ADDITIONAL CROSSING OF THE CLARENCE RIVER AT GRAFTON

Hydrological Mitigation Report

Prepared for:

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Hydrological Mitigation Report

Limitations Statement

The sole purpose of this report and the associated services performed by Kellogg Brown & Root Pty Ltd (KBR) is to document how the Minister's Conditions of Consent have been met in accordance with the scope of services set out in the contract between KBR and The Government of New South Wales (Roads and Maritime Services) ('the Client'). That scope of services was defined by the requests of the Client, by the time and budgetary constraints imposed by the Client, and by the availability of access to the site.

KBR derived the data in this report primarily from hydraulic models prepared by BMT WBM on behalf of KBR and data provided by the Client. The passage of time, manifestation of latent conditions or impacts of future events may require further exploration at the site and subsequent data analysis, and re-evaluation of the findings, observations and conclusions expressed in this report.

No warranty or guarantee, whether express or implied, is made with respect to the data reported or to the findings, observations and conclusions expressed in this report. Further, such data, findings, observations and conclusions are based solely upon system model and site survey provided by the Client and BMT WBM in existence at the time of the investigation.

This report has been prepared on behalf of and for the exclusive use of the Client, and is subject to and issued in connection with the provisions of the agreement between KBR and the Client. KBR accepts no liability or responsibility whatsoever for or in respect of any use of or reliance upon this report by any third party.

Revision	Date	Comment	Originated By	Verified By	Authorised By
0	7 June 2016	Issue for Use	E Roberts	H Betts	L Mottee
1	29 July 2016	Issue for Public Release	E Roberts	H Betts	L Mottee

Executive Summary

INTRODUCTION

The proposal for an additional crossing of the Clarence River at Grafton has been assessed as a State Significant Infrastructure (SSI) project under Part 5.1 of the *Environmental Planning & Assessment Act 1979* (EP&A Act) and was approved by the Department of Planning and Environment on 19 December 2014 (Application No. SSI-6103).

Roads and Maritime Services (Roads and Maritime) has recently announced the preferred tenderer for the design and construction of the new bridge over the Clarence River. This will involve the construction of a new bridge approximately 70 m downstream of the existing bridge as well as upgrades to the road network in South Grafton and Grafton.

PURPOSE OF THE HYDROLOGICAL MITIGATION REPORT

The ministerial planning approval included a Condition of Approval (D23) that requires the preparation of a Hydrological Mitigation Report (HMR) to detail feasible and reasonable mitigation measures for properties where flood impacts are predicted to increase as a result of the SSI.

This report documents the predicted effects of the project and outlines how Roads and Maritime will address minor increases in flood level to ensure that landowners upstream and downstream have little to no flood impact from the project.

The purpose of flood mitigation in relation to the project is to mitigate the flood impact resulting from the SSI. It is not intended to improve the flood protection to any particular area.

METHODOLOGY

This report has been prepared by Kellogg, Brown & Root Pty Ltd (KBR) whose appointment in the role as a suitably qualified and experienced flooding specialist was approved by the Department of Planning and Environment on 29 October 2015. Hydraulic modelling services have been provided by BMT WBM. BMT WBM are specialist flood modellers and have been modelling flood behaviour of the Clarence River since the late 1980s.

The flood model provides a means of measuring the flood impacts that result from the project.

A flood model based on the Clarence Valley Council's lower Clarence River flood model has been used. The flood model uses TUFLOW software which is widely used in the industry and was considered to be ideally suited to modelling floodplains and determining flood impacts. This model was originally developed and calibrated as part of the Lower Clarence River Flood Study Review (WBM 2004) and has since been updated by BMT WBM to include:

- 8.5 km of bathymetry (riverbed level) data surveyed in 2015
- more detailed levee survey data surveyed in 2015, including data on the levee wall alongside the Gwydir Highway
- refined representation of the new bridge that presents a streamlined pier shape which in turn reduces the hydraulic obstruction and reduces upstream increase in water level

- incorporation of local inflows, local drainage channels and minor elevation changes to increase the accuracy of the model at particular locations
- an update to the Flood Frequency Analysis (FFA)
- the developed concept design (preferred Construction Contractor's bridge design).

The flood model has been verified against the 2001 flood and the 2013 floods and shows good correlation to measured water levels during these flood events. Roads and Maritime have confidence that the results of the model are representative of actual flood behaviour in the Clarence River.

An Independent Hydrologist (WMA Water) has been engaged to provide independent flooding advice as necessary and to undertake an independent peer review of the flood modelling and this report. The appointment of the Independent Hydrologist has been approved by the Department of Planning and Environment.

EFFECTS OF THE PROJECT WORKS

When the project's Environmental Impact Statement (EIS) was prepared in 2014, the predicted increase in flood levels upstream of the existing bridge due to bridge and proposed levee augmentation works was approximately 90 mm in a 100 year average recurrence interval (ARI) flood event. Since then the model has been refined as outlined above. Furthermore, the increase in water level upstream of the bridges has been reduced due to a more streamlined pier shape in the bridge's design. This in turn, required a shorter length of levee augmentation in order to maintain the flood immunity of Grafton and South Grafton.

The reduction of flood impact since the EIS is summarised in Table 1.

Table 1 Changes since the EIS

Parameter	EIS	Now
Increase in height of floodwater in the river immediately upstream of the bridges (due to bridge and levee works) in a 100 year ARI flood event	90 mm	30 mm
Length of Levee Works	Approx. 11 km	Approx. 5.7 km
Height of Levee Works	Raised by 200 mm	Regrade (raise by up to 50 to 200 mm)
Number of land parcels impacted by levee works	174	101
Number of properties with remaining flood impacts	45	15

Figures 1 and 2 show the increase in water level due to the new bridge and levee works in the 50 year and 100 year ARI events.

Areas not protected by a levee system will be affected by increases in flood levels in the river. Predicted increases are typically between 10 mm and 20 mm at Carrs Island and Carrs Peninsular.

There are also some minor increases in water levels for a small number of properties in areas protected by levees.

Where the project results in an increased flood impact, landowners are consulted and some works on individual properties are proposed in keeping with the project's flood management objectives.

Flood management objectives have been set to be consistent with other Roads and Maritime Services projects. These flood management objectives are identified in Table 2 and Table 3 below.

The overall flood management objective is to maintain the existing level of flood protection as committed to in the EIS. This is to be achieved by adhering to the following flood management objectives in Table 2 and 3 that have been determined in consultation with Clarence Valley Council, Office of Environment and Heritage, Department of Planning and Environment and NSW State Emergency Service.

Table 2 Flood Management Objectives (Increase in water level and duration)

Location	Flood Management Objectives
Residences	• To limit increase in water level to less than or equal to 30 mm
Major Outbuildings	• To limit increase in water level to less than or equal to 30 mm
Minor Outbuildings	• To limit increase in water level to less than or equal to 50 mm
Commercial/Not-for-Profit	• To limit increase in water level to less than or equal to 30 mm
Agricultural Land/Stock	• To limit increase in water level to less than or equal to 40 mm
Urban Land	• To limit increase in duration to less than or equal to 5%
Agricultural Land	• To limit increase in duration to less than or equal to 10%

The flood management objectives regarding increase in water level apply to inundation of floor areas, in the 20 year ARI, 50 year ARI and 100 year ARI events.

Table 3 Flood Management Objectives (Velocity, direction and flood immunity)

Attribute	Flood Management Objectives
Velocity	• To limit increase in velocity to less than or equal to 0.6 m/s • To limit increase in velocity such that at no location a velocity less than 2 m/s is increased to a velocity greater than 2 m/s
Direction	• To prevent any significant changes in direction of flood water
Flood immunity	• To provide flood immunity for the approaches to the proposed Grafton Bridge in a 20 year ARI event

CONSULTATION

Roads and Maritime has consulted with key stakeholders and landowners during development of the this report to ensure that its recommendations capitalise on local knowledge and expertise, are consistent with plans held by other local authorities, and are understood and influenced by those affected. Consulted parties included:

1. Government agencies (November 2015–February 2016) (Clarence Valley Council, Office of Environment and Heritage, NSW State Emergency Service and Department of Planning and Environment)
2. potentially affected landowners (December 2015–May 2016)
    a. properties where the existing levee will need to be altered
    b. properties where the flood management objectives will not be met.

An Independent Hydrologist (WMA Water) has been engaged to provide independent flooding advice as necessary. The appointment of the Independent Hydrologist has been approved by the Department of Planning and Environment.

CONCLUSION

Since the EIS there have been a number of refinements to the flood model, including incorporating more detailed information. Furthermore, the bridge design has been refined to use a more streamlined bridge pier shape. The streamlined pier shape enables water to flow around the piers more easily and therefore reduces the increase in water level upstream of the bridge.

These changes have resulted in a greatly reduced flood impact due to the bridge and associated levee works. The benefits of this reduction are seen in the:

- reduced number of properties with increased flood impact
- reduced flood impact to those that do have increased flood impact, when compared to the EIS.

The majority of landowners should see no change in flood behaviour as a result of the project.

The mitigation measures proposed in this report mitigate the adverse hydraulic impacts of the project. It is recommended that the hydrological mitigation measures contained in this report are adopted.

Positive outcomes for the HMR process have been achieved through consultation with Clarence Valley Council, Office of Environment and Heritage, Department of Planning and Environment and NSW State Emergency Service and landowners and residents including:

- minimising adverse environmental and property impacts as far as practicable
- no adverse impact to emergency management and evacuation processes
- no adverse impact to existing infrastructure that cannot be managed during the detailed design stage
- equitable community outcomes:

  - maintaining the same flooding impacts to lands behind levees for Grafton and South Grafton
  - engagement of all affected residents inside and outside levees in a fair and consistent manner
- open and honest communication and consultation with statutory authorities, affected landowners and residents.

