The **Ordinary Meeting** of
Bayside Council
will be held in the Rockdale Town Hall, Council Chambers,
Level 1, 448 Princes Highway, Rockdale
on Wednesday, 10 October 2018 at 7:00 pm.

UNDER SEPARATE COVER ATTACHMENTS

BAYSIDE COUNCIL

ARNCLIFFE PARK CONCEPT REFINEMENT

FINAL REPORT

AUGUST 2018

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ARNCLIFFE PARK CONCEPT REFINEMENT

FINAL REPORT

AUGUST 2018

Project Arncliffe Park Concept Refinement Final Report	**Project Number** 116016
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Date 1 August 2018	**Verified by**

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Cover photo WMAwater

EXECUTIVE SUMMARY

Arncliffe Park has been identified by Bayside Council (Council) as a potential location for a synthetic turf soccer field. Being located within the Bonnie Doon channel catchment's overland flow path (Reference 1), flood impacts resulting from the field construction, and the possibility of using this site to mitigate flood risk are key considerations.

Following initial investigation in October 2017 (Reference 2), Bayside Council has engaged WMAwater to further refine a concept design for the field. The preferred option is to install a synthetic turf playing field atop a suspended slab. Underneath the slab, it is proposed to allow overland flow across the full width of the field from west to east. One option comprises just the field and flow path, while another would also include excavating beneath the overland flow path to create a flood storage tank. In both options, the design objective is to keep the synthetic turf flood free in at least the 5% AEP event (or rarer if possible) to minimise damage that can be caused by overland flow on the field. This design represents a hybrid of various options assessed in the October 2017 (Reference 2) report.

This concept refinement investigation has been undertaken to achieve two main objectives:

- Confirm the proposed arrangement functions appropriately during flood events (10% AEP and 1% AEP have been tested specifically); and
- Prepare concept design drawings for the purpose of progressing the project and for communication with other stakeholders.

In regards to the above objectives, the flood assessment undertaken has confirmed the proposed design functions as intended, and does not cause adverse offsite flood impacts. The overland flow path is maintained beneath the suspended synthetic soccer pitch and mimics existing conditions closely enough to not cause flood level impacts outside the park area. Furthermore, the raised field and detention tank option was confirmed to reduce peak flood levels downstream of Arncliffe Park as far as Arncliffe Street downstream of the train line.

Concept drawings have been prepared by Warren Smith & Partners and are included as Appendix A.

BONNIE DOON CATCHMENT FLOOD RISK MANAGEMENT CONCEPT DESIGN REPORT

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AAD	Annual Average Damages
AEP	Annual Exceedance Probability
ARI	Average Recurrence Interval
ARR	Australian Rainfall and Runoff
B/C	Cost Benefit Ratio
DRAINS	Hydrologic Modelling Package
DEM	Digital Elevation Model
ENM	Excavated Natural Material
EPA	Environmental Protection Authority
FRMP	Floodplain Risk Management Plan
mAHD	meters above Australian Height Datum
OEH	Office of Environment and Heritage
PMF	Probable Maximum Flood
TUFLOW	one-dimensional (1D) and two-dimensional (2D) flood and tide simulation software (hydraulic model)
WBNM	Watershed Bounded Network Model (hydrologic model)

1. INTRODUCTION

1.1. Background

Bayside Council is responsible for local planning and land management in the Bonnie Doon channel catchment including the management of the floodplain of the drainage system. The Bonnie Doon catchment has been the subject of a number of flood investigations over time, with various potential flood risk mitigation options identified and assessed. Arncliffe Park, which lies on the main Bonnie Doon overland flow-path, has been identified by Council as a potential location for a synthetic turf playing field to meet the increasing demand for sport and recreational facilities. Synthetic turf offers an alternative to existing natural turf fields, which are subject to maintenance issues and frequent closure due to weather conditions.

In 2017, Council commissioned a concept design report (WMAwater, October 2017, Reference 2) that assessed a number of flood mitigation options at Arncliffe Park. The main options at the outset were upgrading the stormwater drainage along Wollongong Road in Arncliffe between Athelstane Avenue and Allen Street, and investigating the potential benefits of constructing a detention basin in Arncliffe Park to temporarily store flood water to mitigate flooding of downstream properties. Both synthetic and natural playing field surfaces were investigated in the options. It was identified that if a synthetic field were built at ground level, it would require very large drainage swales around the pitch to prevent damage from overland flow, and these swales would significantly reduce amenity of the field and aesthetic features of the heritage listed areas of the park.

This report evaluates the preferred options for refinement, representing a hybrid of the options assessed in Reference 2. The preferred option is to install a synthetic turf playing field atop a suspended slab. Underneath the slab, it is proposed to allow overland flow across the full width of the field from west to east. One option comprises just the field and flow path, while another would also include excavating beneath the overland flow path to create a flood storage tank. In both options, the design objective is to keep the synthetic turf flood free in at least the 5% AEP event (or rarer if possible) to minimise damage caused by overland flow on the field.

1.2. Summary of Previous Option Assessment

WMAwater completed a preliminary options assessment in October 2017 (Reference 2) which investigated the following options:

- WR1: Wollongong Road Pipe Upgrade
- Arncliffe Park Options:
  - AP01: Synthetic turf Field at base of detention basin with swale around the field;
  - AP02: Synthetic turf Field at natural surface with swale around the field;
  - AP03: Synthetic turf field above a concrete detention tank;
  - AP04: Synthetic field above 'Atlantis' (or equivalent) cell storage tank; and
  - AP05: Non-synthetic field at base of detention basin.

The assessment found that out of the above options, upgrading the pipe along Wollongong Road between Athelstane Avenue and Firth Street offered the greatest reduction in flood damages. The pipe upgrade would cover approximately 1 km, and was estimated to reduce the Annual Average Damages by 8.6% ($141,000). The high estimated capital cost of this option (~$4.5M) however results in a BC ratio of less than 0.5, indicating it is not economically viable. This option has not been progressed in this current study.

Out of the Arncliffe Park options, it was found that Option AP05 (i.e. non-synthetic field at base of detention basin) was the most effective option in terms of flood damage reduction, however it did not include a synthetic turf surface. As Council's preference is to pursue a synthetic turf field, the following considerations in terms of flooding are important:

- Synthetic turf surfaces must be protected from overland flow. Overland runoff can cause costly damage to synthetic playing surfaces as the rubber crumb infill becomes clogged with silt and fines, preventing infiltration and resulting in water logged fields, or ingressing beneath the surface and damaging the field via uplift forces;
- Raised structures (either for field construction or detention basin storage) must be designed so as to not cause upstream flood impacts and increase flood risk on Mitchell Street;
- It has been acknowledged that the use of synthetic turf adds significantly to the capital cost of the park and does not contribute to flood mitigation. This affects how costs are considered for the purposes of any flooding cost-benefit ratio for the project; and
- It is also acknowledged that with ongoing redevelopment downstream of Arncliffe Park, fewer properties will be at risk of flooding (as new buildings are built above the Flood Planning Level) and that the direct Annual Average Damages are likely to be reduced in the future. This affects how benefits are considered for the purposes of any flooding cost-benefit ratio for the project.

These points have been considered by Council, and have led to the development of the preferred option, described below.

1.3. Preferred Options

Following discussion with Council on the 5th March 2018, WMAwater progressed the refinement of two preferred options.

1.3.1. Features of Each Option

The following features are common to both options:

- Raised (synthetic turf) field with an assumed surface level of 19 mAHD and a suspended underside of 18.5 mAHD. At the upstream end (towards Mitchell Street) the top of the field surface will be approximately 830 mm above natural ground surface. Due to the fall of the existing natural surface, at the downstream end the top of the field surface would stand between ~1.9 m (flat field) and ~1.2 m above ground (for a field slope of 0.7 %).
- The field dimensions would be consistent with the existing fenced area and not require the removal of existing trees. Discussion of preferred field dimensions is provided in Section 1.3.3.

- The existing overland flow path will be retained beneath the field's superstructure, designed to mimic existing conditions. It is proposed that this surface would be lined with a 200 mm deep rock mattress with nominal diameter 100mm to protect against erosion.
- Natural ground levels beneath the field would be reduced by approximately 200 mm for the first 50 m of the field length, then tied back into natural surface.
- Each option will include a concrete low flow dish drain under the field, with dimensions about 4 m wide and 300 mm deep.
- At the downstream end of the concrete dish drain, a concrete baffle is proposed to redistribute flows across the width of the field and prevent concentration of flow at Broe Avenue.
- The surrounding ground would be filled to either side of the field to tie into existing levels and provide the primary field access. The left-hand side is proposed to have batters of 1:20, while the right-hand side will have a variable batter to tie in the field surface to existing levels alongside Wollongong Road (as flat as practicable).
- Both options would require a large inlet grate structure on the upstream embankment of the field. Iterative modelling has shown an inlet grate width of approximately 40 m will provide adequate inflow capacity. (refer to Section 3.4).
- Flow will exit the below-field dish drain via a low level grate (0.4 m high) the width of the field. A baffle measuring 2 m wide by 0.5 m high immediately upstream of the grate will assist to redistribute flows back across the width of the field, with the intent to mimic existing conditions and not worsen flood behaviour on Broe Avenue.

Note: At this stage a flat field has been modelled, designed and costed, however the field may be sloped towards Broe Avenue. The maximum allowable gradient would be contingent on synthetic turf design requirements and specifications for playability depending on the preferred standard of pitch (e.g. FIFA). A sloped field would be beneficial to reducing the height above natural surface at the downstream end.

1.3.2. Features of Detention Tank Option

This option has the features of the raised field as described above. In addition to the features listed above, this option includes:

- An underground concrete storage tank, with an indicative capacity of 5,400 m^3 (See Section 1.3.4 for discussion of selected tank capacity).
- At the upstream end, flow would enter the tank via an inlet grate below the field. The existing stormwater drainage line could also be diverted into the tank (to be decided at detailed design).
- At the downstream end, flow would be discharged to the existing drainage network via a 750 mm diameter pipe.
- A vertical manhole would provide a connection from underneath the grate into the tank area.

Concept drawings for both options have been provided in Appendix A.

1.3.3. Preferred Field Dimensions

The proposed field dimensions are limited by the trees at the north-eastern end of the park (see Image 1) which are to be retained. The following are noted from Football NSW guidelines (Reference 3):

- FIFA recommendations for field dimensions in professional football are 105 metres in length and 68 metres in width (plus buffer zones). Clubs are encouraged where possible to mark their fields in accordance with this standard.
- There must be buffer zones between the Field of Plane line marking and any Advertising Boards or Perimeter Fence. The minimum distance for a buffer zone from the touch line or goal line is 3 metres, with the exception of the touch line on which side the Technical Area is located, which must extend five metres to allow for the Team Benches.
- The benches in the Technical Area may be set back into the perimeter fence, resulting in the seating being in-line with the perimeter fence (i.e. 3 m buffer zone) and the back of the bench extending 2 metres beyond the perimeter fence.

The current cricket pitch at Arncliffe Park is 61 m wide by 96 m long, and the fenced area assumed to be used as the cricket oval is 93 m wide by 116 m long. With these guidelines in mind, advice from Council recommended the following dimensions (with buffer zones in brackets):

- *minimum length of 96 m (+3 m +3 m) = 102 m and width of 61 m (+3 m +5 m) = 69 m;*
- *An alternative larger option is 100m long (total 106m), width 65m (total 73m). This is still within the current extent of the fenced area.*

Image 1 Aerial photograph of Arncliffe Park

1.3.4. Selection of Detention Tank Capacity

Early in the concept design refinement process, sensitivity analysis was undertaken to determine the flood benefits of detention tanks with varying capacities. These were presented to Council in a memorandum dated 1st May 2018, and have been summarised in Table 1. The original sensitivity assessment figures have been included in Figure 19 to Figure 22 and show the peak flood level impacts of 2,500 m^3, 5,000 m^3, 10,000 m^3 and 15,000 m^3 tank options.

Table 1: Effect of Detention Tank Volume on Peak Flood Depths (1% AEP Event)*

Location	Base Case Depth (m)	2,500 m^3 tank Depth (m) (*Difference*)		5,000 m^3 tank Depth (m) (*Difference*)		10,000 m^3 tank (Depth (m) (*Difference*)		15,000 m^3 tank (Depth (m) (*Difference*)	
Mitchell St	**0.69**	0.69	*(0.00)*	0.69	*(0.00)*	0.68	*(-0.01)*	0.68	*(-0.01)*
Broe Ave	**0.35**	0.35	*(0.00)*	0.35	*(0.01)*	0.35	*(0.00)*	0.31	*(-0.04)*
Kelsey Street	**0.93**	0.93	*(0.00)*	0.91	*(-0.02)*	0.80	*(-0.13)*	0.65	*(-0.28)*
Wollongong Rd (near railway embankment)	**1.65**	1.62	*(-0.03)*	1.55	*(-0.1)*	1.46	*(-0.19)*	1.46	*(-0.19)*
Bidjigal Rd	**1.45**	1.41	*(-0.04)*	1.36	*(-0.09)*	1.18	*(-0.27)*	0.97	*(-0.48)*
Arncliffe St, east of Guess Ave	**1.23**	1.18	*(-0.05)*	1.14	*(-0.09)*	1.10	*(-0.13)*	1.09	*(-0.14)*

** Note that given the variability of the terrain, the depths provided in Table 1 are indicative of the peak flood depths in the vicinity of the inspection point in the 1% AEP event and are intended to show the relativity of impacts caused by each detention tank option. Inspection locations are indicated on Figure 2.*

Tank storage is shown to be effective and beneficial to downstream peak flood levels, but what can be built will largely depend on the following limitations:

- Construction expense;
- Excavation and spoil disposal expenses;
- Existing sewer and stormwater pipes through the park;
- The invert of the receiving pipe which sets the minimum downstream tank invert level. Below this point pumps would be required to drain the detention tank.

Following the sensitivity analysis and consideration of the above constraints, Warren Smith and Partners assumed tank dimensions of approximately 49 m wide by 110 m long, with a height of 1.0 m to limit excavation depth. The resulting tank would a capacity of 5,400 m^3. The flood level impacts associated with this tank capacity are discussed in Section 3.2.2.

