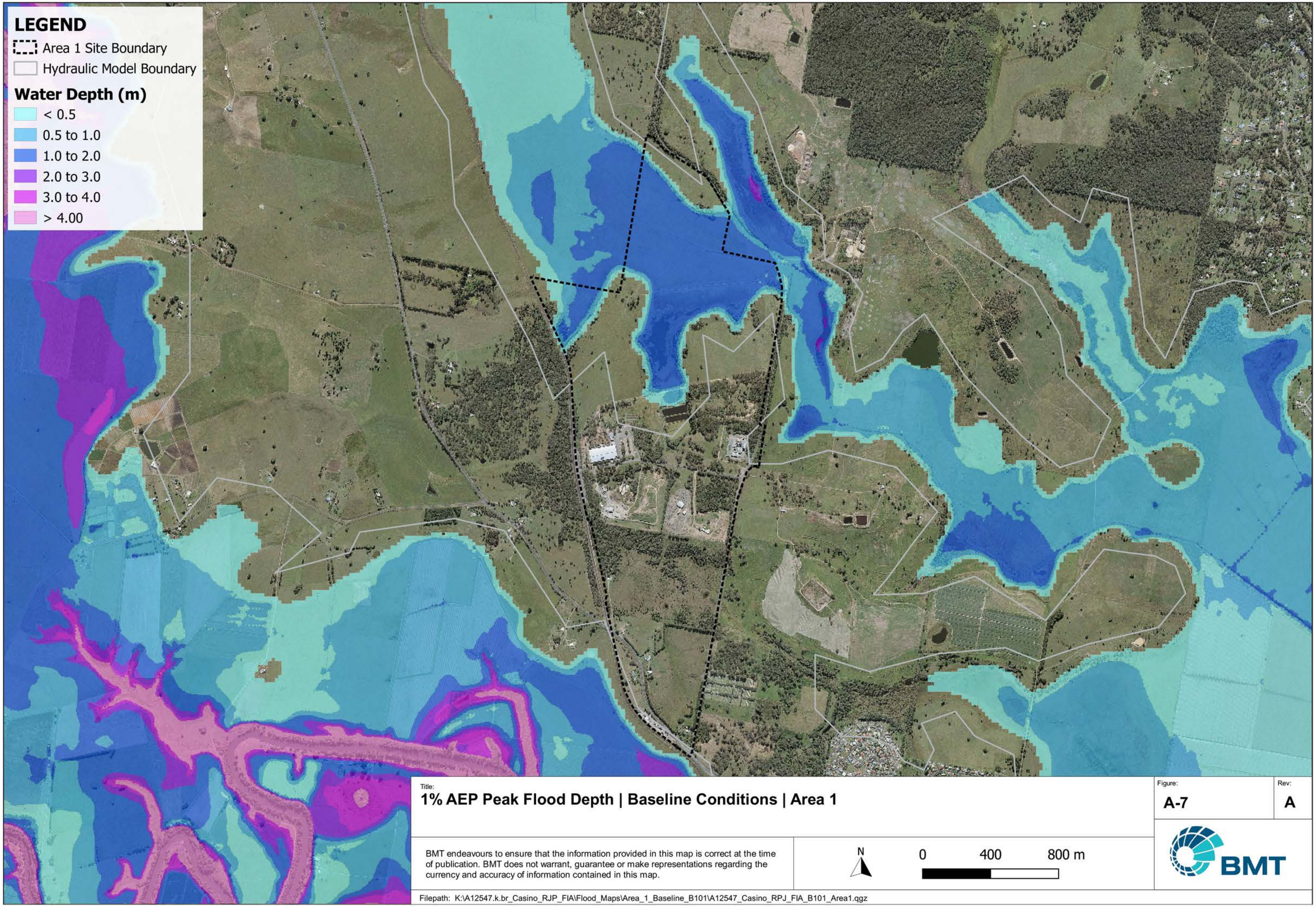

Title:
1% AEP Peak Flood Depth | Baseline Conditions | Area 1

Figure: A-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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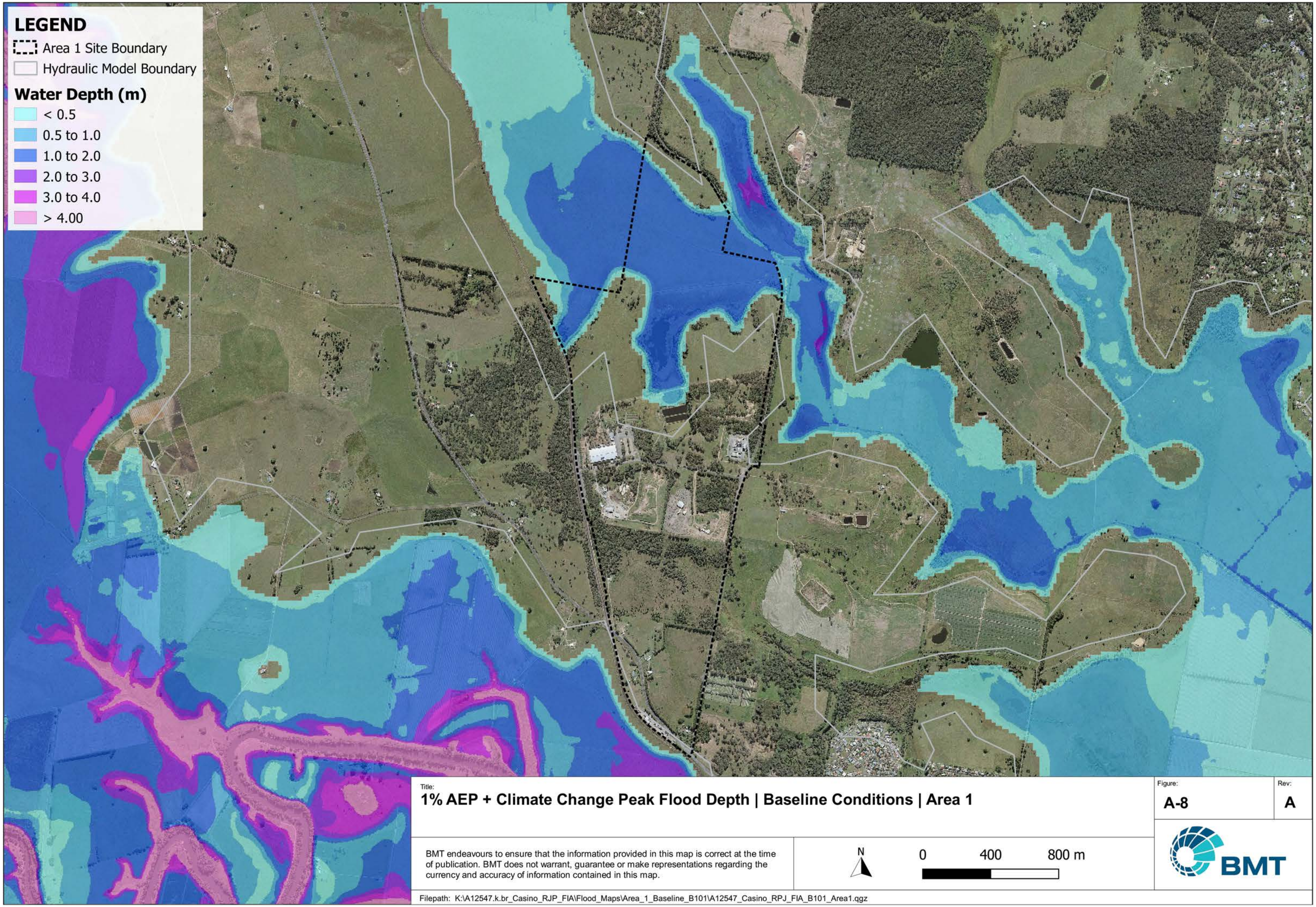

Title:
1% AEP + Climate Change Peak Flood Depth | Baseline Conditions | Area 1

Figure: A-8

Rev: A

BMT

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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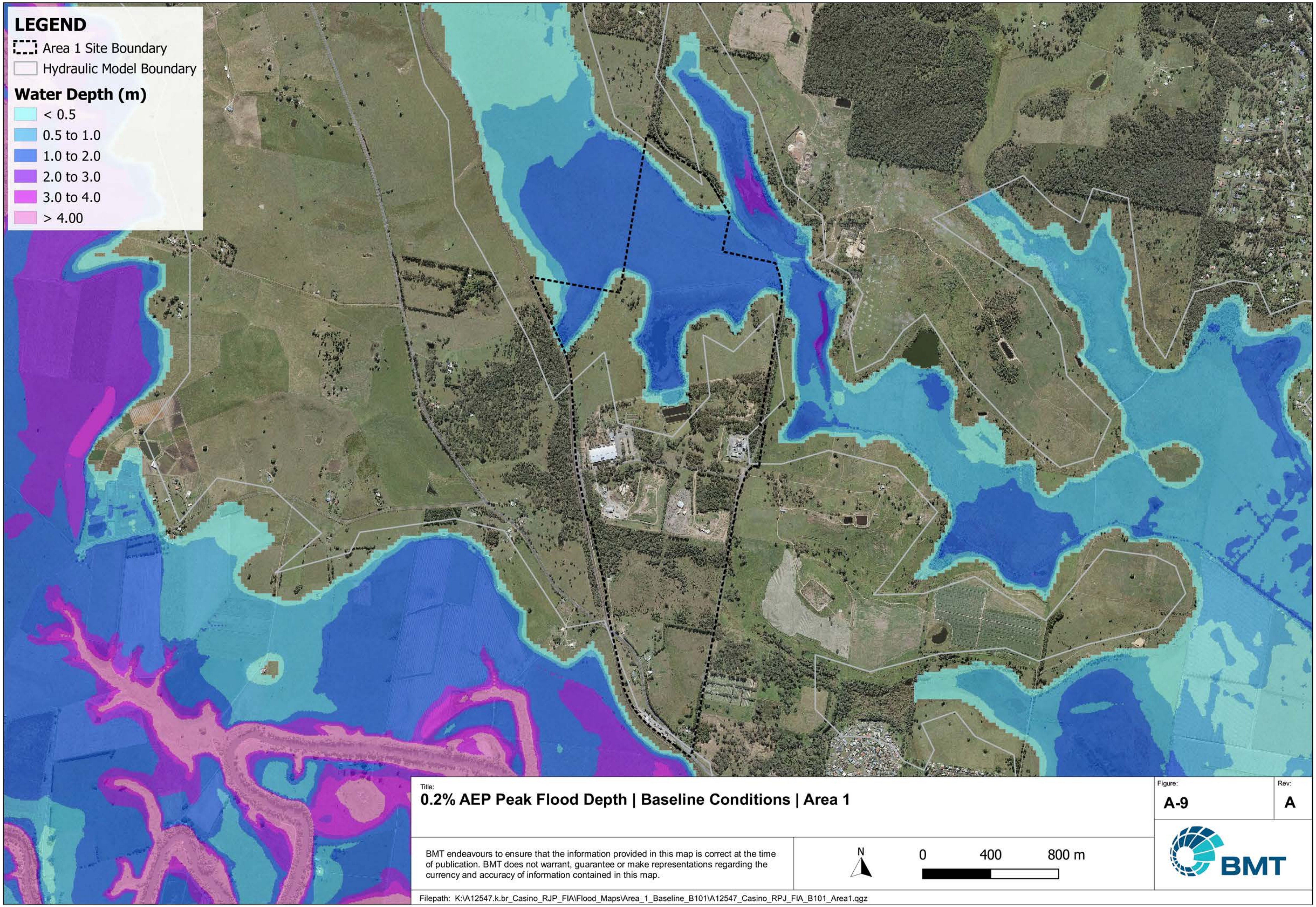

Title:
0.2% AEP Peak Flood Depth | Baseline Conditions | Area 1

Figure: **A-9**

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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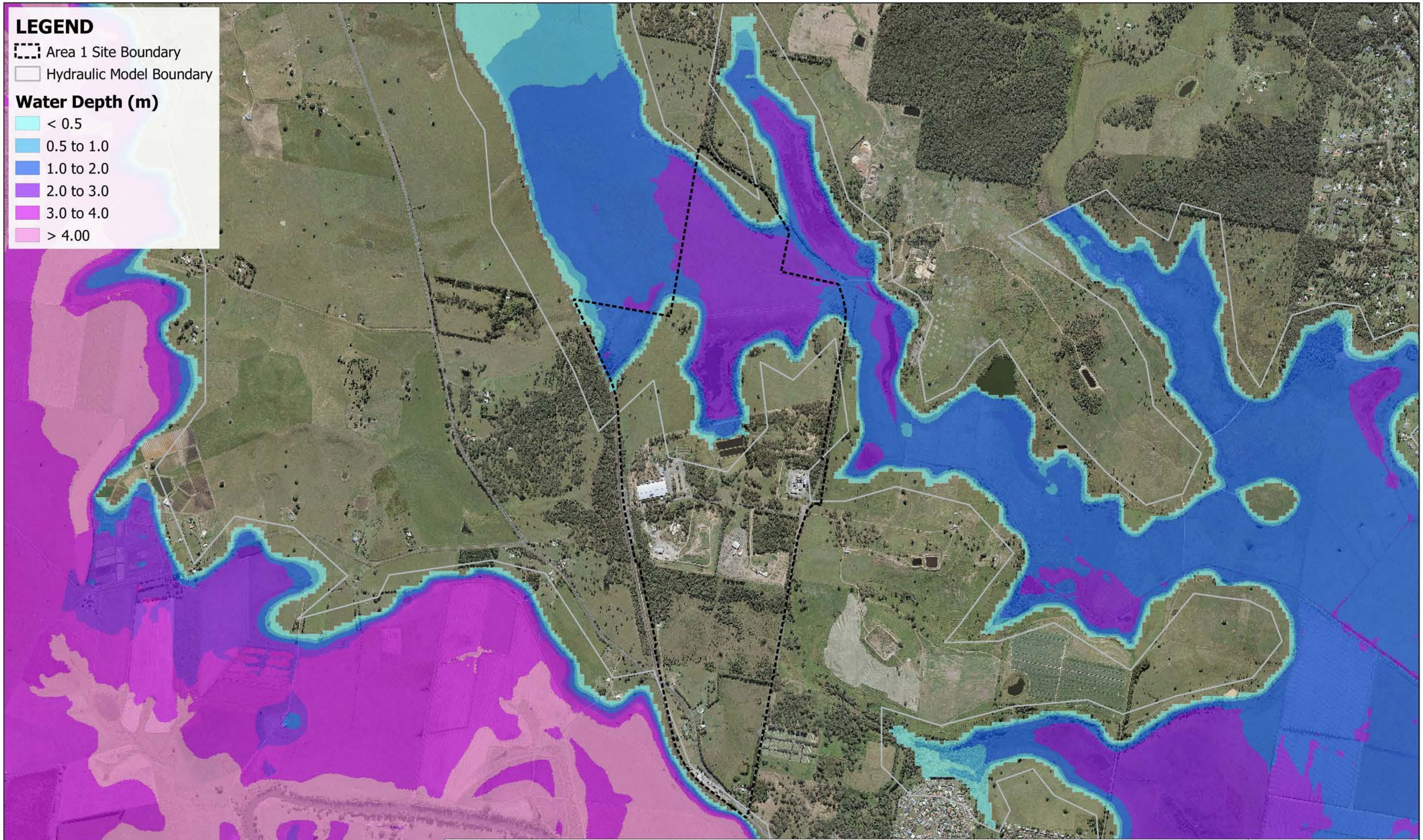

Title:

PMF Peak Flood Depth | Baseline Conditions | Area 1

Figure: A-10

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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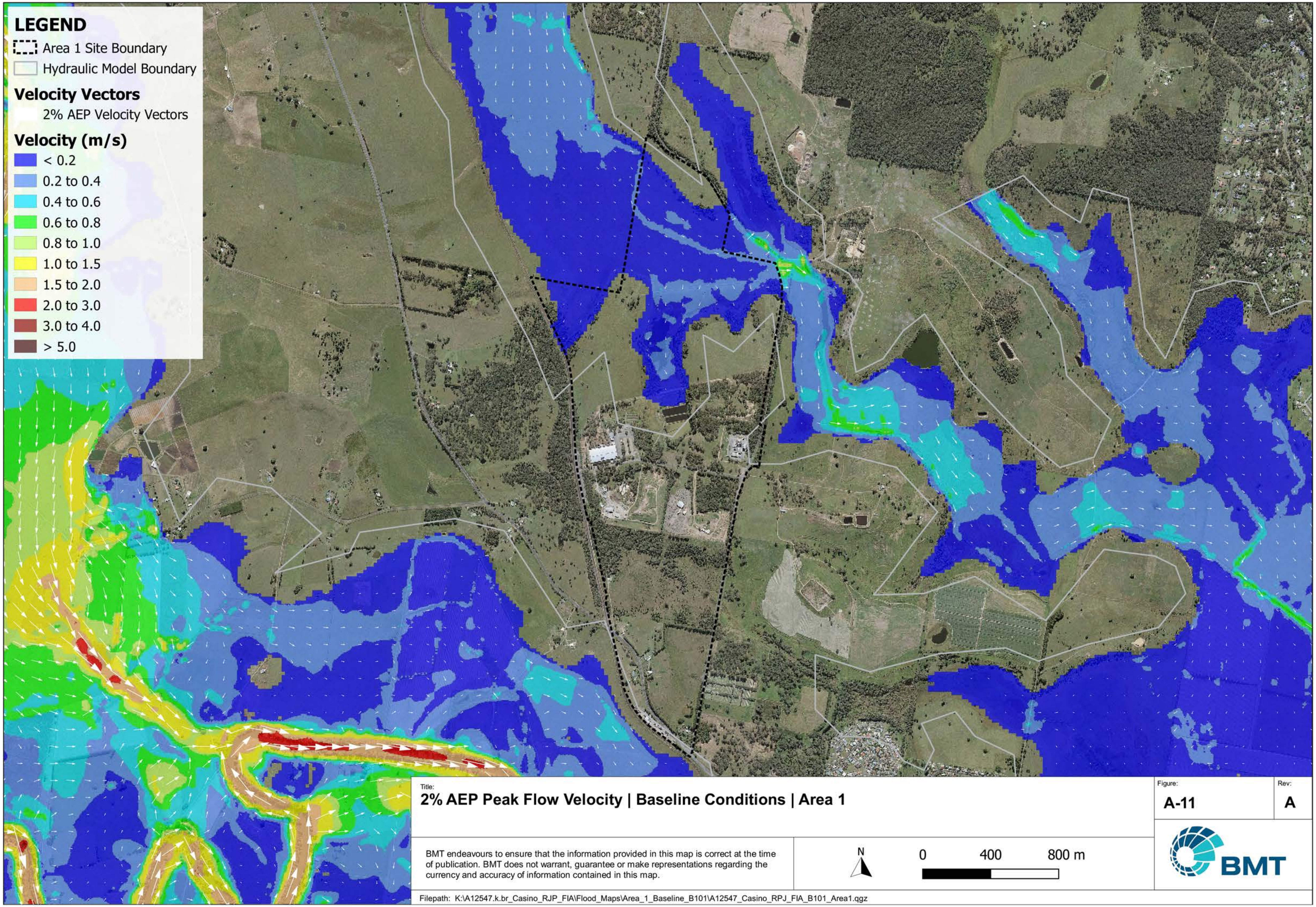

Title:

2% AEP Peak Flow Velocity | Baseline Conditions | Area 1

Figure: **A-11**

Rev: **A**

BMT

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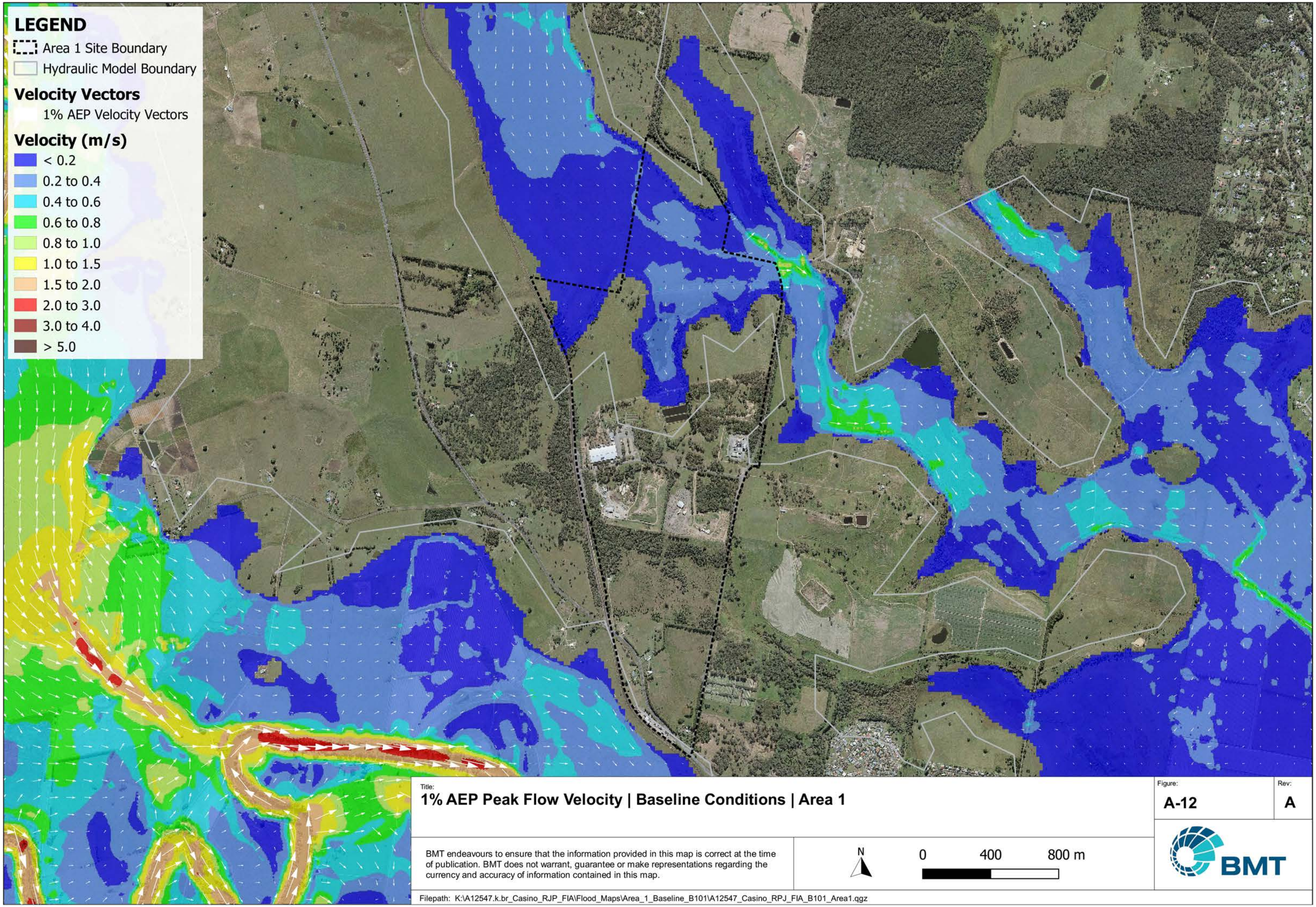


Title:

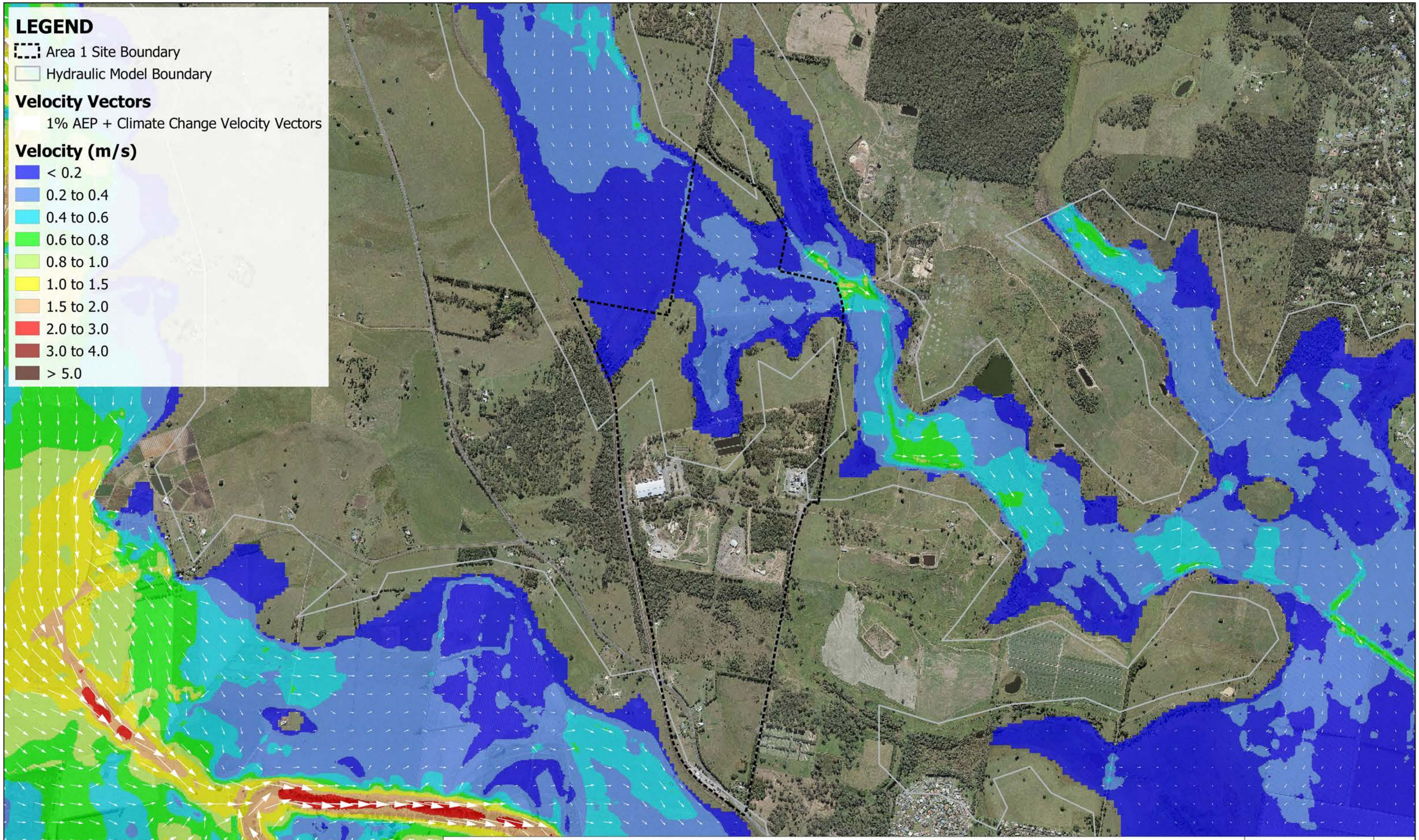
1% AEP Peak Flow Velocity | Baseline Conditions | Area 1

Figure: A-12

Rev: A

BMT

Filepath: K:\A12547.k.br_Casino_RJP_FIA\Flood_Maps\Area_1_Baseline_B101\A12547_Casino_RPJ_FIA_B101_Area1.qgz



Title:
1% AEP + Climate Change Peak Flow Velocity | Baseline Conditions | Area 1

Figure: **A-13**

Rev: **A**

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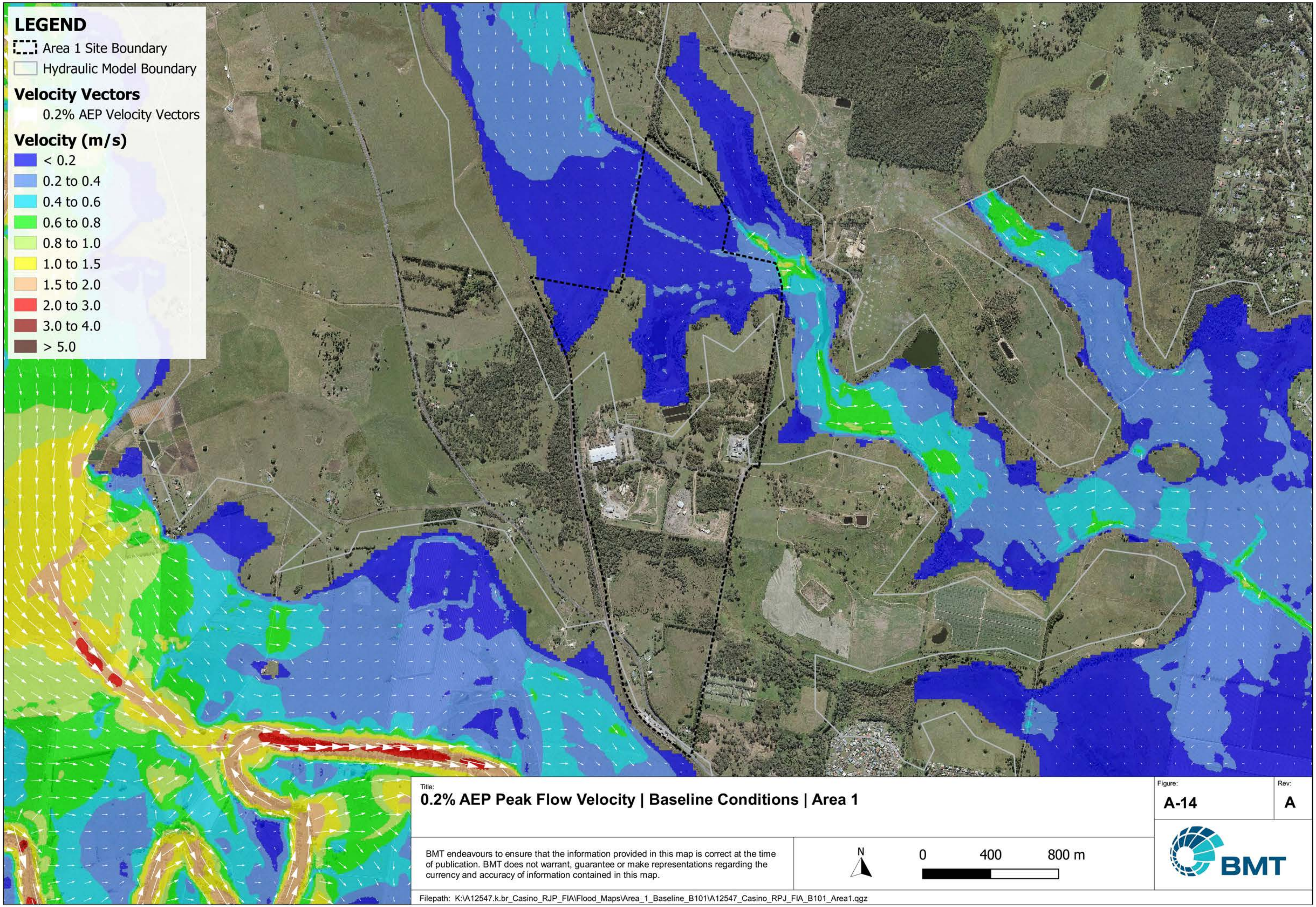

