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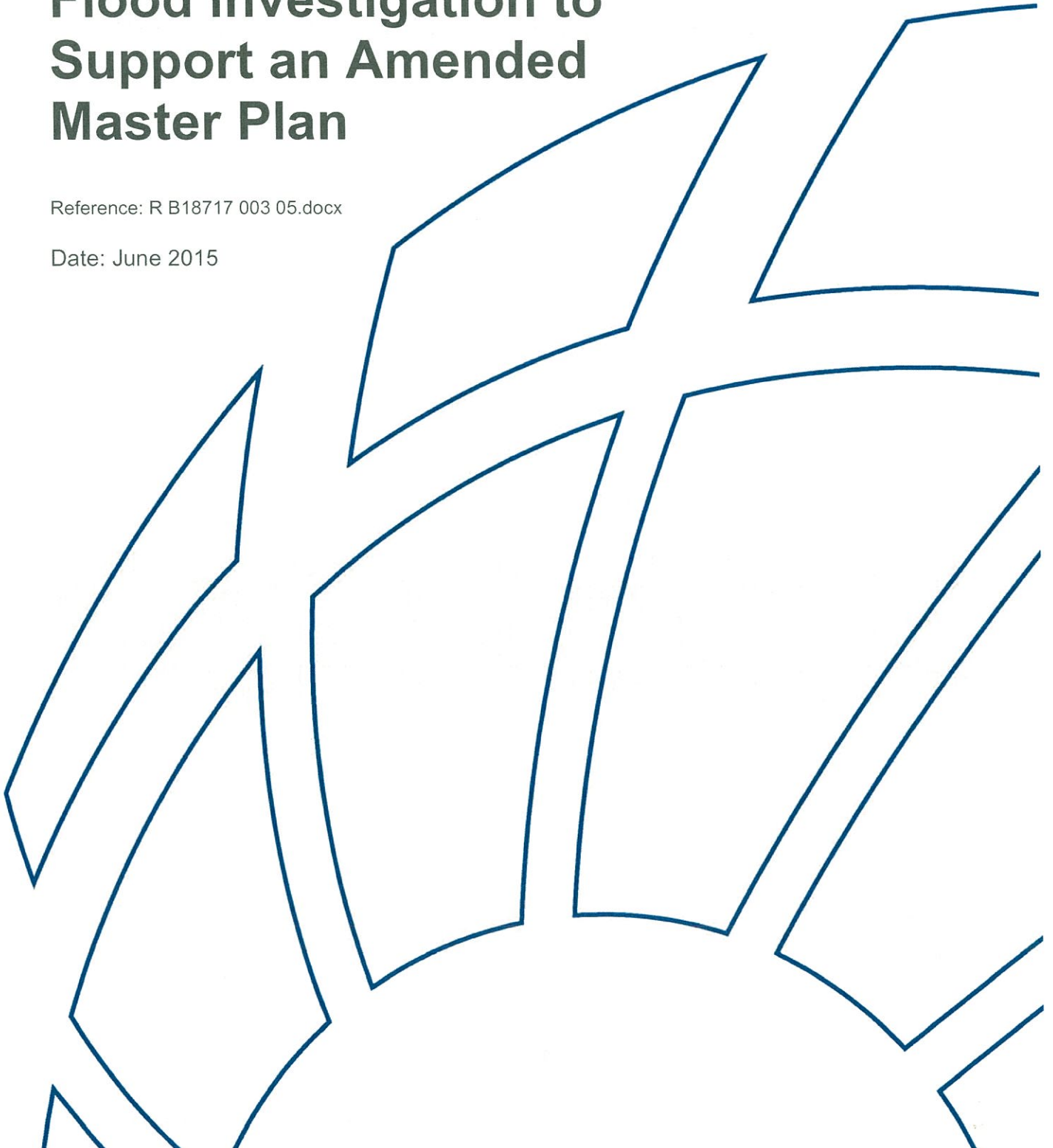
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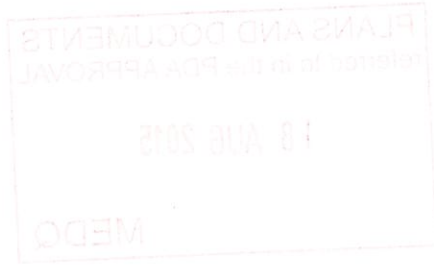
MEDQ

'The Village' Oonoonba, Townsville. Flood Investigation to Support an Amended Master Plan

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'The Village' Oonoonba, Townsville. Flood Investigation to Support an Amended Master Plan

Prepared for: Economic Development Queensland

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Introduction

1 Introduction

This report has been prepared by BMT WBM PTY LTD to provide details into flooding and flood impacts associated with a proposed residential development, 'The Village', located within the suburb of Oonoonba in Townsville, Queensland.

BMT WBM was commissioned by the Economic Development Queensland (EDQ) to prepare a flood study for the site based on a preliminary master plan for the site, incorporating proposed Stages 1 to 17. The study also incorporates the latest revised Ross River Dam flows provided by Townsville City Council.

This investigation details the use of 2 dimensional flood modelling to establish the current ARI 100 year flood levels for the site, based on the revised Ross River Dam outflows, floodplain modifications associated with the proposed development to achieve the desired 100 year flood immunity for the site as well as minimising adverse off site impacts.

Consideration with respect to the proposed draft Townsville planning scheme has been included as part of this master plan assessment and a comparison against the relevant draft codes has been included within Appendix D this report.

Emergency Flood Management is also addressed within the report.

The report supports the current proposed Master Plan for the development (which is included as Figure 2-3 of this report).

Subsequent refinements of the flood assessments and flood management system will be required as the detailed design of the development proceeds.

SITE DESCRIPTION AND PROPOSAL

2 SITE DESCRIPTION AND PROPOSAL

2.1 Existing Site

The subject site is situated within the suburb of Oonoonba, Townsville, Queensland and is approximately 3.5km south of the Townsville city centre. Located within the Townsville City Council local government area the site is approximately 83ha in area.

The Ross River is a dominant feature around the site, bounding the site to the west and the north. The North Coast Railway and Abbott Street form the eastern boundary and the Fairfield Waters residential development makes up the southern boundary.

The majority of the site consists of open space and was formerly the Queensland Government cattle research station.

The current topography levels range from approximately RL2.0m AHD to RL5.8m AHD. A ridge is located centrally within the site whilst an internal drain is located to the west of the ridge, ultimately discharging into the Ross River to the North. The area on the eastern portion of the site is generally quite low lying in nature and abuts the East Coast Rail Line.

Adjacent to the Ross River on the western side of the site is situated an extensive low lying sandbank. The elevation of this sandbank ranges from approximately RL1.3m AHD to RL2.7m AHD.

Figure 2-1 shows the location of the site.

Figure 2-2 provides a more detailed view of the site.

2.2 Proposed Development

The majority of the proposed development will be made up of low-medium density residential lots. The residential area will also be supported by a range of mixed use development consisting of community, retail and recreational facilities.

Figure 2-3 shows an indicative master plan for the site.

The sandbank area situated to the west of the site, adjacent to the Ross River has been deemed unsuitable for development and therefore the developable area for the site is approximately 58ha.

To achieve flood free elevations for the proposed development, filling of the site will be required.

