Norman Griffiths Oval - Flood Risk Investigation

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Synopsis: Flood Risk Investigation for the proposed Norman Griffiths Oval Development		

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Executive Summary

This Flood Risk Investigation aims to quantify the effect on flood behaviour that will occur as a result of the proposed upgrade of Norman Griffiths Oval to an all-weather playing surface, and to provide mitigation options to offset increases to flood affectation. The findings of this study will be used to determine the viability of the field upgrade from a flood risk standpoint.

The proposed upgrade of Norman Griffiths Oval was previously assessed as part of a series of works undertaken by Jacobs. A detailed TUFLOW flood model of the area was constructed, and a series of design options were assessed. This assessment was document in the Norman Griffiths Oval Flood Assessment report (Jacobs, 2017). A field bypass option, wherein drainage capacity underneath the field was increased and landscaping was provided around the field to prevent inundation, was ultimately chosen as the preliminary design. Council now seeks to investigate the potential increases to flood affectation and flood risk downstream of the proposed development which occur as a result of the oval upgrade.

In order to assess the impacts of the proposed mitigation options, the hydraulic model developed as part of the Norman Griffiths Oval Flood Assessment (Jacobs, 2017), has been used. This model has been updated for this study, with changes made to provide a better understanding of flood conditions across the catchment (not just at Norman Griffiths Oval itself).

The bypassing of Norman Griffiths Oval (which currently acts as a flood storage basin) as part of the proposed upgrade works will increase flood levels and velocities in the channel downstream of the oval. Flows discharging from the channel are constrained by the capacity of the under-road drainage network at Yanko Road and within the Ku-ring-gai Fitness and Aquatic Centre carpark and the reach upstream of these locations is most heavily impacted by the proposed bypass. Overtopping depths and flood risk at both locations are increased, and the increase in flood affectation downstream of the proposed oval upgrade has the potential to cause impacts on private property.

Flood mitigation and risk mitigation works have been assessed in an attempt to offset the increases to flood level, velocity and hazard caused by the oval upgrade. Increases to flood hazard caused by the proposed upgrade are localised in existing high-hazard areas. Identifying the high existing risk in these areas as part of the project works would be beneficial to the community. Increases to flood levels have been targeted by a series of basin works within Bicentennial Park which would be lowered to create a temporary artificial flood storage area in order to offset the increases in flood levels immediately upstream and downstream of Yanko Road, although the use of a basin would not be be able to fully offset increases downstream of the Kur-ring-gai Fitness and Aquatic Centre carpark or the oval itself. 3 Basin options were assessed with an estimated cost of between $940 000 and $1 730 000

Increases to flood velocities and levels within the channel between the Fitness Centre carpark and Yanko Road can be targeted by creek stabilisation works. The installation of gabion baskets along length of the channel with high flow velocities to provide stabilisation of the creek bank was assessed to have an estimated cost of $799 200. The report also outlined the potential utilisation of check dams to provide a more ecological solution to the potential for scouring.

This Report should be regarded as an initial concept. The next steps to be undertaken will consist of consultation with stakeholders, detailed designs of the preferred mitigation option, presenting a business case, acquiring of approvals, and project procurement.

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1 Introduction

This report documents works undertaken by BMT to investigate the proposed development of Norman Griffiths Oval, West Pymble into an all-weather synthetic surface. The investigation has assessed the increase in flood affectation and risk posed by the proposed upgrade (which includes landscaping works and drainage capacity increases designed to provide flood immunity of the oval during rare flood events), and the potential flood mitigation options that could be used to nullify or minimise this increase. It has been prepared for Ku-ring-gai Council.

The proposed development of Norman Griffiths Oval was first assessed as part of the Norman Griffiths Oval Flood Assessment report completed by Jacobs in the year 2017 At the time of report completion, the downstream impacts caused by the proposed development were not considered acceptable by Ku-ring-gai Council and the project was abandoned. However, community support for the proposal and a lack of viable alternatives has led to Council reconsidering whether the benefits proposed by the upgrade offset the potential downstream increases in flood affectation. Council now seeks to clarify how flood level and velocity increases downstream of the proposed development influence flood risk in those areas and what options (from both a flood awareness and flood reduction standpoint) will help to mitigate any increases.

In order to assess the impacts of the proposed mitigation options, the hydraulic model developed as part of the Norman Griffiths Oval Flood Assessment (Jacobs, 2017) has been used. This model has been updated for this study, with changes made to in order to best represent worst case flood conditions for the areas downstream of the oval where flood conditions will likely be changed as a result of the upgrade (not just at the oval itself).

The hydraulic models for the existing, Oval upgrade and Oval upgrade with mitigation scenarios were simulated using the 0.2 EY, 10% AEP, 5% AEP, 2% AEP and 1% AEP events, as described in Section 2.

1.1 Study Objective

The purpose of this study is to investigate the change in flood affectation and flood risk caused by the proposed development of Norman Griffiths Oval, and to develop and cost flood mitigation options (from both a flood awareness and flood reduction standpoint) to offset this increase.

1.2 Study Area and Catchment Topography

The study site is located within the Quarry Creek catchment within Ku-ring-gai Council's Local Government Area (LGA). This study focuses on the catchment area upstream and downstream of (and including) Norman Griffiths Oval. The area is bound by Ryde Road to the east, includes the road crossings under Yanko Road and the Ku-ring-gai Fitness and Aquatic Centre (Fitness Centre) carpark and ultimately discharges to Lane Cove River approximately 1.4 km downstream of Norman Griffiths Oval. The catchment area encompasses approximately 1.45 km^2. The study area grades steeply towards Quarry Creek which runs north-south through the catchment.

1.3 Study Approach

- Compilation and review of existing information pertinent to the study;

- Development of a revised baseline model to assess catchment flood conditions;
- Establishment of design flood conditions for a range of design events from the 0.2 EY (5 year ARI to the 1% AEP (100 year ARI) event noting that AEP refers to Annual Exceedance Probability and ARI refers to Average Recurrence Interval;
- Determination of change in flood conditions associated with each option, considering changes to the distribution of key hydraulic parameters such as water level and flood hazard (allowance for assessment of three separate options; and
- Costing of mitigation options.

1.4 Data Collection and Review

1.4.1 Norman Griffiths Oval Flood Assessment (Jacobs, 2017)

The Norman Griffiths Oval Flood Assessment prepared by Jacobs for Ku-ring-gai Council (herein referred to as the Jacobs Report) provides a detailed flood-focused assessment for the potential upgrade of the Norman Griffiths Oval to an all-weather synthetic surface. A TUFLOW hydraulic model was developed for the Quarry Creek catchment (inclusive of the stormwater pit and pipe network) within which the oval is located, in order to assess its potential viability as a flood-free synthetic surface. The TUFLOW model utilised included local LiDAR data in addition to detailed survey of the drainage in the vicinity of the Oval – from the channel upstream of the Fitness centre all the way to the Yanko Road culvert – to represent terrain within the catchment. Inflows into the TUFLOW model were extracted from an existing Council DRAINS model of the same area and events from the 0.2 EY to the 1% AEP were assessed for the 25 minute, 2 hour, 6 hour and 9 hour durations (with the 2 hour found to be critical).

As highlighted in the study, the existing Norman Griffiths Oval includes an earthen embankment on its downstream side and the study found that under existing conditions the oval acts as a flood basin. Excess flows from the channel upstream of the Oval (together with flows from the cross-drainage under Lofberg Road) exceed the capacity of the pipe underneath the Oval and flow onto the Oval itself. These excess flows are then detained by the earthen embankment at the southern end and discharge via a pipe into the channel downstream.

A series of options were investigated as part of the Jacobs Report, with the aim of achieving flood immunity of Norman Griffiths Oval for events up to and including the 2% AEP event. Mitigation options considered included the use of underground detention tanks and a major re-grading of the oval; but due to cost and feasibility these have not been considered further as part of this report. An Oval bypass case - wherein drainage capacity around the Oval is increased to prevent direct ingress and the additional flow is discharged directly into the channel downstream – has been favoured by Council as a preferred option. The Oval bypass option included:

- A tripling of pipe capacity (from one to three 1050 mm pipes) underneath the oval;
- A series of additional surface inlets bordering the oval to capture flows before they inundate the field; and

- Earthworks at the upstream end of the sport field, with an embankment to prevent overtopping and a swale to intercept surface flows approaching the field.

Results for the flow bypass case indicate that the oval is flood free for events up to and including the 1% AEP event, but will increase flood levels and velocities in the channel downstream of the site. Flood levels on Yanko Road and in the Fitness Centre carpark were also increased as a result of the development.

1.5 Report Sections

This report documents the study's objectives, results and recommendations.

- Section 1 provides an overview of the study and summary of background information.
- Section 2 details the development of the baseline scenario and proposed scenario flood models.
- Section 3 details the existing flood conditions and design flood results and associated flood mapping.
- Section 4 details the existing and proposed risk conditions and summarises risk mitigation options flood damages assessment.
- Section 5 details the proposed mitigation options
- Section 6 details the conclusions of the assessment.

Title:

Study Area

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2 Flood Model Development

This section provides information on the development of the flood assessment model which has been used to establish flood conditions in the study area and assess the flood impacts of the proposed upgrade of Norman Griffiths Oval and potential mitigation options.

The following section documents the changes to the flood model developed as part of the Norman Griffiths Oval Flood Assessment (Jacobs, 2017), for the purposes of this study.

2.1 Hydraulic Model Updates

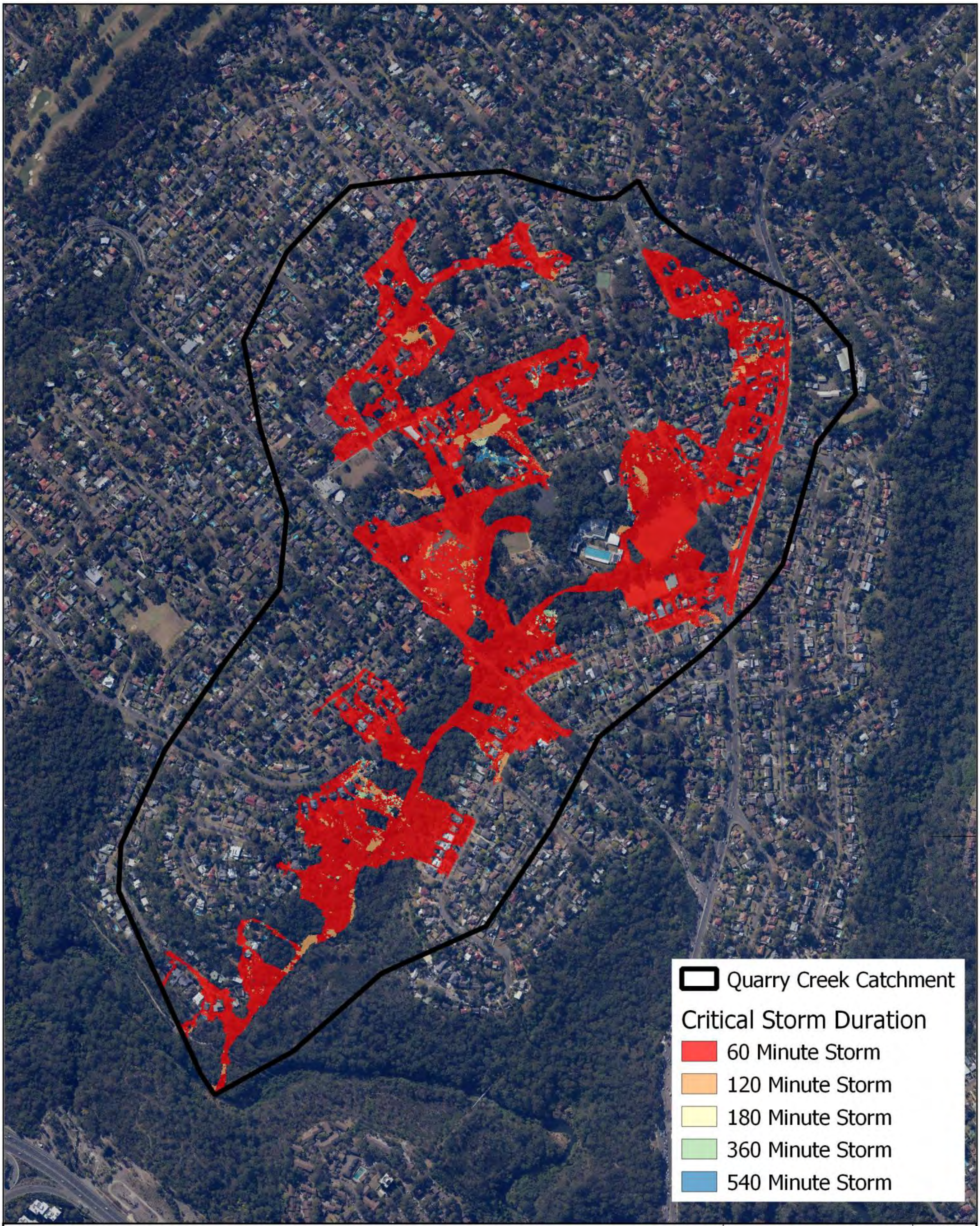
BMT has updated the existing Norman Griffiths Oval (Jacobs, 2017) TUFLOW model. Updates have been made to:

- The critical duration used as part of the assessment;
- Representation of Quarry Creek downstream of Yanko Road; and
- Some TUFLOW modelling parameters (such as cell wet/dry depth and shallow depth factor).

The updates made to the existing TUFLOW model are discussed in further detail below (with the exception of changes to TUFLOW modelling parameters, which were considered to have a negligible effect).

2.1.1 Critical Duration Update

The Norman Griffiths Oval Flood Assessment (Jacobs, 2017) identified a critical duration of 2-hours for the Quarry Creek catchment. While a 2-hour duration produces the highest flood levels in the Oval Upgrade case at Norman Griffiths Oval itself, in the areas downstream of the oval (and throughout much of the rest of the catchment) a 1-hour duration produces the highest flood level for the 1% AEP event (with a negligible difference between the 1-hour and 2-hour events at Norman Griffiths Oval itself). A critical duration assessment comparing the 1-hour, 2 hour, 3-hour, 6-hour and 9-hour events for the existing 1% AEP event is included as Figure 2-1 below. The 1-hour storm has been adopted for use within this report.



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Critical Duration Assessment

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2.1.2 Quarry Creek Channel Discretisation

Within the TUFLOW modelling software, mass balance checks provide an indication of overall model health by comparing model inflows against model outflows and flows remaining within the model. Significant divergence of these two numbers is indicative of potential model instability or the presence of mass error. Healthy models typically have a cumulative mass error (which considers the total volume in vs total volume out and volume remaining) of +/- 1%. The TUFLOW modelling undertaken as part of the Norman Griffiths Oval Flood Assessment (Jacobs, 2017) had cumulative mass errors of greater than +/-2.5%. Investigation of the mass balance check files produced within TUFLOW indicated that most of the mass balance issues were located along the Quarry Creek channel, in heavily vegetated areas downstream of Yanko Road. Heavy vegetation can sometimes affect the quality of LiDAR survey as the variability in both surface type and elevations can interfere with the laser reading. This can lead to unrealistic terrain profiles along heavily vegetated creeks, which in turn can lead to unrealistic model results in these areas.

To correct the mass balance errors along the downstream sections of Quarry Creek a representative channel was overlayed onto the problem areas. The representative channel was produced by identifying the lowest point along several reaches of the channel from a 2019 LiDAR survey of the area and then replicating typical channel cross-sections from the detailed survey works undertaken as part of the Norman Griffiths Oval Flood Assessment. Following overlay of the representative channel, the model was re-run for the full suite of existing and design events. Cumulative mass errors for the revised model were within the +/- 1% threshold of healthy models, and changes to flood levels within the model were localised along reaches of Quarry Creek with no direct impact/effect on other areas of the catchment.

Peak flood conditions at Norman Griffiths Oval were not impacted by the inclusion of the representative channel, but decreases in cumulative mass error as a result of its inclusion indicate that the revised model is suitable for assessment of design options. See Figure 2-2 below for an indication of the extent of the representative channel.

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Downstream Channel Discretisation

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3 Model Results

The following results for the baseline (existing) scenario and Oval Upgrade scenario are presented in Appendix A – Existing Flood Conditions and Appendix B – Oval Upgrade Conditions:

Peak flood condition (depth with flood level contours) maps for each of the modelled design flood events produced using the 1-hour duration storm for the 0.2 EY, 10% AEP, 5% AEP, 2% AEP and 1% AEP events.

3.1 Description of Flood Behaviour under Current Conditions

Design flood simulations in the baseline TUFLOW model was undertaken for the 0.2 EY, 10% AEP, 5% AEP, 2% AEP and 1% AEP events.

As shown in the Appendix A figures, overland flows are concentrated in two major channel reaches in the upstream sections of the catchment, specifically:

- Between Inverallan Avenue and Bicentennial Park in the north-west; and
- Between Shaddock Avenue and Lofberg Road in the north-east (upstream of the area of interest).

Flows along the north-east channel section discharge initially through the pipe underneath Norman Griffiths Oval (and then overland via the Oval detention basin once capacity is exceeded) to a channel running underneath the Ku-ring-gai Fitness and Aquatic Centre Carpark and past the West Pymble Guide and Scout Halls. This channel in turn discharges into Quarry Creek via a structure underneath Yanko Road. Primarily flows along this reach are concentrated within the channel/Quarry Creek itself, but heavy depths are observed in several key locations including:

- The southern end of Norman Griffiths Oval;
- The channel crossing underneath the Ku-ring-gai Fitness and Aquatic Centre Carpark (which is overtopped by depths of up to 300 mm from a 0.2 EY event)
- The channel crossing underneath Yanko Road (which is overtopped by depths of up to 300 mm from a 0.2 EY).

Downstream of Yanko Road, the Quarry Creek catchment grades steeply towards and heavily concentrates flows within the channel itself.

Simulated flood levels at selected locations identified in Figure 3-1 are shown in Table 3-1 for the full range of design flood events considered.

3.2 Flood Impacts

The revised Norman Griffiths Oval TUFLOW flood model has been used to test the oval upgrade option (field bypass) investigated in the Jacobs report for the 0.2 EY, 10% AEP, 5% AEP, 2% AEP and 1% AEP events. These results are then used to derive the change in peak flood levels and the change in flood hazard (as outlined in Section 4).

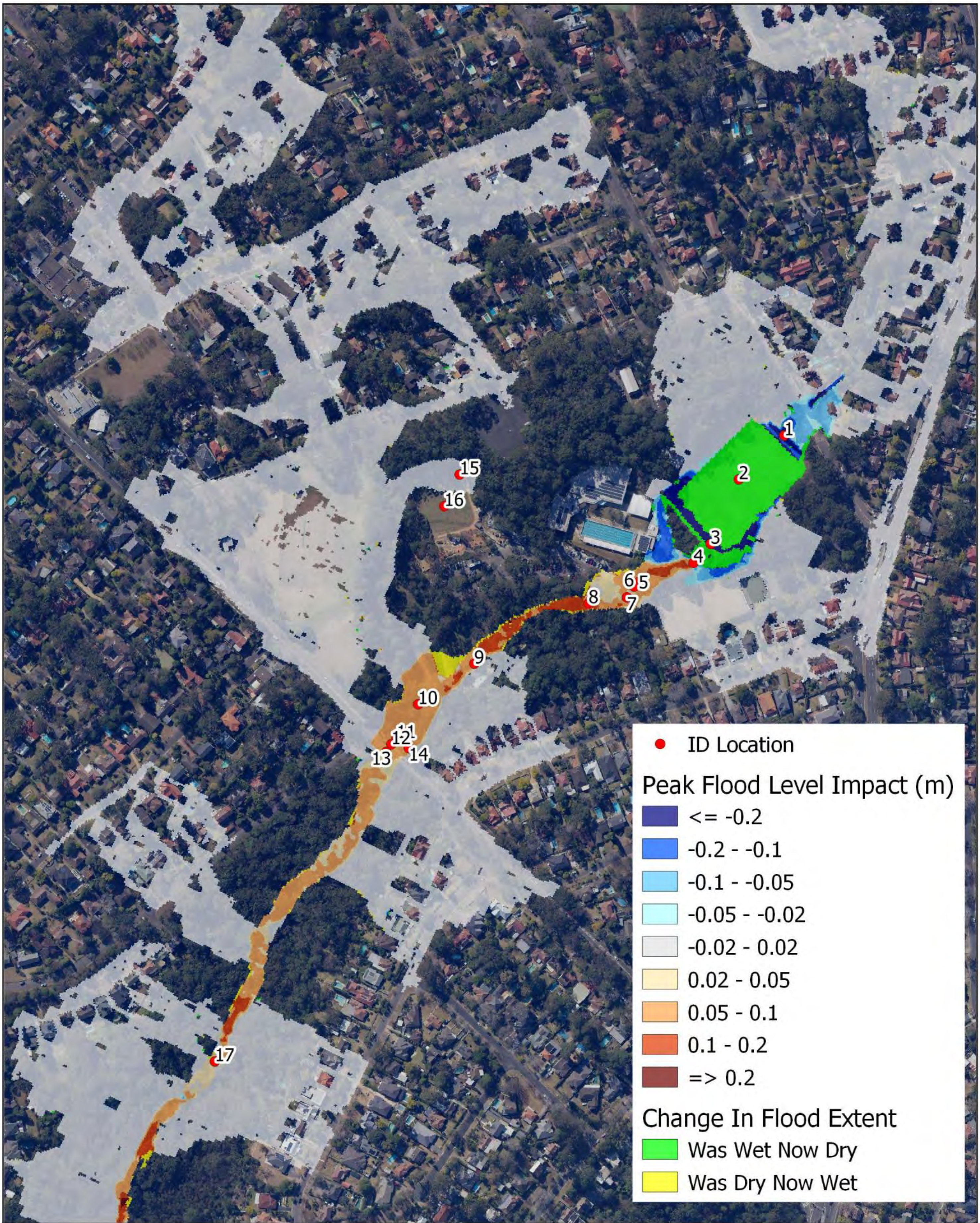
Afflux figures are presented in Appendix B – Oval Upgrade Option, depicting the change in peak flood level and velocity for the design events simulated. These figures show the change in flood conditions resulting from the proposed field bypass development option. They are useful for presenting the magnitude and extent of potential flood impacts associated with the proposed mitigation options. The following impact results are presented below:

- Figure 3-1 – 1% AEP Bypass Option Change in Peak Flood Level

Peak water levels have been extracted from a number of point locations around the study area for the “baseline” and “proposed” mitigation scenarios (refer to Figure 3-1 for locations) in Table 3-1 below.

Table 3-1 Peak Flood Level Results – Existing and Oval Bypass Conditions

ID (refer Figure 1-1)	Baseline scenario (m AHD)					Proposed Oval Bypass Oval (m AHD)				
	0.2 EY	10% AEP	5% AEP	2% AEP	1% AEP	0.2 EY	10% AEP	5% AEP	2% AEP	1% AEP
1	72.5	72.5	72.6	72.6	72.7	72.2	72.2	72.2	72.2	72.3
2	71.2	71.2	71.2	71.3	71.3	N/A	N/A	N/A	N/A	N/A
3	70.3	70.5	70.8	70.9	70.9	70.1	70.1	70.1	70.1	70.2
4	66.1	66.1	66.1	66.1	66.2	66.1	66.1	66.2	66.2	66.3
5	65.4	65.4	65.4	65.5	65.5	65.4	65.5	65.5	65.6	65.6
6	65.3	65.4	65.4	65.4	65.5	65.4	65.4	65.4	65.5	65.5
7	63.2	63.2	63.2	63.3	63.3	63.2	63.3	63.3	63.4	63.4
8	60.2	60.2	60.3	60.3	60.3	60.2	60.3	60.3	60.3	60.4
9	56.8	56.8	56.9	56.9	56.9	56.8	56.9	56.9	56.9	57
10	53.5	53.8	54	54.1	54.3	53.6	53.9	54.1	54.2	54.3
11	53.5	53.8	54	54.1	54.2	53.5	53.9	54.1	54.1	54.3
12	53.5	53.8	54	54	54.2	53.5	53.8	54	54.1	54.3
13	53.5	53.7	53.8	53.9	54	53.5	53.7	53.9	54	54.1
14	53.6	53.8	54	54.1	54.2	53.7	53.9	54.1	54.1	54.3
15	62.5	62.6	62.7	62.8	62.9	62.5	62.6	62.7	62.8	62.9
16	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17	37.9	38.1	38.2	38.4	38.5	37.9	38	38.4	38.4	38.5



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1% AEP Peak Flood Level Impact - Oval Bypass Design

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Across all modelled events, the earthworks and drainage capacity increase along the oval prevent it from being inundated. Bypassing flows are discharged directly into the channel immediately downstream of Norman Griffiths Oval, where they add to the already concentrated flows within the channel and cause localised flood level increases all the way down to the intersection with the Lane Cove River (scaling with an increase in event magnitude). Increases in peak flood levels along Quarry Creek downstream of Yanko Road are concentrated within densely vegetated sections of the channel well away from development.

Along the channel reach between Norman Griffiths Oval and Yanko Road, flood level increases within the channel will impact upon the Ku-ring-gai Fitness and Aquatic Centre carpark and Yanko Road itself. While it is unlikely that the increase in flood behaviour will have a material effect on whether and for how long each road is overtopped, an increase in the relative flood hazard at each location is likely to occur. This is discussed in more detail in Section 4 below.

Increases to flood levels upstream of Yanko Road fall partially within the boundary of 51 Kamilaroy Road. For the 1% AEP event, the proposed Oval Bypass will cause flood level increases of up to 80 mm up to 6 m inside of the property boundary. Increases to flood levels on private property because of Council works will likely be considered unacceptable, and further mitigation measures to prevent this increase may be required. Flood mitigation options investigated as part of this assessment are discussed in Section 5.

4 Flood Risk Assessment

The Best Practice Flood Risk Management approach to flood hazard mapping (AIDR, 2017) classifies the floodplain into six distinct hazard zones (H1 to H6) as shown in Figure 4-1, based on important thresholds of flood depth, velocity, and depth-velocity product. The adopted thresholds identify when flood conditions are likely to present a risk to people, vehicles and buildings. A description of each hazard threshold is provided in Table 4-1.

Table 4-1 Flood Hazard Classification Thresholds

Hazard Classification	Description
H1	Relatively benign flow conditions. No vulnerability constraints.
H2	Unsafe for small vehicles.
H3	Unsafe for all vehicles, children and the elderly.
H4	Unsafe for all people and vehicles.
H5	Unsafe for all people and vehicles. Buildings require engineering design and construction.
H6	Unconditionally dangerous. Not suitable for any type of development or evacuation access. All building types considered vulnerable to failure.

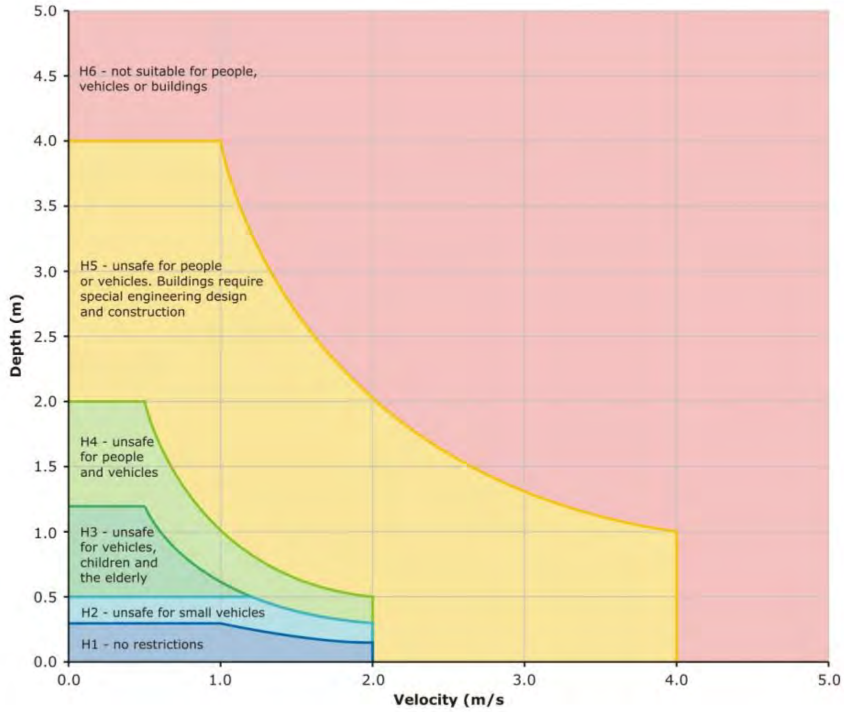


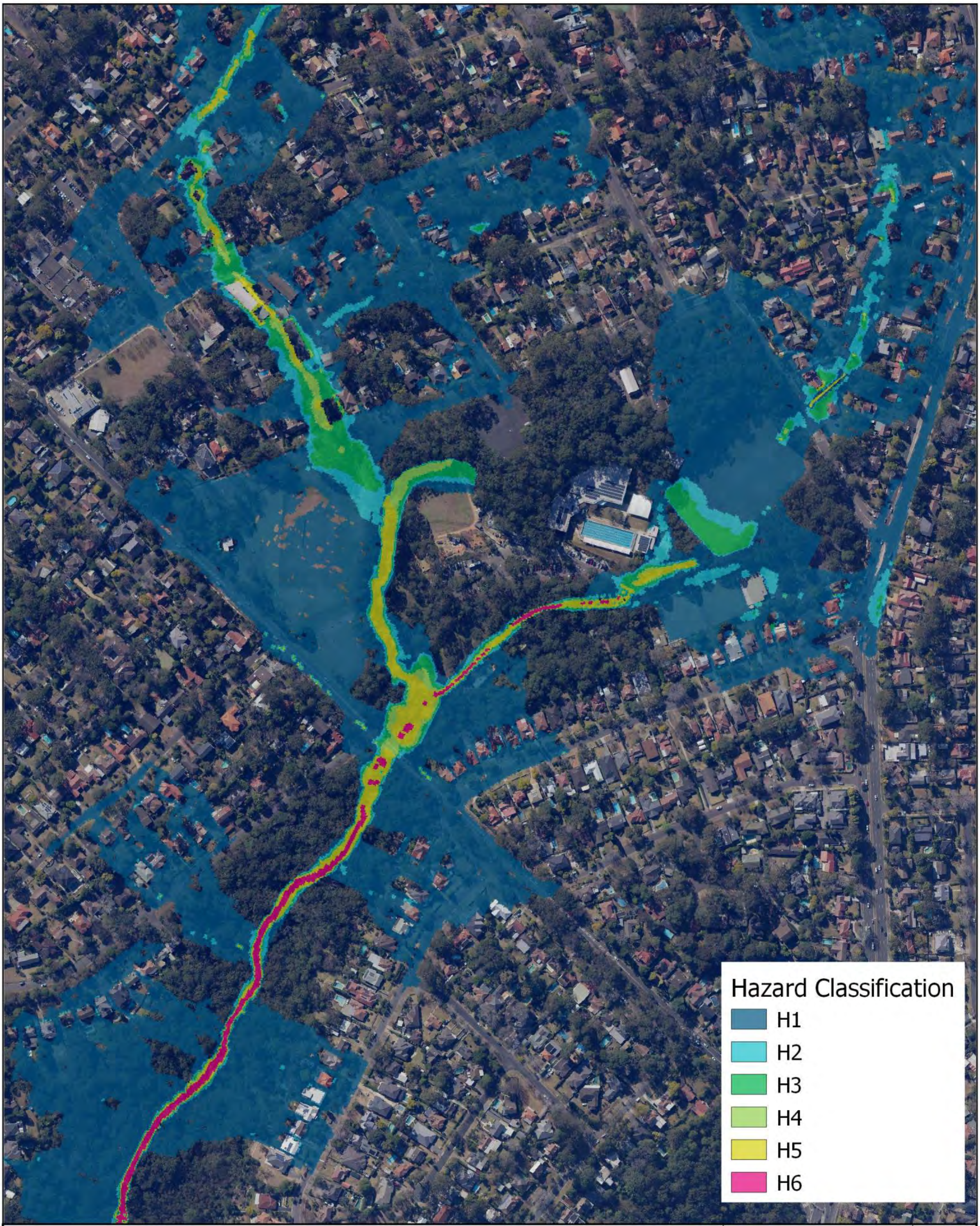
Figure 4-1 Flood Hazard Curves

4.1 Existing Flood Risk

Under existing conditions during rare floods such as the 1% AEP event, Norman Griffiths Oval is subject to the low H1 hazard level across much of its area, with the exception of the ponded waters at the downstream of the basin (where H3 hazards are present) and within the channel immediately upstream of the Oval (where H4 hazards are present). Across the Quarry Creek catchment, the flatter residential areas draining to Quarry Creek are classified as low hazard H1 areas, while hazards as high as H6 are observed in the concentrated flows within the creek.

Within the Ku-ring-gai Fitness and Aquatic Centre carpark, flows from Quarry Creek overtopping the road have hazards between a H3 and a H4 classification making them unsafe for all people and vehicles. Along Yanko Road, overtopping flows also have a H4 classification and even higher H5 classifications (indicating flood conditions that pose a hazard to building structures) along the footpath.

Peak Flood Hazards under existing conditions are shown in Figure 4-2.



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1% AEP Flood Hazard - Existing Case

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4.2 Post-Construction Flood Risk

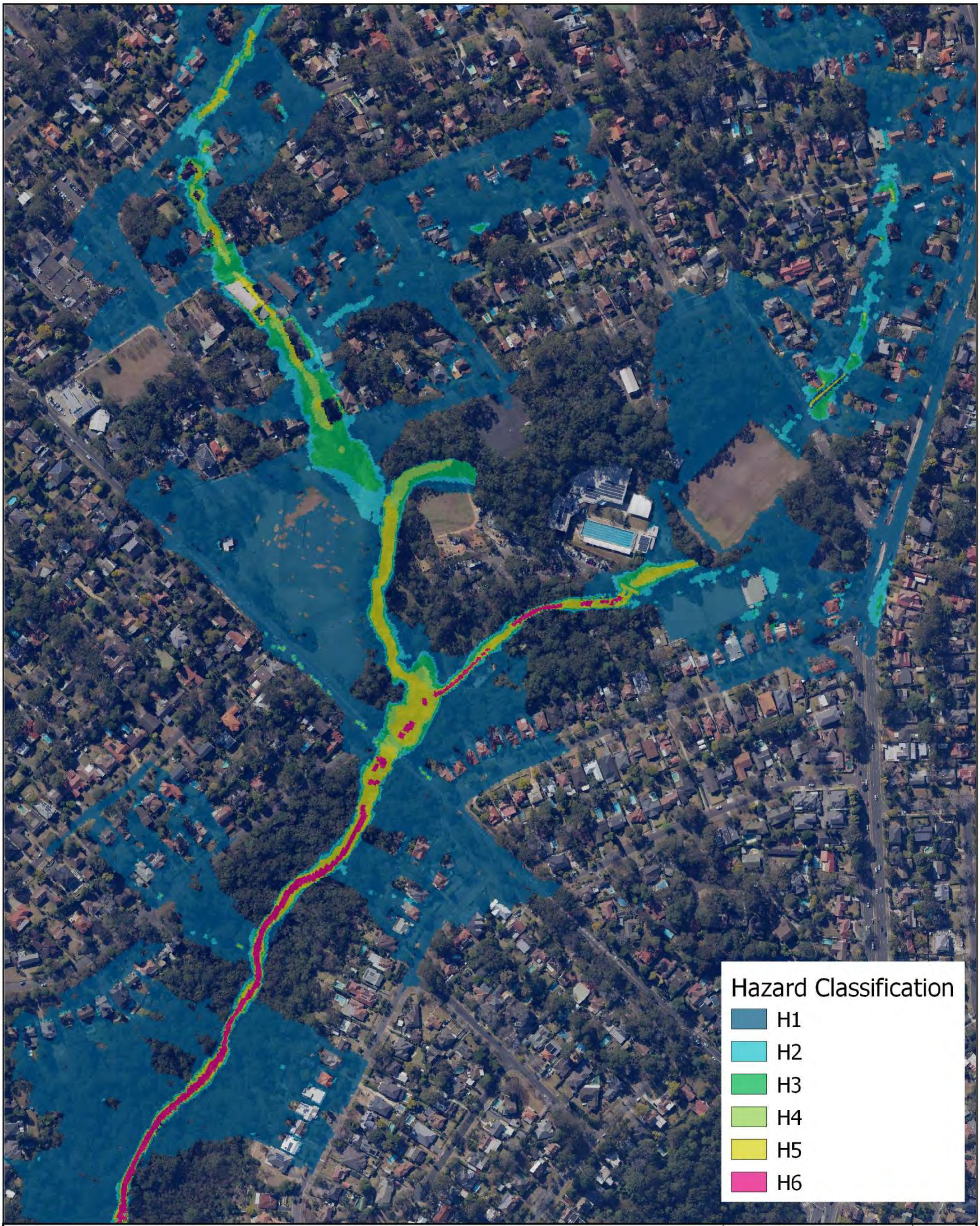
Under the proposed oval upgrade scheme in rare floods such as the 1% AEP event, Norman Griffiths Oval is flood free, and increases to drainage capacity at the upstream end of the oval have decreased hazards in the channel upstream of the oval from a H4 to a H2. However, the increases to flows within Quarry Creek downstream as a result of the proposed bypass in turn lead to increases in the flood hazard in these areas.

Within the Ku-ring-gai Fitness and Aquatic Centre carpark, the Oval bypass will increase the flood hazard of flows overtopping the road to between a H3 and H5 classification and widen the total high hazard area by several metres. Along Yanko Road, the Oval bypass will increase the hazard of overtopping flows to a H5 classification within the road corridor itself.

