CCL22/100 Draft Geurie Flood Risk Management Plan for Public Exhibition

Geurie Floodplain Risk Management Study

Draft Report
Volume 1

March 2022

Prepared for
Dubbo Regional Council
PO Box 81
Dubbo, NSW 2830
Email:
council@dubbo.nsw.gov.au

Prepared by
HydroSpatial Pty Ltd
Suite 25, Level 2
104 Bathurst Street
Sydney NSW 2000
Email: info@hydrospatial.com.au

HYDROSPATIAL

Project Details	
Project Name	Geurie Floodplain Risk Management Study and Plan
Client	Dubbo Regional Council
Author	Jamie Brooks, Michael Wyk, Erika Taylor
Job Number	18020
Document Stage	Draft
Document Version	R06
Document Name	18020_Geurie_FRMSP_Draft_R06_Vol1.doc

Document Version Control					
Version	Type	Release	Author	Reviewer	Date
01	Stage 1	Submission	Jamie Brooks, Michael Wyk	Erika Taylor	05/07/2021
02	Stage 2	Submission	Jamie Brooks, Michael Wyk	Erika Taylor	28/09/2021
03	Stage 3	Submission	Jamie Brooks, Michael Wyk	Erika Taylor	25/10/2021
04	Stage 3	Submission	Jamie Brooks, Michael Wyk	Erika Taylor	29/10/2021
05	Stage 3	Submission	Jamie Brooks, Michael Wyk	Erika Taylor	07/12/2021
06	Draft	Submission	Jamie Brooks, Erika Taylor	Michael Wyk	28/03/2022

Document Approval	
Erika Taylor	Signature
Director	

HYDROSPATIAL

Table of Contents

Appendices

Table of Tables

Table of Figures

HYDROSPATIAL

Table of Abbreviations

AEP	Annual Exceedance Probability
AHD	Australian Height Datum
AAD	Average Annual Damage
ARI	Average Recurrence Interval
ARR	Australian Rainfall and Runoff
DEM	Digital Elevation Model
DPIE	Department of Planning, Industry and Environment
EY	Exceedances per Year
FMC	Floodplain Management Committee
FPA	Flood Planning Area
FPL	Flood Planning Level
LGA	Local Government Area
LiDAR	Light Detection and Ranging
NSW	New South Wales
OEH	Office of Environment and Heritage
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
SES	State Emergency Services

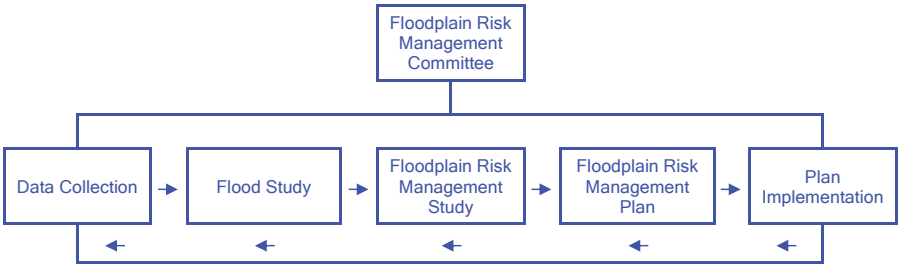
HYDROSPATIAL

Forward

Flood-Related Legislation, Policies and Guidelines

The New South Wales (NSW) State Government's *Flood Prone Land Policy* places the primary responsibility for floodplain risk management with Councils and the *Local Government Act 1993 - Section 733* indemnifies Council from liability if the Council has acted in "good faith" in relation to floodplain risk management. Additionally, the State Government, through the Department of Planning, Industry and Environment (DPIE) (formerly the Office of Environment and Heritage (OEH)), provides financial and technical support to Council in meeting its floodplain risk management obligations.

The NSW *Floodplain Development Manual* (2005) supports the NSW *Flood Prone Land Policy*. The manual provides direction on the floodplain risk management process, as detailed below.



Data Collection	Flood Study	Floodplain Risk Management Study	Floodplain Risk Management Plan	Plan Implementation
Compilation of existing data and collection of additional data.	Defines the nature and extent of the flood problem, in technical rather than map form.	Determines options in consideration of social, ecological and economic factors relating to flood risk.	Preferred options publicly exhibited and subject to revision in light of responses.	Implementation of flood response and property modification measures (including mitigation works, planning controls, flood warnings, flood readiness and response plans, environmental rehabilitation, ongoing data collection and monitoring) by Council.

There are a number of industry guidelines that provide technical guidance through the floodplain risk management process. This includes the *Australian Emergency Management Series* (particularly *Handbook 7: Managing the Floodplain Best Practice in Flood Risk Management in Australia*), and *Australia Rainfall and Runoff* (ARR). ARR has undergone several revisions since its inception; with the first publication in 1958, the second publication in 1977, the third publication in 1987 and the fourth (and latest) publication in 2019.

The current study has been undertaken in accordance with the aforementioned legislation, policies and guidelines.

HYDROSPATIAL

Terminology

ARR 2019 has standardised the design flood terminology used in the industry. Very frequent events are expressed as Exceedances per Year (EY), frequent to very rare events are expressed as Annual Exceedance Probability (AEP) as a percentage, and very rare to extreme events are expressed as a 1 in x AEP. This is detailed in Table 0-1, which has been extracted from Section 2.2.5., Chapter 2, Book 1 of ARR 2019.

Table 0-1: Design event terminology

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI
Very Frequent	12			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.5
	1	63.21	1.58	1
Frequent	0.69	50	2	1.44
	0.5	39.35	2.54	2
	0.22	20	5	4.48
	0.2	18.13	5.52	5
	0.11	10	10	9.49
Rare	0.05	5	20	20
	0.02	2	50	50
	0.01	1	100	100
Very Rare	0.005	0.5	200	200
	0.002	0.2	500	500
	0.001	0.1	1000	1000
	0.0005	0.05	2000	2000
Extreme	0.0002	0.02	5000	5000
			PMP	

HYDROSPATIAL

Executive Summary

The NSW State Government, through the Department of Planning, Industry and Environment (DPIE), oversee the Floodplain Management Program. The program provides support to local councils in the implementation of the NSW Government's Flood Prone Land Policy as outlined in the NSW Government's Floodplain Development Manual. The primary objective of the policy and manual is to reduce the impacts of flooding and flood liability on individual owners and occupiers of flood prone property.

As part of the Floodplain Management Program, Dubbo Regional Council and DPIE commissioned the Geurie Flood Study and the Geurie Floodplain Risk Management Study and Plan. HydroSpatial Pty Ltd were engaged to undertake both studies. The Geurie Flood Study was completed in 2020 and the subsequent Geurie Floodplain Risk Management Study and Plan is presented in the following.

Geurie is in Central West NSW and is located on the Mitchell Highway and the Wellington – Dubbo railway line. The town is a limited service town for the local area, with a post office, a primary school and some shopping facilities. The suburb of Geurie has a population of 755 people and the urban centre of Geurie has a population of 477 people, according to the 2016 Australian Bureau of Statistics Census.