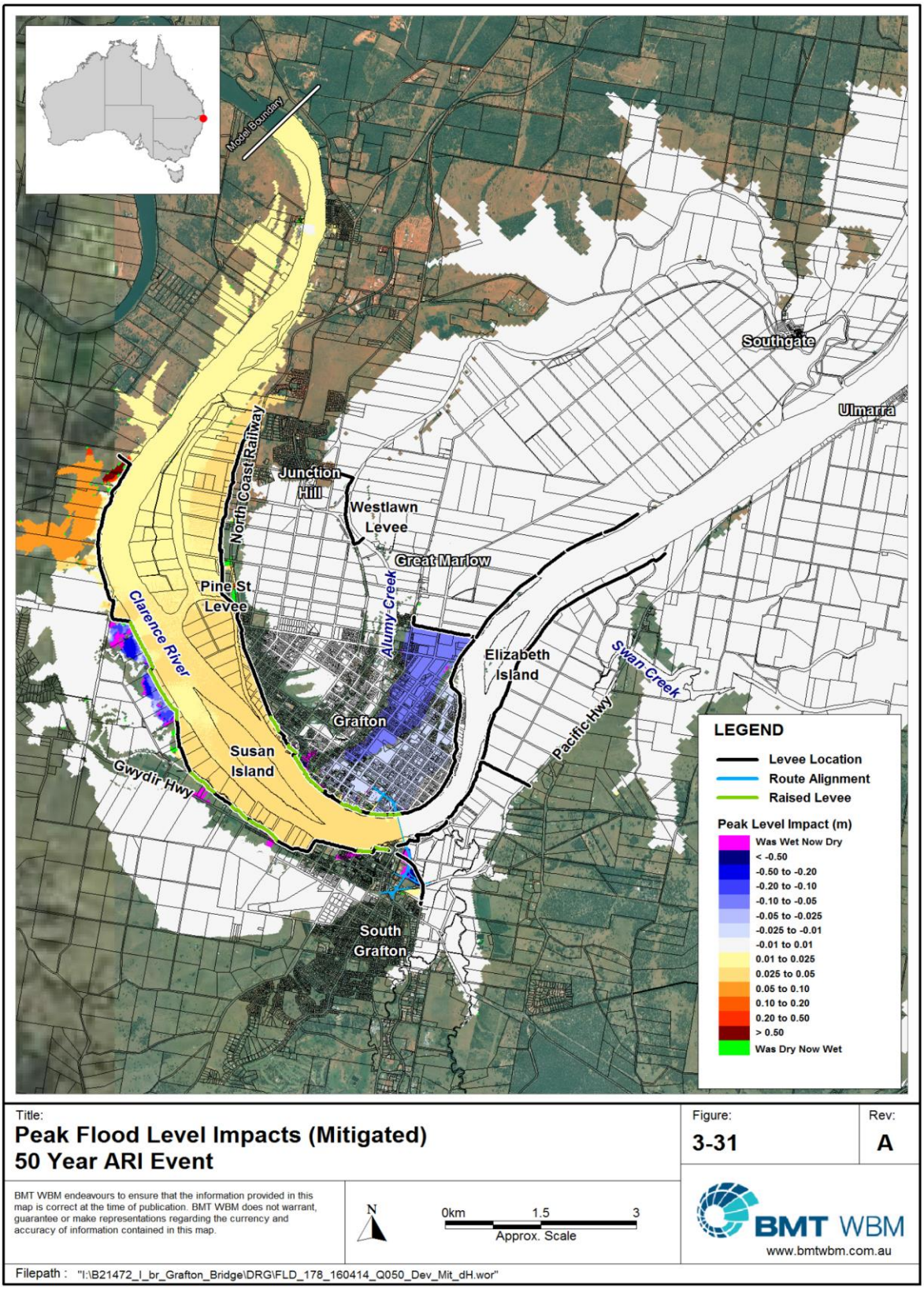

Figure 1
50 YEAR ARI FLOOD MAP (MITIGATED)

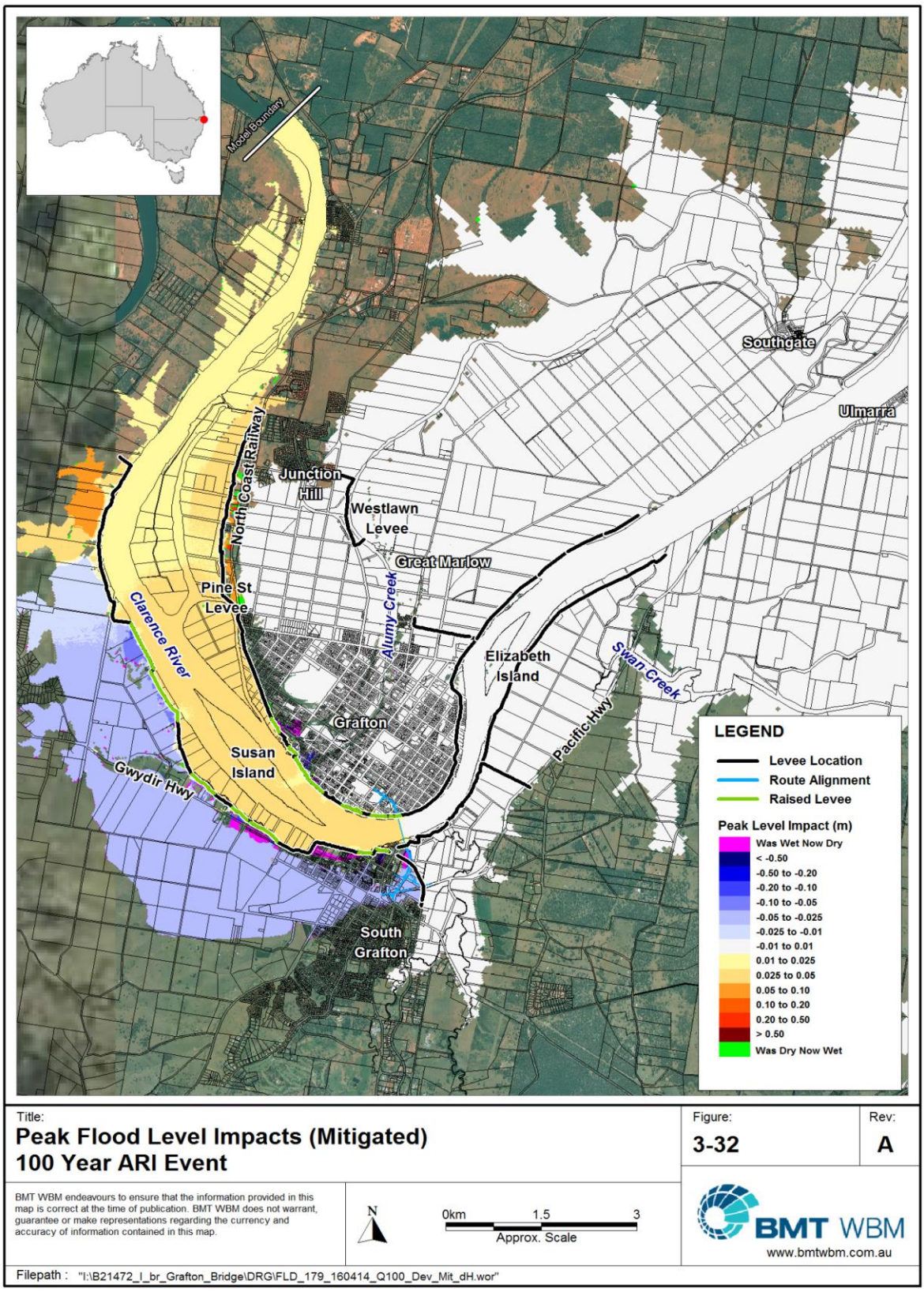

FIGURE 2
100 YEAR ARI FLOOD MAP (MITIGATED)

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List of Abbreviations

Acronym	Definition
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ARI	Average Recurrence Interval
BMT WBM	BMT WBM Pty Ltd
cm	Centimetre
CVC	Clarence Valley Council
DPE	Department of Planning and Environment
EIS	Environmental Impact Statement
FFA	Flood Frequency Analysis
HMR	Hydrological Mitigation Report
KBR	Kellogg, Brown & Root Pty Ltd
km	Kilometre
km^2	Square kilometre
m	Metre
MCoA	Minister's Conditions of Approval
mm	Millimetre
m/s	Metres per second
NSW	New South Wales
OEH	Office of Environment and Heritage
Public Works	NSW Department of Public Works
PMF	Probable maximum flood event
Roads and Maritime	Roads and Maritime Services
SES	State Emergency Service
SSI	State Significant Infrastructure

List of Terms

The definitions presented in this table are based on KBR and its subconsultant's understanding of terms and abbreviations presented in this report and agreed industry and government standards.

Term	Meaning
Aerial Laser Survey	Also referred to as Airborne Laser Scanning or LIDAR, involves the acquisition of data relating to the objects on the earth's surface using a laser scanner from an airborne platform
Afflux	The increase in flood level due to proposed works
Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood level (height) has an AEP of 5%, there is a 5% chance (that is, a one-in-20 chance) of such a level or higher occurring in any one year (see also Average Recurrence Interval)
Average Recurrence Interval (ARI)	The long-term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods reaching a height as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years
Australian Height Datum (AHD)	This is the standard elevation reference used for mapping purposes throughout Australia. Elevation is in metres.
Australian Rainfall and Runoff (ARR) guidelines	ARR is a national guideline document and software for the estimation of design flood characteristics in Australia
Bathymetry	The configuration of the bed of a water body (eg. riverbed or sea floor) as measured by depth contours
Catchment (river basin)	The land area draining through the main river, as well as tributary watercourses, to a particular site
Concept Design	The conceptual design developed to inform the EIS
Conditions of approval	The Planning Minister's conditions of approval for the project
Construction Contractor	The contractor selected by Roads and Maritime to undertake the detailed design and construction of the project
Construction Flood Management Plan	A plan to be prepared by the Construction Contactor to: • address a condition of approval • detail how construction impacts on hydrology and flooding

Term	Meaning
	from works on the flood levee with the Clarence River and its floodplain will be minimised and managed • detail how any significant adverse impacts to people and property are avoided
Council	Clarence Valley Council
Developed Concept Design	The design prepared by the preferred tenderer as part of their tender submission
Downstream	Moving or situated in the direction that a river flows; further from the source of the river
Dry flood proofing	A method of sealing a structure such that it is protected from flood damage by floodwaters. The structure is made water-tight below the flood protection level
Flood	Relatively high water level that overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences, including Tsunami
Floodplain	The area of land subject to flooding and outside the main waterway area
Flood level	The height of the flood described either as a depth of water above a particular location (e.g. 2 m above a floor, yard or road) or as a depth of water related to a standard level such as Australian Height Datum (e.g. the flood level was 5.6 m AHD)
Flood Frequency Analysis (FFA)	An analysis that uses recorded and related flood data to select and fit a probability model of flood peaks at a particular location in the catchment
Flood immunity	The level at which land is protected from a flood event
Flood mitigation	Permanent or temporary measures taken in advance of a flood to reduce its impacts
Floor level survey	A survey to obtain the current floor heights of buildings and structures
Freeboard	Freeboard is expressed as a height above the design flood level. It is used to allow for flood prediction uncertainties and factors which increase flood levels, such as a wave action, debris and localised hydraulic effects. For example, a residence may be raised 0.5m above the predicted flood level so there is 0.5m freeboard or “gap” between the predicted flood height and the floor level

Term	Meaning
Habitable room	Within a residential property, a living or working area, such as a lounge room, dining room, rumpus room, kitchen, or bedroom susceptible to flood damage in the event of a flood. Does not include utility rooms like garages.
Hydrological Mitigation Report (HMR)	This report. A condition of the Minister for Planning's Approval, a report that details all feasible and reasonable flood mitigation measures for properties where flood impacts are predicted to increase as a result of the project
Inundation	Being covered by flood water
Levee	An embankment or wall that regulates water levels (including flooding). e.g. earth-fill embankment, concrete blockwork
Major outbuildings	Outbuildings that house significant equipment that cannot be easily moved in the event of a flood, have a concrete floor and are connected to utilities and/or contribute significantly to the livelihood of the owner.
Minor outbuildings	Outbuildings other than those classed as major outbuildings.
Peak flood level	The maximum flood level during a flood event
Probable maximum flood (PMF)event	The largest flood that could conceivably be expected to occur at a particular location, usually estimated from probable maximum precipitation. The PMF identifies the maximum extent of flood prone land, that is, the floodplain
Runoff	The amount of rainfall that ends up as stream flow
Scour	Scour is a process that causes the removal of particles of soil or rock, for example around the abutment or pier of a bridge spanning over a water body. Scouring usually occurs when the velocity of the flowing water increases resulting in sediment transport
Spatial Information Exchange (SIX) Maps	An online mapping service delivered by the NSW Department of Finance and Services, Land and Property Information Division
State Significant Infrastructure (SSI)	The State significant infrastructure (otherwise referred to as 'the project' in this report) approved under SSI-6103
Stock mound	A raised area of land where stock can take refuge during a flood
TUFLOW	A software package used to model floods

Term	Meaning
Upstream	Moving or situated in the opposite direction from that in which a river flows; nearer to the source of that river
Velocity	The speed of floodwaters, usually in metres per second
Water level	See flood level
Wet flood proofing	A method of flood proofing that utilises permanent or temporary measures applied to a structure or its contents to prevent or provide resistance to damage from flooding while allowing floodwaters to enter the structure or area

1 Introduction

This chapter introduces the project and provides a brief outline of its need, scope, and location.