Title: **0.2% AEP Peak Flow Velocity | Baseline Conditions | Area 1**

Figure: **A-14**

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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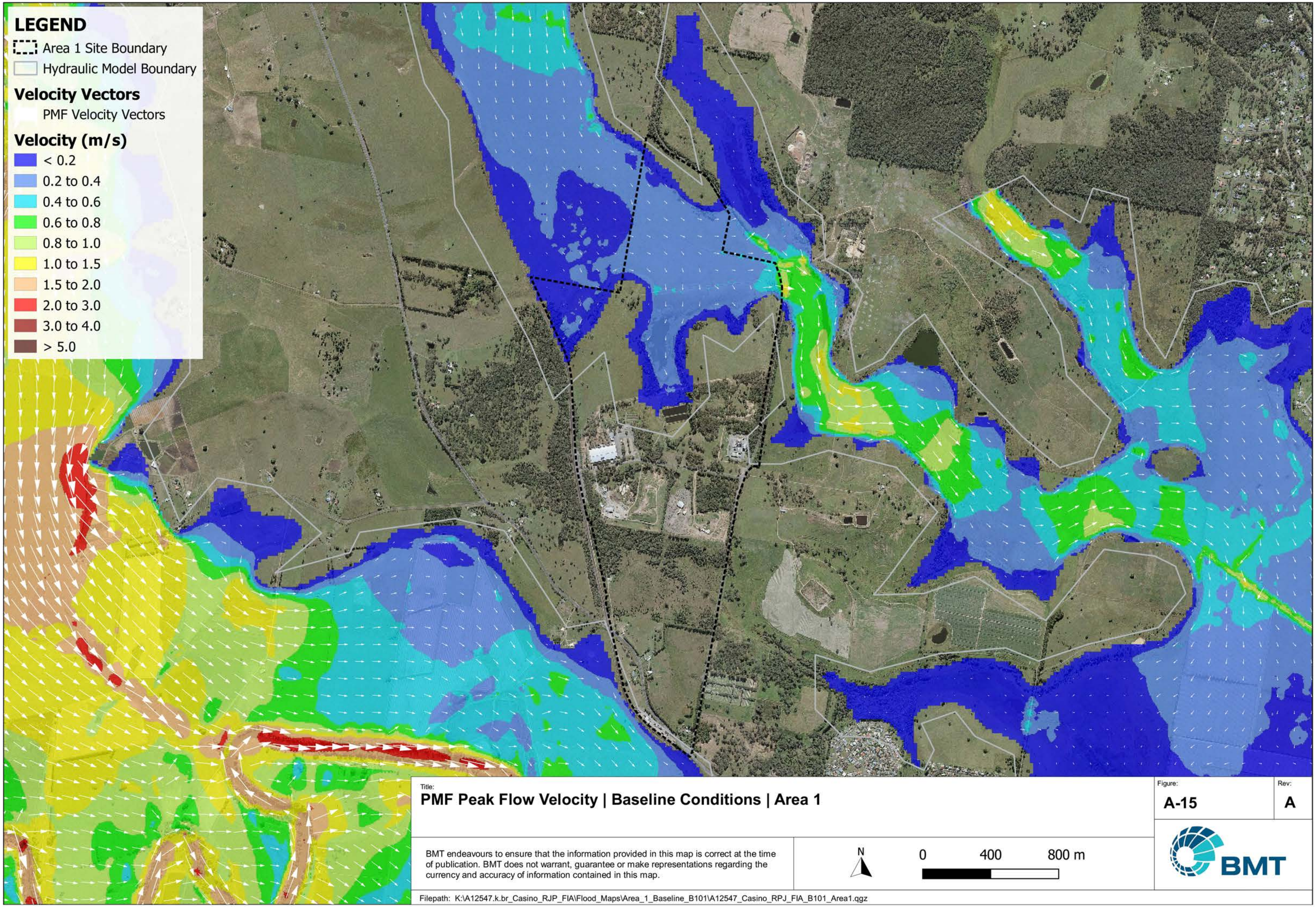

Title:

PMF Peak Flow Velocity | Baseline Conditions | Area 1

Figure: A-15

Rev: A

BMT

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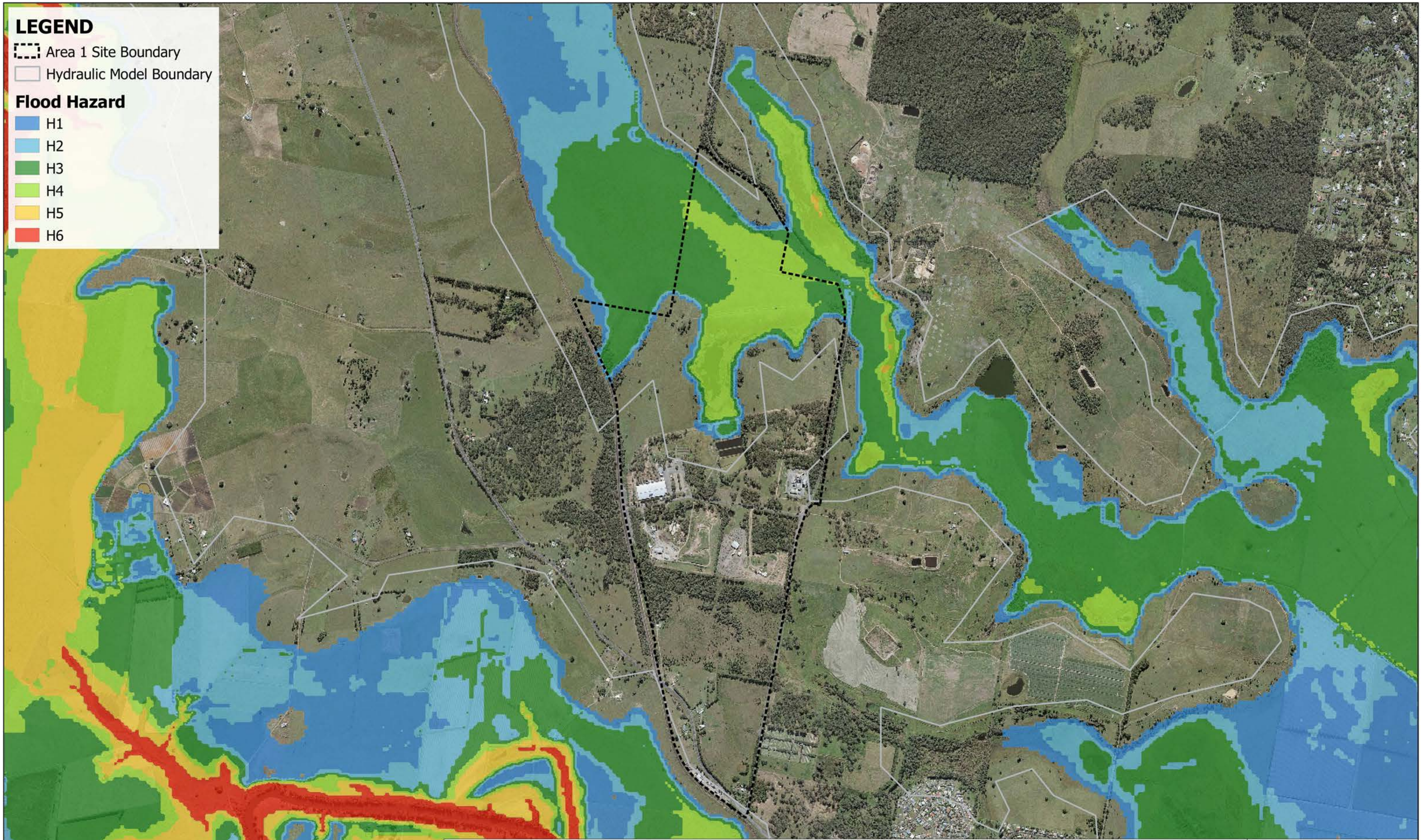


Title:
2% AEP Peak Flood Hazard | Baseline Conditions | Area 1

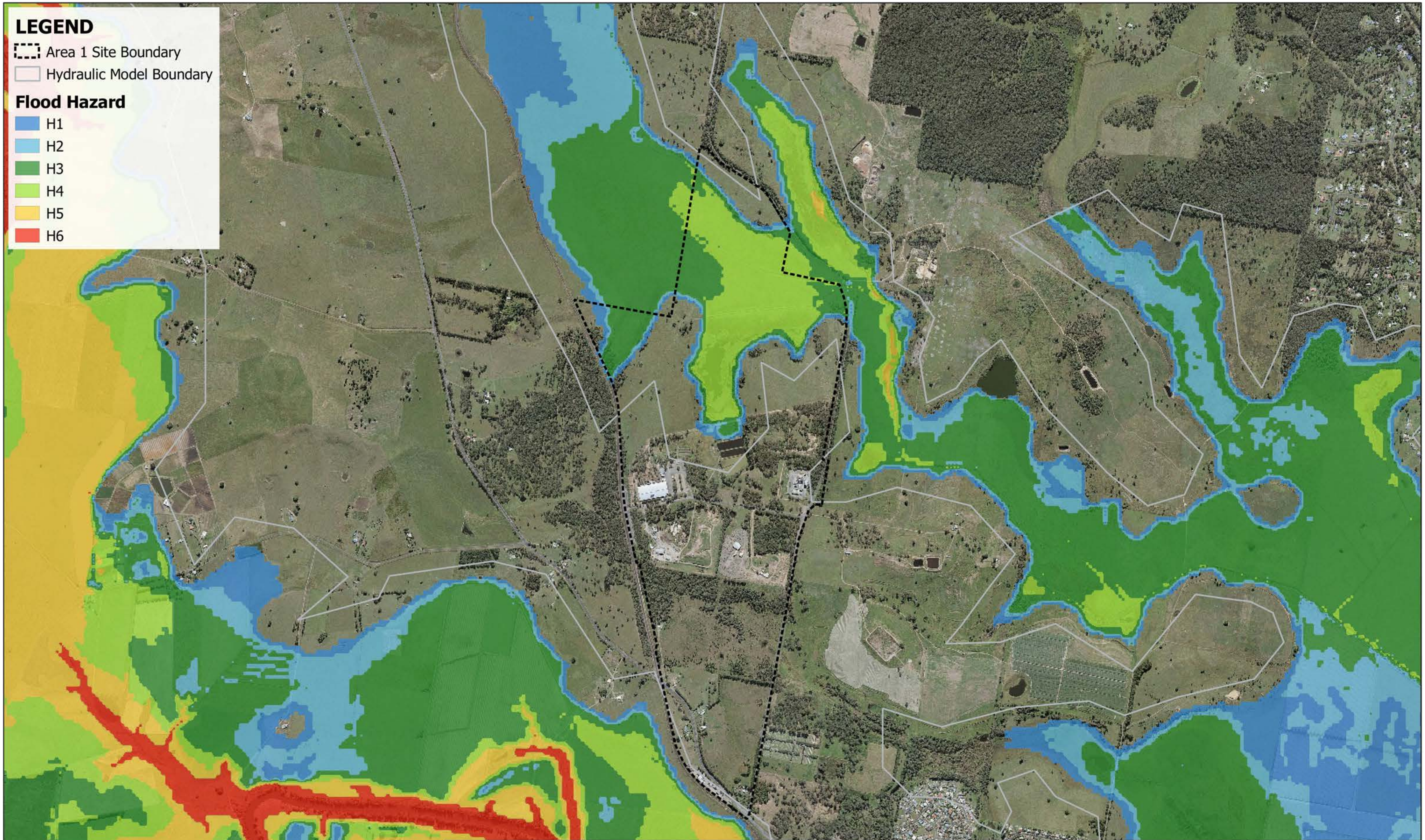
Figure: A-16

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.

BMT

Filepath: K:\A12547.k.br_Casino_RJP_FIA\Flood_Maps\Area_1_Baseline_B101\A12547_Casino_RPJ_FIA_B101_Area1.qgz



Title:

1% AEP Peak Flood Hazard | Baseline Conditions | Area 1

Figure: A-17

Rev: A

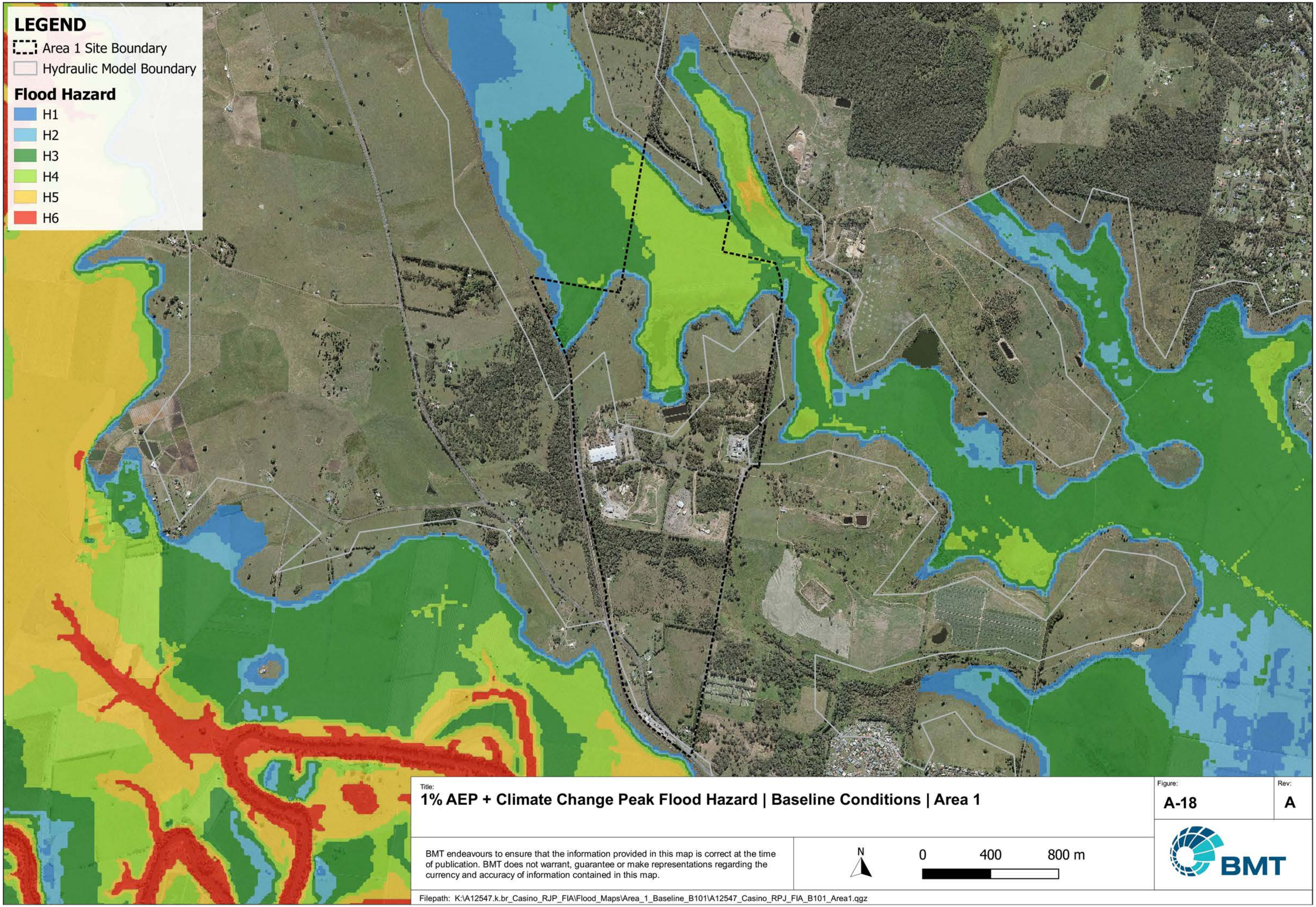
BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 400 800 m

BMT

Filepath: K:\A12547.k.br_Casino_RJP_FIA\Flood_Maps\Area_1_Baseline_B101\A12547_Casino_RPJ_FIA_B101_Area1.qgz



Title:
1% AEP + Climate Change Peak Flood Hazard | Baseline Conditions | Area 1

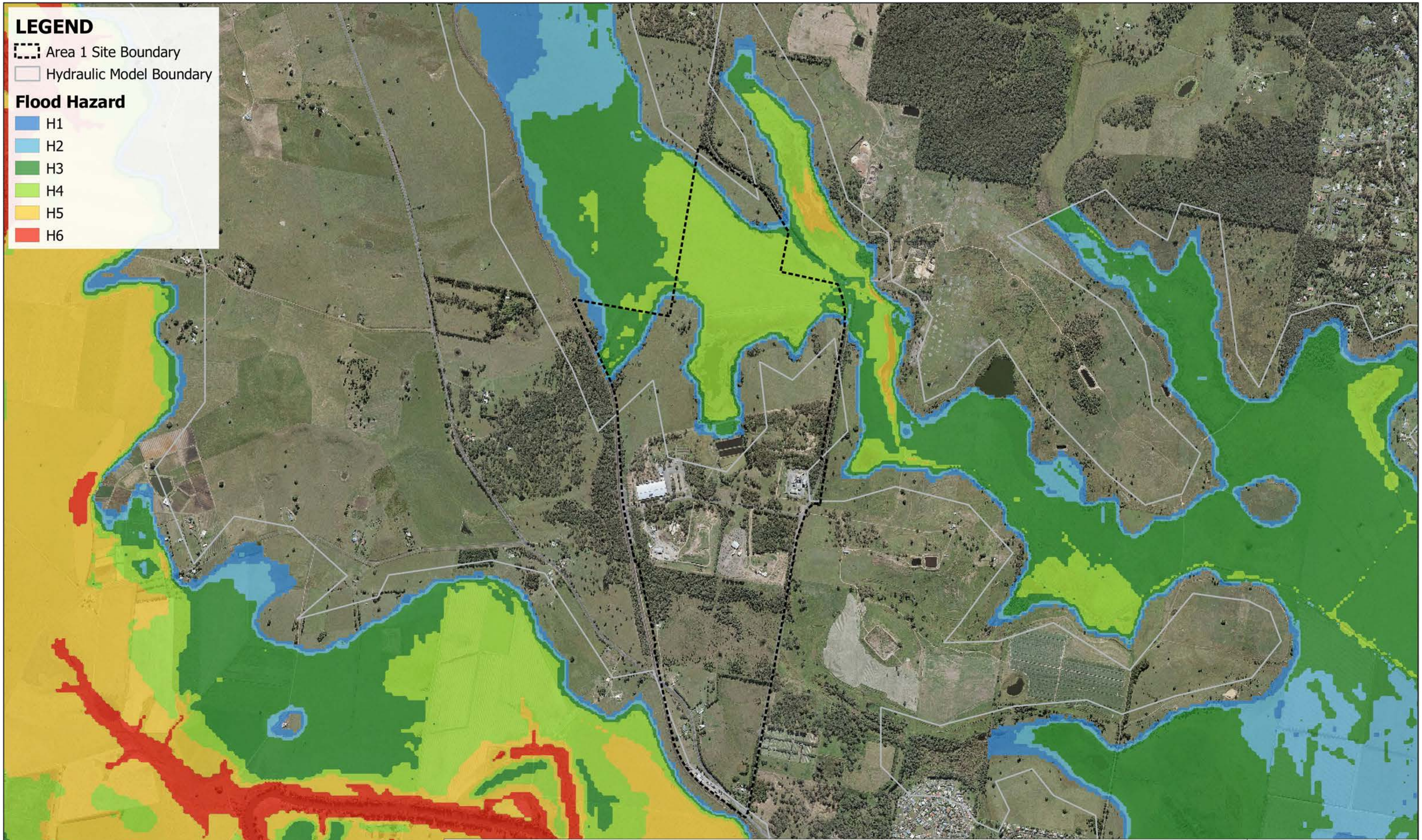
Figure: A-18

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.

BMT

Filepath: K:\A12547.k.br_Casino_RJP_FIA\Flood_Maps\Area_1_Baseline_B101\A12547_Casino_RPJ_FIA_B101_Area1.qgz



Title:

0.2% AEP Peak Flood Hazard | Baseline Conditions | Area 1

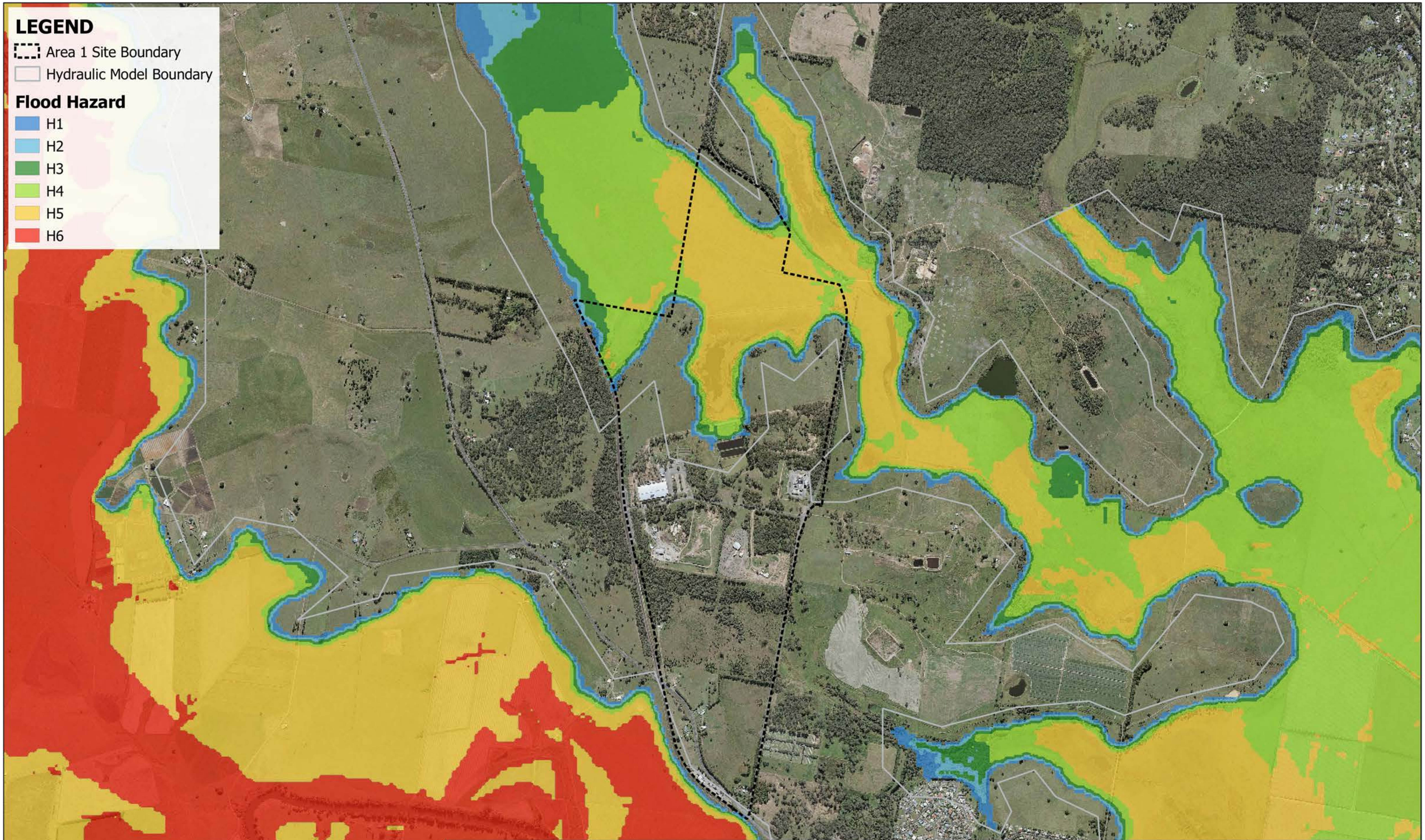
Figure: **A-19**

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.