1.3.5. Tank Construction

It was identified that for the tank option, there may be significant advantages in removing the separation between the detention tank and the overland flow path beneath the field. That is, the area below the field could be constructed as a large excavated open tank, and all overland flow would enter the tank, which would either be transferred to the existing downstream stormwater network via an outlet pipe, or spill when full at the downstream end in a similar manner to the existing overland flow path. This option would provide significant benefits in terms of cost, available flood detention volume, access for maintenance, and other benefits. If the tank storage option is found to be feasible, this design refinement should be considered at the detailed design stage. Such an excavation would potentially be very dangerous to the public (especially children) if access is not adequately restricted with appropriate fencing.

2. AVAILABLE DATA

2.1. Study Area

The main area of interest in this study is the sports field located in the southern portion of Arncliffe Park. This field is enclosed within a picket fence and is used for cricket in the summer and soccer in the winter. The study area comprises part of Lot 100 in Deposited Plan 1081168, as shown in Figure 1.

Arncliffe Park also contains an amenities block in the centre of the park, and children's playground in the western corner. The Arncliffe RSL is located at the southern corner, on the corner of Wollongong Road and Mitchell Street. A number of features of the park have heritage value, including entry signs and the sandstone walls around the perimeter of the block (excluding Mitchell Street paths). There is also war memorial, as well as a number of established trees at the downstream (eastern end) of the existing field.

2.2. Topographic Survey

Council provided Aerial Laser Scanning (ALS) survey covering the LGA (Figure 1). The ALS survey provides ground level spot heights at approximately 1 m to 2 m spacing and was used to derive a Digital Terrain Model (DTM). Technical data provided by the ALS supplier indicates that for well-defined points mapped in clear areas, the expected nominal point accuracies (based on a 68% confidence interval) are between:

Vertical accuracy	±0.04 m,
Horizontal accuracy	±0.55 m.

However when interpreting the above, it should be noted that the accuracy of the ground definition can be adversely affected by the nature and density of vegetation and/or the presence of steeply varying terrain.

The topographic data used in the flood model has been refined to represent redevelopment in the Bonar Street precinct.

2.3. Floor Level Database

Bayside Council provided floor level survey of 2112 properties, including residential, commercial and industrial properties. The floor levels were used in the flood damages assessment described in Reference 2.

2.4. Geotechnical Assessment

A Geotechnical Investigation Report and a Waste Classification Assessment were undertaken by Geo-Environmental Engineering Pty Ltd (GEE) as part of the proposed flood mitigation works at Arncliffe Park. Arncliffe Park is located within a flood zone and therefore a geotechnical investigation is required to provide information on the subsurface conditions to assist with the design and installation of proposed works. The geotechnical investigation was carried out in conjunction with a waste classification assessment in accordance with NSW Environment Protection Authority (NSW EPA) *Waste classification Guidelines Part 1: Classifying Waste* and classification of Excavated Natural Material (ENM). Due to the site's location the Council specifically requested an acid sulfate soil assessment to also be completed.

GEE concluded that there was sufficient information in the investigations to confidently characterise the geotechnical conditions of the site. Based on results and considering the proposed works, it was determined that an acid sulfate soil management plan is not warranted. Findings classified the fill material across the site as General Solid Waste (non-putrescible), with the topsoil material not meeting the criteria for ENM. However, with appropriate testing and applications the EPA may issue a waste exemption, to allow the re-use of waste top soil on certain areas of the site. Based on the results this option is feasible and would lead to considerable reductions in overall excavation and disposal costs.

The Geotechnical Report and Waste Classification Report are provided in Appendix B to Reference 2.

2.5. Flood Behaviour

A stormwater trunk drain runs from west to east through the middle of Arncliffe Park parallel to Wollongong Road and Hirst Street, along a former creek line. Some decades ago the creek bed was used as a landfill depository, and Arncliffe Park was constructed over the top. This alignment forms the major overland flow path in the area, and Arncliffe Park is subject to inundation from overland flow during periods of heavy rain.

The flood behaviour within the study area was defined in the *Bonnie Doon, Eve Street / Cahill Park Pipe and Overland 2D Flood Study* (Reference 1). The model developed in this study utilised a DRAINS hydrologic model and a 2D TUFLOW hydraulic model with a 2m grid cell size. The results of the modelling indicated that the critical duration (event producing the highest flood level) was the 60 minute storm duration. The results of the modelling for all design flood events are presented in Reference 2, and the peak flood depth maps have been reproduced for the 1% AEP and 10% AEP events in Figure 2 and Figure 3 respectively.

The results presented in these figures have been used as the base case against which each mitigation option is assessed in order to determine peak flood level impacts.

2.1. Synthetic Turf Playing Surfaces

A number of synthetic turf football (soccer) fields have been installed across Sydney in the last 10 years. The technology is developing rapidly and is providing a viable alternative to natural turf fields. The main benefits of synthetic fields are the ability to play sooner after a rain event due to improved drainage, easier ongoing maintenance, as well as benefits to playability including an improved predictability of the bounce on the surface.

Proper functioning of the field's drainage relies on rain being able to infiltrate through the weave. If overland flow from upstream occurs, sediment can be deposited which can clog the infill material and interfere with the drainage capacity, and can require replacement of the playing surface. The force of overland flow can also cause 'ripples' in the playing surface which can be expensive to rectify. For these reasons it is necessary to design the field to prevent overland flow.

3. MODELLING APPROACH

3.1. Model Setup

The existing Bonnie Doon TUFLOW hydraulic model (References 1 and 2) was modified to represent each option. The study area and digital elevation model contours are presented in Figure 1. The model schematisation for the raised field option is shown in Figure 4 and the raised field with detention option in Figure 5. Both schematisations assumed an inlet width of 40 m with an applied blockage factor of 40%. This size was arrived at via a sensitivity assessment described in Section 3.4.

A concrete lined dish drain was modelled running the length of the field along the main flow path alignment. The flood detention tank option was modelled as a 1D nodal storage with a total capacity of 5,400 m^3 (see Section 1.3.4) regarding the selection of this capacity). It was assumed that the upstream pipe network was redirected into the tank.

3.2. Impact Assessment Results

In each proposed option, the overland flow path across Arncliffe Park is maintained, and the filled batters along the field sides prevent flow from being diverted around the field.

Peak flood depths and levels for the raised field with no detention are shown on Figure 6 and Figure 7 for the 1% AEP and 10% AEP events respectively, and indicate some localised inundation along the northern toe of the batter near the clubhouse/ change room in both events.

Peak flood depths and levels for the raised field with detention are shown on Figure 8 and Figure 9 for the 1% AEP and 10% AEP events respectively, and show much the same pattern of inundation, however flood depths are slightly reduced due to the effect of the storage tank. The flood level impacts are described below.

The flood impact results for the two options are favourable, with or without the detention tank underneath. Flood protection for the field in each option is higher than 1% AEP. The flood impacts caused by each option are described below.

3.2.1. Modelled Flood Impacts: Raised Field Option

In the 1% AEP and 10% AEP events, peak flood level impacts are confined to within Arncliffe Park. There are no adverse impacts on nearby roads or properties, however the option does not offer benefits offsite. This indicates that existing flood behaviour is being maintained in the proposed case and demonstrates that the overland flow path beneath the field would function as intended. Offsite peak flood level impacts (or lack thereof) are tabulated at key locations in Table 2. Peak flood level impacts on the filled side batters are a reflection of the raised ground surface rather than increased depth of inundation, and it can be seen that the batters themselves are largely no longer flooded.

There is some afflux upstream of the field inlet within the park, but importantly these peak flood level increases do not extend as far upstream as Mitchell Street. The peak flood level impacts for the 1% AEP and 10% AEP events are shown on Figure 10 and Figure 11 respectively. A localised area is newly flooded downstream of the northern fill batter, however as shown on the corresponding peak flood depth figures, the depths in this area are shallow, and the impact does not extend to Broe Avenue.

3.2.2. Modelled Flood Impacts: Raised Field and Detention

This option includes an underground detention tank with a total capacity of 5,400 m^3. The on-site flood impacts within Arncliffe Park are comparable to those noted in the raised field option, that is, there are some localised peak flood level increases upstream of the field inlet structure, though not extending to Mitchell Street, and some newly flooded area downstream of the northern filled batter, contained to the park upstream of Broe Avenue. The peak flood level impacts for the 1% AEP and 10% AEP events are shown on Figure 12 and Figure 13 respectively.

Outside of Arncliffe Park, the flood storage provided by the tank offers peak flood level reductions for the remainder of the downstream flow path with the greatest reductions noted just upstream of the railway embankment. In the 1% AEP event, the downstream end of Wollongong Road between Martin Avenue and Firth Street, and Martin Avenue itself, are subject to peak flood level reductions of approximately 0.13 m (from approximately 1.65 m to 1.52 m). The changes to peak flood depth at key roads are summarised in Table 2.

As discussed previously, it is not clear what benefit these reductions would have in terms of ongoing flood damages, as due to recent redevelopment it is likely floor levels are (or will soon be) above the flood planning level. However, the reduction of peak flood levels on roads including Bonar Street, Bidjigal Road, Martin Avenue, the downstream end of Wollongong Road, Arncliffe Street, Willis Street and Guess Avenue, may reduce flood risk to motorists and pedestrians.

Table 2: Difference in Peak Flood Depths in the 1% AEP event (both options)

		Peak Flood Depths (m), 1% AEP Event				
Location	**Base Case Peak Flood Level (mAHD)**	**Base Case Depth (m)**	**Raised Field, no Tank**	***Difference (m)***	**Raised Field, 5,400 m^3 Tank**	***Difference (m)***
Mitchell Street	18.9	0.69	0.69	*0.00*	0.69	*0.00*
Broe Avenue	15.7	0.35	0.35	*0.00*	0.35	*0.00*
Kelsey Street	12.2	0.93	0.93	*0.00*	0.87	*-0.06*
Wollongong Road (near railway embankment)	5.7	1.65	1.65	*0.00*	1.52	*-0.13*
Bidjigal Road	6.7	1.45	1.45	*0.00*	1.38	*-0.07*
Arncliffe Street, east of Guess Ave	2.6	1.23	1.23	*0.00*	1.18	*-0.05*

**Note that given the variability of the terrain, the depths provided in Table 2 are indicative of the peak flood depths in the vicinity of the inspection point in the 1% AEP event and are intended to show the relativity of impacts caused by each detention tank option. Inspection locations are indicated on Figure 12 and Figure 13.*

3.3. Sensitivity Analysis

The sub-field structure being modelled is complex, and not easily represented in the hydraulic model. It is not a standard structure and there is no literature available on appropriate energy losses, afflux, etc., and no standard way to model it. To address this and schematise the structure as accurately as possible, WMAwater tested a range of different assumptions about blockage, head losses, and geometry of the inlet grate (see discussion below) to understand what the key issues are for the grate hydraulic behaviour. It should be noted that the sensitivity analysis was undertaken earlier in the modelling process. The exact position of the field has since been refined and will be situated slightly closer to Wollongong Road. The impact assessment described in Section 3.2 has confirmed the findings of the initial sensitivity assessment are still valid.

Following initial analysis, it appears that the blockage assumption is the main issue, and the results are relatively insensitive to the form loss assumption, as shown in Figure 14 and Figure 15. The 'form loss' refers to the energy lost (factor of dynamic head) due to bends, bridge, piers etc of the hydraulic structure. A blockage of 40% is being assumed for the design modelling, which incorporates both the obstruction caused by the grate as well as an allowance for debris blockage.

3.4. Inlet Grate Optimisation

The inlet grate structure is likely to be a relatively costly part of the project, and so it is important to identify the minimum grate dimensions that will achieve the design objectives, that is, allow the 1% AEP flow to enter beneath the field without causing afflux on Mitchell Street. An example of the type of grate assumed is shown in Photo 1, although on a steeper slope.

Photo 1: Example of inlet grate type assumed on upstream field slope

An alternative to the raked grate could be a stepped grate, which may be of benefit if field access from Mitchell Street is required. It is noted however that compared to a raked grate, steps may be more prone to blockage due to debris, and may also pose a public safety concern. If steps are required for access it is likely that a hand rail would be required to ensure the stairs are compliant with Australian Standards. It is noted that an appropriate handrail/ kickboard arrangement may also contribute to the blockage of the inlet, and has not been allowed for in the inlet grate optimisation discussed in this section.

Two options were initially modelled to optimise the required grate inlet width:

- 50 m wide inlet grate with 40% blockage;
- 30 m wide inlet grate with 40% blockage;

The impacts of the two options in the 1% AEP event are shown on Figure 16 and Figure 17 respectively. The results indicate that the 30 m wide grate is of insufficient width as it causes upstream peak flood levels on Mitchell Street to increase by up to 50 mm in the 1% AEP event. The 50 m wide option with 40% blockage appears to achieve the design objectives, without causing upstream impacts on the road. A 40 m wide inlet grate was then tested, and confirmed to be appropriate, with impacts shown on Figure 18. As described above, the location of the inlet grate was moved slightly closer to Wollongong Road once field dimensions were refined, and the impact assessment described in Section 3.2 has confirmed the 40 m inlet is still appropriate.

3.5. Hydraulic Assessment Conclusions

The key objective of this report was to determine if the proposed design would work in terms of flood behaviour. The flood impact assessment has confirmed that this arrangement, with the raised field, overland flow path and sub-surface storage tank, would not cause adverse offsite flood impacts. This is due to the proposed sub-field overland flow path functioning in much the same way as it does currently. Furthermore, the addition of the below ground flood detention tank yields benefits for the remainder of the downstream flow path, around residential areas near Bonar Street and Bidjigal Road, and downstream of the railway.

It is likely that if the “open tank” design refinement (i.e. no tank roof slab) were included for the tank option (see Section 1.3.5), then the outcomes for downstream flood benefits would be further improved.

4. DISCUSSION OF OTHER FACTORS

A number of other factors need to be considered when discussing whether or not a particular option should be implemented. A brief description of some relevant considerations is provided below, discussion of which should be factored into the decision making process.

4.1. Sensitivity to Waste Classification

As discussed in the site description, Arncliffe Park is founded on a former landfill site containing largely unknown materials and contaminants. The geotechnical assessment and waste classification report included in Appendix B to Reference 2 indicated that due to elevated concentration of lead in one of the 14 soil samples, the soil did not meet requirements to be classified as Excavated Natural Material. However, as the levels of contaminant were relatively limited, it did not meet the threshold to be classified as General Solid Waste; meaning with appropriate testing and applications the EPA may issue a waste exemption, to allow the re-use of waste top soil on certain areas of the site. Based on the results and expert advice, this option may be feasible and would lead to considerable reductions in overall costs.