1.1 PROJECT CONTEXT

The New South Wales (NSW) Roads and Maritime Services (Roads and Maritime) has an approval for, and is preparing to build, an additional crossing of the Clarence River in Grafton, on the NSW North Coast. The project involves:

- construction of a new road bridge about 70 metres (m) downstream of the existing road and rail bridge
- several upgrades to the road network in Grafton and South Grafton to connect the new bridge to the existing road network
- replacing part of the rail viaduct where it crosses Pound Street in Grafton
- providing a pedestrian and cycle path and signalised pedestrian crossings
- associated flood impact mitigation works.

The new bridge is designed to contemporary standards and will provide an increase in traffic capacity across the Clarence River while allowing the safe movement of all vehicles and pedestrians. It will also allow Grafton to evacuate more quickly during flood events.

Grafton is located 600 km north-east of Sydney and 200 km south of the border with Queensland, and is 36 km west of the coast in NSW's mid-north. It is situated on the northern bank of a U-shaped bend in the Clarence River, with the upstream bend of the river adjacent to the western extent of the settlement and the downstream bend adjacent to the east. The current road and rail bridge, opened in 1932, is the only connection to the southern bank for 41 km.

1.2 PURPOSE OF THIS REPORT

As a condition of the NSW Minister for Planning's Approval for the additional crossing of the Clarence River in Grafton (Application No. SSI-6103), Roads and Maritime is required to prepare a Hydrological Mitigation Report (HMR). This report considers the existing flood conditions, reports on the modelling undertaken, refines proposed mitigation works, such as levee works, and further considers the need to undertake at property mitigation works where residual flooding impacts are predicted as a result of the project. Additionally, impacts to access and infrastructure are considered.

This report has been prepared by Kellogg, Brown and Root Pty Ltd (KBR) whose appointment in the role was approved by the Department of Planning and Environment (DPE) on 29 October 2015. Hydraulic modelling services have been provided by BMT WBM in the development of the report. Once the HMR has been approved by DPE, Roads and Maritime will prepare the schedule of feasible and reasonable flood mitigation measures and provide this to the Construction Contractor. The

Construction Contractor will be responsible for finalising the detailed design of the mitigation measures and the construction of the mitigation measures.

This report documents the predicted effects of the project and outlines how Roads and Maritime will address minor increases in flood level to ensure that landowners upstream and downstream have little to no flood impact from the project.

The purpose of flood mitigation in relation to the project is to mitigate the flood impact resulting from the project. It is not intended to improve the flood protection to any particular area.

1.2.1 CONDITIONS OF APPROVAL

The following table is an extract of the Minister's Conditions of Approval for the project, which have been addressed in this HMR.

Table 1.1 Minister's Conditions of Approval Requirements

Condition of Approval Reference	Condition of Approval	Where addressed
D22.	The Proponent shall undertake further flood modelling based on the detailed design of the SSI. The flood modelling shall consider the recommendations of WMA Water outlined in Appendix A EIS flooding and hydrology technical paper peer review in the document listed in Condition A2(c):	Section 1.4, Section 2.1 to 2.6 Appendix C
	(a) Include a detailed floor level survey of potentially affected properties, as identified in the flood modelling.	Section 2.2, Section 3.3.2 Appendix C
	(b) Update the flood frequency analysis and application of the latest hydrological practice of the new Australian Rainfall and Runoff publication.	Section 2.2 Appendix C
	(c) Assess the same design flood events as those in the EIS, including the probable maximum flood (PMF) event; and	Section 2.2 Appendix C
	(d) assess and report all flood height changes to a resolution no coarser than 1 cm.	Section 2.1, Section 2.2 and Section 3.3.1 Appendix A Appendix C

Condition of Approval Reference	Condition of Approval	Where addressed
D23.	The Proponent shall prepare a Hydrological Mitigation Report that details all feasible and reasonable flood mitigation measures for properties where flood impacts are predicted to increase as a result of the SSI. The Report shall be prepared by a suitably qualified and experienced expert, whose appointment has been approved by the Secretary. The Report shall:	This report Section 1.2
	(a) Be informed by the detailed surveys (e.g. floor levels) of potentially affected properties and the results of the flood modelling of the detailed design carried out under Condition D22 of this approval and in consultation with EPA[1] and Council.	Section 2.2, Section 3.3.2 and Section 4.1 (Note: consultation was conducted with OEH rather than EPA. OEH is the appropriate agency and this has been endorsed by DPE).
	(b) Include mitigation measures based on documented flood management objectives for affected properties. The flood management objectives shall cover flood level (height), duration, velocity and direction, and flood evacuation and be developed in consultation with Council and the SES.	Sections 3.1 to 3.6, Section 4.1 and Section 5.1 to 5.6 Appendix B
	(c) Ensure mitigation measures that include changes to the height of the levees have no detrimental impact on residences and urban land uses protected by the levees and properties downstream of the SSI.	Section 3.3 and Section 5.1 Appendix B and Appendix C
	(d) Identify properties in those areas likely to have an increased/exacerbated flooding impact and detail the predicted impact. The types of impacts to be considered include all those examined in the EIS including but not limited to changes in flood levels and velocities, alteration to drainage, reduction in flood evacuation access or capability and impacts on infrastructure.	Section 3.3.2 and Section 3.4 to 3.6 Appendix A
	(e) Identify mitigation measures to be implemented to address these impacts.	Section 5.1 to Section 5.3 Appendix C
	(f) Identify measures to be implemented to minimise scour and dissipate energy at locations where flood velocities are predicted to increase as a result of the SSI.	Section 3.5 and Section 5.5 Appendix C

[1] As modified by application SSI 6103 MOD 1 dated 20 October 2015.

Condition of Approval Reference	Condition of Approval	Where addressed
	(g) Demonstrate consistency with the flood management objectives in Subsection (b).	Section 5.2, Section 5.3 and, Section 5.5
	(h) Be developed in consultation with directly-affected landowners, and Council and in relation to public assets and community flood evacuation issues.	Section 4.1–4.4 and Appendix B
	(i) Where house raising is proposed, ensure habitable floor levels are raised to a minimum height of the 100 year ARI flood plus 0.5 m freeboard, unless justified by site-specific assessment.	Section 5.2, Appendix B
	Where the flood management objectives in Subsection (b) cannot be complied with, the Proponent shall achieve compliance through modified design of the SSI; or achieve an acceptable level of mitigation of impacts through at property design measures (e.g. raised access tracks, flood refuge, house raising) in consultation with affected landowners. The Report shall be submitted for the approval of the Secretary one month prior to the commencement of construction within the floodplain that has potential to alter flood behaviour, unless otherwise agreed by the Secretary. Construction shall not commence on any components of the SSI that have potential to alter flood conditions until such time as works identified in the hydrological mitigation report have been completed, unless otherwise agreed by the Secretary.	The mitigation measures in this report (Section 5) are based upon an acceptable level of mitigation and refinement of the design. As noted in Section 5.8 and 6, any changes to the design (during detailed design phase) will be assessed subsequent to the approval of the HMR.
D24.	Based on the mitigation measures identified in the Hydrological Mitigation Report, the Proponent shall prepare and implement a final schedule of feasible and reasonable flood mitigation measures proposed at each directly-affected property in consultation with the landowner, and consistent with the flood management objectives described in Condition D23(b). The schedule shall be provided to the relevant landowner(s) prior to the implementation/construction of the mitigation works, unless otherwise agreed by the Secretary. A copy of each schedule of flood mitigation measures shall be provided to the Department and Council prior to the implementation/construction of the mitigation measures on the property.	Section 5.8 Will be addressed subsequent to the approval of the HMR during detailed design.
D25.	The Proponent shall undertake engineering and property investigations of the Grafton and South levees prior to detailed design to inform the structural capability of changes to the levees. Any work to augment the structure of the levees shall be carried out in consultation with Council and affected landowners. Note: Should additional assessment of work arising from the engineering and property investigations of the levees be required, the proponent shall undertake a review of the consistency of those works with the SSI approval. Work that is inconsistent with the SSI may require a modification of the approval.	Section 5.8 Will be addressed subsequent to the approval of the HMR during detailed design.

Condition of Approval Reference	Condition of Approval	Where addressed
D26.	The proposed Grafton and South Grafton levee flood mitigation measures shall be implemented prior to construction commencing in the Clarence River, including pier/pile construction and the installation of temporary in-river rock platforms, unless otherwise agreed by the Secretary.	Section 5.7 and Section 5.8
D27.	The Proponent shall employ a suitably qualified and experienced independent hydrological expert, whose appointment has been endorsed by the Secretary, to provide independent advice for all hydrological matters, including assistance to landowners in resolving feasible and reasonable mitigation measures.	Section 1.4 Appendix E

1.3 DEVELOPMENT OF THE BRIDGE DESIGN

Subsequent to the EIS, the design of the bridge has been refined in order to reduce the hydraulic obstruction in the river.

The refinement of the design occurred in two stages.

Firstly, the concept design of the bridge and associated levee works was developed. The concept design flood model predicted an increase in water level of around 40 mm immediately upstream of the existing bridge in the 100 year ARI event. This was a significant reduction from the 90 mm estimated in the EIS and is due to improved representation of the bridge and updated bathymetry and levee survey data. This design is referred to as the 'Concept design'.

Secondly, the detailed design and construction of the bridge went out to tender. Roads and Maritime encouraged the shortlisted construction contractors to further minimise the water level increase caused by the bridge. The preferred construction contractor has proposed to replace the two rows of four piles plus pile cap for each pier (concept design) with just two piles and no pile cap. This is in order to provide less obstruction in the direction of flow and a more streamlined profile, thereby minimising the increase in water level upstream of the bridge. Figure 1-1 shows the pier configuration in the concept design and Figure 1-2 shows the smaller obstruction used in the construction contractor's developed concept design. The smaller obstruction causes less increase in water level upstream of the bridge and in the turn reduces the extent and size of the levee works. The reduction to 30 mm increase in water level also reduces the number of properties with residual impacts and the size of the impacts.