SITE DESCRIPTION AND PROPOSAL

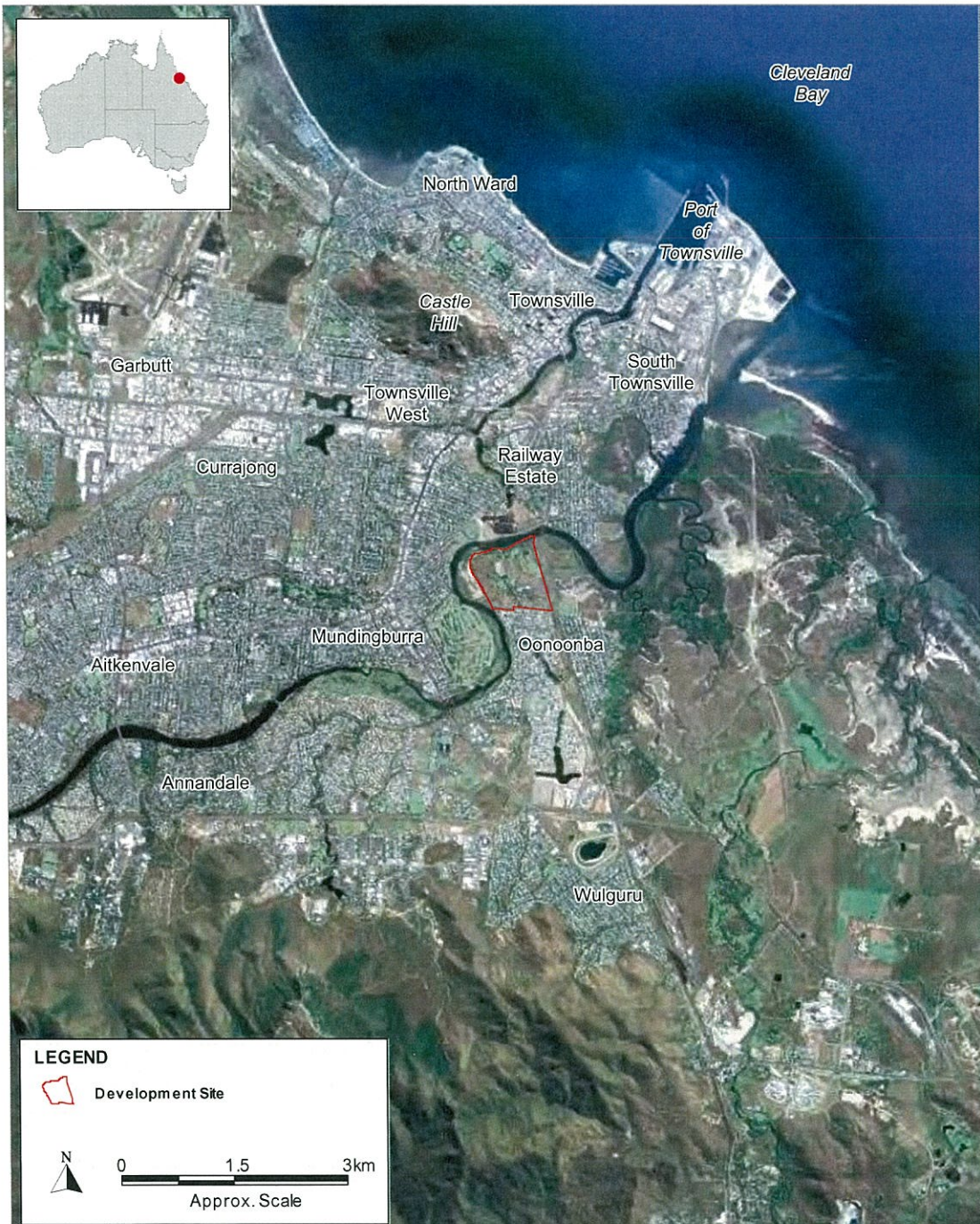


Figure 2-1 Site Location

SITE DESCRIPTION AND PROPOSAL

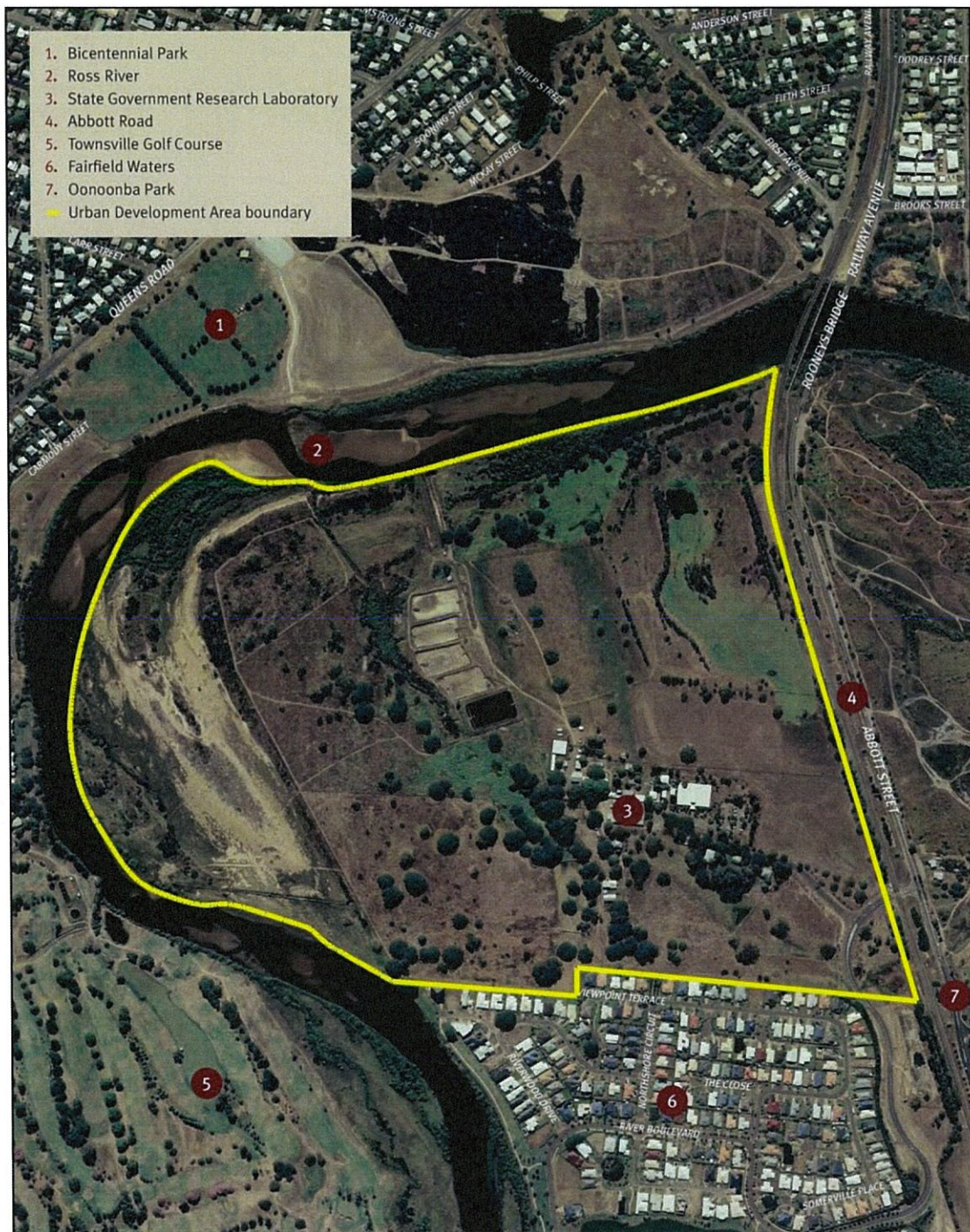


Figure 2-2 The site

SITE DESCRIPTION AND PROPOSAL



Figure 2-3 Proposed Development Master plan

FLOOD ASSESSMENT

3 FLOOD ASSESSMENT

3.1 Methodology

To summarise the approach used to conduct this study, BMT WBM adopted the following methodology:

- Obtain revised Ross River dam discharges for the ARI 100 year design storm event from Council
- Utilise these flows as boundary conditions and run Councils supplied regional Ross River flood model
- Extract boundary conditions from Council's model to use as sub-model boundary conditions
- Utilise AECOM's previously established fine scale sub-model to establish existing 100 year flood levels for the site
- Use the sub-model to investigate proposed development scenarios.

The hydraulic models used for this investigation were based on the DHI MIKEFLOOD hydraulic modelling system. As indicated above Townsville City council had provided a regional flood model which was used to firstly model the revised Ross River Dam discharge hydrograph and secondly from these results, extract boundary conditions to use within a finer grid sub-model of the site.

Figure 3-1 shows the Ross River Dam discharge hydrograph used for the regional flood model.