Geurie Creek is located to the east of the town and is aligned north to south, discharging into the Macquarie River to the south. Boori Creek is a tributary to Geurie Creek and runs west to east through the town. A small portion of Boori Creek is concrete-lined between Douglas Street and Wellington Street. The remainder of the creek system is naturally channelised and grass-lined.

Existing Flood Damages

Direct flood damages within the study area were estimated to have an Average Annual Damage (AAD) value of $202,988 and a Net Present Value (NPV) of $3,004,377.

Identifying Options

A number of flood mitigation options were identified and investigated, including:

- Potential flood modification measures:
  - FM01 – Detention basin within Wise Park
  - FM02 – Detention basin under Geurie Tennis Courts
  - FM03 – Detention basin within Tom Culkin Oval
  - FM04 – Detention basin within 72 Severne Street
  - FM05 – Detention basin on Geurie Creek upstream of the railway embankment
  - FM06 – Cascading detention basins alongside railway
  - FM07 – Additional culverts along Geurie Creek through the railway embankment
  - FM08 – Additional culverts along Geurie Creek under the Mitchell Highway
  - FM09 – Construct swales adjacent to the roadway edges
  - FM10 – Earthen levee along the Mitchell Highway
- Potential property modification measures:
  - PM01 – Update development controls
  - PM02 – Update zoning controls
  - PM03 – Voluntary property purchase

Assessing Options

The flood mitigation options investigated were assessed against a multi-criteria matrix. This included assessment of the change in flood behaviour, the economic impacts, the social impacts, the environmental and heritage impacts.

HYDROSPATIAL

Recommended Options

Based upon the multi-criteria assessment of the flood mitigation options, a number of options were recommended for implementation and others were recommended for further investigation. This is summarised in Table 0-1.

Table 0-1: Summary of recommended measures

Measure ID	Measure Description	Estimated Cost	Priority
PM01	Update development controls	N/A	High
PM02	Update zoning controls	N/A	Medium
FM10	Earthen levee along the Mitchell Highway	$536,000	Medium

1 Introduction

1.1 Overview

Dubbo Regional Council, with the support of the NSW DPIE, has commissioned HydroSpatial Pty Ltd to prepare the following Geurie Floodplain Risk Management Study and Plan.

1.2 Study Objectives

The objectives of the FRMS&P were to utilise the hydrologic and hydraulic models, developed as part of the Geurie Flood Study (HydroSpatial, 2020) to:

- Identify potential flood mitigation measures;
- Estimate the cost to undertake the potential mitigation measures;
- Assess the benefit-cost of the potential mitigation measures;
- Recommend mitigation measures to be implemented; and
- Provide input into the priorities and timing on implementation of recommended mitigation measures.

1.3 Study Area Description

Geurie is located in the Dubbo Regional Council Local Government Area (LGA) in Central West NSW. The town is located on the Mitchell Highway and the Wellington – Dubbo railway line. The town is a limited service town for the local area, with a post office, a primary school and some shopping facilities. The suburb of Geurie has a population of 755 people and the urban centre of Geurie has a population of 477 people, according to the 2016 Australian Bureau of Statistics Census.

Geurie Creek is located to the east of the town and is aligned north to south, discharging into the Macquarie River to the south. Boori Creek is a tributary to Geurie Creek and runs west to east through the town. A small portion of Boori Creek is concrete-lined between Douglas Street and Wellington Street. The remainder of the creek system is naturally channelised and grass-lined.

There is limited underground stormwater drainage in and around the town. As such, stormwater is primarily conveyed through table drains adjacent to the roadways and discharging into the creeks.

2 Study Methodology

The following tasks were undertaken as part of the Geurie Floodplain Risk Management Study and Plan Project:

- Analysis of catchment characteristics;
- Review of hydrologic and hydraulic modelling;
- Assessment of flood behaviour;
- Assessment of flood response arrangements;
- Assessment of flood planning policies;
- Investigate the consequences of flooding; and
- Investigate flood modification measures.

An analysis of catchment characteristics was carried out to gather information on the varied effects of flooding. These included social, sensitive land use, cultural and heritage, environmental, and levee system characteristics. This data was later used to inform the assessment of mitigation options. Further details on the catchment characteristics analysis are discussed in Section 4.

A review of hydrologic and hydraulic modelling was undertaken to assess the effectiveness and accuracy of the modelling, as well as the currency of the data and guidelines used. Further details on the hydrologic and hydraulic modelling review are discussed in Section 5.

An assessment of existing flood behaviour was carried out to determine the effect on multiple relevant factors. These factors included bridge and culvert capacity, road access and duration of inundation. Further details on the existing flood behaviour assessment are discussed in Section 6.

An assessment of existing flood response arrangements was undertaken to determine the effectiveness of current response arrangements, as well as determine whether an update to existing arrangements was necessary. This included an assessment of the existing Local Emergency Plan, Flood Emergency Sub Plan, Emergency Service operators, evacuation centres, and historical flood responses. Further details on the existing flood response assessment are discussed in Section 7.

An assessment of existing flood planning policies was carried out to determine the effectiveness of current flood planning policies, as well as whether an update to existing policies was necessary. Multiple relevant NSW state planning policies were assessed, as well as applicable ministerial directions. Furthermore due to the 2016 local government amalgamations that formed the Dubbo Regional Council and the continuance of the former Council's planning policies, the Local Environmental Plans and Development Control Plans for both the former City of Dubbo and Wellington Council's were assessed. Further details on the existing flood planning policies assessment are discussed in Section 8.

An investigation into the consequences of flooding under existing conditions was carried out to assess the economic, social, heritage and environmental impacts of flooding. The economic impacts were also quantified for the direct flood damages impacting both residential and commercial premises. Further details on the flooding consequences investigation are discussed in Section 10.

An investigation into flood mitigation measures was carried out in order to identify, assess, recommend and prioritise a number of potential mitigation measures. Options were identified through the analysis of existing flood behaviour, as well as through consultation with Council and the community. Identified options were then assessed through a multi-criteria matrix system, in order to recommend and prioritise their implementation. Further details on the flood mitigation measures investigation are discussed in Section 11.

3 Consultation

As part of this study, consultation has been undertaken with a number of stakeholders, as discussed within the following.

3.1 Community Consultation

3.1.1 Flood Study

As part of the previous Geurie Flood Study (HydroSpatial, 2020) process, two community consultation sessions were held at different stages of the study.

3.1.1.1 First Round

A community consultation process was undertaken during the data collection stage of the study through the October 2018 period. The purpose of this community consultation work was to gather data from the community on historical flood events in the study area. This was achieved by conducting a "drop-in" style community information desk.

The community information desk was held at the Geurie General Store on the 31 October 2018 between 9am to 5pm. The information desk was occupied by representatives from HydroSpatial, Council and DPIE. Twelve community members attended the information desk throughout the day.

The key issues raised and data provided during this community consultation process were:

- The issues raised were predominantly related to local drainage, rather than mainstream flooding.
- Other residents who did not raise specific issues indicated that the town did not have a significant flooding issue and that no flooding had been observed in recent years.

3.1.1.2 Second Round

A community consultation process was undertaken during the public exhibition stage of the study through the February-March 2020 period. The purpose of this community consultation work was to inform the community of the Draft Flood Study Report and gain feedback, including to stimulate discussion on possible mitigation measures to be investigated at the next stage of the process. This was achieved by conducting a "drop-in" style community information desk.