In more frequent events such as the 0.2 EY, overtopping flows along Yanko Road are below a H2 in areas outside of the sag point over the creek, although flows within the carpark still vary between a H3 and a H4 classification (indicating that even in frequent events, the carpark is unsafe for all people and vehicles). Aside from a minor increase in high hazard flow widths, this behaviour is replicated in the existing case. The increase in the area classified as high hazard within the carpark does not infringe on existing spaces.

It should be noted in both cases that existing hazard conditions within the carpark and over Yanko Road are considered unsafe for all people and vehicles, with modelling results suggesting high hazards are present within the catchment even in frequent events. The increase in hazard caused by the oval upgrade only serves to highlight the presence of these high hazard conditions within the existing catchment. Even if the Oval upgrade is not undertaken, potential risk mitigation options (which are discussed in Section 0 below) in these areas would still benefit the community under existing conditions.

A comparison of hazards within the Ku-ring-gai Fitness and Aquatic Centre Carpark and Yanko Road for both the Existing and Oval Bypass 1% AEP event are included as Figure 4-4 to Figure 4-7.



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1% AEP Flood Hazard - Oval Bypass Design

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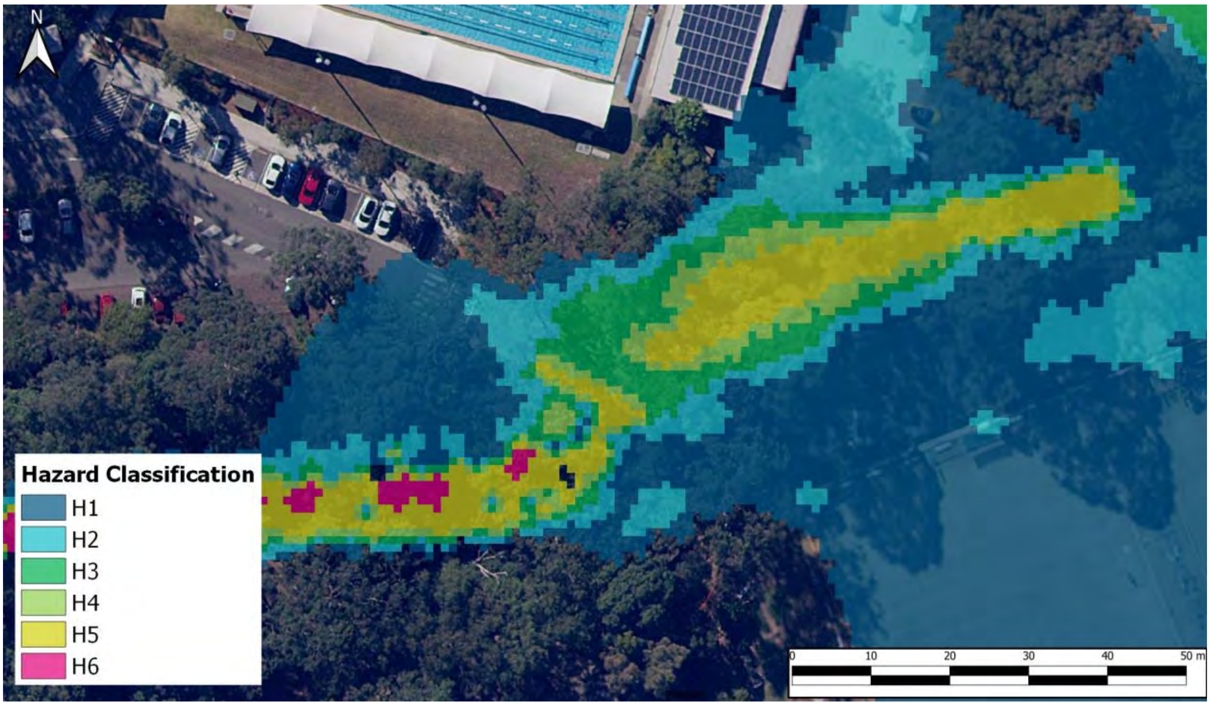


Figure 4-4 1% AEP Flood Hazard (Existing Case) – Fitness Centre Carpark

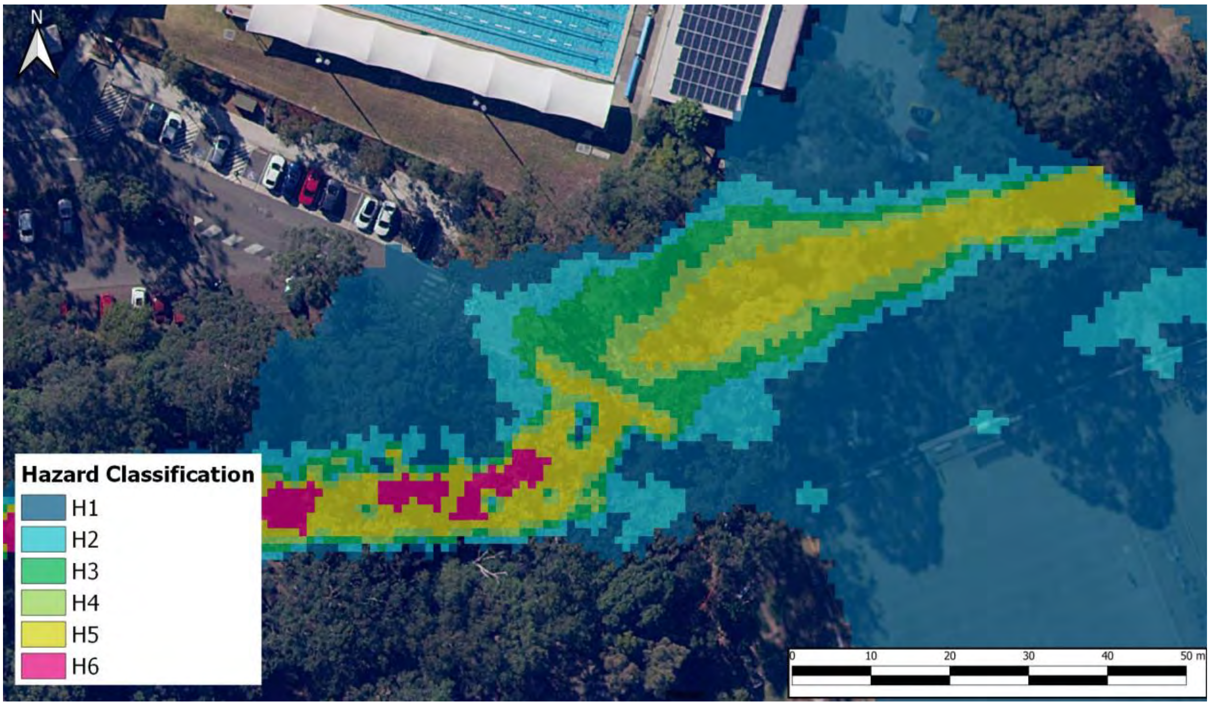


Figure 4-5 1% AEP Flood Hazard (Oval Bypass Case) – Fitness Centre Carpark

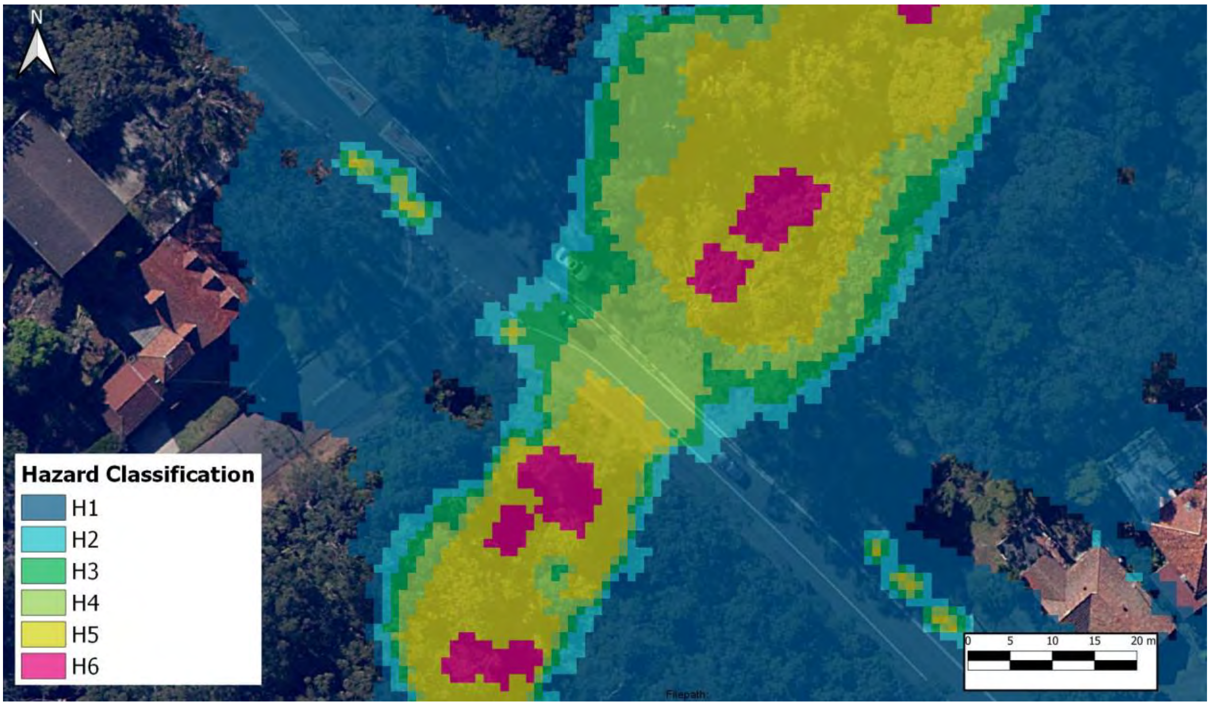


Figure 4-6 1% AEP Flood Hazard (Existing Case) – Yanko Road

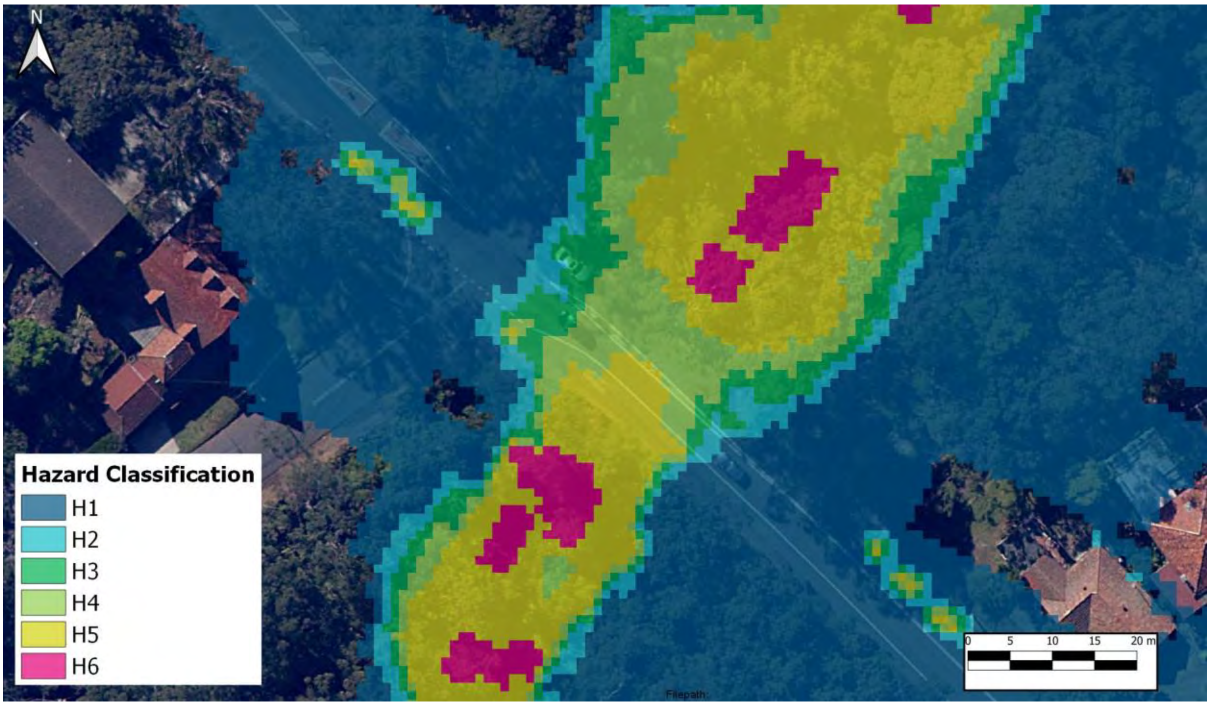


Figure 4-7 1% AEP Flood Hazard (Oval Bypass Case) – Yanko Road

4.3 Risk Mitigation Options

While the flood hazard curves and classifications identified in the section above may indicate that the hazard may be manageable, in practice flood hazard is highly variable and subject to a range of situational factors. Current best practice is to avoid entering flood waters wherever possible, and under no circumstances should floodwater be considered “safe”.

Risk Mitigation within the Quarry Creek catchment can be partially achieved through the use of effective flood warning systems. The area draining to Quarry Creek is small and heavily urbanised, with a critical duration (the time taken for peak flood conditions to occur) of 1 hour across much of the catchment. The rapid onset of flooding indicated by the catchment modelling suggests that in the event of a major storm event it would be both:

- Difficult to provide advanced flood warning to the public; and
- Unrealistic to expect emergency management assistance from the State Emergency Service (SES).

Risk Mitigation efforts should therefore be focussed on providing direct flood warning to the community at high hazard locations. As outlined above, much of the high flood hazard within the Quarry Creek catchment is localised within the channel itself, but high hazard flows will overtop the roadway at Yanko Road and within the Fitness Centre carpark. The installation of flood warning signs at these locations would help to notify the public of the potential dangers of road flooding during heavy rainfall. The use of automated flood warning signs in particular would have the added benefits of:

- Being activated when water levels within the channel reached a pre-determined height (which could be determined via the use of a water level sensor within the channel).
- Providing a realistic depth to sign viewers (without the need for the user to interpret the markers on a static sign).
- Having built in communication options such as SMS to alert Council to a change in road status.

Figure 4-8 shows a sample warning sign that could be installed at either of the locations. A typical sign set-up would include the water level sensor upstream of the road itself to provide the activation threshold and warning messages on the sign itself. For the less trafficable carpark area a static sign may be enough to deter facility users from entering or exiting the carpark during a flood event.

Figure 4-8 Example Automatic Flood Warning Sign

5 Flood Mitigation Works

5.1 Flood Mitigation Options

5.1.1 Flood Basin Options

Ku-ring-gai Council has proposed the use of a flood basin to mitigate against the increased flood levels and velocities downstream of Norman Griffiths Oval caused by the proposed upgrade. Three basin locations were considered as part of this assessment:

- The Lofberg Dog Oval;
- The park to the west of the West Pymble Guide and Scout Halls; and
- Bicentennial Park

Due to the steep catchment terrain within the Quarry Creek catchment, only shallow flows are observed at each proposed basin location; and therefore, extensive earthworks would need to be undertaken to create temporary flood storage large enough to offset the increases to flood affectation caused by the proposed oval upgrade.

Due to both its:

- Flat grade;
- Proximity to an anabranch of Quarry Creek; and
- Sizeable potential development area, Bicentennial Park was considered the most feasible and effective location for the construction of a flood detention basin.

Three Bicentennial Park flood basin options were investigated, with a varying depth adopted for each in order to provide Council with an understanding of the likely effect and cost posed by differing levels of earthworks. Details of the changes made to the TUFLOW model to represent the proposed Bicentennial Park flood basin are outlined in the following sections.

5.1.1.1 Bicentennial Park Flood Basin

The Bicentennial Park Flood Basin option involves excavation and regrading of the existing Bicentennial Park and the construction of a flood bund. The purpose of these works is to create a flood storage area for excess flows from the Quarry Creek tributary and detain those excess flows to reduce impacts caused by the Norman Griffiths Oval upgrade. In the TUFLOW flood model, 3100 m^2 of area was lowered and graded towards a discharge point at the south-west corner of the park where dual 600 mm wide outlet pipes discharging to Quarry Creek were included. A flood bund set to a height of 63.5 mAHD (0.5 m above the peak flood level observed upstream of the basin) was also included to prevent flows from discharging from the flood storage area.

3 separate lowering options were investigated:

- Basin Option 1 with a maximum ground level set at 62.9 mAHD (100 mm below the peak flood level of 63.0 mAHD observed upstream);

- Basin Option 2 with a maximum ground level set at 62.7 mAHD (300 mm below the peak flood level of 63.0mAHD observed upstream); and
- Basin Option 3 with a maximum ground level set at 62.3 mAHD (700 mm below the peak flood level of 63.0mAHD observed upstream).

The proposed extent of the Bicentennial Park Basin is shown in Figure 5-1 below.

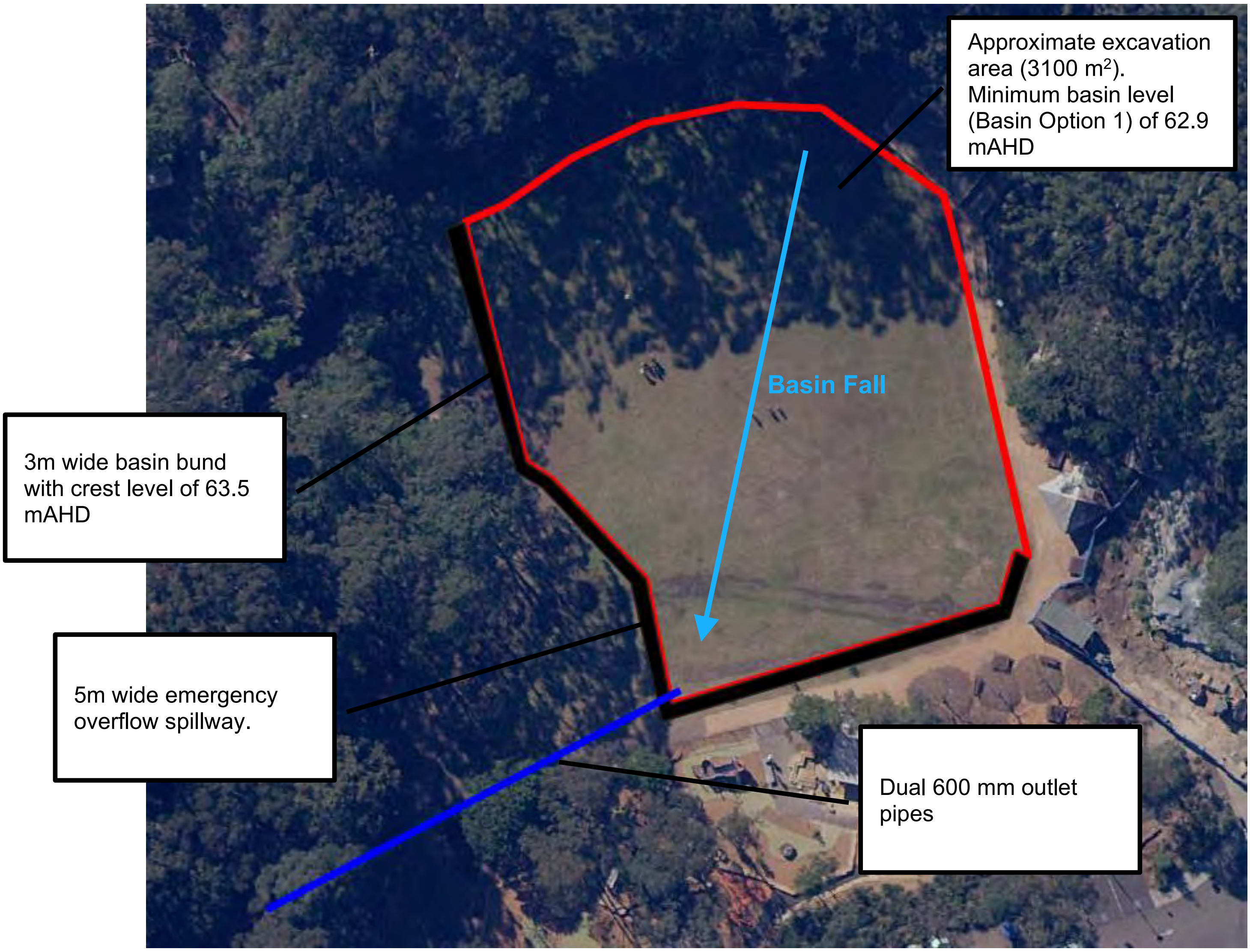


Figure 5-1 Proposed Bicentennial Park Flood Basin Layout

Flood results for the proposed Norman Griffiths Oval Upgrade with each of the Bicentennial Park Basin options are discussed in Section 5.2.

Estimated costs for each of the Basin Options (detailed in Appendix D) are as follows:

- Basin Option 1 - $941,477
- Basin Option 2 - $1,182,267
- Basin Option 3 - $1,730,163

The estimated costs are based on the assumption that the underlying material at the existing Bicentennial Park site is uncontaminated clean fill. The presence of contaminated material at the site (a possibility given Bicentennial Park rests on a former quarry site) could increase costs by a factor of 4 depending on the material type and the basin option utilised.

5.1.2 Creek Stabilisation Works

As outlined in Section 3.2, increases to peak flood levels and velocities within the Quarry Creek catchment occurring as a result of the proposed Norman Griffiths Oval Bypass, are primarily concentrated within the channel itself. The existing channel reach from the discharge point downstream of Norman Griffiths Oval to the culvert under Yanko Road is in poor condition, and the additional flows eventuating from the bypass of the previous flood basin on the oval has the potential to cause significant scouring and erosion along the length of this channel. This in turn may potentially cause heavy deposits of debris along Yanko Road in major storm events or worsening conditions in this area over time. Implementing creek stabilisation works in areas where high velocity are likely to be present (such as those indicated in Figure 5-2 below) would help to offset some of the potential damage caused by the flow increases occurring as a result of the bypass. While stabilisation works may not have a direct mitigating impact on increased flood levels in the region or further downstream, ensuring the continued function of the channel during major storm events will help to reduce the potential long-term impacts of the proposed design.

As part of this assessment, two creek stabilisation methods were considered: the use of gabion baskets and the use of check dams. These options are discussed in more detail below.

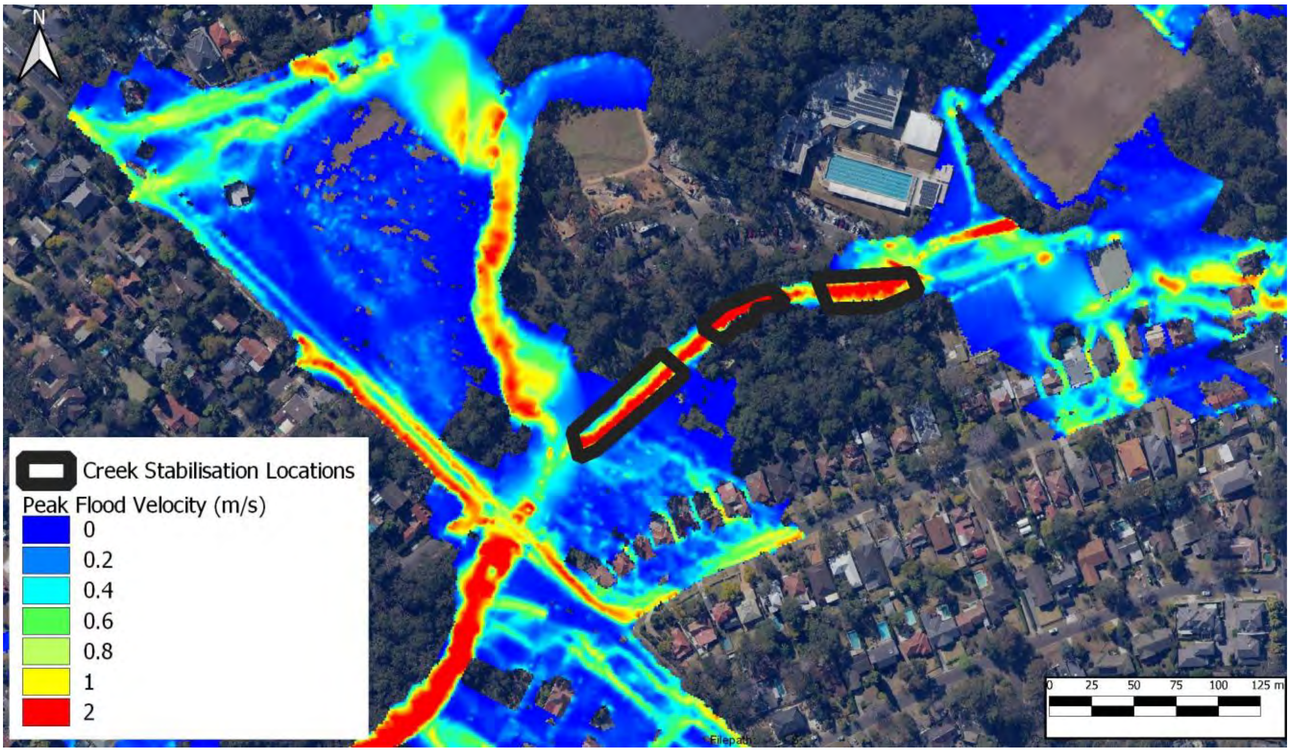


Figure 5-2 Indicative Creek Stabilisation Extent

5.1.2.1 Gabion Baskets

A gabion basket is a wire cage filled with rocks or other heavy earth material. They are often used as erosion control measures along river banks, as their solid free draining structure helps to dissipate high velocity flows within the stream. These slowed streams are then in turn less likely to erode the outer bank of the channel.

Installation of gabion baskets along both sides of the channel to a height equivalent to the 100-year ARI event plus 0.5 m will help to protect against the increased possibility of erosion as a result of the field bypass. A typical gabion basket is 0.5 m x 0.5 m and 1.0 m high. Based on typical cross-sections along the length of the reach it is likely that 8 gabion baskets (4 on each side) would need to be stacked together to offer protection in rare events. An example of gabion baskets installed on Dairy Creek in Mortdale is shown in Figure 5-3 below.

Figure 5-3 Gabion baskets installed along Dairy Creek

It should be noted that while gabion baskets are effective, they are prone to both durability and vandalism issues. It is also noted that Ku-ring-gai Council have indicated a preference to utilise more “natural” creek stabilisation works in the area and that the use of larger rock retardants (such as sandstone blocks) would be preferable. The inclusion of Gabion Baskets in this report aims to provide Council with an understanding of the typical costs for the installation of a “cheaper” erosion control measure along the potential length of waterway that may be required to offset the velocity increases caused by the Oval upgrade. It can be assumed that the installation of sandstone blocks along the same length would have a significant cost increase (although would greatly increase durability of the solution. The costs for the installation of Gabion Baskets along the 180 m of high velocity area identified in Figure 5-2 are $799,200. Detailed costings are outlined in Appendix D.

5.1.2.2 Check Dams

Check dams are small dam structures constructed across a channel intended primarily to temporarily dam stream flows in order to slow down flow velocities. This helps to reduce the chance of erosion within the channel and has the added benefit of controlling the movement of sediment. Check dams can be engineered to fail downstream during rare events, can be formed of natural materials and over time can become a natural home to animals within the channel ecosystem.

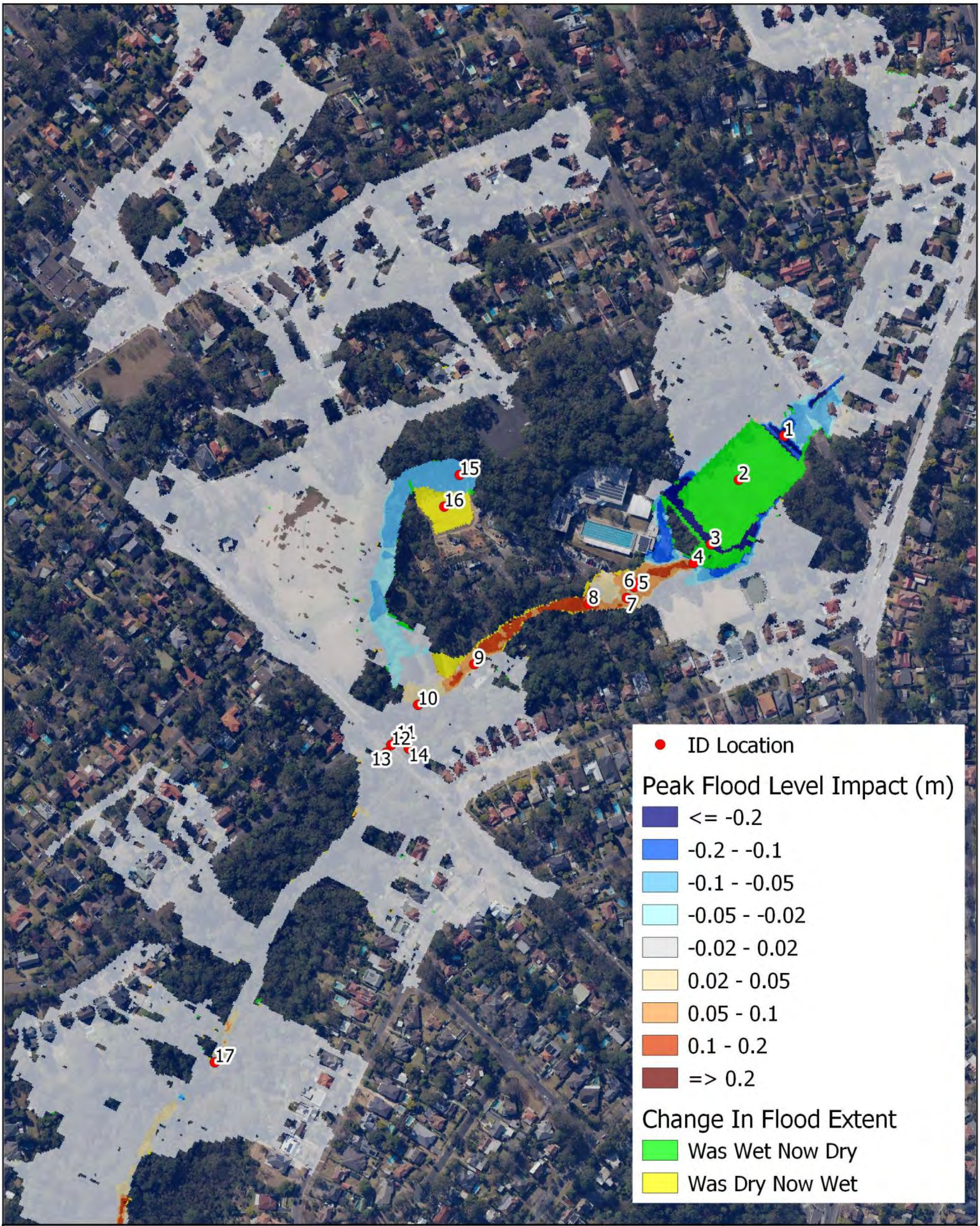
Installation of check dams could be combined with other creek stabilisation measures along the length of the channel, including retards, riffles, geofabric, planting and rock mattresses. Costing would be on a time and materials basis, but determination of either is difficult to quantify at this preliminary stage. As an initial estimate, extensive creek stabilisation works inclusive of check dams would cost around $2 million.

5.2 Flood Basin Mitigation Option Results

The revised Norman Griffiths Oval TUFLOW flood model has been used to test the oval upgrade option with the proposed Bicentennial Park basins outlined above. These results are then used to derive the change in peak flood levels.

Peak flood level and depth, and afflux diagrams are presented in Appendix C – Basin Options, highlighting the change in peak flood level for the design events simulated. These diagrams show the change between flood conditions resulting from the proposed oval upgrade with the inclusion of the Bicentennial Park basin, and existing conditions. They are useful for presenting the magnitude and extent of potential flood impacts associated with the proposed mitigation options. The following impact results are presented below:

- Figure 5-4 – 1% AEP Bypass with Basin Option 3 Change in Peak Flood Level



Title:

1% AEP Peak Flood Level Impact - Oval Bypass Design With Basin Option 3

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Peak water levels have been extracted from a number of point locations around the study area for the “Existing” and “Basin Option” mitigation scenarios (refer to Figure 5-4 for locations) for the 5% AEP and 1% AEP flood events in Table 5-1 below.

Table 5-1 Peak Flood Level Results

ID (refer Figure 5-4)	Existing Conditions (m AHD)		Basin Option 1 (m AHD)		Basin Option 2 (m AHD)		Basin Option 3 (m AHD)	
	5% AEP	1% AEP	5% AEP	1% AEP	5% AEP	1% AEP	5% AEP	1% AEP
1	72.6	72.7	72.2	72.3	72.2	72.3	72.2	72.3
2	71.2	71.3	N/A	N/A	N/A	N/A	N/A	N/A
3	70.8	70.9	70.1	70.2	70.1	70.2	70.1	70.2
4	66.1	66.2	66.2	66.3	66.2	66.3	66.2	66.3
5	65.4	65.5	65.5	65.6	65.5	65.6	65.5	65.6
6	65.4	65.5	65.4	65.5	65.4	65.5	65.4	65.5
7	63.2	63.3	63.3	63.4	63.3	63.4	63.3	63.4
8	60.3	60.3	60.3	60.4	60.3	60.4	60.3	60.4
9	56.9	56.9	56.9	57	56.9	57	56.9	57
10	54	54.3	54.1	54.3	54.1	54.3	54	54.3
11	54	54.2	54.1	54.3	54	54.3	54	54.3
12	54	54.2	54	54.3	54	54.2	54	54.2
13	53.8	54	53.9	54.1	53.9	54.1	53.9	54.1
14	54	54.2	54.1	54.3	54.1	54.3	54	54.3
15	62.7	62.9	62.7	62.8	62.6	62.8	62.5	62.8
16	N/A	N/A	62.5	62.7	62.5	62.8	62.5	62.8
17	38.2	38.5	38.4	38.6	38.4	38.5	38.3	38.6
18	17.2	17.5	17.3	17.6	17.3	17.5	17.3	17.5

Modelling indicates that for all events the Basins act to store overflow from the Quarry Creek channel north of Bicentennial Park. Shallow flows overtop the lowered ground levels and fill the park basin before eventually discharging to Quarry Creek via the basin outlet.

Across all modelled events, the Basin options will act to reduce the flood level increase caused by the Bypass Option immediately upstream and downstream of Yanko Road. However, it is noted that:

- The Basin Options will not reduce flood levels along the channel reach between Norman Griffiths Oval and Yanko Road.
- The flood detention effects of even Basin 3 (which provides the most flood storage of all the options) will not fully offset the increases caused by the Bypass Option.

As a result, even with the Basin mitigation options included the proposed oval bypass will still cause an afflux to flood behaviour downstream of the discharge point. Of the basin options investigated, only Basin 3 will prevent an increase to flood levels at 51 Kamilaroy Road. It is likely that further excavation of the oval will help to further alleviate flood level increases, but there is a strong possibility that the significant additional expense would produce quickly diminishing returns.

To minimise the effects of the proposed oval upgrade, the use of flood basins may need to be employed in conjunction with the creek stabilisation works outlined above in order if Council wishes to provide mitigation against the effects of the bypass across all affected areas of the catchment.

6 Conclusions

The objective of this report was to assess the impacts of the proposed Norman Griffiths Oval upgrade (including changes to flood affectation and increases to flood risk in the catchment) and to develop mitigation options to offset these increases. Central to this assessment was the use of a hydraulic flood model of the Quarry Creek catchment to quantify existing, post-development and post-mitigation flood conditions and impacts. Preliminary costings for the proposed mitigation options were also undertaken.

In completing the Norman Griffiths Oval Flood Risk Assessment, the following activities were undertaken:

- The existing TUFLOW model was updated to better reflect conditions in the whole of the Quarry Creek catchment. Model updates included changes to topography and the selected critical storm duration. Design flood conditions were re-established using the 'existing scenario' (reflective of existing conditions) and 'oval upgrade scenario' (inclusive of Council's preferred upgrade option for Norman Griffiths Oval) for the 0.2 EY, 10% AEP, 5% AEP, 2% AEP and 1% AEP design storm.
- The 'oval upgrade scenario' TUFLOW model was further updated to establish 'oval upgrade plus basin scenario' models (inclusive of Council's preferred upgrade option for Norman Griffiths Oval and 3 flood detention basin options within Bicentennial Park). Model updates included changes to topography and the 1D network and the model was run for the 0.2 EY, 10% AEP, 5% AEP, 2% AEP and 1% AEP design storm for all 3 models.
- Comparison of the 'existing scenario', 'oval upgrade scenario' and 'oval upgrade plus basin scenarios' design flood levels was undertaken. In general, increases to flood levels downstream and immediately upstream of Yanko Road as a result of the bypass (shown in the 'oval upgrade scenario') were offset by the inclusion of a flood basin (shown in the 'oval upgrade plus basin scenarios') but increases between the Fitness Centre carpark and Yanko Road were generally not.
- A detailed assessment of increases to flood hazard as a result of the development was undertaken and flagged that the proposed oval upgrade was likely to increase flood hazard in areas where high hazard was already present. While this increase was unlikely to impact on the usage of these areas, it was recommended that warning signs be installed in these areas to provide the community with an understanding of the existing flood risk.
- Creek stabilisation options for the stretch of channel between the Fitness Centre carpark and Yanko Road were discussed, with specific mention of the use of gabion baskets and check dams. It is recommended that some creek stabilisation works be undertaken along the channel reach offset the increases caused by the bypass, but acknowledged that costs associated with installation of stabilisation works along the entire creek length may be prohibitive.
- A preliminary cost estimate was supplied for the 3 basin options, the installation of Gabion Baskets along high velocity areas in the channel and the installation of check dams and other creek stabilisation works over the course of several days. These costs are included as Appendix D.