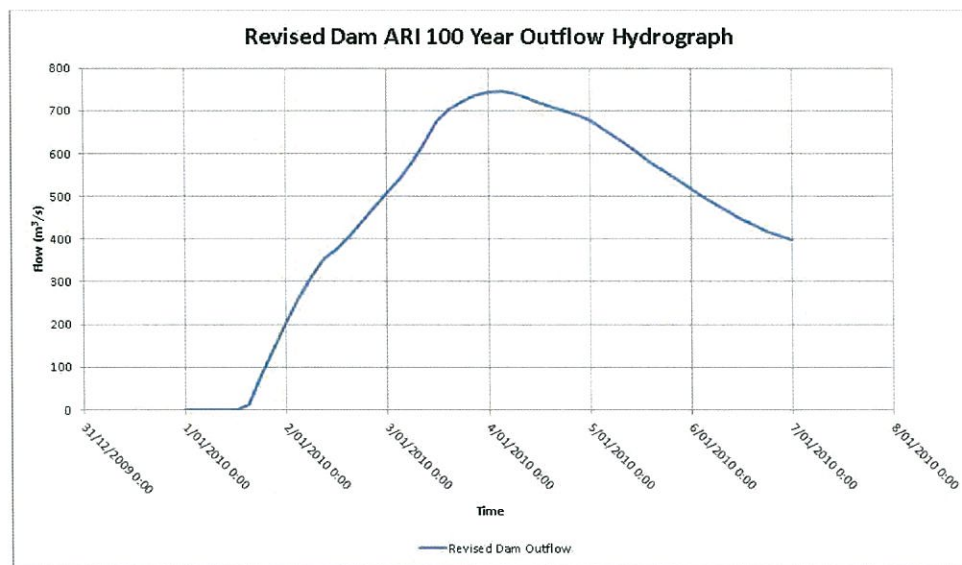


Figure 3-1 Ross River Dam ARI 100 Year Outflow

FLOOD ASSESSMENT

3.2 Existing Case

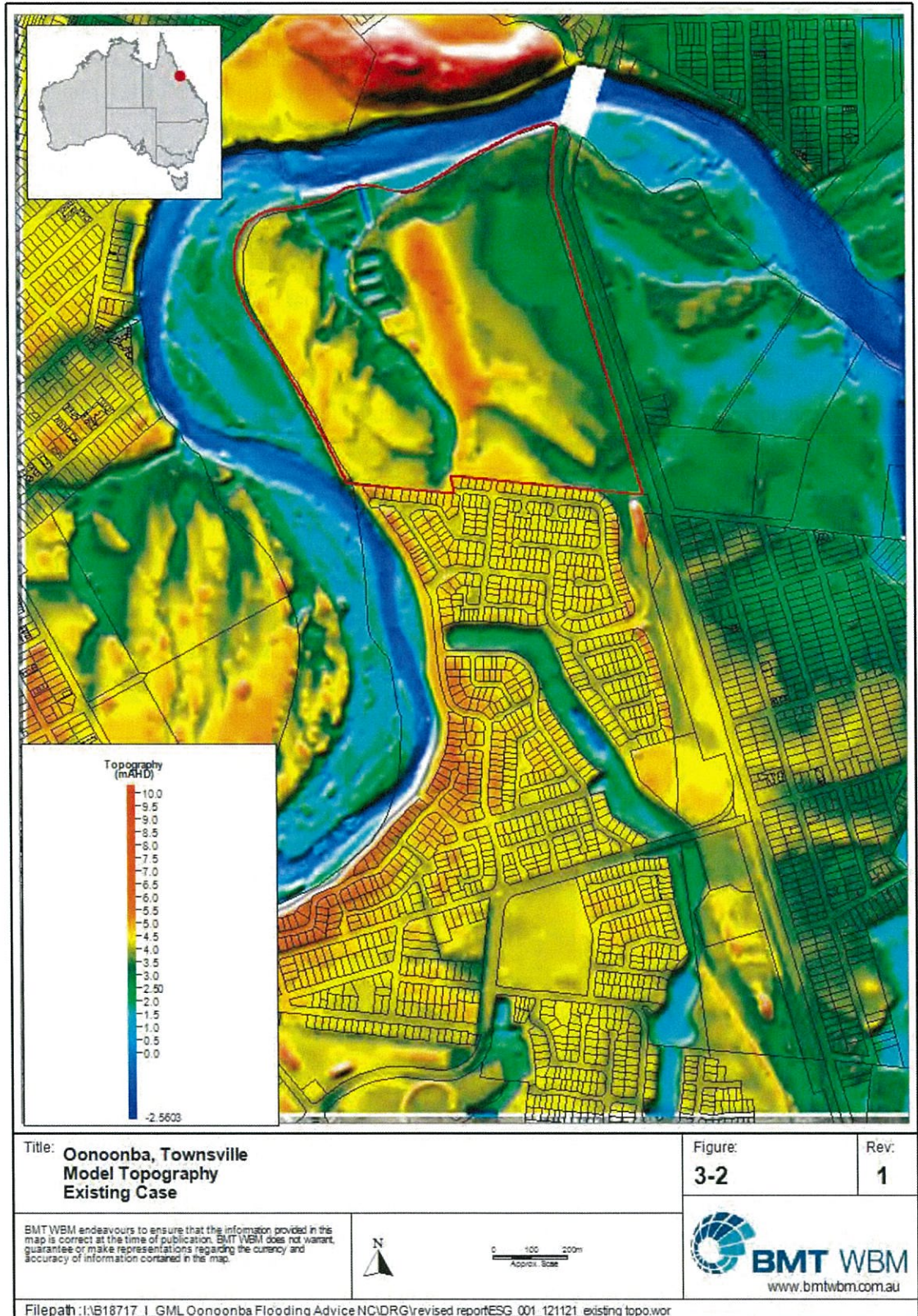
The sub-model used was provided by AECOM who had previously setup the model to conduct initial concept master plan modelling for the site. The model is based on a 5m topographic grid.

Figure 3-2 shows the sub-model extent and topography.

All model parameters including roughness, structures and local inflows remain virtually unchanged. External boundary conditions (including upstream inflows and downstream water levels) were obtained from the regional flood model. Full documentation of the model development is described in the AECOM report 'Oonoonba Flood and Stormwater Management Study', September 2010.

The model was run for the existing ARI 100 year design storm event initially to establish 100 year existing water levels and then modified to represent the proposed development.

FLOOD ASSESSMENT



FLOOD ASSESSMENT

3.3 Developed Case

To investigate the proposed development for the site, the base topography was modified to represent the concept master plan. Numerous iterations and model runs were conducted to achieve a development foot print that resulted in 100 year flood immunity for habitable areas whilst achieving a no significant adverse impact on adjacent properties.

In summary, the areas of the site below the 100 year design flood levels are proposed to be filled to provide the required flood immunity. Within the site, the centrally located drain is proposed to be re-shaped in accordance with the proposed development layout, as shown in Figure 2-3.

Within the central drain, several water quality features are proposed, primarily in the form of wetlands. Upstream of the proposed crossing, ground levels within the drainage area generally range from RL 2.0m to RL2.4m AHD. Therefore, some excavation/earthworks within this area is required.

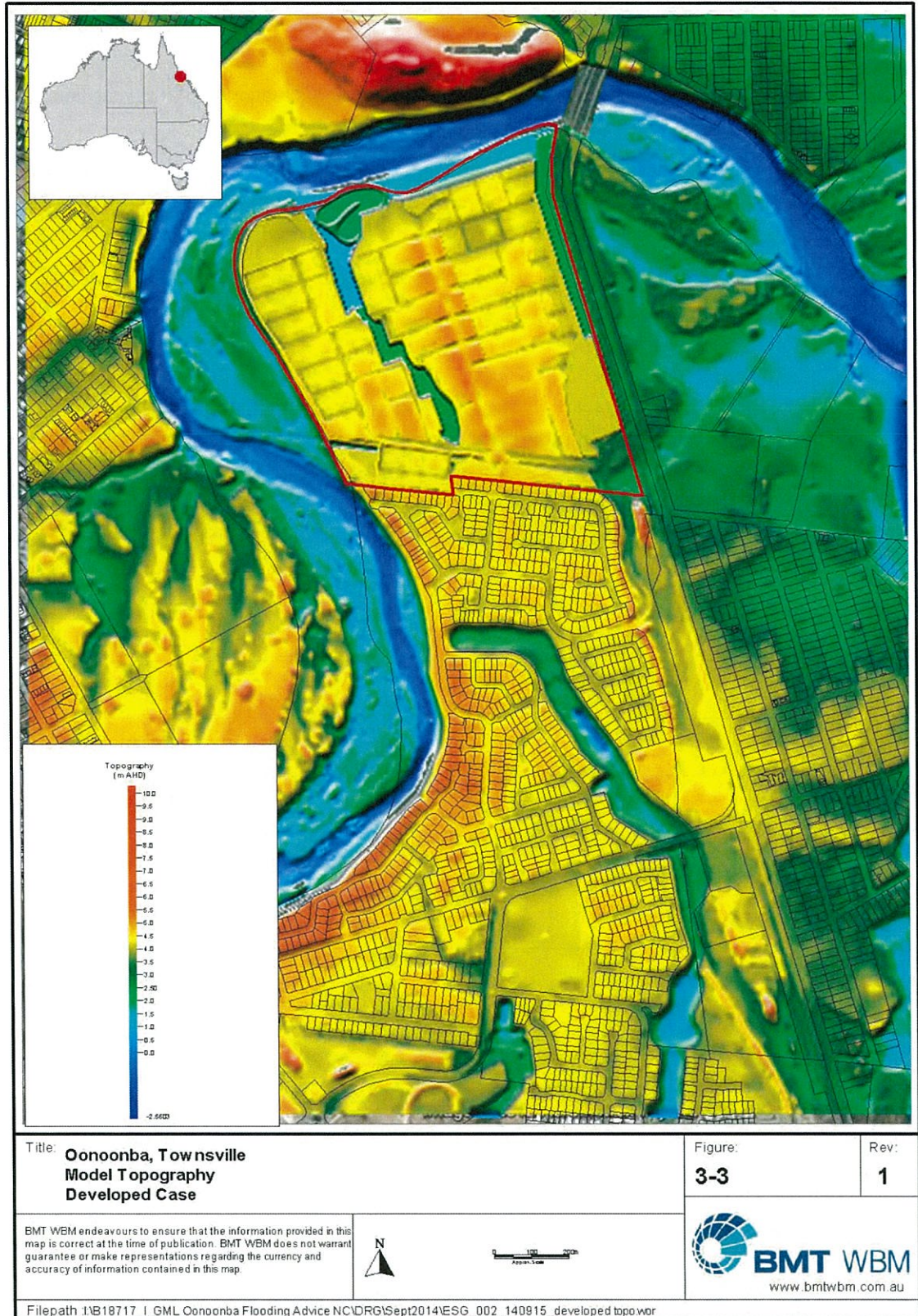
In the area adjacent to the river and central drain outlet, a wetland of approximately 1ha is proposed. The outer bund of this wetland is proposed at a level of RL 2.85m with a normal operating level of 1.85m. The flood model has been updated to reflect these wetland features.

To the east, adjacent to the East Coast Railway, a 50m wide open channel, tapering to 30m wide at the southern end is proposed to maintain conveyance over the this section of floodplain and provide flood storage. Invert levels within the proposed channel are approximately RL2.0m AHD.

These flood management components were identified and refined jointly with the EDQ.

Figure 3-3 presents the model topography for the proposed case.

FLOOD ASSESSMENT



Results

4 Results

4.1 Existing Situation

Appendix A contains detailed results for the existing situation ARI 100 year flood events including peak water surface levels, depths and velocities.

In summary, peak water levels for the site range from RL4.58m AHD at the upstream extent of the site to RL3.79m AHD at the downstream extent of the site. Flooding across the site predominantly occurs within the internal drain and across the eastern and north-eastern portions of the site.

Table 4-1 provides peak ARI 100 year flood levels for specific points around the site.

Reporting point locations are shown in Appendix A.

Table 4-1 Existing ARI 100 Year Peak Water Levels

Reporting Point	Existing Peak Water Level (mAHD)
A	5.026
B	4.783
C	4.564
D	4.478
E	4.257
F	4.081
G	3.776
H	2.966

Results

4.2 Developed Situation

Appendix B contains the detailed results for the site with the proposed development in place including the ARI 100 year flood event impacts, peak water surface levels, depths and velocities.

Table 4-2 details the peak 100 year water surface levels and impacts for the reporting points as outlined above.

Table 4-2 Existing ARI 100 Year Peak Water Levels

Reporting Point	Existing Peak Water Level (mAHD)	Developed Peak Water Level (mAHD)	Impact (mm)
A	5.026	5.006	-20
B	4.783	4.758	-25
C	4.564	4.531	-33
D	4.478	4.442	-36
E	4.257	4.211	-46
F	4.081	4.033	-48
G	3.776	3.780	4
H	2.966	2.966	0

100 Year Flood Event

In summary, the inclusion of the proposed development and associated earthworks results in a reduction of peak flood levels of up to 48mm on areas adjacent to the development on the opposite bank of the Ross River. A large portion of this area includes the golf course with a smaller area of residential urban area northwards of the golf course west of the site. These areas are already flood affected in the ARI 100 year design storm event.