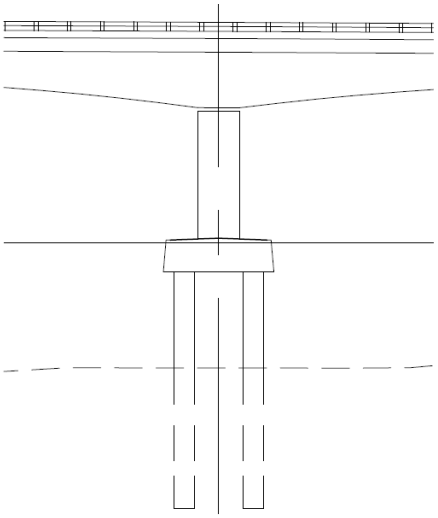

Figure 1-1
Roads and Maritime Concept Design – Pier Shape

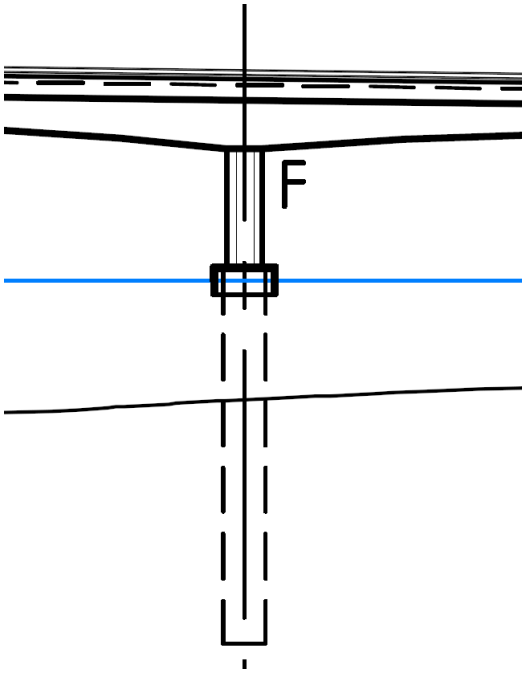

Figure 1-2
Developed Concept Design – Pier Shape

1.4 INDEPENDENT HYDROLOGIST

An Independent Hydrologist (WMA Water) has been engaged to provide independent flooding advice to landowners if requested. They have also conducted an independent peer review of the flood model and this report. Their appointment was approved by DPE.

Details of the review undertaken by the Independent Hydrologist are provided in Appendix E and F.

2 Flooding Behaviour

2.1 FLOOD MODELLING METHODOLOGY

The flood modelling for this project has been completed by BMT WBM using the lower Clarence River flood model, originally developed and calibrated as part of the Lower Clarence River Flood Study Review (WBM 2004) and subsequently updated for Clarence Valley Council (CVC) by BMT WBM (BMT WBM 2013). The flood modelling conducted by BMT WBM is summarised Appendix C.

In accordance with the Minister's Conditions of Approval Requirement D22 (d) flood results, including flood heights and changes in water levels due to the proposed works are reported to a resolution of 10 mm.

BMT WBM are specialist flood modellers and have been modelling flood behaviour of the Clarence River since the late 1980s. The flood model uses TUFLOW software which is widely used in the industry and is considered to be ideally suited to modelling floodplains and determining flood impacts.

2.2 UPDATES OF FLOOD MODEL

The flood model developed by BMT WBM for the EIS in 2014 was updated by BMT WBM to include:

- 8.5 km of bathymetry (riverbed level) data surveyed in 2015
- more detailed levee data surveyed in 2015, including data on the levee wall alongside the Gwydir Highway
- improved representation of the new bridge
- incorporation of local inflows, local drainage channels and minor elevation changes to increase the accuracy of the model at particular locations.

A number of more minor improvements were also made as discussed in Appendix C.

An update to the Flood Frequency Analysis (FFA) has been undertaken for this assessment by extending the gauged record to 2014. The methodology used in the update is consistent with current recommendations given in the draft ARR guidelines (2015).

The rating curves developed for the 2004 Flood Study have been used to convert recent flood levels at Prince Street gauge to peak flows at Mountain View (upstream of Grafton). The updated flood model was used to reassess the rating curve for the current period (post 1996, following the last major works on the levee scheme). However, there was minimal change between the curves and so the 2004 rating curves were maintained for consistency.

The recommendations made in an independent peer review of the EIS flooding and hydrology technical paper were considered and have been addressed. This resulted in no significant changes to the model or its performance.

Two bridge concepts were modelled. Firstly the concept design of the bridge was incorporated into the model.

Secondly the developed concept design (preferred Construction Contractor's bridge design) was incorporated into the model. Appendix C contains more detailed information regarding the flood modelling undertaken.

The updated model will be provided to CVC at the completion of detailed design.

2.3 LIMITATIONS OF FLOOD MODEL

The flood model is a catchment scale model and has a grid size of 30 m in the main river and 10 m in the flood plain at Grafton and South Grafton. It is limited in its ability to represent features smaller than the model grid. The bridges have been modelled using a lumped form (energy) loss to represent the energy loss associated with all the bridge's components.

The model is well suited to comparing the baseline case to the developed case. The absolute flood levels (to m AHD) however are subject to greater uncertainty as they rely on the accuracy of the input data.

The accuracy of the model is expected to be +/- 150 mm for flood levels and +/- 10 mm for relative changes in flood levels. This level of accuracy is consistent with industry standards.

Appendix C contains more detailed information regarding limitations of the flood model.

2.4 EXISTING FLOODING BEHAVIOUR

The project is located in Grafton on the Clarence River, a major coastal river in New South Wales. The lower floodplain areas of the Clarence are subject to frequent and extensive flood inundation. The total catchment area of the river is approximately 20,000 km^2 upstream of Grafton and the extent of flooding in the floodplain can result in inundation of 500 km^2 or more downstream of Grafton.

Minor tributaries within the lower floodplain of the Clarence River also have the potential to cause flooding. However, the flooding behaviour of the lower Clarence is largely dominated by the runoff generated by the catchment area upstream of Grafton. 80-90 per cent of the total volume of floodwater comes from the catchment upstream from Grafton/Mountain View during main flood events. Floods typically occur in the Clarence River from low rainfall intensity events that may last several days or weeks.

Grafton and South Grafton are currently provided with some flood protection by a series of levees, in addition to the natural high ground along the railway. The existing Grafton and South Grafton levees overtop when flood levels are at or close to 8.0 m on the Prince Street gauge. 50 and 100 year ARI floods would cause overtopping of the levee system and extensive flooding of Grafton and South Grafton.

The largest flood in recent memory was in January 2013 which peaked at 8.09 m at the Prince Street Gauge. This flood has been estimated to be approximately a 20 to 30 year ARI flood, and caused minor overtopping of the levee system. Larger floods have been recorded since 1839, but have not reached as high on the Prince Street gauge as they occurred prior to the completion of the levee system.

The HMR has also taken account of impacts on properties that lie outside of levee protection.

2.5 EFFECTS OF THE PROJECT WORKS

Modelling undertaken by BMT WBM (2016) shows that the additional bridge crossing would result in an increase in peak flood levels upstream of the crossing within the Clarence River. These upstream impacts are considered relatively minor (approximately 20 mm in a 50 year and 100 year average recurrence interval (ARI) event and approximately 30 mm in a 20 year ARI event) and no impacts are predicted to occur downstream of the crossing within the river.

Without the mitigation measures documented in this report, the most significant effect is observed in the South Grafton basin, with additional overtopping of the Waterview and South Grafton rural levees. The 100 year ARI event shows increases in ponding levels of approximately 100 mm which would affect residences on the edge of the South Grafton urban area. If not mitigated, approximately 80 properties in Grafton and South Grafton would have direct flood impacts.

Downstream from the bridges it is predicted there will be less overtopping. Overall this results in a small net reduction of overtopping volume into Grafton and minor reduction in peak flood levels.

It is not expected that there will be any noticeable impact upon the flow velocity or direction.

Areas where there is currently no levee system in place would be subject to increases in flood levels in the river. Predicted increases are typically between less than 10 mm to 20 mm at Carrs Island and Carrs Peninsular.

Figures 2-1 and 2-2 show the increase in water level due to the new bridge in the 50 year and 100 year ARI events.