The principal outcome of the report is the recommendation that Council considers the installation of flood warning signs in the Fitness Centre carpark and along Yanko Road, and the potential flood impact and implications of scouring that may be caused by the oval upgrade.

The next steps to be undertaken will consist of consultation with stakeholders. If Council wishes to pursue a basin mitigation strategy, a series of due diligence studies including:

- Geotechnical;
- Contamination;
- Utilities;
- Heritage (including Aboriginal heritage);
- Ecology;
- Dam failure consequence assessment; and
- Dam failure risk assessment, are recommended.

A Review of Environmental Factors (REF) will also likely be required prior to construction.

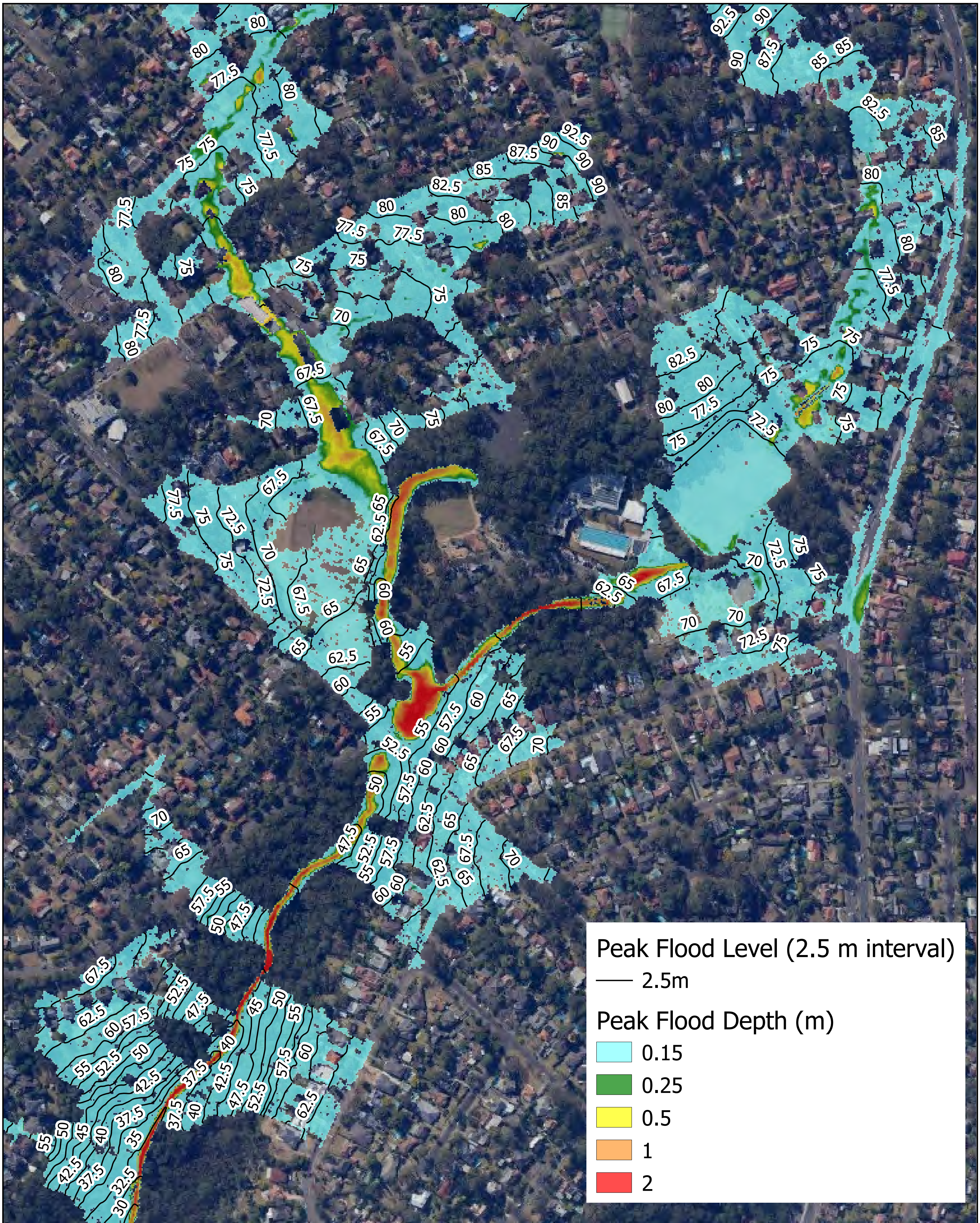
7 References

Australian Institute for Disaster Resilience (2017) Australian Disaster Resilience Handbook Collection Flood Hazard Guideline 7-3

Jacobs (2017). Norman Griffiths Oval Flood Assessment, Prepared for Ku-ring-gai Council.

Rawlinsons (2019). Construction Cost Guide 2019 For housing, small commercial and industrial buildings, Edition 27, Perth W.A.

Appendix A Existing Flood Conditions



Title:

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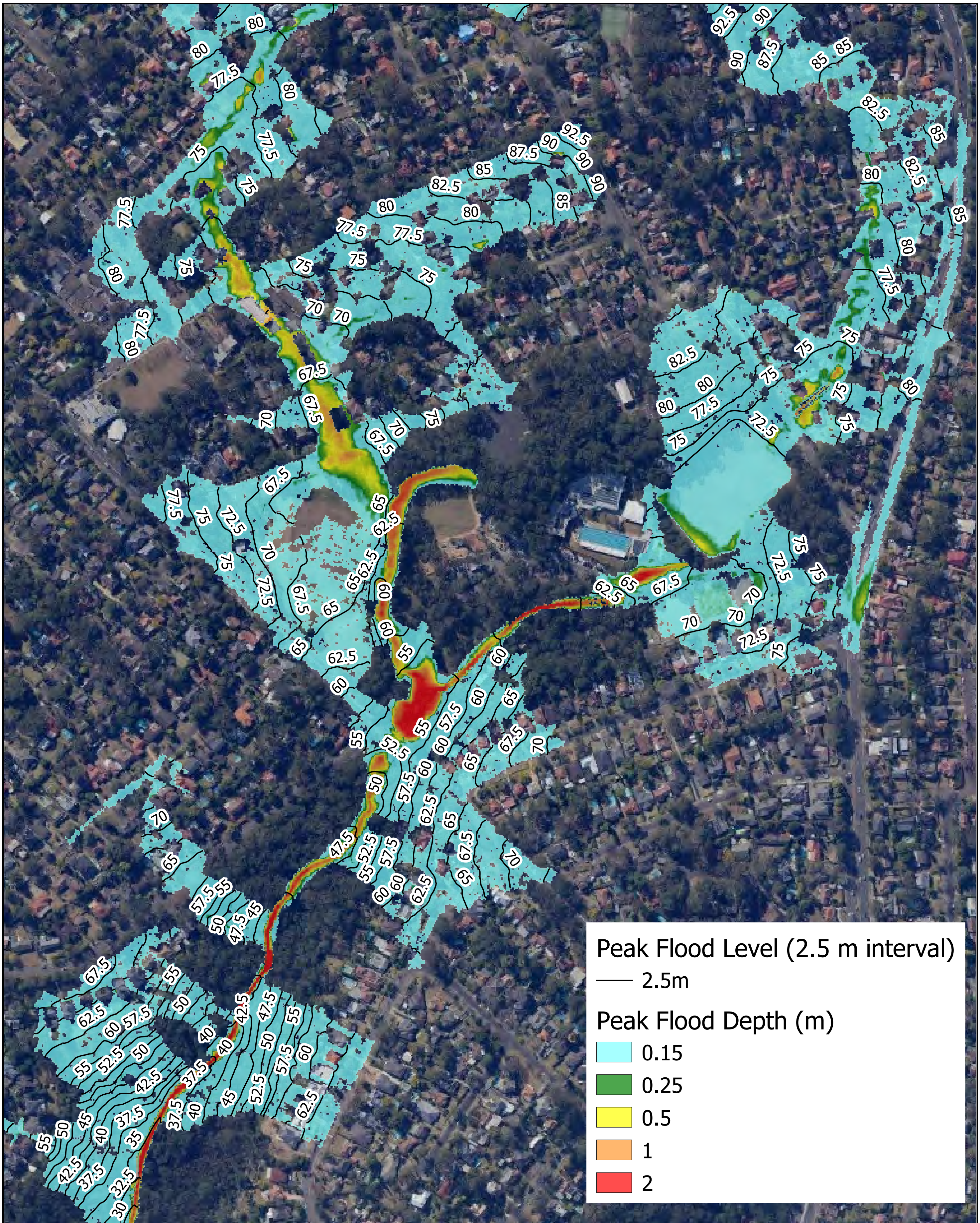

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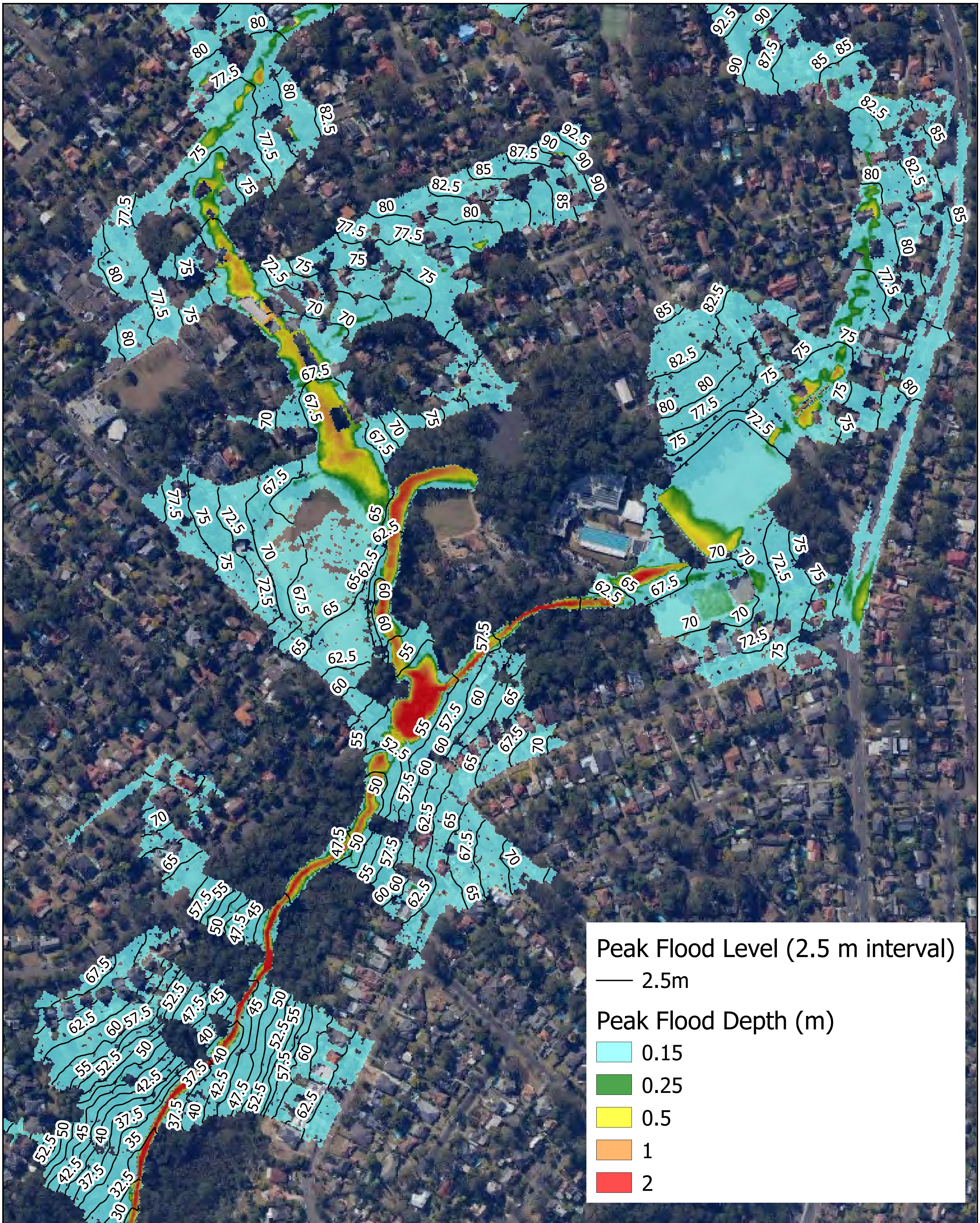

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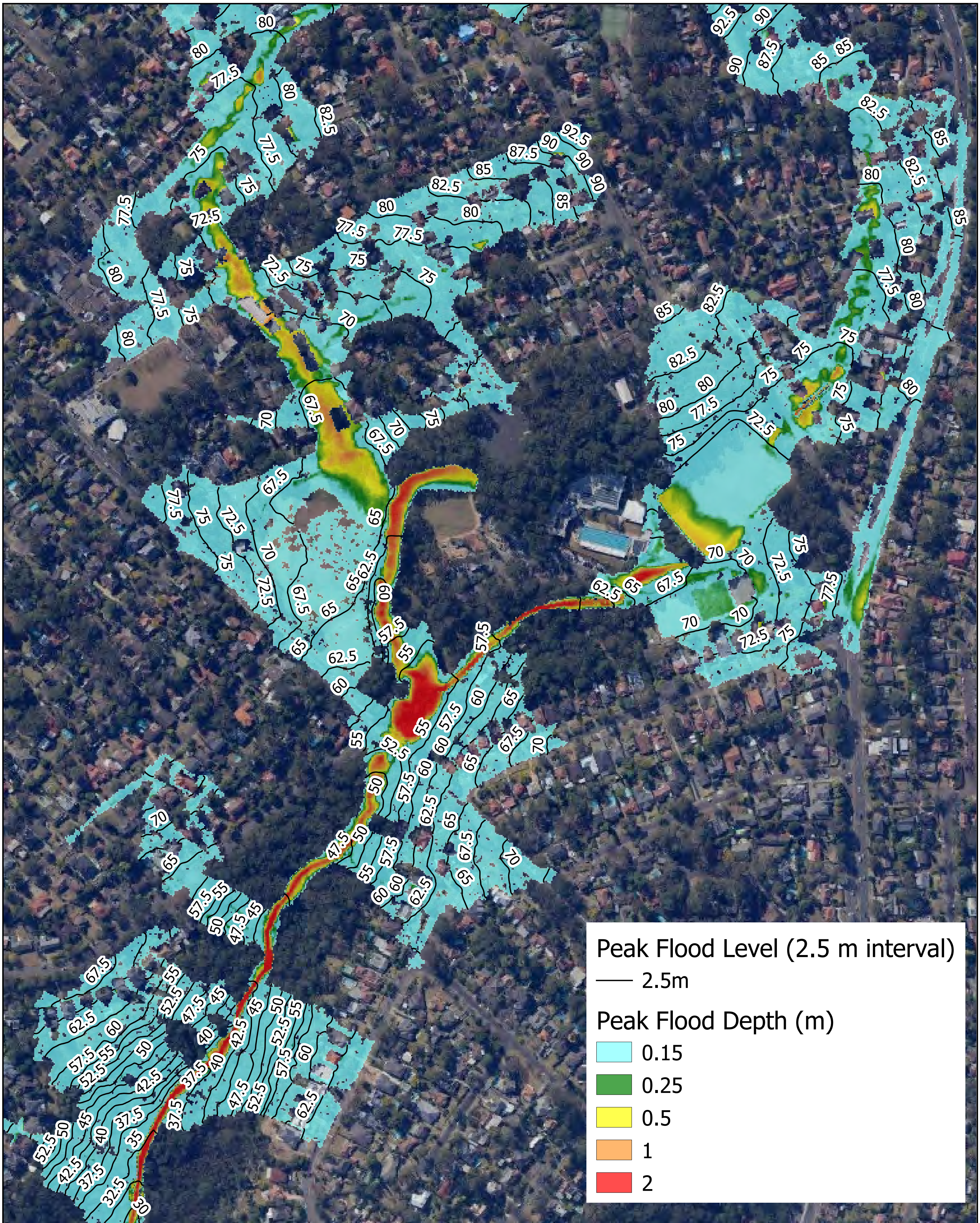

Title:

2% AEP Peak Water Level and Depth - Existing Case

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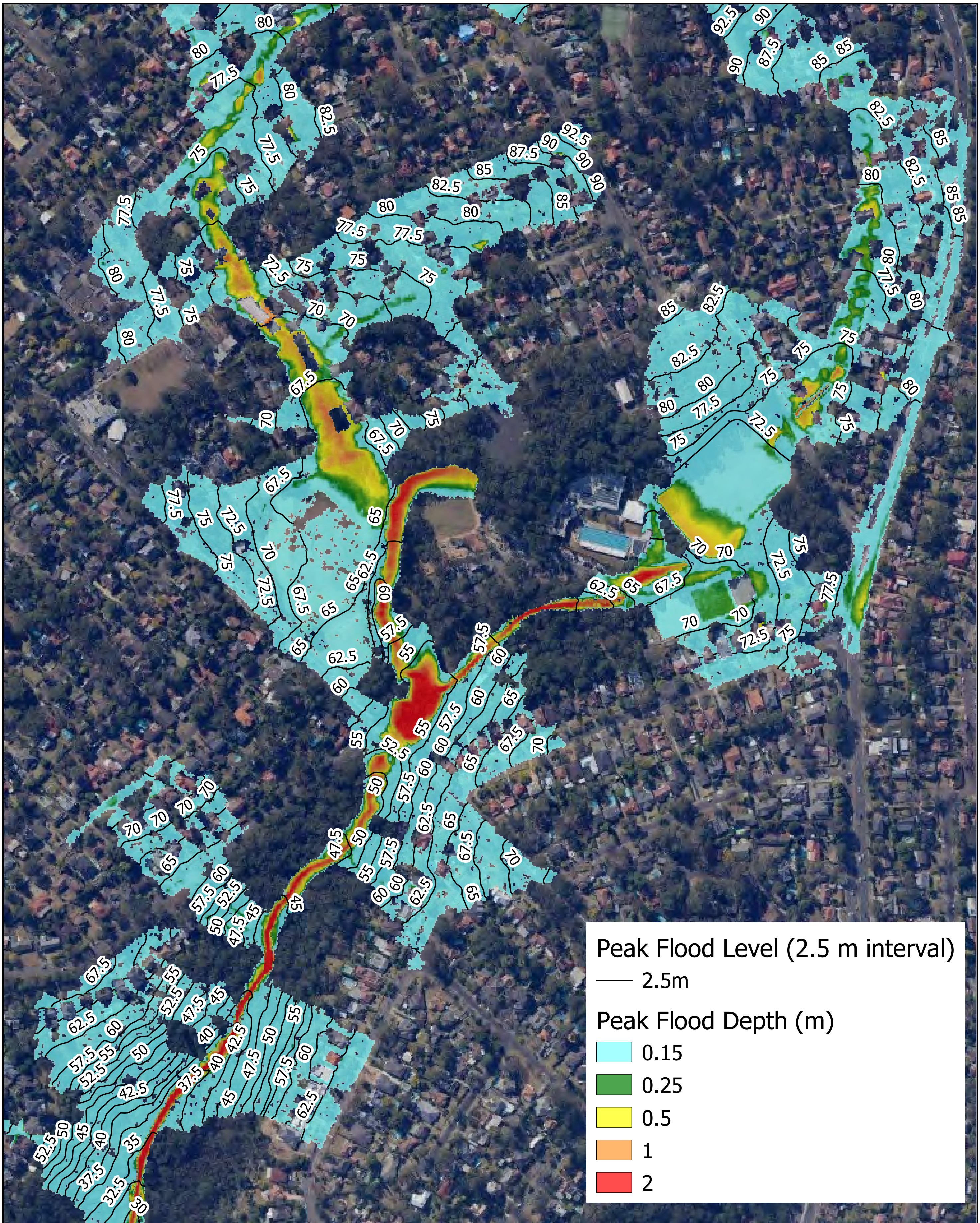

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1% AEP Peak Water Level and Depth - Existing Case

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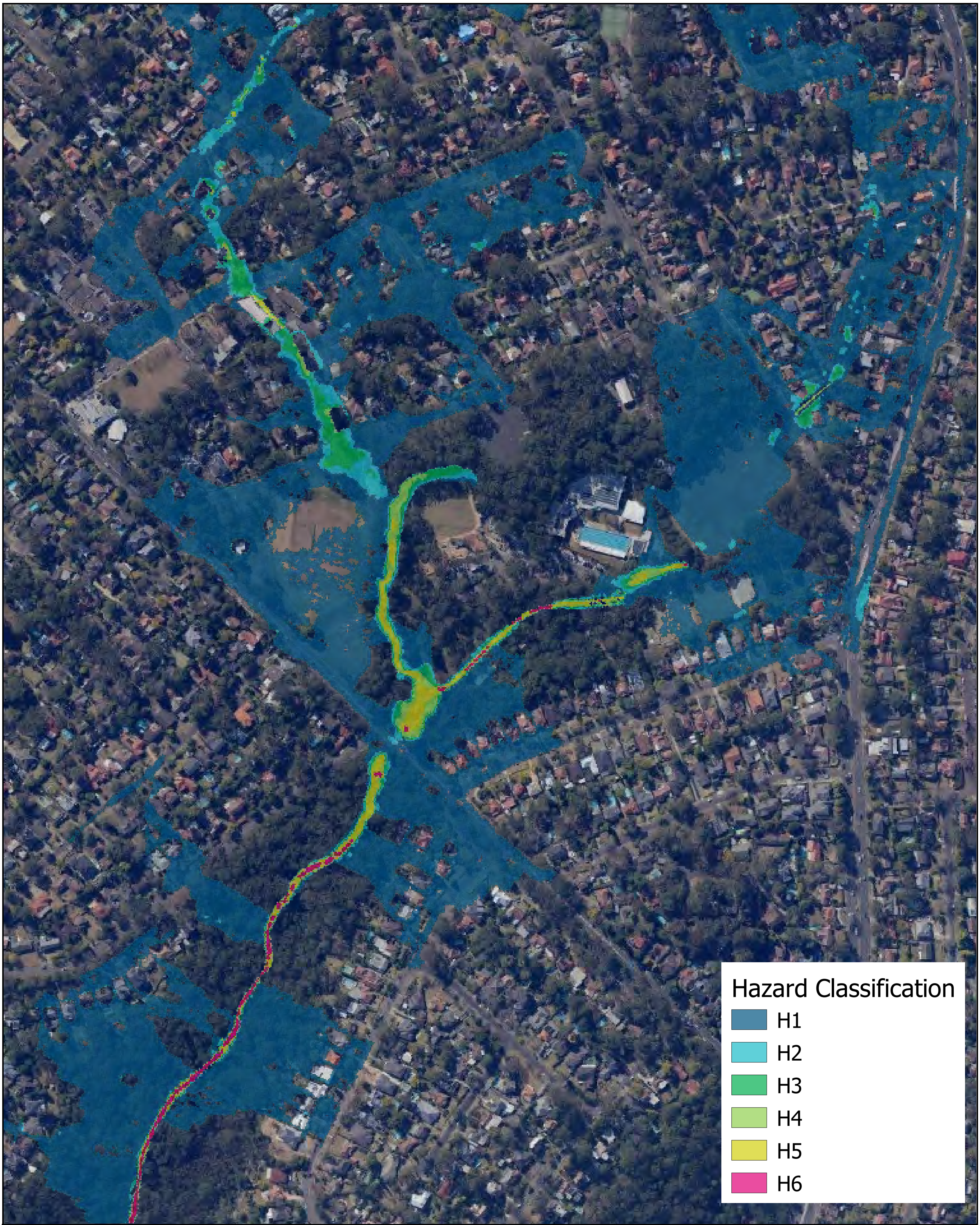

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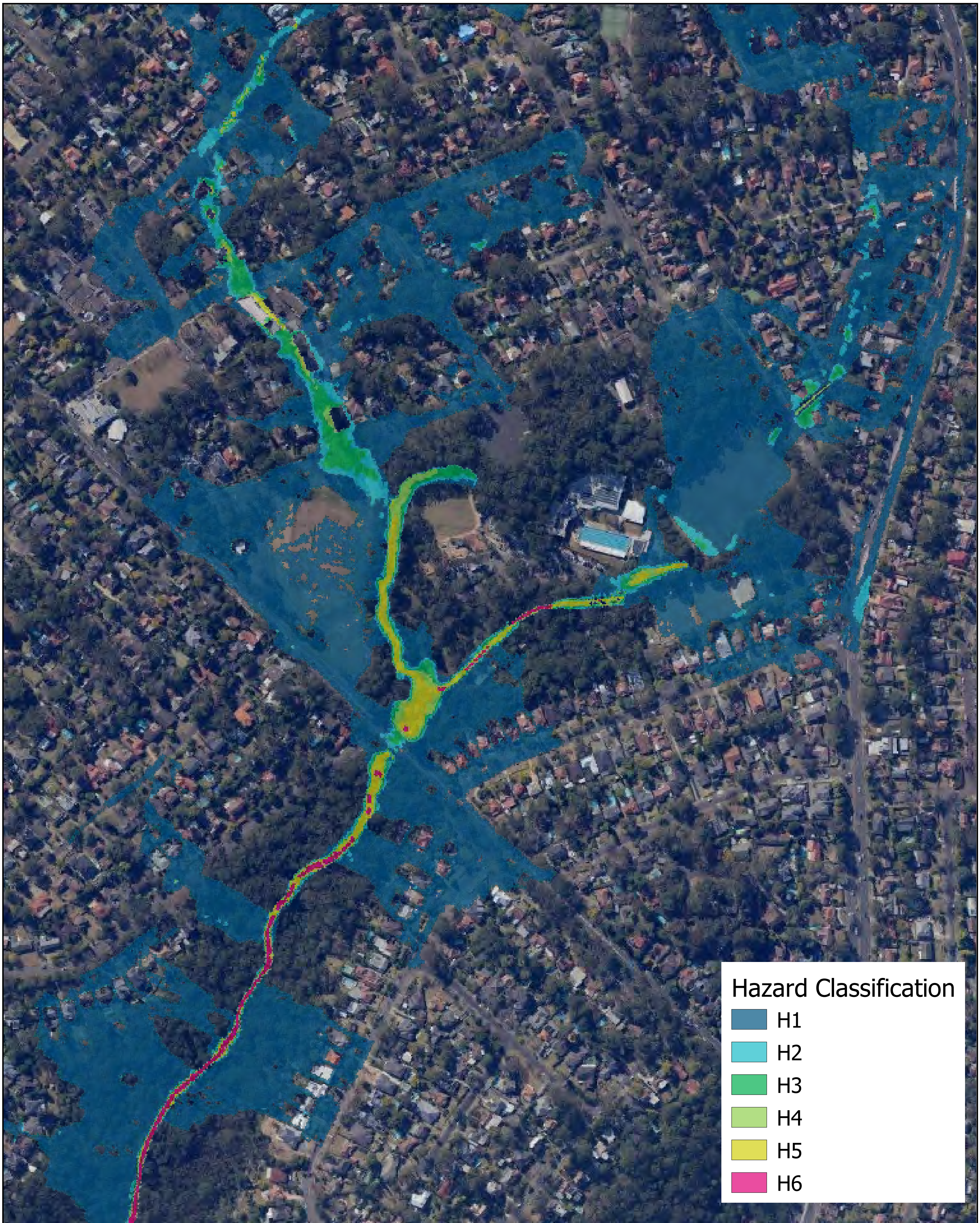

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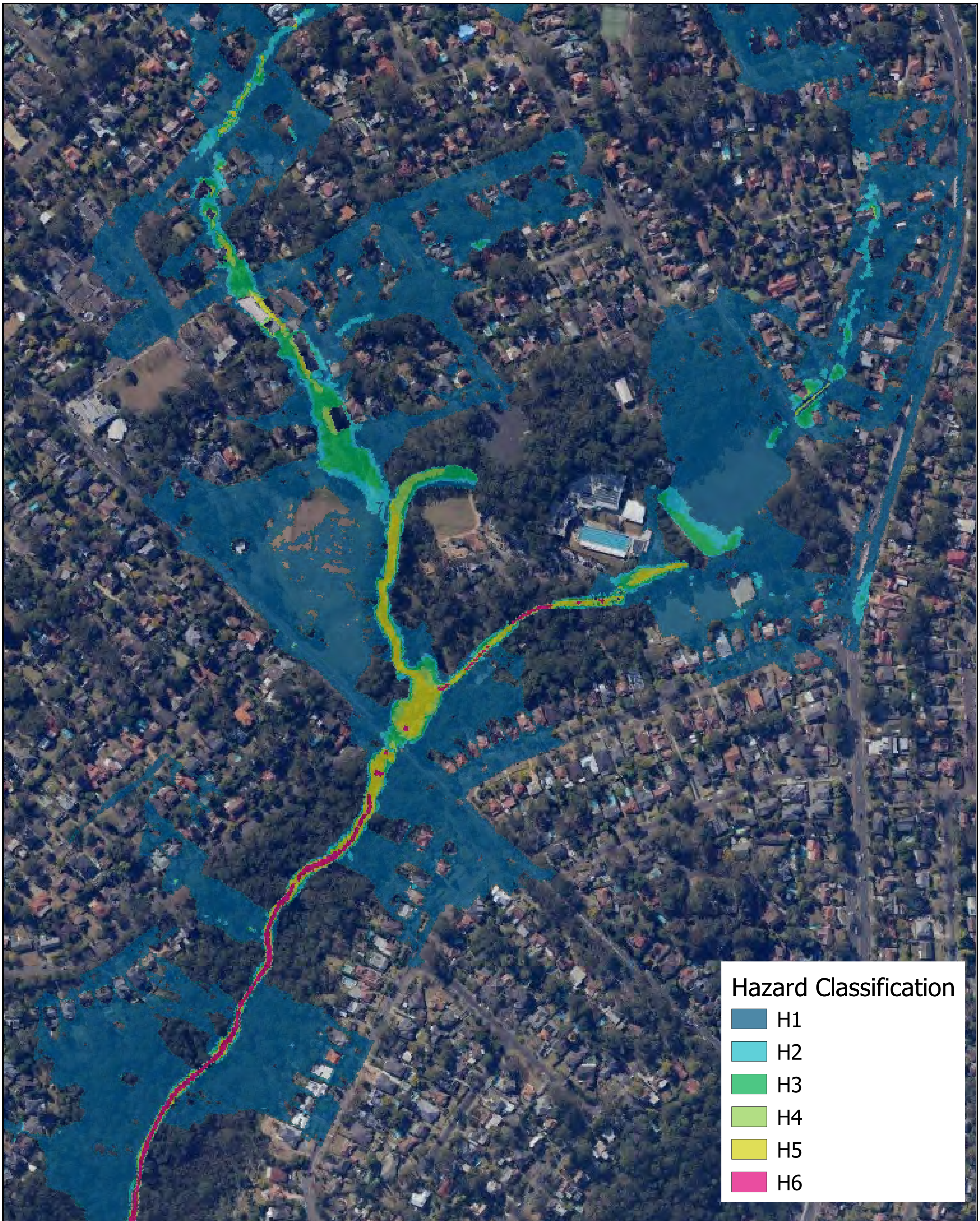

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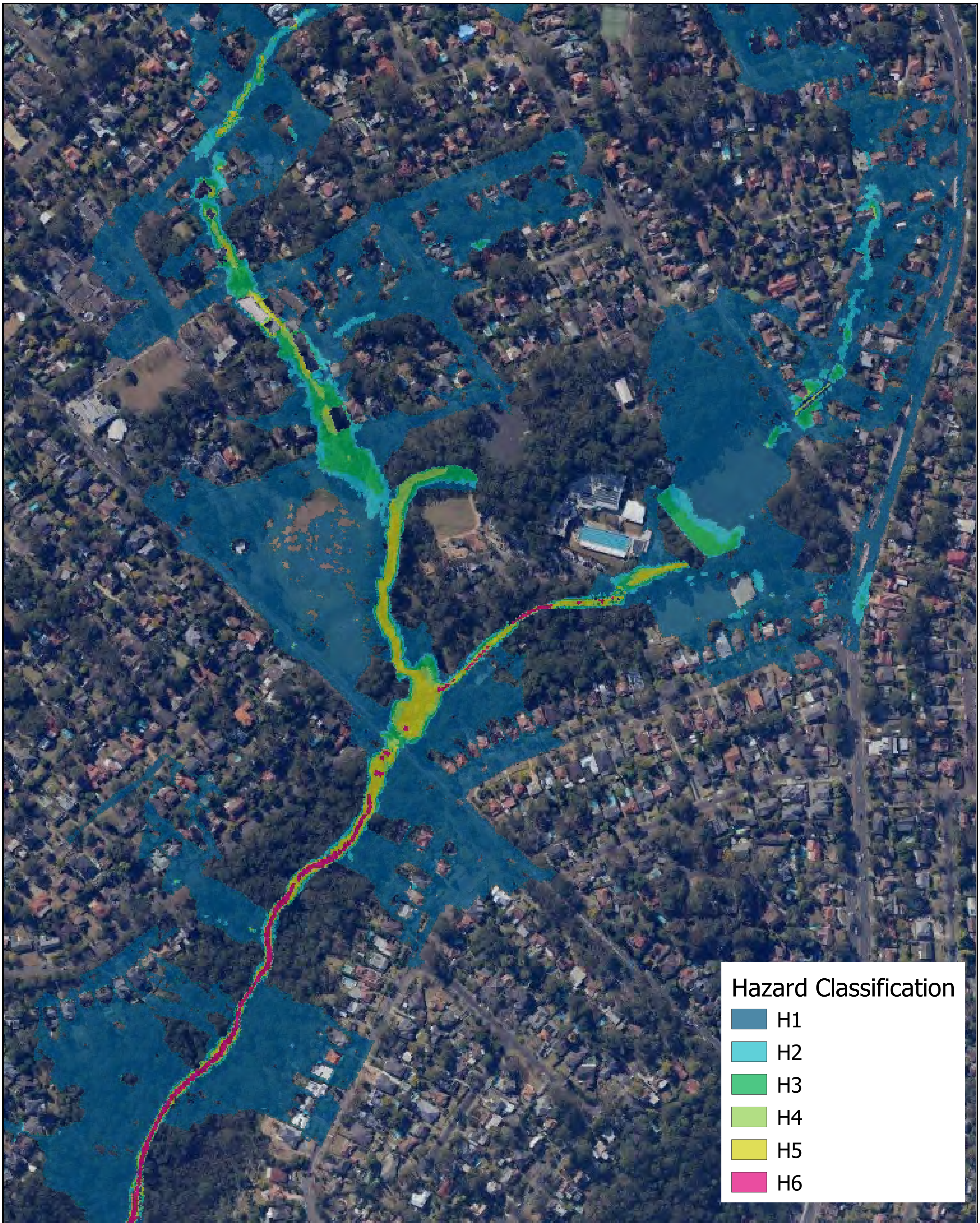

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1% AEP Flood Hazard - Existing Case

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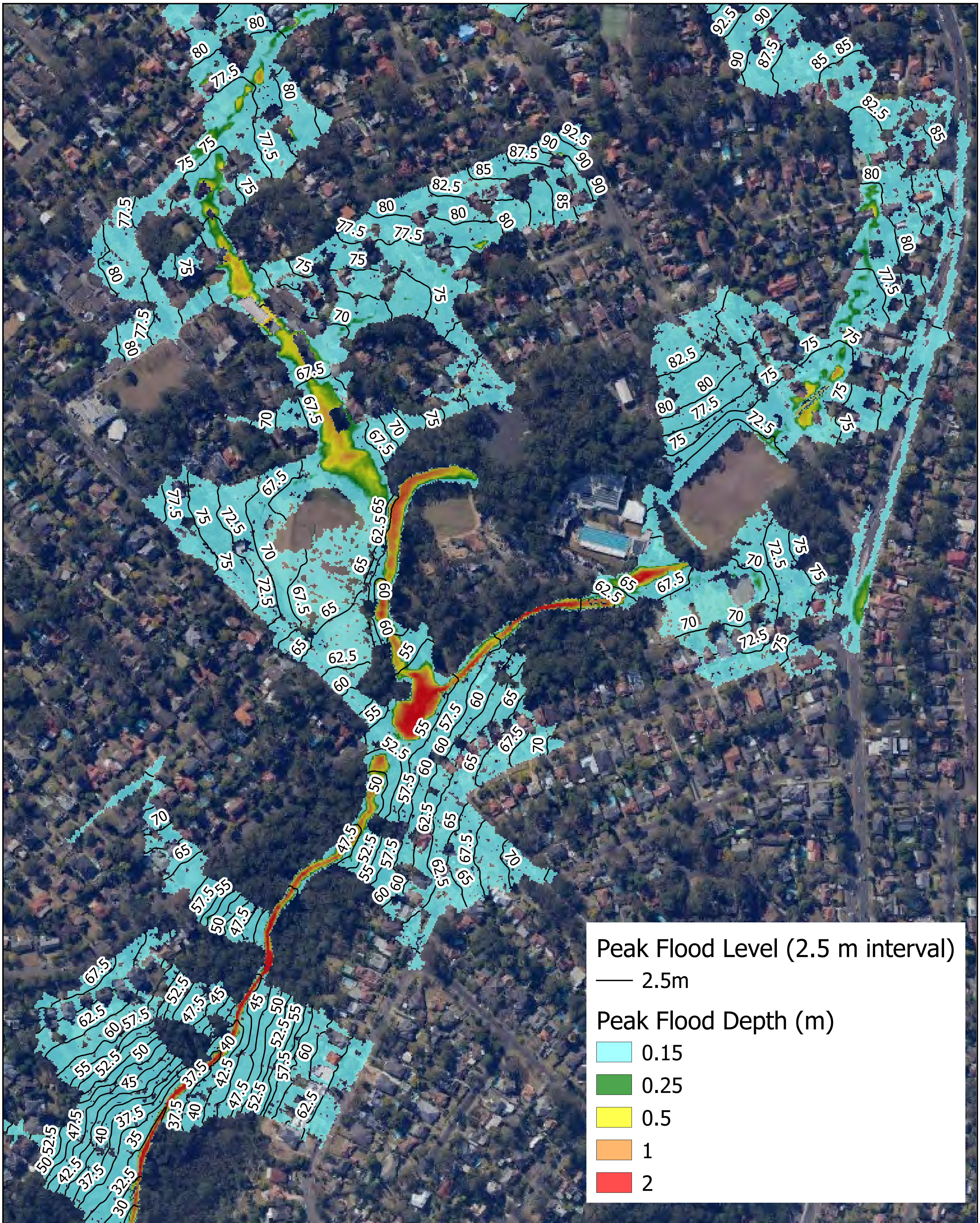
Appendix B Oval Upgrade