BMT

Filepath: K:\A12547.k.br_Casino_RJP_FIA\Flood_Maps\Area_1_Baseline_B101\A12547_Casino_RPJ_FIA_B101_Area1.qgz



Title:

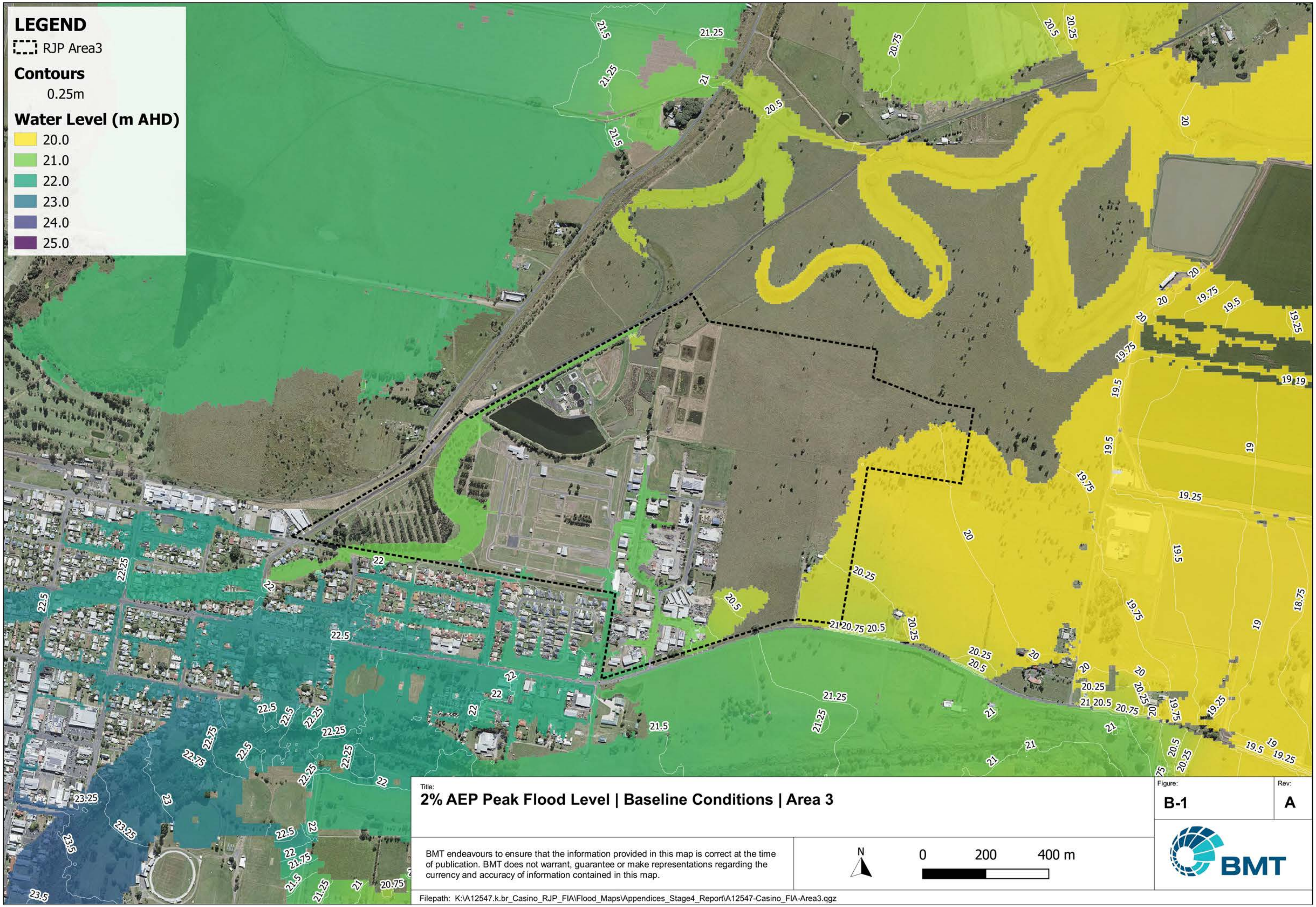
PMF Peak Flood Hazard | Baseline Conditions | Area 1

Figure: A-20

Rev: A

Filepath: K:\A12547.k.br_Casino_RJP_FIA\Flood_Maps\Area_1_Baseline_B101\A12547_Casino_RPJ_FIA_B101_Area1.qgz

Annex B: Flood Maps | Baseline Conditions | Area 3



Title:

2% AEP Peak Flood Level | Baseline Conditions | Area 3

Figure: B-1

Rev: A

BMT

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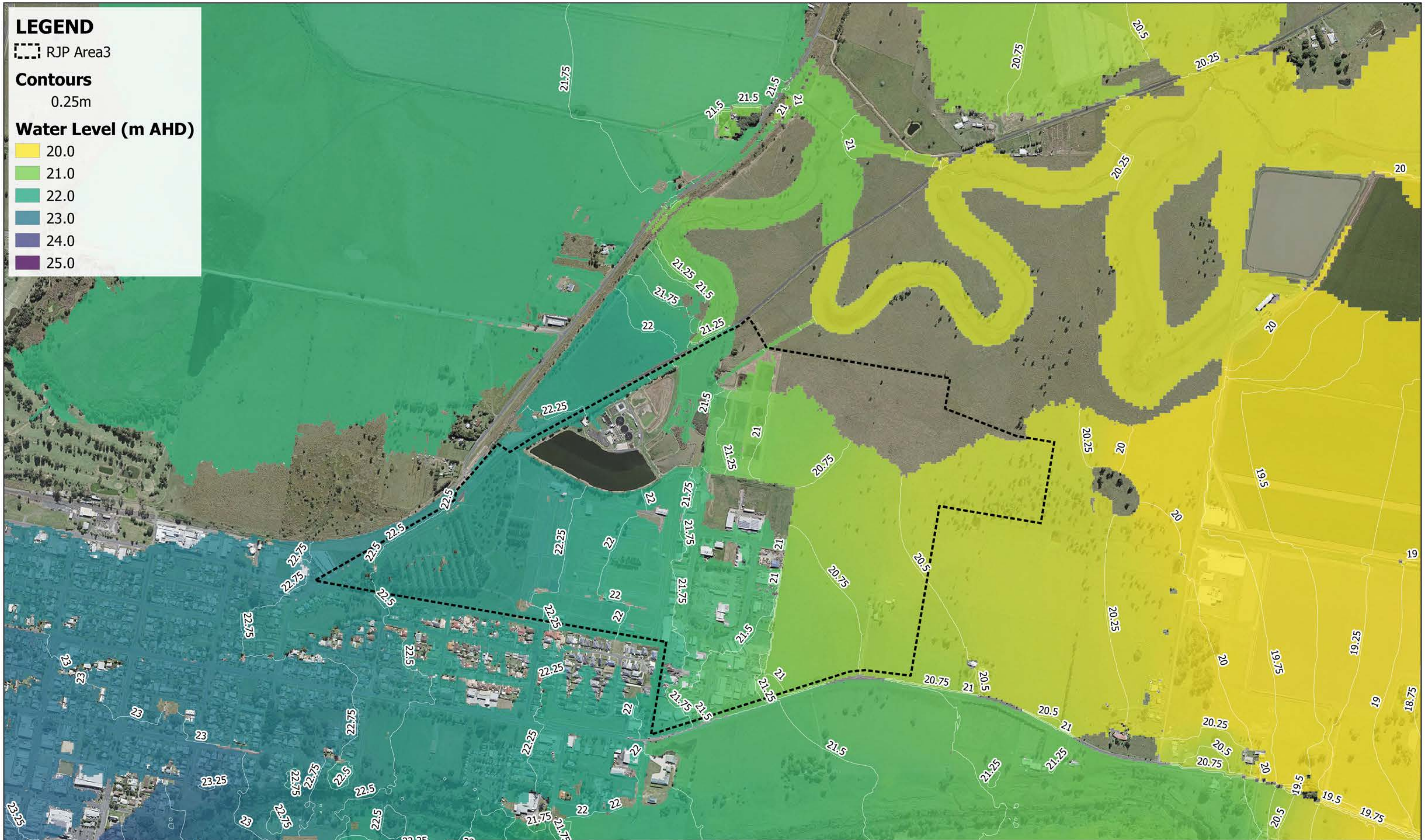


Title:

1% AEP Peak Flood Level | Baseline Conditions | Area 3

Figure: B-2

Rev: A

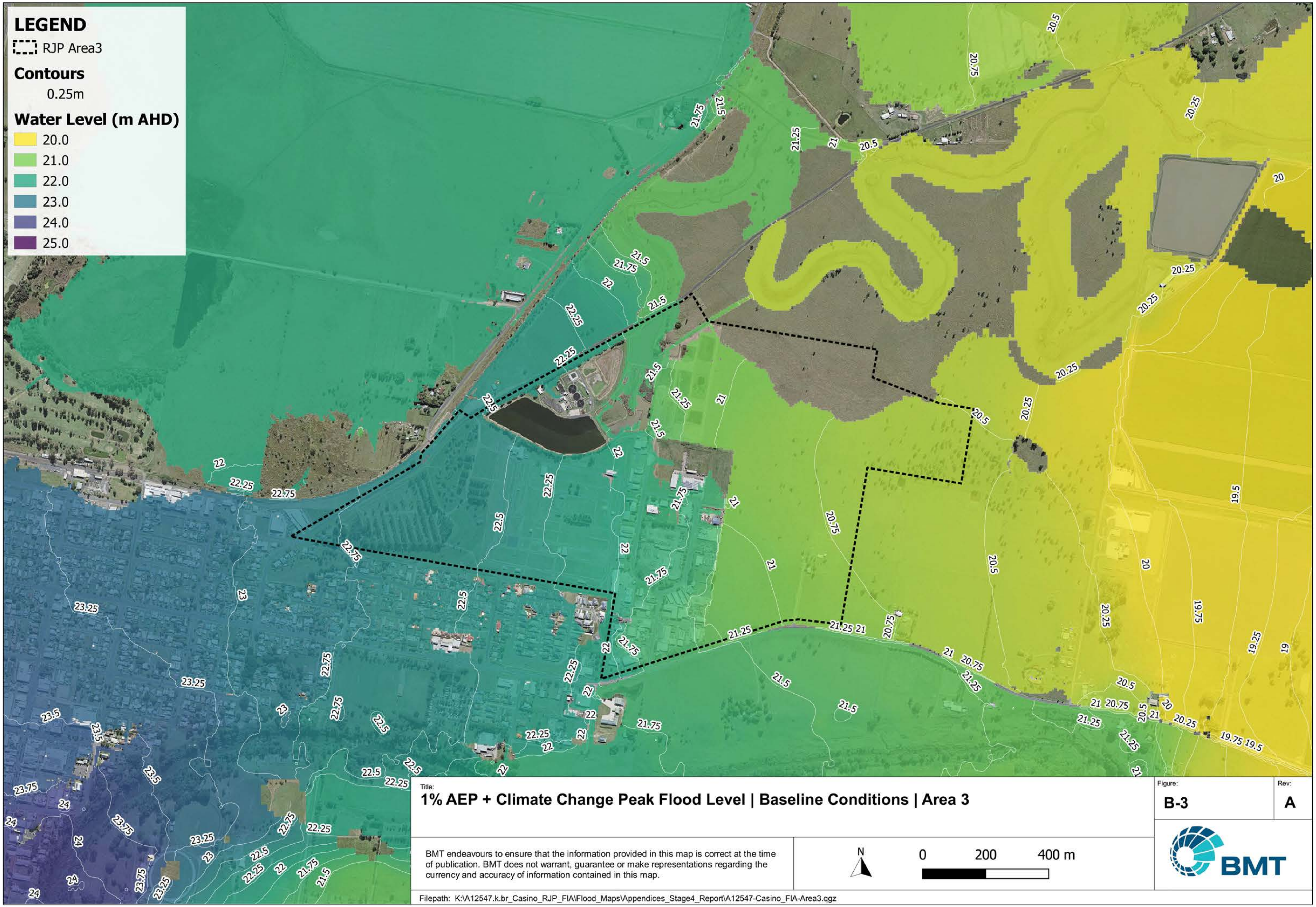
BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 200 400 m

BMT

Filepath: K:\A12547.k.br_Casino_RJP_FIA\Flood_Maps\Appendices_Stage4_Report\A12547-Casino_FIA-Area3.qgz



Title:

1% AEP + Climate Change Peak Flood Level | Baseline Conditions | Area 3

Figure: B-3

Rev: A

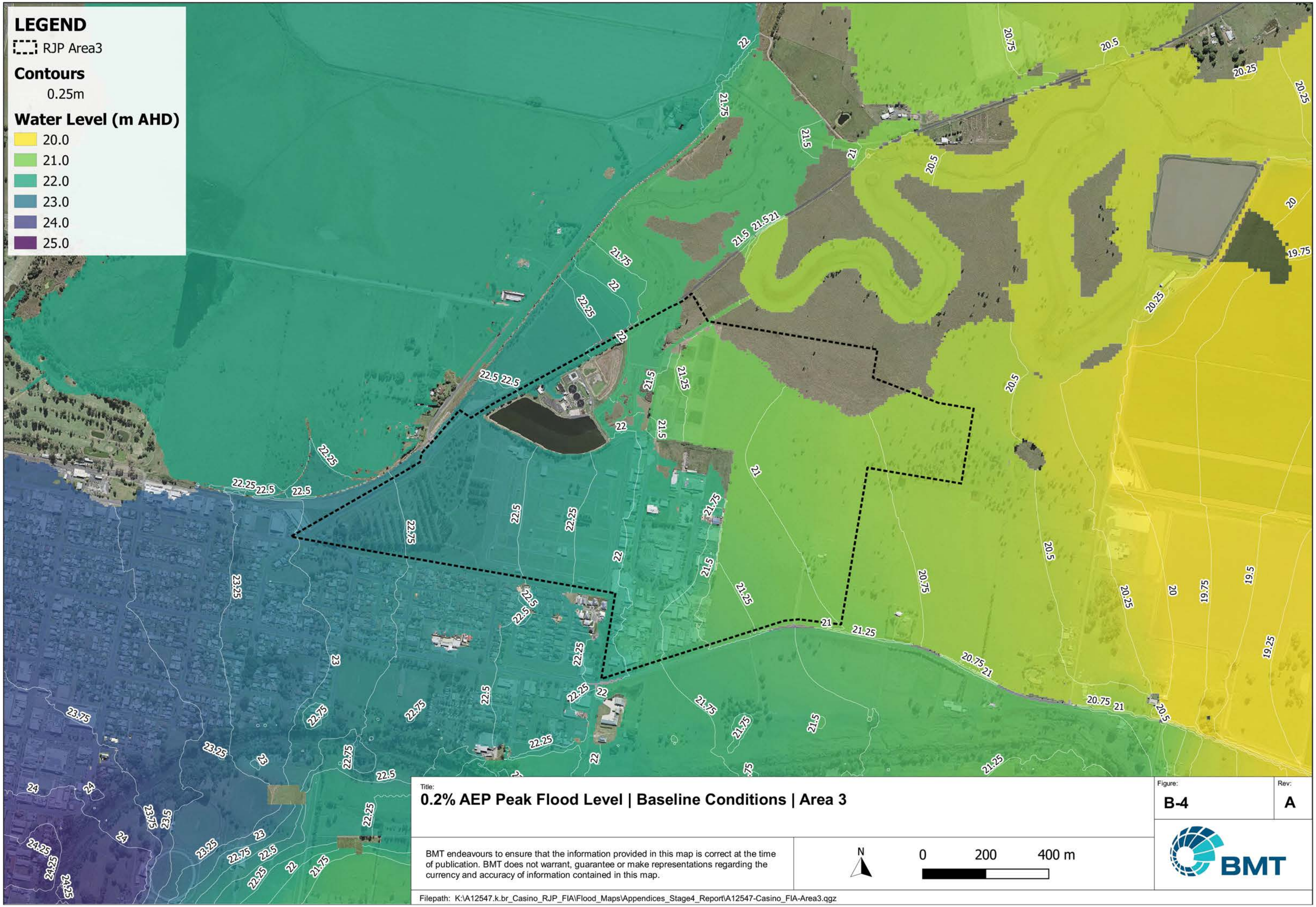
BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 200 400 m

BMT

Filepath: K:\A12547.k.br_Casino_RJP_FIA\Flood_Maps\Appendices_Stage4_Report\A12547-Casino_FIA-Area3.qgz



Title:

0.2% AEP Peak Flood Level | Baseline Conditions | Area 3

Figure: **B-4**

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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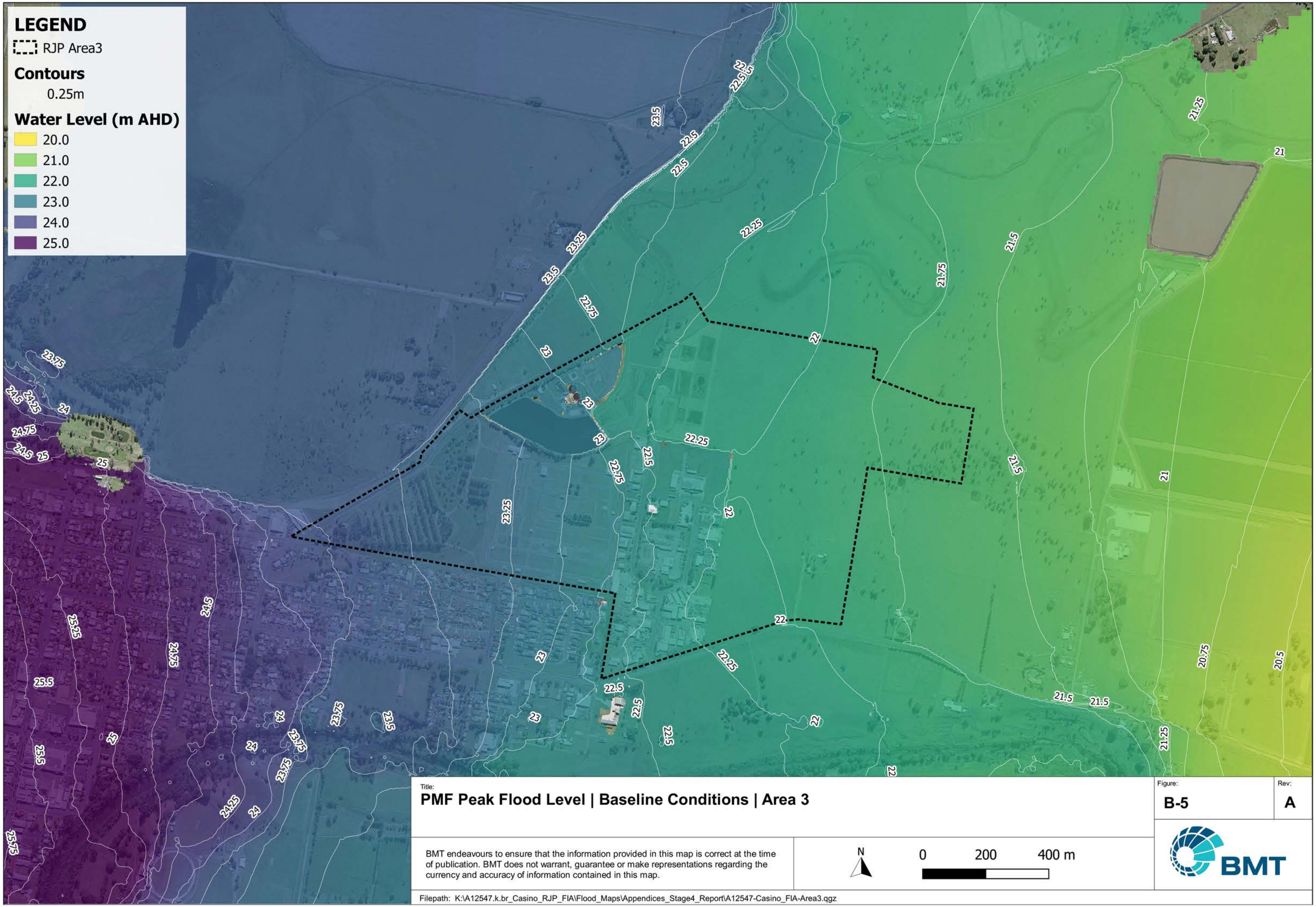

Title:

PMF Peak Flood Level | Baseline Conditions | Area 3

Figure: B-5

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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Title:

2% AEP Peak Flood Depth | Baseline Conditions | Area 3

Figure: B-6

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.

BMT

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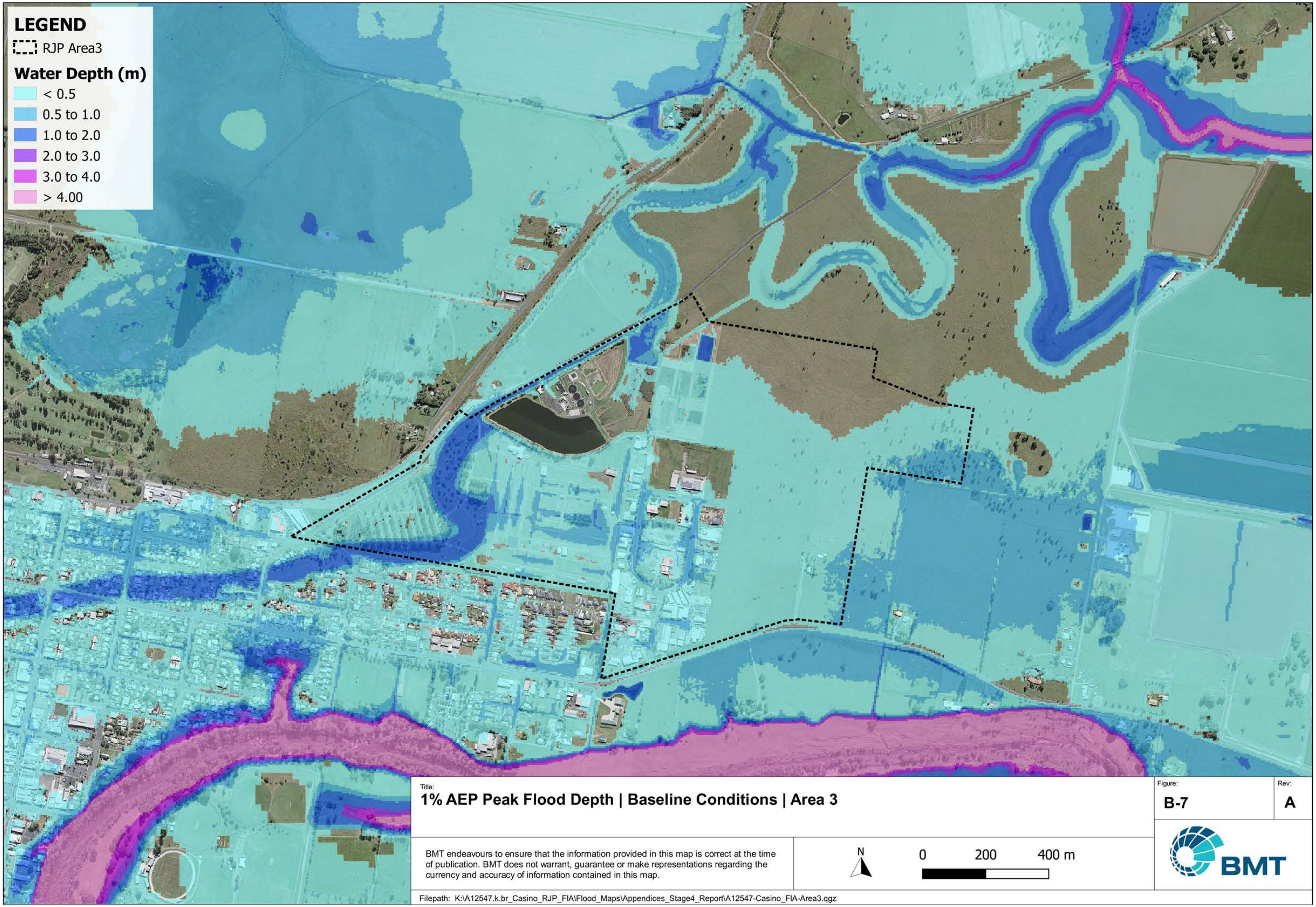

Title:

1% AEP Peak Flood Depth | Baseline Conditions | Area 3

Figure: B-7

Rev: A

BMT

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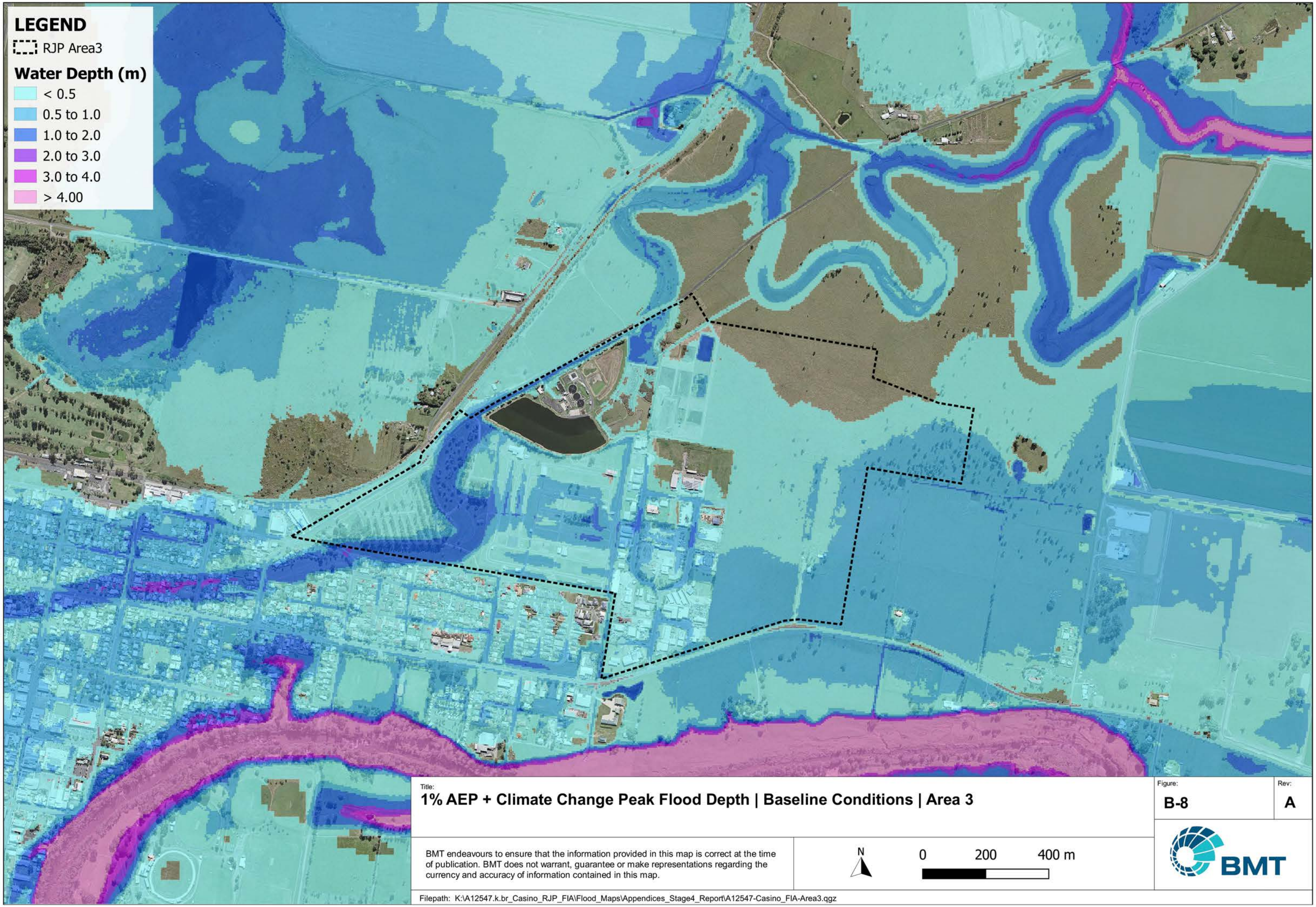

Title:

1% AEP + Climate Change Peak Flood Depth | Baseline Conditions | Area 3

Figure: B-8

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.

BMT

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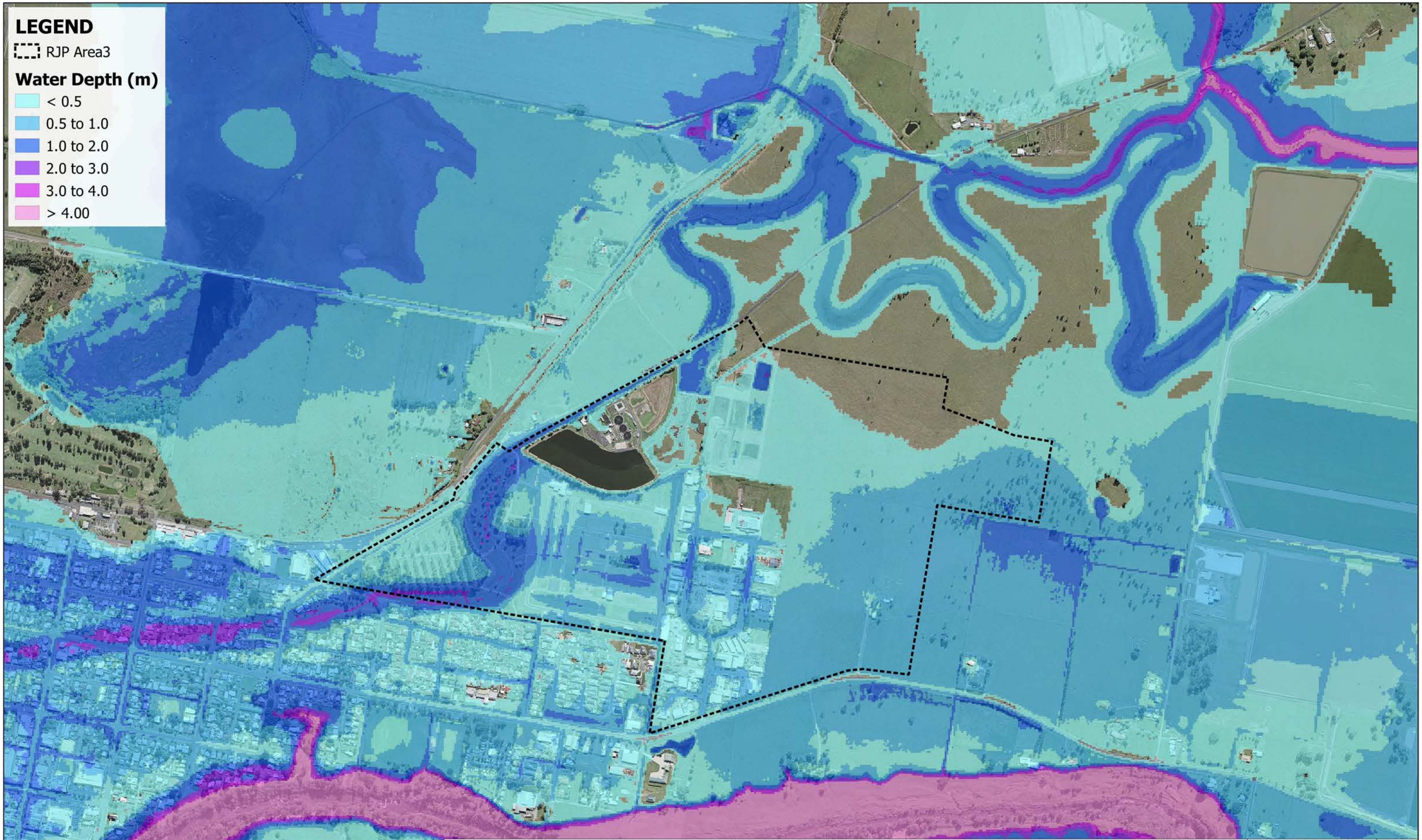

Title:

0.2% AEP Peak Flood Depth | Baseline Conditions | Area 3

Figure: B-9

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.