4.2. Environmental Impacts

The proposed extent of works does not extend beyond the existing fenced area, and therefore the works will not require the removal of any of the established trees within Arncliffe Park. See Section 1.3.3 for preferred field dimensions. The impact of proposed excavation on existing tree roots however should be considered, especially for the option with the detention tank.

The proposed field would be ~1.2 m above ground at the downstream end, if the field is sloped at 0.7%, and approximately 1.9 m high if the field were to be flat. The visual amenity of the raised construction should be considered, and could be ameliorated with selection of field gradient and landscaping design where appropriate.

4.3. Future Development

The main benefit of installing a flood detention tank at Arncliffe Park is that it reduces flood levels around downstream properties along the flow path between Broe Avenue and Bonar Street. It is likely that in the near future many of these properties will be redeveloped in a similar way to the recently completed high density residential development in the Bonar Street Precinct. This type of development would require minimum floor levels to be located at or above the Flood Planning Level, which for this area is the 1% AEP event plus 0.5 m freeboard. If this is to occur the benefits of the detention basin would be significantly reduced. However, any reduction in flood levels on roads and pavements would still be of benefit, improving safety for pedestrians and motorists.

4.4. Maintenance Requirements

Aside from the ongoing maintenance of the synthetic turf surface itself (which is not discussed in this report), maintenance of the overland flow area, detention tank and inlet and outlet arrangements should be considered. Aspects of maintenance would likely include (but not be limited to):

- Routine visual inspection of the inlet grate and dish drain to identify defects and remove debris or blockage. Visual inspections should also be undertaken following all flood events;
- Removal of sediment from the upstream sediment trap following rain events (perhaps with use of an excavator or as per regular Council maintenance operations);
- High pressure hosing to remove excess sediment from dish drain following flood event;
- Routine inspection and removal of excess sediment from flood detention tank.

It is noted that with the limited clearance below the field surface, the dish drain and detention tank would be classified as confined spaces. Maintenance in these spaces must be undertaken in accordance with Australian Standards (AS 2865- 2009), with incorporation of sufficient access and egress points and maintenance requirements considered during the detailed design stage.

5. CONCLUSIONS

This report has examined two options to install a synthetic turf playing field at Arncliffe Park, ensure it is protected from the 1% AEP flood event and maintain the existing overland flow path beneath the field.

The hydraulic assessment has confirmed that such a design is feasible in terms of flood impacts, if certain criteria (minimum field level and inlet grate width) are adhered to. The flood impact assessment has also demonstrated the benefits available downstream if a detention tank is included in the project.

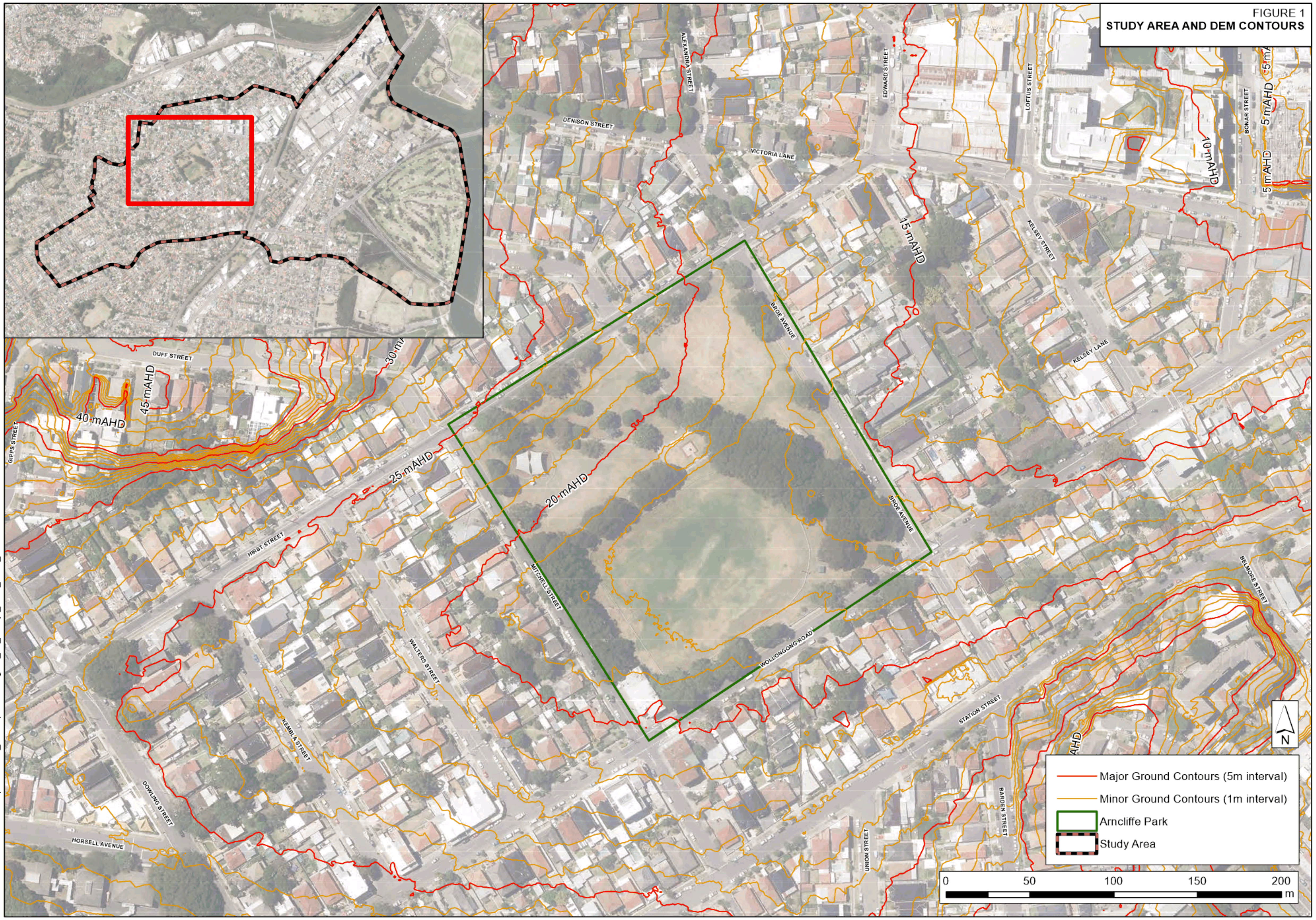
Pre-development application concept designs have been prepared for the purpose of further developing the project and obtaining detailed input regarding the structural requirements of the suspended slab, underground tank, and all piers and footings.

6. REFERENCES

1. WMAwater
Bonnie Doon, Eve Street/ Cahill Park Pipe and Overland 2D Flood Study
Bayside Council, February 2017

2. WMAwater
Bonnie Doon Catchment Flood Risk Management Concept Design
Bayside Council, October 2017

3. Football NSW
Field Markings & Equipment
November 2015



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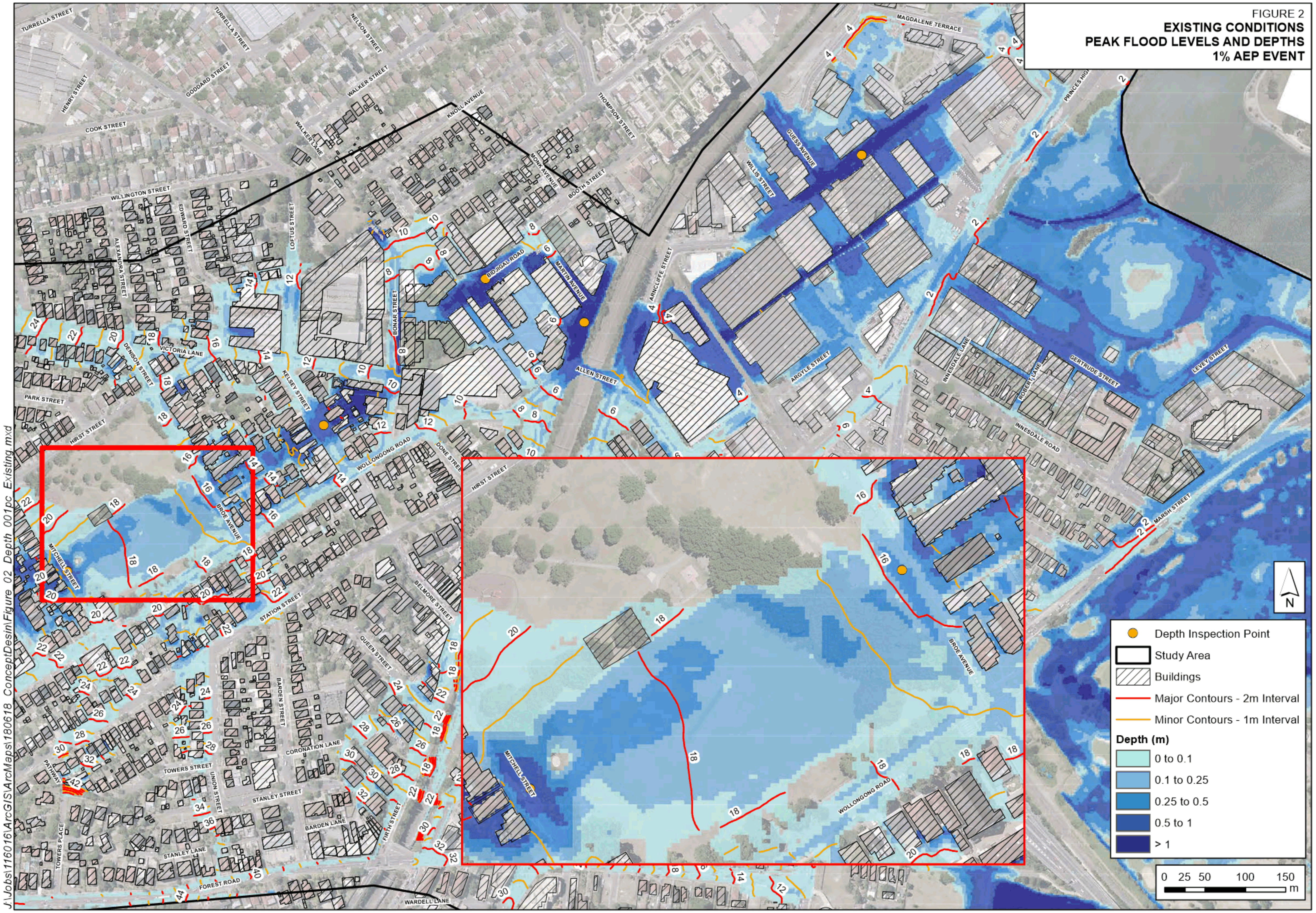
FIGURE 2
EXISTING CONDITIONS
PEAK FLOOD LEVELS AND DEPTHS
1% AEP EVENT
Depth Inspection Point
Study Area
Buildings
Major Contours - 2m Interval
Minor Contours - 1m Interval
Depth (m)
0 to 0.1
0.1 to 0.25
0.25 to 0.5
0.5 to 1
> 1
0 25 50 100 150
m
N
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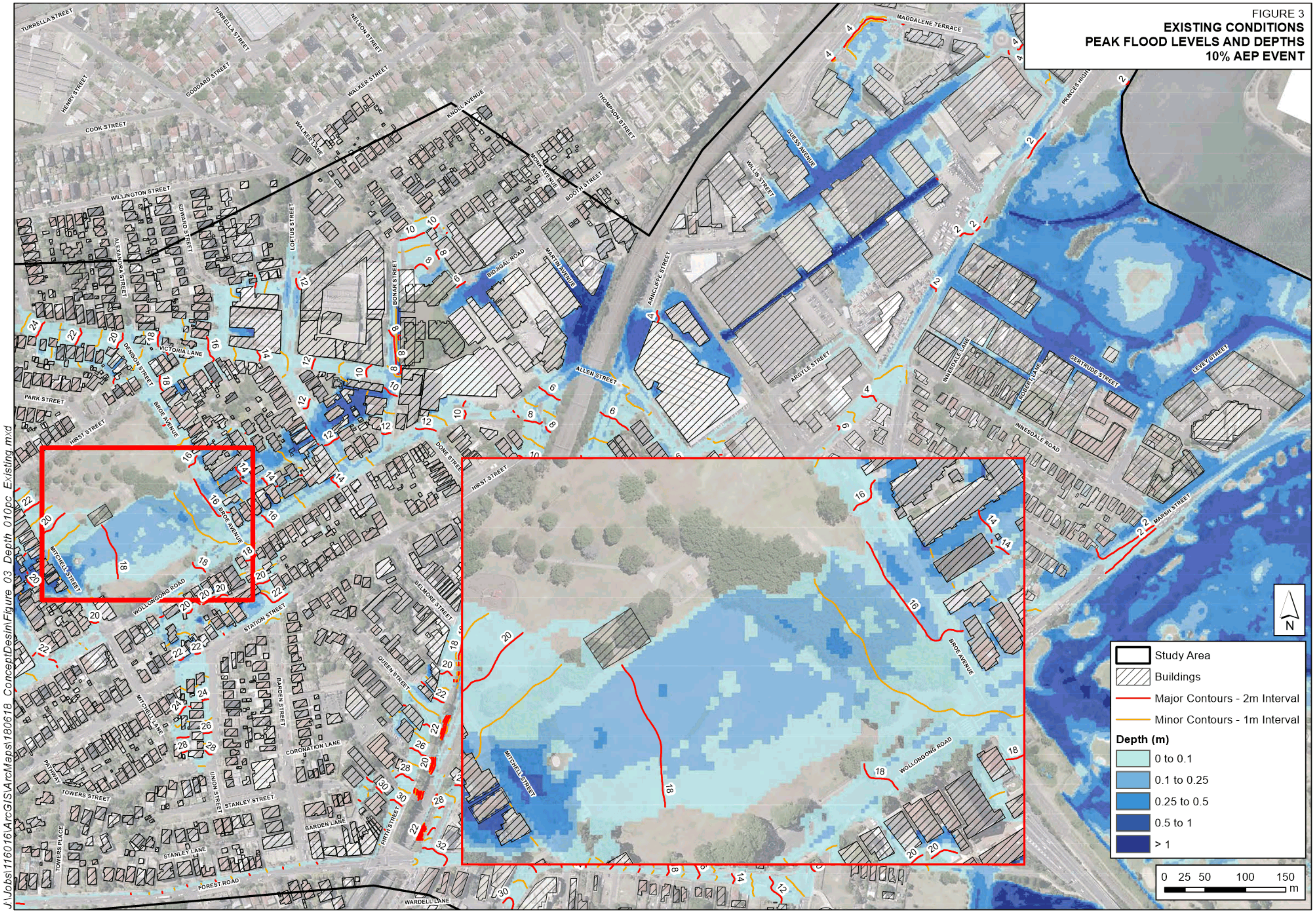