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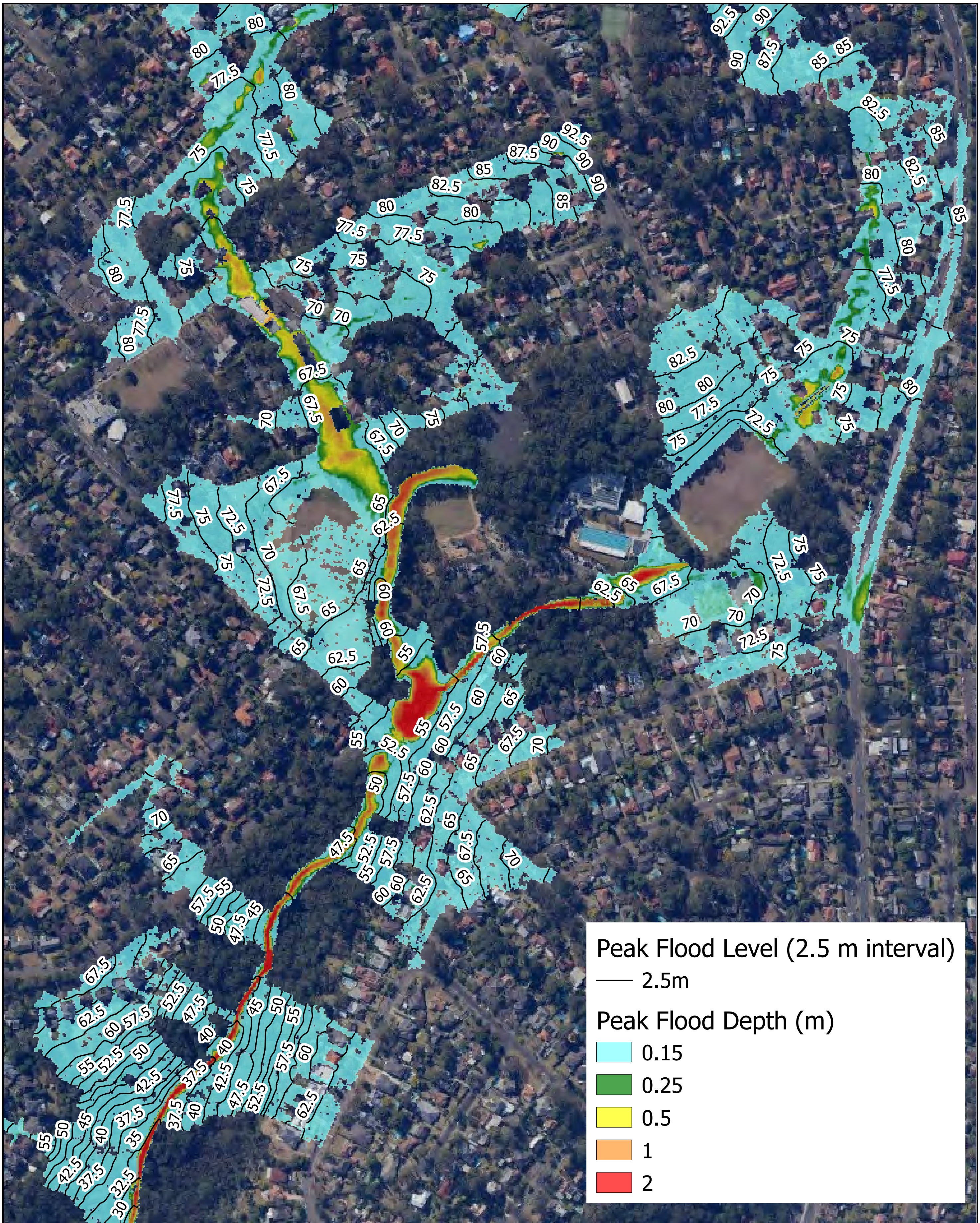

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10% AEP Peak Water Level and Depth - Oval Bypass Design

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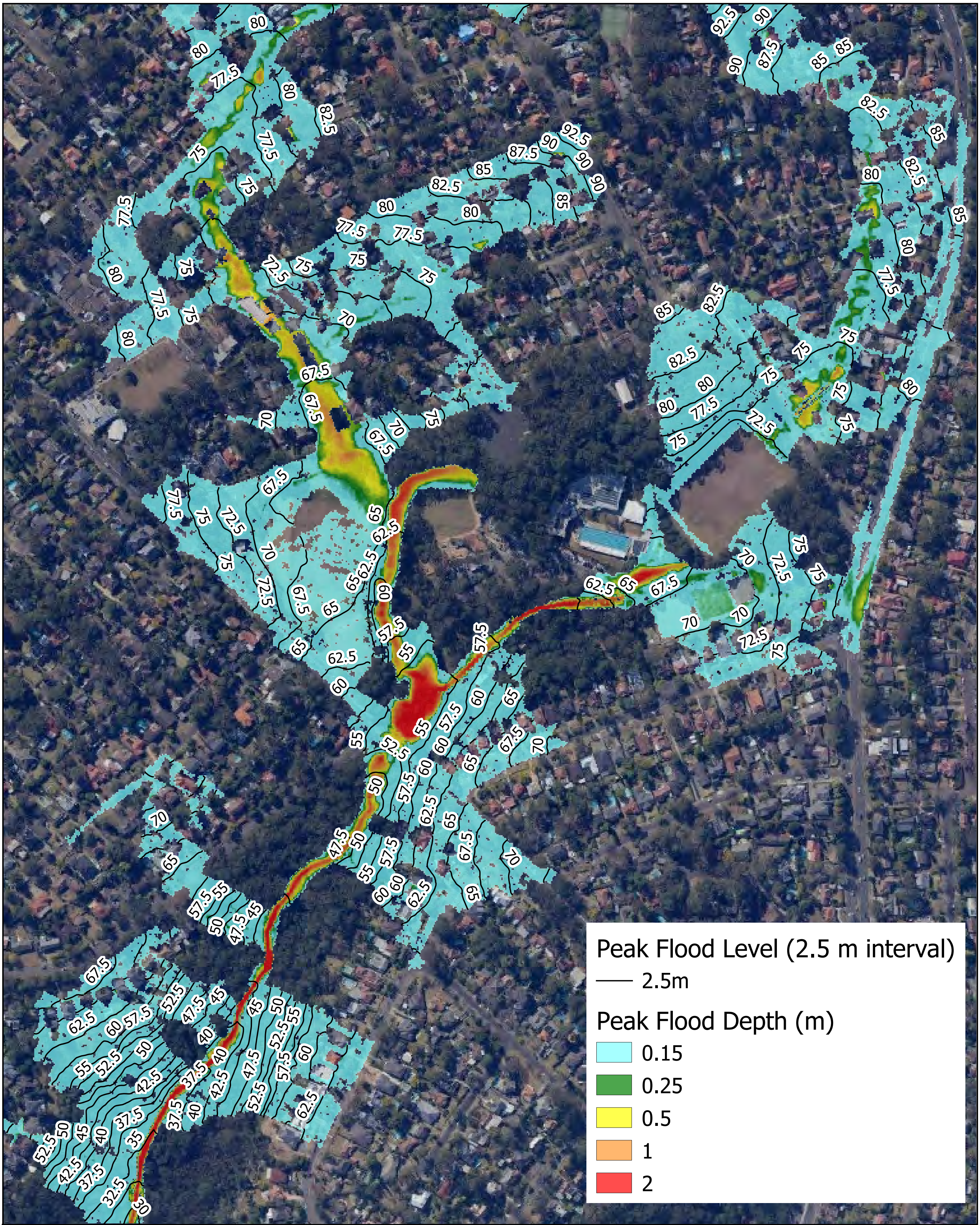

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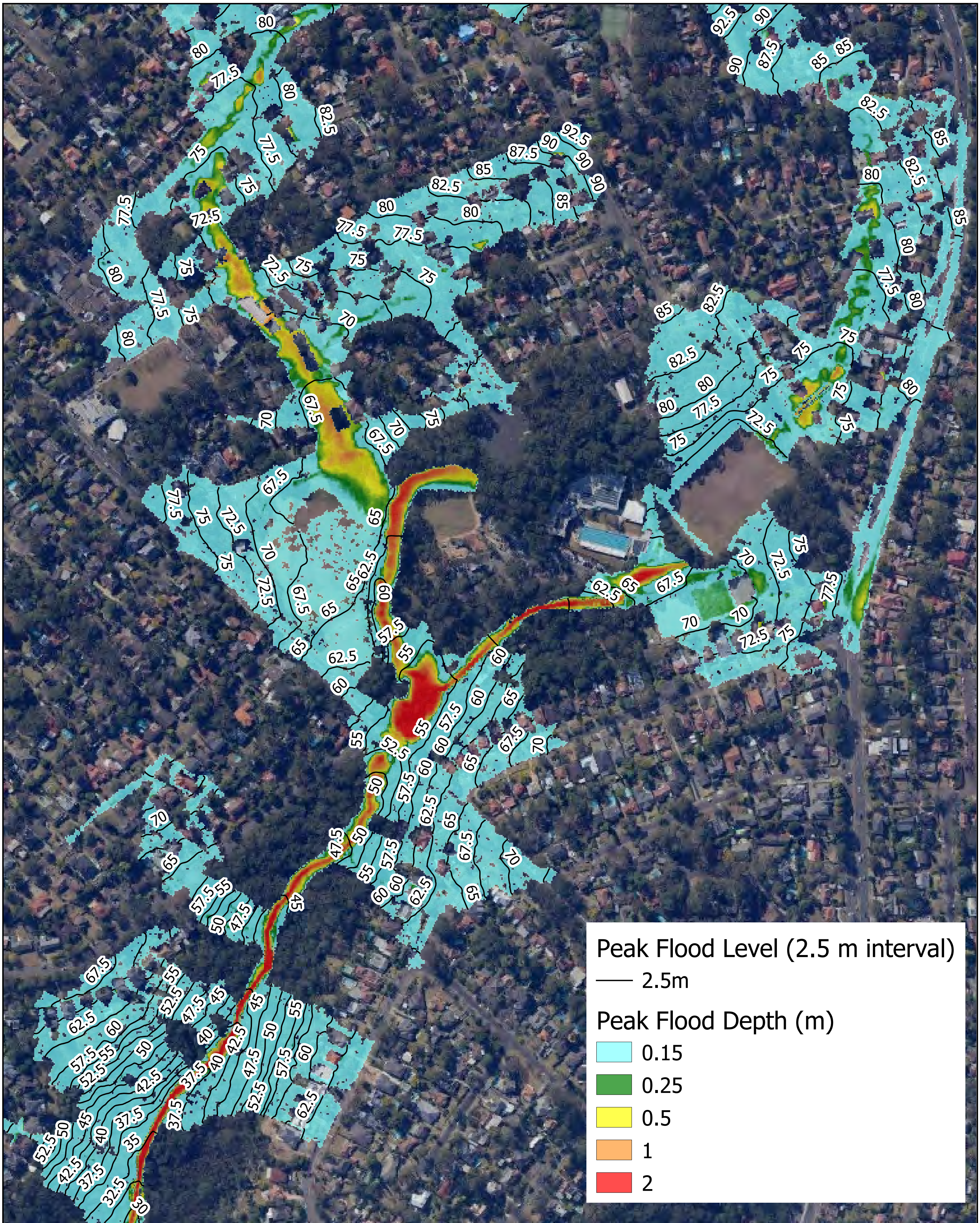

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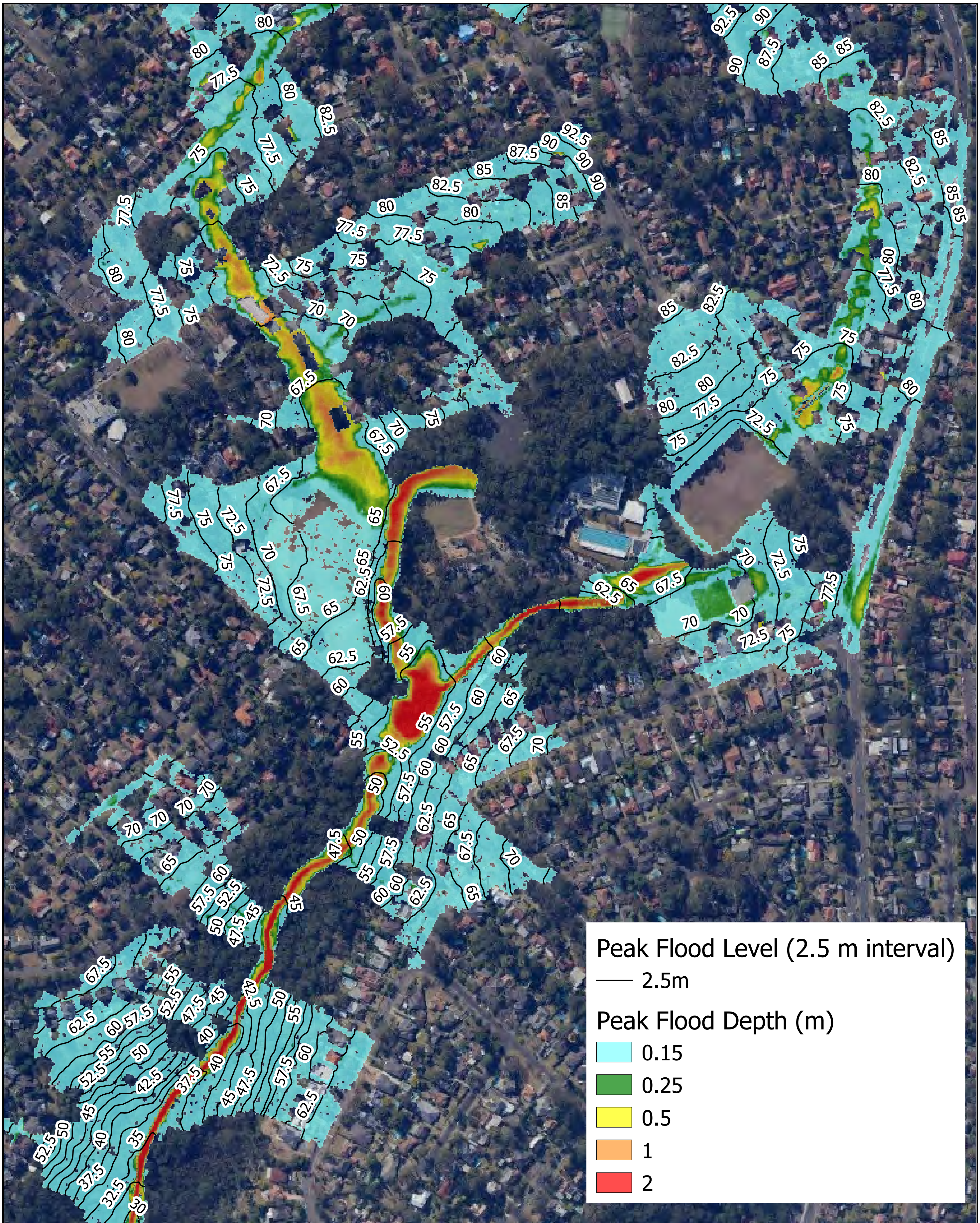

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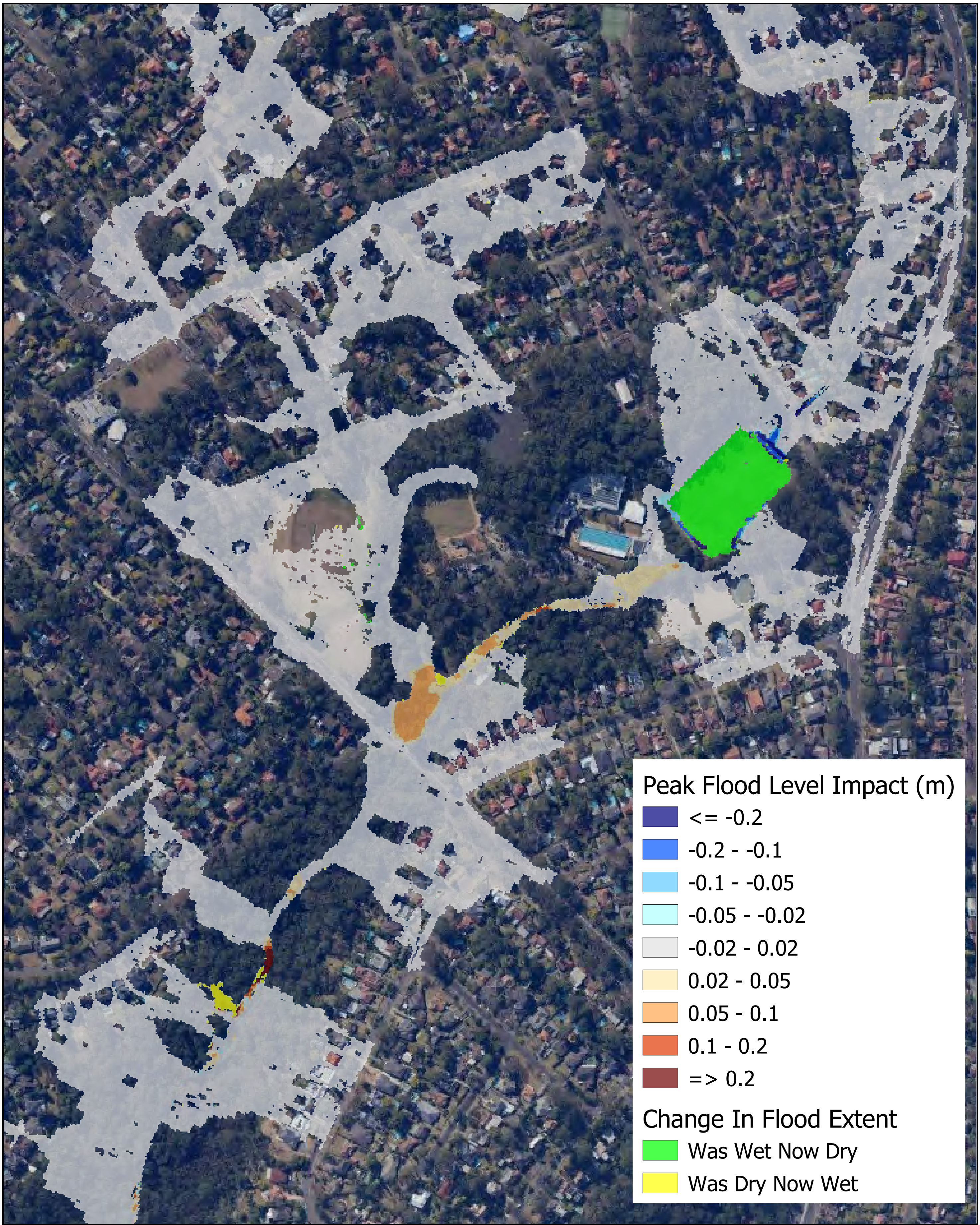

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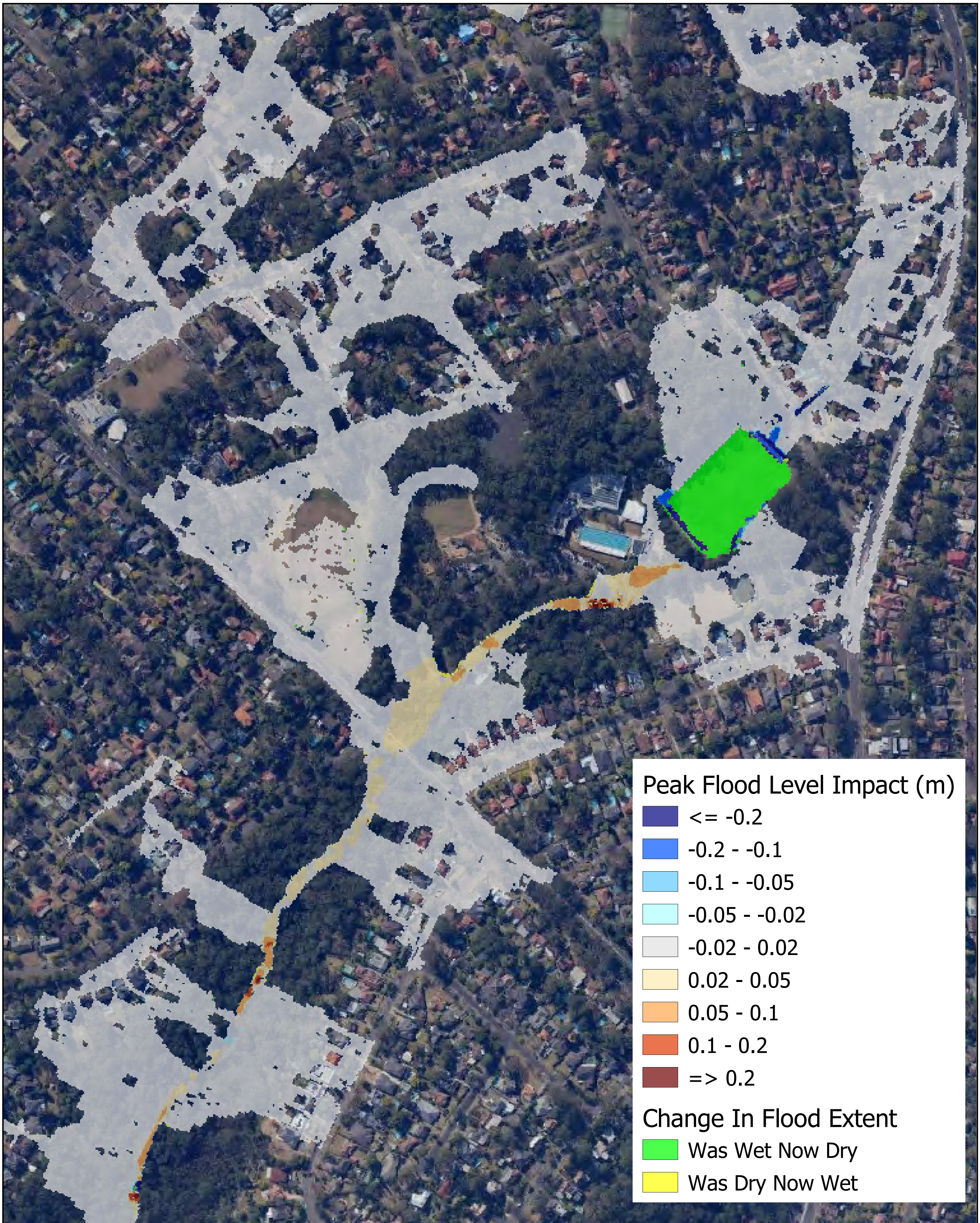

Title:

10% AEP Peak Flood Level Impact - Oval Bypass Design

Drawing: **B7**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

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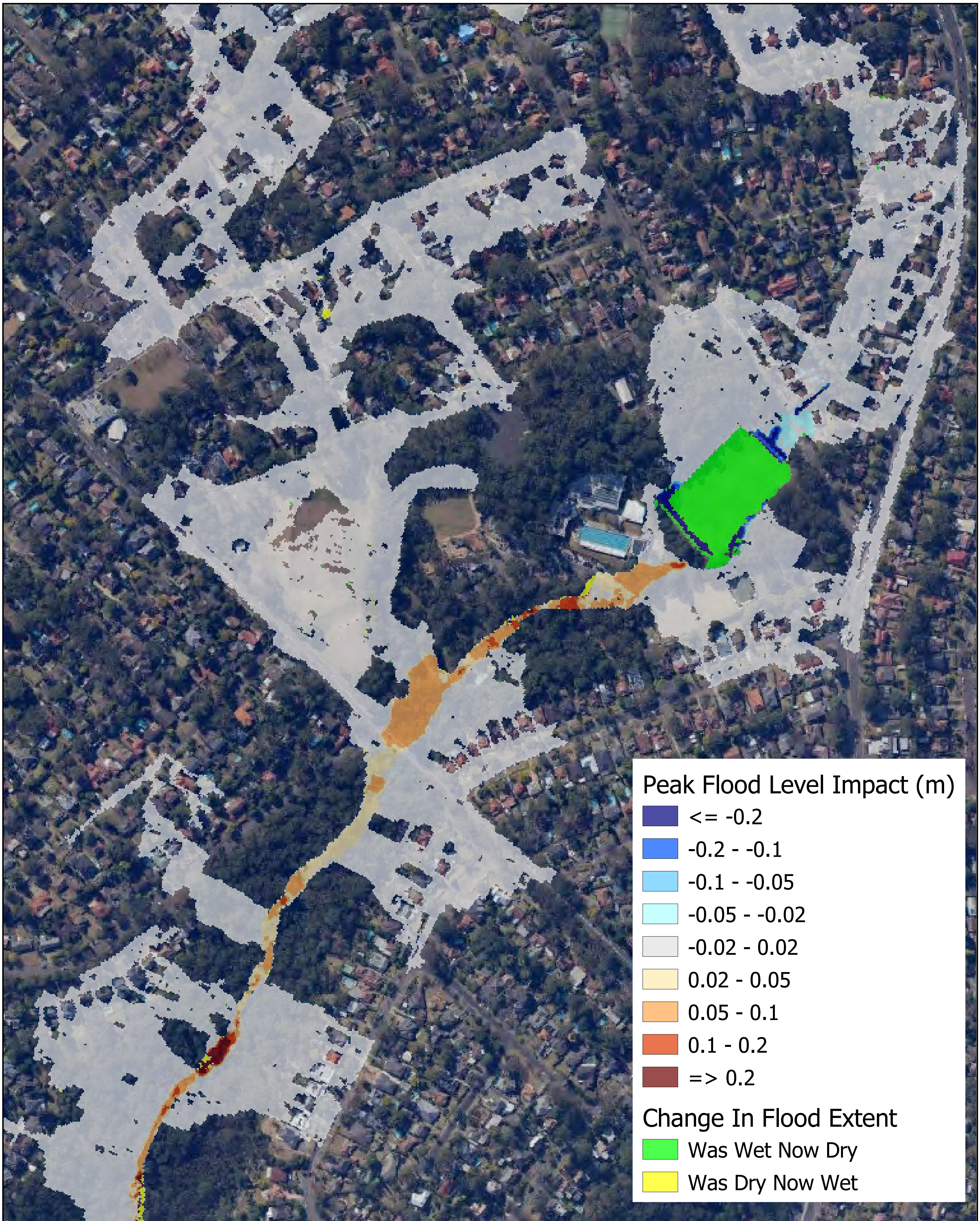

Title:

5% AEP Peak Flood Level Impact - Oval Bypass Design

Drawing: **B8**

Rev: **A**

0 100 200 m

www.bmt.org

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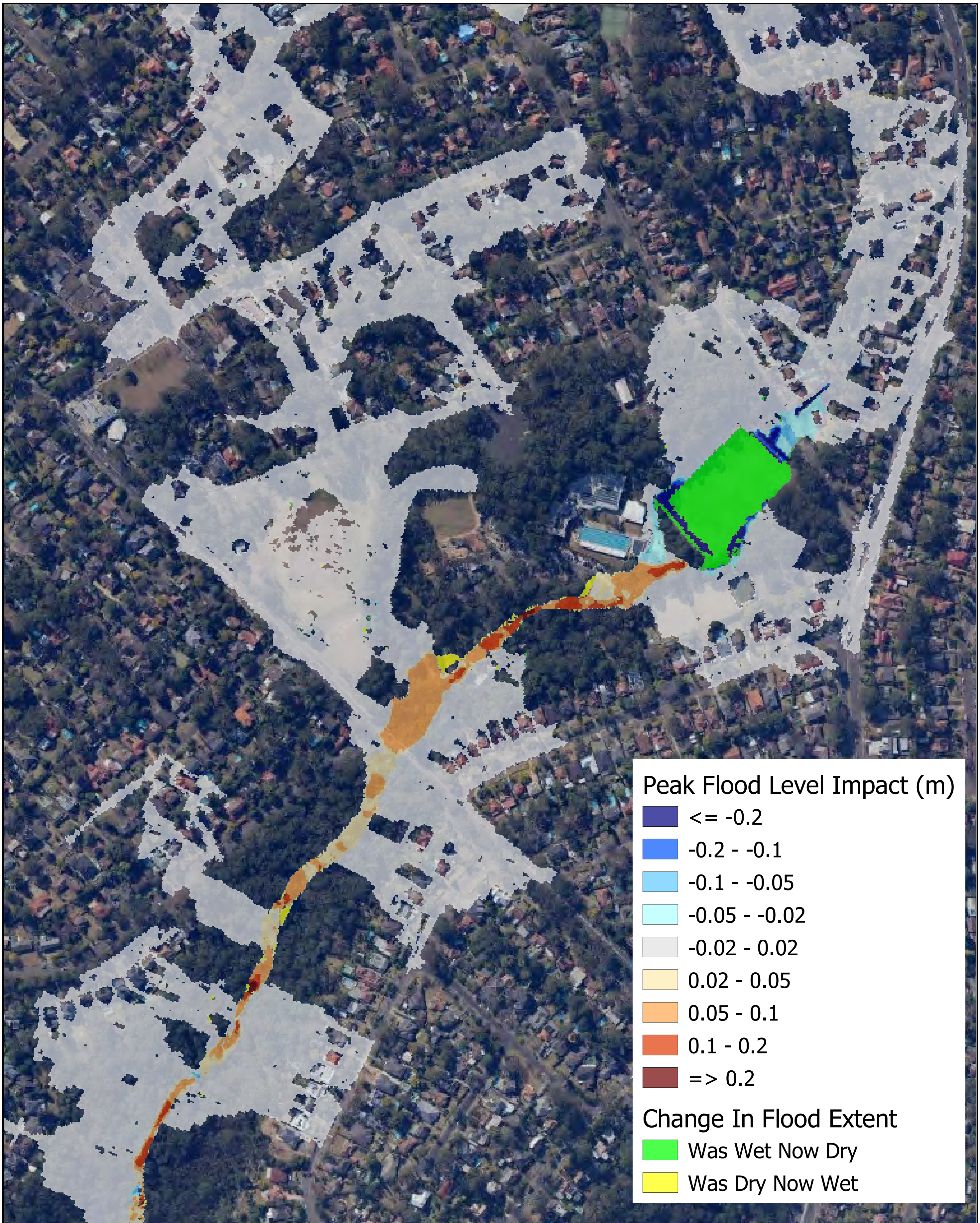

Title:

2% AEP Peak Flood Level Impact - Oval Bypass Design

Drawing: **B9**

Rev: **A**

0 100 200 m

www.bmt.org

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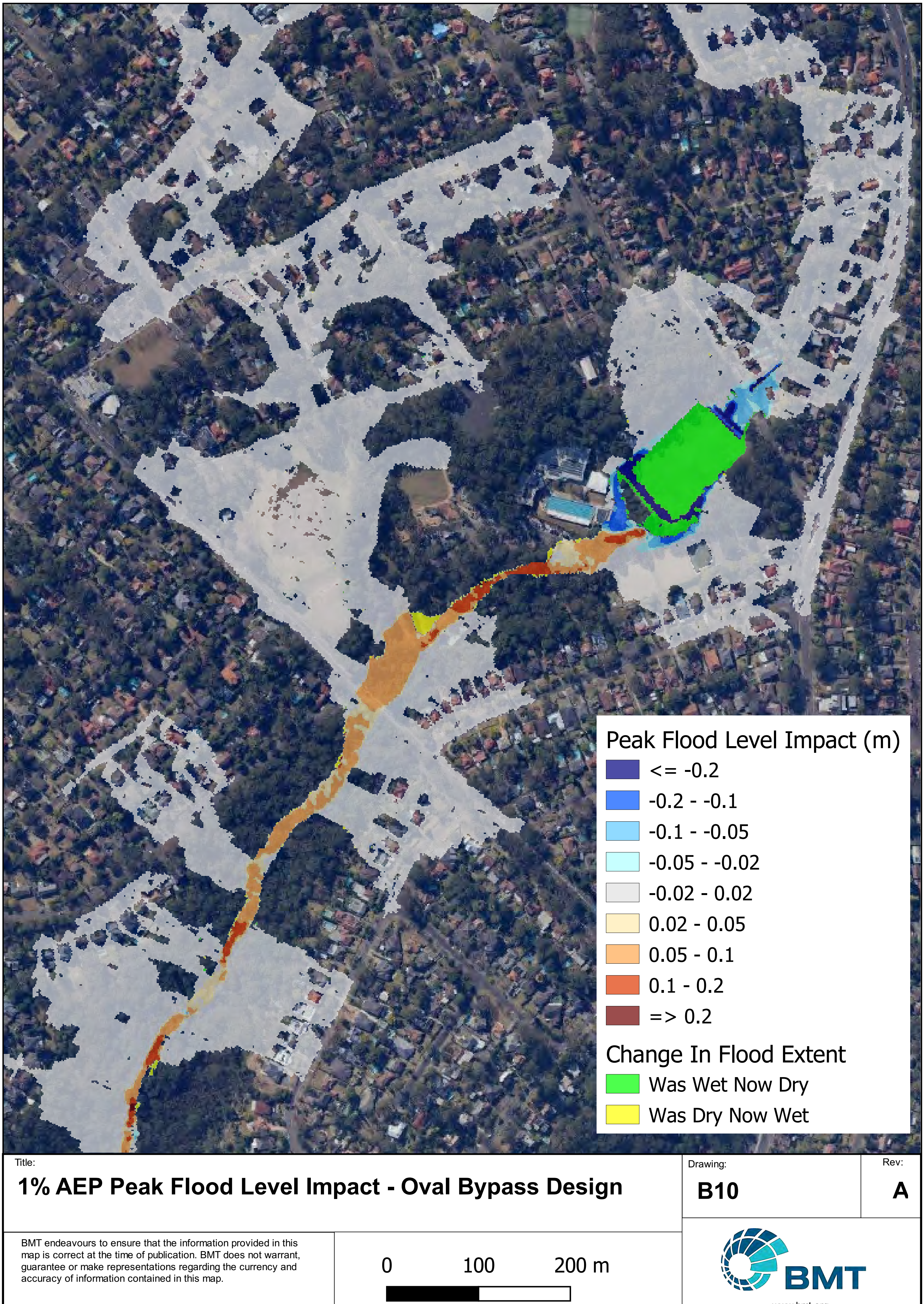


Title:

1% AEP Peak Flood Level Impact - Oval Bypass Design

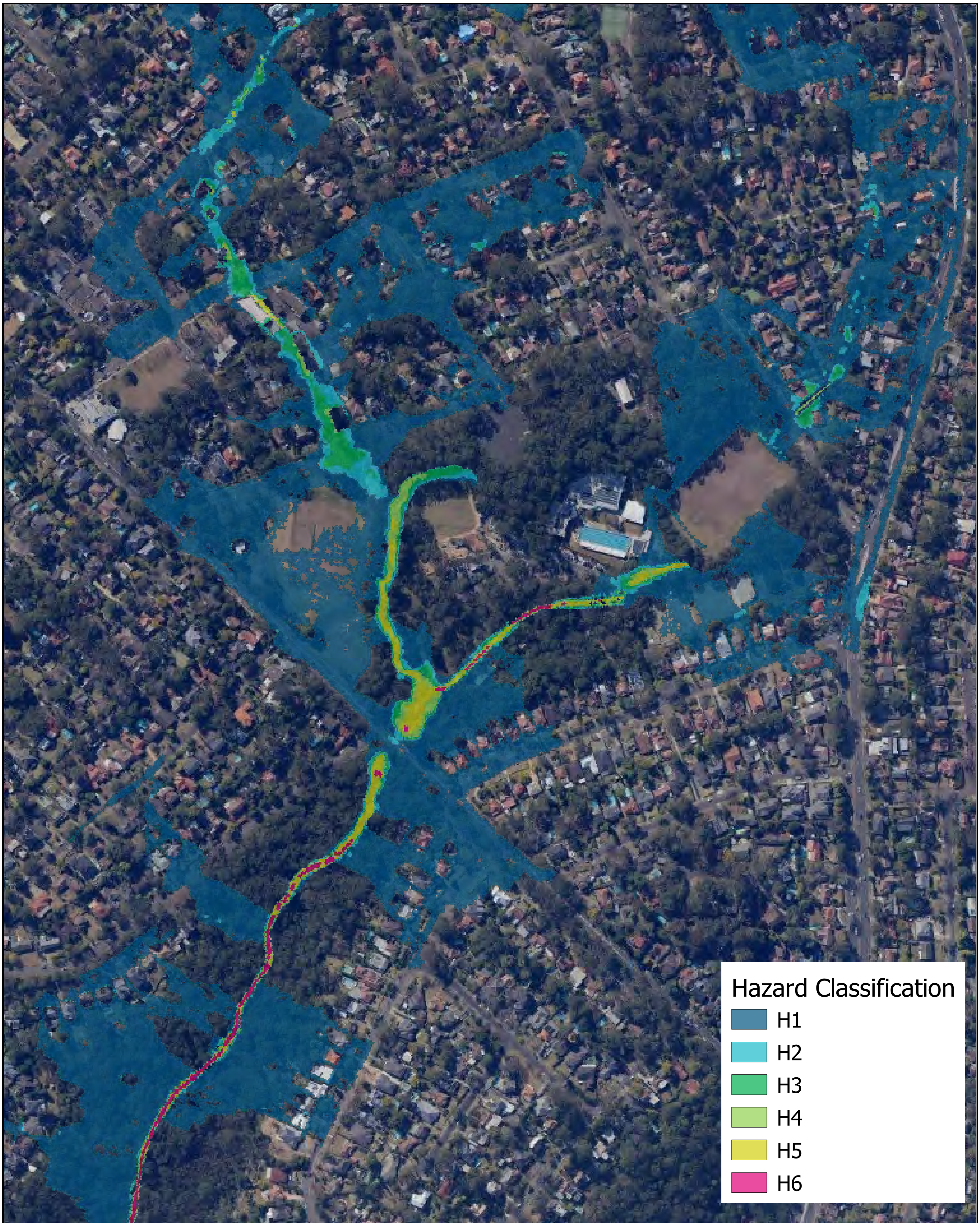
Drawing: **B10**

Rev: **A**

BMT

www.bmt.org

Filepath: S:\WATER\PROJECTS\S20504_MiddleHarbourSouthernCatchments_FS\QGIS\NGO\Report\Figure_Generator_200115\Project\Appendices.qgz