Some increases in peak flood levels are predicted to the east of the site however these increases are confined to a relatively small area of uninhabited land and are not predicted to have adverse impacts.

Peak velocities and flow patterns remain virtually unchanged as a result of these modifications.

Coastal Hazard

5 Coastal Hazard

The site itself is situated within the tidal reach of the Ross River. With the exception of the central drainage area and the sandbank area on the western side, the site is free from tidal inundation.

Tide levels for Mean High Water Spring (MHWS) and the Highest Astronomical Tide (HAT) are reported to be 1.254m AHD and 2.25m AHD respectively.

5.1 Storm Tide Inundation

Councils overlay map OM - 03.2 of the draft planning scheme indicates that the eastern section of the site and the central drainage channel are situated in areas of predicted high and medium hazard as a result of storm tide inundation.

To provide protection against storm tide inundation, filling is proposed in the eastern section of the site which, in consideration with the proposed freeboard of 500mm to habitable floors, will protect the development and residents from potential storm tide inundation.

5.2 Erosion Prone Area

Council's overlay map OM – 03.3 of the draft planning scheme shows that the site is outside the erosion prone area.

Coastal Hazard

5.3 Climate Change

In Council's Ross River Flood Study, scenarios have been investigated to represent the likely impacts of Ross River flooding due to predicted future climate change.

Scenarios adopted to represent the predicted changes by 2100 include a 0.88m AHD increase in sea levels and a 15% increase in rainfall intensity within the Ross River catchment.

From councils report, the predicted increase in peak 100 year ARI flood levels for the combined scenario of 0.88m sea level rise and 15% increase in rainfall intensity is less than 300mm.

Appendix E provides an extract from Council's report demonstrating the predicted increase in the vicinity of the site.

Based on this information, the predicted increase in peak flood levels from climate change is not expected to adversely impact on the developed site due to proposed fill and floor levels.

Emergency Management

6 Emergency Management

As part of the flood assessment investigation, a review into the emergency management of the site during an extreme flood event has also been conducted. The PMF event, being the most extreme, was investigated.

The report relies on the council PMF flood mapping for the Oonoonba area, which is presented in Appendix C. The map shows extensive inundation surrounding and including the site which virtually isolates the site during an event of this magnitude.

From Council's mapping, PMF peak levels range for RL5.6m AHD to RL4.8m AHD. These levels are generally 1.0m above the predicted peak ARI 100 year water levels. Assuming the proposed residential floor levels will be set at the ARI 100 year peak flood level + 0.5m freeboard, the resulting depth over floors in the PMF event will be approximately 0.5m. Hence, the potential for structural damage or loss of life is low, and first floor refuges are safe under all flood events.

As evacuation from the site is potentially very difficult as a result of the extensive flooding surrounding the site, a 'stay put' option is proposed for residents. It is also proposed that two story dwelling be specified for inclusion throughout the development to provide refuge/shelter during an extreme event should over floor flooding occur.

High, flood free ground is also located centrally within the site which would also provide safe refuge for residents in the event of an extreme flood event.

The emergency flood management planning for the site will be refined at the detailed design stage, adhering to the above concepts.

Conclusions

7 Conclusions

From the investigations outlined in this report it can be shown that, subject to suitable detailed design, the subject site may be filled to above the Ross River ARI 100 year design flood event level providing two key features are included within the design. These features include:

- A 50m to 30m wide channel with invert at RL2.0m AHD located at the eastern side of the site adjacent to the East Coast Railway
- Modification of the proposed central drainage area to accommodate wetlands and enhance flood storage.

The 50m wide channel allows flow to be maintained in a similar fashion to the existing flows in this area.

The inclusion the above measures generally results in reductions of off-site impacts of up to 46mm on adjacent properties during the ARI 100 year flood event. This area includes the golf course and a proportion of existing residential areas. Some isolated impacts are predicted to the east of the development. These impacts are in an area of open space and do not impact on existing residential properties.

Qualifications

8 Qualifications

This report has been prepared by BMT WBM PTY LTD specifically for the Economic Development Queensland and specifically to provide advice on flooding issues associated with 'The Village' Oonoonba, Townsville for the Master Planning stage of the project. Subsequent refinements of the flood assessments and flood management system will be required as the detailed design of the development proceeds.

Our analysis and overall approach has been specifically catered for the particular requirements of Economic Development Queensland, and may not be applicable beyond this scope. For this reason any other third parties are not authorised to utilise this report without further input and advice from BMTWBM.

BMTWBM has relied on the following information provided by others:

- Townsville City Council's regional Ross River MIKEFLOOD hydraulic model supplied by Townsville City Council
- Revised Ross River Dam outflows supplied by Townsville City Council
- Detailed site MIKEFLOOD hydraulic model supplied by AECOM
- Preliminary developed site layout supplied by the Economic Development Queensland
- Preliminary finished site DTM provided by Flanagan and Associates.

.The accuracy of this report is dependent upon the accuracy of this information.

While BMTWBM's report accurately assesses peak flows and flood levels from design storms, it is an ungauged catchment in the vicinity of the site; consequently future observed flows and flood levels may vary from that predicted.

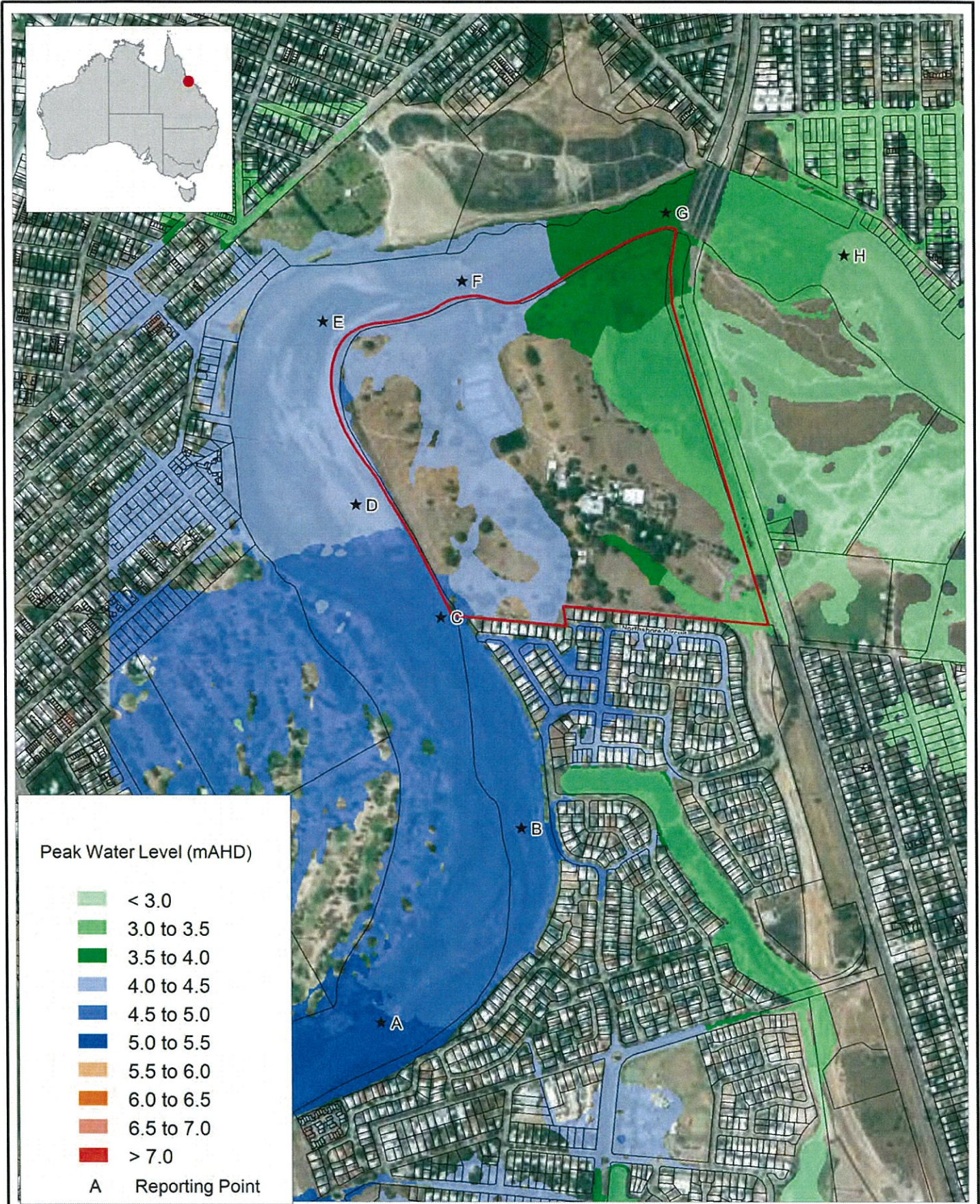
References

9 References

Oonoonba Flood and Stormwater Management Study. AECOM. September 2010

Ross River Flood Study. Base-Line Flooding Assessment. Townsville City Council, January 2013