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FIGURE 4
PLAYING FIELD ELEVATED @19MAHD
INLET 70% BLOCKED, 40M WIDE
MODEL LAYOUT
HIRST STREET
MITCHELL STREET
WOLLONGONG ROAD
BROE AVENUE
N
Wall
Existing Stormwater
Dish drain
Blockage 70% with obvert at 18.5mAHD playin field at 19mAHD
Batter
Buildings
0 25 50 100 150 m
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FIGURE 5
PLAYING FIELD ELEVATED @19MAHD
INLET 70% BLOCKED, 40M WIDE, TANK 5,400M3
MODEL LAYOUT
HIRST STREET
MITCHELL STREET
WOLLONGONG ROAD
BROE AVENUE
N
1D tank
Wall
Existing Stormwater
Dish drain
Blockage 70% with obvert at 18.5mAHD playin field at 19mAHD
Outlet
Tank Inlet
Batter
Existing Stormwater
Buildings
0
25
50
100
150
m
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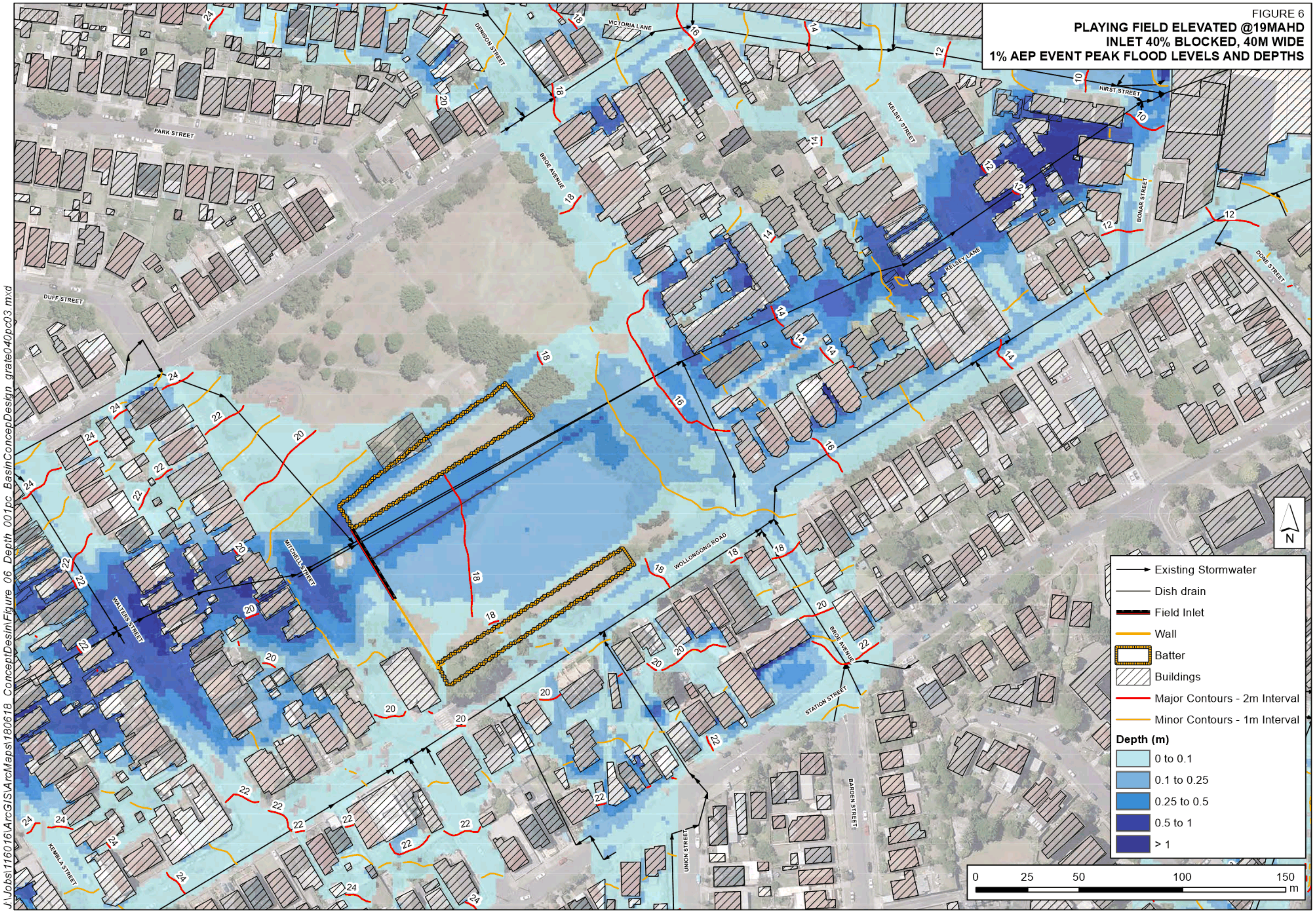
FIGURE 6
PLAYING FIELD ELEVATED @19MAHD
INLET 40% BLOCKED, 40M WIDE
1% AEP EVENT PEAK FLOOD LEVELS AND DEPTHS
PARK STREET
DUFF STREET
VICTORIA LANE
DENISON STREET
BROE AVENUE
KELSEY STREET
HIRST STREET
BONAR STREET
KELSEY LANE
DONE STREET
MITCHELL STREET
WALTERS STREET
WOLLONGONG ROAD
STATION STREET
UNION STREET
GARDEN STREET
KEMBLA STREET
N
Existing Stormwater
Dish drain
Field Inlet
Wall
Batter
Buildings
Major Contours - 2m Interval
Minor Contours - 1m Interval
Depth (m)
0 to 0.1
0.1 to 0.25
0.25 to 0.5
0.5 to 1
> 1
0 25 50 100 150
m
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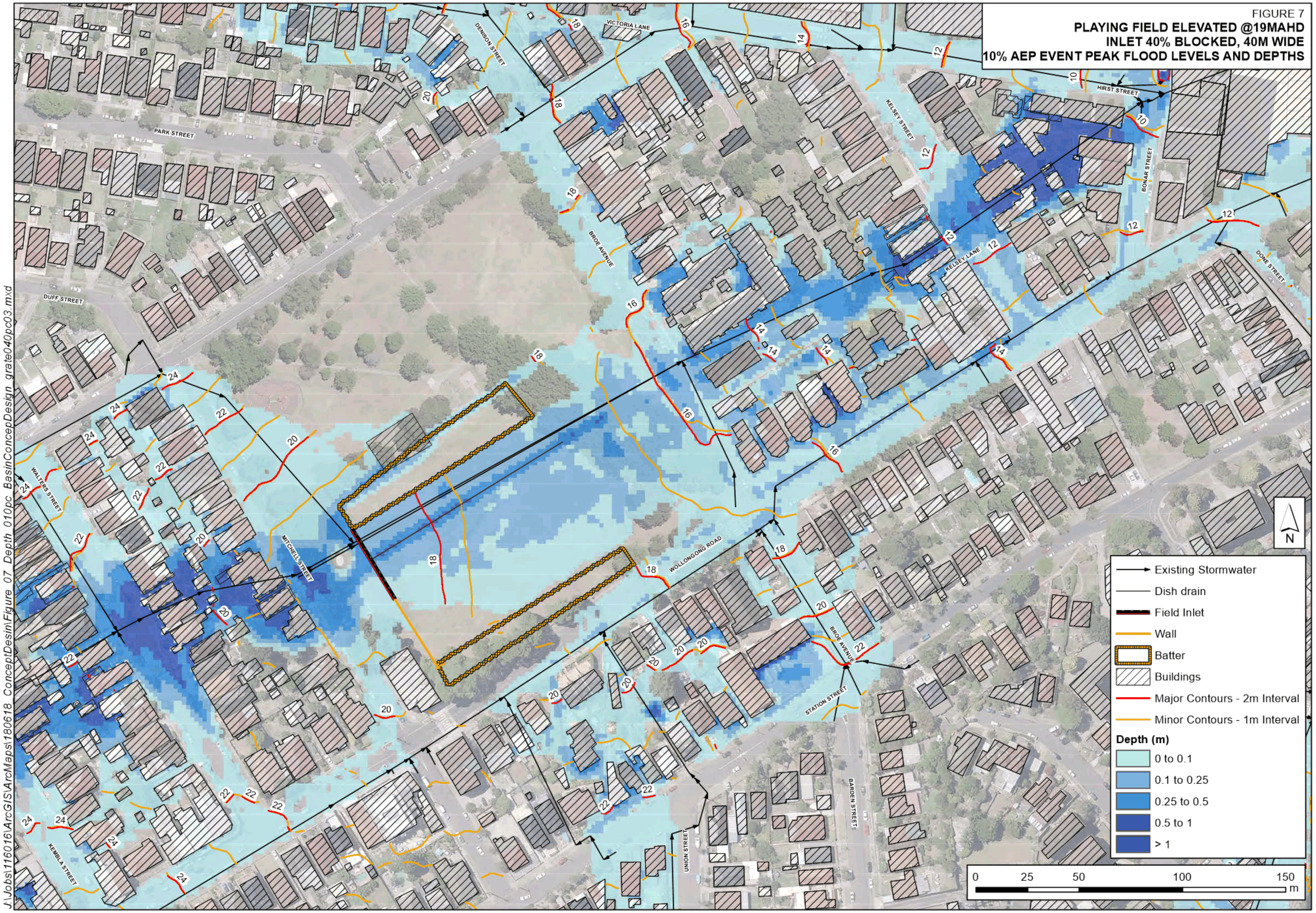
FIGURE 7
PLAYING FIELD ELEVATED @19MAHD
INLET 40% BLOCKED, 40M WIDE
10% AEP EVENT PEAK FLOOD LEVELS AND DEPTHS
Existing Stormwater
Dish drain
Field Inlet
Wall
Batter
Buildings
Major Contours - 2m Interval
Minor Contours - 1m Interval
Depth (m)
0 to 0.1
0.1 to 0.25
0.25 to 0.5
0.5 to 1
> 1
0 25 50 100 150 m
N
PARK STREET
DUFF STREET
WOLLONGONG ROAD
BROE AVENUE
MITCHELL STREET
STATION STREET
KELSEY LANE
KELSEY STREET
HIRST STREET
DENISON STREET
VICTORIA LANE
BONAR STREET
DONE STREET
WALTERS STREET
KEMBLA STREET
UNION STREET
GARDEN STREET
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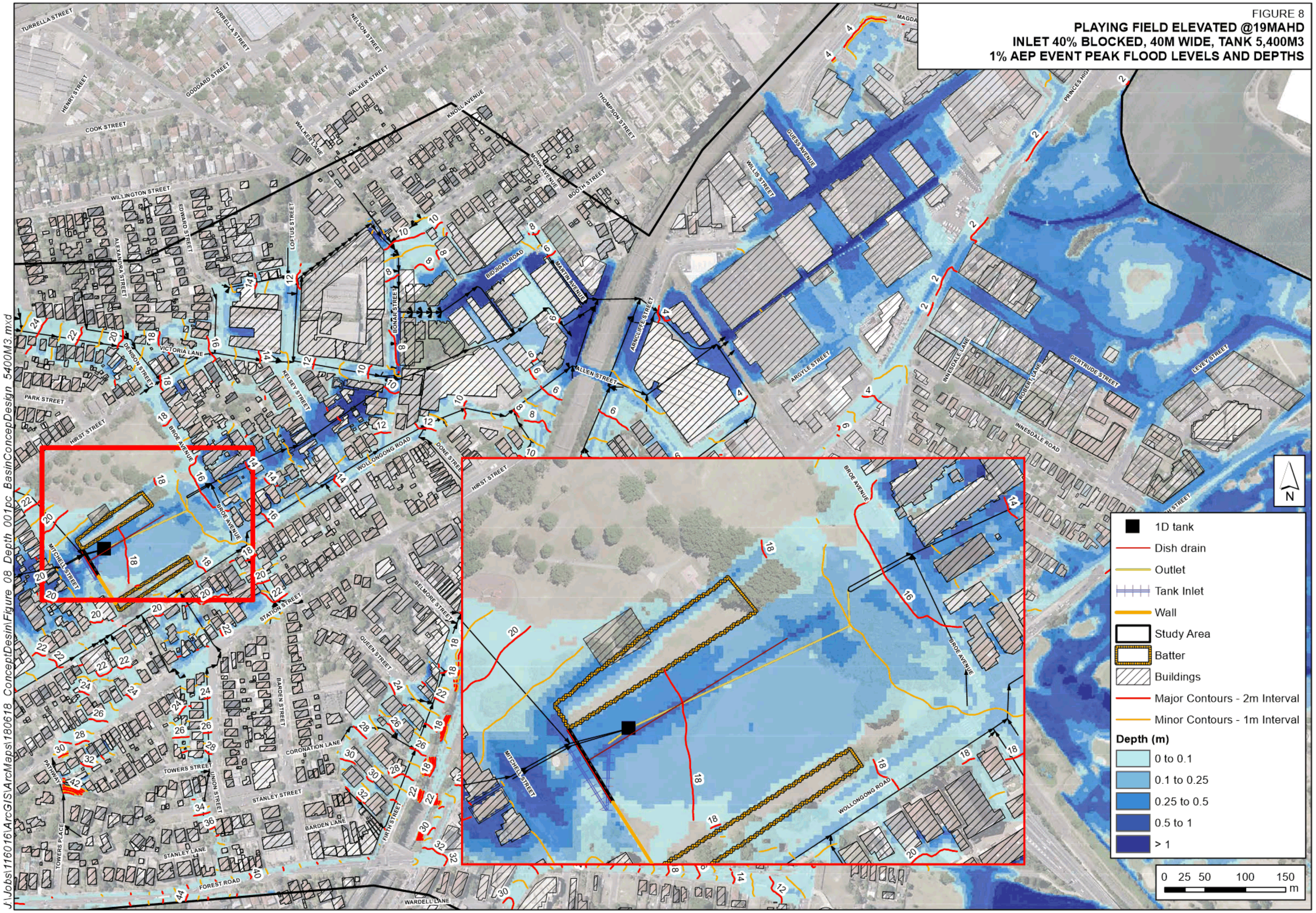
FIGURE 8
PLAYING FIELD ELEVATED @19MAHD
INLET 40% BLOCKED, 40M WIDE, TANK 5,400M3
1% AEP EVENT PEAK FLOOD LEVELS AND DEPTHS
1D tank
Dish drain
Outlet
Tank Inlet
Wall
Study Area
Batter
Buildings
Major Contours - 2m Interval
Minor Contours - 1m Interval
Depth (m)
0 to 0.1
0.1 to 0.25
0.25 to 0.5
0.5 to 1
> 1
0 25 50 100 150 m
N
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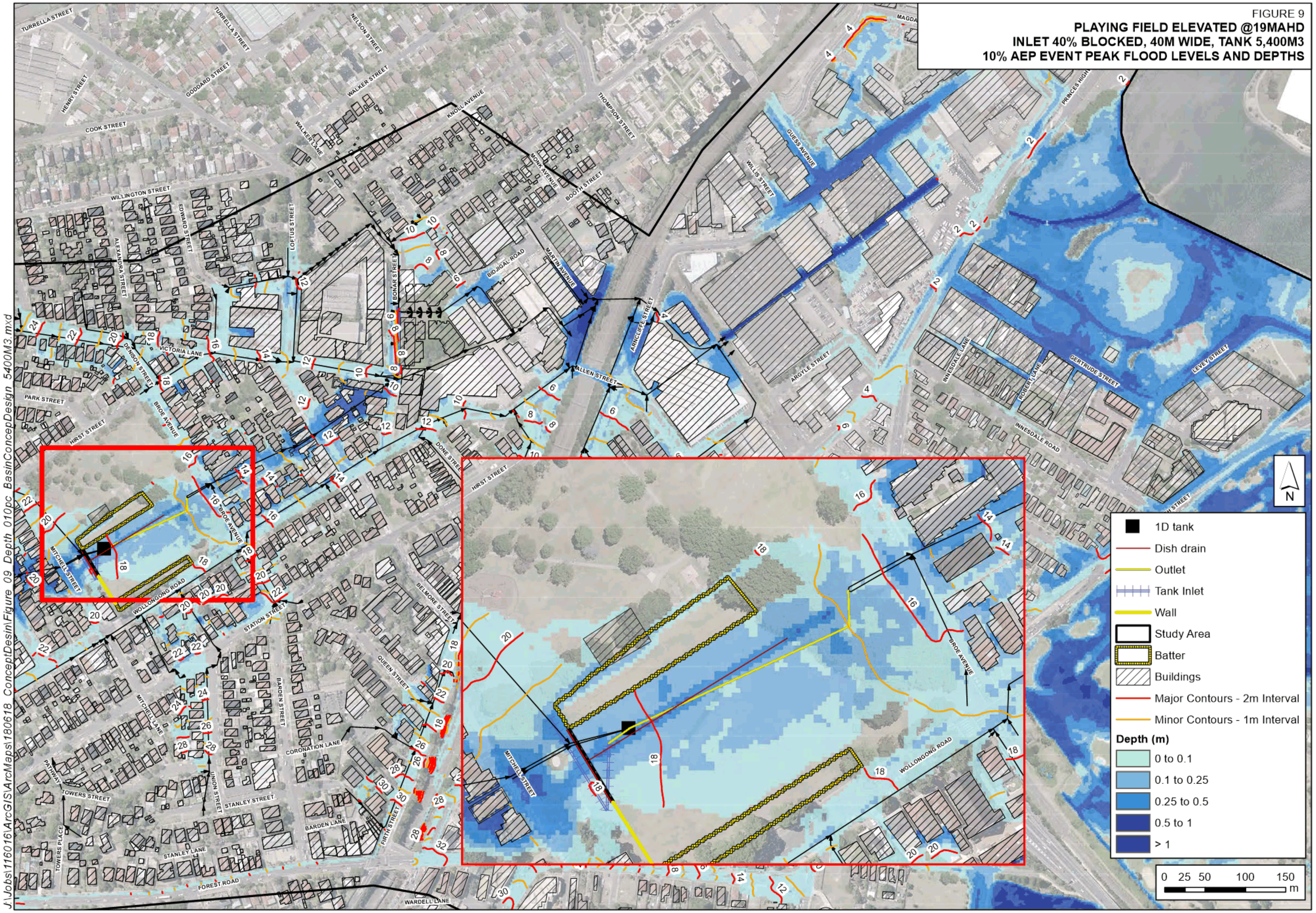
FIGURE 9
PLAYING FIELD ELEVATED @19MAHD
INLET 40% BLOCKED, 40M WIDE, TANK 5,400M3
10% AEP EVENT PEAK FLOOD LEVELS AND DEPTHS
1D tank
Dish drain
Outlet
Tank Inlet
Wall
Study Area
Batter
Buildings
Major Contours - 2m Interval
Minor Contours - 1m Interval
Depth (m)
0 to 0.1
0.1 to 0.25
0.25 to 0.5
0.5 to 1
> 1
0 25 50 100 150 m
N
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FIGURE 10
PLAYING FIELD ELEVATED @19MAHD
INLET 40% BLOCKED, 40M WIDE
1% AEP EVENT PEAK FLOOD LEVEL IMPACT
Existing Stormwater
Dish drain
Field Inlet
Wall
Batter
Buildings
Impact (m)
< -0.2
-0.2 - -0.1
-0.1 - -0.05
-0.05 - -0.01
-0.01 - 0.01
0.01 - 0.05
0.05 - 0.1
0.1 - 0.2
> 0.2
No Longer Flooded
Newly Flooded
0 25 50 100 150
m
N
PARK STREET
DUFF STREET
WOLLONGONG ROAD
MITCHELL STREET
HIRST STREET