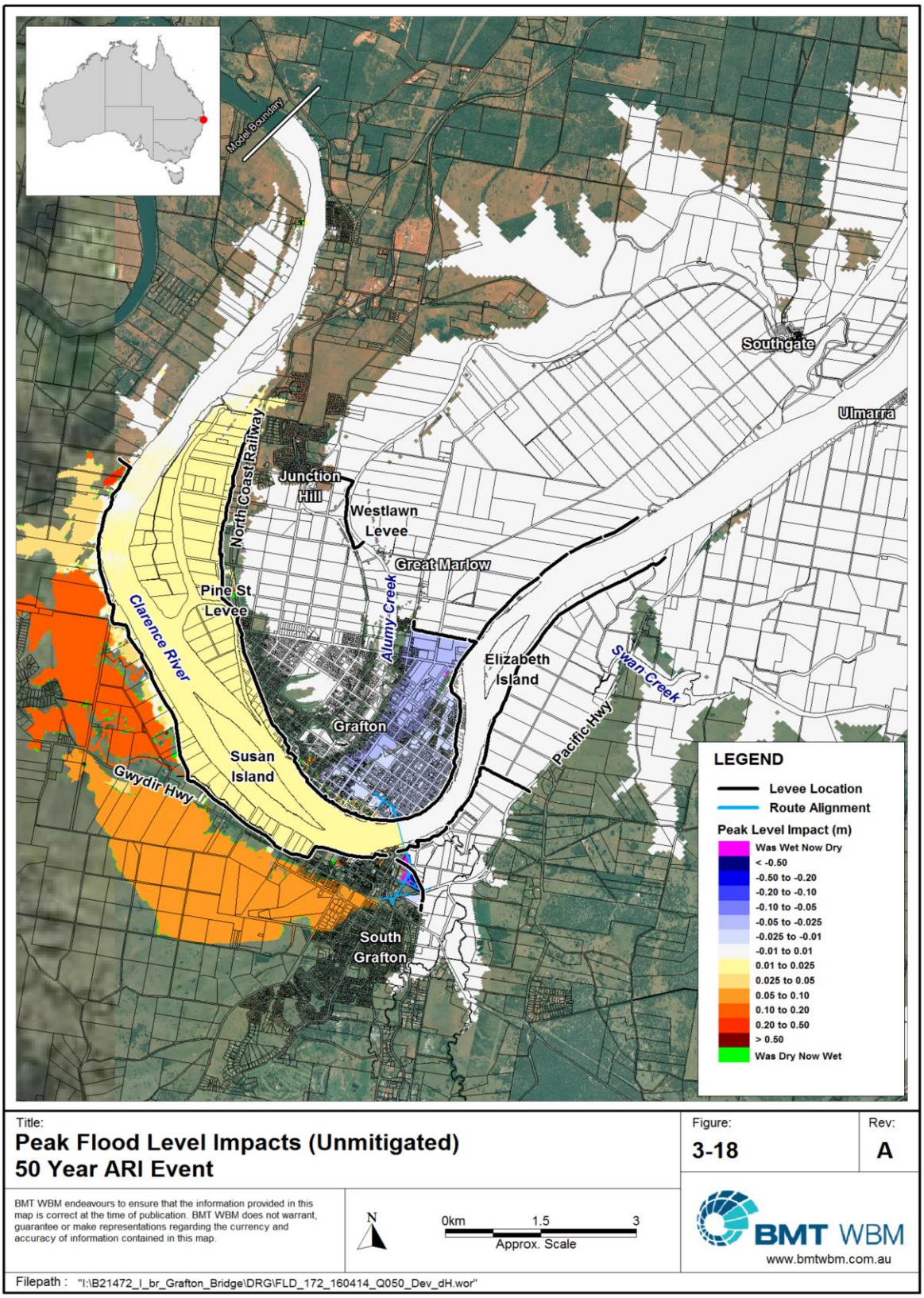

Figure 2-1
50 year ARI Flood Map

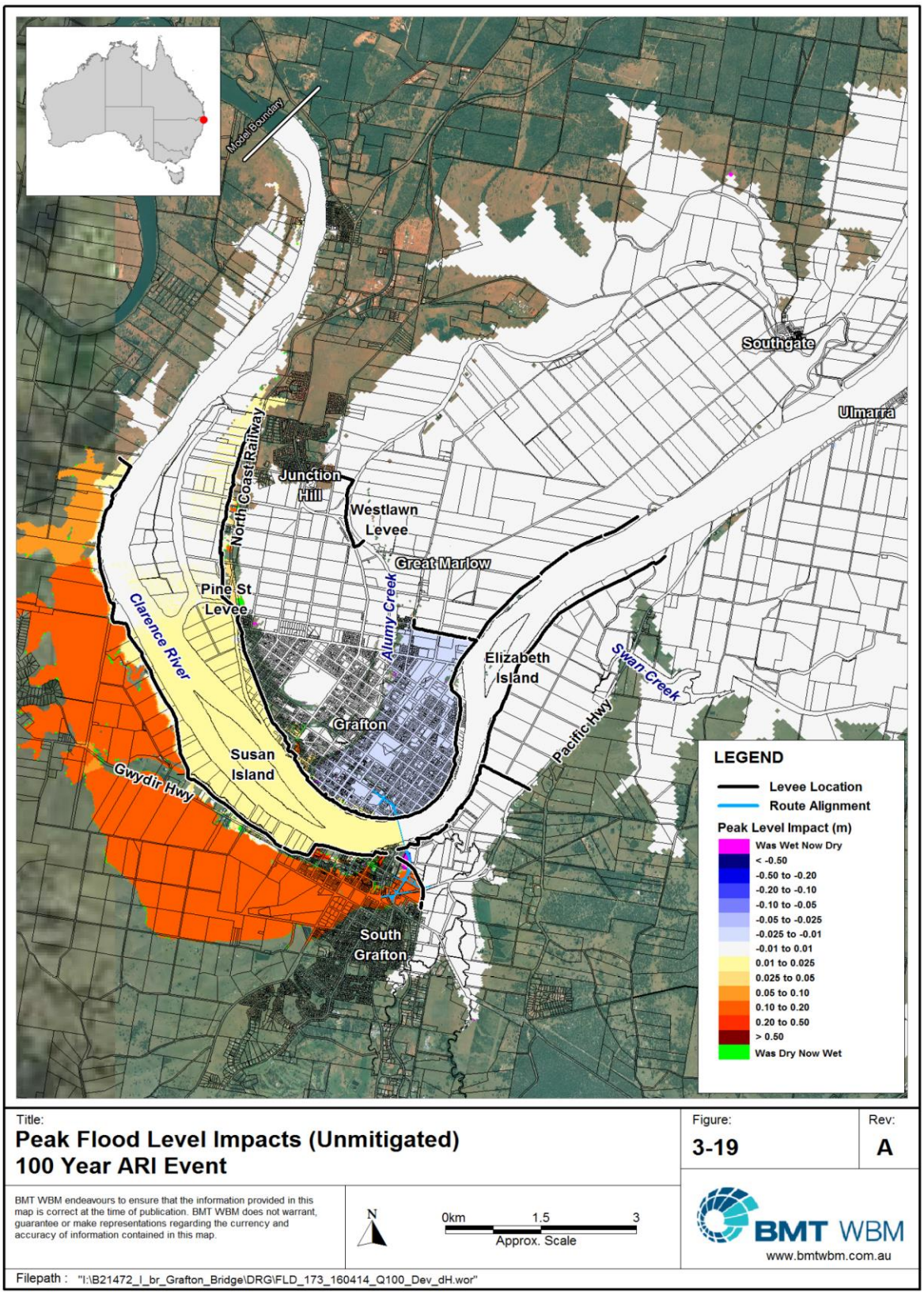

Figure 2-2
100 year ARI Flood Map

These impacts can be mitigated firstly by undertaking works on the existing levee system. The residual effects of the project works – after undertaking work on the existing levee system – are outlined in Section 5.1. Secondly, any residual impacts will require works on individual properties as outlined in Section 5.2.

2.6 CLIMATE CHANGE

The EIS considered the bridge (and levee mitigation) scenarios under future climate scenarios. As required by Condition D22(c) the same design flood events are to be examined as those in the EIS during the updating of the flood modelling for the project.

Two climate change scenarios were examined using the 20 and 100 year ARI events as their basis:

- 2050 Climate: 0.4 m rise in sea level and 10 per cent increase in rainfall intensity
- 2100 Climate: 0.9 m rise in sea level and 20 per cent increase in rainfall intensity.

These were the same climate change scenarios that had been examined in the EIS.

The predicted increase in water levels due to the project works in the climate change scenarios were generally within 10 mm of the increase in water levels due to the project works without considering climate change. In the South Grafton Common, the ponding level increases by 20 mm in the 100 year ARI event for project works under a future climate compared to the future climate without the project works due to increase levee overtopping. The impact of climate change on the proposed works is outlined in further detail in Appendix C.

It should be noted that the mapping presented in this report shows the current day scenarios.

3 Impact Assessment

3.1 FLOOD MANAGEMENT OBJECTIVES

The flood management objectives were set to be consistent with past Roads and Maritime projects. A summary of the process for establishing the objectives is provided below.

The flood management objectives in seven Roads and Maritime projects from across NSW were reviewed. The majority of projects reviewed were located in the Northern Rivers area of NSW in the Roads and Maritime - Northern Region jurisdiction. A number of objectives and considerations were identified in projects relating primarily to flood levels, inundation times, protection of stock and structures (for example, houses and sheds) and flood evacuation.

The key justifications for the adoption of objectives included:

- the increase in water level objective proposed by the project is consistent with the lower end of the increases of projects reviewed
- the duration changes proposed by the project are consistent with the projects reviewed
- the velocity changes proposed by the project are consistent with the projects reviewed.

The flood objectives proposed in this section have been determined in consultation with CVC, Office of Environment and Heritage (OEH), DPE and NSW State Emergency Service (SES) during the HMR consultation activities as discussed in Section 3.2 and Section 4.1.

The flood management objectives have been assessed for the 20, 50 and 100 year ARI events. Flood management objectives for the PMF or extreme flood event have not been considered. This is consistent with industry practice.

3.1.1 INCREASE IN WATER LEVEL (HEIGHT)

The following flood management objectives have been adopted for this project.

Table 3.1 Flood Management Objectives

Location	Flood Management Objectives
Residences	• ≤ 30 mm increase Where there is inundation of primary habitable floor areas, limit the increase in water level to less than or equal to 30 mm for the 20 year ARI, 50 year ARI and 100 year ARI events
Major Outbuildings	• ≤ 30 mm increase Where there is inundation of floor areas, limit the increase in water level to less than or equal to 30 mm for the 20 year ARI, 50 year ARI and 100 year ARI events

Location	Flood Management Objectives
Minor Outbuildings	• ≤ 50 mm increase Where there is inundation of floor areas, limit the increase in water level to less than or equal to 50 mm for the 20 year, 50 year and 100 year ARI events
Commercial/Not-for-Profit	• ≤ 30 mm increase Where there is inundation of floor areas, limit the increase in water level to less than or equal to 30 mm for the 20 year, 50 year and 100 year ARI events
Agricultural Land/Stock	• ≤ 40 mm increase Where there is water over an existing stock mound, limit the increase in water level to less than or equal to 40 mm for any of the 20 year, 50 year and 100 year ARI events for all properties that do not have any dry ground in a 100 year ARI event

Any structures known to be constructed without the appropriate planning approvals will not be considered.

3.1.2 DURATION

The following flood management objectives have been adopted for this project.

Table 3.2 Flood Management Objectives

Location	Flood Management Objectives
Urban Land	• Limit increase in duration to less than or equal to 5%
Agricultural Land	• Limit increase in duration to less than or equal to 10%

3.1.3 VELOCITY AND DIRECTION

The following flood management objectives have been adopted for this project. Any locations where these objectives are not met shall be examined further to determine if these changes would likely result in a significant impact that necessitates mitigation such as damage to infrastructure or scour of large areas of productive farmland.

Table 3.3 Flood Management Objectives

Attribute	Flood Management Objectives
Velocity	• To limit increase in velocity to less than or equal to 0.6 m/s • To limit increase in velocity such that at no location a velocity less than 2 m/s is increased to a velocity greater than 2 m/s
Direction	• To prevent any significant changes in direction of flood water apart from in new stormwater drainage works

3.1.4 FLOOD IMMUNITY

The following flood management objectives have been adopted for this project, as identified in the EIS and to match or improve on the existing level of flood immunity.

Table 3.4 Flood Management Objectives

Attribute	Flood Management Objectives
Flood immunity	• To provide flood immunity for the approaches to the proposed Grafton Bridge in a 20 year ARI event

3.2 PROCESS OUTLINE AND CONSULTATION

In order to minimise the project's impacts, the design of the bridge piers was streamlined to minimise the associated increase in water level upstream of the bridge. Further to this, as described in Section 5.1, a program of levee works has been designed to ensure, that generally, the volumes spilling over the levees match existing volumes. The summary below describes the impacts expected after both the bridge and levee works have been undertaken.

The contents of this report and the hydrological mitigation measures have been reviewed by and discussed at meetings with representatives of CVC, OEH, and the SES. The DPE has been provided with copies of the technical papers that formed the basis of the institutional stakeholder consultation and has provided comment. This report and the hydrological mitigation measures have been refined based on the comments of all these institutional stakeholders. These agencies will be provided a copy of this report.

Further information regarding the consultation process is provided in Section 4.

3.3 SUMMARY OF IMPACTS – WATER LEVEL

3.3.1 FLOOD EVENTS REVIEWED

Property impacts were reviewed for the 20, 50 and 100 year ARI events.

3.3.2 INDIVIDUAL PROPERTY ASSESSMENT

Structures of potential interest were identified by comparing flood mapping results and aerial photography. This review identified structures that were located within, or close to, areas having 25 mm or more increase in water level (in a 20, 50 or 100 year ARI events) in the concept design scenario. The desktop review was again undertaken using the results of the developed concept design to ensure all potentially affected structures were identified.

Apart from in a small number of cases where initial assessment clearly showed that the structure would not be impacted, structures identified were surveyed and information regarding their use was collected in consultation with owners. Some structures had more than one point surveyed, for example a ground floor and first floor. Furthermore at the request of some landowners during the survey, additional outbuildings not observed in aerial photography were included in the survey. In addition, stock mounds were also surveyed at the same time. All structures identified were given a unique number.

Surveyed floor levels were compared to predicted flood heights in the developed concept design to identify properties that would have increased inundation greater than the flood mitigation objective in a 20, 50 or 100 year ARI flood event. As a check, the height of floor compared to adjacent ground levels was compared to the depth of flooding predicted.

The following table shows a summary of survey results. (The increase in water level identified is that expected after both the bridge construction and levee works have been undertaken.)

Table 3.5 Summary of Surveyed and Impacted Structures

Type of Structure	Number of Structures Surveyed	Mitigation Objective	Number of Structures with increase in water level greater than Objective
Residence (habitable floor level)	82	Less than or equal to 30 mm	2
Commercial/Not-for-profit	27	Less than or equal to 30 mm	4
Outbuilding	69	Major - Less than or equal to 30 mm	4
		Minor - Less than or equal to 50 mm	6
Stock Mounds	3	Less than or equal to 40 mm	0

Flood mapping was reviewed in order to identify any locations where stock mounds may have inundation greater than the objective. In the developed concept design, there were no rural properties that had an increase of 40 mm in either the 50 year or 100 year ARI event that did not also have some land that remained dry. Therefore, at all properties, the objective relating to stock mounds was met.

Stock evacuation routes are also not affected.