Appendix A Existing Case Model Results



Title: **Oonooba, Townsville**
ARI 100 Year Peak Water Levels
Existing Case

Figure:
A-1

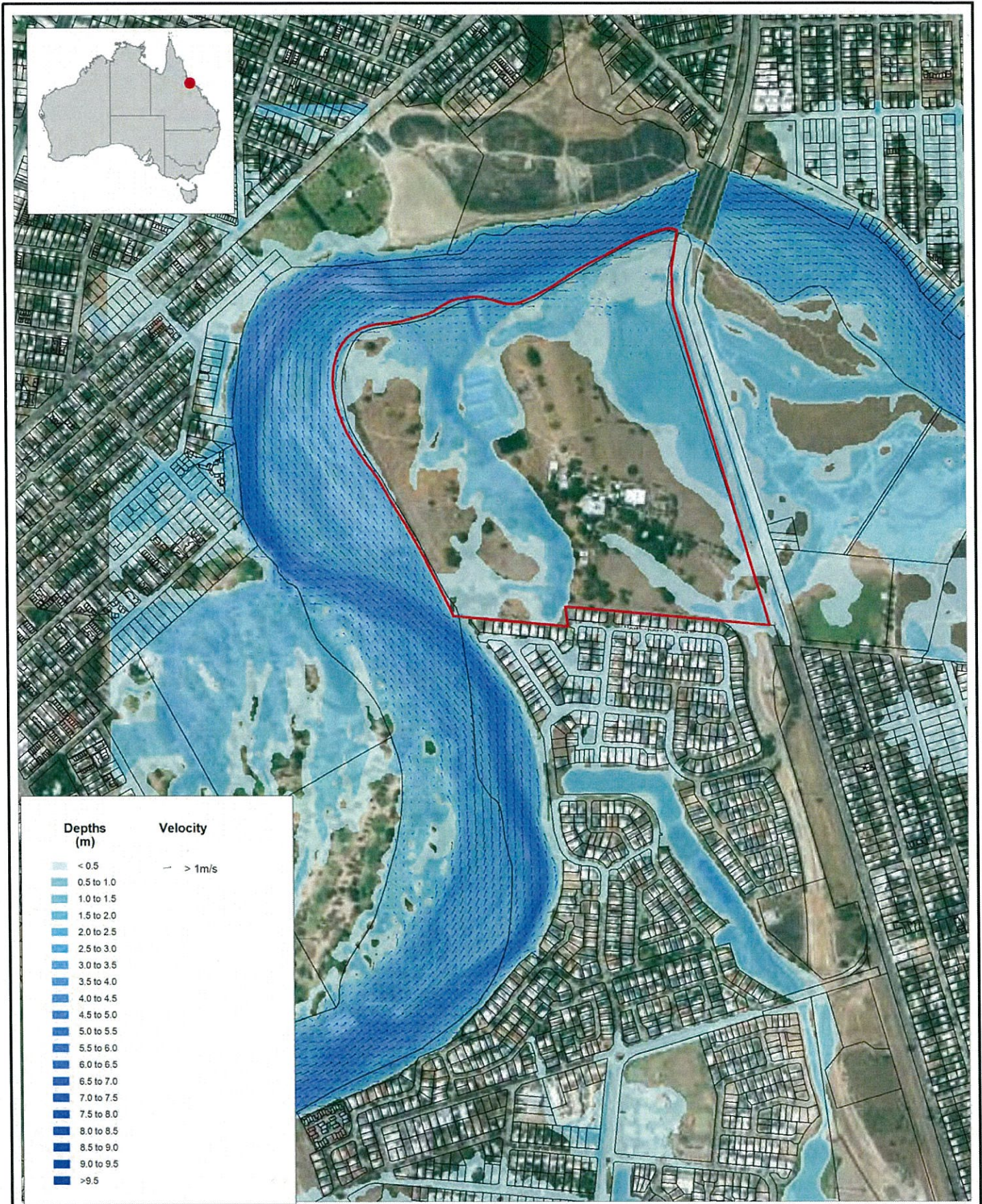
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0 100 200m
 Approx. Scale





Title: **Oonoonba, Townsville
ARI 100 Year Peak Depths
Existing Case**

Figure:
A-2

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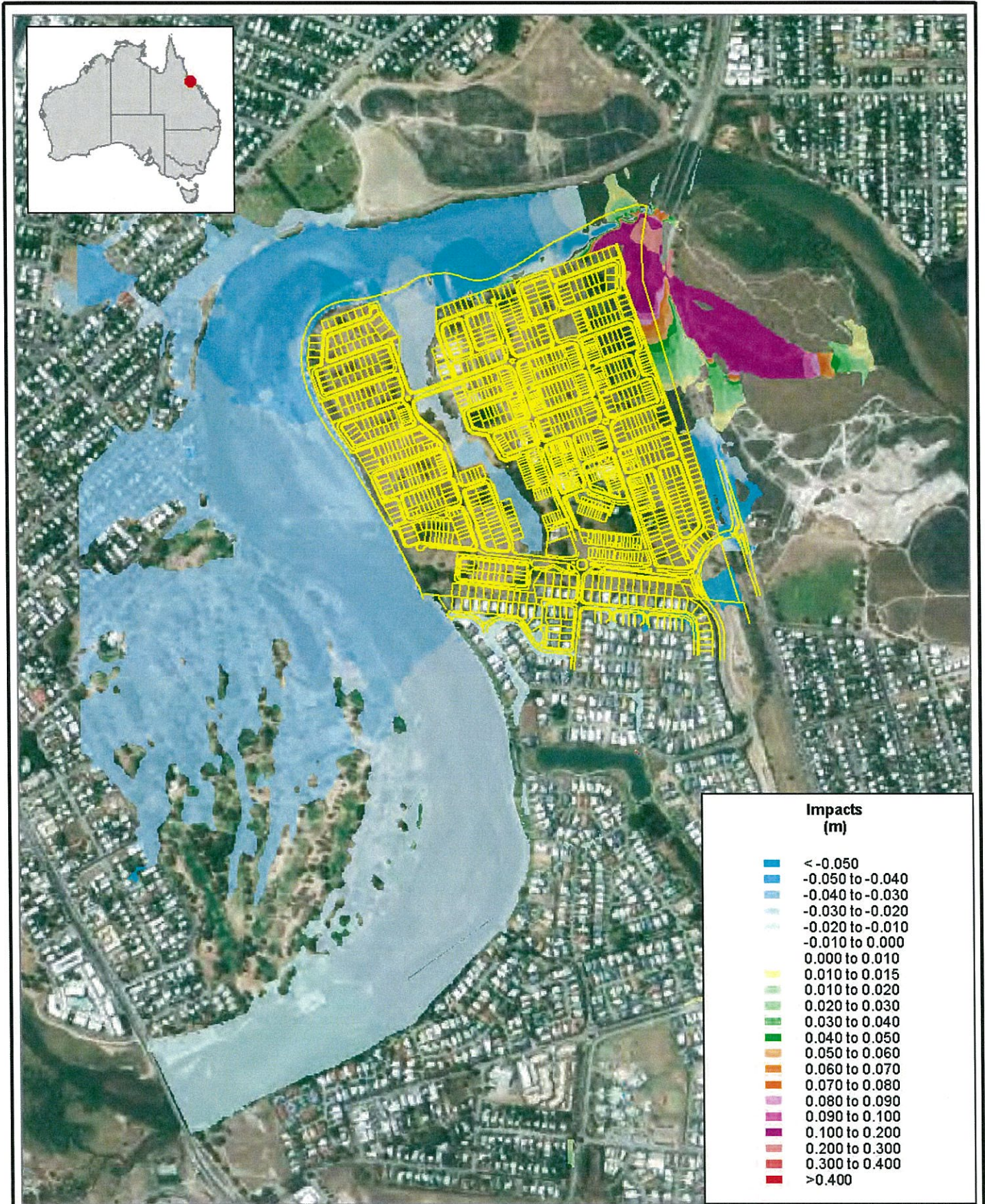


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Approx. Scale



Developed Case Model Results

Appendix B Developed Case Model Results



Title: **Oonoonba, Townsville
ARI 100 Year Impacts
Developed Case**

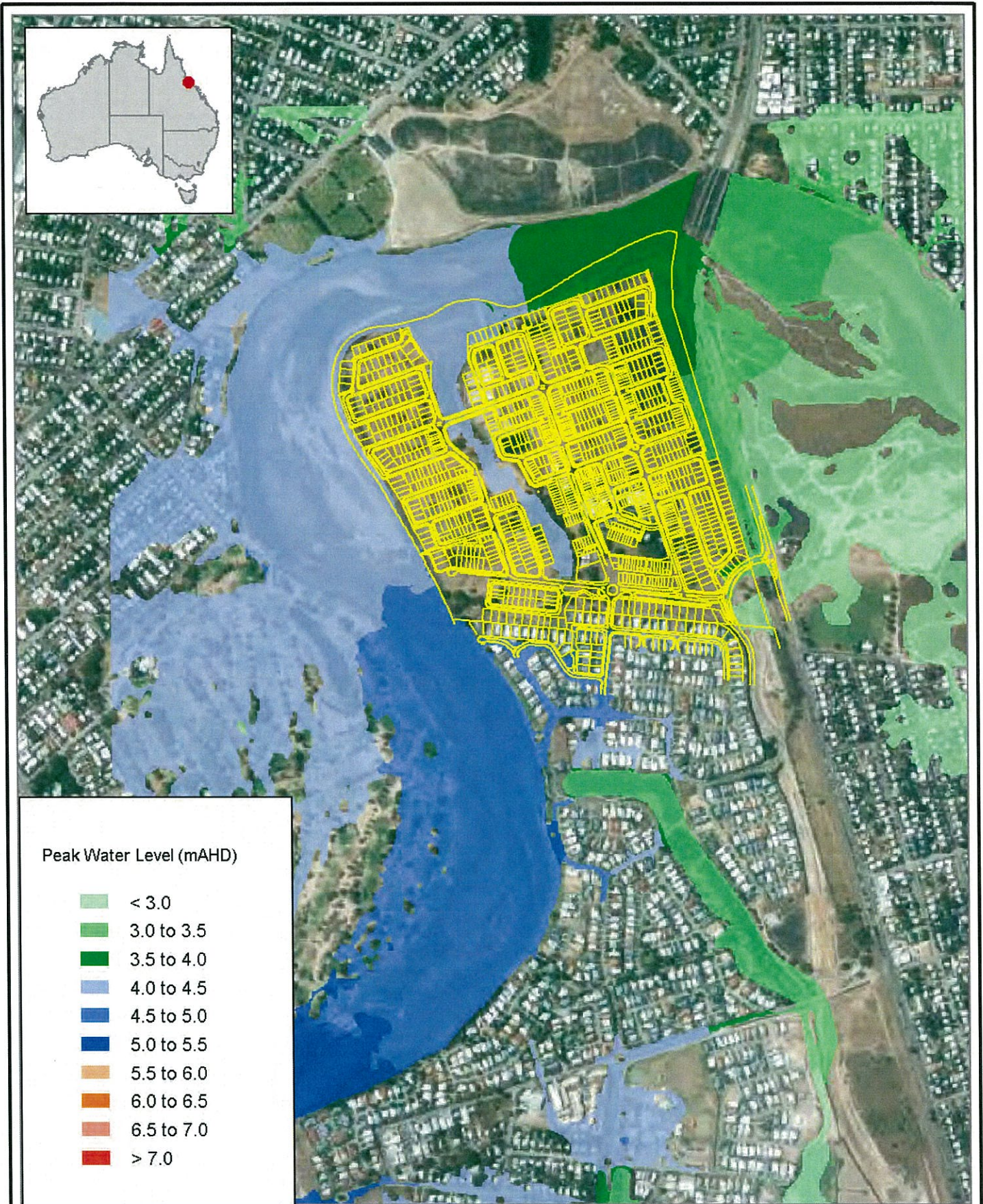
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B-1