BMT

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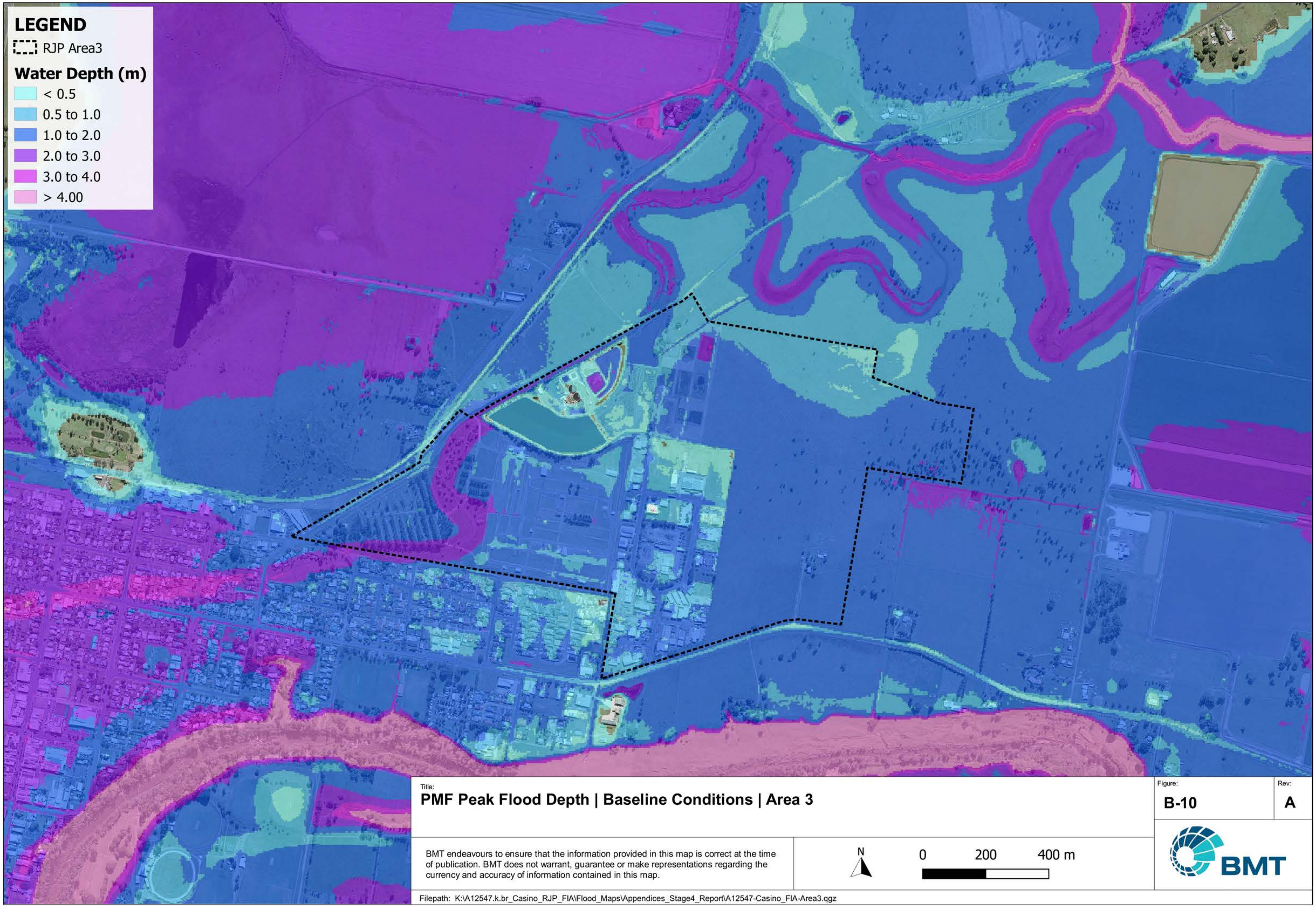

Title:

PMF Peak Flood Depth | Baseline Conditions | Area 3

Figure: **B-10**

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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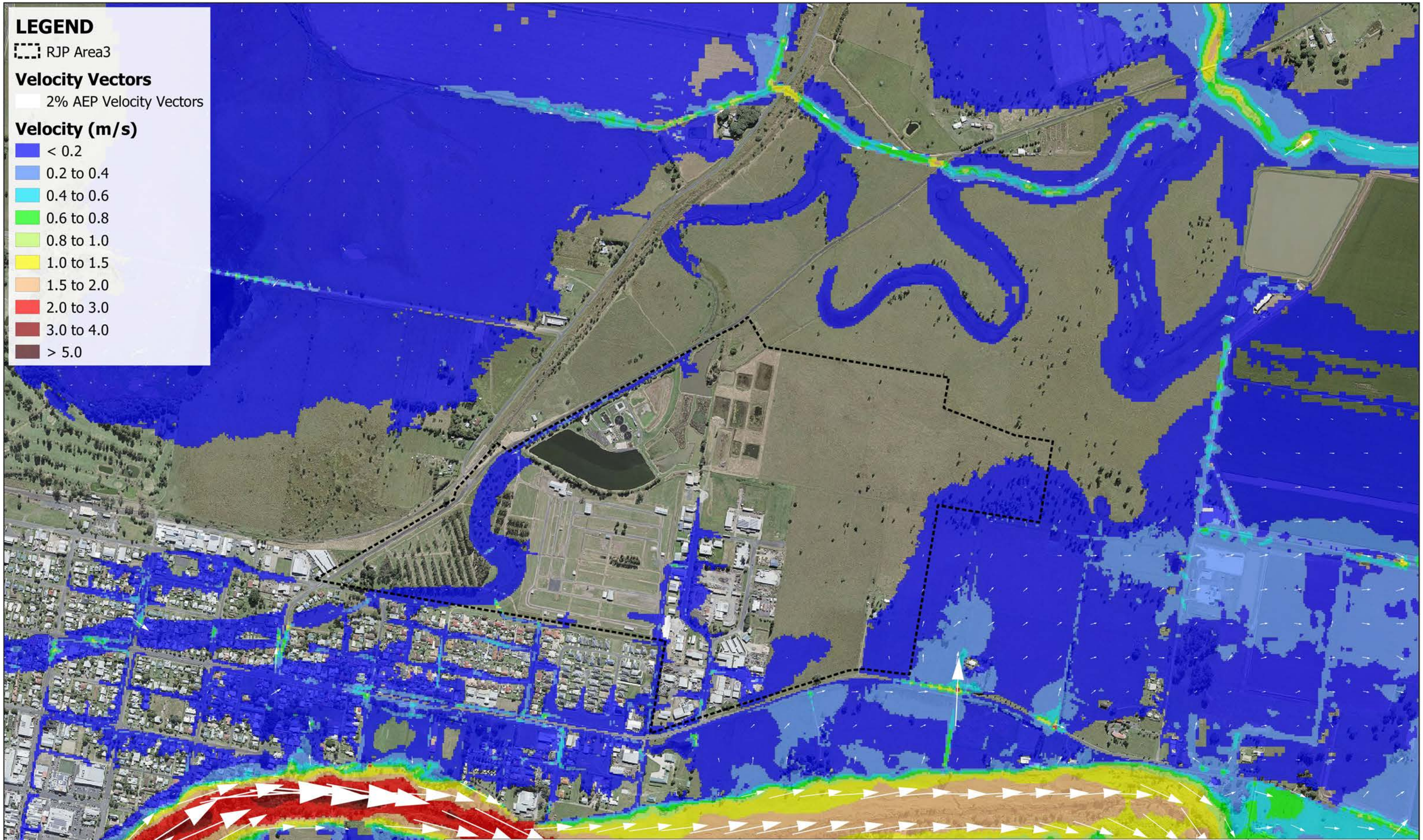

Title:

2% AEP Peak Flow Velocity | Baseline Conditions | Area 3

Figure: **B-11**

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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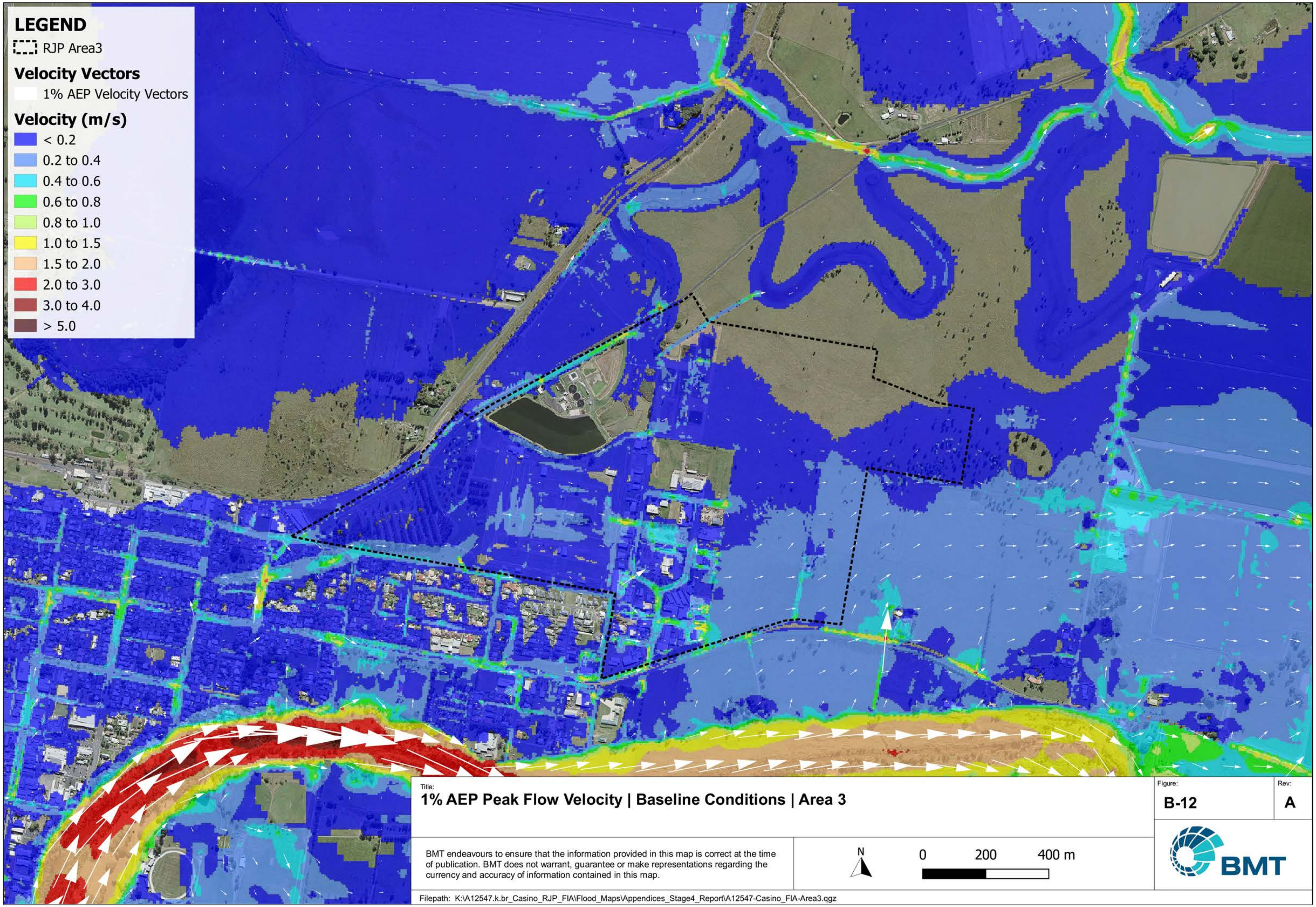

Title:

1% AEP Peak Flow Velocity | Baseline Conditions | Area 3

Figure: **B-12**

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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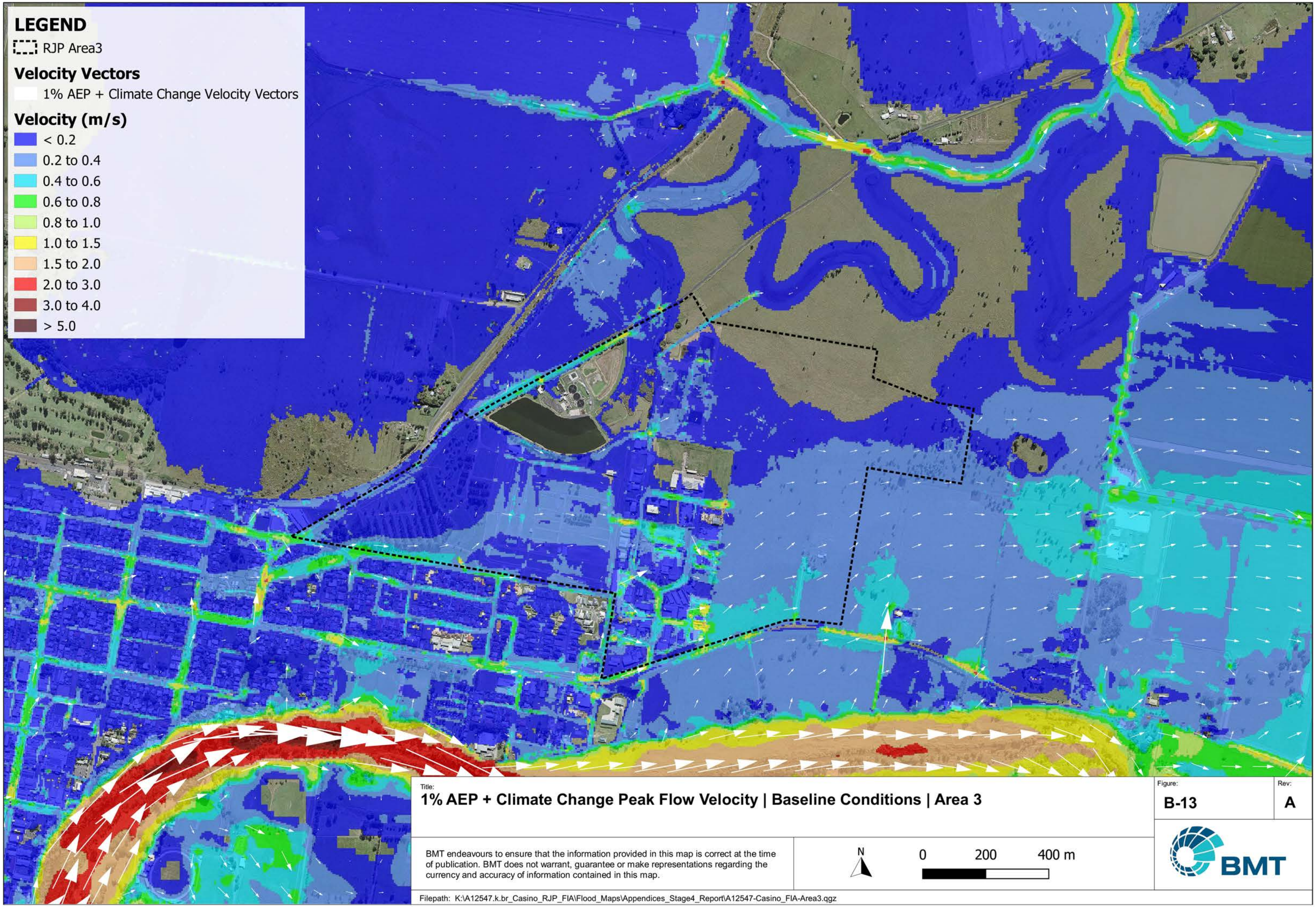

Title:

1% AEP + Climate Change Peak Flow Velocity | Baseline Conditions | Area 3

Figure: **B-13**

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.

BMT

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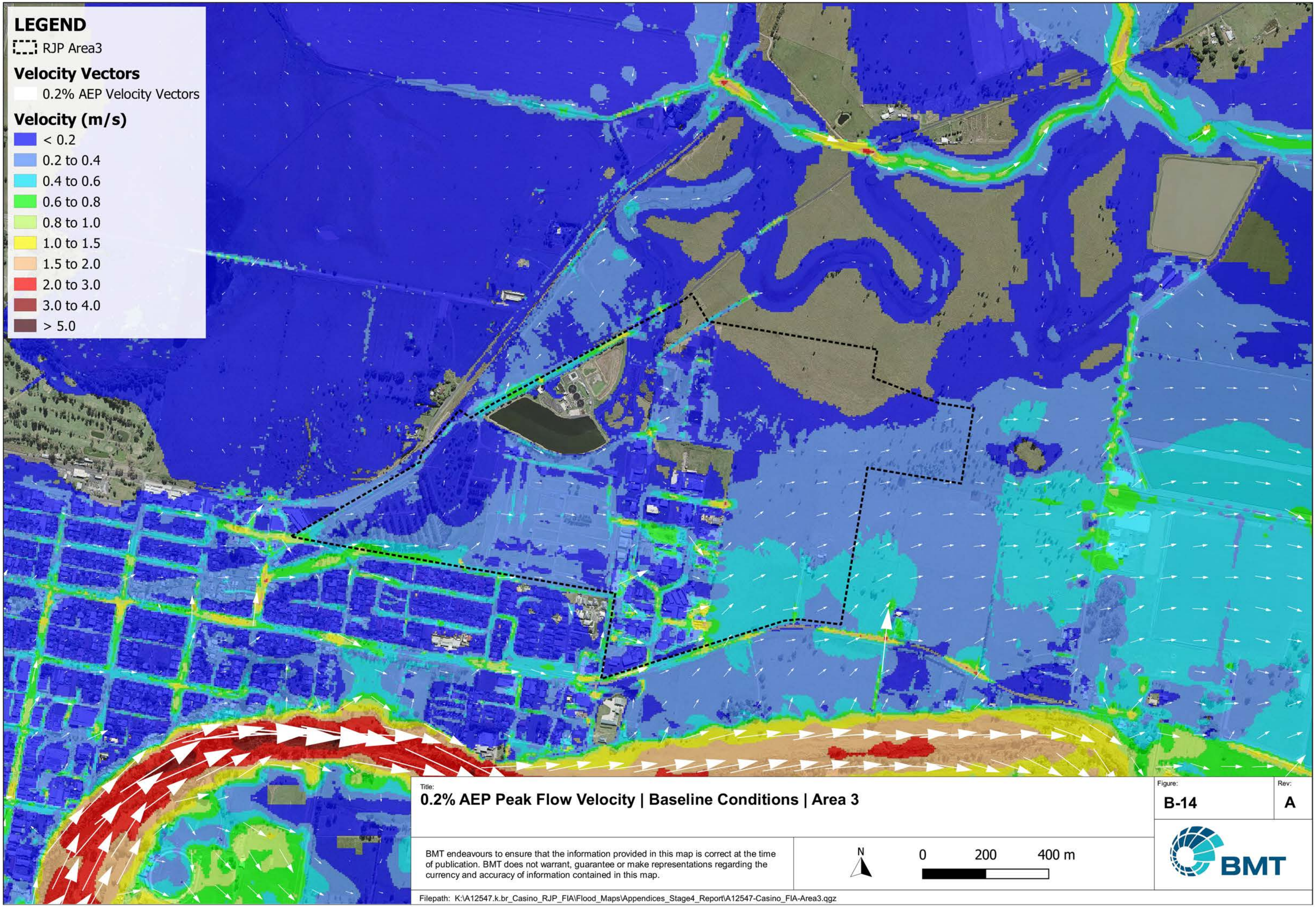

Title:

0.2% AEP Peak Flow Velocity | Baseline Conditions | Area 3

Figure: **B-14**

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.

BMT

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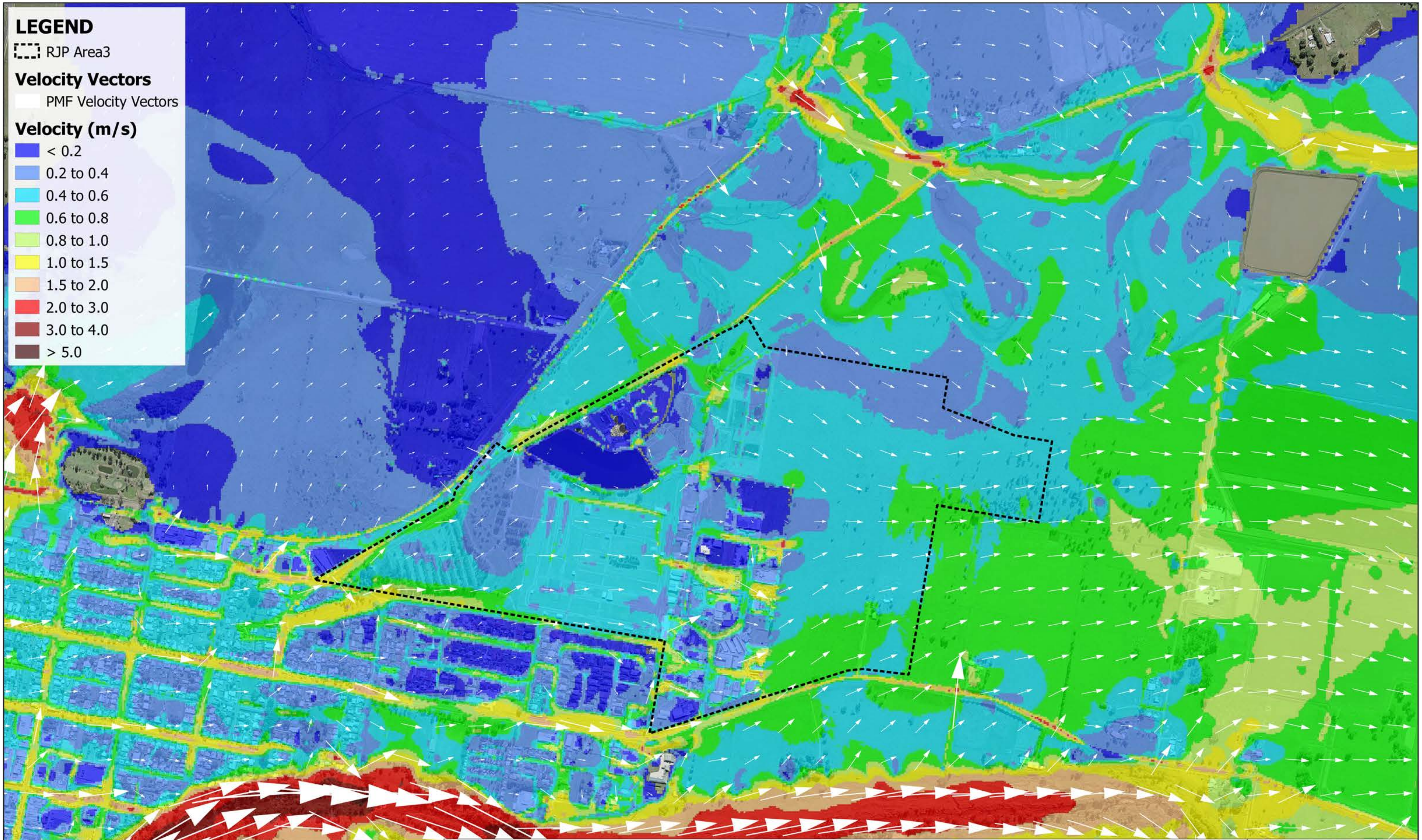

Title:
PMF Peak Flow Velocity | Baseline Conditions | Area 3

Figure: B-15

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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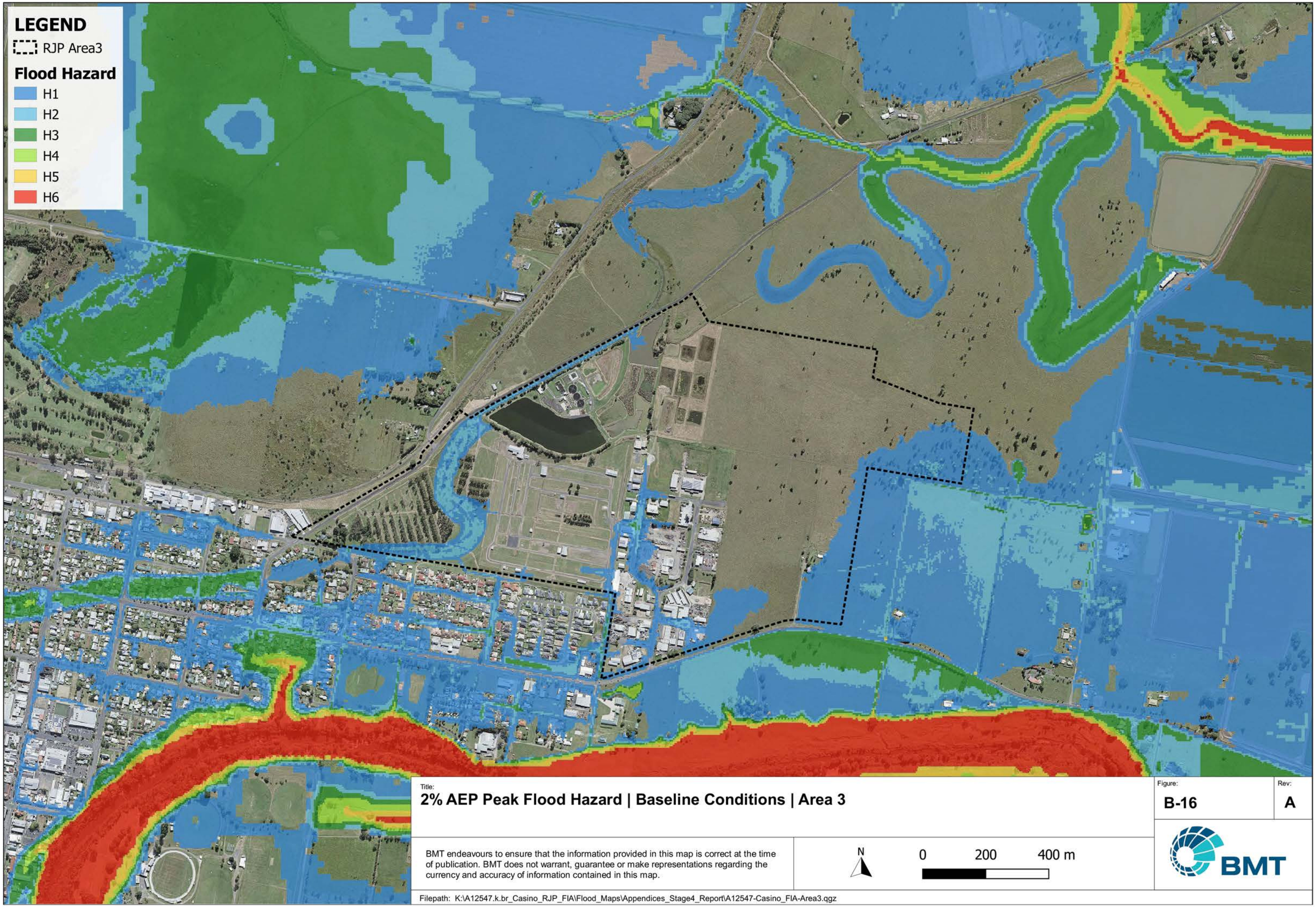

Title:

2% AEP Peak Flood Hazard | Baseline Conditions | Area 3

Figure: **B-16**

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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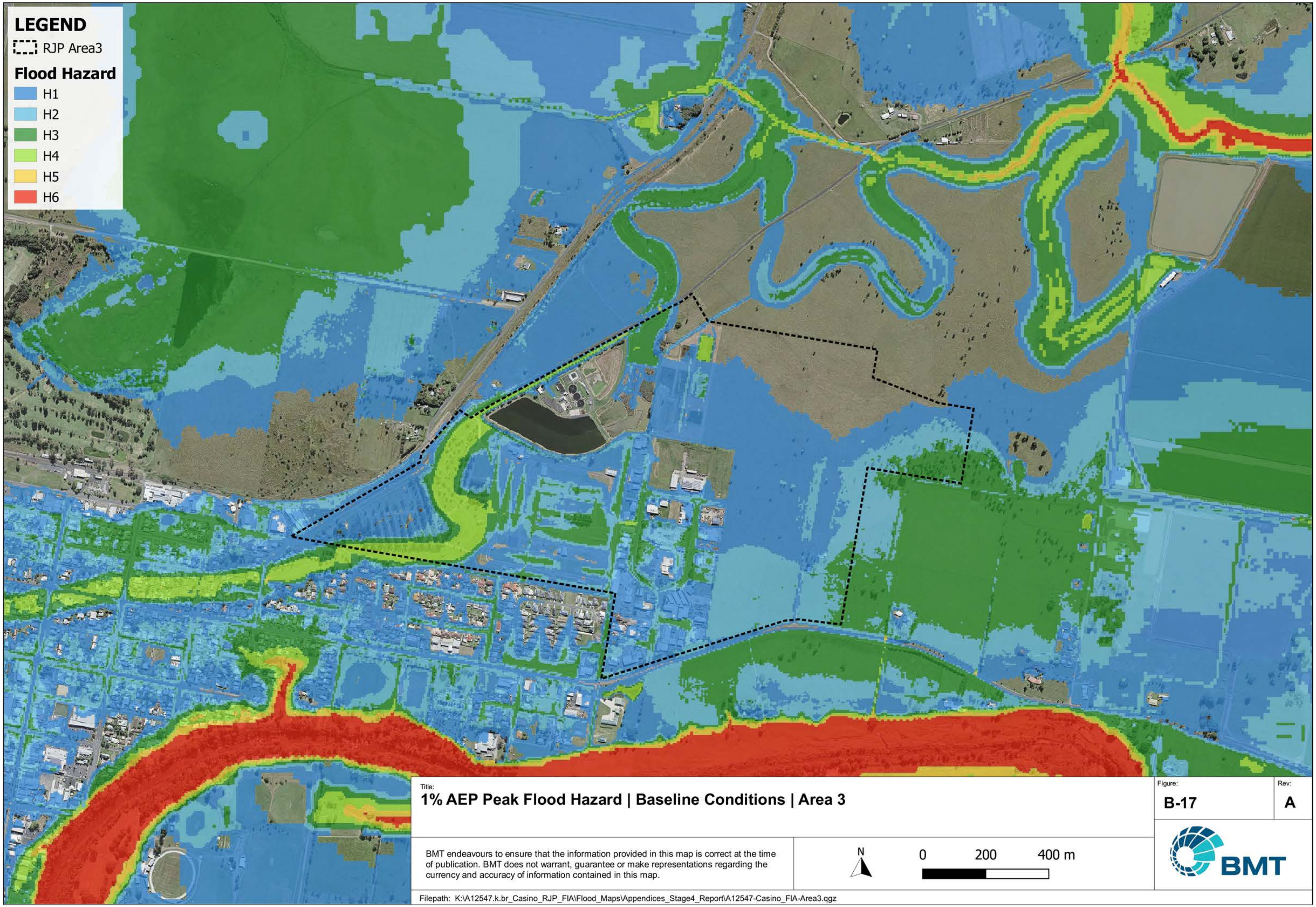