Title:

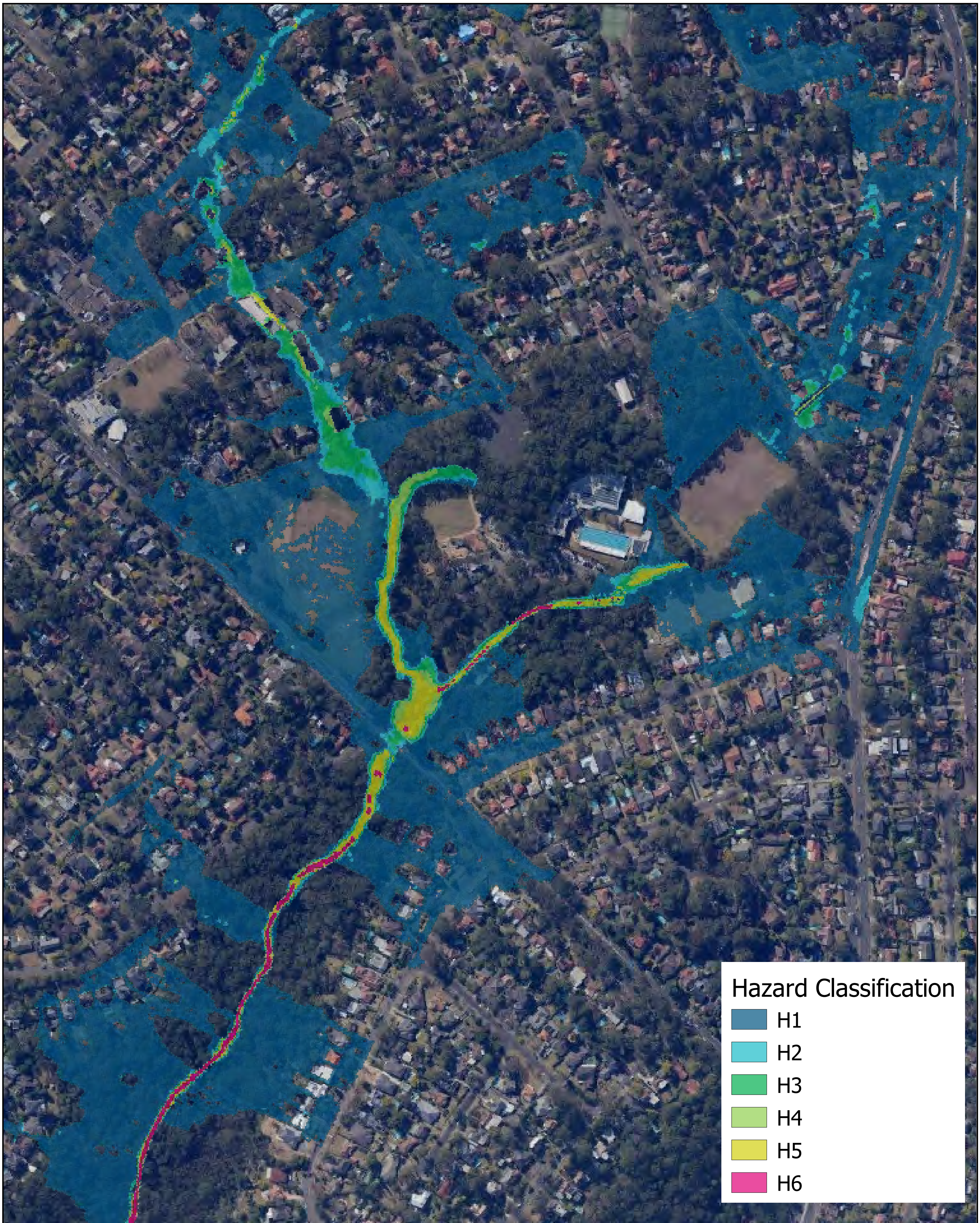
0.2 EY Flood Hazard - Oval Bypass Design

Drawing: **B11**

Rev: **A**

BMT
www.bmt.org

Filepath: S:\WATER\PROJECTS\S20504_MiddleHarbourSouthernCatchments_FS\QGIS\NGO\Report\Figure_Generator_200115\Project\Appendices.qgz



Title:

10% AEP Flood Hazard - Oval Bypass Design

Drawing: **B12**

Rev: **A**

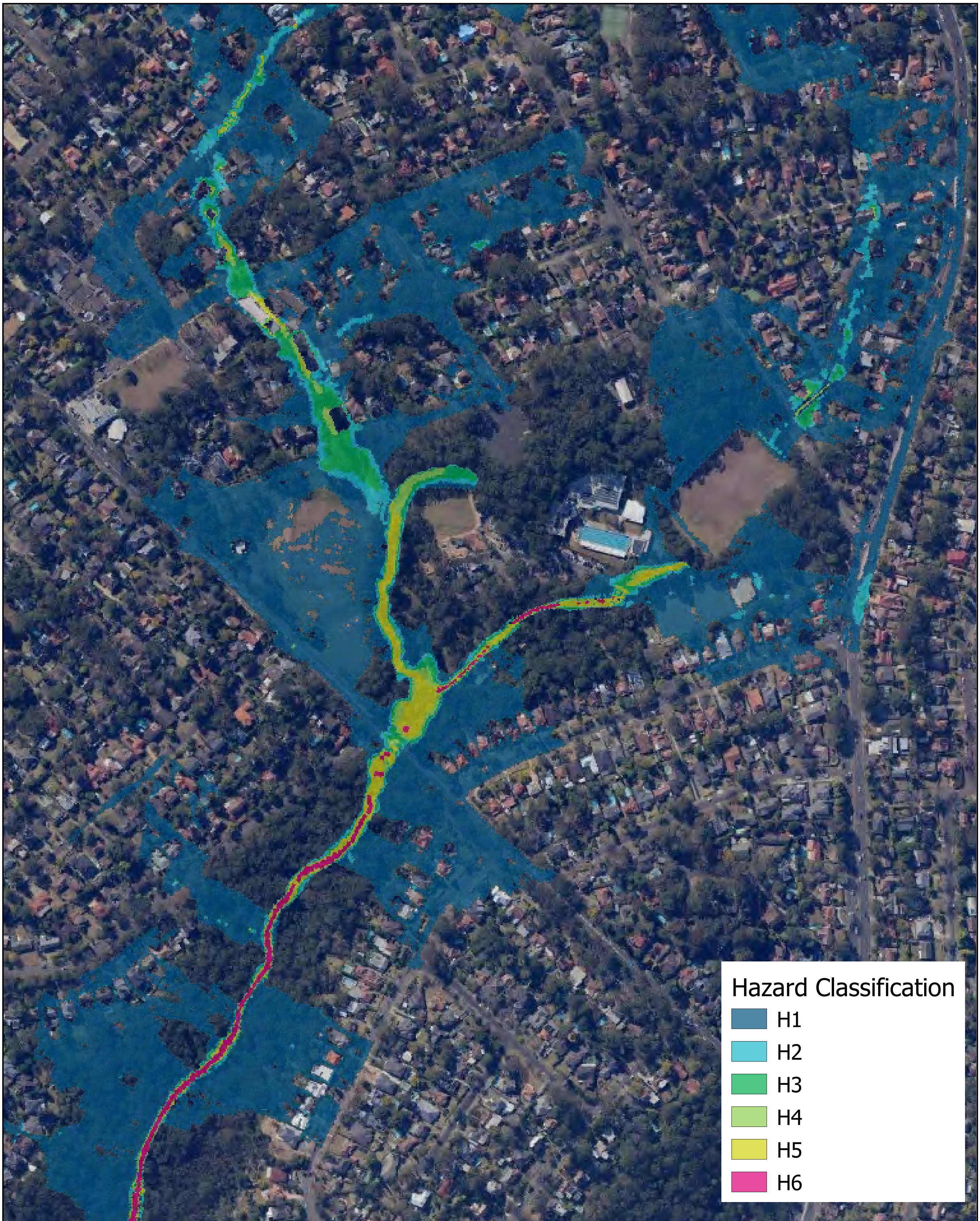
BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

0 100 200 m

BMT

www.bmt.org

Filepath: S:\WATER\PROJECTS\S20504_MiddleHarbourSouthernCatchments_FS\QGIS\NGO\Report\Figure_Generator_200115\Project\Appendices.qgz



Title:

5% AEP Flood Hazard - Oval Bypass Design

Drawing: **B13**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

Filepath: S:\WATER\PROJECTS\S20504_MiddleHarbourSouthernCatchments_FS\QGIS\NGO\Report\Figure_Generator_200115\Project\Appendices.qgz

Title:

2% AEP Flood Hazard - Oval Bypass Design

Drawing: **B14**

Rev: **A**

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0 100 200 m

BMT
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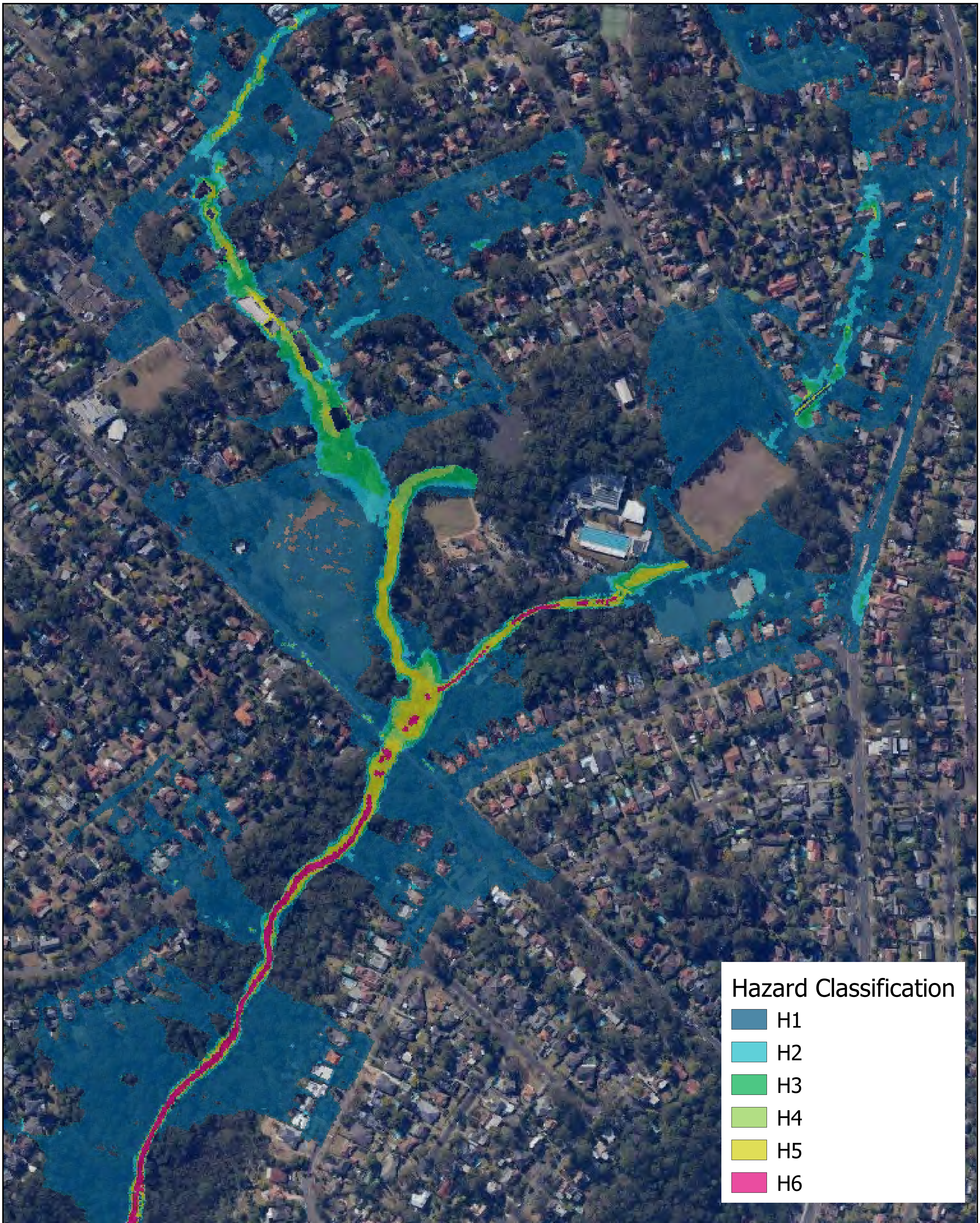

Title:

1% AEP Flood Hazard - Oval Bypass Design

Drawing: **B15**

Rev: **A**

0 100 200 m

BMT
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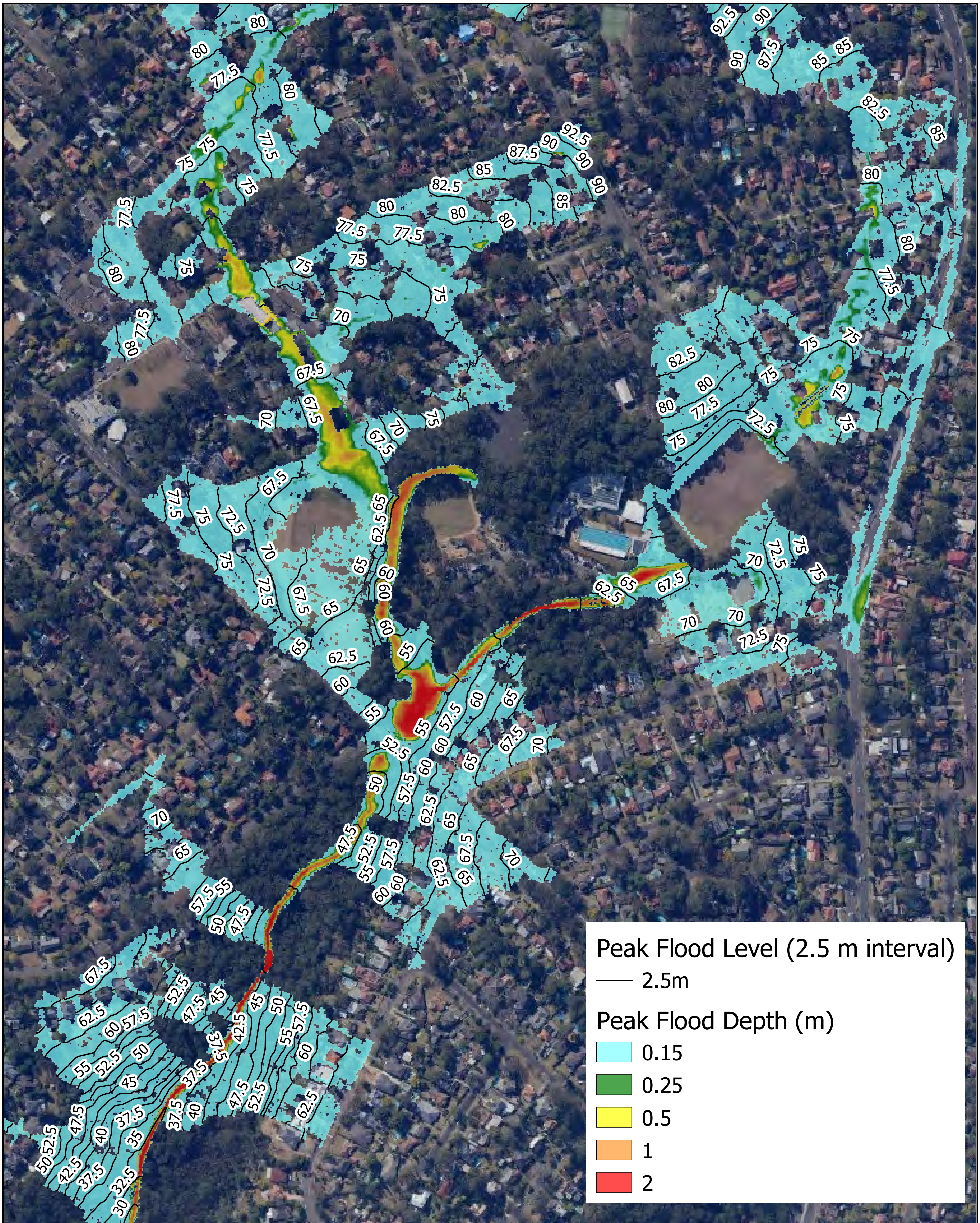
Filepath: S:\WATER\PROJECTS\S20504_MiddleHarbourSouthernCatchments_FS\QGIS\NGO\Report\Figure_Generator_200115\Project\Appendices.qgz

Appendix C Oval Upgrade With Basin Mitigation Option



Title:

0.2 EY Peak Water Level and Depth - Oval Bypass Design With Basin Option 1

Drawing: C1

Rev: A

0 100 200 m

BMT
www.bmt.org

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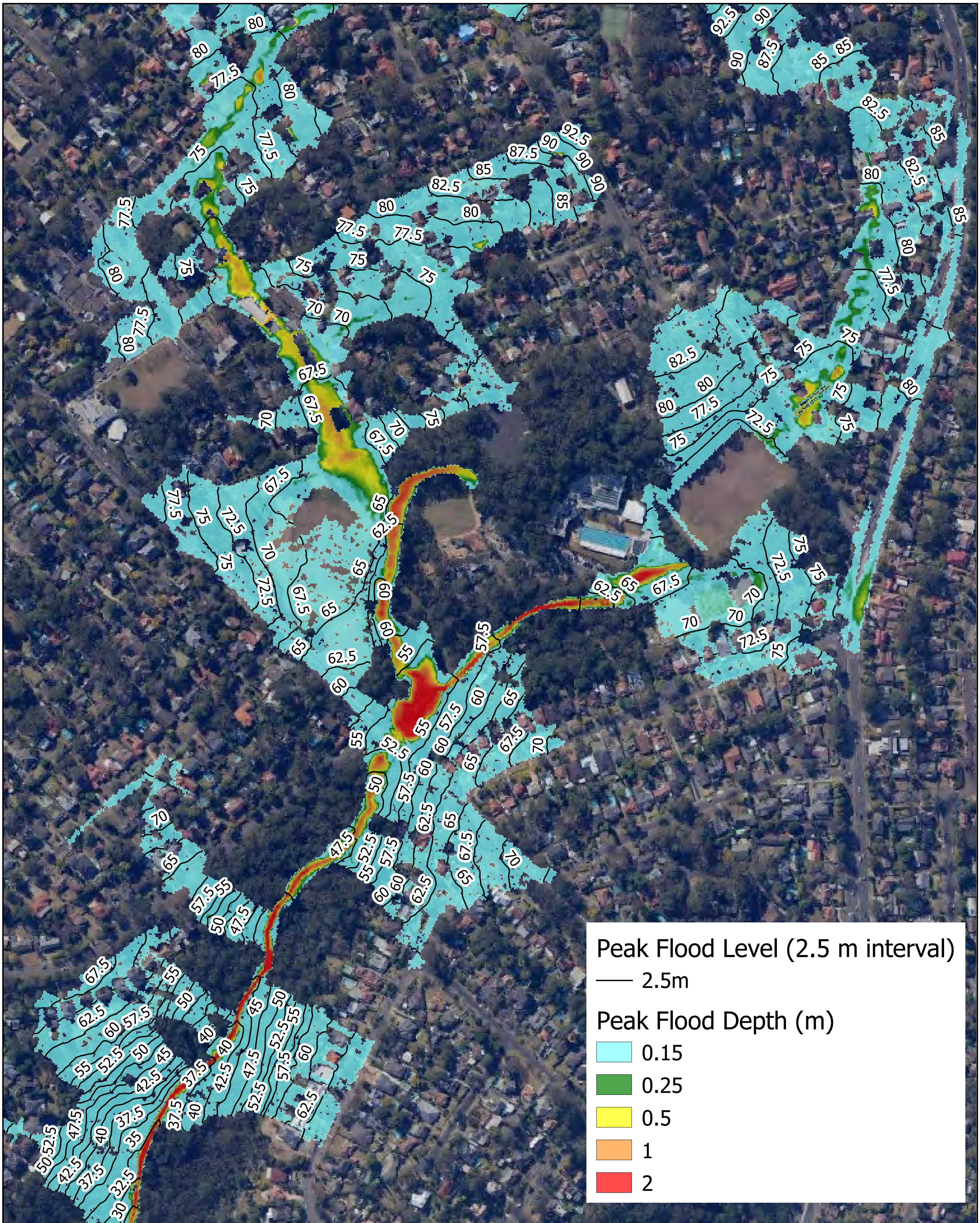

Title:

10% AEP Peak Water Level and Depth - Oval Bypass Design With Basin Option 1

Drawing: **C2**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

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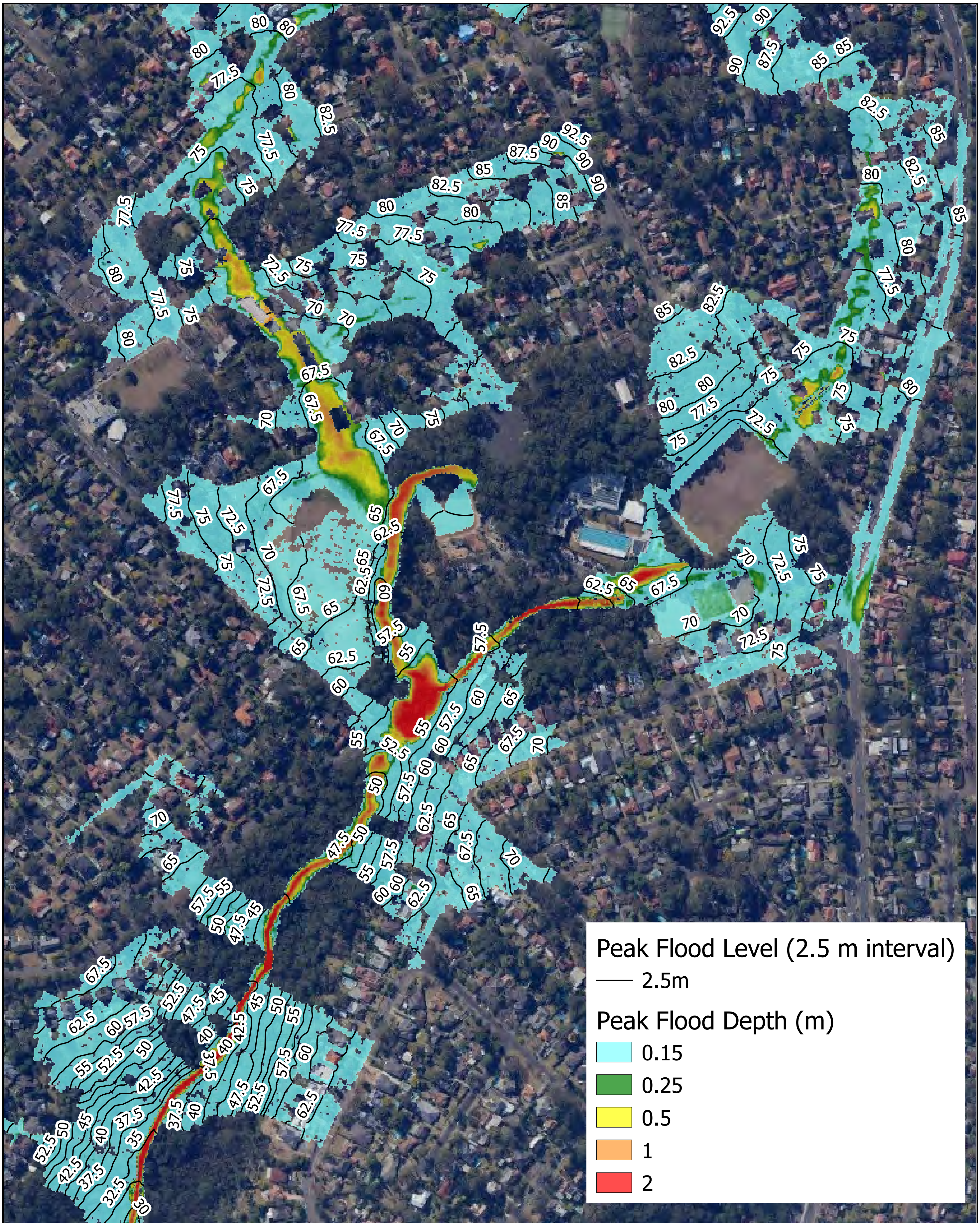


Title:

5% AEP Peak Water Level and Depth - Oval Bypass Design With Basin Option 1

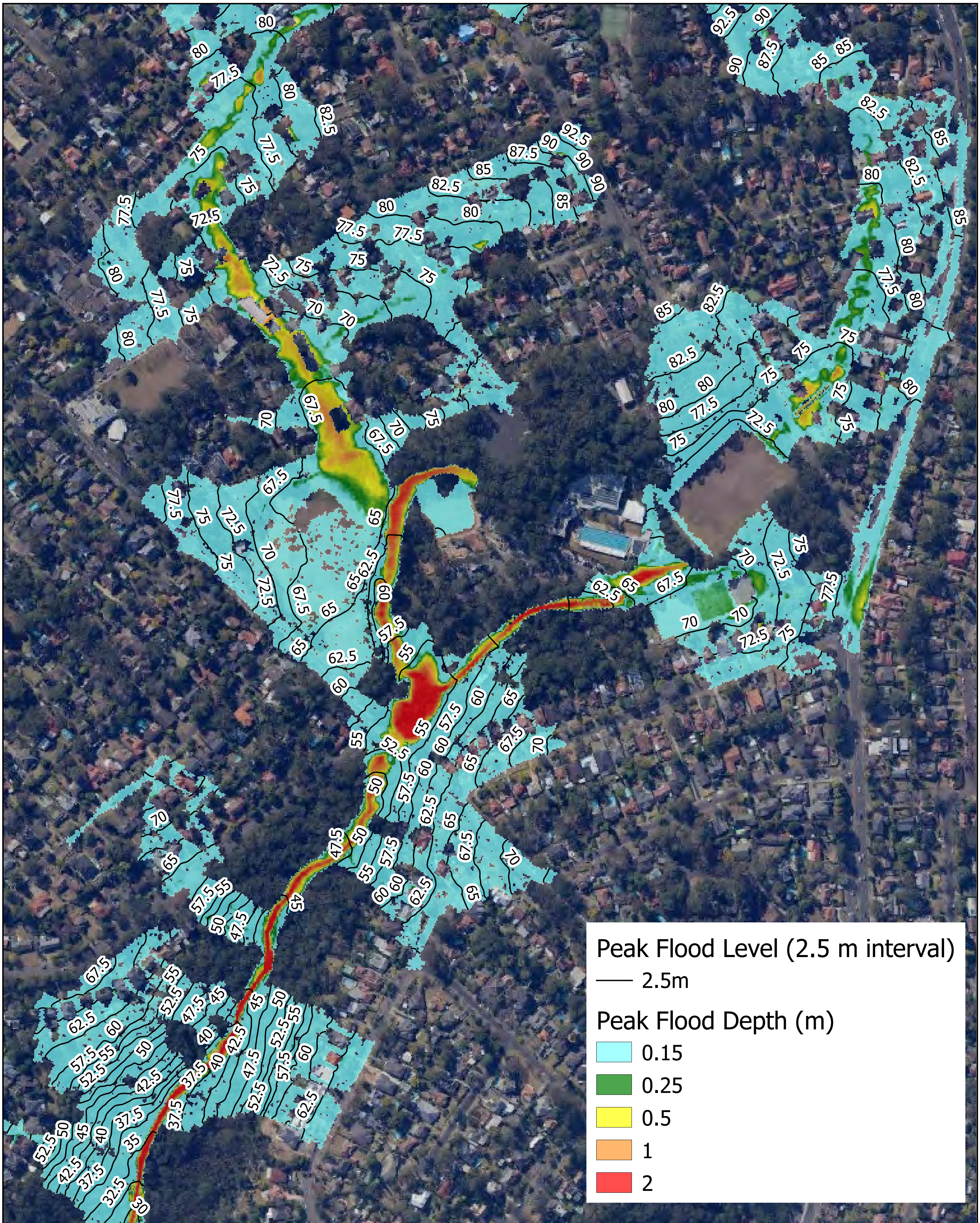
Drawing: **C3**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

Filepath: S:\WATER\PROJECTS\S20504_MiddleHarbourSouthernCatchments_FS\QGIS\NGO\Report\Figure_Generator_200115\Project\Appendices.qgz



Title:

2% AEP Peak Water Level and Depth - Oval Bypass Design With Basin Option 1

Drawing: **C4**

Rev: **A**

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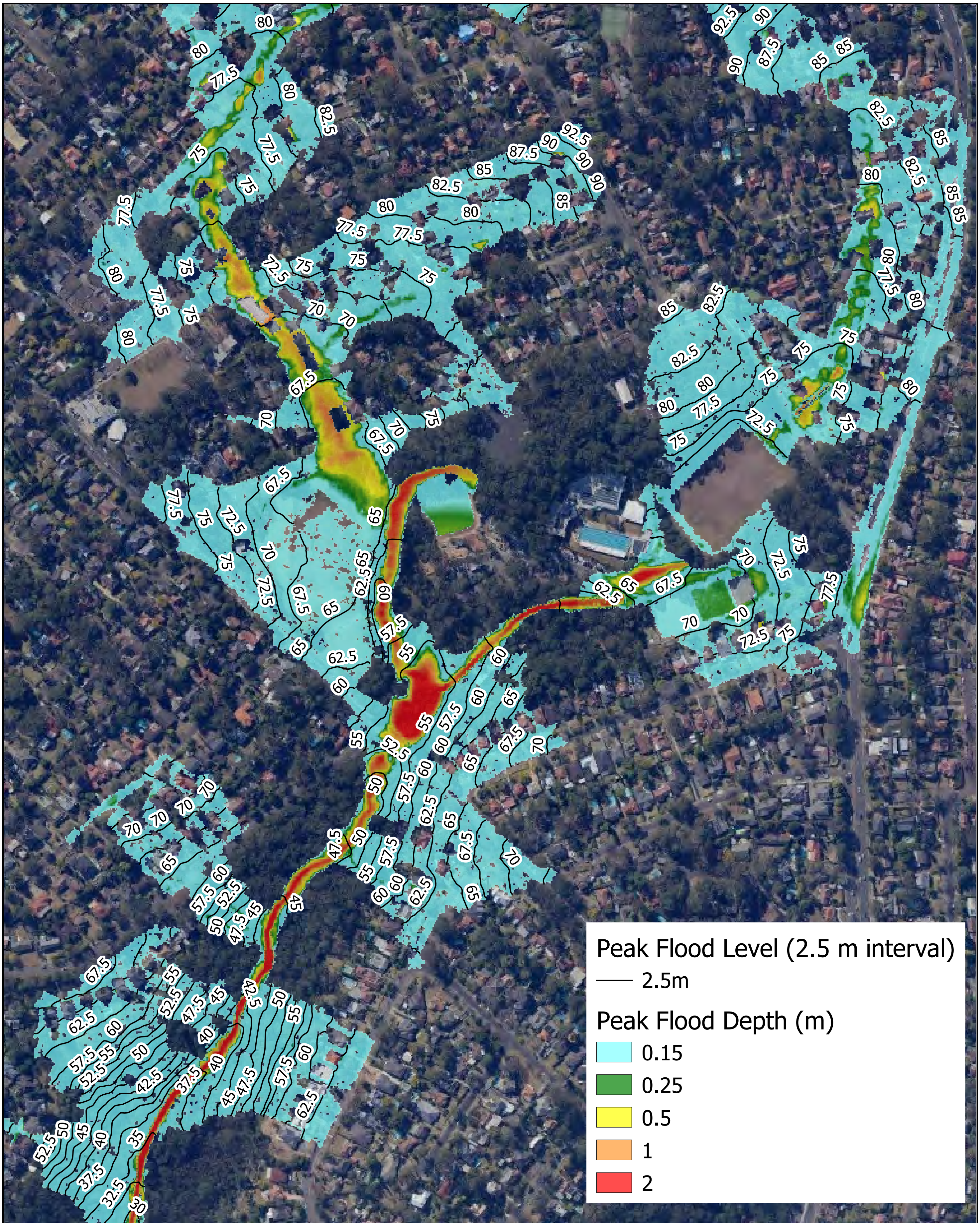
Filepath: S:\WATER\PROJECTS\S20504_MiddleHarbourSouthernCatchments_FS\QGIS\NGO\Report\Figure_Generator_200115\Project\Appendices.qgz



Title:

1% AEP Peak Water Level and Depth - Oval Bypass Design With Basin Option 1

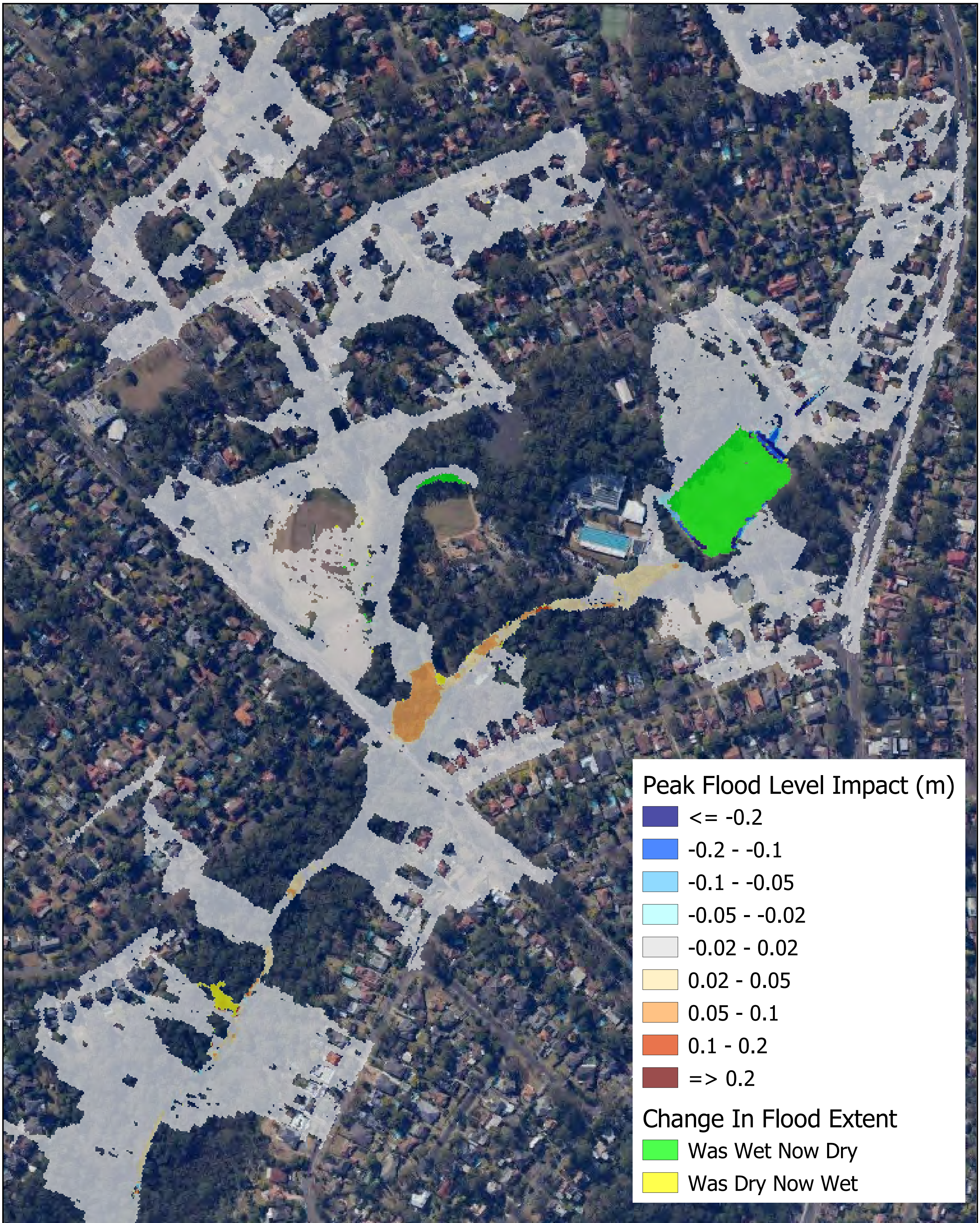
Drawing: **C5**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