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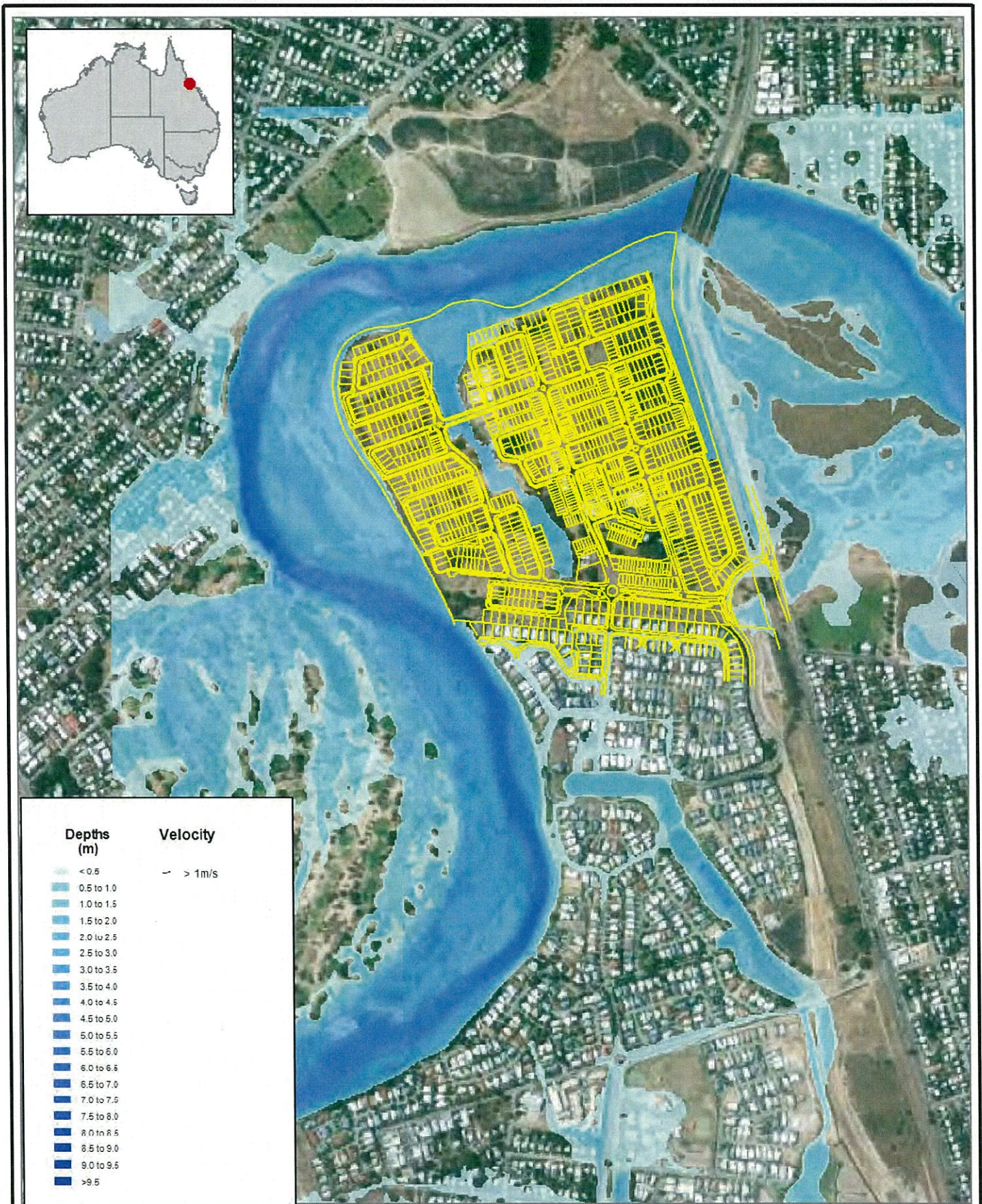
**Title: Oonoonba, Townsville
ARI 100 Year Peak Water Levels
Developed Case**

Figure:
B-2

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**Title: Oonoonba, Townsville
ARI 100 Year Peak Depths
Developed Case**

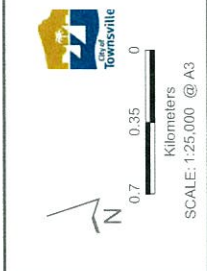
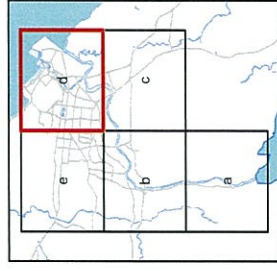
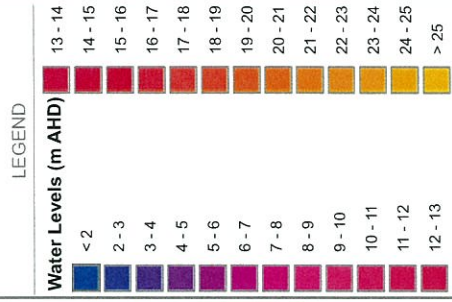
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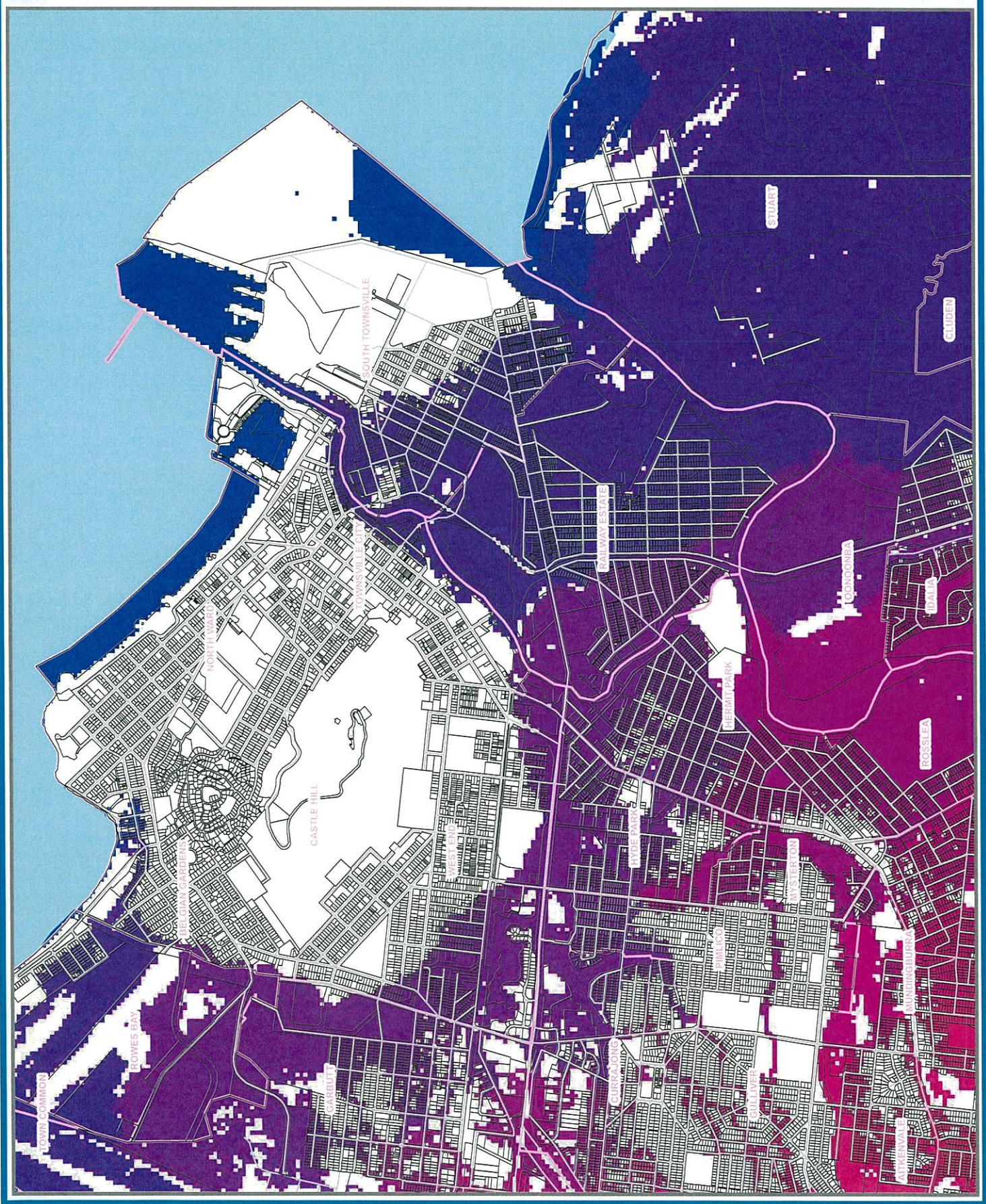