Title:
1% AEP Peak Flood Hazard | Baseline Conditions | Area 3

Figure: B-17

Rev: A

BMT

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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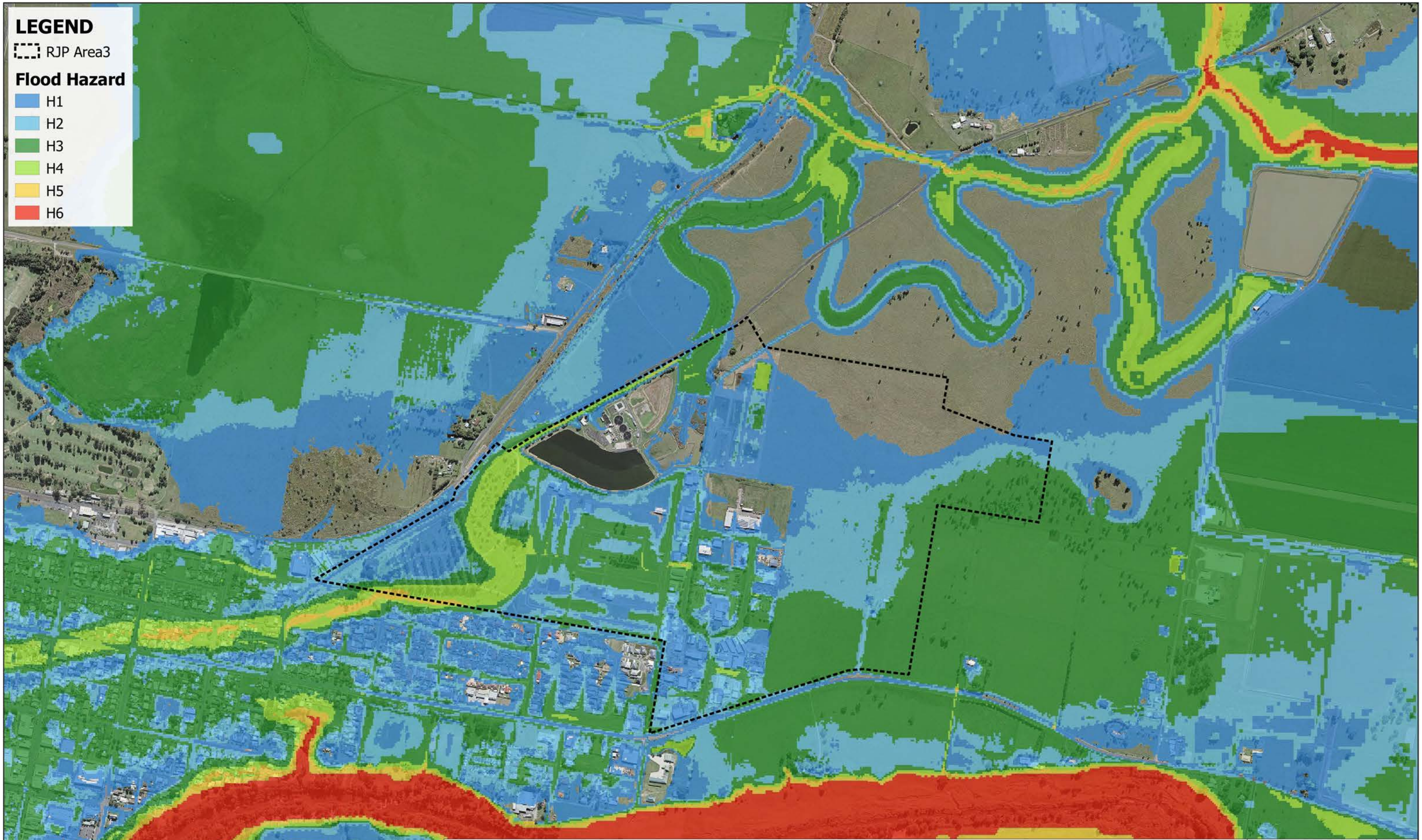


Title:

1% AEP + Climate Change Peak Flood Hazard | Baseline Conditions | Area 3

Figure: B-18

Rev: A

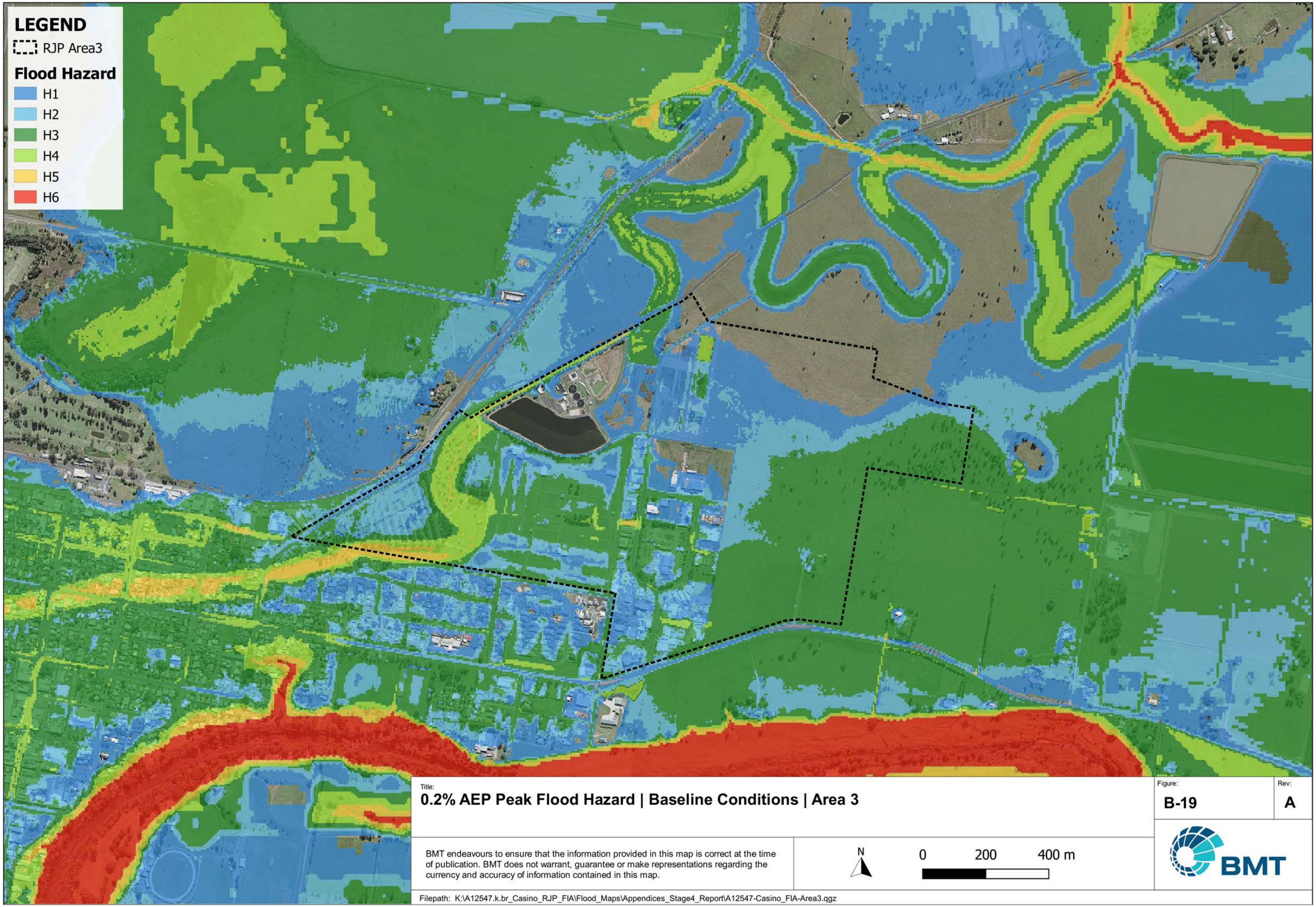
BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 200 400 m

BMT

Filepath: K:\A12547.k.br_Casino_RJP_FIA\Flood_Maps\Appendices_Stage4_Report\A12547-Casino_FIA-Area3.qgz



Title:

0.2% AEP Peak Flood Hazard | Baseline Conditions | Area 3

Figure: **B-19**

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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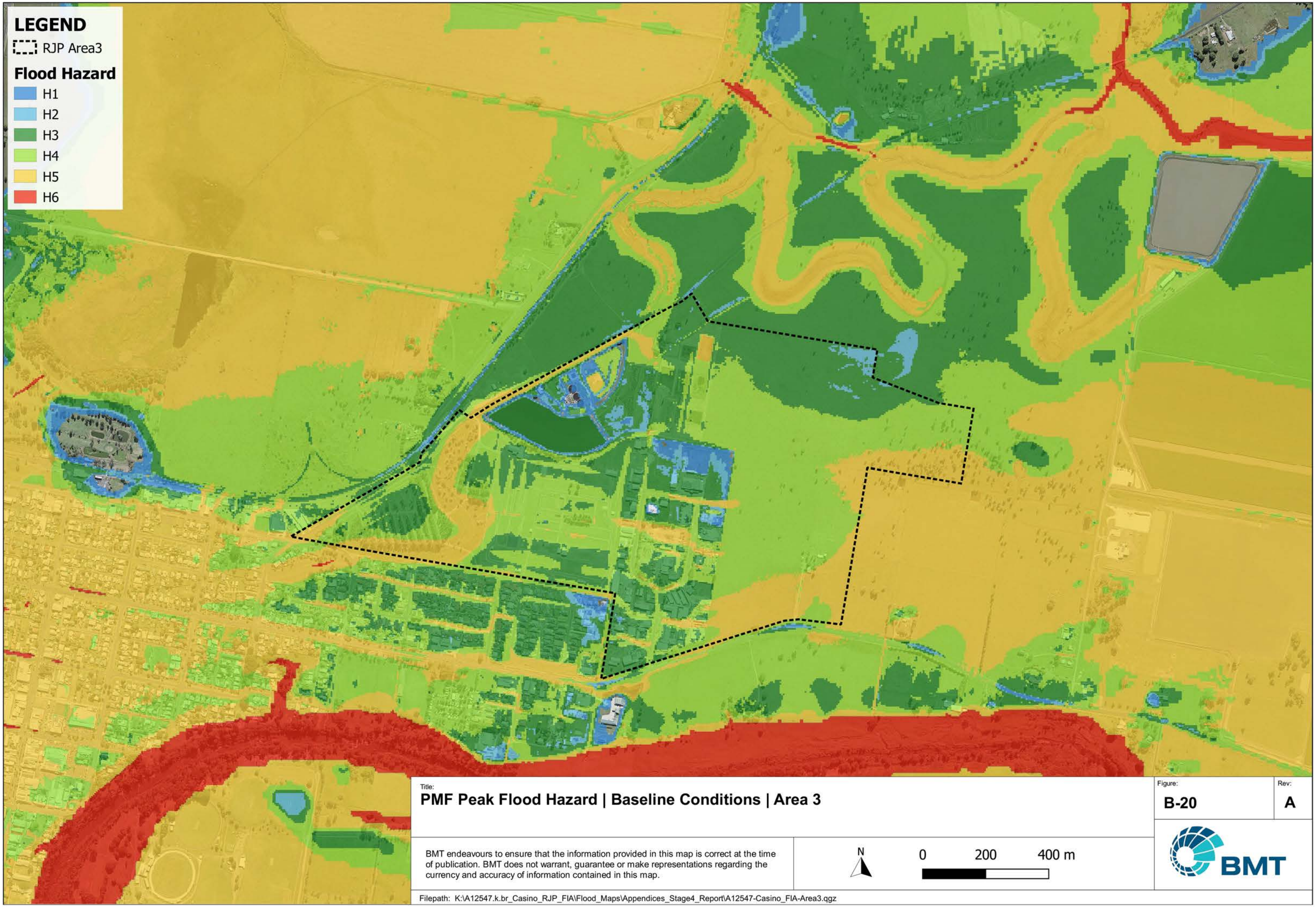

LEGEND
RJP Area3
Flood Hazard
H1
H2
H3
H4
H5
H6
Title:
PMF Peak Flood Hazard | Baseline Conditions | Area 3
Figure:
B-20
Rev:
A
BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
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200
400 m
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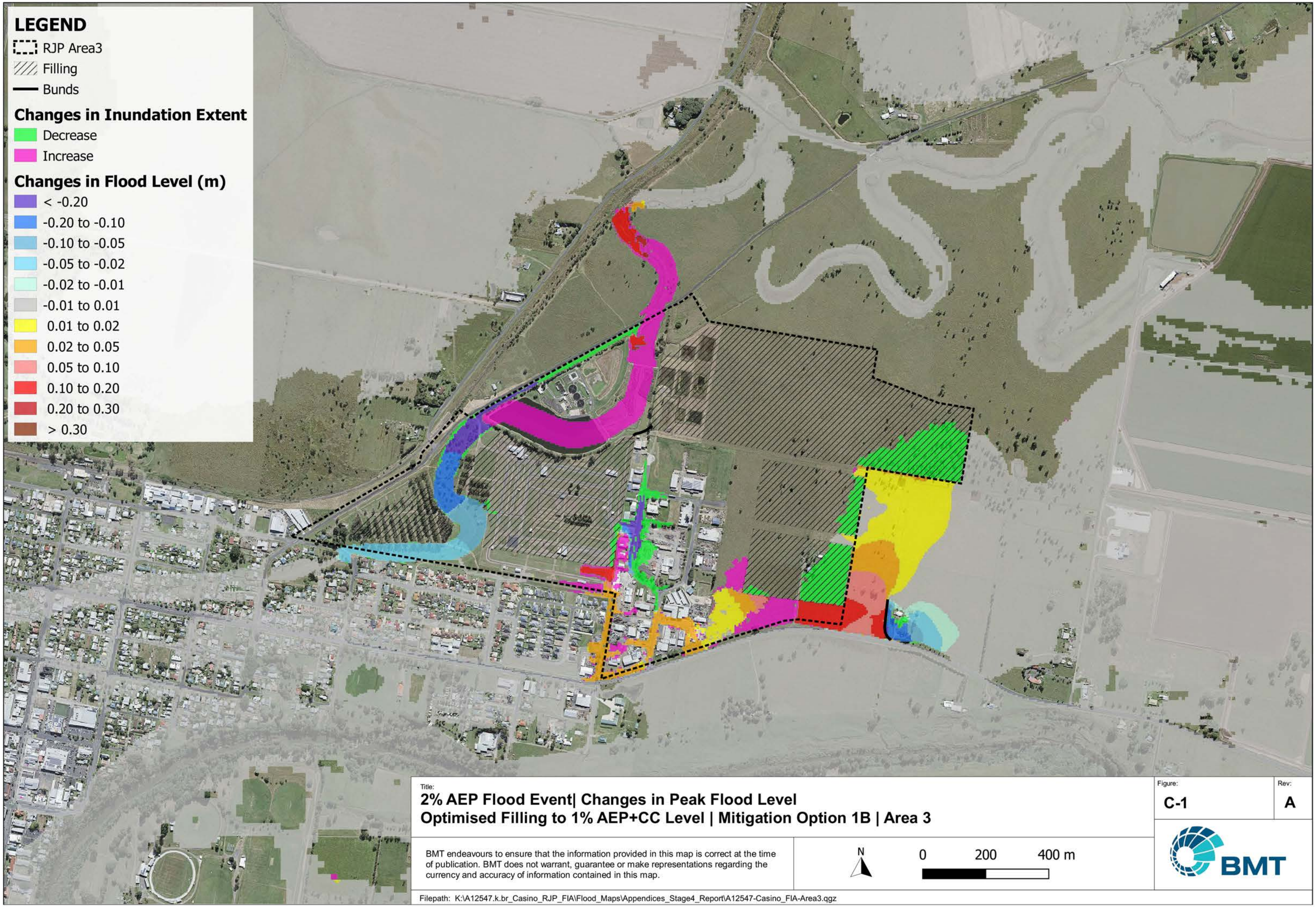
Filepath: K:\A12547.k.br_Casino_RJP_FIA\Flood_Maps\Appendices_Stage4_Report\A12547-Casino_FIA-Area3.qgz

Annex C: Flood Impact Maps | Optimised Fill and Mitigation | Area 3



Title:
2% AEP Flood Event| Changes in Peak Flood Level
Optimised Filling to 1% AEP+CC Level | Mitigation Option 1B | Area 3

Figure: **C-1**

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.

Filepath: K:\A12547.k.br_Casino_RJP_FIA\Flood_Maps\Appendices_Stage4_Report\A12547-Casino_FIA-Area3.qgz

Title:

1% AEP Flood Event | Changes in Peak Flood Level
Optimised Filling to 1% AEP+CC Level | Mitigation Option 1B | Area 3

Figure: C-2

Rev: A

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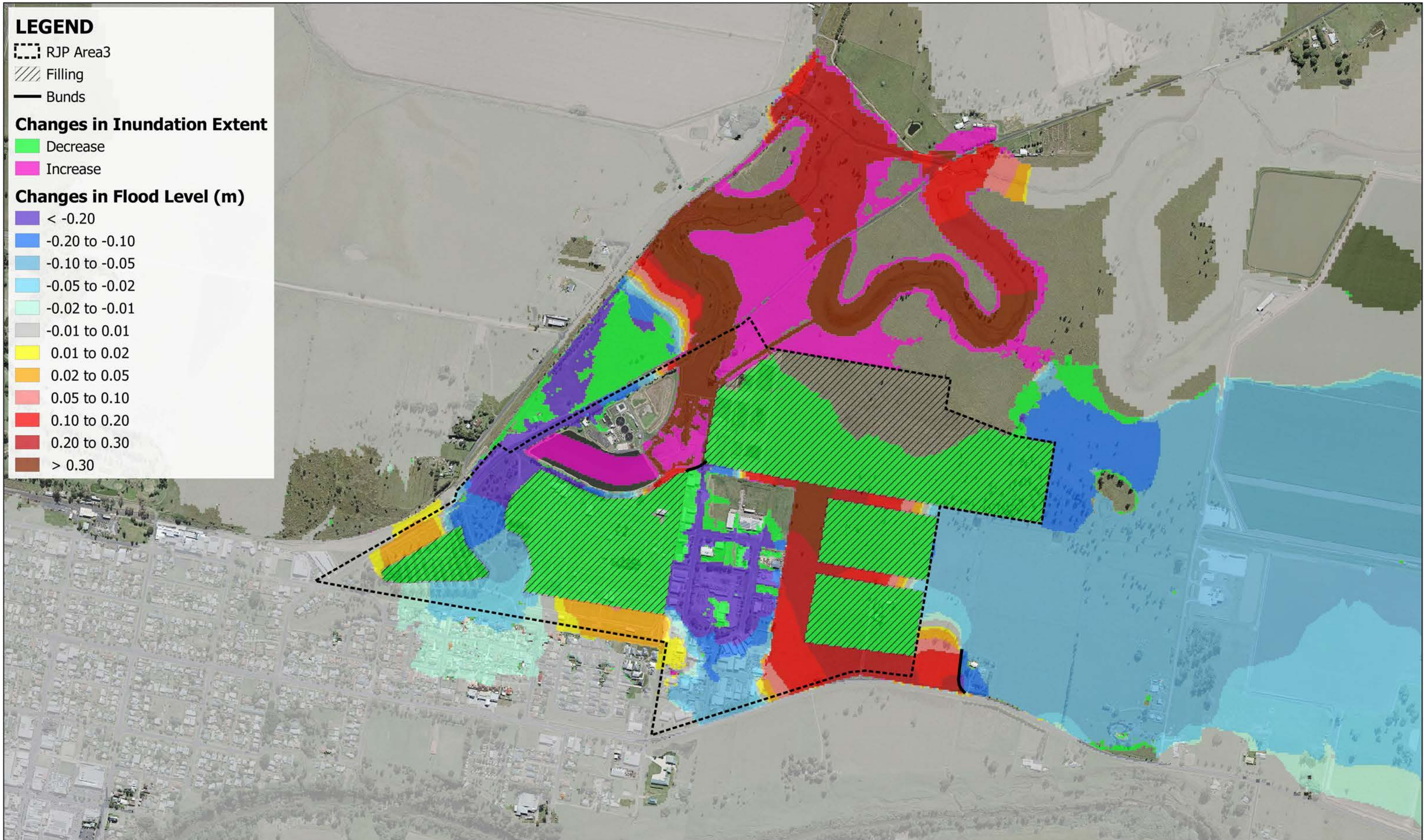

Title:
1% AEP + Climate Change Flood Event | Changes in Peak Flood Level
Optimised Filling to 1% AEP+CC Level | Mitigation Option 1B | Area 3

Figure: C-3

Rev: A

BMT

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Title:

0.2% AEP Flood Event | Changes in Peak Flood Hazard
Optimised Filling to 1% AEP+CC Level | Mitigation Option 1B | Area 3

Figure: C-4

Rev: A

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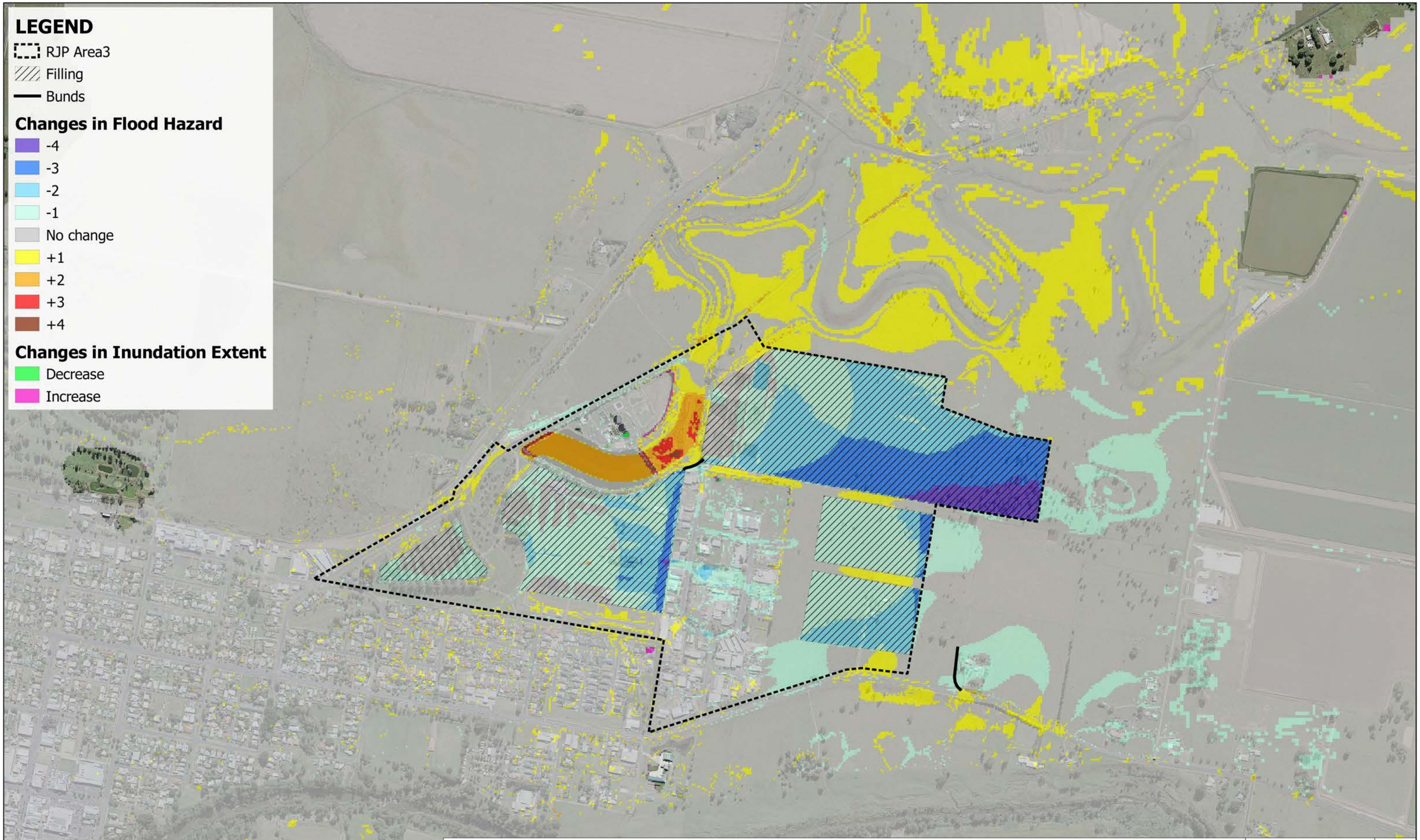

Title:
PMF Flood Event | Changes in Peak Flood Hazard
Optimised Filling to 1% AEP+CC Level | Mitigation Option 1B | Area 3

Figure: C-5

Rev: A

BMT

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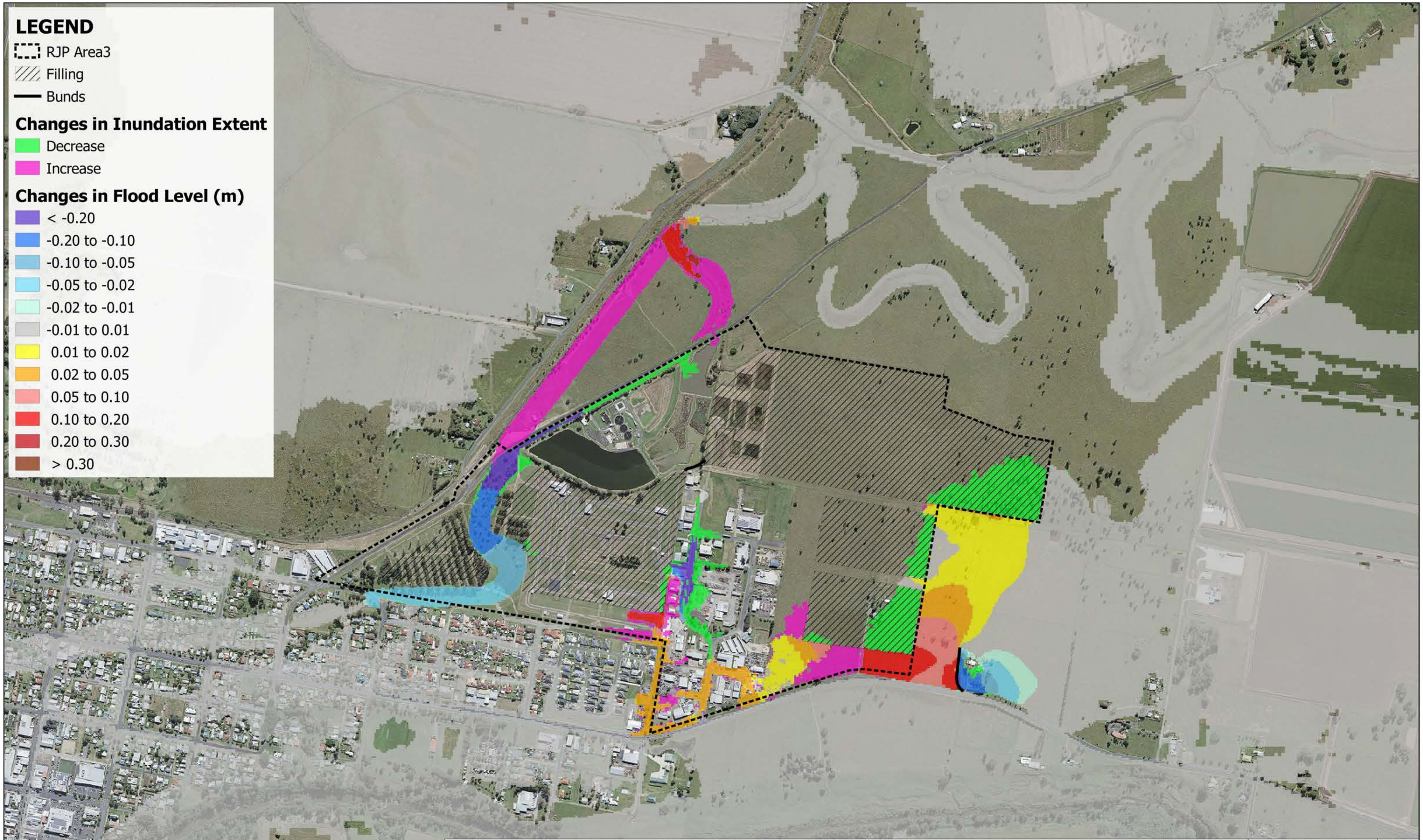

Title:

2% AEP Flood Event | Changes in Peak Flood Level
Optimised Filling to 1% AEP+CC Level | Mitigation Option 2B | Area 3