Filepath: S:\WATER\PROJECTS\S20504_MiddleHarbourSouthernCatchments_FS\QGIS\NGO\Report\Figure_Generator_200115\Project\Appendices.qgz



Title:

0.2 EY Peak Flood Level Impact - Oval Bypass Design With Basin Option 1

Drawing: **C6**

Rev: **A**

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0 100 200 m

BMT

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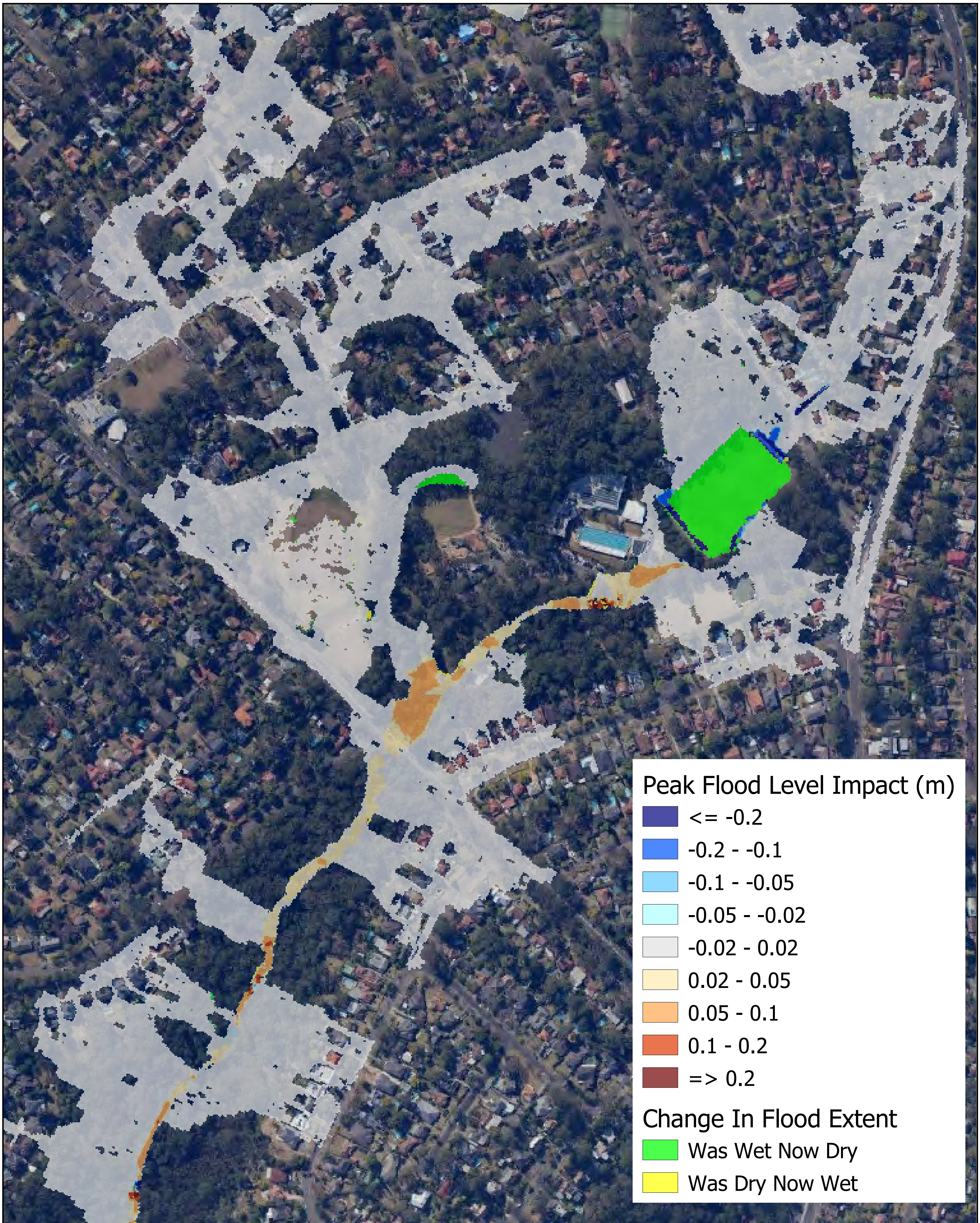


Title:

10% AEP Peak Flood Level Impact - Oval Bypass Design With Basin Option 1

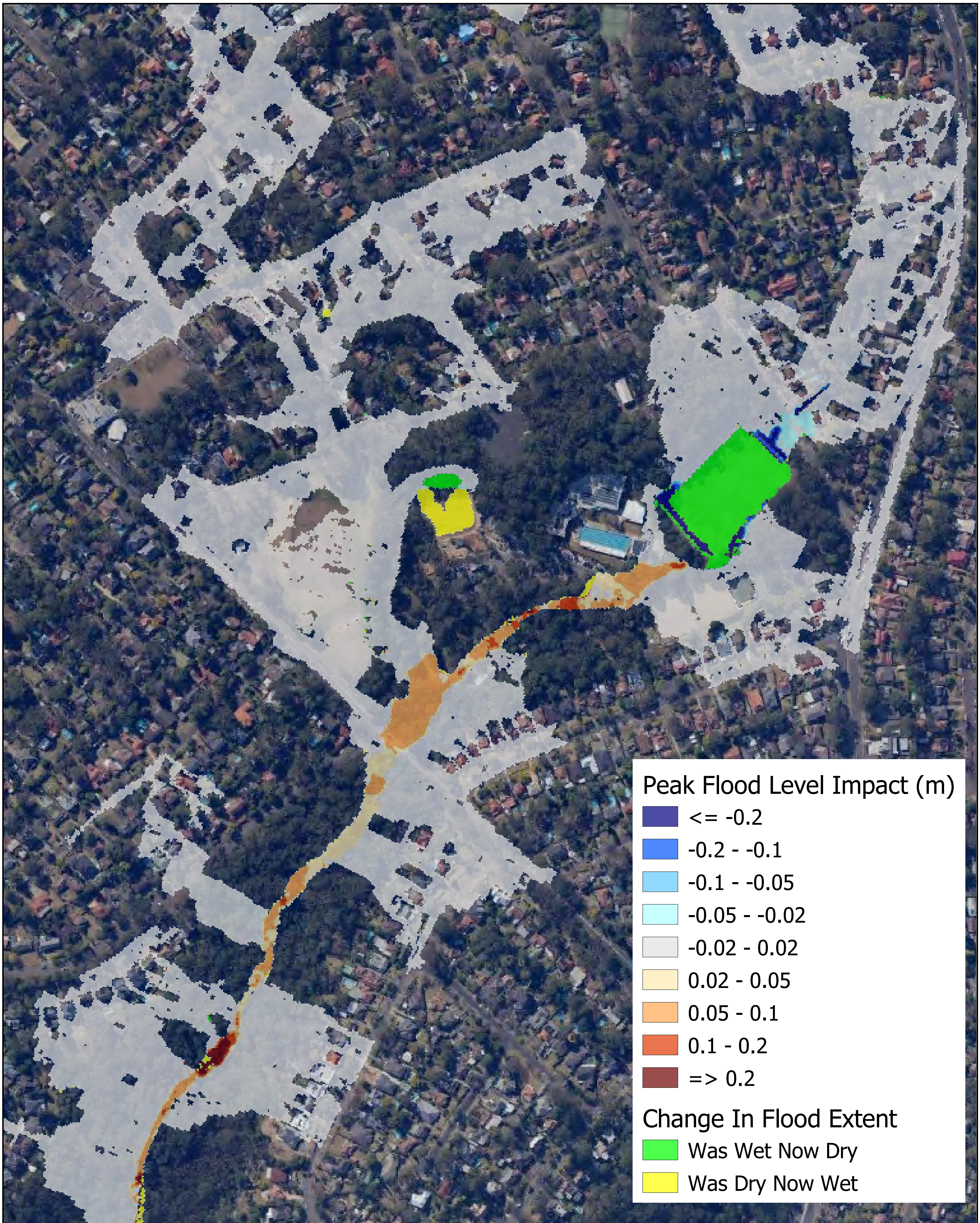
Drawing: **C7**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

Filepath: S:\WATER\PROJECTS\S20504_MiddleHarbourSouthernCatchments_FS\QGIS\NGO\Report\Figure_Generator_200115\Project\Appendices.qgz



Title:

5% AEP Peak Flood Level Impact - Oval Bypass Design With Basin Option 1

Drawing: **C8**

Rev: **A**

0 100 200 m

www.bmt.org

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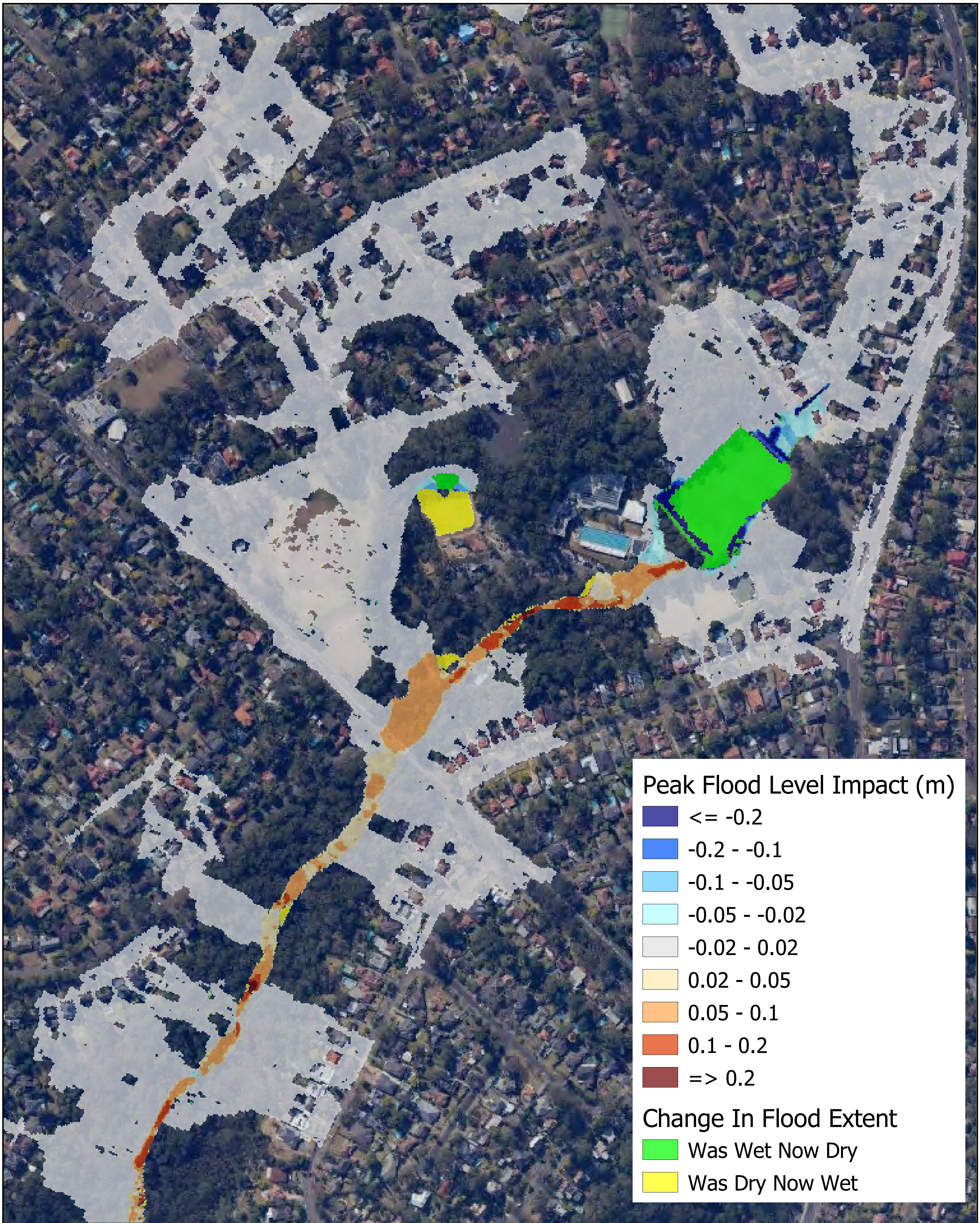

Title:

2% AEP Peak Flood Level Impact - Oval Bypass Design With Basin Option 1

Drawing: **C9**

Rev: **A**

0 100 200 m

BMT

www.bmt.org

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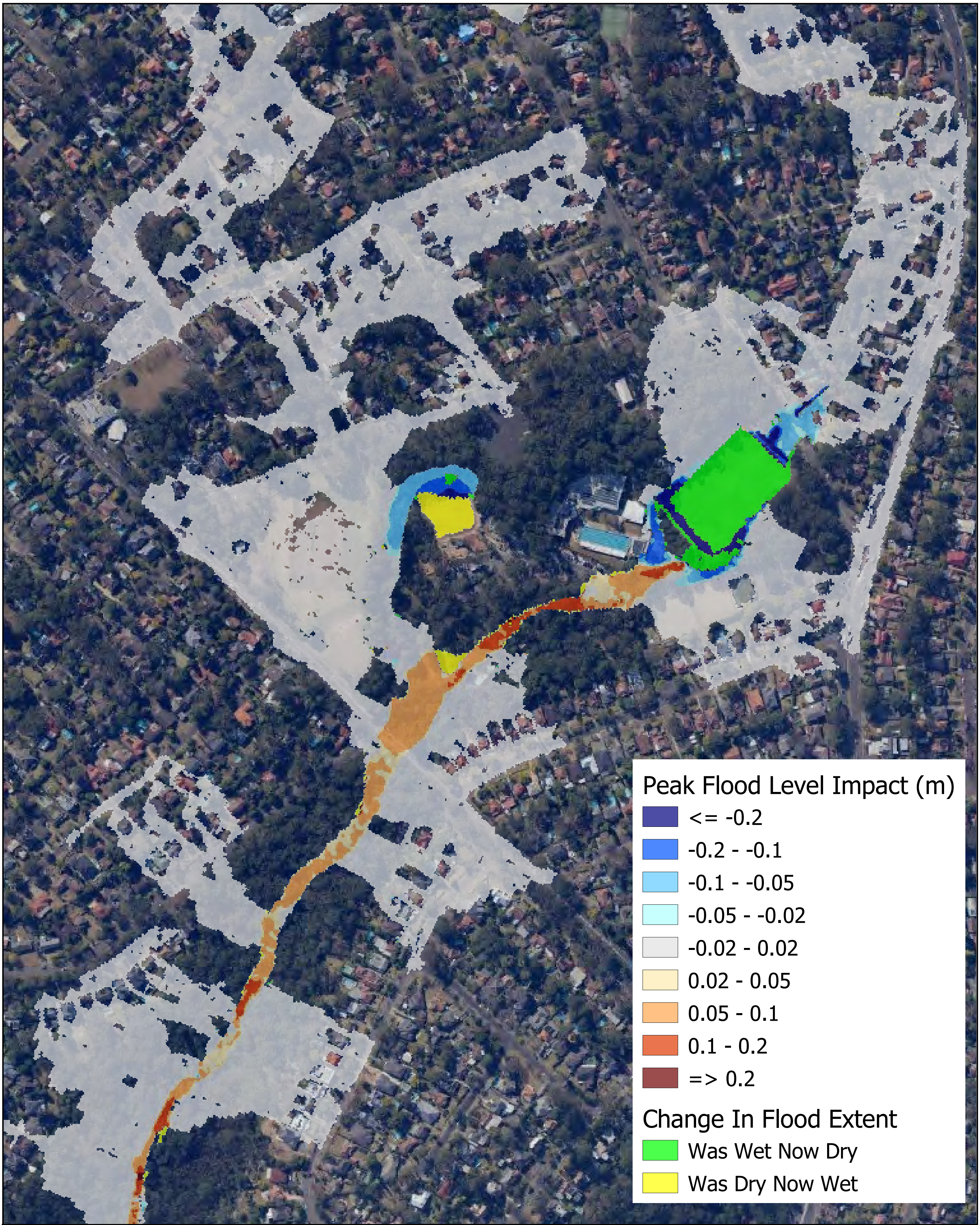


Title:

1% AEP Peak Flood Level Impact - Oval Bypass Design With Basin Option 1

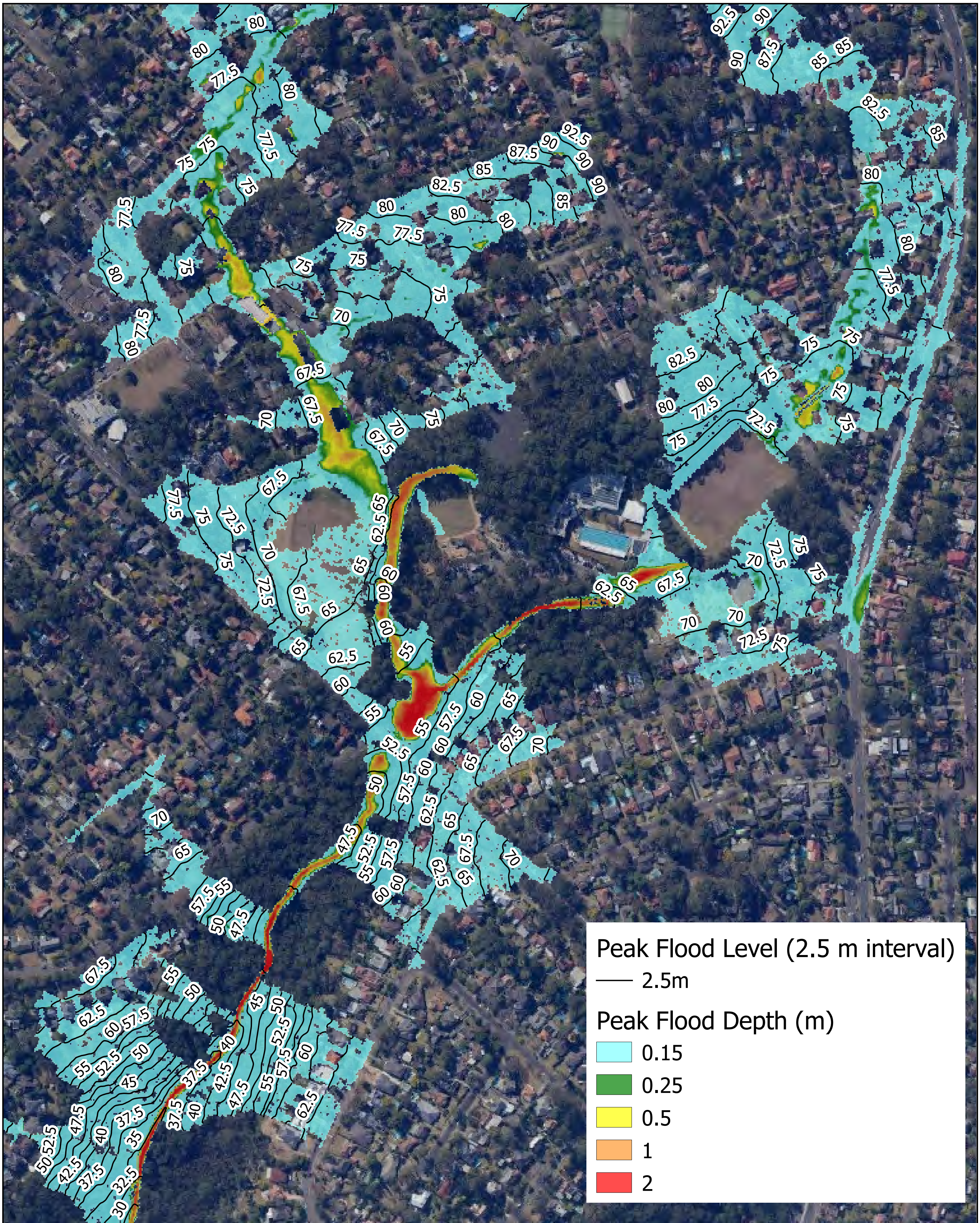
Drawing: **C10**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

Filepath: S:\WATER\PROJECTS\S20504_MiddleHarbourSouthernCatchments_FS\QGIS\NGO\Report\Figure_Generator_200115\Project\Appendices.qgz



Title:

0.2 EY Peak Water Level and Depth - Oval Bypass Design With Basin Option 2

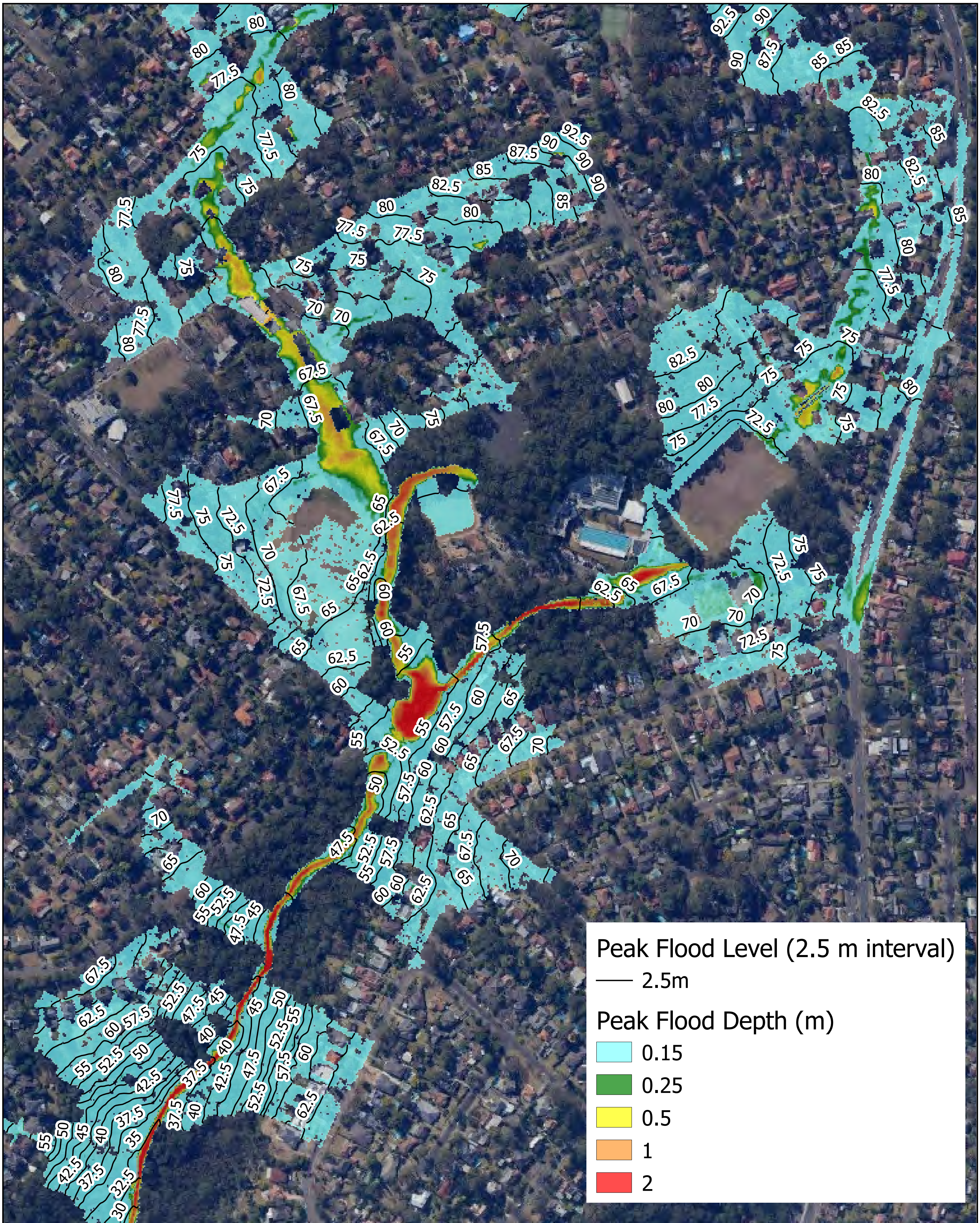
Drawing: **C11**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

Filepath: S:\WATER\PROJECTS\S20504_MiddleHarbourSouthernCatchments_FS\QGIS\NGO\Report\Figure_Generator_200115\Project\Appendices.qgz



Title:

10% AEP Peak Water Level and Depth - Oval Bypass Design With Basin Option 2

Drawing: **C12**

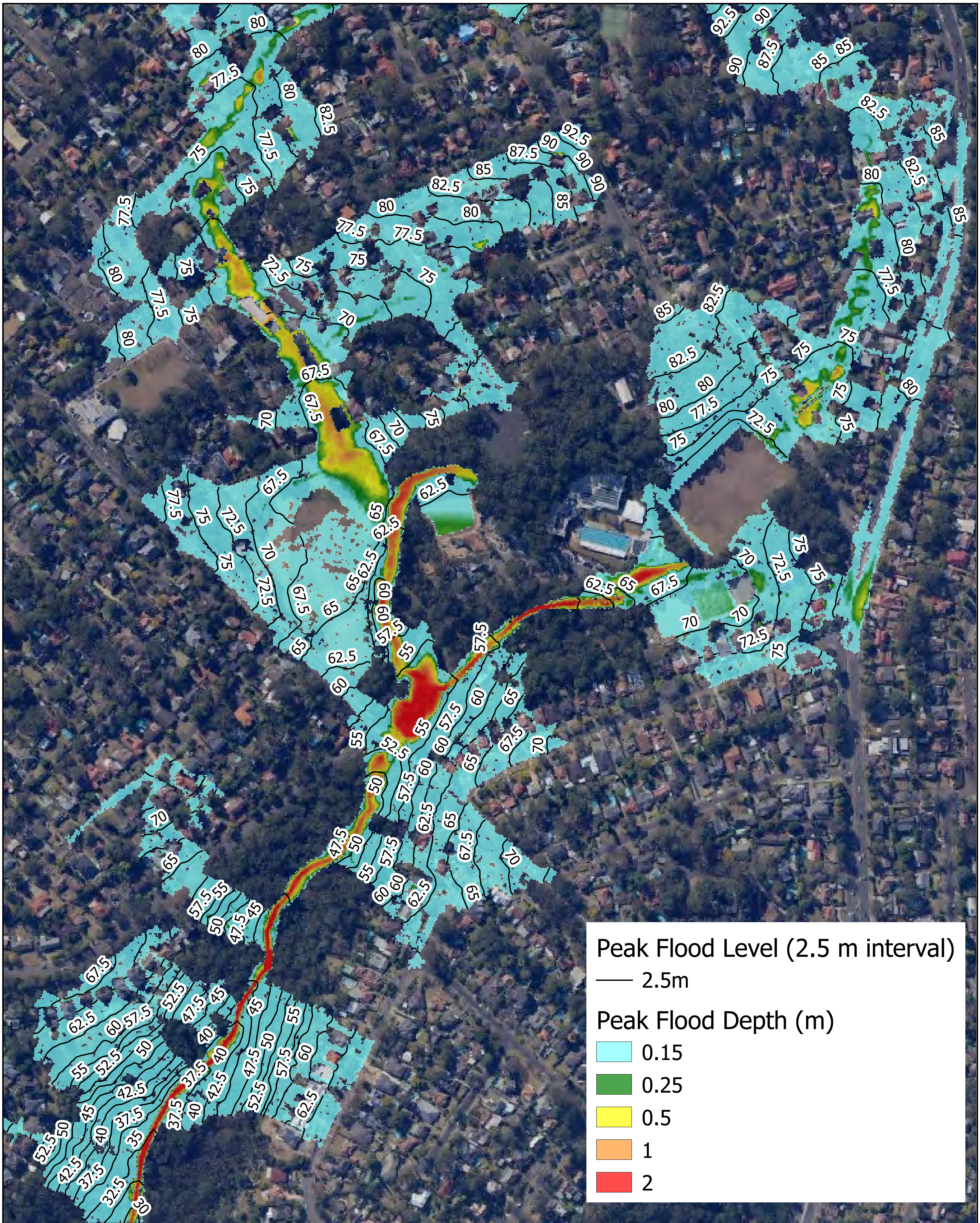
Rev: **A**

0 100 200 m

BMT

www.bmt.org

Filepath: S:\WATER\PROJECTS\S20504_MiddleHarbourSouthernCatchments_FS\QGIS\NGO\Report\Figure_Generator_200115\Project\Appendices.qgz



Title:

5% AEP Peak Water Level and Depth - Oval Bypass Design With Basin Option 2

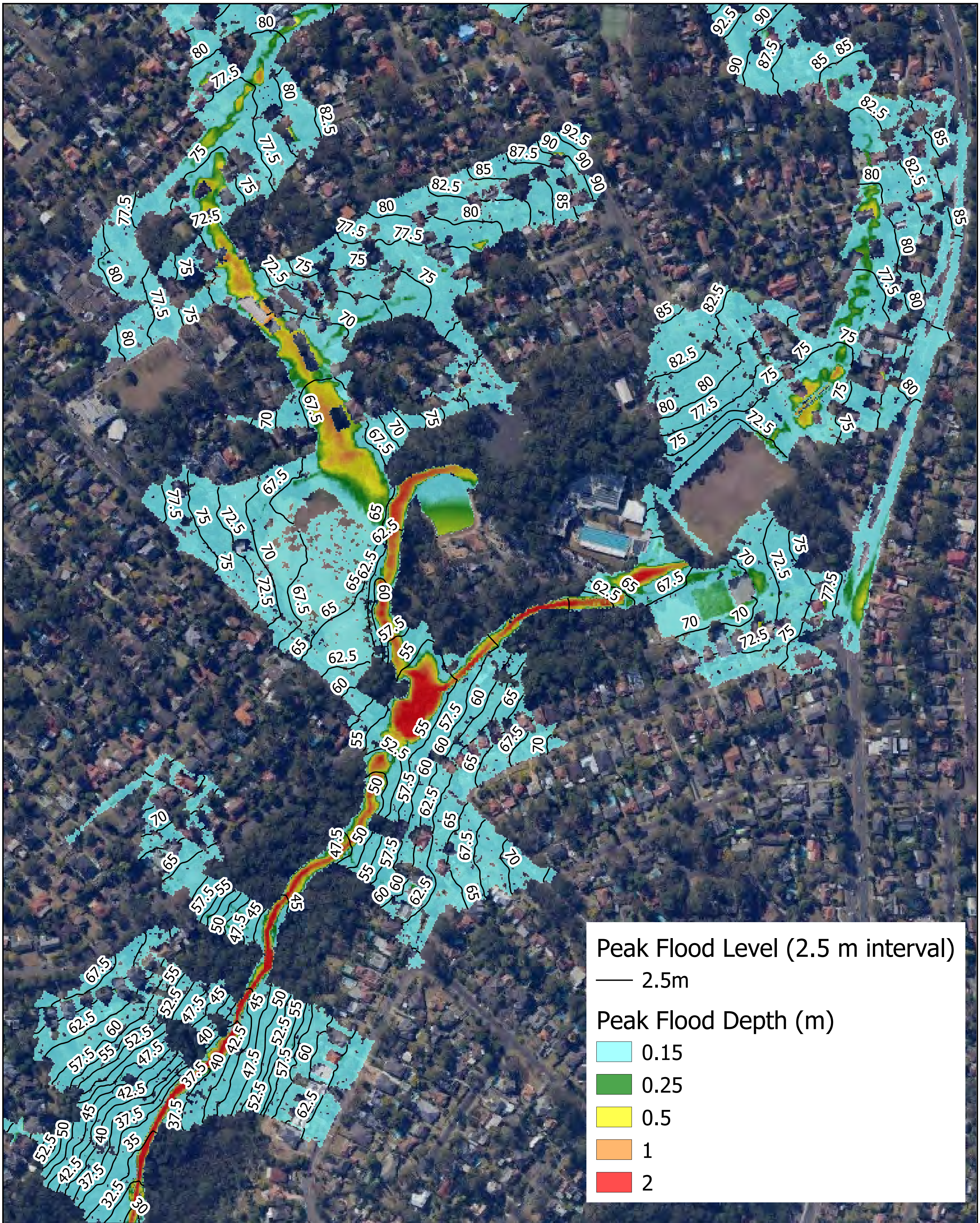
Drawing: **C13**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

Filepath: S:\WATER\PROJECTS\S20504_MiddleHarbourSouthernCatchments_FS\QGIS\NGO\Report\Figure_Generator_200115\Project\Appendices.qgz



Title:

2% AEP Peak Water Level and Depth - Oval Bypass Design With Basin Option 2

Drawing: **C14**

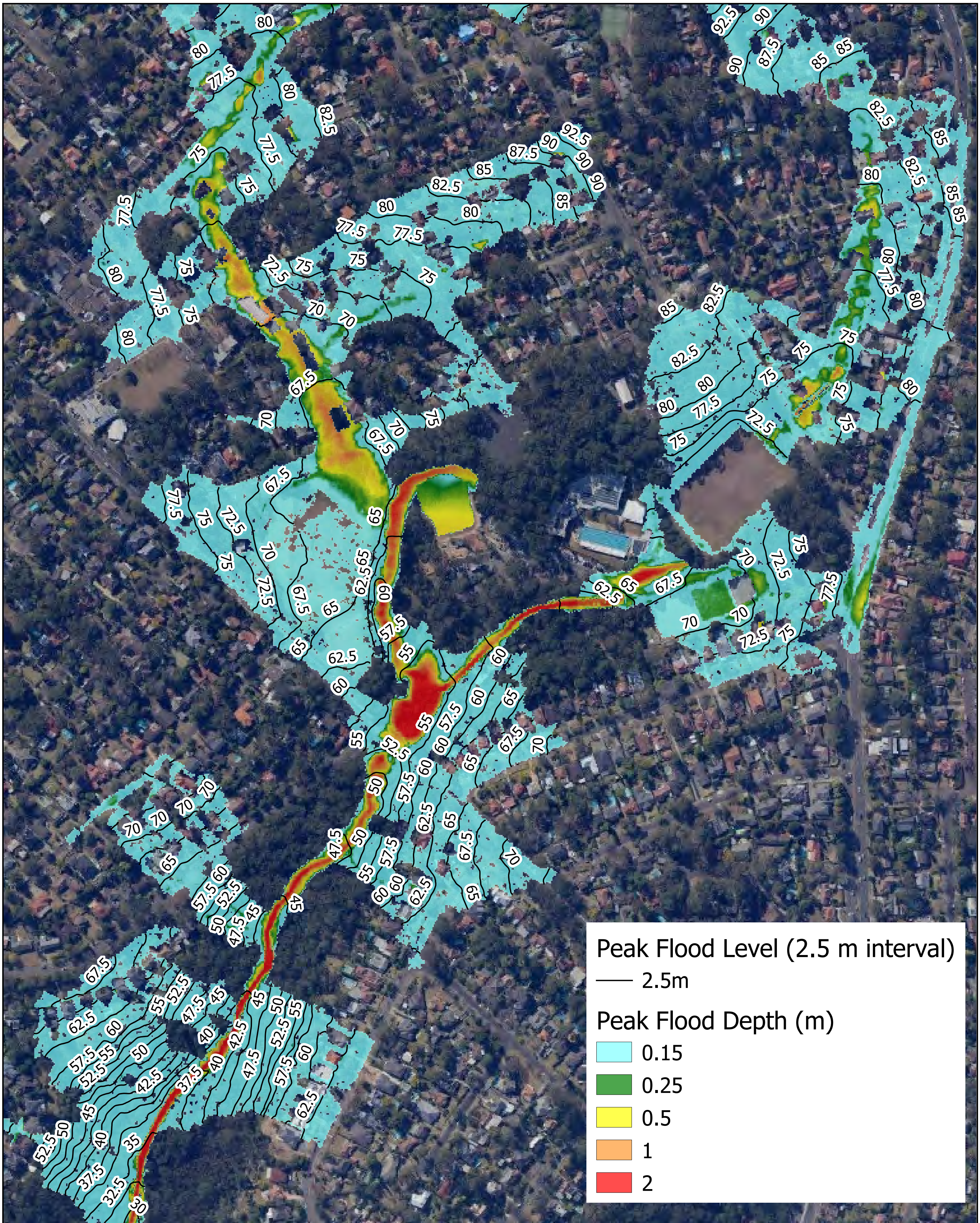
Rev: **A**

0 100 200 m

BMT

www.bmt.org

Filepath: S:\WATER\PROJECTS\S20504_MiddleHarbourSouthernCatchments_FS\QGIS\NGO\Report\Figure_Generator_200115\Project\Appendices.qgz



Title:

1% AEP Peak Water Level and Depth - Oval Bypass Design With Basin Option 2

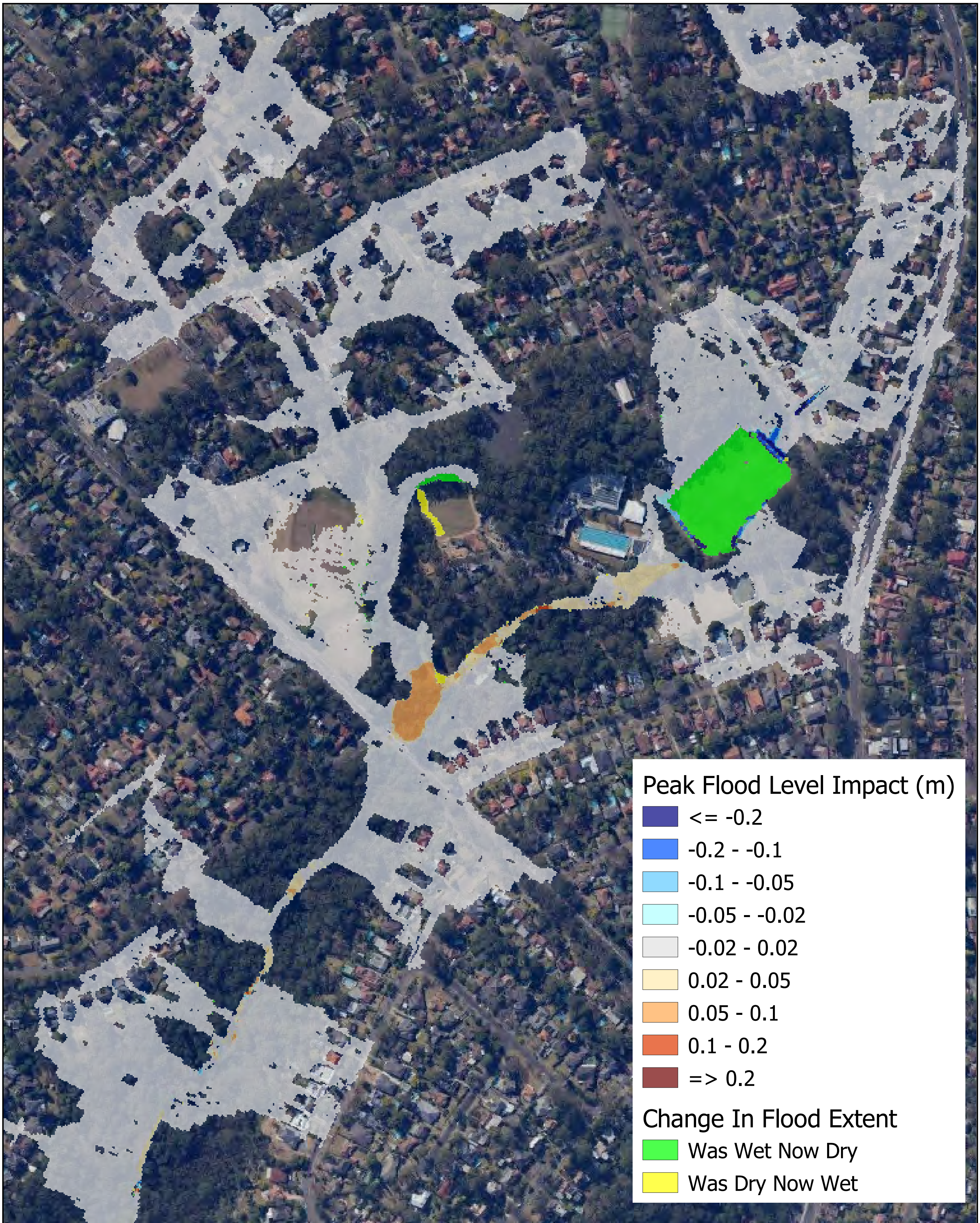
Drawing: **C15**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

Filepath: S:\WATER\PROJECTS\S20504_MiddleHarbourSouthernCatchments_FS\QGIS\NGO\Report\Figure_Generator_200115\Project\Appendices.qgz



Title:

0.2 EY Peak Flood Level Impact - Oval Bypass Design With Basin Option 2

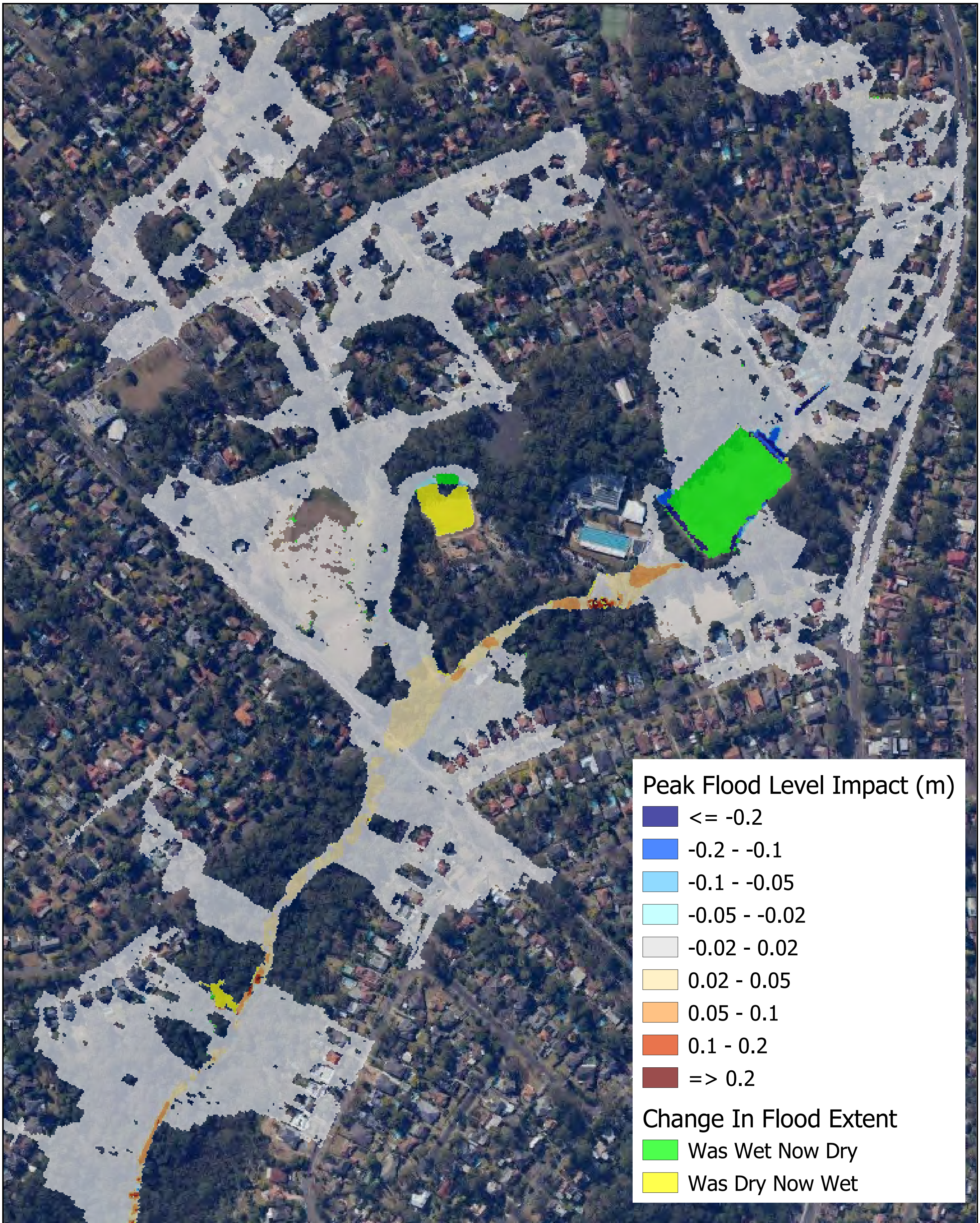
Drawing: **C16**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

Filepath: S:\WATER\PROJECTS\S20504_MiddleHarbourSouthernCatchments_FS\QGIS\NGO\Report\Figure_Generator_200115\Project\Appendices.qgz



Title:

10% AEP Peak Flood Level Impact - Oval Bypass Design With Basin Option 2

Drawing: **C17**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

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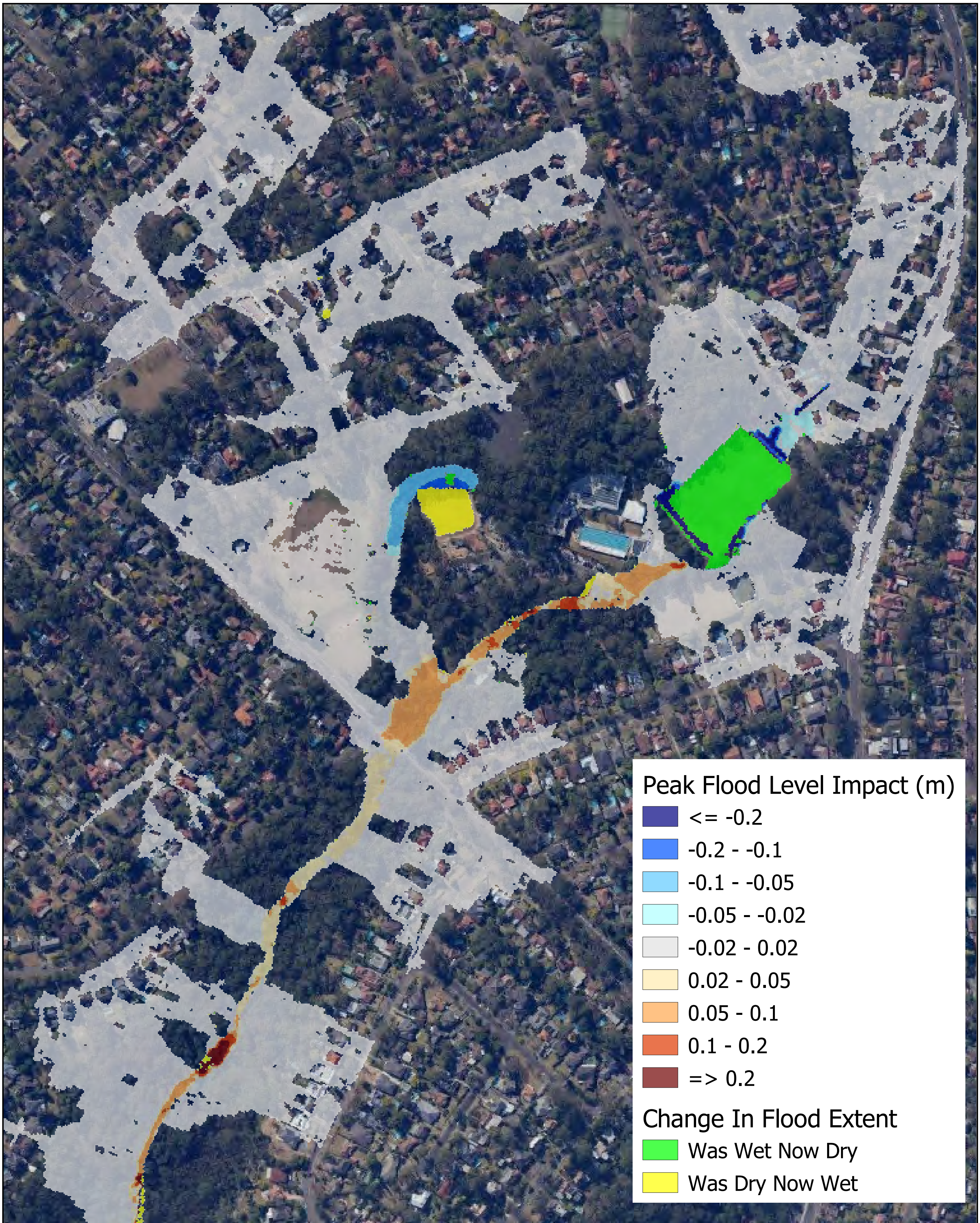


Title:

5% AEP Peak Flood Level Impact - Oval Bypass Design With Basin Option 2

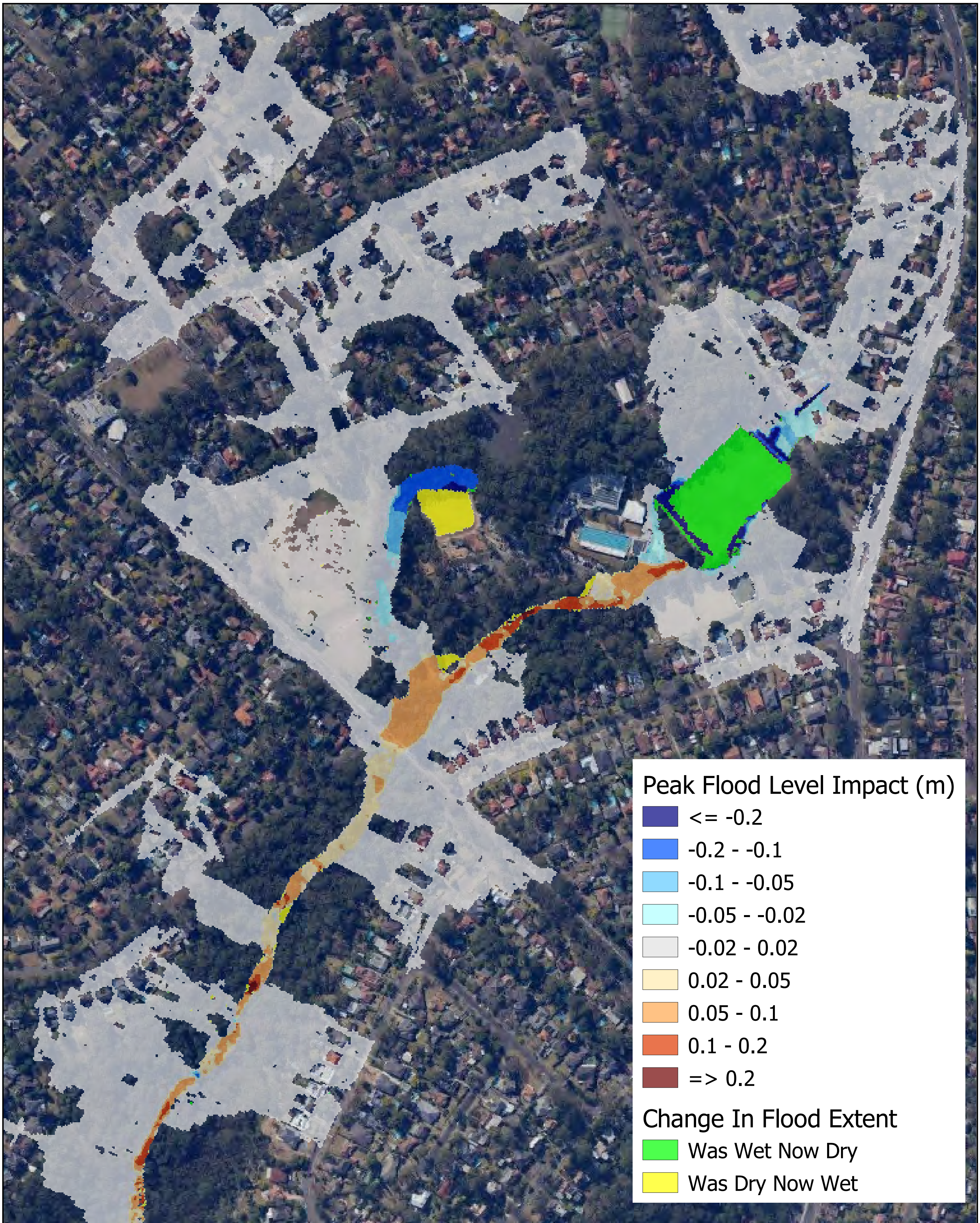
Drawing: **C18**

Rev: **A**

0 100 200 m

www.bmt.org

Filepath: S:\WATER\PROJECTS\S20504_MiddleHarbourSouthernCatchments_FS\QGIS\NGO\Report\Figure_Generator_200115\Project\Appendices.qgz



Title:

2% AEP Peak Flood Level Impact - Oval Bypass Design With Basin Option 2

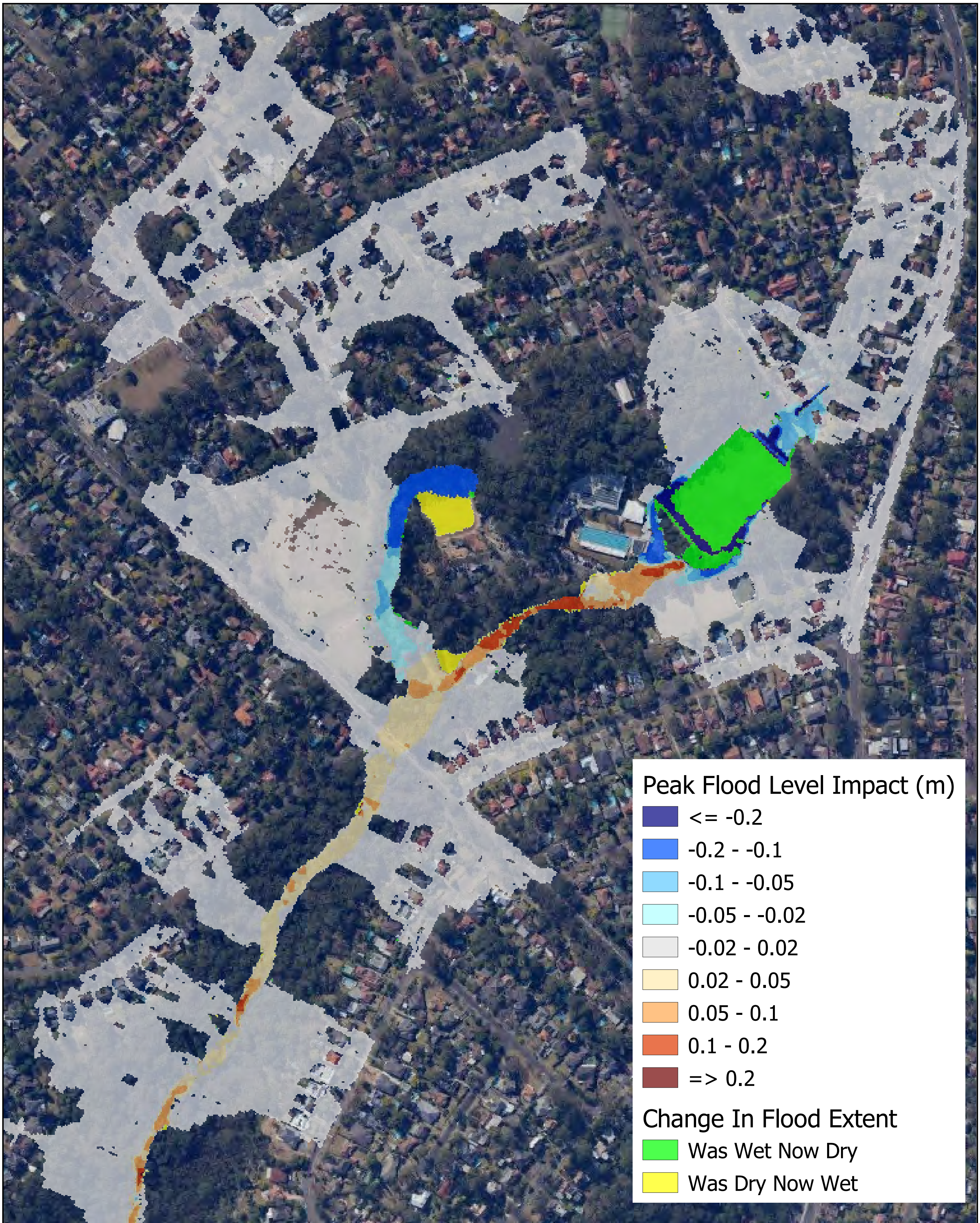
Drawing: **C19**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

Filepath: S:\WATER\PROJECTS\S20504_MiddleHarbourSouthernCatchments_FS\QGIS\NGO\Report\Figure_Generator_200115\Project\Appendices.qgz



Title:

1% AEP Peak Flood Level Impact - Oval Bypass Design With Basin Option 2

Drawing: **C20**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

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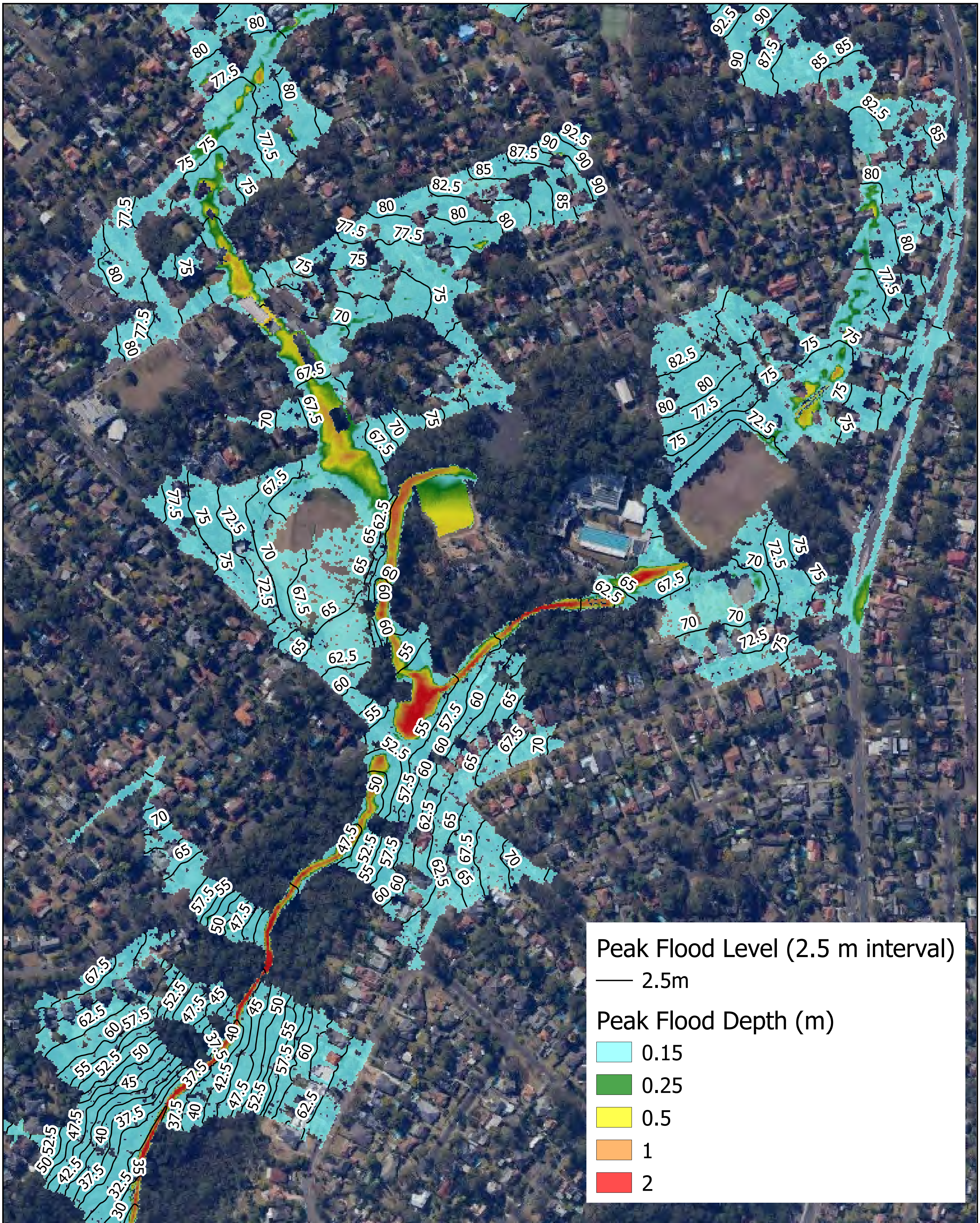


Title:

0.2 EY Peak Water Level and Depth - Oval Bypass Design With Basin Option 3

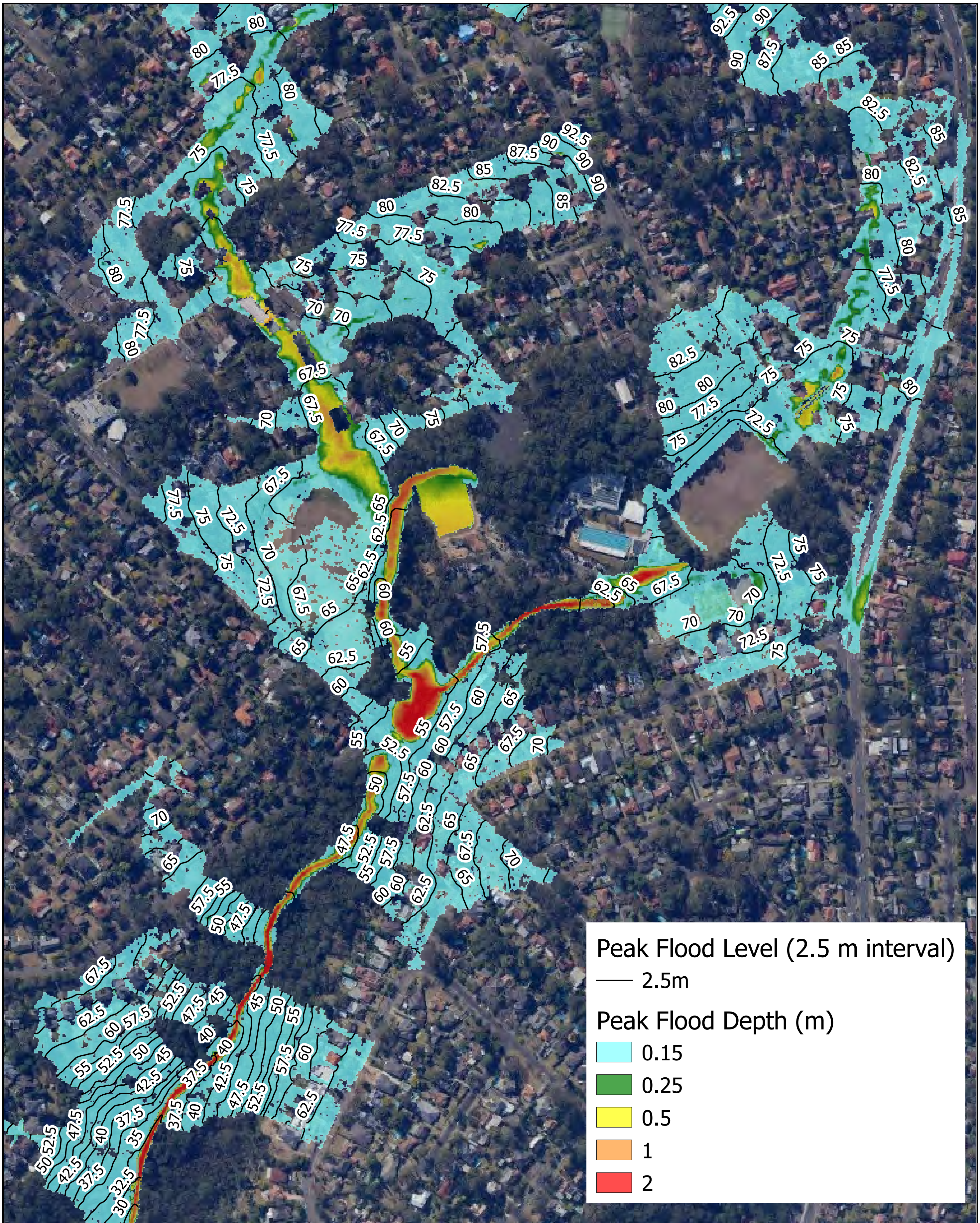
Drawing: **C21**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

Filepath: S:\WATER\PROJECTS\S20504_MiddleHarbourSouthernCatchments_FS\QGIS\NGO\Report\Figure_Generator_200115\Project\Appendices.qgz



Title:

10% AEP Peak Water Level and Depth - Oval Bypass Design With Basin Option 3

Drawing: **C22**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

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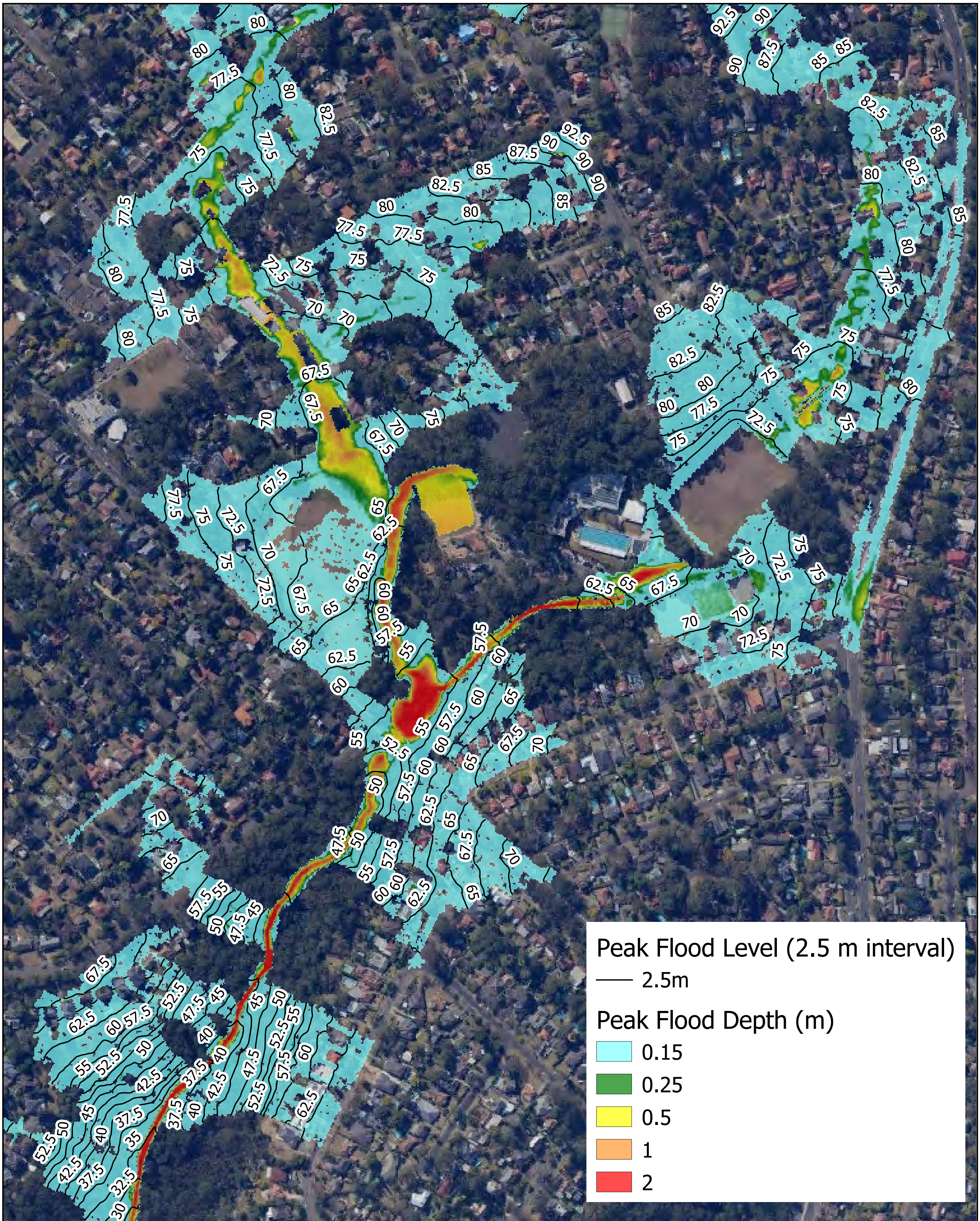


Title:

5% AEP Peak Water Level and Depth - Oval Bypass Design With Basin Option 3

Drawing: **C23**

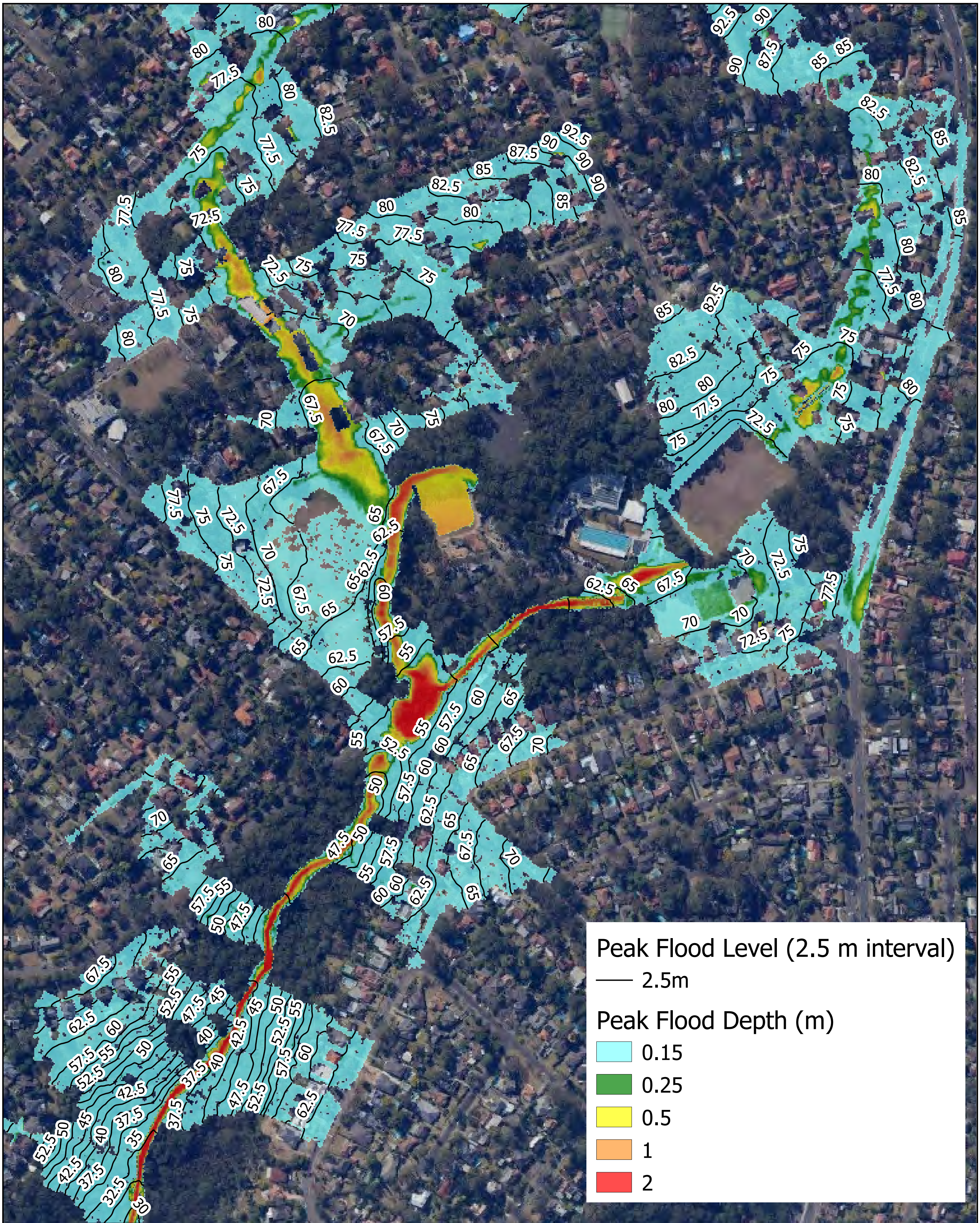
Rev: **A**

0 100 200 m

BMT

www.bmt.org

Filepath: S:\WATER\PROJECTS\S20504_MiddleHarbourSouthernCatchments_FS\QGIS\NGO\Report\Figure_Generator_200115\Project\Appendices.qgz



Title:

2% AEP Peak Water Level and Depth - Oval Bypass Design With Basin Option 3

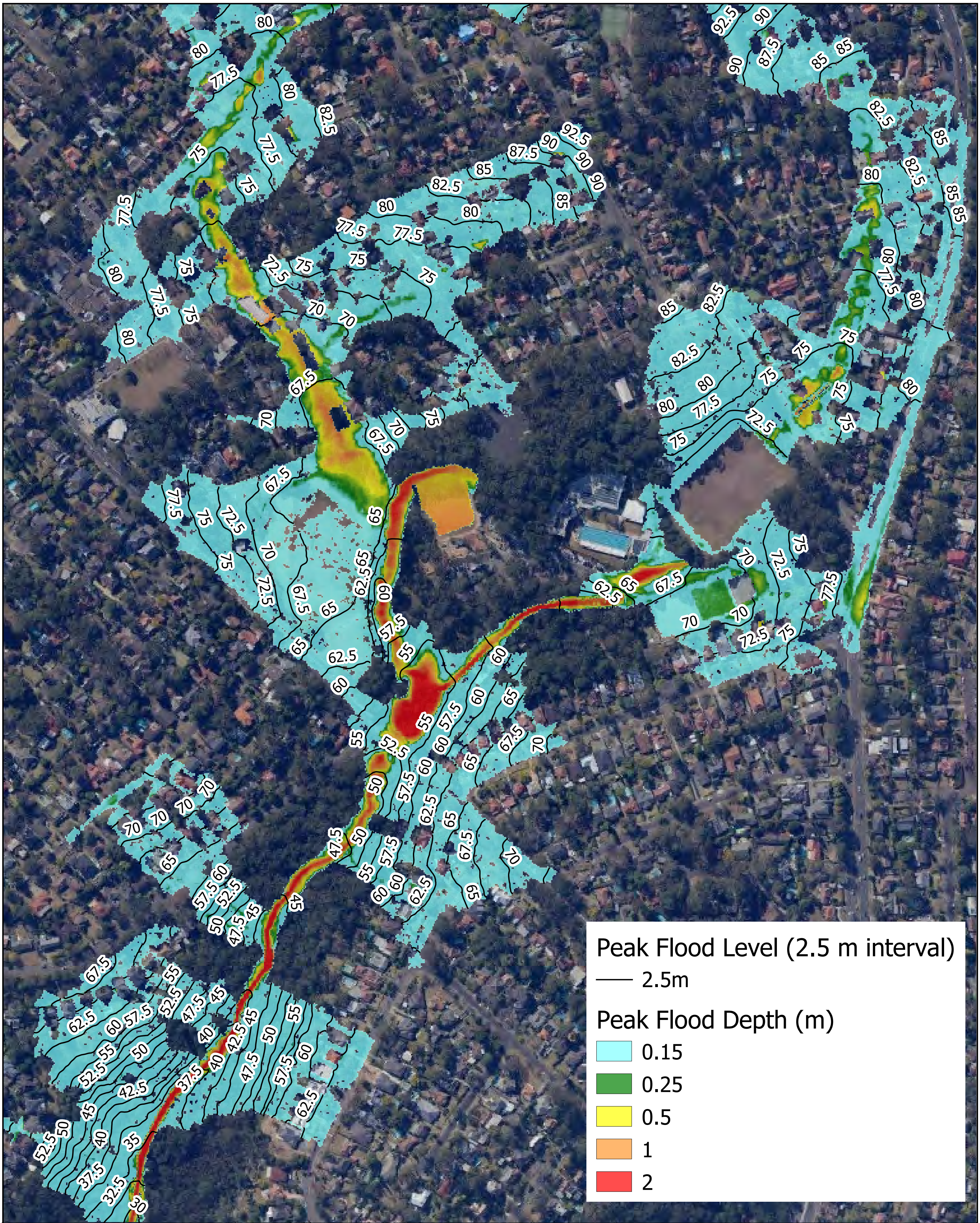
Drawing: **C24**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