3.3.3 UTILITIES

Flooding is unlikely to adversely affect buried and aboveground services within the project area.

There are not expected to be any additional flood impacts to utilities as a result of the afflux due to the bridge.

3.4 SUMMARY OF IMPACTS – DURATION

3.4.1 SOUTH GRAFTON COMMON

The proposed levee works have been designed so that the volume of water overtopping the South Grafton Levee would closely resemble the existing flood situation. Table 3-10 of Appendix C shows that the volume of water overtopping the levee in the design scenario closely resembles the existing scenario for the 50 and 100 year ARI events. As the volumes overtopping the levee are similar, the volumes stored behind the levee are similar. The drain down times are related to the volume of water stored and so would be similar. Therefore the duration of inundation in the design situation closely resembles the existing situation.

No further mitigation is required to address duration.

3.4.2 GRAFTON

The proposed levee works have been designed so that the volume of water overtopping the North Grafton Levee would closely resemble the existing situation. Table 3-8 of Appendix C shows that the volume of water overtopping the levee in the design scenario closely resembles the existing scenario for the 50 and 100 year ARI events. As the volumes overtopping the levee are similar, the volumes stored behind the levee are similar. The drain down times are related to the volume of water stored and so would be similar. Therefore the duration of inundation in the design situation closely resembles the existing situation.

No further mitigation is required to address duration.

3.4.3 OTHER LOCATIONS

In areas not protected by the levee system, the duration of inundation in the design situation closely resembles the existing situation. Figure 3-27 of Appendix C shows the similarity of flood elevation against time for the existing and design situation.

There are not expected to be any other impacts to the duration of inundation in other areas.

No further mitigation is required to address duration.

3.5 SUMMARY OF IMPACTS – VELOCITY AND DIRECTION

The flood model velocity results for the situation after both the bridge and levee works are completed have been reviewed. There were some changes in the immediate vicinity of bridge and associated road works. Apart from these, there were no significant increases in velocity or significant changes in direction.

There were a small number of isolated locations where the increase in velocity was greater than the objective. As velocities at these locations are generally less than 1.0 m/s these were considered insignificant.

There were minor changes in direction due to the bridge and levee works. None were considered to be significant changes, and none were in locations where velocities were above 2 m/s.

The effect of changes in velocity causing scour of utilities was considered, and it was concluded that there were negligible changes compared to the existing situation.

Apart from the immediate vicinity of the bridge and road works, no mitigation for velocity or direction impacts is required.

Erosion protection in the immediate vicinity of the bridge and road works will be considered by the Construction Contractor as part of the detailed design.

3.6 SUMMARY OF IMPACTS – TIME TO INUNDATION AND FLOOD EVACUATION

The flood model results for time to inundation and maximum depth of inundation for the 20, 50 and 100 year ARI events have been reviewed.

3.6.1 GRAFTON

Evacuation during flood events will be improved with access to the new bridge as well as the existing bridge remaining flood free in a 20 year ARI flood event.

Levee overtopping order has been reviewed. The order in which levee sections overtop is, for the most part, unchanged. The exact location along the levee may be changed due, in part, to the adjustment of the levee levels.

SES representatives were satisfied that the new bridge would not cause any significant problems, nor would they need to alter their emergency responses. SES further advised that an additional crossing of the Clarence River at Grafton would improve evacuation of Grafton in the event of a large flood.

3.6.2 CARRS ISLAND

A low level bridge provides access to Carrs Island that is overtopped in a 5 year ARI event. This bridge will have less than 10 mm increase in water level during the 5 year ARI event and up to 30 mm increase during the 100 year ARI event. There is no discernible change to the onset of overtopping between the existing and developed cases.

SES representatives were satisfied that the new bridge would not cause any significant problems, nor would they need to alter their emergency responses in relation to the evacuation of Carrs Island.

3.6.3 CARRS PENINSULAR

The access to Carrs Peninsular is a low level road that is overtopped in a 5 year ARI event. This road will have less than 10 mm increase in water level during the 5 year ARI event and up to 30 mm increase during the 100 year ARI event. There is no discernible change to the onset of overtopping between the existing and developed cases.

SES representatives were satisfied that the new bridge would not cause any significant problems, nor would they need to alter their emergency responses in relation to the evacuation of Carrs Peninsular.

3.6.4 PACIFIC HIGHWAY

In a 100 year ARI event the Pacific Highway is overtopped more than 24 hours after the start of the modelled flood event in both the existing and proposed scenarios.

SES representatives were satisfied that the new bridge would not cause any significant problems, nor would they need to alter their emergency responses with regard to the Pacific Highway.

3.6.5 WATERVIEW HEIGHTS

The flood model has been updated to include local rainfall into the catchments draining into the Clarence River at Waterview Heights. Some driveways in the Waterview Heights and Sealands areas are overtopped in the modelled 100 year ARI events between 9 and 24 hours after the start of the modelled events due to the local rain falling into these local catchments. Rainfall in the local catchment ponds as it is not able to flow into the Clarence River (due to the river being high resulting in closure of flood gates at the outlets of local drainage channels in the area).

This means that there is no change due to the project works.

4 Consultation

Roads and Maritime has consulted with key stakeholders and landowners during development of the HMR to ensure that its recommendations capitalise on local expertise, is consistent with plans held by other local authorities, and is understood and influenced by those affected.

The level of consultation undertaken in this phase is more expansive and intensive than that conducted earlier. Consultation will continue during the detailed design and construction phases as the Construction Contractor seeks to further minimise impacts.

Consultation was undertaken with reference to the MCoA, including B7 and D23.

Further detail is provided in Appendix B regarding the outcomes of consultation carried out as part of the preparation of this HMR.

4.1 CONSULTATION WITH GOVERNMENT BODIES

During late 2015 and early 2016, Roads and Maritime coordinated a series of individual meetings and group workshops with local and state government bodies to understand their interest in flood management in Grafton, and to seek their input to the HMR. Meeting invitations were extended to representatives of:

1. NSW Department of Planning and Environment (written feedback provided)
2. NSW State Emergency Service
3. Office of Environment and Heritage
4. Clarence Valley Council.

Key topics raised through this series of consultation events included:

1. maintaining existing flood protection levels – as far as is practicable – for North and South Grafton, and up- and downstream communities
2. ensuring flood evacuation routes remained available for the same amount of time as before the bridge's construction
3. ensuring minor bridge mitigation works did not interfere with other organisations' abilities to conduct wider flood mitigation projects in the future
4. planning for flood events with varying sizes and characteristics
5. ease of CVC access and maintenance for any altered levees
6. understanding and minimising community impacts
7. flood education and emergency preparedness exercises led by SES and CVC, and updating the underlying data used
8. information exchange between bodies (flood modelling, historic data, survey information) to ensure maximum community benefit from work undertaken.

Participants provided contextual information about:

1. historic local flood mitigation efforts, including flood studies, levee building, and house raising
2. observed flood events, including the 2013 flood
3. current activities, including levee easement negotiations with landowners
4. future planning for flood mitigation in the area

4.1.1 NOVEMBER 2015 WORKSHOP

The first workshop was held on 24 November 2015 from 9:30 am - 2 pm and was attended by representatives of CVC, OEH and SES. The workshop was facilitated by KBR and presentations were made by the project team, including Roads and Maritime, KBR, BMT WBM, and Public Works (undertaking levee design). The independent hydrologist (WMA Water) was also present. Papers were circulated in advance to facilitate informed discussion of topics including, but not limited to:

- newly available information since the 2014 Environmental Impact Statement
- updates to the existing CVC flood model, including bathymetric survey extents and findings
- potential bridge afflux
- levee refinement options
- setting flood management objectives, and best practice approaches
- potential levee and at-property mitigation measures, to ensure the objectives were met
- evacuation routes.

Flood mitigation options that affected the levee system (maintained by CVC) were discussed at length and information was shared regarding past experience with access, easements and materials. Roads and Maritime agreed with CVC that they would jointly conduct a review of materials for levee adjustments to ensure suitability for CVC upkeep.

Participants reviewed mapping of peak flood level impact as they applied to different potential mitigation approaches. Participants were also given the opportunity to contrast bridge mitigation strategies and query the hydrologist who conducted the modelling. Participants were also given access to the appointed independent hydrologist if they needed a second opinion.

Attendees participated actively in discussions during the workshop.

After the workshop, additional data was assembled and circulated to answer attendees' questions.

4.1.2 JANUARY 2016 WORKSHOP

The flood management objectives were further refined based on the November 2015 input from these government representatives and the revised objectives were presented during a subsequent workshop on 12 January 2016 from 10 am–12:30 pm and was attended by representatives of CVC and OEH.

A draft of the HMR (based on the Concept Design) was provided to all representatives prior to the meeting.

The second workshop focused on project progress and updating attendees on areas of key interest.

Roads and Maritime outlined:

- updates to the flood management objectives in response to stakeholder suggestions made at the November workshop
- baseline mapping
- assumptions used in the development of the mapping
- flood survey work undertaken and planned
- the detailed strategy to identify properties requiring survey, including the incorporation of LIDAR technology
- how the bridge might work with or impact upon public assets such as drains and pump stations, and committed to ongoing consultation with CVC through the detailed design stage
- how CVC would provide ongoing input into decisions regarding levee mitigation measures, given their maintenance obligations
- updates on evacuation routes, based on interim meeting with SES.

The group jointly considered how the project and associated changes to the levee system would relate to broader flood management strategies being investigated by other authorities, and how the flood model updates generated through the project could be incorporated into other authorities' planning processes.

4.1.3 ADDITIONAL CONSULTATION WITH NSW STATE EMERGENCY SERVICE AND CLARENCE VALLEY COUNCIL

Two separate meetings were held with representatives of the NSW State Emergency Service on 8 January 2016 and 8 February 2016. The second meeting was also attended by a CVC officer having emergency management responsibilities.

These meetings were held to provide detailed information specific to evacuation routes. SES representatives were able to ask questions regarding precise timings and order of predicted levee overtopping, and the use of evacuation routes. They made recommendations regarding additional data to be presented on the maps to assist them in flood response planning. The maps were updated to incorporate their recommendations.

SES representatives were satisfied that the new bridge would not cause any significant problems, nor would they need to alter their emergency responses. They were satisfied with the information provided to date, and specified additional data they would like to receive upon project completion to inform subsequent updates to their emergency planning materials and publications. SES and CVC are cognizant that the afflux levels are subject to minor variation during the detailed design process.

Roads and Maritime agreed to provide all such feasible and reasonable assistance to both CVC (now and upon bridge completion) to enable updating of their flood model and LEP, and to SES to enable updating of their evacuation, traffic management and flood plans. The input received from these events and correspondence influenced the development of the HMR.

4.2 CONSULTATION WITH AFFECTED LANDOWNERS

For the purposes of this report, affected landowners are divided into those with:

1. Properties where the existing levee will need to be altered.
2. Properties that don't meet the flood management objectives.

Key messages in speaking to both of these groups were that the project is expected to:

- commence construction in late 2016, with detailed investigations currently underway
- maintain existing levels of flood protection, wherever it is reasonable and feasible to do so
- mitigate against bridge impacts as required by the planning approval, rather than addressing local flood management
- avoid creating winners and losers – explaining that creating new flood protection benefits in one area would displace water in a way that disadvantaged another neighbourhood
- add 30–40 mm of extra flood depth in many areas, regardless of flood size (information tailored to each property where possible). It was noted that these levels are subject to change should there be an improved bridge design and reduced afflux by the construction contractor.