Appendix C PMF Flood Extent



Strategic Planning Department
PLANNING AND DEVELOPMENT
DATE: 13/04/2011
DRAWN BY: WGB
DIGITAL FILE: mwf
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Figure B-22



Draft Planning Scheme Code Comparison

Appendix D Draft Planning Scheme Code Comparison

8.2.7 Flood hazard overlay code

Table 8.2.7.3(a)—Self-assessable and assessable development (Part)

Performance outcomes	Acceptable outcomes	Response
<p>For assessable development</p> <p>PO3 Development does not intensify use in high hazard areas, in order to avoid risks to people and property.</p> <p>Editor's note—High hazard areas are those likely to experience deep or fast moving water in a defined flood event.</p>	<p>AO3.1 New buildings are located outside High hazard areas identified on overlay map OM07.1 or 07.2.</p> <p>AO3.2 New lots or roads are not created within High hazard areas identified on overlay map OM07.1 or 07.2.</p> <p>AO3.3 Sites for non-permanent accommodation such as tents, cabins or caravans (whether intended for short or long-term accommodation) are located outside the High hazard areas identified on overlay map OM07.1 or 07.2.</p> <p>Where reconfiguring a lot</p> <p>AO4.5 Where reconfiguring a lot, new lots contain designated building envelopes (whether or not for residential purposes) outside the Medium hazard areas identified on overlay map OM07.1 or 07.2, and those building envelopes are of a sufficient size to accommodate buildings associated with the development.</p> <p>AO4.6 In new subdivisions, arterial and sub-arterial roads or major collector streets are located above the 2% AEP flood level.</p> <p>AO4.7 Reconfiguration of lots does not involve cul-de-sacs or dead end streets within high and Medium hazard areas identified on overlay map OM07.1 or 07.2.</p>	<p>The proposed earthworks and site layout provides development outside high hazard areas.</p>
<p>PO4 Siting and layout of development maintains the safety of people and property in Medium hazard areas.</p> <p>Editor's note—the Building Regulation 2006 establishes requirements with which development will need to comply. The defined flood event is identified in this planning scheme as the 1% annual exceedance probability (AEP) flood and is mapped as the combined extent of the High and Medium flood hazard areas identified on overlay map OM07.1 and 7.2. Other than in the Medium hazard – further investigation, council will be able to make available the height of the flood level for any particular location upon request.</p> <p>Applicants must be aware that in some areas storm tide hazard areas will also coexist with flood hazard areas. In these instances, the floor levels and other design responses will need to be sufficient to comply with this code, the coastal protection overlay code and the Building Regulation 2006 as amended.</p>	<p>Where reconfiguring a lot</p> <p>AO4.5 Where reconfiguring a lot, new lots contain designated building envelopes (whether or not for residential purposes) outside the Medium hazard areas identified on overlay map OM07.1 or 07.2, and those building envelopes are of a sufficient size to accommodate buildings associated with the development.</p> <p>AO4.6 In new subdivisions, arterial and sub-arterial roads or major collector streets are located above the 2% AEP flood level.</p> <p>AO4.7 Reconfiguration of lots does not involve cul-de-sacs or dead end streets within high and Medium hazard areas identified on overlay map OM07.1 or 07.2.</p>	<p>The proposed earthworks and site layout provides development outside medium hazard areas.</p> <p>All roads to be located above 2% AEP</p>

Performance outcomes	Acceptable outcomes	Response
<p>PO5 Signage is provided within High and Medium hazard areas to alert residents and visitors to the flood hazard.</p> <p>PO6 Development within High and Medium hazard areas ensures any changes to the depth, duration, velocity of flood waters are contained within the site. Editor's note—impacts on a range of floods may need to be assessed and in most instances can be evaluated by analysing the minor drainage system capacity event and the defined flood event for the catchment wide critical duration, unless the site is located in an area noted in the Flood hazard planning scheme policy SC6.7.</p> <p>PO7 Development within High and Medium hazard does not directly, indirectly or cumulatively worsen flood characteristics outside the development site, having regard to: a) increased scour and erosion; or b) loss of flood storage; or c) loss of or changes to flow paths; or d) flow acceleration or retardation; or e) reduction in flood warning times. Editor's note—to adequately assess the impacts of development on flooding regimes, applicants may need to have a hydrological and hydraulic assessment carried out by a suitably qualified and experienced hydrologist or engineer.</p> <p>PO8 Facilities with a role in emergency management and vulnerable community services are able to function effectively during and immediately after flood events. Editor's note—this provision applies to High, Medium and Low flood hazard areas.</p>	<p>AO5 Signage is provided onsite (regardless of whether land will be public or private ownership) to indicate depth at key hazard points, such as at roadway crossings, entrances to low-lying reserves or car parks. No acceptable outcome is nominated.</p> <p>No acceptable outcome is nominated.</p> <p>No acceptable outcome is nominated.</p>	<p>Signage will be applied where appropriate</p> <p>The hydraulic assessment associated with the proposed development indicates that no adverse off site flood impacts are predicted.</p> <p>The hydraulic assessment associated with the proposed development indicates that no adverse off site flood impacts are predicted. Existing flow paths are generally maintained by the retention of the central drainage path and the provision of the 30-50m wide channel adjacent to the rail line.</p> <p>The proposed development incorporates an area flood immune up to and including the PMF event.</p>

Performance outcomes	Acceptable outcomes	Response
<p>PO9 Public safety and the environment are not adversely affected by the detrimental impacts of flooding on hazardous materials manufactured or stored in bulk. Editor's note-'hazardous materials in bulk' is defined in Section 9, Glossary of SPP1/03 Guideline.</p>	<p>AO9.1 Development does not involve the manufacture or storage of hazardous materials within a High flood hazard area identified on overlay map OM07.1 or 07.2. AO9.2 Within the Low or Medium flood hazard area identified on overlay map OM07.1 or 07.2, structures used for the manufacture or storage of hazardous materials in bulk are designed to prevent the intrusion of flood waters up to at least a 0.2% AEP flood event.</p>	NA

Table 8.2.7.3(b) Flood immunity for community services and facilities

Performance outcomes	Acceptable outcomes	Response
<p>Development</p> <p>Development involving:</p> <ul style="list-style-type: none"> a) emergency services; b) hospitals and associated facilities; c) major electricity infrastructure. <p>Development involving:</p> <ul style="list-style-type: none"> a) emergency/evacuation shelters; b) the storage of valuable records or items of historic/cultural significance (e.g. libraries, galleries); c) aeronautical facilities; d) telecommunication facilities; e) substations; f) water treatment plants; g) regional fuel storage; h) food storage warehouse; i) retirement facility and residential care facility. 	<p>Level of flood immunity annual exceedance probability (AEP)</p> <p>0.2% AEP flood event</p> <p>0.5% AEP flood event</p>	<p>The proposed development incorporates an area flood immune up to and including the PMF event.</p> <p>The proposed development incorporates an area flood immune up to and including the PMF event.</p>
<p>Sewerage treatment plants (requiring licensing as an environmentally relevant</p>	<p>1% AEP flood event</p>	

Performance outcomes activity).	Acceptable outcomes	Response
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Performance outcomes	Acceptable outcomes	Response
<p>Development in coastal hazard areas erosion prone area</p> <p>PO2 Development locates outside erosion-prone areas identified on overlay map OM03.3, apart from:</p> <ul style="list-style-type: none"> a) temporary or relocatable structures for safety and recreational purposes; or b) development that does not intensify the extent of existing development within the erosion prone area; or c) development that does not extend any further seaward than the existing adjacent buildings. 	<p>No acceptable outcome is nominated.</p>	<p>The development is located outside the erosion-prone area.</p>
<p>PO3 Development mitigates any increase in risk to people and property from adverse coastal-erosion impacts, avoiding the need for coastal protection works as far as practicable, having regard to:</p> <ul style="list-style-type: none"> a) minimising the footprint of the development of the part within the erosion prone area and locating the development as far landward as possible; b) the practical design life of the development in the context of future erosion threat; c) the ability for buildings or structures to be decommissioned, disassembled or relocated either on the site or to another site; and d) use of appropriate foundations for the building or structure. 	<p>No acceptable outcome is nominated.</p>	<p>The development is located outside the erosion-prone area.</p> <p>Proposed filling of the site reduces the risk of potential erosion.</p>
<p>PO4 Where used, coastal protection works are:</p> <ul style="list-style-type: none"> a) consistent with shoreline erosion 	<p>No acceptable outcome is nominated.</p>	

Performance outcomes	Acceptable outcomes	Response
<p>management plan that has been prepared for the area; or</p> <p>b) in response to a demonstrated need to protect existing permanent structures from an imminent threat of coastal erosion, if abandonment or relocation of the structures is not feasible, and a relevant shoreline erosion management plan has not been prepared.</p>		
<p>PO5 Coastal erosion is mitigated by:</p> <p>a) beach nourishment undertaken in accordance with a program of nourishment works; or</p> <p>b) the construction of an erosion control structure where it is demonstrated that installing an erosion control structure is the only feasible option for protecting existing permanent structures from an imminent threat of coastal erosion at the location.</p> <p>Editor's note—where a shoreline erosion management plan has not been prepared and coastal protection work is required to protect existing structures from coastal erosion threats, beach nourishment is favoured in preference to erosion control structures, such as seawalls and groyne. The location and materials for beach nourishment works are to ensure the natural characteristics and landform of the beach or foreshore is maintained. Applications involving erosion control structures must demonstrate the consideration of beach nourishment techniques and include a statement of why nourishment (in whole or part) has not been adopted as the preferred means of controlling the erosion risk.</p>	<p>No acceptable outcome is nominated.</p>	<p>NA</p>
<p>PO6 Any development using erosion control structures to protect private property from threat of coastal erosion ensures:</p> <p>a) erosion control structures are located</p>	<p>No acceptable outcome is nominated.</p>	<p>NA</p>