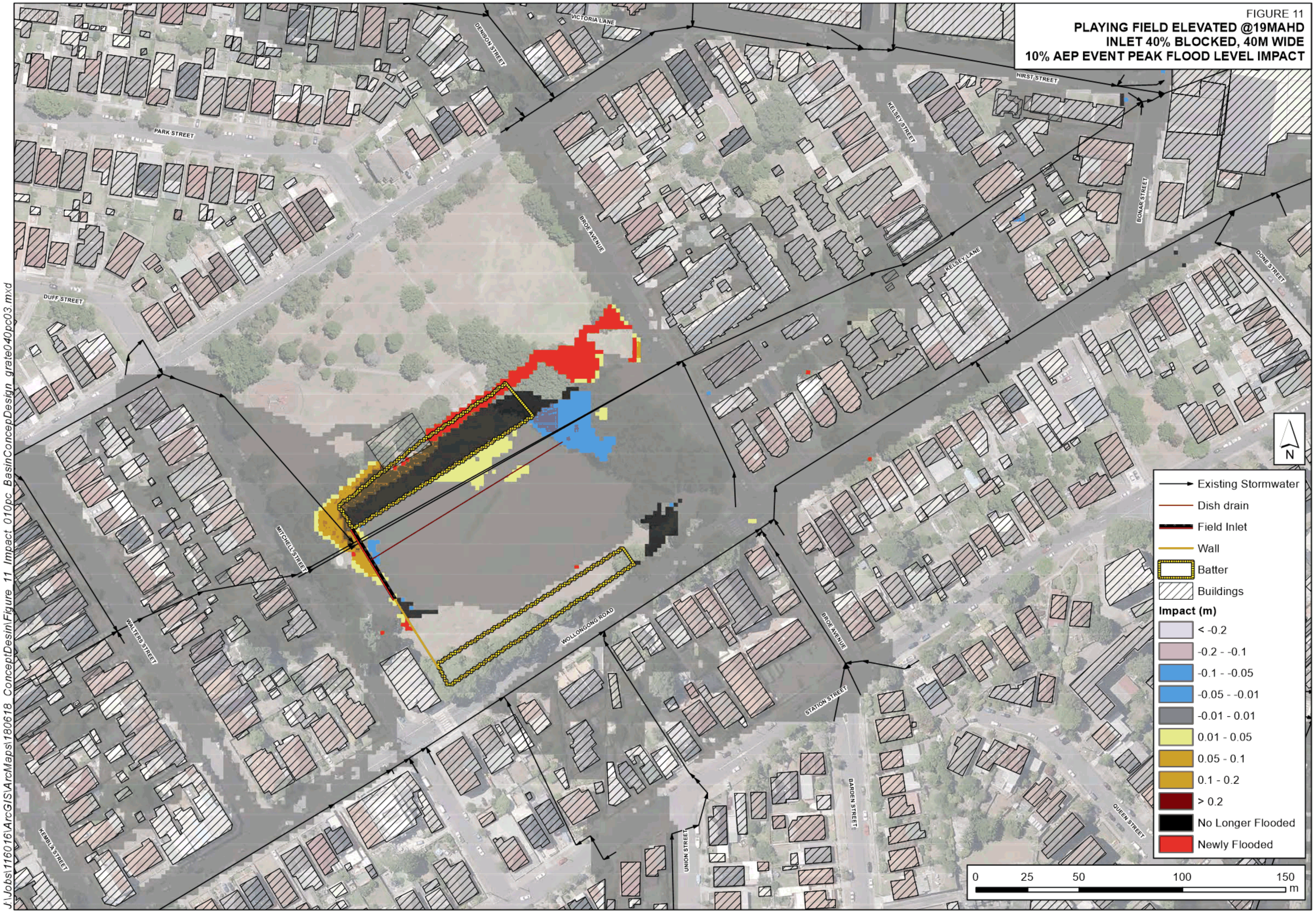
FIGURE 11
PLAYING FIELD ELEVATED @19MAHD
INLET 40% BLOCKED, 40M WIDE
10% AEP EVENT PEAK FLOOD LEVEL IMPACT
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PARK STREET
DUFF STREET
VICTORIA LANE
DENISON STREET
HIRST STREET
KELSEY STREET
BONAR STREET
BROE AVENUE
KELSEY LANE
DONE STREET
MITCHELL STREET
WALTERS STREET
WOLLONGONG ROAD
STATION STREET
GARDEN STREET
UNION STREET
QUEEN STREET
KEMBLA STREET
N
Existing Stormwater
Dish drain
Field Inlet
Wall
Batter
Buildings
Impact (m)
< -0.2
-0.2 - -0.1
-0.1 - -0.05
-0.05 - -0.01
-0.01 - 0.01
0.01 - 0.05
0.05 - 0.1
0.1 - 0.2
> 0.2
No Longer Flooded
Newly Flooded
0 25 50 100 150
m