4.2.1 PROPERTIES WHERE THE EXISTING LEVEE WILL NEED TO BE ALTERED

To enable the Construction Contractor to undertake levee works, Roads and Maritime will need to access existing levees on privately held land.

102 parcels of land are recommended for levee alteration. Of these, 77 parcels are owned by 66 private landowners (or groups of landowners), counting each strata owner separately. The remainder are government landowners (crown land, road reserves and Transport for NSW). Over half of these private parcels of land have an existing easement over the property that allows for this work to be undertaken. Separate agreements are being sought with the owners of the remaining parcels.

During the development of the HMR, Roads and Maritime project team members met individually with landowners to discuss the project and how it would affect them.

Key messages and questions specific to this group were:

- Are you aware of an easement over your property, or would you be happy to have one?
- Minor alterations to the levee are required to maintain the existing level of flood protection.
- The refinements to levee height are less than what was expected at the EIS stage.
- The refinements will match the existing type of levee and materials where possible.
- Access will be required to private property and on the levee to survey levels, and again to undertake the alteration work.
- Roads and Maritime will work with the landowner to seek access permission and approval of the levee works in a way that is appropriate to the work (offering a Works Access Licence over existing easements, or a lease over the levee works area where there is no easement).

- Roads and Maritime will consult with each landowner (and CVC) to discuss specific design aspects and landowner impacts and land management requirements at the detailed design stage, and before any works commence.

Further consultation will occur between landowners and the construction contractor to formally agree any subsequent design, access and timing elements for levee work.

CVC has continued to participate in a constructive ongoing dialogue regarding levee work. This includes levee work on CVC land, land managed and roads managed by CVC. Roads and Maritime is currently negotiating an agency agreement with CVC to undertake works on CVC managed infrastructure (the levee system) under CVC's authority.

These discussions have also covered items not directly related to the HMR such as:

- typical geometry and treatments
- Council involvement in the construction surveillance process
- other construction related matters such as haulage routes, dilapidation surveys on haul roads and defects liability period requested by CVC.

CVC have provided in-principle agreement to the necessary works. This involvement will continue throughout the project.

Roads and Maritime has been in regular contact with ARTC about project design and construction issues as they relate to ARTC infrastructure.

It is planned that the levee work on rail land will be covered under a works deed with ARTC and works will be undertaken to ARTC conditions.

Roads and Maritime is currently negotiating the works deed with ARTC that will include:

- location and form of the levee works
- design requirements
- construction requirements
- access requirements
- environmental requirements
- safety requirements
- maintenance obligations
- warranties
- insurances and indemnities.

4.2.2 PROPERTIES THAT DO NOT MEET THE FLOOD MANAGEMENT OBJECTIVES

Through levee and streamlining the bridge piers, Roads and Maritime has endeavoured to mitigate hydraulic impacts of the bridge in keeping with the Conditions of Approval. The developed concept design has further reduced the number of structures where the flood management objectives cannot be met without considering at-property mitigation, as shown in the table below.

Table 4.1 Reduced number of structures that do not meet flood management objectives

	EIS (August 2014)	Concept design (January 2016)	Developed concept design (May 2016)
Residences	Not assessed	13	1
Outbuildings	Not assessed	38	11
Commercial/Not-for-Profit	Not assessed	5	4
Landowners	45	34*	15*

* Note that some landowners have more than one affected structure on their property.

The consultation strategy for approaching these landowners was to consult early and provide detailed information, tailored to each landowner's needs. Landowners were offered one-to-one meetings, where members of the project team visited their property, inspected the potentially affected structures and discussed how increases in flood depths might change the owners' flood management activities. The project team provided detailed flood depth information and aerial photos for each potentially impacted structure. This personalised approach was taken to recognise the different way that each outbuilding or structure is used and managed during a flood event, and the importance of understanding potential impacts before seeking to address them.

As noted in Table 4.1, 15 landowners have been identified as having structures that have a potential flood impact. Roads and Maritime has met with 13 affected landowners to:

- explain the predicted flood levels under the existing situation without a bridge
- discuss how the bridge will alter water levels and/or movement
- provide detailed property-specific information
- explain how their specific property and structures may be affected
- discuss how those structure are routinely used and managed during flood events
- identify, through discussion, how an acceptable level of mitigation could be achieved
- provide a commitment to giving updates as the project develops.

The mitigation measures proposed during consultation for each property are shown in Appendix B, and include:

- new or altered levees
- house raising
- new, raised concrete slab

- compensation.

Consultation with the remaining two landowners is incomplete for the reasons listed in Appendix B. Consultation will be completed by Roads and Maritime as soon as it is appropriate.

Landowners were encouraged to consider the change in flood level and were given a contact at Roads and Maritime to phone for further information or answers to questions that might arise after the consultation relating to how they may be impacted. No follow up calls were received to identify new impacts or propose new mitigation measures.

In several instances the owner has stated that the impact was not significant to the management of their property in a flood and they could not identify any reasonable or effective mitigation measures. In these cases the landowners have signed a discussion checklist (sample in Appendix D) that states no mitigation measures are proposed at their property.

4.3 OTHER SURVEYED PROPERTIES

Many of the properties surveyed were found to have no impacted structures. Letters have been sent to the landowners on those properties confirming that their structures are not impacted by the project, and thanking them for their cooperation during surveys. The letter also contained a project team member's phone number for any further questions.

In some instances, structures will experience minor changes in flood depth, below the flood management objective levels. Meetings are underway with such landowners to provide information specific to their property.

Beyond the requirements of the HMR, Roads and Maritime will continue to update the Grafton community about the bridge project via the project website and community updates.

4.4 FEEDBACK

Key issues raised during the December 2015-March 2016 consultation were:

- landowners appreciated being provided with information specific to their property, and predicted flood levels before and after the bridge is built
- landowners would use the information provided to modify their flood management practices, and raise valuable property to higher levels during future floods
- landowners appreciated being given time to consider the information and ask further questions or recommend other mitigation measures.

5 Mitigation Measures

5.1 LEVEE WORKS

Without mitigation, the proposed bridge would cause an increase in water level upstream and increase overtopping of the South Grafton rural levee system, which could in turn increase flood levels in South Grafton. If this increase is mitigated by increasing South Grafton levee heights, this, in turn, would lead to an increase in flood levels in Grafton. Therefore, to mitigate the impact of the project works, minor levee works are proposed for both South Grafton and Grafton levee systems.

A program of levee works has been designed to ensure that generally the volumes spilling over the levees match existing volumes. This is shown in Tables 3-8 and 3-10 of Appendix C.

Existing levees will be raised to set elevations. Typically, lengths of levee will be raised by 50 mm to 200 mm, with isolated low points raised more. Approximately 2.0 km of levees in North Grafton and 3.7 km in South Grafton are to be adjusted. It should be noted that the levees are to be raised to target elevations and some sections that are already at or above the target elevation may not need to be adjusted. The developed concept design is shown in Figure 3-22 of Appendix C.

The existing levee system comprises predominantly grassed earth fill embankments. However there are some sections of concrete blockwork levee, concrete blockwork on top of earth fill embankment, brick walls, reinforced concrete walls and buildings forming sections of the levee.

NSW Public Works is currently preparing the detailed design of the levee works on behalf of Roads and Maritime.

Existing earth fill embankment levees will remain earth levees when raised to target elevations (apart from some exceptional circumstances such as a short section of earth levee in between two blockwork levees or when structural requirements dictate a different construction method).

Where a structure is part of the levee, an individual assessment will be made taking into account the building itself, utility openings, stairs etc., that may allow flood water to surcharge into the building. This will be undertaken in the next phase of the project.

For all levee types, the design details will be determined by Roads and Maritime in consultation with landowners and CVC as the maintenance authority. The construction methodology will be determined by the Construction Contractor in consultation with the landowner.

Levee works have been discussed with each landowner. A schedule of levee works is included in Appendix B. The location of each levee is identified on the maps in Appendix A.

A final schedule of mitigation works, including levee works, will be prepared after acceptance of this HMR. The schedule of works shall be provided to the DPE and the CVC prior to the implementation/construction of the mitigation measures in accordance with the Minister's Condition of Approval D24.

Figures 5-1 and 5-2 show the increase in water level due to the new bridge and levee works in the 50 year and 100 year ARI events.

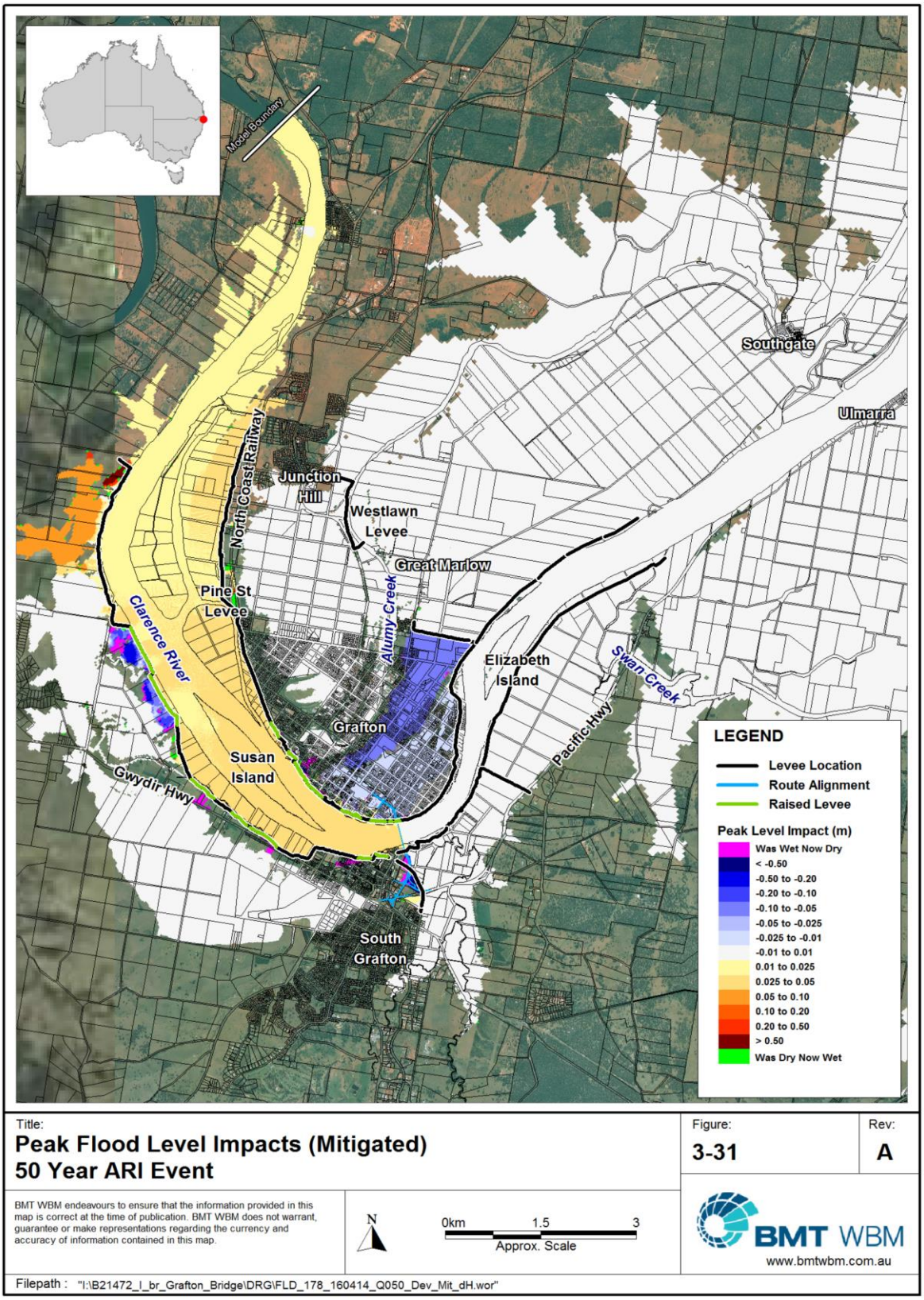

Figure 5-1
50 year ARI Flood Map (Mitigated)