The community information desk was held at the Geurie General Store on the 5 March 2020 between 9am to 5pm. The information desk was occupied by representatives from HydroSpatial, Council and DPIE. Twenty-one community members attended the information desk throughout the day.

The key issues raised and data provided during this community consultation process were:

- Several residents expressed frustrations regarding how they felt recent works located at or near Geurie Racecourse had significantly affected flooding in the area.
- Residents requested a newly built culvert located adjacent to the Geurie General Store be included in the model, as they felt it greatly impacted flood behaviour in the area.
- Several residents raised concerns regarding whether and how the Flood Hazard Category for their properties would be affected.
- Residents whose properties were located in the northern area of Geurie proper, described issues with overland flow sheeting off of roads and into properties.
- The community appears somewhat divided regarding the option to implement kerbs and guttering as a mitigation option.

4 Catchment Characteristics

4.1 Social Characteristics

The social characteristics of an area influences the community's response to a flood event; including the ability to prepare before a flood event, the ability to respond during a flood event and the ability to recover after a flood event has occurred. To quantify the social characteristics of the study area, the 2016 Australian Bureau of Statistics Census data was analysed. This is detailed in Table 4-1.

Table 4-1: Census statistics (ABS, 2016)

	Geurie (SSC)	NSW
Population		
Total Population	755	
< 4 years	5.5%	6.3%
5 - 14 years	16.9%	12.3%
15 - 64 years	61.6%	65.1%
> 65 years	16.0%	16.2%
Assistance		
Core activity need for assistance	4%	
Volunteering		
Provided unpaid assistance to a person with a disability (last two weeks)	15.2%	11.6%
Did volunteer work through an organisation or group (last 12 months)	27.4%	18.1%
Language		
English only spoken at home	90.1%	68.5%
Language top responses (other than English)	Korean 0.4%	
Internet Access		
Internet not accessed from dwelling	20.2%	14.7%
Internet accessed from dwelling	78.2%	83.2%
Not stated	1.6%	2.7%
Registered Motor Vehicles		
None	1.1%	9.2%
1 or more motor vehicles in occupied private dwellings	95.5%	87.1%
Not stated	3.4%	3.7%
Housing Density		
Average number of people per household	2.5	2.6
Median Weekly Income		
Personal	$678	$664

	Geurie (SSC)	NSW
Family	$1,589	$1,734
Household	$1,218	$1,438
Property Tenure		
Owned outright	42.1%	32.2%
Owned with a mortgage	44.0%	32.3%
Rented	12.7%	31.8%
Not stated	1.2%	2.8%
Housing Payments		
Households where rent payments are greater than or equal to 30% of household income	3.9%	12.9%
Households where mortgage payments are greater than or equal to 30% of household income	6.9%	7.4%

According to the 2016 Census, Geurie has a population of 755 people with a median age of 42. Of this population, the proportion of the people aged under 4 and over 65 was relatively similar to the NSW average, though slightly lower. However, the proportion of people aged between 5 and 14 years of age was moderately higher than the NSW average. Furthermore, the proportion of the population that requires assistance in one or more of the three core activities of self-care, mobility and communication accounted for 4% of the population. These vulnerable community members are likely to require additional assistance during a flood event.

The proportion of the population that were involved in volunteer work and had provided unpaid assistance to a person with a disability was greater within the Geurie community compared to the NSW average. This indicates a greater willingness to support others in the community and increases the likelihood that the community will provide assistance to each other during a flood event.

The linguistic diversity of Geurie is relatively low, with a large proportion of the area speaking English exclusively at home. This proportion was far greater than the NSW average. Furthermore, of those that do speak another language at home, their proficiency in English was rated very well or well. Of the overseas migrants living in the area, the majority have lived in Australia for longer than 16 years. As such, it is unlikely that translation services will be required to disseminate flood preparation material and flood warnings in the lead up to a flood event.

Within Geurie, the proportion of the population with internet access within their homes was less than the NSW average. Therefore, it is advisable that any flood preparation initiatives and flood warnings provide information across a range of different media forms to communicate with a wider breadth of the community.

The number of homes with a registered motor vehicle in Geurie was higher than the NSW average and accounted for a large proportion of the population. Therefore, the community have a greater ability to self-evacuate and are less likely to require assistance during a flood event.

The median family/household income in Geurie is slightly lower than the NSW average. However, the number of properties that are owned outright was higher than the NSW average and the proportion of the population experiencing housing payment stress (typically defined as mortgage/rent payments greater than 30% of the household income) was lower than the NSW average. Therefore, the community are likely to be relatively financially resilient and able to recover after a flood event.

The proportion of properties within Geurie that were rented was relatively low and the proportion of the population that had the same residential address 5 years prior to the 2016 Census was relatively high (accounting for approximately 58.7% of the population). As such, the population of Geurie could be considered relatively stable. This increases the likelihood that community flood preparation and/or flood awareness initiatives will be retained.

4.2 Sensitive Land Use Characteristics

Sensitive land uses can be characterised as:

- Vulnerable community facilities, such as aged care centres, child care centres, and schools, etc.
- Critical community facilities, such as law enforcement centres (police stations, correctional centres etc.), emergency services centres (fire stations, RFS centres, SES centres etc.) and health services centres (hospitals, medical centres etc).
- Critical community infrastructure, such as electricity substations, pumps for potable water or sewage water, sewage treatment plants, and waste depots etc.

The location and flood affectation of sensitive land uses in an area influences the community's response to a flood event; including planning before a flood event, the ability to respond during a flood event and the ability to recover after a flood event has occurred. Therefore, the sensitive land uses in the study area have been investigated.

The sensitive land uses found within the study area are detailed in Table 4-2 and the location of these sensitive land use sites is shown on Figure B 2.

Table 4-2: Sensitive land uses

Type	Name	Address	Population*
Vulnerable Community Facilities			
Primary School	Geurie Public School	60-64 Narragal Street, Geurie	26
Critical Community Facilities			
Law Enforcement	Geurie Police Station	58 Jennings Street, Geurie	
Critical Community Infrastructure			
	Waste Depot	214 Comobella Road, Geurie	

* Population numbers taken from the Geurie Public School Strategic Improvement Plan 2021-2024

4.3 Cultural and Heritage Characteristics

The preservation of the cultural and heritage characteristics of an area need to be considered when investigating modification measures. Therefore, the cultural and heritage characteristics of the study area have been investigated and discussed below; with the location of these sites are shown on Figure B 3.

4.3.1 Indigenous Australian Cultural Heritage

The Indigenous Australian cultural heritage sites were found through a search of the Aboriginal Heritage Information Management System (AHIMS) in December 2019. From this, 12 Aboriginal heritage sites were found in the study area. Three of these had restrictions applied that prevented the identification of the feature and location of the heritage site. Of the nine remaining sites, the heritage feature type of these sites included:

- 1 was a camp site;

- 1 was a resource gathering site;
- 1 was the site of a scarred tree; and
- 6 were the site of an artefact.