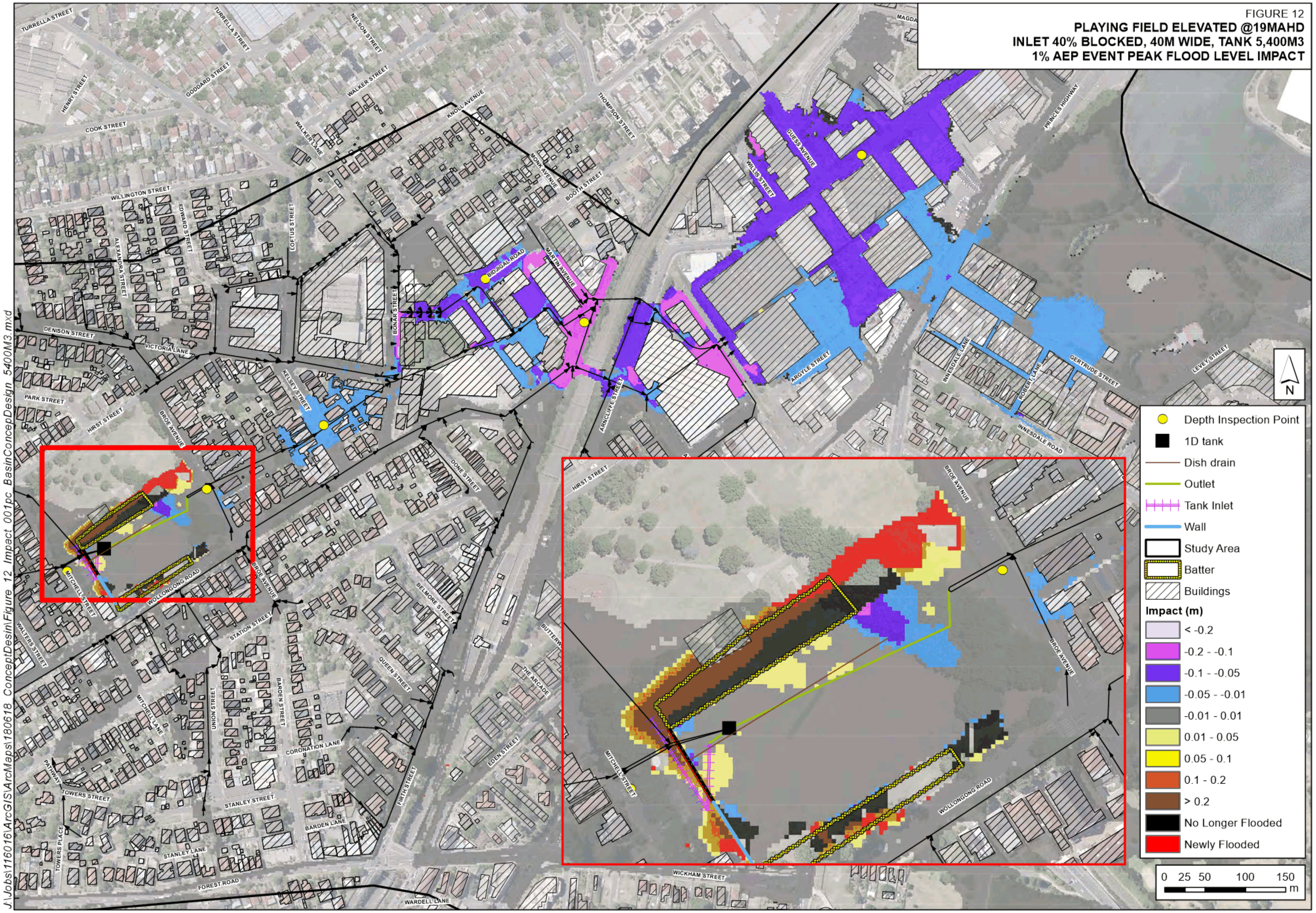
FIGURE 12
PLAYING FIELD ELEVATED @19MAHD
INLET 40% BLOCKED, 40M WIDE, TANK 5,400M3
1% AEP EVENT PEAK FLOOD LEVEL IMPACT
Depth Inspection Point
1D tank
Dish drain
Outlet
Tank Inlet
Wall
Study Area
Batter
Buildings
Impact (m)
< -0.2
-0.2 - -0.1
-0.1 - -0.05
-0.05 - -0.01
-0.01 - 0.01
0.01 - 0.05
0.05 - 0.1
0.1 - 0.2
> 0.2
No Longer Flooded
Newly Flooded
0 25 50 100 150
m
N
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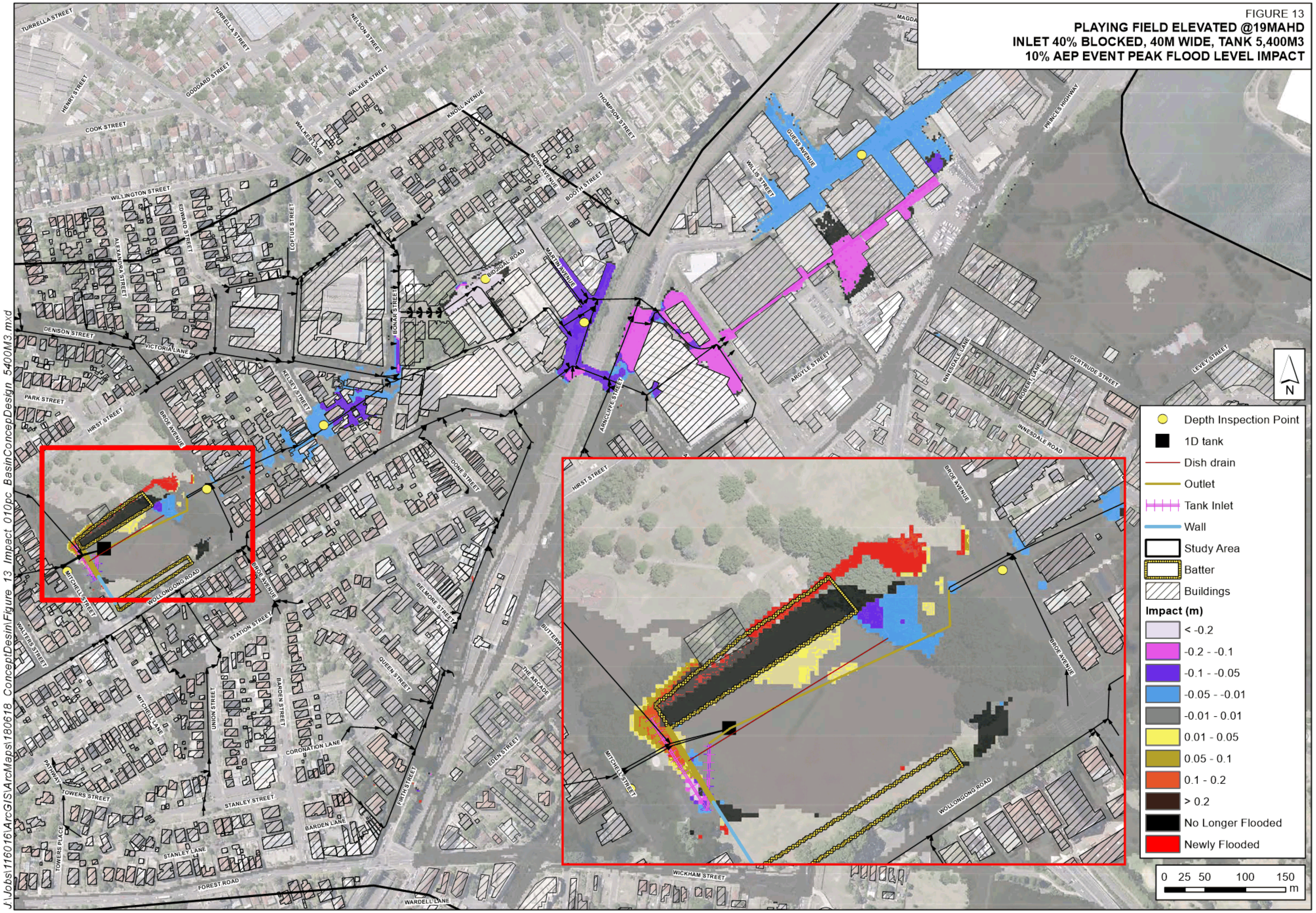
FIGURE 13
PLAYING FIELD ELEVATED @19MAHD
INLET 40% BLOCKED, 40M WIDE, TANK 5,400M3
10% AEP EVENT PEAK FLOOD LEVEL IMPACT
Depth Inspection Point
1D tank
Dish drain
Outlet
Tank Inlet
Wall
Study Area
Batter
Buildings
Impact (m)
< -0.2
-0.2 - -0.1
-0.1 - -0.05
-0.05 - -0.01
-0.01 - 0.01
0.01 - 0.05
0.05 - 0.1
0.1 - 0.2
> 0.2
No Longer Flooded
Newly Flooded
0 25 50 100 150 m
N
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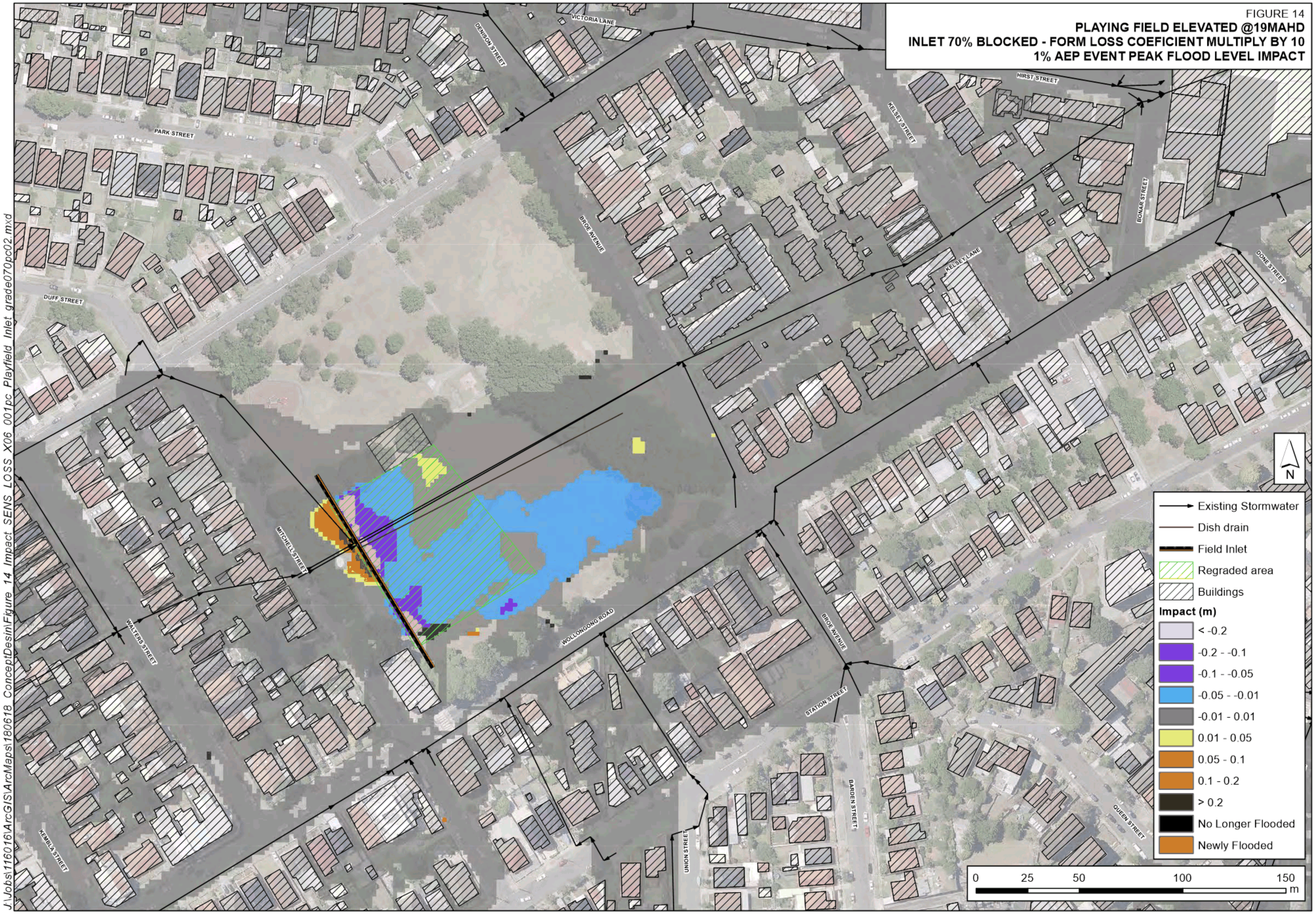
FIGURE 14
PLAYING FIELD ELEVATED @19MAHD
INLET 70% BLOCKED - FORM LOSS COEFICIENT MULTIPLY BY 10
1% AEP EVENT PEAK FLOOD LEVEL IMPACT
Existing Stormwater
Dish drain
Field Inlet
Regraded area
Buildings
Impact (m)
< -0.2
-0.2 - -0.1
-0.1 - -0.05
-0.05 - -0.01
-0.01 - 0.01
0.01 - 0.05
0.05 - 0.1
0.1 - 0.2
> 0.2
No Longer Flooded
Newly Flooded
0 25 50 100 150 m
N
PARK STREET
DUFF STREET
HIRST STREET
VICTORIA LANE
MITCHELL STREET
WALTERS STREET
WOLLONGONG ROAD
STATION STREET
GARDEN STREET
QUEEN STREET
UNION STREET
KELSEY LANE
DONE STREET
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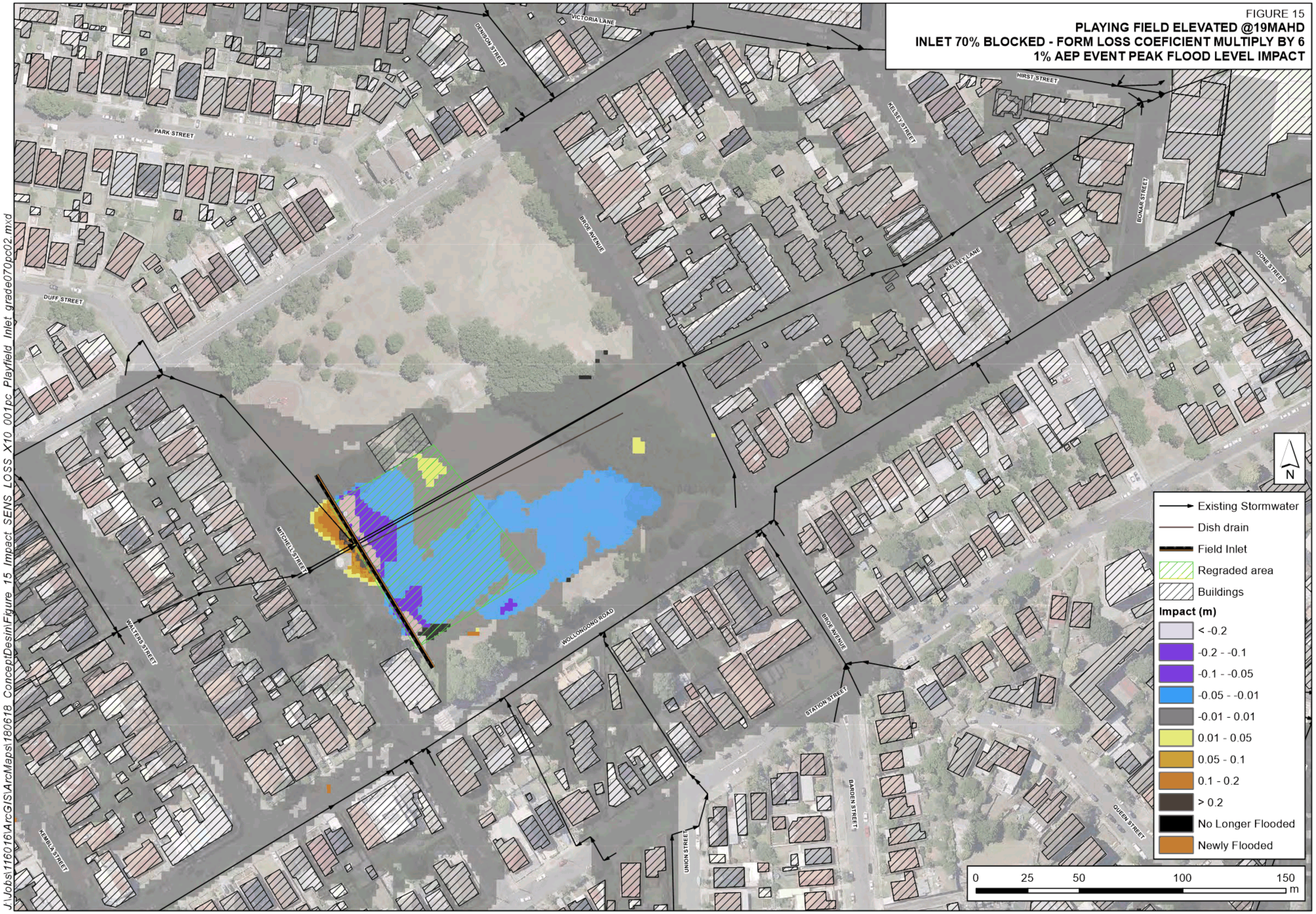
FIGURE 15
PLAYING FIELD ELEVATED @19MAHD
INLET 70% BLOCKED - FORM LOSS COEFICIENT MULTIPLY BY 6
1% AEP EVENT PEAK FLOOD LEVEL IMPACT
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Existing Stormwater
Dish drain
Field Inlet
Regraded area
Buildings
Impact (m)
< -0.2
-0.2 - -0.1
-0.1 - -0.05
-0.05 - -0.01
-0.01 - 0.01
0.01 - 0.05
0.05 - 0.1
0.1 - 0.2
> 0.2
No Longer Flooded
Newly Flooded
0 25 50 100 150 m
N
PARK STREET
DUFF STREET
MITCHELL STREET
WALTERS STREET
WOLLONGONG ROAD
BROE AVENUE
KELSEY STREET
KELSEY LANE
HIRST STREET
BONAR STREET
DONE STREET
VICTORIA LANE
DENISON STREET
STATION STREET
UNION STREET
BARDEN STREET
QUEEN STREET
KEMBLA STREET