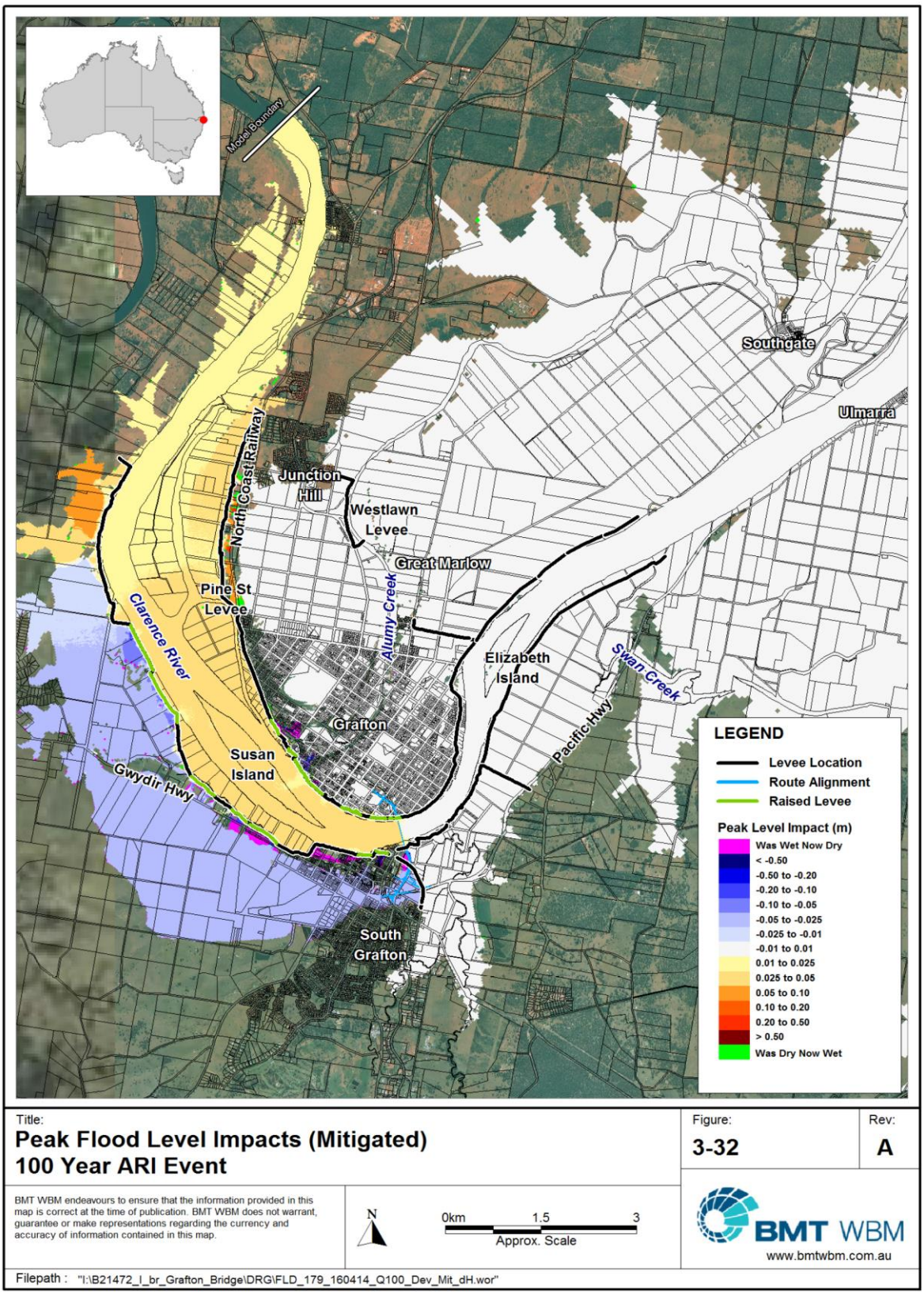

Figure 5-2
100 year ARI Flood Map (Mitigated)

5.2 RESIDENCES AND STRUCTURES MITIGATION MEASURES

At properties with residual impacts greater than the flood objectives, residual impacts will be addressed on a property-by-property basis.

Mitigation measures being considered include the following:

- house raising (where house raising is undertaken, properties would be raised to the 100 year flood level plus 0.5 m freeboard)
- minor raising/moving of existing levees
- construction of new short sections of levees around buildings
- floor raising (for sheds and other outbuildings)
- water proofing works (dry flood proofing or wet flood proofing)
- compensation.

Mitigation measures are being determined on a case-by-case basis in consultation with the land owner and will be based on what is reasonable and feasible for each particular property. Possible mitigation measures have been discussed with the landowners. A schedule of expected mitigation measures is included in Appendix B. The location of each structure is identified in Appendix A.

A final schedule of mitigation works will be prepared after acceptance of this HMR. The schedule of works shall be provided to the DPE and the CVC prior to the implementation/construction of the mitigation measures in accordance with the Minister's Condition of Approval D24.

5.3 ACCESS AND INFRASTRUCTURE MITIGATION MEASURES

No mitigation measures for access and infrastructure such as driveways are required as no impacts have been identified.

5.4 RESPONSIBILITY FOR MAINTENANCE

The responsibility of maintenance of the levee system will remain with CVC.

The responsibility of maintenance of work on structures or private levees will lie with the landowner.

5.5 SCOUR PROTECTION MEASURES

One landowner has expressed concerns regarding existing scour of the foundations of its building. Further assessment is required to determine if the existing scour will be exacerbated as a result of the project. If it is concluded that the project may make the situation worse, scour protection works may be required as part of project works at this location. Any works would be included in the schedule of feasible and reasonable flood mitigation measures which will be provided to DPE and CVC. It should be noted that while the model does not show any significant changes in velocity at this location, the flood model, due to its cell resolution, is not the appropriate tool to assess velocity changes at this complicated site.

Local increases in velocity in the immediate vicinity of the new bridge that require permanent scour protection will be addressed as part of the detailed design of the bridge.

Permanent scour protection might be installed around the piers and river banks to protect them from riverbank instability, riverbank erosion and riverbed erosion during flood or high-flow events. This includes placement of rip rap (or similar treatment that is preferable from an urban design perspective) on the abutments.

Any velocity increases in the stormwater drainage system that may require permanent scour protection will be addressed as part of the detailed design of the stormwater system.

Scour protection measures may include:

- establishing vegetation on exposed soil surfaces, including using grass-lined channels
- protection of inlets and outlets with rock rip rap (or similar treatment that is preferable from an urban design perspective)
- using rough surfaces, such as rip rap (or similar treatment that is preferable from an urban design perspective), to reduce velocities to minimise erosion
- flattening of surfaces and drains to limit velocities and thereby minimise erosion.

When appropriate scour protection measures are implemented, no residual velocity or scour impacts are expected to affect existing structures.

An engineering assessment is being conducted by NSW Public Works on sections of the levee where levee works will occur. If existing scour is identified, scour protection may be proposed after consultation with CVC. (This would be to address an existing condition as there is not a predicted increased scour risk resulting from the project.)

5.6 REVIEW OF EXISTING EVACUATION PLAN

SES has been provided with detailed information regarding flooding, sequence of levee overtopping, and time to overtopping of levees in the concept design case.

SES has advised that they are comfortable that the overtopping of the levees remains very similar to the existing situation and the no changes will be required to their response plans.

SES will be provided with the developed concept design and, when it is available, final updated flood model, incorporating the final design.

5.7 CHANGES IN FLOOD IMPACT SINCE THE EIS

At the time that the EIS was prepared, the predicted increase in flood levels upstream of the existing bridge due to bridge and levee raising works was approximately 90 mm in a 100 year ARI event. Since then the model has been refined. Furthermore, the increase in water level upstream of the bridges has been reduced due to a more streamlined pier shape. This in turn, requires a shorter length of levee augmentation in order to maintain the flood immunity of Grafton and South Grafton.

The reduction of flood impact since the EIS is summarised in Table 5.1.

Table 5.1 Changes since the EIS

Parameter	EIS	Now
Increase in height of floodwater upstream of the bridges (due to bridge and levee works) in a 100 year ARI flood event	90 mm	30 mm
Length of Levee Works	Approx. 11 km	Approx. 5.7 km
Height of Levee Works	Raised by 200 mm	Regrade (raise by up to 50 to 200 mm)
Number of land parcels impacted by levee works	174	101
Number of properties with remaining flood impacts	45	15

5.8 CONSTRUCTION PHASE IMPACTS AND TIMING OF WORKS

The construction options will be developed by the Construction Contractor to minimise flood impact due to construction activities. The Construction Contractor will develop a Construction Flood Management Plan that minimises risk of flood impact during construction. This will be monitored by Roads and Maritime.

5.9 FUTURE WORKS

The developed concept design presented in this report shall be further refined to incorporate the detailed design as the project progresses. The requirements of outstanding ministerial approval conditions to be complied with (D24 and D25) as detailed in Table 1.1 will be addressed through the progression of the detailed design. These activities will include:

- The schedule of final mitigation works (D24)
- Engineering assessment of the levees prior to levee design works (D25).

6 Conclusions and Recommendation

The project will provide an increase in traffic capacity across the Clarence River while allowing the safe movement of all vehicles and pedestrians. It will also allow Grafton to evacuate more quickly during flood events.

Since the EIS there have been a number of refinements of the flood model, including incorporating more detailed information. Furthermore, the bridge design has been refined to use a more streamlined bridge pier shape. These changes have resulted in a greatly reduced flood impact due to the bridge and associated levee works.

Positive outcomes for the HMR process have been achieved through Roads and Maritime's consultation with, DPE, CVC, SES and landowners and residents including:

- minimising adverse environmental and property impacts as far as practicable
- no adverse impact to emergency management and evacuation processes
- no adverse impact to existing infrastructure that cannot be managed during the detailed design stage
- equitable community outcomes:
    - maintaining the same flooding impacts to lands behind levees for Grafton and South Grafton
    - engagement of all affected residents in a fair and consistent manner
- open and honest communication and consultation with government agencies, affected landowners and residents.

The mitigation measures proposed in this report are considered adequate to manage the adverse hydraulic impacts of the new bridge, and to meet the Conditions of Approval. It is recommended that the hydrological mitigation measures contained in this report are adopted.

7 References

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Appendix A Flood Extent and Water Level Mapping

Appendix A contains property ownership and other confidential information and is therefore not included in this publically available document.

Appendix B Property Mitigation Measures

Appendix B contains property ownership and other confidential information and is therefore not included in this publically available document.

Appendix C Additional Crossing of the Clarence River at Grafton: Flood Modelling Design Services Support

Appendix D Landowner's Agreement

Appendix E Independent Hydrologist Letter

Appendix F Independent Hydrologist Review Comments

Appendix F contains private information and and is therefore not included in this publically available document.