The location of these 9 sites ranged from:

- 3 were on Freehold land that was privately-owned; and
- 6 were on Freehold land that was Council-owned.

Of the sites where a location was able to be identified, all of these sites were located south of the Geurie township, mostly located around Geurie Creek. The traditional indigenous community within the Geurie area are the Wiradjuri People.

The organisations that recorded the majority of the heritage sites (and that may be contacted for further information) were the Dubbo Local Aboriginal Land Council (LALC), the Wellington Valley Wiradjuri Aboriginal Corporations, and OzArk Environmental and Heritage Management.

4.3.2 Non-Indigenous Australian Cultural Heritage

The non-Indigenous Australian cultural heritage sites were found through searches of:

- Local heritage items from the Wellington Local Environmental Plan (LEP) 2012 (since amalgamated to form the Dubbo Regional Council).
- State heritage items from the NSW State Heritage Inventory (which includes items listed on the State Heritage Register, items listed on State Agency Heritage Registers, and listed Interim Heritage Orders).
- National heritage items from the Australian Heritage Database (which includes the World Heritage List, the Commonwealth Heritage List, the National Heritage List, and the Register of the National Estate; however the latter register was closed in 2007 and is no longer a statutory list).

From this, the non-Indigenous Australian cultural heritage sites within the study area were found to be:

- Geurie Union Church and Hall
- Geurie Public School
- St Matthew's Anglican Rectory
- St Matthew's Anglican Church
- Spillsbury's House
- Geurie War Memorial Hall
- Cobborah Shire Building (former)
- Geurie Garden Café/Alladins Cave
- CBC Bank (former)
- Geurie Antiques
- 37 Buckenbah Street
- Geurie Post Office
- Geurie Police Station, lock-up and house
- Holy Name Catholic Church
- Geurie Grandstand

4.4 Environmental Characteristics

The preservation of the environmental characteristics of an area need to be considered when investigating modification measures. To identify the environmental characteristics of the study area the following searches have been undertaken.

4.4.1 Contaminated Land

The NSW Environmental Protection Agency's (EPA) list of notified contaminated land was consulted to determine whether any known contaminated sites existed within the Geurie catchment. No known sites were discovered in the catchment.

4.4.2 Acid Sulfate Soils

Acid Sulfate Soils (ASS) are the result of soils containing iron sulfides being exposed to air and consequently oxidizing to sulfuric acid. In inland regions this occurs most commonly as the result of excavation. As the presence of sulfuric acid can detrimentally affect the environment, it is important to be aware of the distribution of ASS throughout the study area.

The NSW Government has little data available regarding inland acid sulfate soil distribution in or around the study area.

4.4.3 Flora and Fauna

A search was conducted using the NSW Bionet Wildlife Atlas in January 2020 for sighted flora and fauna in a 35 km by 28 km area including the catchment. This search returned a total of 175 species of fauna, most of which were vulnerable, protected, or endangered, and 469 species of flora.

A search was conducted in the area utilizing the Environmental Protection and Biodiversity Act 1999 (EPBC Act) Protected Matters Search Tool. This search identified:

- 4 wetlands of international importance
  - Banrock Station Wetland Complex
  - The Macquarie Marshes
  - Riverland
  - The Coorong, and Lakes Alexandrina and Albert Wetland
- threatened ecological communities
  - Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions
  - Grey Box (Eucalyptus microcarpa) Grassy Woodlands and Derived Native Grassylands of South-Eastern Australia
  - Natural Grasslands of the basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland
  - Poplar Box Grassy Woodlands on Alluvial Plains
  - Weeping Myall Woodlands
  - White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grasslands
- 29 threatened species
- 10 migratory species

Table 4-3: Flora and fauna

Name	Status
Birds	
Anthochaera Phrygia Regent Honeyeater [82338]	Critically Endangered
Botaurus Poiciloptilus Australasian Bittern [1001]	Endangered
Calidris Ferruginea	Critically Endangered

Name	Status
Curlew Sandpiper [856]	
Grantiella Picta Painted Honeyeater [470]	Vulnerable
Hirundapus Caudacutus White-throated Needletail [682]	Vulnerable
Lathamus Discolor Swift Parrot [744]	Critically Endangered
Leipoa Ocellata Malleefowl [934]	Vulnerable
Numenius Madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered
Polytelis Swainsonii Superb Parrot [738]	Vulnerable
Rostratula Australis Australian Painted Snipe [77037]	Endangered
Fish	
Galaxias Rostratus Flatheaded Galaxias, Beaked Minnow, Flat-headed Galaxias, Flat-Headed Jollytail, Flat-headed Minnow [84745]	Critically Endangered
Maccullochella Macquariensis Trout Cod [26171]	Endangered
Maccullochella Peelii Murray Cod [66633]	Vulnerable
Macquaria Australasica Macquarie Perch [66632]	Endangered
Mammals	
Chalinolobus Dwyeri Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable
Dasyurus Maculatus Maculatus (SE mainland population) Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered
Nyctophilus Corbeni Corben's Long-eared Bat, South-eastern Long-eared Bat [83395]	Vulnerable

Name	Status
Phascolarctos Cinereus Koala [85104]	Vulnerable
Pteropus Poliocephalus Grey-headed Flying-fox [186]	Vulnerable
Plants	
Androcalva Procumbens [87153]	Vulnerable
Austrostipa Wakoolica [66623]	Endangered
Euphrasia Arguta [4325]	Critically Endangered
Indigofera Efoliata [4951]	Endangered
Prasophyllum Petilum Tarengo Leek Orchid [55144]	Endangered
Prasophyllum sp. Wybong (C.Phelps ORG 5269) A leek-orchid [81964]	Critically Endangered
Swainsona Recta Small Purple-pea, Mountain Swainson-pea, Small Purple Pea [7580]	Endangered
Tylophora Linearis [55231]	Endangered
Reptiles	
Aprasia Parapulchella Pink-tailed Worm-lizard, Pink-tailed Legless Lizard [1665]	Vulnerable
Delma Impar Striped Legless Lizard, Striped Snake Lizard [1649]	Vulnerable

5 Computational Modelling

The previous Geurie Flood Study (HydroSpatial, 2020) included computational hydrologic and hydraulic modelling of the study area under existing conditions. This model was reviewed and discussed below.

5.1 Review Hydrologic Modelling

The hydrologic model developed in the flood study used the WBNM software package. The input data used and parameters applied are discussed in detail in the flood study report.

Given the short timeframe between the completion of the previous flood study and the commencement of the current study, it was found that the input data used in the hydrologic model remains relevant to the current study. Furthermore, the parameters applied remain consistent with the current industry guidelines, which have not undergone any significant change during this period.

5.2 Review Hydraulic Modelling

The hydraulic model developed in the flood study used the TUFLOW software package. The input data used and parameters applied are discussed in detail in the flood study report.

Given the short timeframe between the completion of the previous flood study and the commencement of the current study, it was found that the input data used in the hydraulic model remains relevant to the current study. Furthermore, the parameters applied remain consistent with the current industry guidelines, which have not undergone any significant change during this period.

6 Assessment of Existing Flood Behaviour

6.1 Overview

The study area is subject to creek flooding and overland flooding. Both flood mechanisms have been investigated as part of the previous Geurie Flood Study (HydroSpatial, 2020) and as part of this current study.