Figure: C-6

Rev: A

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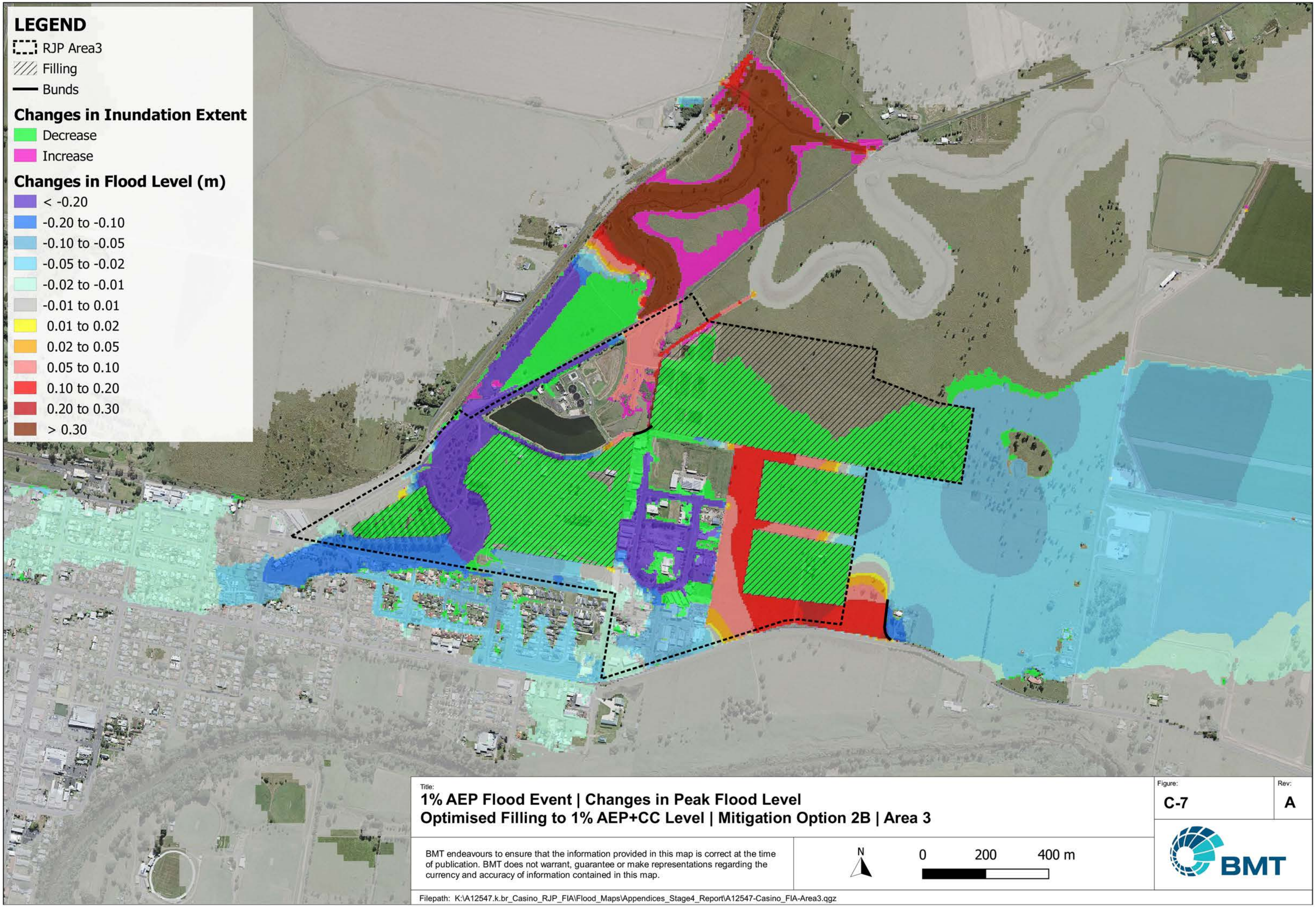

Title:
1% AEP Flood Event | Changes in Peak Flood Level
Optimised Filling to 1% AEP+CC Level | Mitigation Option 2B | Area 3

Figure: C-7

Rev: A

BMT

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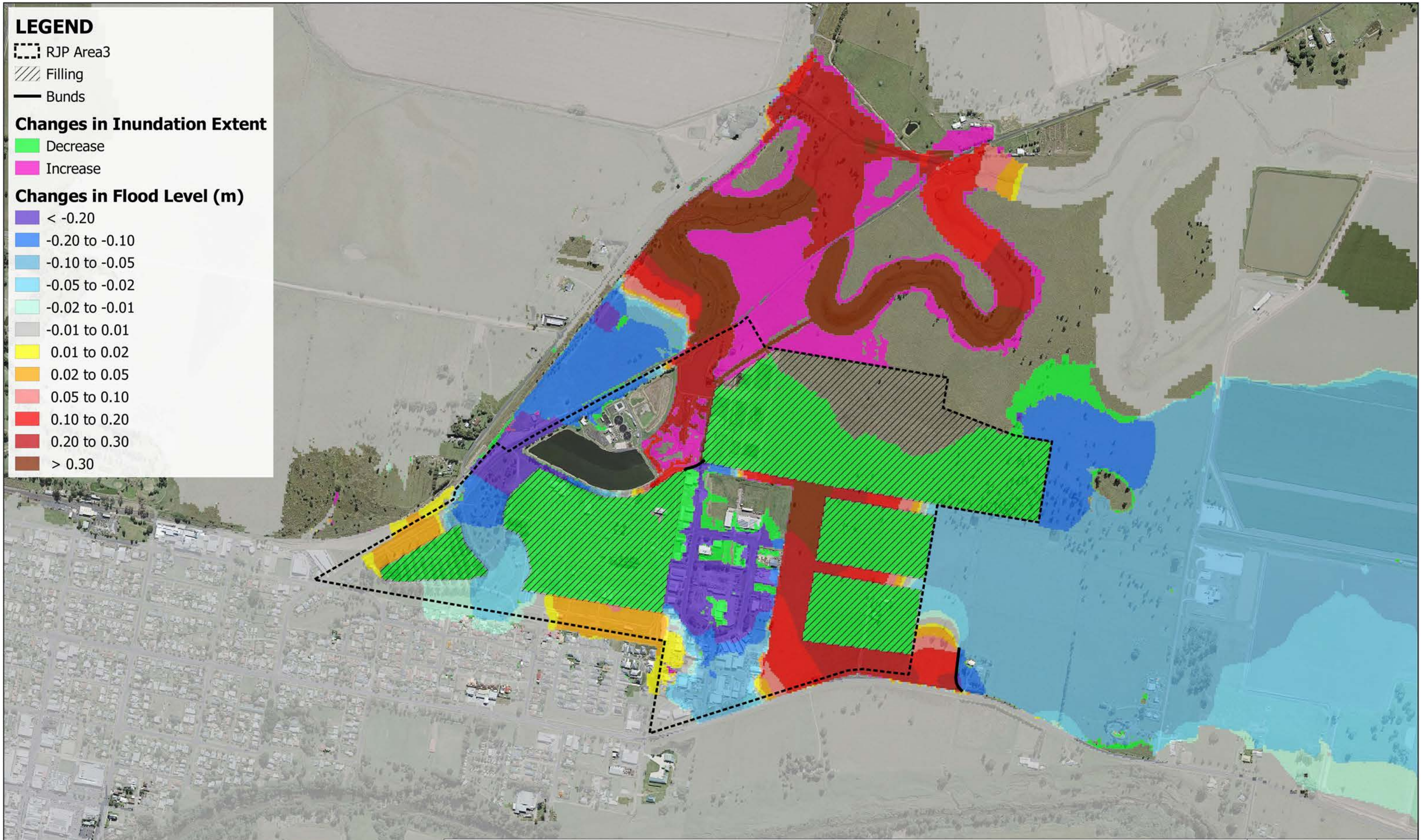

Title:
1% AEP + Climate Change Flood Event | Changes in Peak Flood Level
Optimised Filling to 1% AEP+CC Level | Mitigation Option 2B | Area 3

Figure: C-8

Rev: A

BMT

Filepath: K:\A12547.k.br_Casino_RJP_FIA\Flood_Maps\Appendices_Stage4_Report\A12547-Casino_FIA-Area3.qgz

Title:
0.2% AEP Flood Event | Changes in Peak Flood Hazard
Optimised Filling to 1% AEP+CC Level | Mitigation Option 2B | Area 3

Figure: C-9

Rev: A

BMT

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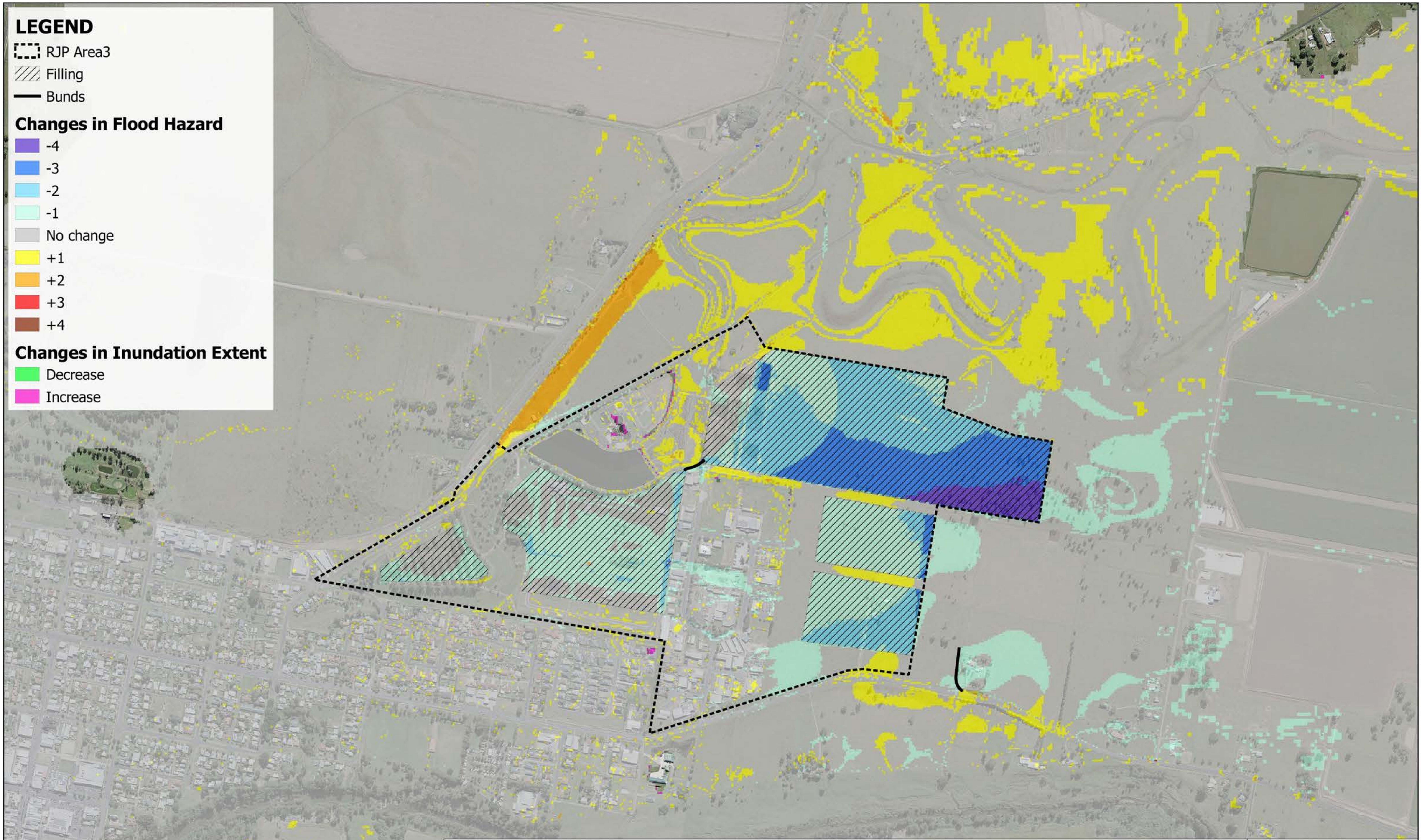

Title:

PMF Flood Event | Changes in Peak Flood Hazard
Optimised Filling to 1% AEP+CC Level | Mitigation Option 2B | Area 3

Figure: C-10

Rev: A

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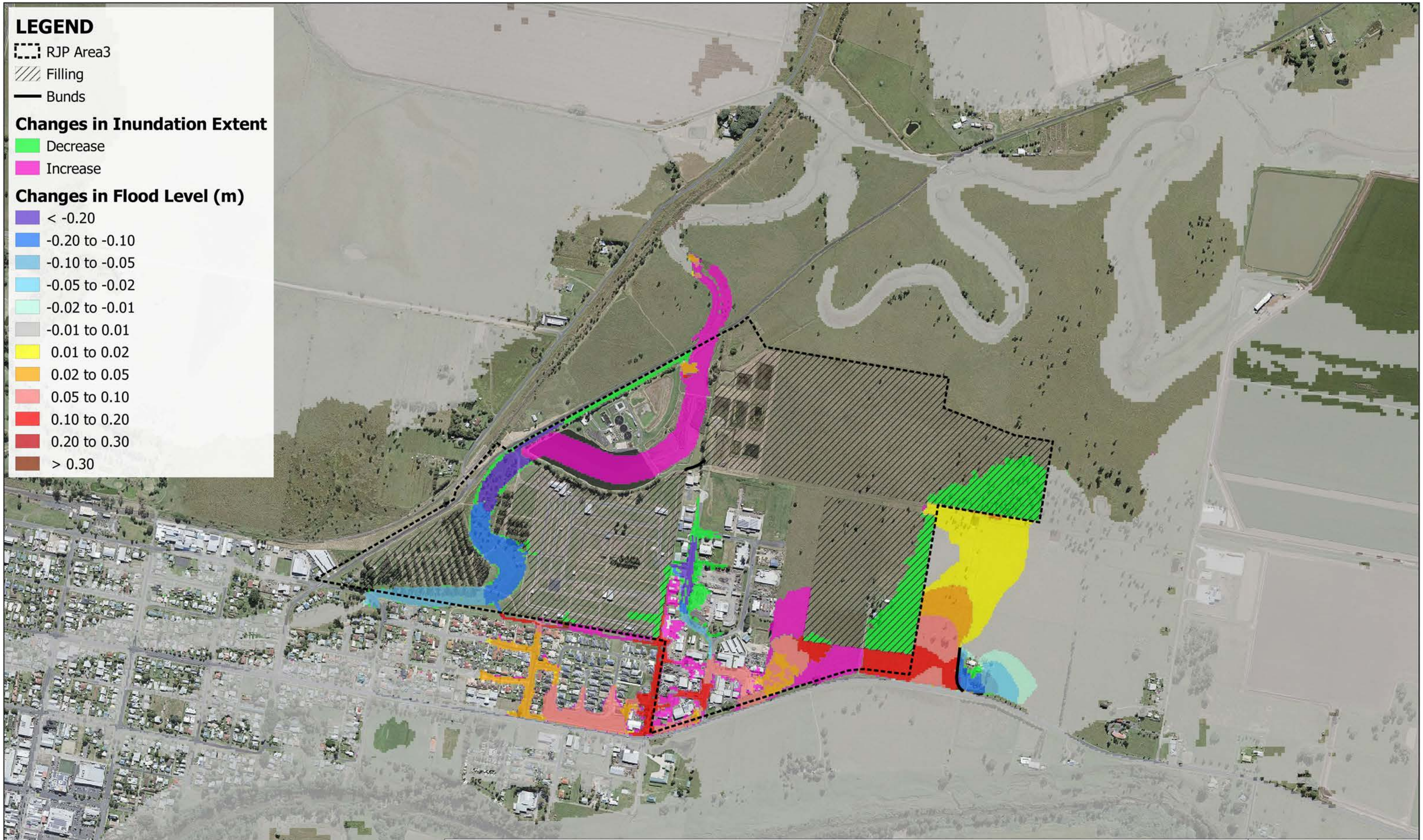
Annex D: Flood Impact Maps | Extended Fill and Mitigation | Area 3



Title:

2% AEP Flood Event | Changes in Peak Flood Level
Filling to 1% AEP Level | Mitigation Option 1B | Area 3

Figure: D-1

Rev: A

BMT

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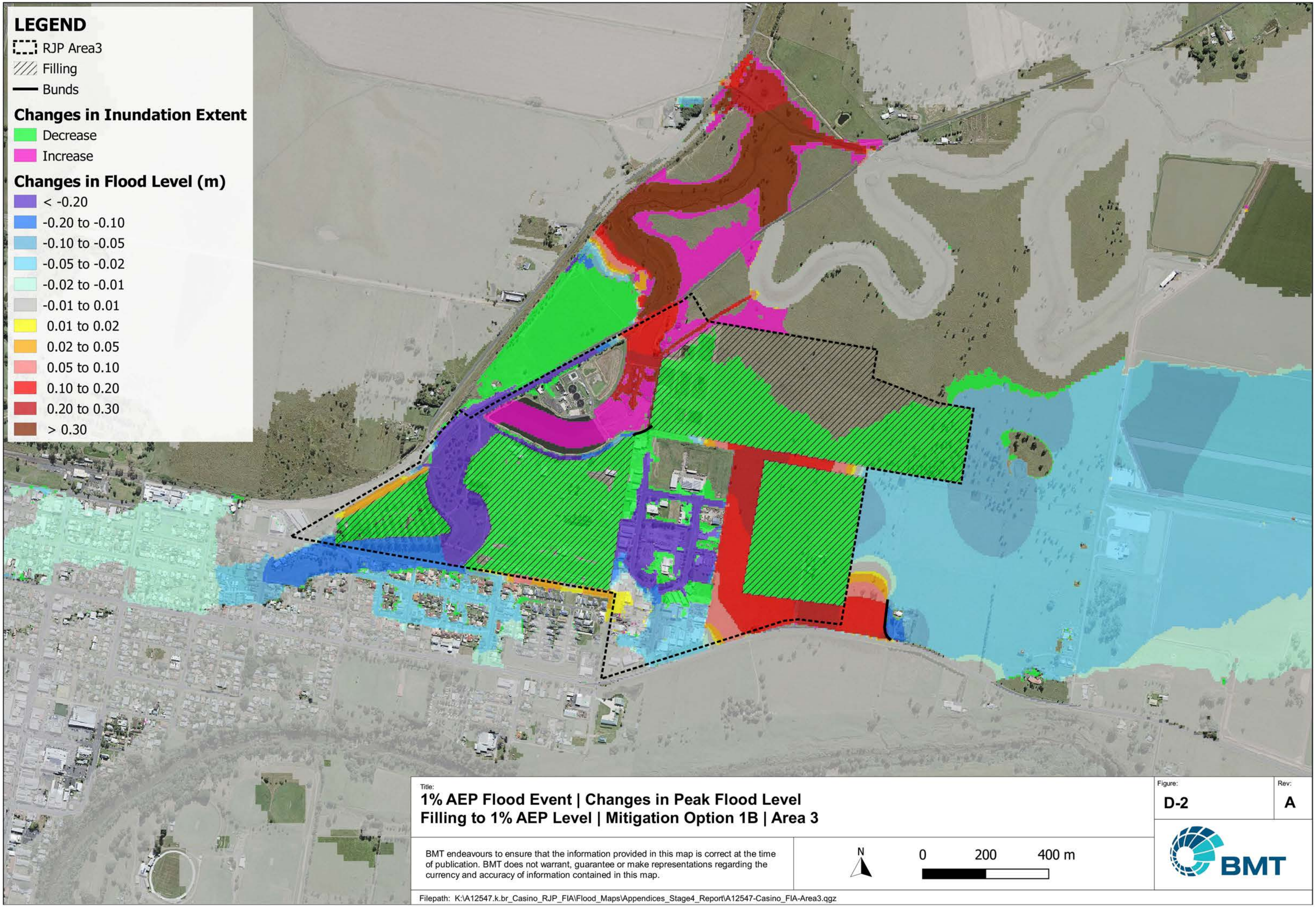
LEGEND
RJP Area3
Filling
Bunds
Changes in Inundation Extent
Decrease
Increase
Changes in Flood Level (m)
< -0.20
-0.20 to -0.10
-0.10 to -0.05
-0.05 to -0.02
-0.02 to -0.01
-0.01 to 0.01
0.01 to 0.02
0.02 to 0.05
0.05 to 0.10
0.10 to 0.20
0.20 to 0.30
> 0.30
Title:
1% AEP Flood Event | Changes in Peak Flood Level
Filling to 1% AEP Level | Mitigation Option 1B | Area 3
Figure:
D-2
Rev:
A
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N
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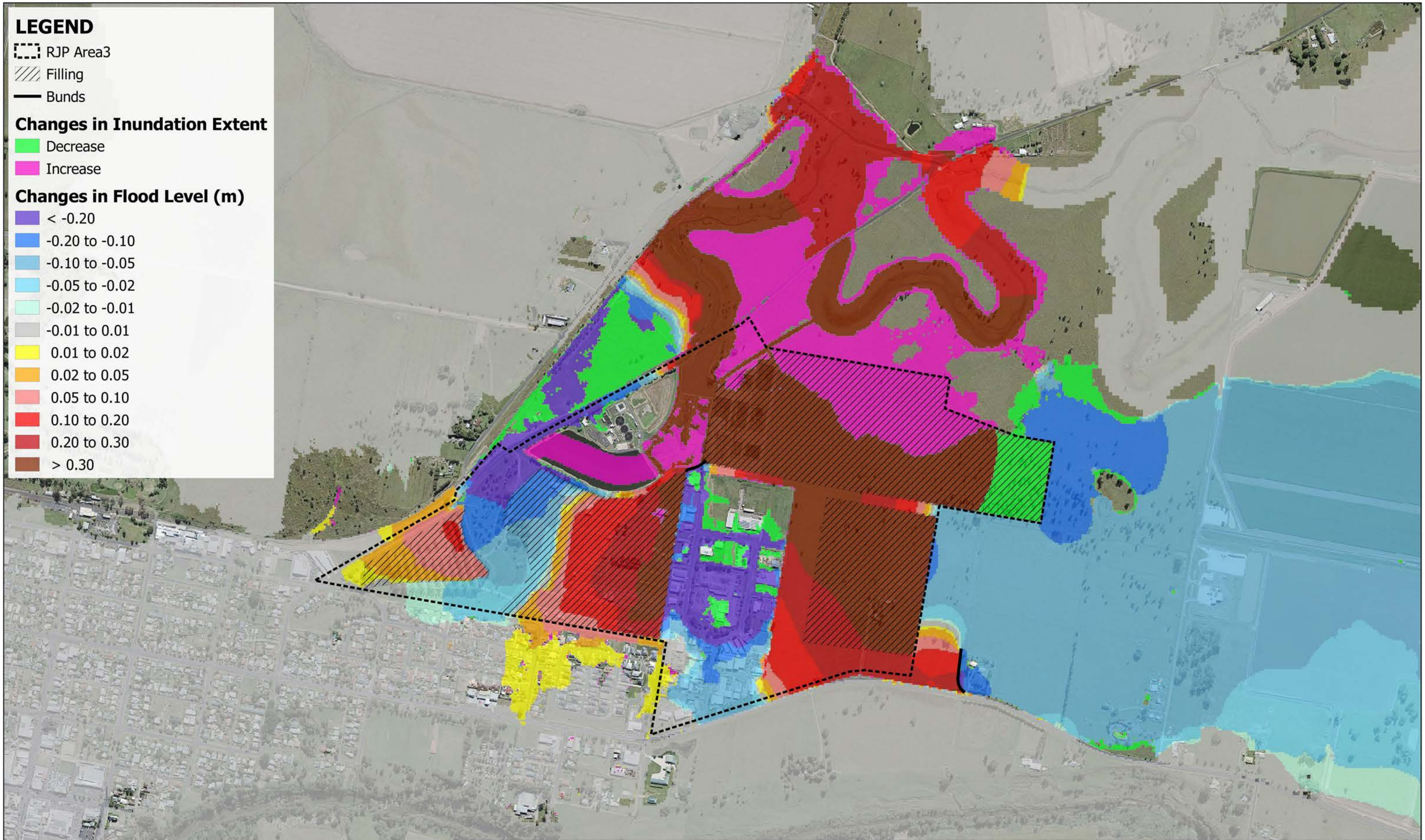
Filepath: K:\A12547.k.br_Casino_RJP_FIA\Flood_Maps\Appendices_Stage4_Report\A12547-Casino_FIA-Area3.qgz



Title:

1% AEP + Climate Change Flood Event | Changes in Peak Flood Level
Filling to 1% AEP Level | Mitigation Option 1B | Area 3

Figure: D-3

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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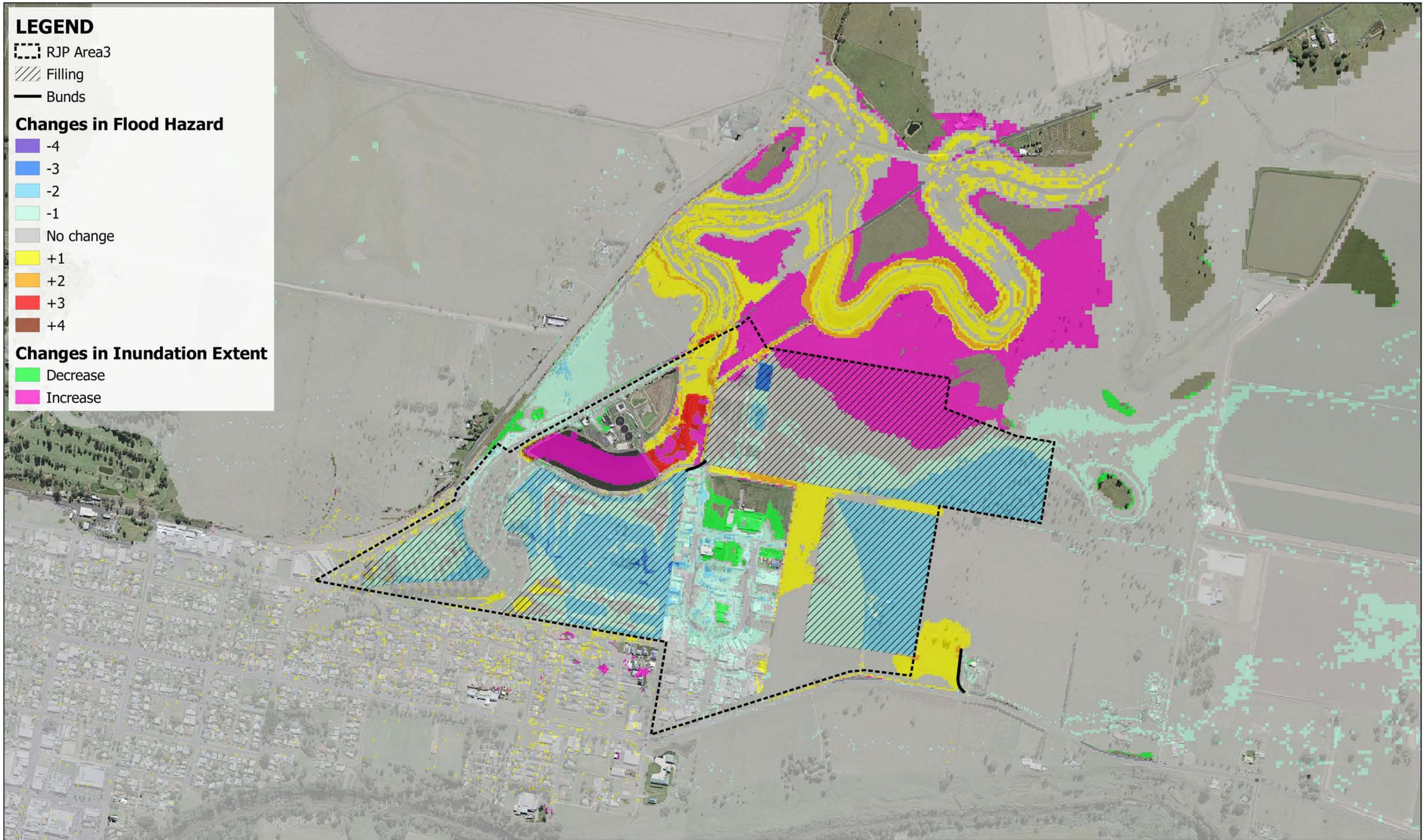

Title:

0.2% AEP Flood Event | Changes in Peak Flood Hazard
Filling to 1% AEP Level | Mitigation Option 1B | Area 3

Figure: D-4

Rev: A

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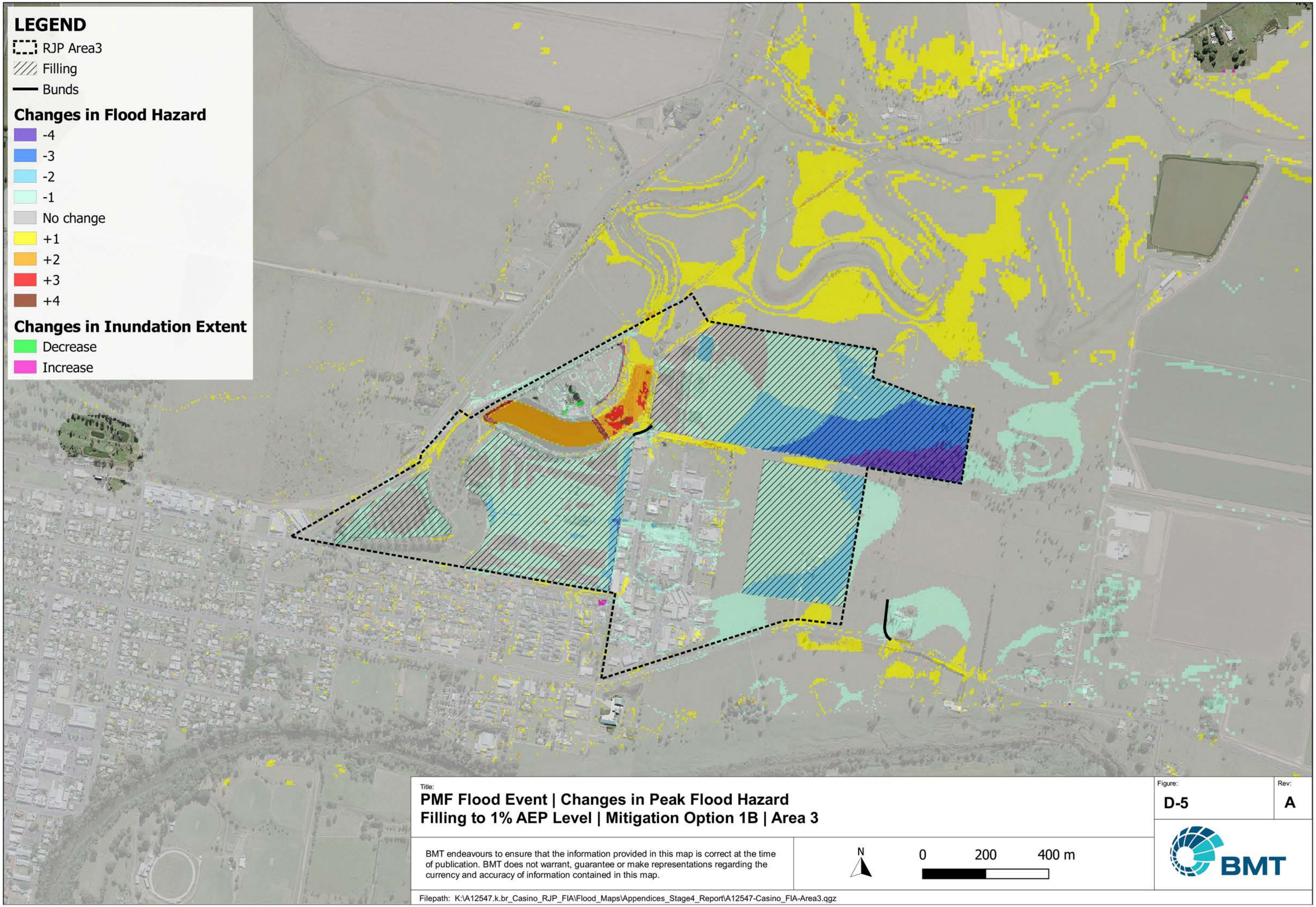