Filepath: S:\WATER\PROJECTS\S20504_MiddleHarbourSouthernCatchments_FS\QGIS\NGO\Report\Figure_Generator_200115\Project\Appendices.qgz



Title:

1% AEP Peak Water Level and Depth - Oval Bypass Design With Basin Option 3

Drawing: **C25**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

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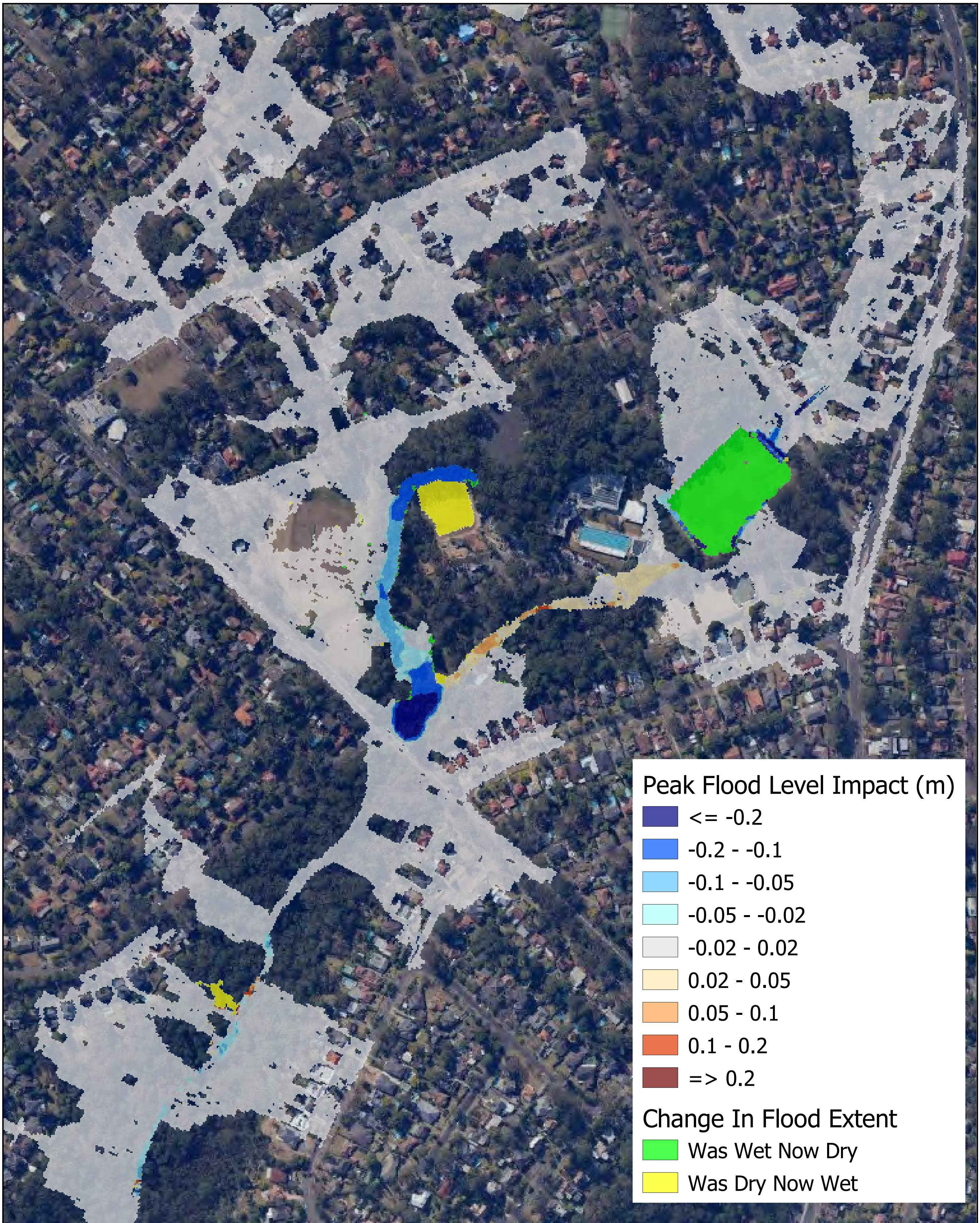

Title:

0.2 EY Peak Flood Level Impact - Oval Bypass Design With Basin Option 3

Drawing: **C26**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

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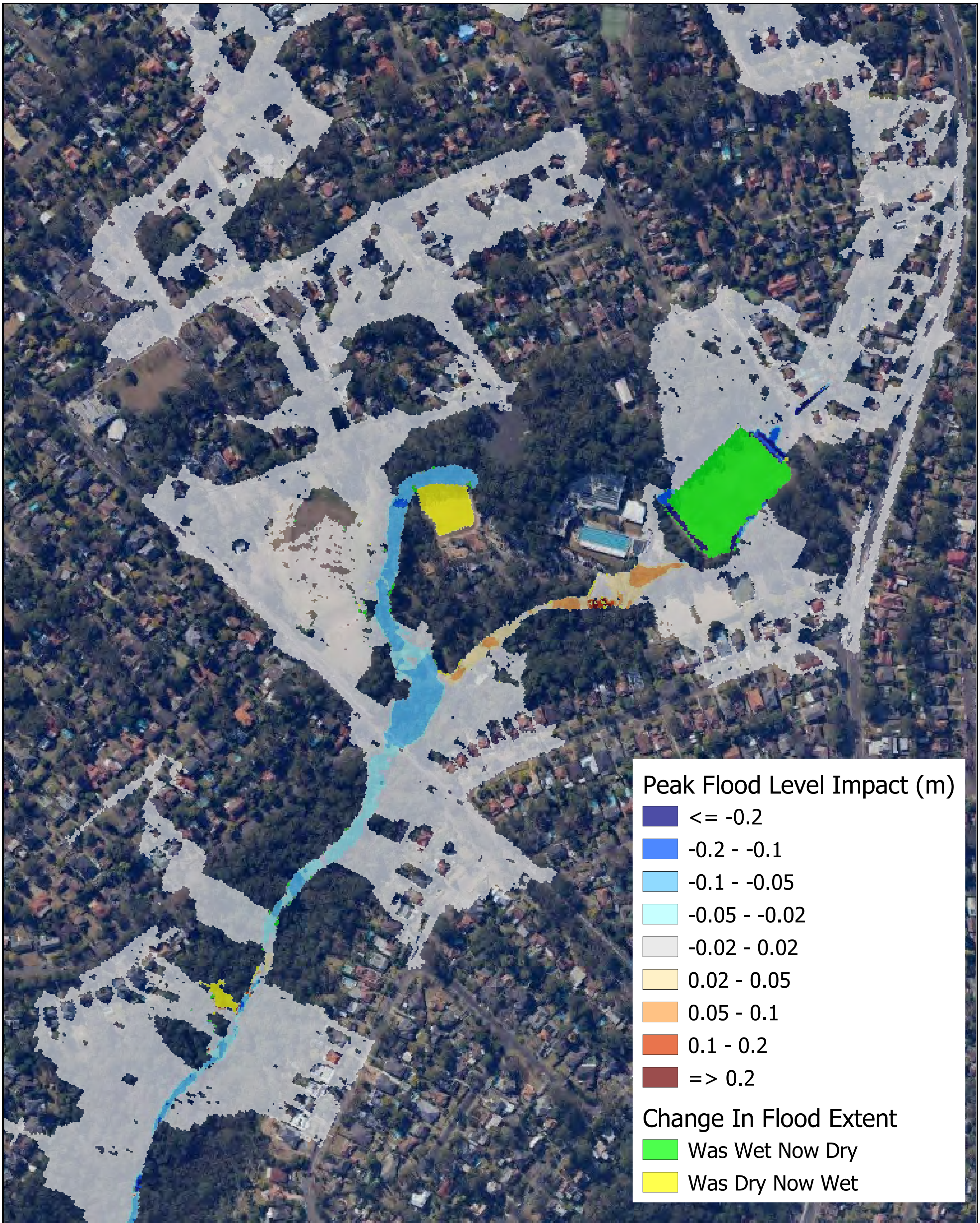

Title:

10% AEP Peak Flood Level Impact - Oval Bypass Design With Basin Option 3

Drawing: **C27**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

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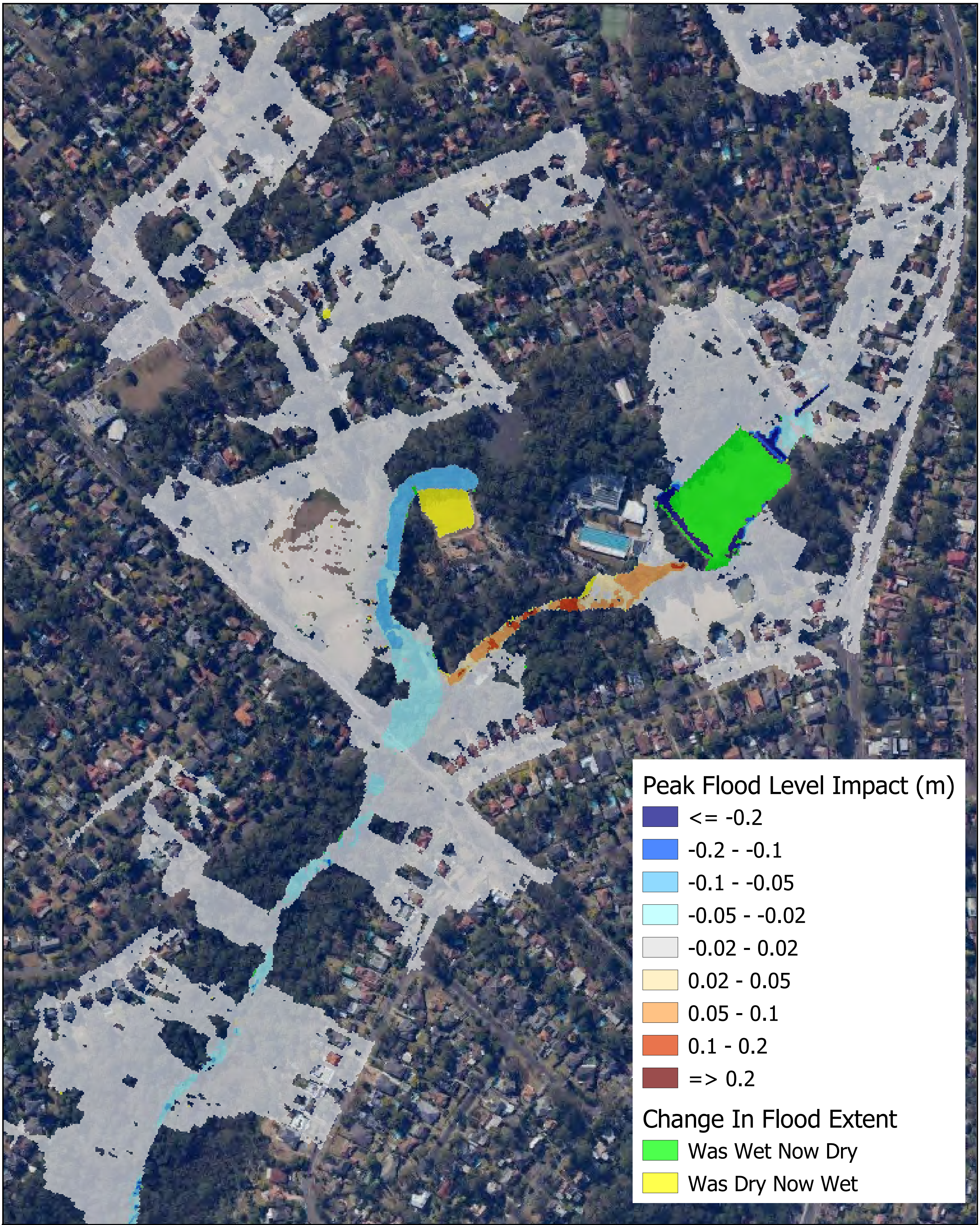


Title:

5% AEP Peak Flood Level Impact - Oval Bypass Design With Basin Option 3

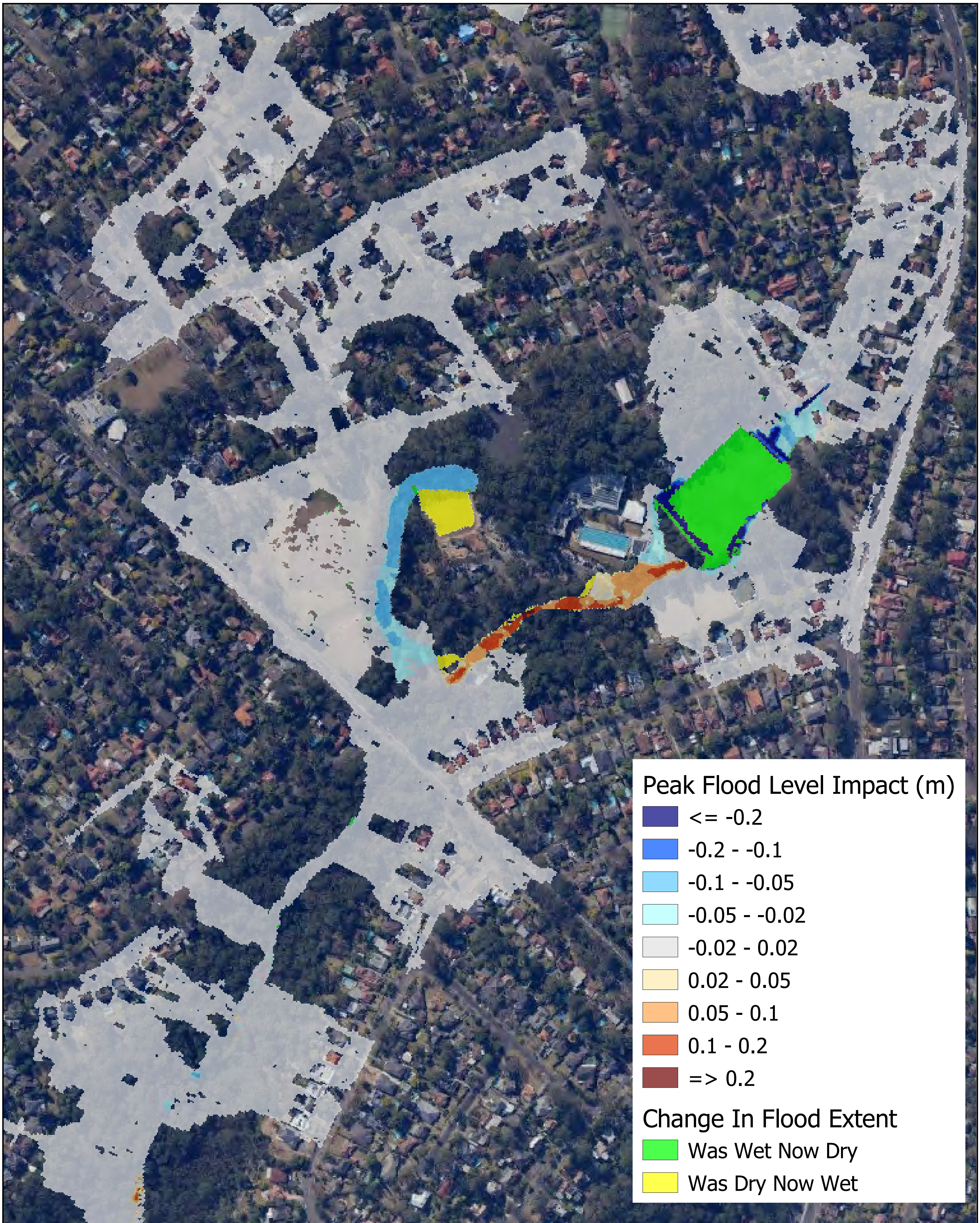
Drawing: **C28**

Rev: **A**

0 100 200 m

www.bmt.org

Filepath: S:\WATER\PROJECTS\S20504_MiddleHarbourSouthernCatchments_FS\QGIS\NGO\Report\Figure_Generator_200115\Project\Appendices.qgz



Title:

2% AEP Peak Flood Level Impact - Oval Bypass Design With Basin Option 3

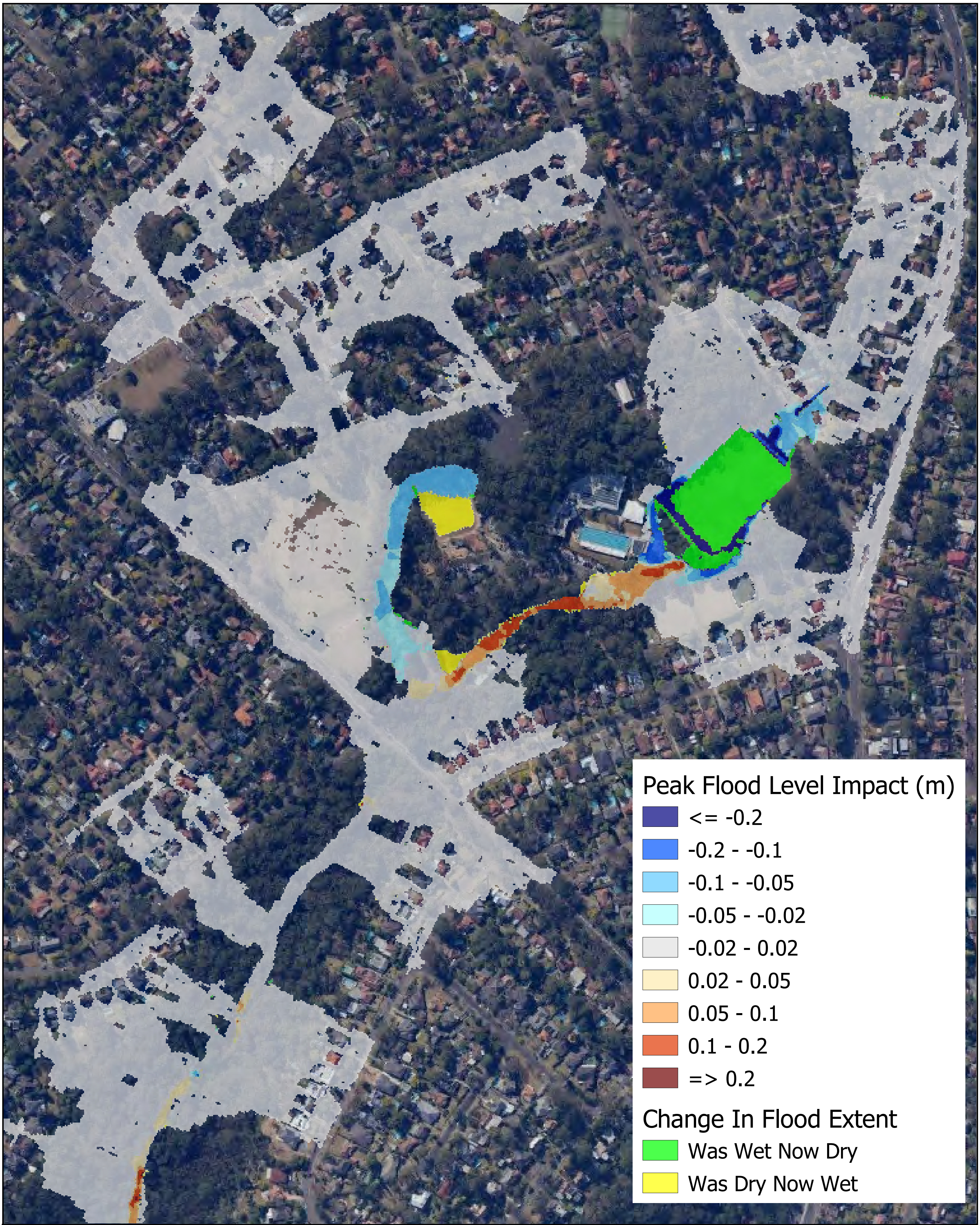
Drawing: **C29**

Rev: **A**

0 100 200 m

BMT
www.bmt.org

Filepath: S:\WATER\PROJECTS\S20504_MiddleHarbourSouthernCatchments_FS\QGIS\NGO\Report\Figure_Generator_200115\Project\Appendices.qgz



Title:

1% AEP Peak Flood Level Impact - Oval Bypass Design With Basin Option 3

Drawing: **C30**

Rev: **A**

0 100 200 m

www.bmt.org

Filepath: S:\WATER\PROJECTS\S20504_MiddleHarbourSouthernCatchments_FS\QGIS\NGO\Report\Figure_Generator_200115\Project\Appendices.qgz

Appendix D Cost Estimates

Basin Option 1

Note: Cost estimates for some works estimated from the Rawlinsons Australian Construction Handbook 2012. Prices indicated have been 'scaled' to 2020 prices using the Building Price Index. This is noted in source for each individual instance.

ITEM	Quantity	Unit	Unit-Rate	Cost	Source	Note
Preliminaries						
Site Establishment	1	item	10,000	$ 10,000	Estimate	
- Temporary establishment of ammenities and facilities for staff						
- Fencing of site; including environmental screening, security and safety considerations.						
- Protection of existing landscaping, structures and surfaces						
Environmental Mitigation	1	item	10,000	$ 10,000	Estimate	
- Noise and vibration screening						
- Temporary flood mitigation						
- Erosion and sediment control						
Earthworks						
Clear site of vegetation and cart away	3100	sq.m	0.4	$ 1,240	Rawlinsons Construction Cost Guide 2019	
Excavate over site to reduce levels in clay	1700	cu.m	35	$ 59,840	Rawlinsons Construction Cost Guide 2019	
Excavated material as filling (on site)	500	cu.m	10	$ 4,800	Rawlinsons Construction Cost Guide 2019	Excavated material assumed suitable for filling on site.
Compaction 300mm lifts (5 Total)	1600	sq.m	4	$ 5,840	Rawlinsons Construction Cost Guide 2019	
Turf, 400 mm wide roll turf laid, rolled and watered for two weeks	3100	sq.m	9	$ 28,210	Rawlinsons Construction Cost Guide 2019	
Cartage of excess excavated material (assume 15 km)	1000	cu.m	3	$ 3,000	Rawlinsons Construction Cost Guide 2019	
Disposal of excess excavated material	1600	t	150	$ 240,000	Rawlinsons Construction Cost Guide 2019	Disposal rates vary between $0 and $200 - use 150
Emergency Overflow Spillway						
Spillway scour protection (Macmat)	25	sq.m	7	$ 175		
Concrete Spillway	1	cu.m	360	$ 360	N25, Minicrete	
Waterproof membrane for Concrete Spillway	5	sq.m	47	$ 234	Rawlinsons Australian Construction Handbook 2012 (Scaled to 2020 Using Building Price Index)	
Spillway Tailwater scour protection (rip-rap)	35	t	120	$ 4,200	Estimate	
Spillway Tailwater scour protection (rip-rap underlay)	30	t	100	$ 3,000	Estimate	
Spillway Scour protection geotextile fabric	50	sq.m	9	$ 467	Rawlinsons Australian Construction Handbook 2012 (Scaled to 2020 Using Building Price Index)	
Outlet Pipe						
2 x 600 mm outlet pipes	100	m	760	$ 76,000	Previous experence, up to 2.5 m embedment	
Sumps and pits, 900 x 900 x 900 deep with 150 mm concrete base and walls	2	item	2,379	$ 4,758	Rawlinsons Australian Construction Handbook 2012 (Scaled to 2020 Using Building Price Index)	
Pit Lid	2	item	919	$ 1,839	Rawlinsons Australian Construction Handbook 2012 (Scaled to 2020 Using Building Price Index)	
Concrete (outlet)	1	item	5,000	$ 5,000	Estimate	
Tailwater scour protection (rip-rap)	30	t	120	$ 3,600	Estimate	
Tailwater scour protection (rip-rap underlay)	20	t	100	$ 2,040	Estimate	
Scour protection geotextile fabric	40	sq.m	9	$ 373	Rawlinsons Australian Construction Handbook 2012 (Scaled to 2020 Using Building Price Index)	
Sand filter	200	t	50	$ 10,000	Estimate	
Inlet screen	1	item	3,000	$ 3,000	Estimate	
Landscaping and Finishes						
Signs (free standing)	6	item	494	$ 2,966	2012 (Scaled to 2020 Using Building Price Index)	

<u>Geotechnical Requirements</u>											
Compaction testing (assuming 3 tests per day, 4 week construction time)	60	item	200	$	12,000	Estimate					
Geotechnical inspections (Assume 4 weeks earthworks construction, engineer half time)	80	hours	120	$	9,600	Estimate					
<u>Allowances</u>											
Concrete joints	4	m	36	$	178	Rawlinsons Australian Construction Handbook 2012 (Scaled to 2020 Using Building Price Index)					
Concrete testing	2	item	250	$	500	Estimate					
<u>Project Finalisation</u>											
Site disestablishment and Cleanup	1	item	10,000	$	10,000						
		SUB-TOTAL		$	513,219						
<u>Indirect costs</u>											
Design costs			13%	$	66,718	Assume REF					
Risk + consequence assesment		**item**		$	30,000						
Contractor costs			35%	$	179,627	Management costs + contractor margin					
Contingency			20%	$	151,913	Applied to materials and labour, design and contractor costs					
		TOTAL		**$**	**941,477**						

Basin Option 2

Note: Cost estimates for some works estimated from the Rawlinsons Australian Construction Handbook 2012. Prices indicated have been 'scaled' to 2020 prices using the Building Price Index. This is noted in source for each individual instance.

ITEM	Quantity	Unit	Unit-Rate	Cost	Source	Note
Preliminaries						
Site Establishment	1	item	10,000	$ 10,000	Estimate	
- Temporary establishment of ammenities and facilities for staff						
- Fencing of site; including environmental screening, security and safety considerations.						
- Protection of existing landscaping, structures and surfaces						
Environmental Mitigation	1	item	10,000	$ 10,000	Estimate	
- Noise and vibration screening						
- Temporary flood mitigation						
- Erosion and sediment control						
Earthworks						
Clear site of vegetation and cart away	3100	sq.m	0.4	$ 1,240	Rawlinsons Construction Cost Guide 2019	
Excavate over site to reduce levels in clay	2100	cu.m	35	$ 73,920	Rawlinsons Construction Cost Guide 2019	
Excavated material as filling (on site)	500	cu.m	10	$ 4,800	Rawlinsons Construction Cost Guide 2019	Excavated material assumed suitable for filling on site.
Compaction 300mm lifts (5 Total)	1600	sq.m	4	$ 5,840	Rawlinsons Construction Cost Guide 2019	
Turf, 400 mm wide roll turf laid, rolled and watered for two weeks	3100	sq.m	9	$ 28,210	Rawlinsons Construction Cost Guide 2019	
Cartage of excess excavated material (assume 15 km)	1500	cu.m	3	$ 4,500	Rawlinsons Construction Cost Guide 2019	
Disposal of excess excavated material	2400	t	150	$ 360,000	Rawlinsons Construction Cost Guide 2019	Disposal rates vary between $0 and $200 - use 150
Emergency Overflow Spillway						
Spillway scour protection (Macmat)	25	sqm	7	$ 175		
Concrete Spillway	1	cu.m	360	$ 360	N25, Minicrete	
Waterproof membrane for Concrete Spillway	5	sqm	47	$ 234	Rawlinsons Australian Construction Handbook 2012 (Scaled to 2020 Using Building Price Index)	
Spillway Tailwater scour protection (rip-rap)	35	t	120	$ 4,200	Estimate	
Spillway Tailwater scour protection (rip-rap underlay)	30	t	100	$ 3,000	Estimate	
Spillway Scour protection geotextile fabric	50	sqm	9	$ 467	Rawlinsons Australian Construction Handbook 2012 (Scaled to 2020 Using Building Price Index)	
Outlet Pipe						
2 x 600 mm outlet pipes	100	m	760	$ 76,000	Previous experence, up to 2.5 m embedment	
Sumps and pits, 900 x 900 x 900 deep with 150 mm concrete base and walls	2	item	2,379	$ 4,758	Rawlinsons Australian Construction Handbook 2012 (Scaled to 2020 Using Building Price Index)	
Pit Lid	2	item	919	$ 1,839	Rawlinsons Australian Construction Handbook 2012 (Scaled to 2020 Using Building Price Index)	
Concrete (outlet)	1	item	5,000	$ 5,000	Estimate	
Tailwater scour protection (rip-rap)	30	t	120	$ 3,600	Estimate	
Tailwater scour protection (rip-rap underlay)	20	t	100	$ 2,040	Estimate	
Scour protection geotextile fabric	40	sqm	9	$ 373	Rawlinsons Australian Construction Handbook 2012 (Scaled to 2020 Using Building Price Index)	
Sand filter	200	t	50	$ 10,000	Estimate	
Inlet screen	1	item	3,000	$ 3,000	Estimate	
Landscaping and Finishes						
Signs (free standing)	6	item	494	$ 2,966	2012 (Scaled to 2020 Using Building Price Index)	

<u>Geotechnical Requirements</u>						
Compaction testing (assuming 3 tests per day, 4 week construction time)	60	item	200	$	12,000	Estimate
Geotechnical inspections (Assume 4 weeks earthworks construction, engineer half time)	80	hours	120	$	9,600	Estimate
<u>Allowances</u>						
Concrete joints	4	m	36	$	178	Rawlinsons Australian Construction Handbook 2012 (Scaled to 2020 Using Building Price Index)
Concrete testing	2	item	250	$	500	Estimate
<u>Project Finalisation</u>						
Site disestablishment and Cleanup	1	item	10,000	$	10,000	
		SUB-TOTAL		$	648,799	
<u>Indirect costs</u>						
Design costs			13%	$	84,344	Assume REF
Risk + consequence assesment		**item**		$	30,000	
Contractor costs			35%	$	227,080	Management costs + contractor margin
Contingency			20%	$	192,044	Applied to materials and labour, design and contractor costs
		TOTAL		**$**	**1,182,267**	

Basin Option 3

Note: Cost estimates for some works estimated from the Rawlinsons Australian Construction Handbook 2012. Prices indicated have been 'scaled' to 2020 prices using the Building Price Index. This is noted in source for each individual instance.

ITEM	Quantity	Unit	Unit-Rate	Cost	Source	Note
Preliminaries						
Site Establishment	1	item	10,000	$ 10,000	Estimate	
- Temporary establishment of ammenities and facilities for staff						
- Fencing of site; including environmental screening, security and safety considerations.						
- Protection of existing landscaping, structures and surfaces						
Environmental Mitigation	1	item	10,000	$ 10,000	Estimate	
- Noise and vibration screening						
- Temporary flood mitigation						
- Erosion and sediment control						
Earthworks						
Clear site of vegetation and cart away	3100	sq.m	0.4	$ 1,240	Rawlinsons Construction Cost Guide 2019	
Excavate over site to reduce levels in clay	3100	cu.m	35	$ 109,120	Rawlinsons Construction Cost Guide 2019	
Excavated material as filling (on site)	500	cu.m	10	$ 4,800	Rawlinsons Construction Cost Guide 2019	Excavated material assumed suitable for filling on site.
Compaction 300mm lifts (5 Total)	1600	sq.m	4	$ 5,840	Rawlinsons Construction Cost Guide 2019	
Turf, 400 mm wide roll turf laid, rolled and watered for two weeks	3100	sq.m	9	$ 28,210	Rawlinsons Construction Cost Guide 2019	
Cartage of excess excavated material (assume 15 km)	2600	cu.m	3	$ 7,800	Rawlinsons Construction Cost Guide 2019	
Disposal of excess excavated material	4200	t	150	$ 630,000	Rawlinsons Construction Cost Guide 2019	Disposal rates vary between $0 and $200 - use 150
Emergency Overflow Spillway						
Spillway scour protection (Macmat)	25	sqm	7	$ 175		
Concrete Spillway	1	cu.m	360	$ 360	N25, Minicrete	
Waterproof membrane for Concrete Spillway	5	sqm	47	$ 234	Rawlinsons Australian Construction Handbook 2012 (Scaled to 2020 Using Building Price Index)	
Spillway Tailwater scour protection (rip-rap)	35	t	120	$ 4,200	Estimate	
Spillway Tailwater scour protection (rip-rap underlay)	30	t	100	$ 3,000	Estimate	
Spillway Scour protection geotextile fabric	50	sqm	9	$ 467	Rawlinsons Australian Construction Handbook 2012 (Scaled to 2020 Using Building Price Index)	
Outlet Pipe						
2 x 600 mm outlet pipes	100	m	760	$ 76,000	Previous experence, up to 2.5 m embedment	
Sumps and pits, 900 x 900 x 900 deep with 150 mm concrete base and walls	2	item	2,379	$ 4,758	Rawlinsons Australian Construction Handbook 2012 (Scaled to 2020 Using Building Price Index)	
Pit Lid	2	item	919	$ 1,839	Rawlinsons Australian Construction Handbook 2012 (Scaled to 2020 Using Building Price Index)	
Concrete (outlet)	1	item	5,000	$ 5,000	Estimate	
Tailwater scour protection (rip-rap)	30	t	120	$ 3,600	Estimate	
Tailwater scour protection (rip-rap underlay)	20	t	100	$ 2,040	Estimate	
Scour protection geotextile fabric	40	sqm	9	$ 373	Rawlinsons Australian Construction Handbook 2012 (Scaled to 2020 Using Building Price Index)	
Sand filter	200	t	50	$ 10,000	Estimate	
Inlet screen	1	item	3,000	$ 3,000	Estimate	
Landscaping and Finishes						
Signs (free standing)	6	item	494	$ 2,966	2012 (Scaled to 2020 Using Building Price Index)	

Geotechnical Requirements					
Compaction testing (assuming 3 tests per day, 4 week construction time)	60	item	200	$ 12,000	Estimate
Geotechnical inspections (Assume 4 weeks earthworks construction, engineer half time)	80	hours	120	$ 9,600	Estimate
Allowances					
Concrete joints	4	m	36	$ 178	Rawlinsons Australian Construction Handbook 2012 (Scaled to 2020 Using Building Price Index)
Concrete testing	2	item	250	$ 500	Estimate
Project Finalisation					
Site disestablishment and Cleanup	1	item	10,000	$ 10,000	
		SUB-TOTAL		$ 957,299	
Indirect costs					
Design costs			13%	$ 124,449	Assume REF
Risk + consequence assesment		**item**		$ 30,000	
Contractor costs			35%	$ 335,055	Management costs + contractor margin
Contingency			20%	$ 283,360	Applied to materials and labour, design and contractor costs
		TOTAL		**$ 1,730,163**	

Gabion Basket Creek Stabilisation

Note: Cost estimates for some works estimated from the Rawlinsons Australian Construction Handbook 2012. Prices indicated have been 'scaled' to 2020 prices using the Building Price Index. This is noted in source for each individual instance.

ITEM	Quantity	Unit	Unit-Rate	Cost	Source	Note
Preliminaries						
Site Establishment	1	item	10,000	$ 10,000	Estimate	
- Temporary establishment of ammenities and facilities for staff						
- Fencing of site; including environmental screening, security and safety considerations.						
- Protection of existing landscaping, structures and surfaces						
Environmental Mitigation	1	item	10,000	$ 10,000	Estimate	
- Noise and vibration screening						
- Temporary flood mitigation						
- Erosion and sediment control						
Materials						
Gabion Baskets (500 mm H x 500 mm W x 1000 mm L filled with 450 kg of blue metal or equvalent)	1440	item	150	$ 216,000	Estimate	Filled cost. No potential discounts for larger potential quantities applied. 450 kg of blue metal nominated supplier capacity of a 500 mm H x 500 mm W x 1000 mm L basket)
Labour						
Crew (assumed crew of 4 for 12 week period)	1680	hour	100	$ 168,000	Rawlinsons Australian Construction Handbook 2012 (Scaled to 2020 Using Building Price Index)	
Excavator hire (assumed 12 week hire period)	60	day	600	$ 36,000	Kennards	Cost for mini-excavator
Project Finalisation						
Site disestablishment and Cleanup	1	item	10,000	$ 10,000		
		SUB-TOTAL		$ 450,000		
Indirect costs						
Design + approvals			13%	$ 58,500	Assume simple REF	
Contractor costs			35%	$ 157,500	Management costs + contractor margin	
Contingency			20%	$ 133,200	Applied to materials and labour, design and contractor costs	
		TOTAL		**$ 799,200**		

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