6.2 Assessment of Bridge and Culvert Capacity

The magnitude of event that results in the bridges and culverts reaching capacity is shown in Figure B 5.

From this, it was found that the majority of culverts through road embankments reach capacity in events greater than and equal to the 5% AEP event.

6.3 Assessment of Time to Peak

The time between the rainfall commencing and the flood level reaching its peak is shown in Figure B 6. It should be noted that this time to peak was dependent upon the storm duration and that the critical storm duration was the one that produced the highest average flood level (for the overland, urban area of the catchment). Therefore, there could be storm events that have a shorter time to peak but a lower flood level than the critical storm.

For the 0.2% AEP event (with a 90 minute storm duration), the time to peak across the urban properties was generally between 60-90 minutes. Along Geurie Creek, through the rural properties, the time to peak was longer and in the range of 120-180 minutes.

For the 1% AEP event (with a 90 minute storm duration), the time to peak across the urban properties was generally between 60-90 minutes. Along Geurie Creek, through the rural properties, the time to peak was longer and in the range of 120-180 minutes.

For the 5% AEP event (with a 120 minute storm duration), the time to peak across the urban properties was generally between 60-90 minutes. Along Geurie Creek, through the rural properties, the time to peak was longer and in the range of 120-160 minutes.

For the 20% AEP event (with a 360 minute storm duration), the time to peak across the urban properties was generally between 60-90 minutes. Along Geurie Creek, through the rural properties, the time to peak was longer and in the range of 120-160 minutes.

6.4 Assessment of Road Access and Duration of Inundation

Road accessibility was assessed using the ARR 2019 vehicle stability criteria, detailed in Table 6-1. Using this criteria, the time between the rainfall event commencing and road inaccessibility occurring as well as the duration of road inaccessibility was assessed for a range of flood events for a number of access roads into Geurie, detailed in Table 6-2 and Table 6-3 respectively. From this, no roads out of the nine were inaccessible to a large 4WD vehicle in the 20% AEP flood event, with this number increasing to two in the 5% AEP event, and four in the 1% AEP event. Of the roads rendered inaccessible in the 1% AEP event, there was a period of 1.2 to 2 hours between the beginning of the event and the time at which the roads became inaccessible. It should be noted that if there is water over the road it is likely to be closed by the NSW SES and/or Council in the interests of public safety and to prevent damage to the road itself.

Table 6-1: Stability criteria for vehicles

Class of vehicle	Limiting still water depth (m)	Limiting velocity (m/s)	Equation of stability
Small passenger	0.3	3.0	DV ≤ 0.3
Large passenger	0.4	3.0	DV ≤ 0.45
Large 4WD	0.5	3.0	DV ≤ 0.6

Table 6-2: Time between the rainfall event commencing and road inaccessibility occurring

Location	Small passenger vehicle	Large passenger vehicle	Large 4WD vehicle
20% AEP event (with a 360 minute storm duration)			
The Old Rd (crossing Geurie Ck, east of Mitchell St)	2.7 hours	N/A	N/A
Jennings St (between Severne St and Mitchell St)	2.0 hours	2.3 hours	N/A
Paxton St (north of Fitzroy St and south of Geurie Racecourse)	2.5 hours	3.0 hours	N/A
Comobella St (north of Geurie Racecourse)	3.2 hours	N/A	N/A
5% AEP event (with a 120 minute storm duration)			
The Old Rd (crossing Geurie Ck, east of Mitchell St)	1.8 hours	2.2 hours	N/A
Jennings St (between Severne St and Mitchell St)	1.2 hours	1.4 hours	1.7 hours
Wellington St (between Severne St and Chambers St)	1.7 hours	N/A	N/A
Paxton St (north of Fitzroy St and south of Geurie Racecourse)	1.6 hours	1.8 hours	2.0 hours
Comobella St (north of Geurie Racecourse)	1.9 hours	2.4 hours	N/A
1% AEP event (with a 90 minute storm duration)			
The Mitchell Hwy	2.2 hours	N/A	N/A
The Old Rd (crossing Geurie Ck, east of Mitchell St)	1.3 hours	1.6 hours	2.0 hours
Mitchell St (between the Mitchell Hwy and Wellington St)	1.4 hours	N/A	N/A
Jennings St (between Severne St and Mitchell St)	0.9 hours	1.0 hours	1.2 hours

Location	Small passenger vehicle	Large passenger vehicle	Large 4WD vehicle
Wellington St (between Severne St and Chambers St)	1.2 hours	N/A	N/A
Paxton St (north of Fitzroy St and south of Geurie Racecourse)	1.2 hours	1.3 hours	1.5 hours
Comobella St (north of Geurie Racecourse)	1.3 hours	1.6 hours	1.9 hours
0.2% AEP event (with a 90 minute storm duration)			
The Mitchell Hwy	1.1 hours	1.7 hours	1.9 hours
The Old Rd (crossing Geurie Ck, east of Mitchell St)	1.1 hours	1.3 hours	1.5 hours
Mitchell St (between the Mitchell Hwy and Jennings St)	1.2 hours	N/A	N/A
Severne St	1.9 hours	2.0 hours	2.1 hours
Jennings St (between Severne St and Mitchell St)	0.7 hours	0.8 hours	1.0 hours
Wellington St (between Severne St and Chambers St)	1.0 hours	1.2 hours	1.9 hours
Douglas (between the Mitchell Hwy and Jennings St)	1.2 hours	N/A	N/A
Paxton St (north of Fitzroy St and south of Geurie Racecourse)	1.0 hours	1.1 hours	1.2 hours
Comobella St (north of Geurie Racecourse)	1.1 hours	1.3 hours	1.4 hours

Table 6-3: Duration of road inaccessibility

Location	Small passenger vehicle	Large passenger vehicle	Large 4WD vehicle
20% AEP event (with a 360 minute storm duration)			
The Old Rd (crossing Geurie Ck, east of Mitchell St)	5.8 hours	N/A	N/A
Jennings St (between Severne St and Mitchell St)	4.6 hours	1.0 hours	N/A
Paxton St (north of Fitzroy St and south of Geurie Racecourse)	6.3 hours	3.7 hours	N/A
Comobella St (north of Geurie Racecourse)	3.5 hours	N/A	N/A
5% AEP event (with a 120 minute storm duration)			