Title:

PMF Flood Event | Changes in Peak Flood Hazard
Filling to 1% AEP Level | Mitigation Option 1B | Area 3

Figure: **D-5**

Rev: **A**

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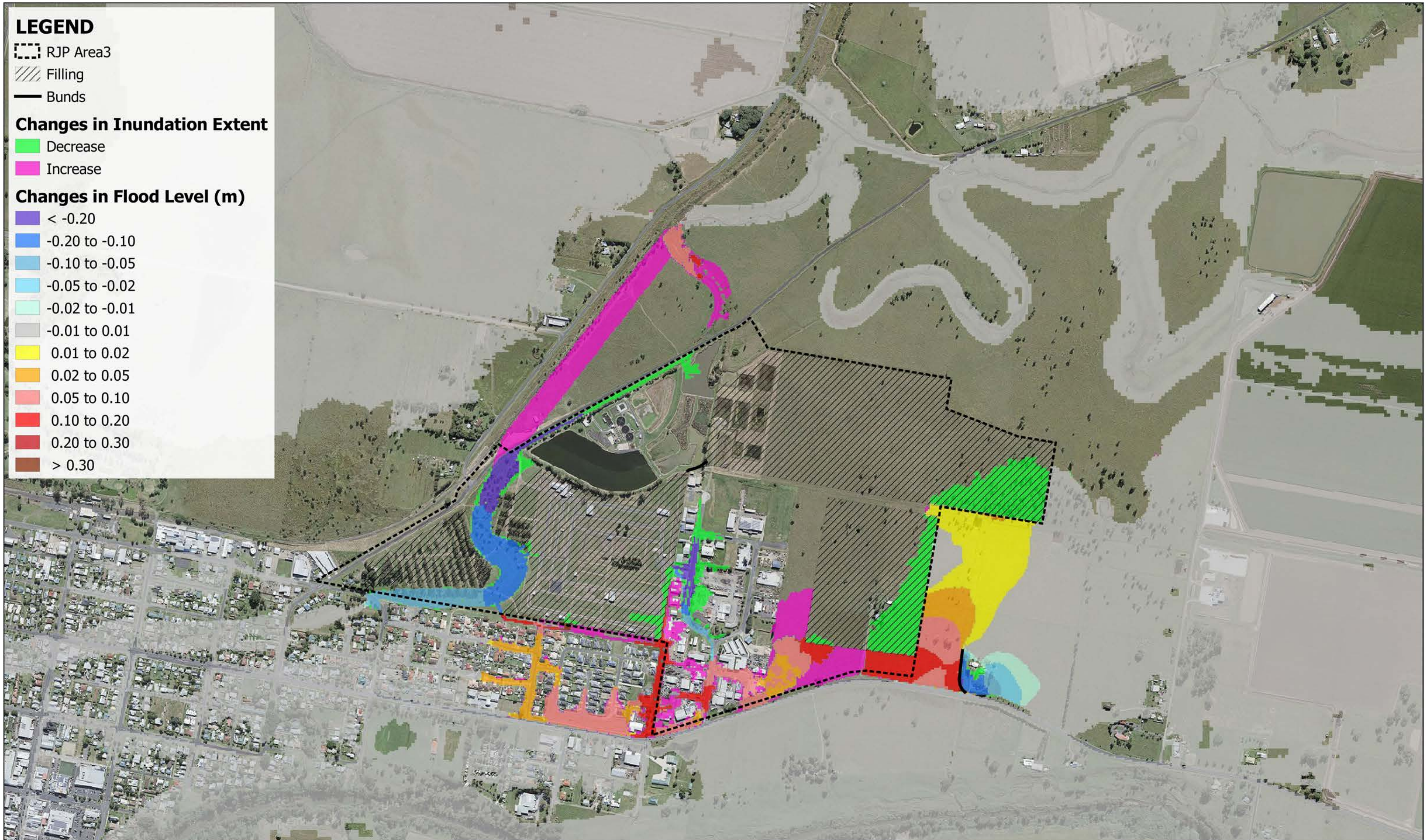
Filepath: K:\A12547.k.br_Casino_RJP_FIA\Flood_Maps\Appendices_Stage4_Report\A12547-Casino_FIA-Area3.qgz



Title:

2% AEP Flood Event | Changes in Peak Flood Level
Filling to 1% AEP Level | Mitigation Option 2B | Area 3

Figure: D-6

Rev: A

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Title:
1% AEP Flood Event | Changes in Peak Flood Level
Filling to 1% AEP Level | Mitigation Option 2B | Area 3

Figure: D-7

Rev: A

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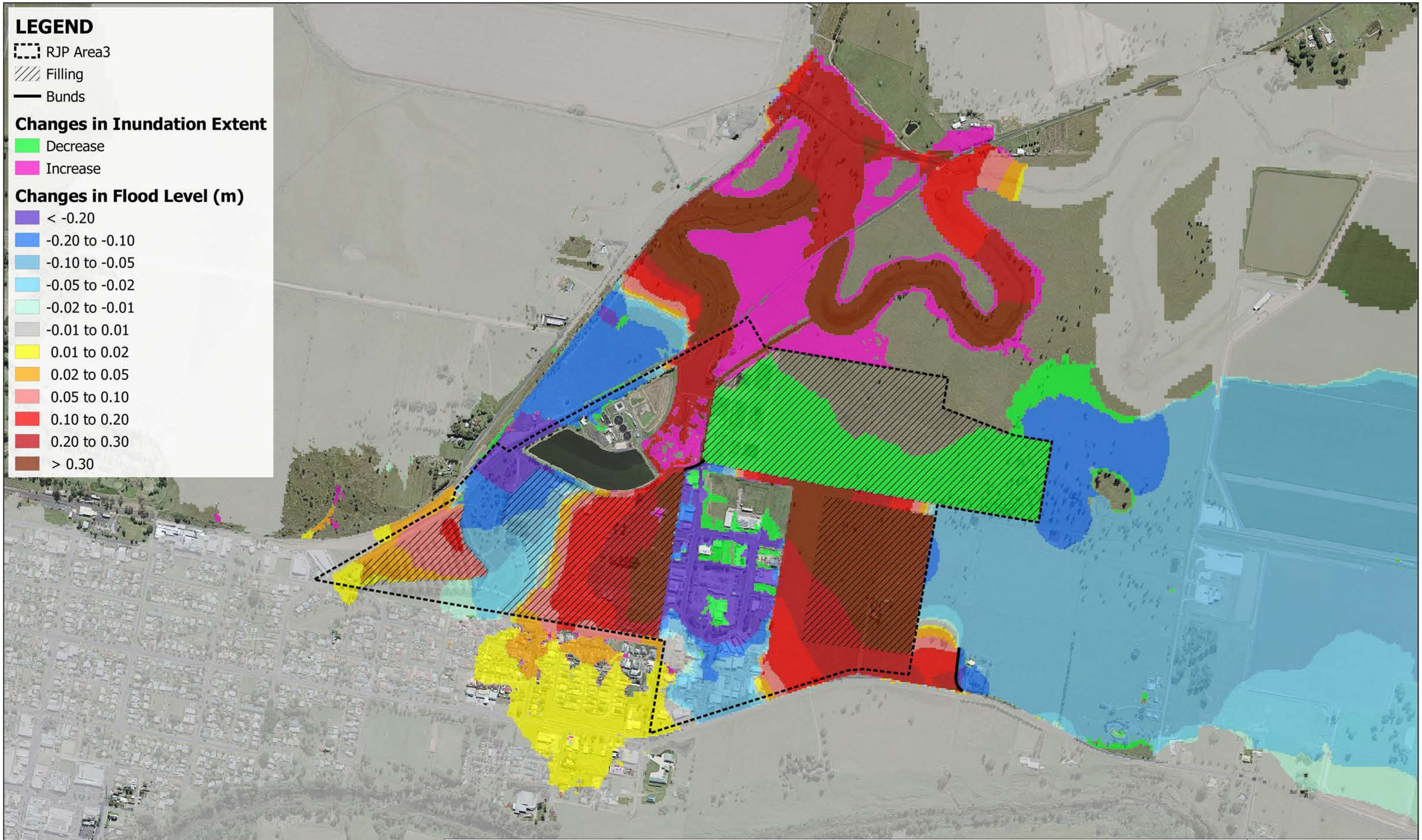

Title:
1% AEP + Climate Change Flood Event | Changes in Peak Flood Level
Filling to 1% AEP Level | Mitigation Option 2B | Area 3

Figure: D-8

Rev: A

BMT

Filepath: K:\A12547.k.br_Casino_RJP_FIA\Flood_Maps\Appendices_Stage4_Report\A12547-Casino_FIA-Area3.qgz

Title:

0.2% AEP Flood Event | Changes in Peak Flood Hazard
Filling to 1% AEP Level | Mitigation Option 2B | Area 3

Figure: D-9

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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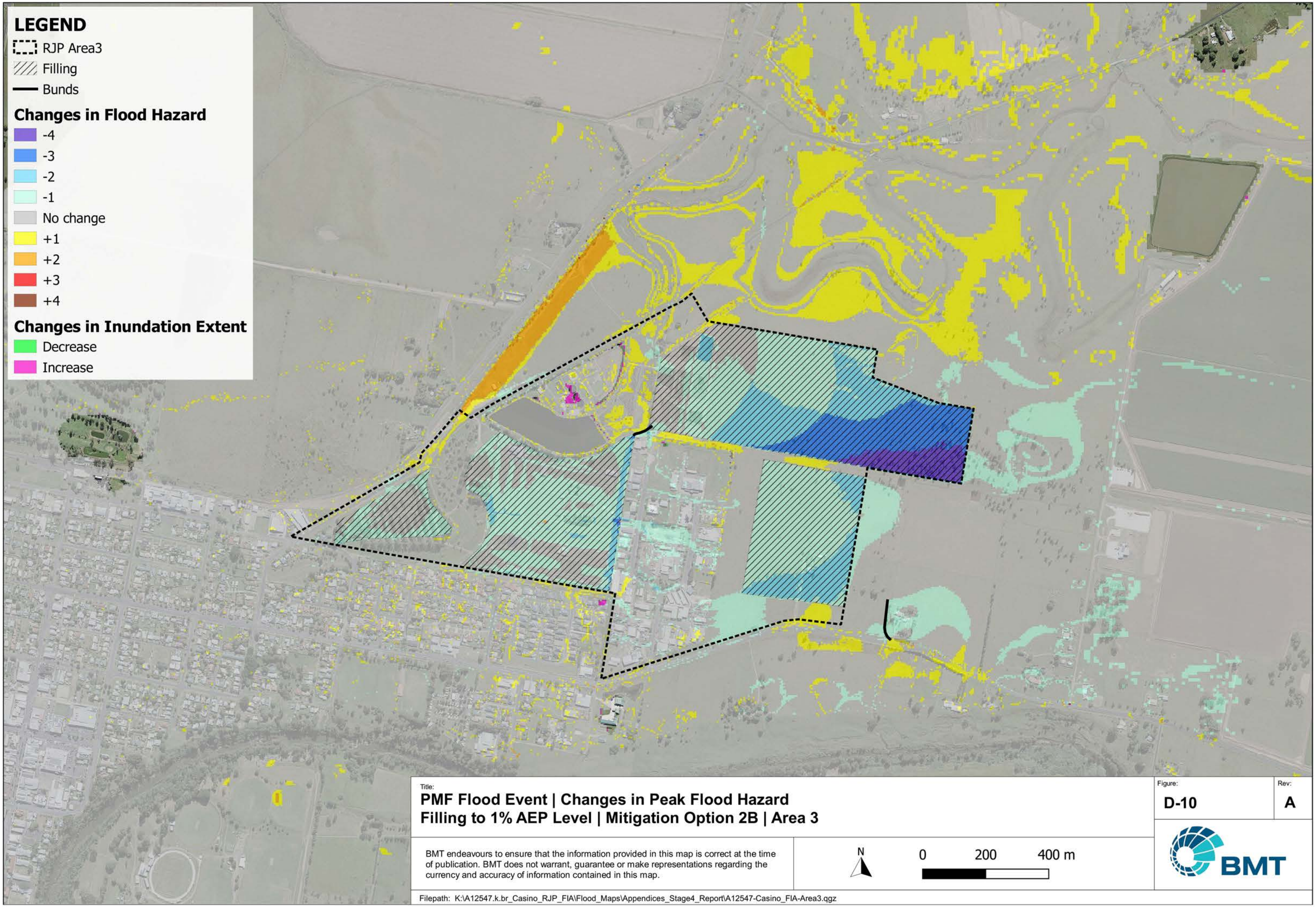

Title:

PMF Flood Event | Changes in Peak Flood Hazard
Filling to 1% AEP Level | Mitigation Option 2B | Area 3

Figure: D-10

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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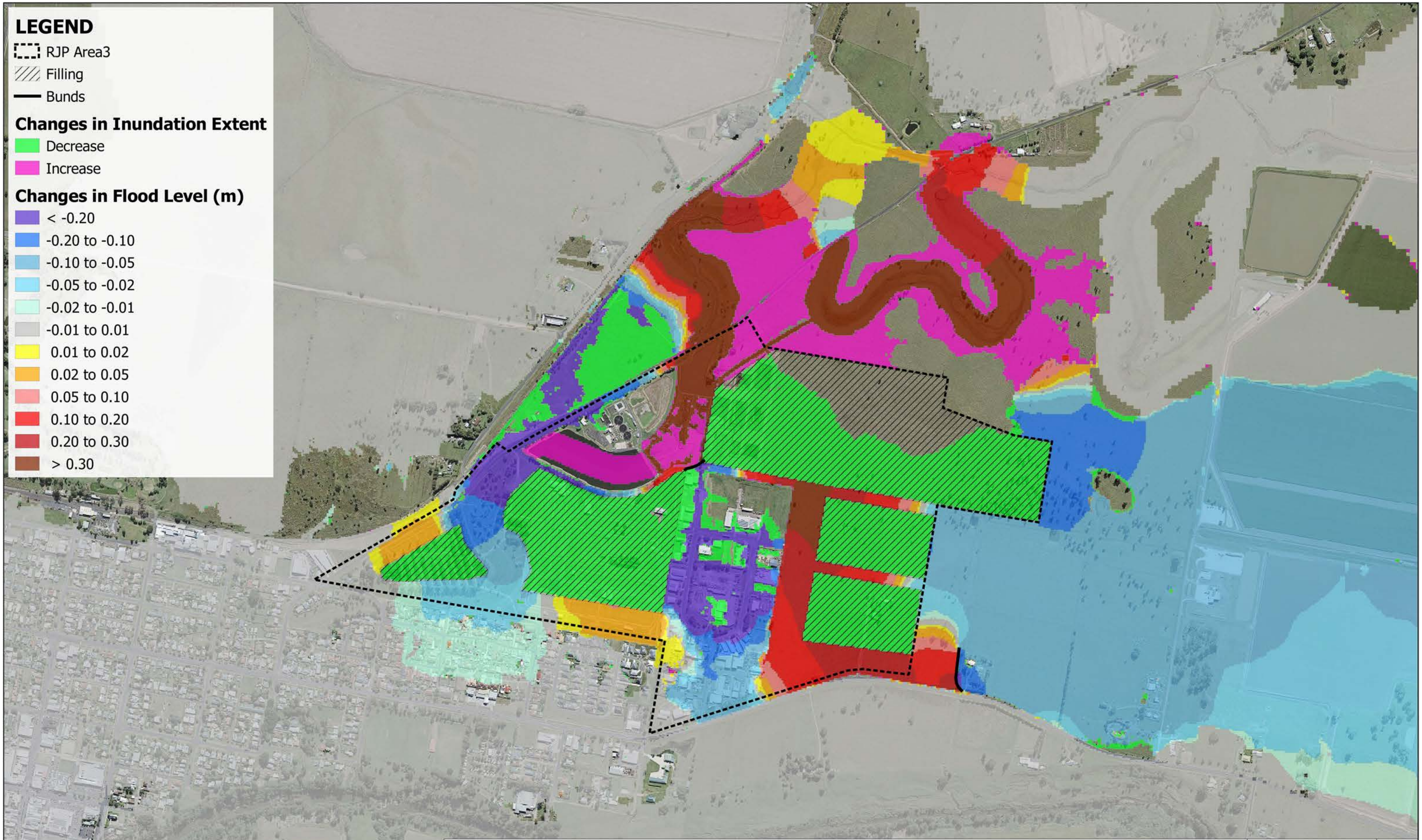
Filepath: K:\A12547.k.br_Casino_RJP_FIA\Flood_Maps\Appendices_Stage4_Report\A12547-Casino_FIA-Area3.qgz

Annex E: Flood Impact Maps | Alternative Fill and Mitigation | Area 3



Title:

1% AEP + Climate Change Flood Event | Changes in Peak Flood Level
Optimised Filling to 1% AEP+CC Level | Mitigation Option 1A | Area 3

Figure: E-1

Rev: A

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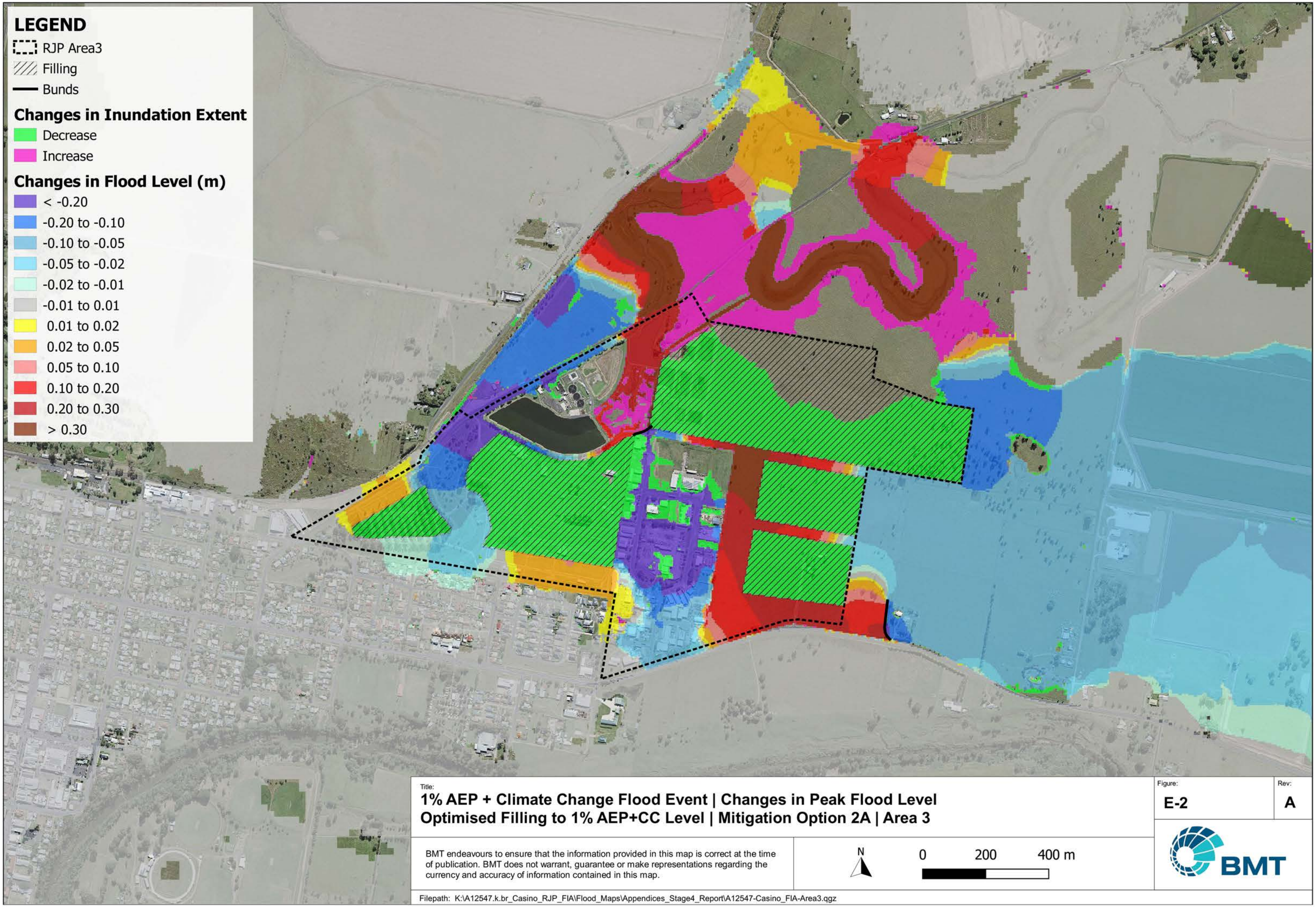
LEGEND
RJP Area3
Filling
Bunds
Changes in Inundation Extent
Decrease
Increase
Changes in Flood Level (m)
< -0.20
-0.20 to -0.10
-0.10 to -0.05
-0.05 to -0.02
-0.02 to -0.01
-0.01 to 0.01
0.01 to 0.02
0.02 to 0.05
0.05 to 0.10
0.10 to 0.20
0.20 to 0.30
> 0.30
Title:
1% AEP + Climate Change Flood Event | Changes in Peak Flood Level
Optimised Filling to 1% AEP+CC Level | Mitigation Option 2A | Area 3
Figure:
E-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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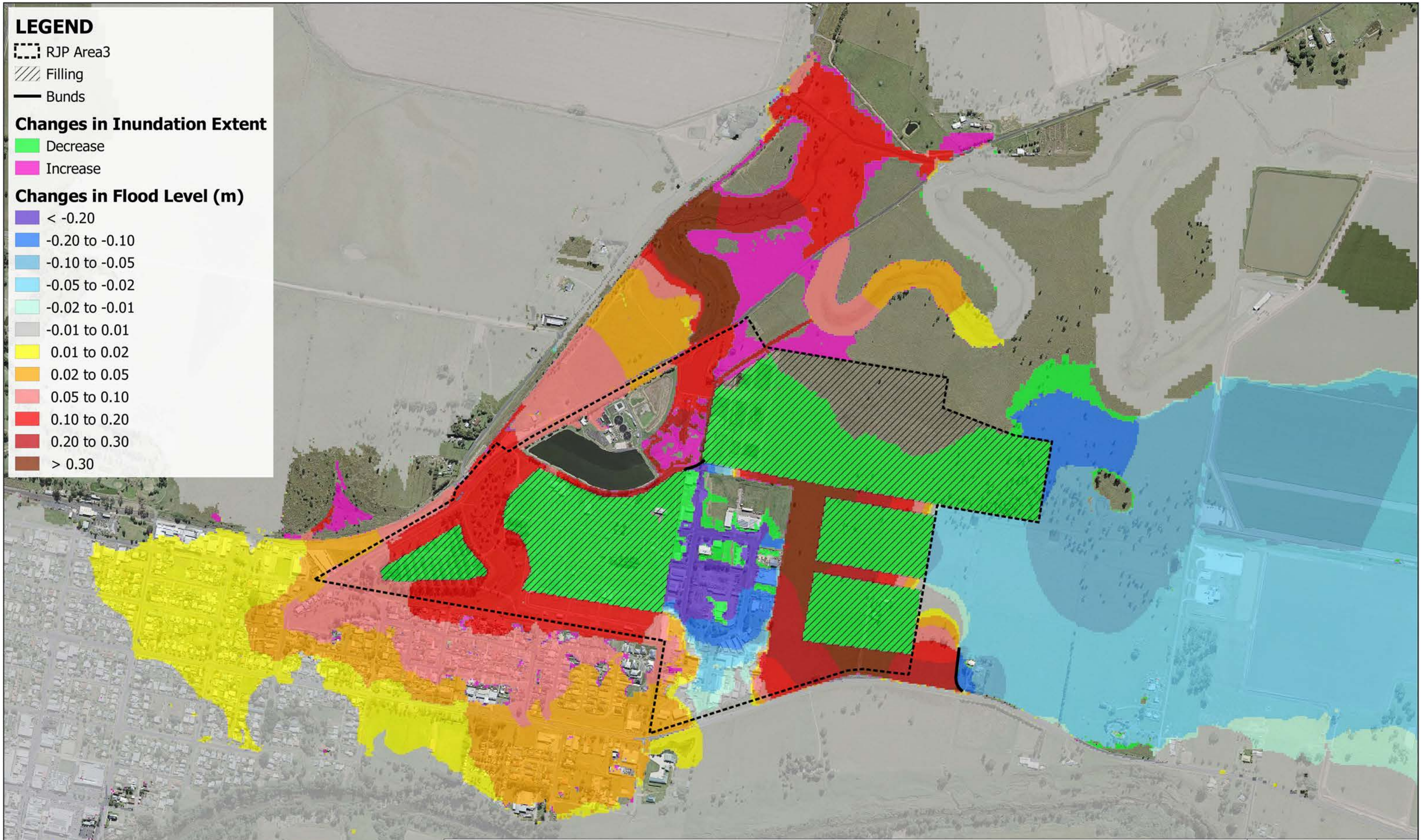

Title:
1% AEP + Climate Change Flood Event | Changes in Peak Flood Level
Optimised Filling to 1% AEP+CC Level | Mitigation Option 3 | Area 3

Figure: E-3

Rev: A

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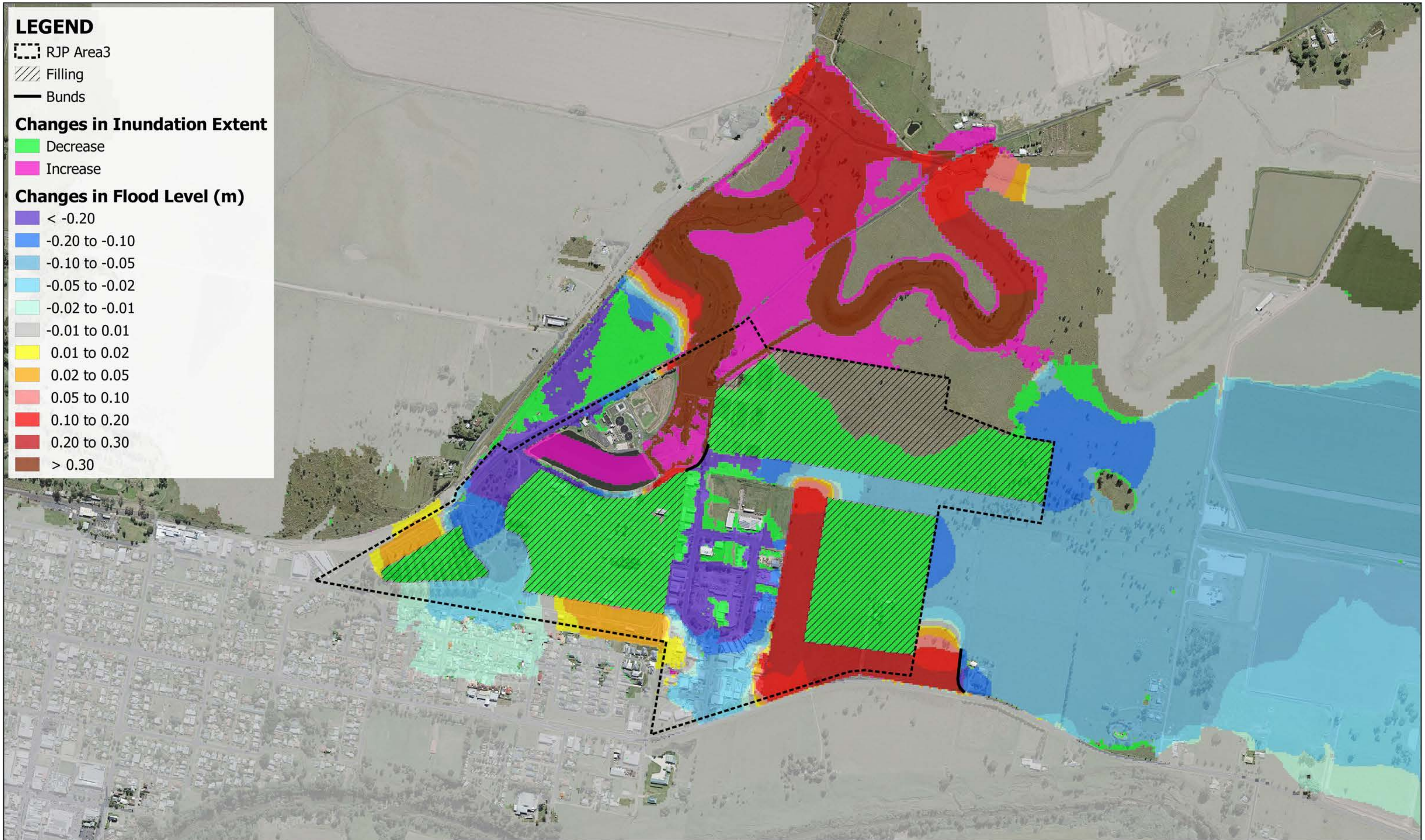