FIGURE 16
PLAYING FIELD ELEVATED @19MAHD
INLET 40% BLOCKED, 50M LONG
1% AEP EVENT PEAK FLOOD LEVEL IMPACT
Field Inlet
Wall to 19mAHD
Dish drain
Existing Stormwater
Regraded area
Buildings
Impact (m)
< -0.2
-0.2 - -0.1
-0.1 - -0.05
-0.05 - -0.01
-0.01 - 0.01
0.01 - 0.05
0.05 - 0.1
0.1 - 0.2
> 0.2
No Longer Flooded
Newly Flooded
0 25 50 100 150 m
N
PARK STREET
DUFF STREET
MITCHELL STREET
WALTERS STREET
WOLLONGONG ROAD
BROE AVENUE
STATION STREET
HIRST STREET
KELSEY LANE
DONE STREET
BONAR STREET
BARDEN STREET
UNION STREET
QUEEN STREET
VICTORIA LANE
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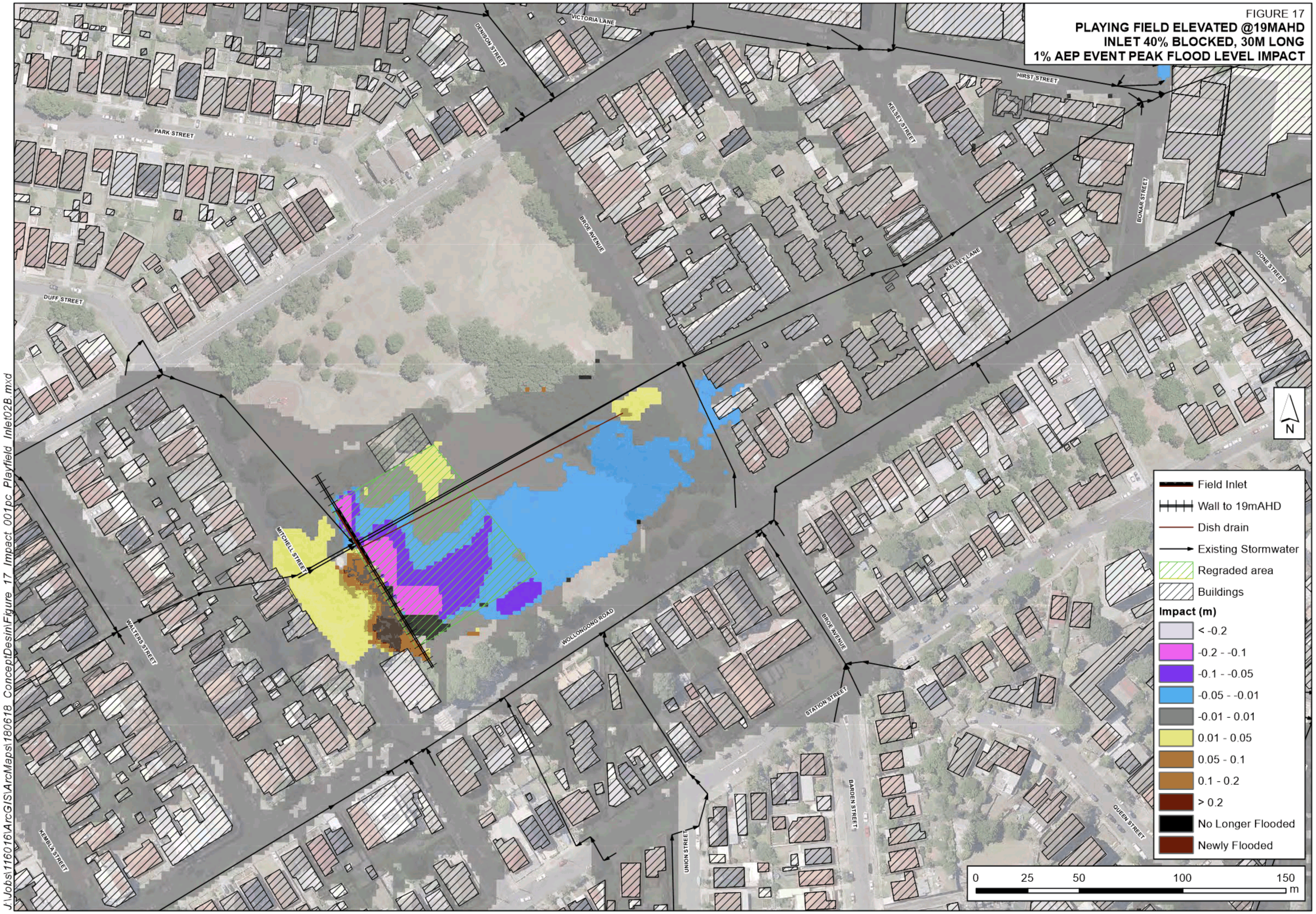
FIGURE 17
PLAYING FIELD ELEVATED @19MAHD
INLET 40% BLOCKED, 30M LONG
1% AEP EVENT PEAK FLOOD LEVEL IMPACT
Field Inlet
Wall to 19mAHD
Dish drain
Existing Stormwater
Regraded area
Buildings
Impact (m)
< -0.2
-0.2 - -0.1
-0.1 - -0.05
-0.05 - -0.01
-0.01 - 0.01
0.01 - 0.05
0.05 - 0.1
0.1 - 0.2
> 0.2
No Longer Flooded
Newly Flooded
0 25 50 100 150 m
N
PARK STREET
DUFF STREET
VICTORIA LANE
DENISON STREET
HIRST STREET
KELSEY STREET
KELSEY LANE
BONAR STREET
DONE STREET
BROE AVENUE
MITCHELL STREET
WALTERS STREET
WOLLONGONG ROAD
STATION STREET
BARDEN STREET
UNION STREET
QUEEN STREET
KEMBLA STREET
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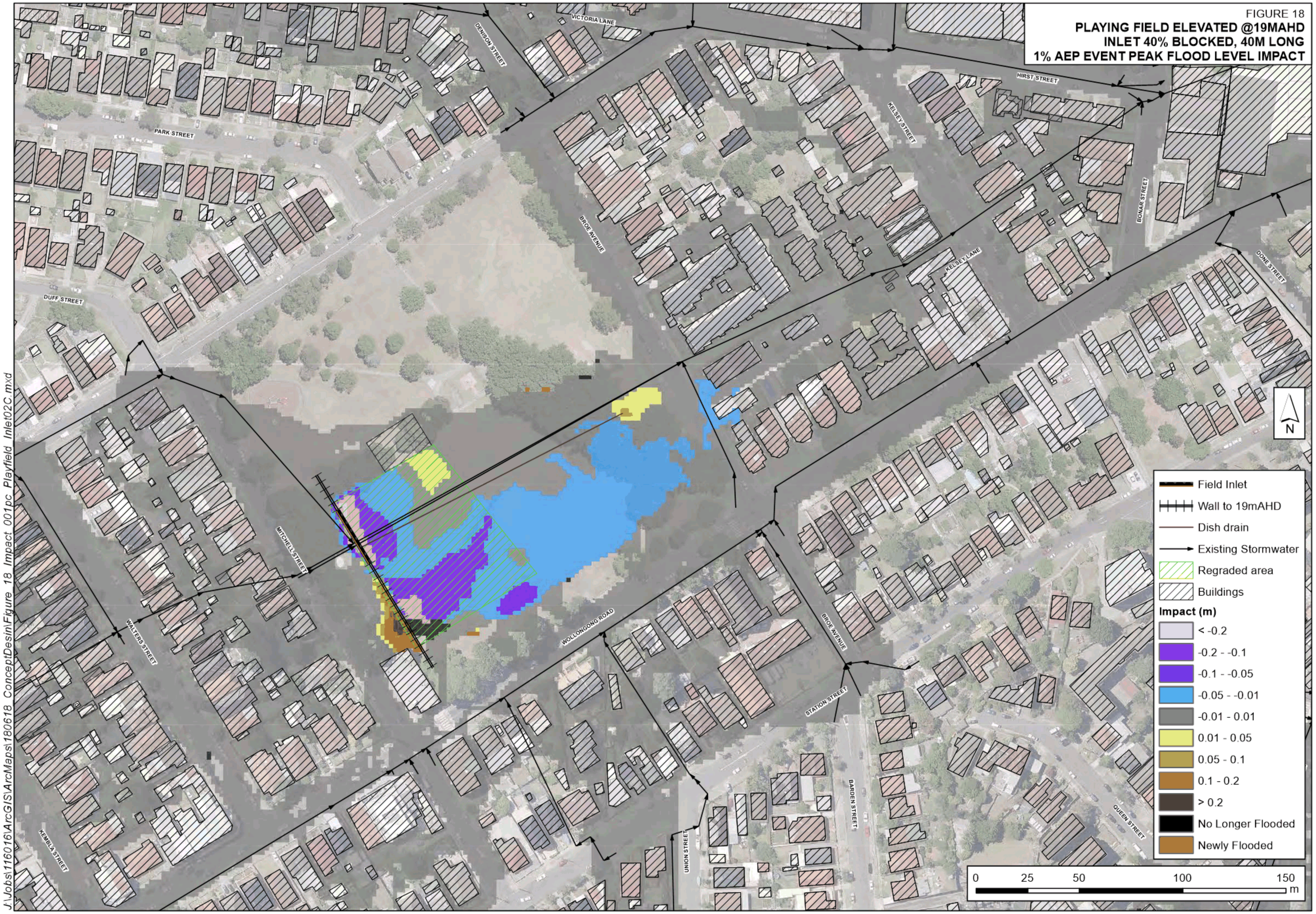
FIGURE 18
PLAYING FIELD ELEVATED @19MAHD
INLET 40% BLOCKED, 40M LONG
1% AEP EVENT PEAK FLOOD LEVEL IMPACT
Field Inlet
Wall to 19mAHD
Dish drain
Existing Stormwater
Regraded area
Buildings
Impact (m)
< -0.2
-0.2 - -0.1
-0.1 - -0.05
-0.05 - -0.01
-0.01 - 0.01
0.01 - 0.05
0.05 - 0.1
0.1 - 0.2
> 0.2
No Longer Flooded
Newly Flooded
N
0 25 50 100 150
m
PARK STREET
DUFF STREET
VICTORIA LANE
HIRST STREET
KELSEY STREET
KELSEY LANE
BONAR STREET
DONE STREET
BROE AVENUE
MITCHELL STREET
WALTERS STREET
WOLLONGONG ROAD
STATION STREET
BARDEN STREET
UNION STREET
QUEEN STREET
KEMBLA STREET
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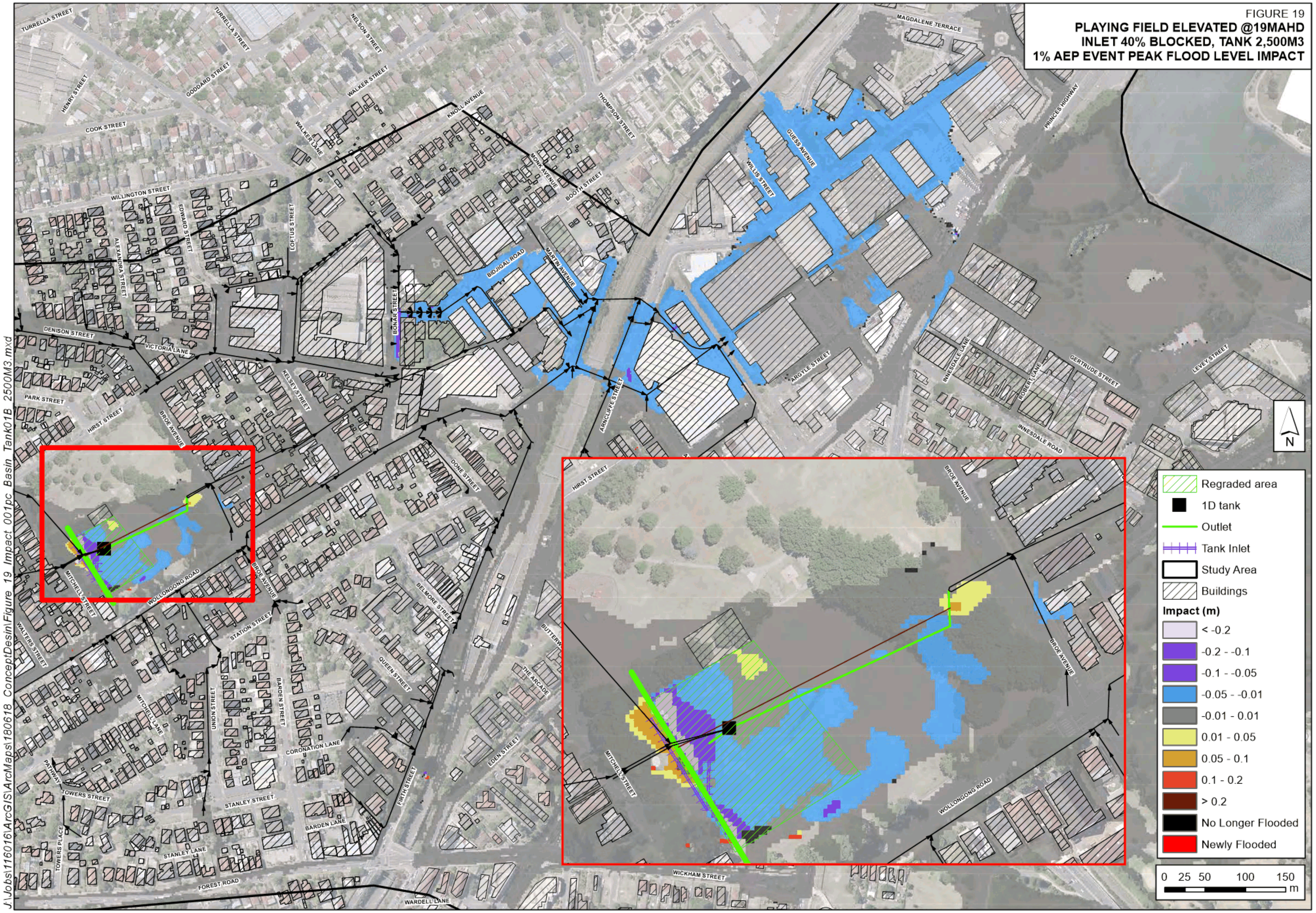
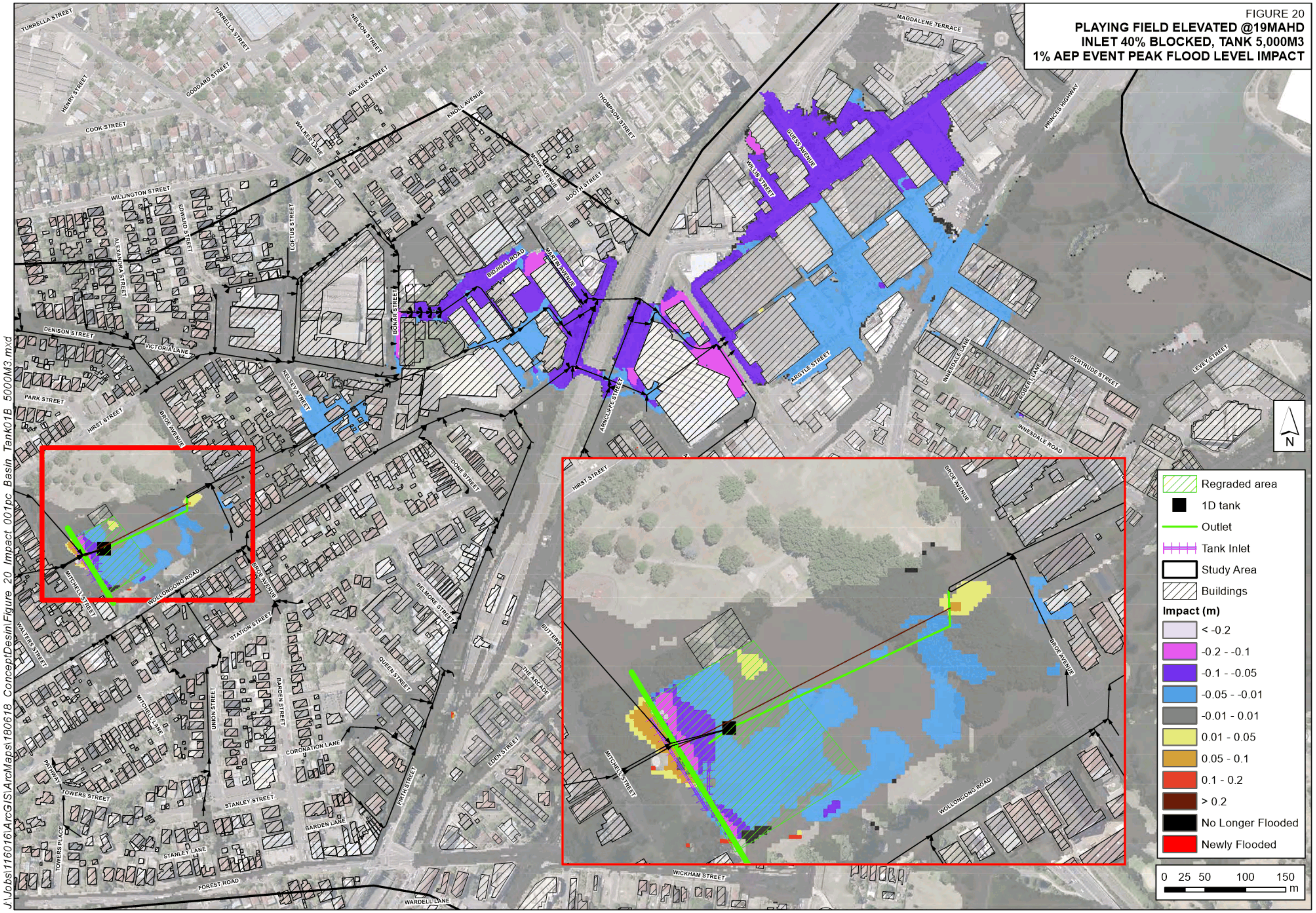