Location	Small passenger vehicle	Large passenger vehicle	Large 4WD vehicle
The Old Rd (crossing Geurie Ck, east of Mitchell St)	4.5 hours	2.1 hours	N/A
Jennings St (between Severne St and Mitchell St)	2.9 hours	1.7 hours	0.9 hours
Wellington St (between Severne St and Chambers St)	0.2 hours	N/A	N/A
Paxton St (north of Fitzroy St and south of Geurie Racecourse)	4.9 hours	3.4 hours	2.3 hours
Comobella St (north of Geurie Racecourse)	3.4 hours	1.6 hours	N/A
1% AEP event (with a 90 minute storm duration)			
The Mitchell Hwy	1.0 hours	N/A	N/A
The Old Rd (crossing Geurie Ck, east of Mitchell St)	5.0 hours	2.8 hours	1.4 hours
Mitchell St (between the Mitchell Hwy and Wellington St)	0.3 hours	N/A	N/A
Jennings St (between Severne St and Mitchell St)	3.2 hours	2.2 hours	1.6 hours
Wellington St (between Severne St and Chambers St)	0.8 hours	N/A	N/A
Paxton St (north of Fitzroy St and south of Geurie Racecourse)	5.4 hours	3.9 hours	2.9 hours
Comobella St (north of Geurie Racecourse)	4.0 hours	2.5 hours	1.2 hours
0.2% AEP event (with a 90 minute storm duration)			
The Mitchell Hwy	2.7 hours	1.4 hours	0.6 hours
The Old Rd (crossing Geurie Ck, east of Mitchell St)	5.5 hours	3.1 hours	2.3 hours
Mitchell St (between the Mitchell Hwy and Jennings St)	2.0 hours	N/A	N/A
Severne St	1.8 hours	1.2 hours	0.6 hours
Jennings St (between Severne St and Mitchell St)	3.9 hours	3.2 hours	2.9 hours
Wellington St (between Severne St and Chambers St)	2.2 hours	1.7 hours	0.6 hours
Douglas (between the Mitchell Hwy and Jennings St)	0.3 hours	N/A	N/A

Location	Small passenger vehicle	Large passenger vehicle	Large 4WD vehicle
Paxton St (north of Fitzroy St and south of Geurie Racecourse)	5.9 hours	4.4 hours	3.6 hours
Comobella St (north of Geurie Racecourse)	4.5 hours	3.2 hours	2.3 hours

6.5 Flood Hazard

There are two standard industry methods for determining the flood hazard categories as defined by the 2005 Floodplain Development Manual (Ref 6) and 2019 Australian Rainfall and Runoff (Ref 2). Both methods use the depth and velocity product, however they differ in the thresholds applied and the categories denoted.

6.5.1 Floodplain Development Manual Categorisation

The FDM method denotes hazard categories as low hazard or high hazard, with each described as follows:

- High hazard - possible danger to personal safety; evacuation by trucks difficult; able-bodied adults would have difficulty in wading to safety; potential for significant structural damage to buildings.
- Low hazard - should it be necessary, truck could evacuate people and their possessions; able-bodied adults would have little difficulty in wading to safety.

The high hazard category is particularly significant as it is a criteria in regulating complying development as per the State Environmental Planning Policy (SEPP) (Exempt and Complying Development Codes) 2008 (discussed in Section 8.1.6), as well as a criteria in determining voluntary property purchase (discussed in Section 11.2.2.3).

6.5.1.1 Provisional Flood Hazard Methodology

Provisional flood hazard categorisation is based upon the depth-velocity curves shown in Chart 6-1. The provisional flood hazard categorisation for the study area was undertaken as part of the Geurie Flood Study (HydroSpatial, 2020).

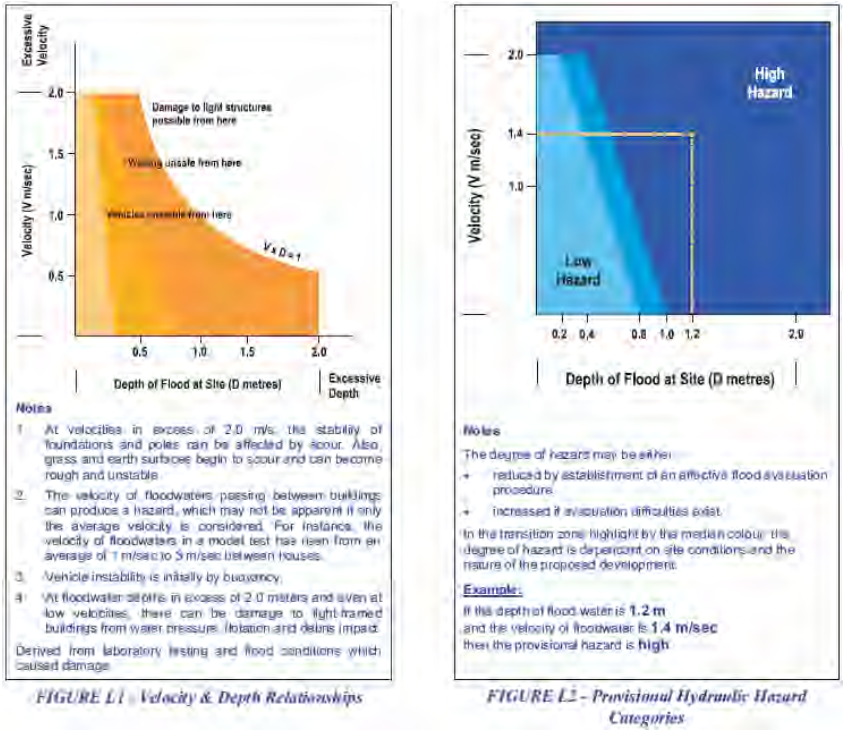


FIGURE L1 - Velocity & Depth Relationships

FIGURE L2 - Provisional Hydraulic Hazard Categories

Chart 6-1: Flood hazard curves (FDM, 2005)

6.5.1.2 True Flood Hazard Methodology

True flood hazard categorisation is based upon the provisional flood hazard categorisations with further refinement to take into consideration the following factors:

- Size of flood;
- Effective warning time;
- Flood readiness;
- Rate of rise of floodwaters;
- Depth and velocity of floodwaters;
- Duration of flooding;
- Evacuation problems;
- Effective flood access; and
- Type of development.

The true flood hazard categorisation for the study area has been undertaken for the 1% AEP event, shown on Figure B 9.

6.5.1.3 Building and Property Affectation

Table 6-4 summarises the number of buildings affected by high flood hazard using the true flood hazard methodology. From this, it was found that events up to and including the 1% AEP event had no buildings affected by high flood hazard.

Table 6-4: FDM flood hazard - building affectation

Design Event	Number of buildings affected by high hazard (using the true flood hazard methodology)
1% AEP	0
0.5% AEP	6
0.2% AEP	11
PMF	76

6.5.2 Australian Rainfall and Runoff Categorisation

This method is defined in both the Australian Rainfall and Runoff Guidelines (Ref 2) and also in the Australian Emergency Management Handbook 7 Guidelines (Ref 1). This method denotes hazard categories as H1, H2, H3, H4, H5 and H6; with the greater risk attributed to the highest category (i.e. H6). These hazard categories are described as follows:

- H1 - Generally safe for vehicles, people and buildings.
- H2 - Unsafe for small vehicles.
- H3 - Unsafe for vehicles, children and the elderly.
- H4 - Unsafe for vehicles and people.
- H5 - Unsafe for vehicles and people. All building types vulnerable to structural damage. Some less robust building types vulnerable to failure.
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.

6.5.2.1 Methodology

The ARR flood hazard categorisation is based upon the depth-velocity curves shown in Chart 6-2. This flood hazard categorisation was undertaken as part of the Geurie Flood Study (HydroSpatial, 2020), with the 1% AEP flood hazard categorisation using this method shown on Figure B 10.