Performance outcomes	Acceptable outcomes	Response
<p>wholly on private land; and</p> <p>b) physical coastal processes outside the area subject to the coastal protection work are maintained.</p> <p>Editor's note—applications for coastal protection work must be supported by a report certified by a registered professional engineer with coastal engineering experience that demonstrates how the engineering solution sought by the work will be achieved.</p>		

Table 8.2.3.3(a)—Self-assessable and assessable development (Part)

Performance outcomes	Acceptable outcomes	Response
<p>Development in coastal hazard areas – storm tide inundation areas</p> <p>P07</p> <p>Development is located outside High or Medium storm tide inundation areas and erosion areas from sea level rise identified on overlay maps OM3.1 and OM03.2 unless it:</p> <p>a) does not result in an increase in the intensity of development on the site;</p> <p>b) is located within the inner city area shown on Figure 8.1 – Coastal hazard areas; storm tide inundation areas and provides measures to</p> <p>c) ensure critical services remain operational up to the defined storm tide event; or</p> <p>d) avoids any increase in risk to people or property from coastal hazard impacts (including impacts on the development's ongoing operation).</p> <p>Editor's note—the inner city area shown on Figure 8.1 – Coastal hazard areas: storm tide inundation areas is intended to be defended from storm surge risk by public works.</p> <p>P08</p> <p>Development in storm tide inundation areas and erosion areas from sea level rise</p>	<p>No acceptable outcome is nominated.</p>	<p>Proposed site filling and habitable floor levels avoids risk to the development from coastal hazard impacts.</p>
<p>AO8.1</p> <p>Development within a High or Medium storm tide inundation area identified on overlay map</p>		<p>Proposed site filling and habitable floor levels avoids risk to the development from storm tide</p>

Performance outcomes	Acceptable outcomes	Response
<p>identified on overlay maps OM03.1OM03.2 located, designed, constructed and operated to:</p> <p>ensure structures can sustain flooding from a defined storm tide event; and maintain the safety of people living and working on the premises from a defined storm tide event.</p>	<p>OM03.2 ensures:</p> <p>a) habitable rooms of built structures are located above the defined storm tide event level;</p> <p>b) underground car parks are designed to prevent the intrusion of flood waters by the incorporation of a bund above the defined storm tide event level; and</p> <p>c) where reconfiguring a lot, at least one evacuation route remains passable for emergency evacuations during a defined storm tide event.</p>	<p>impacts.</p>
<p>PO9 Facilities with a role in emergency management and vulnerable community services are located, designed and constructed to ensure it is able to function during and after a storm tide inundation event</p>	<p>AO9.1 Development is either:</p> <p>a) located in an area that is above the storm tide event level specified for that activity in table 8.2.3.3(b); or</p> <p>b) designed to ensure any components of the infrastructure that are likely to fail to function or may result in contamination when inundated by storm tide inundation are above the storm tide event level for that activity in table 8.2.3.3(b).</p> <p>AO9.2 Emergency services and shelters, police facilities and hospitals, and associated facilities have an emergency rescue area above the storm tide event level specified for that infrastructure in table 8.2.3.3(b).</p>	<p>The proposed development incorporates an area flood immune up to and including the PMF event.</p>

Table 8.2.3.3(b) Storm tide event levels for essential community services and facilities

Performance outcomes	Acceptable outcomes	Response
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Performance outcomes	Acceptable outcomes	Response
<p>Development</p> <p>Development involving:</p> <p>a) hospitals and associated facilities; or</p> <p>b) major electricity infrastructure</p> <p>Development involving:</p> <ul style="list-style-type: none"> • emergency/evacuation shelters; or • fire and police stations; or • the storage of valuable records or items of historic or cultural significance (e.g. libraries, galleries); or • aeronautical facilities; or • telecommunication facilities; or • substations; or • water treatment plants; or • regional fuel storage; or • food storage warehouse; or • retirement facility and residential care facility 	<p>Level of immunity annual exceedance probability (AEP)</p> <p>0.2% AEP event</p> <p>0.5% AEP event</p>	<p>NA</p> <p>The proposed development incorporates an area flood immune up to and including the PMF event suitable for emergency/evacuation purposes.</p>

Impact of Climate Change on 100 Year ARI Flood Levels

**Appendix E Impact of Climate Change on 100 Year ARI
Flood Levels**

**TOWNSVILLE CITY COUNCIL
ROSS RIVER FLOOD STUDY
IMPACT OF SEA LEVEL RISE AND
INCREASED RAINFALL TO 2100
ON 100 YARI**


LEGEND

Water Level Difference (m)

< -1
-1 - -0.5
-0.5 - -0.3
-0.3 - -0.1
-0.1 - -0.05
-0.05 - -0.01
-0.01 - 0.01
0.01 - 0.05
0.05 - 0.1
0.1 - 0.3
0.3 - 0.5
0.5 - 1
> 3

Difference in Extent

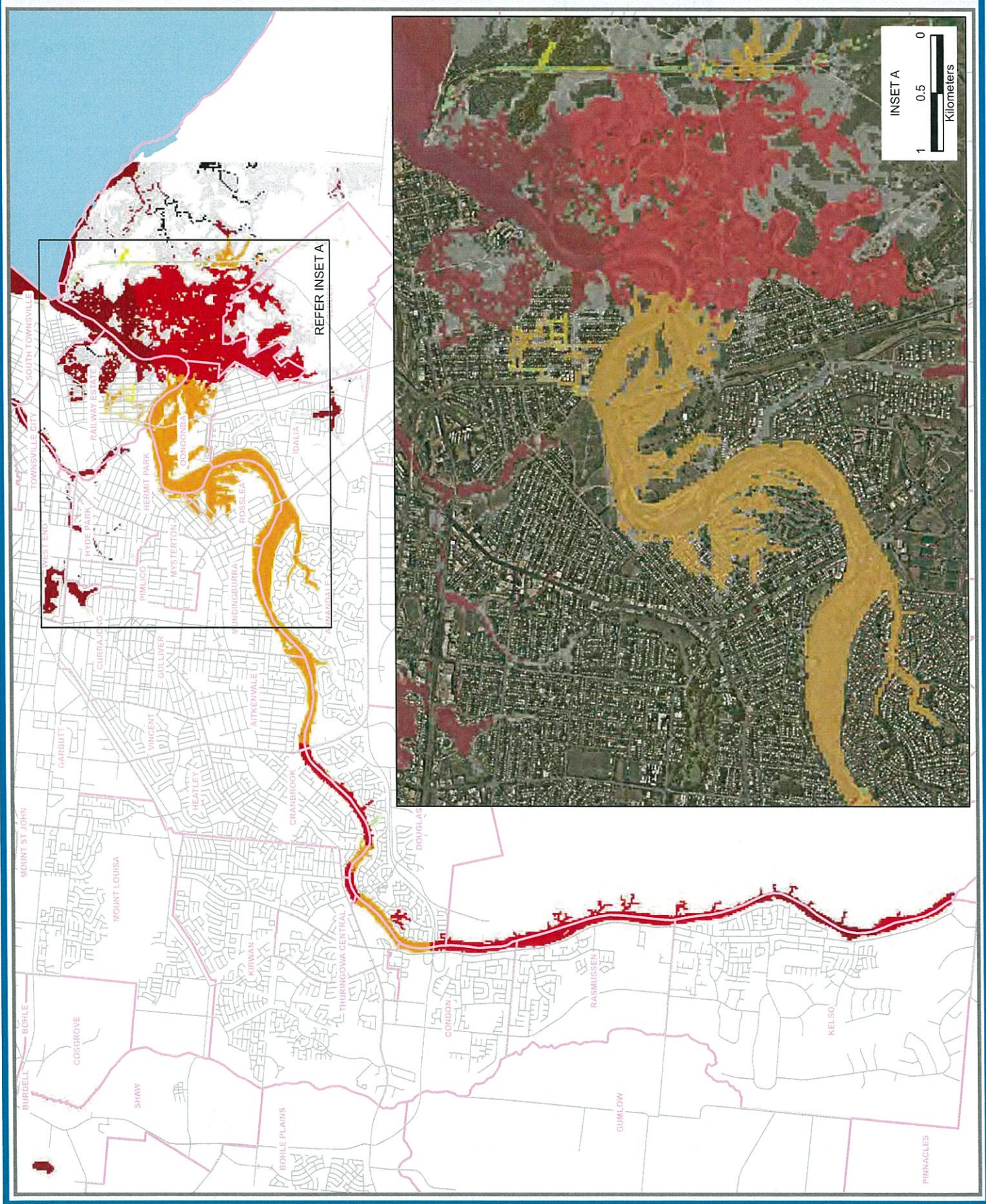
0.88 m Sea Level Rise
15% Increase in Rainfall Intensities



0 1 2
Kilometers
SCALE: 1:60,000 @ A3

Strategic Planning Department
PLANNING AND DEVELOPMENT
DATE: 16/06/2012
DRAWN BY: WGB
DIGITAL FILE: m48
© Townsville City Council 2012

FIGURE 6-4



BRW.
CLIENT
CHOICE
AWARDS
2013
Australia's best professional service firms
WINNER



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