Title:
1% AEP + Climate Change Flood Event | Changes in Peak Flood Level
Alternative Filling Option #4 | Mitigation Option 1B | Area 3

Figure: E-4

Rev: A

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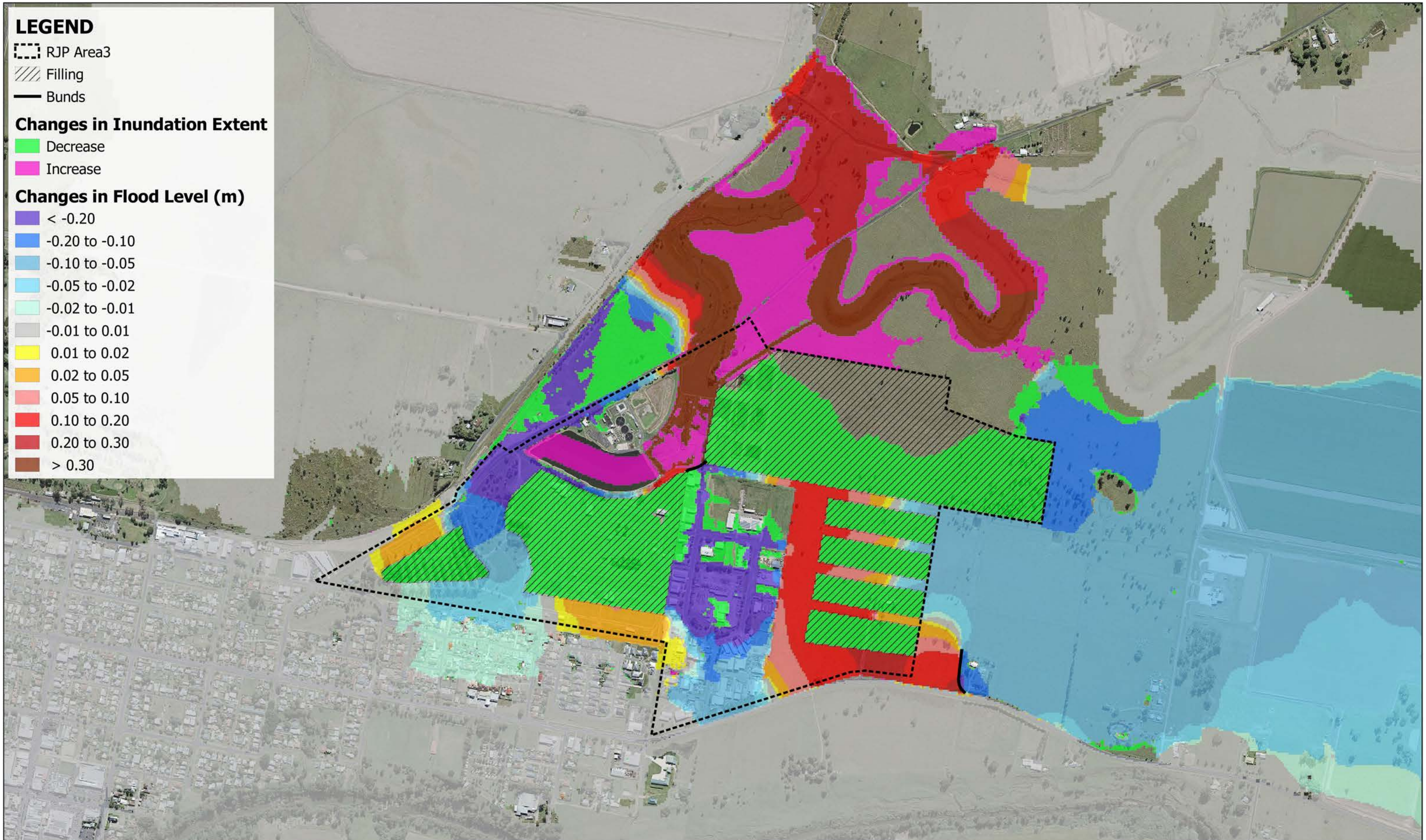

Title:
1% AEP + Climate Change Flood Event | Changes in Peak Flood Level
Alternative Filling Option #5 | Mitigation Option 1B | Area 3

Figure: **E-5**

Rev: **A**

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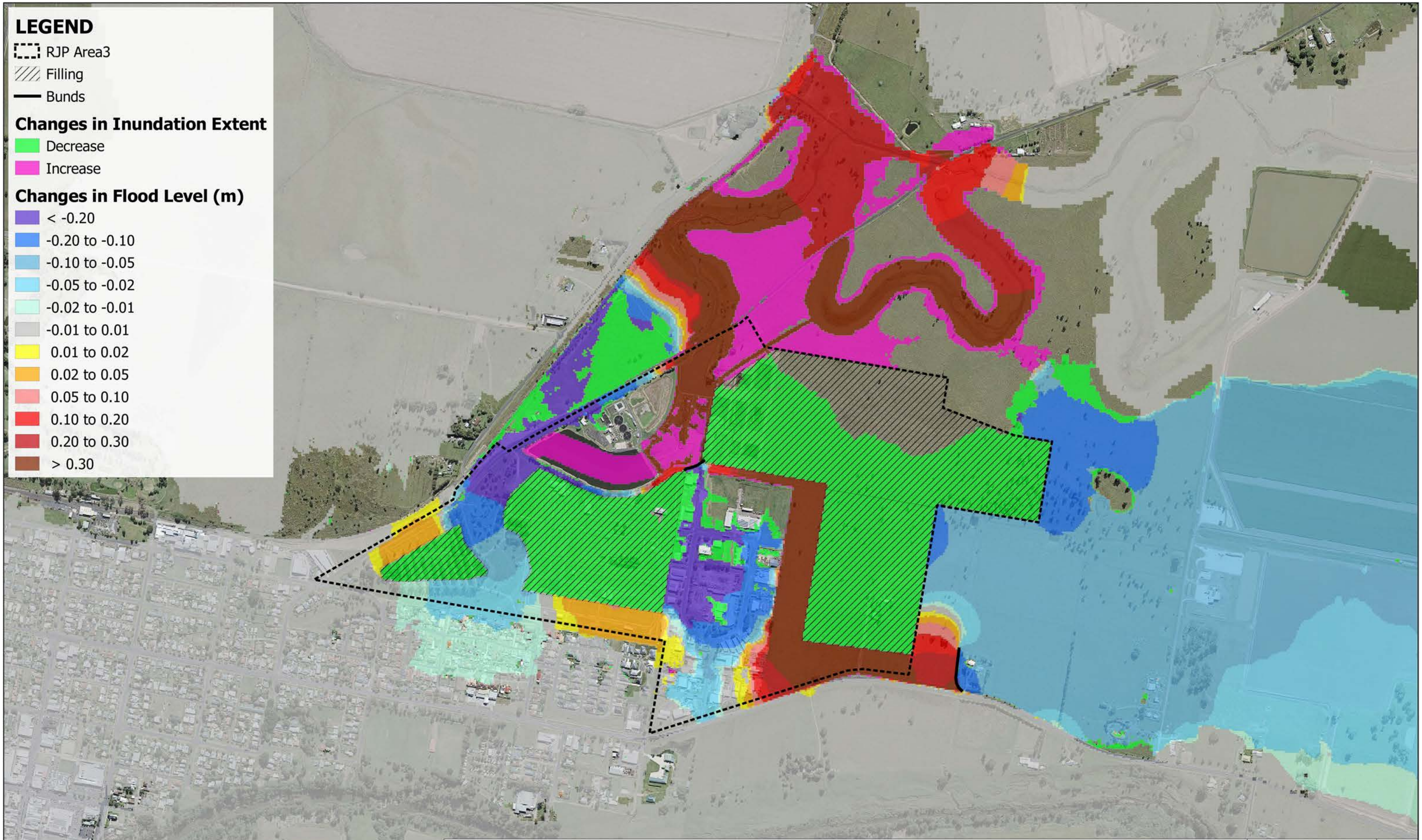

Title:

1% AEP + Climate Change Flood Event | Changes in Peak Flood Level
Alternative Filling Option #6 | Mitigation Option 1B | Area 3

Figure:	Rev:
E-6	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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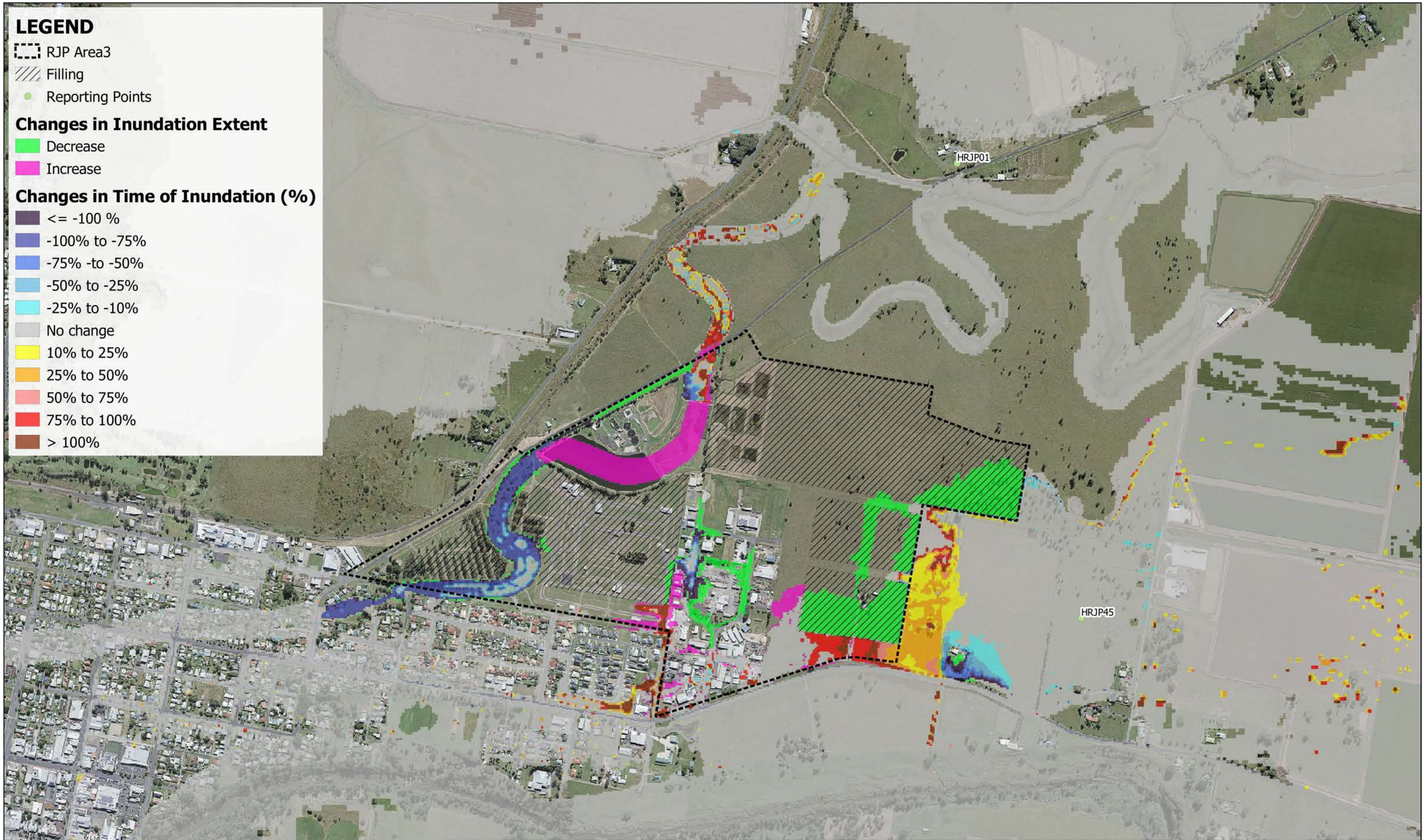
Filepath: K:\A12547.k.br_Casino_RJP_FIA\Flood_Maps\Appendices_Stage4_Report\A12547-Casino_FIA-Area3.qgz

Annex F: Flood Duration Impacts



Title:
2% AEP Flood Event | Changes in Time of Inundation (Percentage)
Optimised Filling to 1% AEP+CC Level | Mitigation Option 1B | Area 3

Figure: F-1

Rev: A

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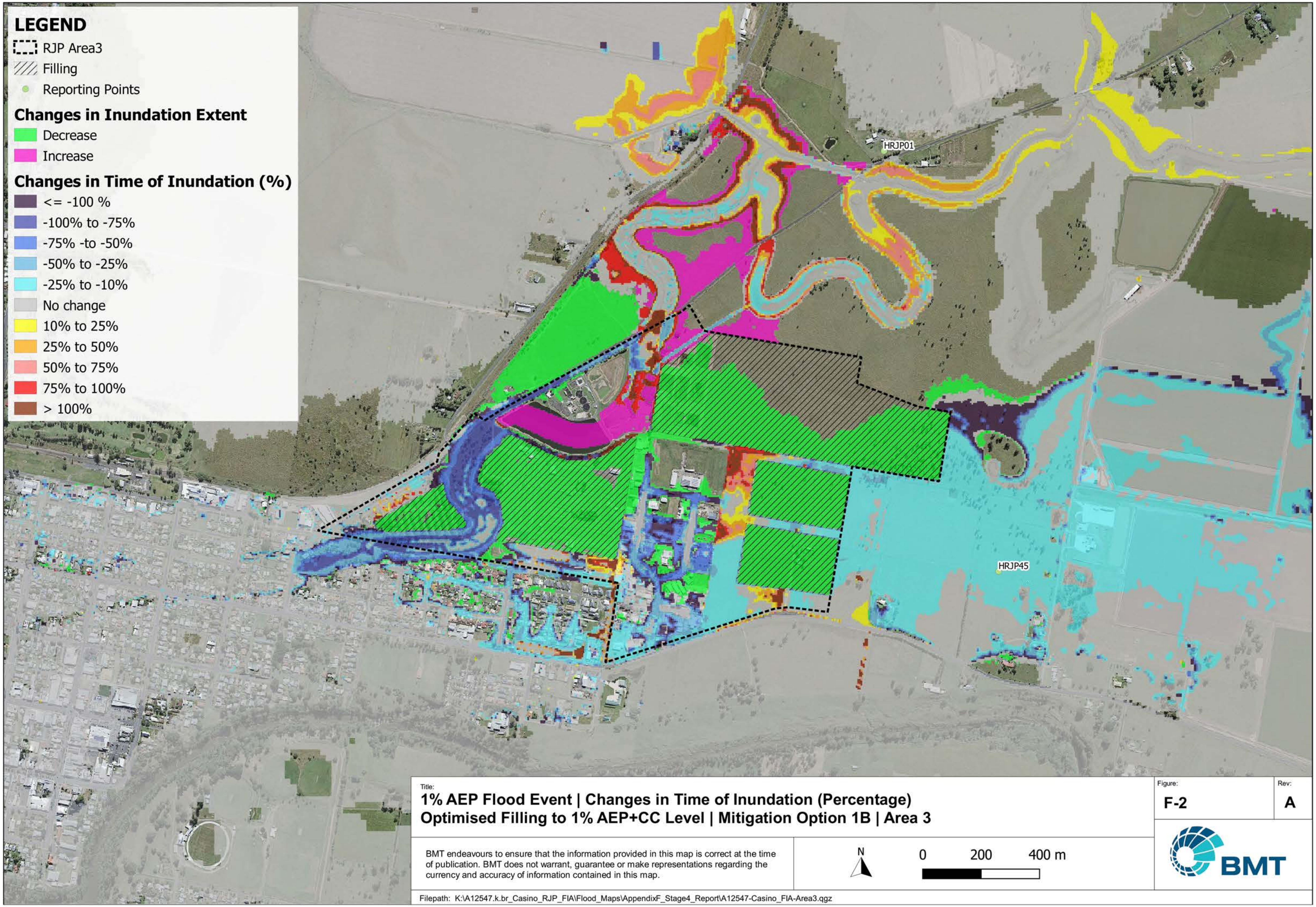

Title:

1% AEP Flood Event | Changes in Time of Inundation (Percentage)
Optimised Filling to 1% AEP+CC Level | Mitigation Option 1B | Area 3

Figure: F-2

Rev: A

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BMT

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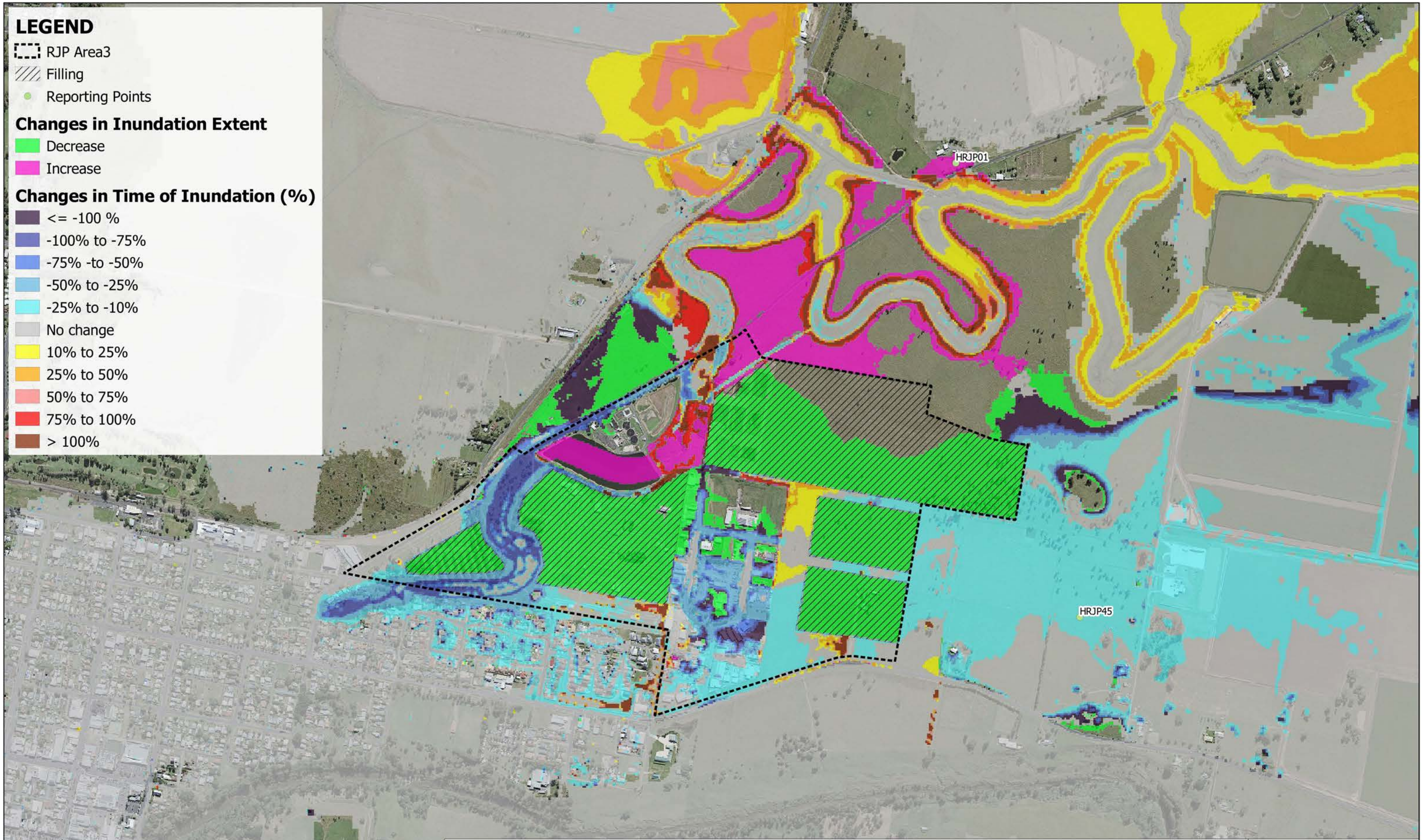

Title:
1% AEP + Climate Change Flood Event | Changes in Time of Inundation (Percentage)
Optimised Filling to 1% AEP+CC Level | Mitigation Option 1B | Area 3

Figure: F-3

Rev: A

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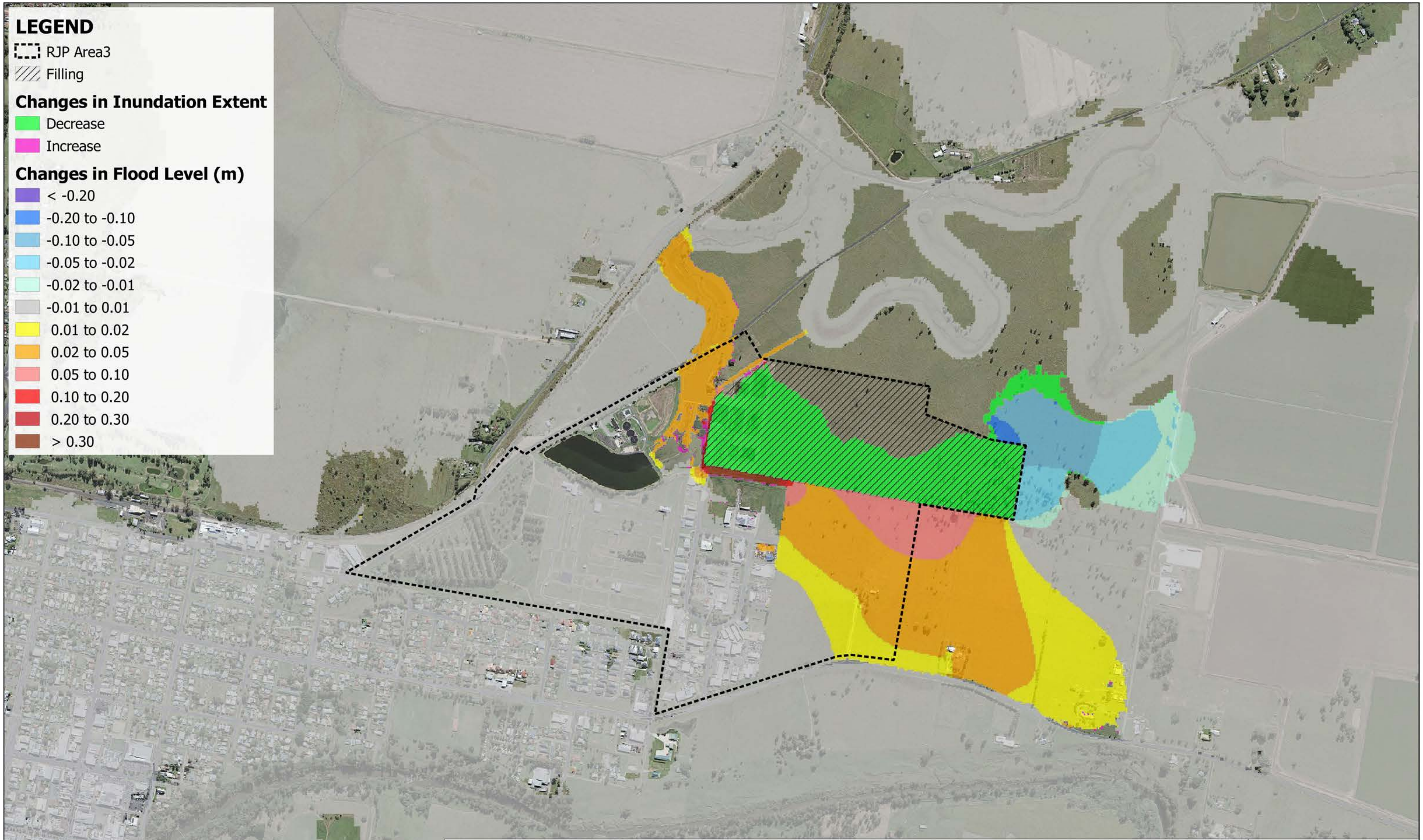
BMT

Filepath: K:\A12547.k.br_Casino_RJP_FIA\Flood_Maps\AppendixF_Stage4_Report\A12547-Casino_FIA-Area3.qgz

Annex G: Partial Area 3 Fill Scenarios prior to Mitigation



Title:
1% AEP + Climate Change Flood Event | Changes in Peak Flood Level
Northern Filling (Cannabis Site) Only | No Mitigation | Area 3

Figure: G-1

Rev: A

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Filepath: K:\A12547.k.br_Casino_RJP_FIA\Flood_Maps\AppendixG_Stage4_Report\A12547-Casino_FIA-Area3.qgz

Title:

1% AEP + Climate Change Flood Event | Changes in Peak Flood Level
Reduced Northern Filling (Cannabis Site) Only | No Mitigation | Area 3

Figure: G-2

Rev: A

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Filepath: K:\A12547.k.br_Casino_RJP_FIA\Flood_Maps\AppendixG_Stage4_Report\A12547-Casino_FIA-Area3.qgz

Annex H: Costing Methodology

This Annex contains a summary of the methodology used to determine the costs of the stormwater quality treatment options outlined in Section 5.

A.1 Methodology Summary

The reported lifecycle costs are the Net Present Value of:

- Design and construction cost
- Maintenance costs (which commence after the establishment period)
- Establishment costs (typically three times annual maintenance costs for the first two years)
- Renewals and adaptation costs:
  - An annualised renewal cost of 0.52% of the acquisition cost was assumed for wetlands, as derived from Taylor (2005)
  - Estimated to be 40% of construction costs for bioretention basins and streetscape bioretention, undertaken after 15 years of operation

The NPV was calculated assuming:

- The inflation rate was assumed to be 2.67% and the discount rate assumed to be 4.62%
- Lifecycle costs are estimated over a 20 year period.

Cost estimates were derived from various sources and are based on actual project costs and data from related research. The costs were escalated to present day using an average of the increase in class index numbers from:

- Index number 30: Building construction, NSW
- Index number 3101: Road and bridge construction, NSW

A summary of the wetland, bioretention basin and streetscape bioretention basin cost assumptions are detailed in Tables C.1 to C.3.

Table A.1. Wetland Cost Assumptions

Wetland Cost (AWC 2013[1])

Construction $/m^2	Maintenance $/m^2/yr	Establishment $/m^2/yr	Renewal $/m^2
175	2.5	7.5	0.91

1 Australian Wetlands Consulting (AWC) (M Bailey, pers. comm., 22 January 2013).

Escalated Wetland Cost ($2023)

Construction $/m^2	Maintenance $/m^2/yr	Establishment $/m^2/yr	Renewal $/m^2
250	3.6	10.7	1.30

Table A.2. Bioretention Basin Cost Assumptions

Bioretention Basin Cost (WbD 2010)

Construction $/m^2	Maintenance $/m^2/yr	Establishment $/m^2/yr	Renewal $/m^2
270	5	15	108

Escalated Bioretention Basin Cost ($2023)

Construction $/m^2	Maintenance $/m^2/yr	Establishment $/m^2/yr	Renewal $/m^2
410	7.6	22.8	164

Table A.3. Streetscape Bioretention Cost Assumptions

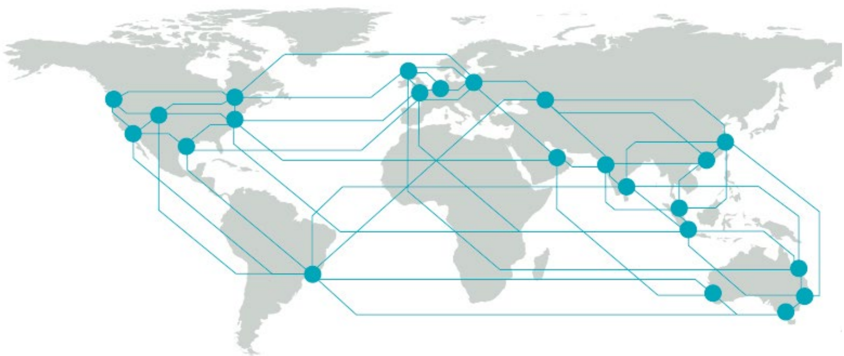
Streetscape Bioretention Cost (MW 2013[1], WbD 2010[2])

Construction $/m^2	Maintenance $/m^2/yr	Establishment $/m^2/yr	Renewal $/m^2
1,000	5	15	100

Escalated Streetscape Bioretention Cost ($2023)

Construction $/m^2	Maintenance $/m^2/yr	Establishment $/m^2/yr	Renewal $/m^2
1,432	7.6	22.8	152

s



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