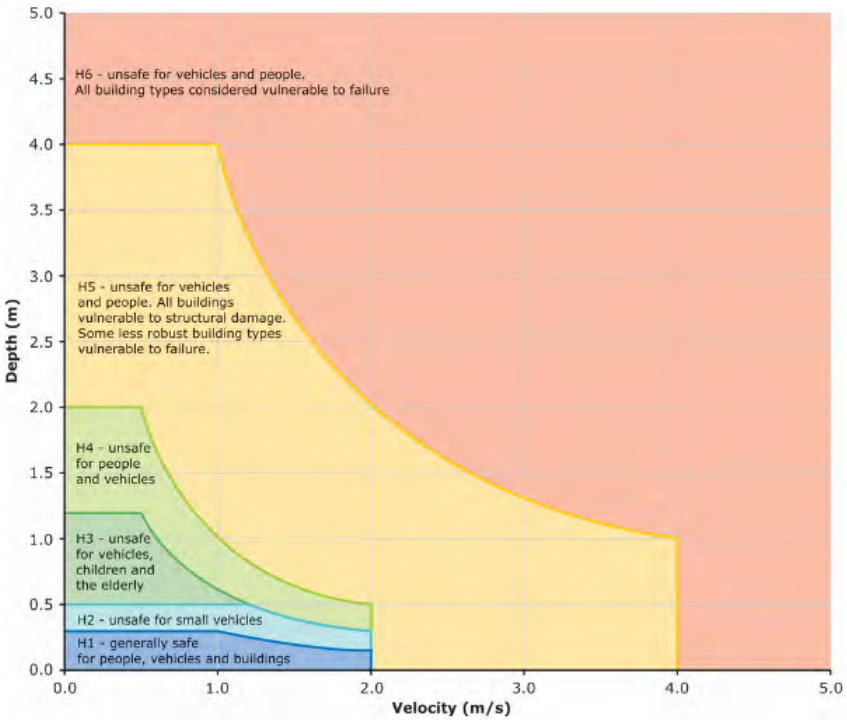


Chart 6-2: Flood hazard curves (ARR, 2019)

6.5.2.2 Building and Property Affectation

The number of buildings and properties affected by the various categories of flood hazard have been investigated for each design event. In the case of the building affectation, this was determined based upon the highest flood hazard category immediately adjacent to the building extent. In the case of the property affectation, this was determined based upon the highest flood hazard category that affected greater than 10% of the property area. Table 6-5 and Table 6-6 summarises the number of buildings and properties affected, respectively.

Table 6-5: ARR flood hazard - building affectation

Design Flood	Number of existing buildings affected					
	H1	H2	H3	H4	H5	H6
20% AEP	98	10	2	0	0	0
10% AEP	100	12	2	0	0	0
5% AEP	96	20	2	0	0	0
2% AEP	90	27	3	1	0	0
1% AEP	86	30	5	0	3	0

0.5% AEP	74	37	5	6	4	0
0.2% AEP	68	35	10	6	7	0
PMF	24	20	5	11	40	33

Table 6-6: ARR flood hazard - property affectation

Design Flood	Number of existing properties affected by >10%					
	H1	H2	H3	H4	H5	H6
20% AEP	174	24	20	32	9	6
10% AEP	168	24	20	42	10	8
5% AEP	170	32	22	43	18	8
2% AEP	162	44	19	46	20	9
1% AEP	147	51	20	44	29	9
0.5% AEP	131	60	24	44	38	9
0.2% AEP	123	52	29	51	44	9
PMF	49	11	8	0	177	97

6.6 Flood Risk

6.6.1 Categorisation

Flood risk is a function of the level of consequence and the likelihood of the consequence occurring. This is illustrated in Chart 6-3 (extracted from the Australian Emergency Management Handbook 7 Guidelines (Ref 1)), which provides a qualitative risk matrix.

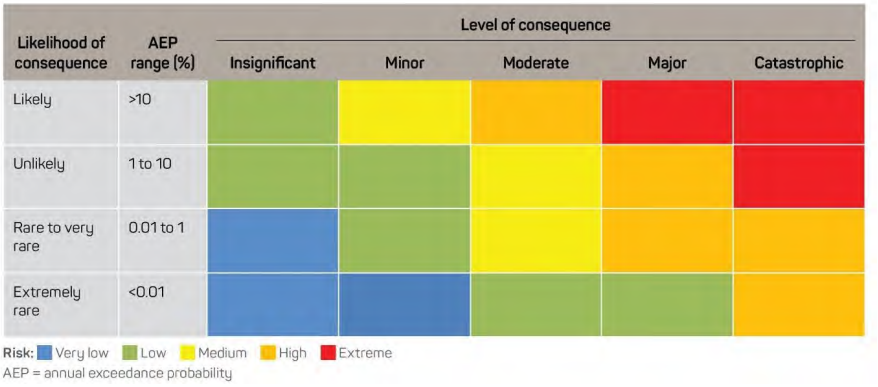


Chart 6-3: Example qualitative risk matrix

This example risk matrix was used in conjunction with the ARR hazard categories (discussed in Section 6.5.2) to define the qualitative flood risk matrix for the study area. This is shown in Table 6-7, whereby the flood risk categories were denoted as:

- Z6 - Extreme risk
- Z5 - High risk
- Z4 - Medium risk
- Z3 - Low risk
- Z2 - Very low risk
- Z1 - Flood free

Table 6-7: Flood risk matrix

Design Flood	Flood risk per hydraulic hazard category					
	H1	H2	H3	H4	H5	H6
20% AEP	Z4	Z5	Z5	Z6	Z6	Z6
10% AEP	Z4	Z5	Z5	Z6	Z6	Z6
5% AEP	Z3	Z4	Z4	Z5	Z6	Z6
2% AEP	Z3	Z3	Z4	Z5	Z5	Z6
1% AEP	Z2	Z3	Z3	Z4	Z5	Z6
0.5% AEP	Z2	Z2	Z3	Z4	Z5	Z6
0.2% AEP	Z2	Z2	Z2	Z3	Z4	Z5
PMF	Z2	Z2	Z2	Z3	Z3	Z4

6.6.2 Building and Property Affectation

The number of buildings and properties affected by the various categories of flood risk have been investigated. In the case of the building affectation, this was determined based upon the highest flood risk category immediately adjacent to the building extent. In the case of the property affectation, this was determined based upon the highest flood risk category that affected greater than 10% of the property area.

Figure B 11 shows the flood risk relative to the property affectation; and Table 6-8 summarises the number of properties affected, the number of the affected properties that contained a building, and the current land zoning of the affected properties.

From this, it was found that Z4 (medium) flood risk category affected the largest number of properties in the study area. By comparison the Z6 (extreme) flood risk category affected the smallest number of properties; and of the properties affected by this flood risk category, none contained an existing building.