FIGURE 19
PLAYING FIELD ELEVATED @19MAHD
INLET 40% BLOCKED, TANK 2,500M3
1% AEP EVENT PEAK FLOOD LEVEL IMPACT
Regraded area
1D tank
Outlet
Tank Inlet
Study Area
Buildings
Impact (m)
< -0.2
-0.2 - -0.1
-0.1 - -0.05
-0.05 - -0.01
-0.01 - 0.01
0.01 - 0.05
0.05 - 0.1
0.1 - 0.2
> 0.2
No Longer Flooded
Newly Flooded
0 25 50 100 150
m
N



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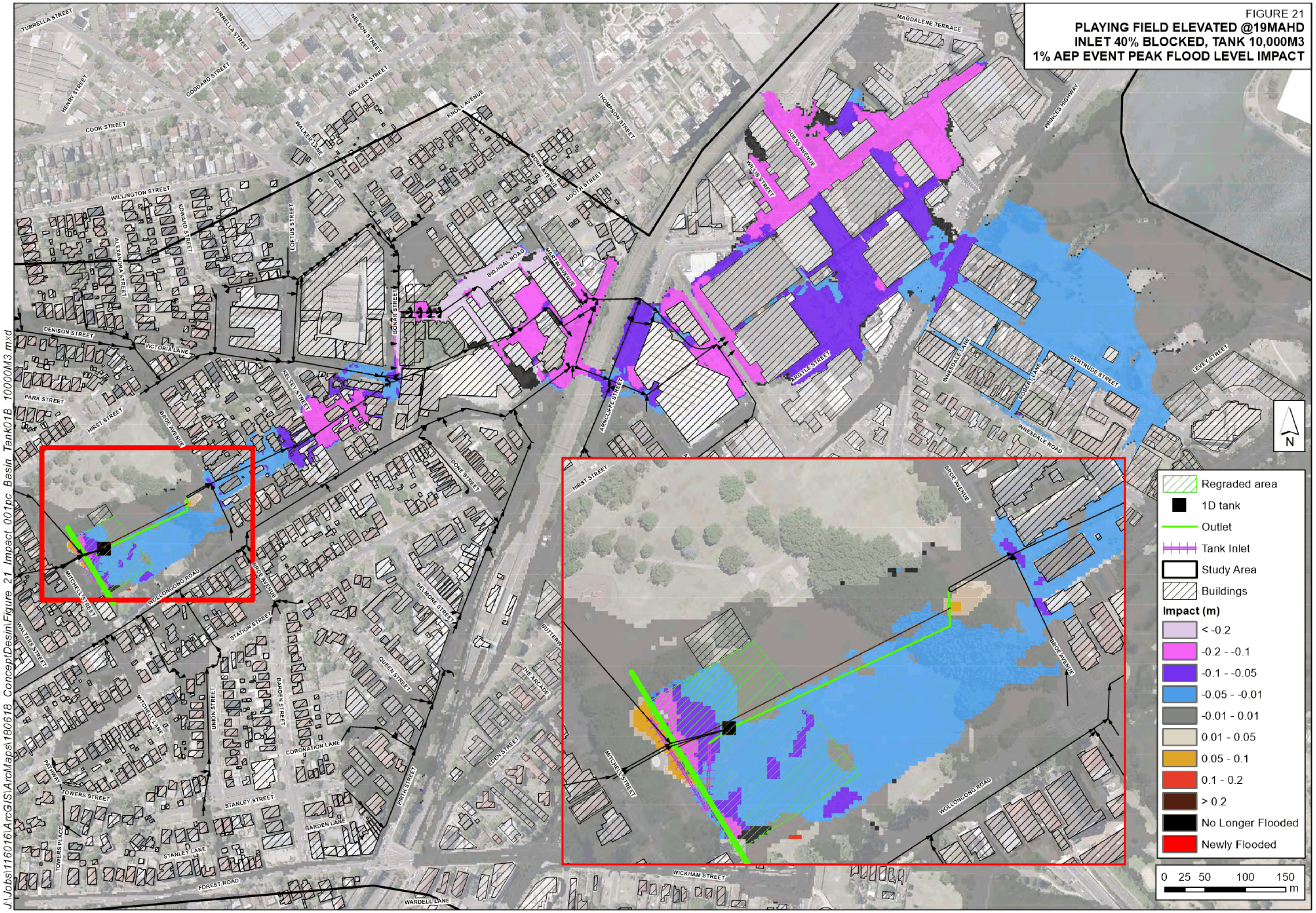
FIGURE 21
PLAYING FIELD ELEVATED @19MAHD
INLET 40% BLOCKED, TANK 10,000M3
1% AEP EVENT PEAK FLOOD LEVEL IMPACT
Regraded area
1D tank
Outlet
Tank Inlet
Study Area
Buildings
Impact (m)
< -0.2
-0.2 - -0.1
-0.1 - -0.05
-0.05 - -0.01
-0.01 - 0.01
0.01 - 0.05
0.05 - 0.1
0.1 - 0.2
> 0.2
No Longer Flooded
Newly Flooded
0 25 50 100 150 m
N

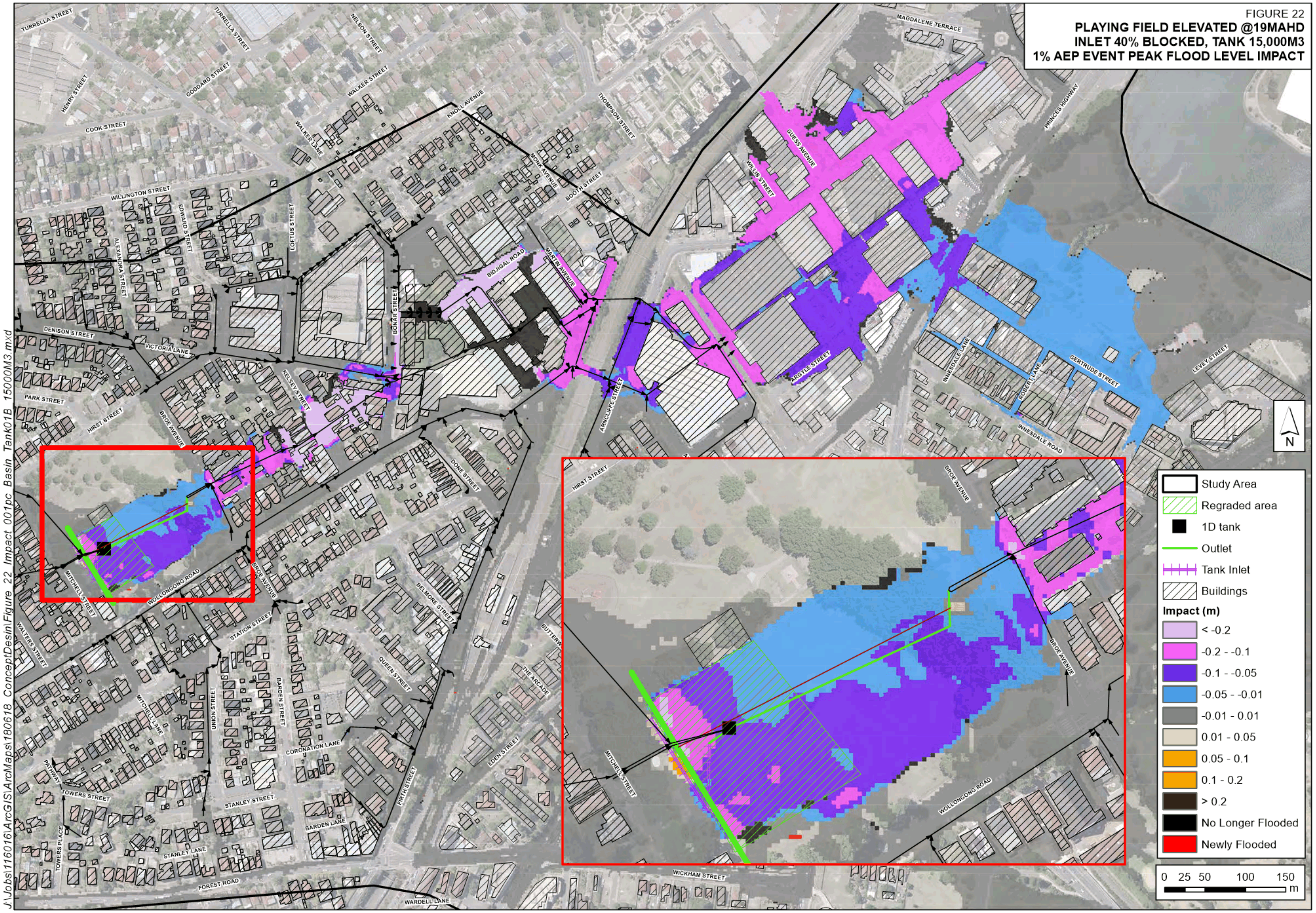
FIGURE 22
PLAYING FIELD ELEVATED @19MAHD
INLET 40% BLOCKED, TANK 15,000M3
1% AEP EVENT PEAK FLOOD LEVEL IMPACT
Study Area
Regraded area
1D tank
Outlet
Tank Inlet
Buildings
Impact (m)
< -0.2
-0.2 - -0.1
-0.1 - -0.05
-0.05 - -0.01
-0.01 - 0.01
0.01 - 0.05
0.05 - 0.1
0.1 - 0.2
> 0.2
No Longer Flooded
Newly Flooded
0 25 50 100 150 m
N
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