Table 6-8: Flood risk affectation

Flood Risk	Number of Properties Affected (total)	Number of Properties Affected (that contain an existing building)	Current Land Zoning of Affected Properties
Z2	44	14	E2 = 3 R5 = 5 RU1 = 8 RU5 = 25 SP2 = 3
Z3	29	17	R5 = 2 RU1 = 3 RU5 = 24
Z4	193	81	E2 = 4 R5 = 13 RE1 = 1 RE2 = 1 RU1 = 50 RU5 = 123 SP2 = 1
Z5	37	5	E2 = 2 R5 = 3 RE2 = 2 RU1 = 26 RU5 = 4
Z6	23	0	E2 = 1 RU1 = 20 RU5 = 2

7 Assessment of Existing Flood Response Arrangements

7.1 Flood Emergency Response Documents

7.1.1 Local Emergency Management Plans

The Dubbo Local Emergency Management Plan (City of Dubbo EMPLAN) (City of Dubbo Council, 2015) and the Wellington Local Emergency Management Plan (Wellington EMPLAN) (Wellington Council, 2016) govern a range of potential hazards across the since amalgamated Dubbo Regional Council area; including flood hazards, fire hazards, and earthquake hazards, etc. The Dubbo EMPLAN and Wellington EMPLAN were prepared in accordance with the State Emergency & Rescue Management Act 1989 by the City of Dubbo Council Local Emergency Management Committee (City of Dubbo LEMC) and the Wellington Council Local Emergency Management Committee (Wellington LEMC) respectively. The purpose of the EMPLANs is to detail the roles and responsibilities of various agencies in an emergency (including preparing for, responding to and recovering from emergencies). The EMPLANs are supported by a collection of hazard/emergency specific sub plans, such as the City of Dubbo Local Flood Plan and the Wellington Local Flood Plan (discussed in Section 7.1.2).

From the EMPLANs, the NSW SES are tasked with the role of combat/responsible agency for both riverine flood emergencies and flash (or overland) flood emergencies in both the former City of Dubbo Council and Wellington Council areas. Across the council area, the NSW SES units available are the NSW SES Dubbo Unit and the NSW SES Wellington Unit.

7.1.2 Flood Emergency Sub-Plans

The City of Dubbo Council Flood Emergency Sub Plan and Wellington Council Flood Emergency Sub Plan were prepared in accordance with the State Emergency Service Act 1989 (NSW) by the NSW SES and the City of Dubbo LEMC and Wellington LEMC respectively. They are the flood specific sub plans that support the Local EMPLANs (discussed in Section 7.1.1).

The Flood Emergency Sub Plans outline the preparation, response, and recovery steps for flood emergencies in the City of Dubbo and Wellington Council areas. It solely focuses on flooding emergencies and details the roles and responsibilities of all parties involved in the event of a flood. They also note key roads that may become flood affected, and lists Council as being responsible for road closures and reopening.

7.2 Evacuation Centres

The City of Dubbo EMPLAN and the Wellington EMPLAN provide details for several evacuation centres across the council areas. The evacuation centre that was located in the study area was the Geurie CWA Hall.

8 Assessment of Existing Flood Planning Policies

8.1 State Government Planning Policies

The role of state government legislation is to provide a robust framework for all local legislation and planning policies to be based upon. Local floodplain management policies must be developed in accordance with relevant state legislation. This section discusses relevant state government legislation regarding flood planning.

8.1.1 NSW Environmental Planning and Assessment Act 1979

The NSW Environmental Planning and Assessment Act 1979 governs the use, development and protection of land in NSW, and is the framework upon which various relevant local government and SES plans are based. The objects of this Act are:

a) *to promote the social and economic welfare of the community and a better environment by the proper management, development and conservation of the State's natural and other resources,*
b) *to facilitate ecologically sustainable development by integrating relevant economic, environmental and social considerations in decision-making about environmental planning and assessment,*
c) *to promote the orderly and economic use and development of land,*
d) *to promote the delivery and maintenance of affordable housing,*
e) *to protect the environment, including the conservation of threatened and other species of native animals and plants, ecological communities and their habitats,*
f) *to promote the sustainable management of built and cultural heritage (including Aboriginal cultural heritage),*
g) *to promote good design and amenity of the built environment,*
h) *to promote the proper construction and maintenance of buildings, including the protection of the health and safety of their occupants,*
i) *to promote the sharing of the responsibility for environmental planning and assessment between the different levels of government in the State,*
j) *to provide increased opportunity for community participation in environmental planning and assessment.*

8.1.2 Ministerial Direction 4.3 (issued 1 July 2009)

As per Section 9.1 of the Environmental Planning and Assessment Act, the Minister for Planning issued direction 4.3 in July of 2021 to local governments requiring they implement the NSW Flood Prone Land Policy into their Local Environmental Plans.

The objectives of the direction and obligations of relevant planning authorities in relation to the direction are:

Objectives

1) *The objectives of this direction are:*
   a) *to ensure that development of flood prone land is consistent with the NSW Government's Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005.*
   b) *to ensure that the provisions of an LEP that apply to flood prone land are commensurate with flood behaviour and includes consideration of the potential flood impacts both on and off the subject land.*

Where this direction applies

2) *This direction applies to all relevant planning authorities that are responsible for flood prone land within their LGA.*

When this direction applies

3) *This direction applies when a planning proposal authority prepares a planning proposal that creates, removes or alters a zone or a provision that affects flood prone land.*

What a relevant planning authority must do if this direction applies

4) *A planning proposal must include provisions that give effect to and are consistent with*
   a) *the NSW Flood Prone Land Policy,*
   b) *the principles of the Floodplain Development Manual 2005,*
   c) *the Considering the flooding in land use planning guideline 2021, and*
   d) *any adopted flood study and/or floodplain risk management plan prepared in accordance with the principles of the Floodplain Development Manal 2005 and adopted by the relevant council.*
5) *A planning proposal must not rezone land within the flood planning area from Recreation, Rural, Special Purpose or Environmental Protection Zones to a Residential, Business, Industrial or Special Purpose Zones.*
6) *A planning proposal must not contain provisions that apply to the flood planning area which:*
   a) *permit development in floodway areas,*
   b) *permit development that will result in significant flood impacts to other properties,*
   c) *permit development for the purpose of residential accommodation in high hazard areas,*
   d) *permit a significant increase in the development and/or dwelling density of that land,*
   e) *permit development for the purpose of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate,*
   f) *permit development to be carried out without development consent except for the purposes of exempt development or agriculture. Dams, drainage canals, levees, still require development consent,*
   g) *are likely to result in a significantly increased requirement for government spending on emergency management services, flood mitigation and emergency response measures, which can include but are not limited to the provision of road infrastructure, flood mitigation infrastructure and utilities, or*
   h) *permit hazardous industries or hazardous storage establishments where hazardous materials cannot be effectively contained during the occurrence of a flood event.*
7) *A planning proposal must not contain provisions that apply to areas between the flood planning area and probable maximum flood to which Special Flood Considerations apply which:*
   a) *Permit development in floodway areas,*
   b) *Permit development that will result in significant flood impacts to other properties,*
   c) *Permit a significant increase in the dwelling density of that land,*
   d) *Permit the development of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate,*
   e) *Are likely to affect the safe occupation of and efficient evacuation of the lot, or*
   f) *Are likely to result in the significantly increased requirement for government spending on emergency management services, and flood mitigation and emergency response measures, which can include but not limited to road infrastructure, flood mitigation infrastructure and utilities.*
8) *For the purposes of preparing a planning proposal, the flood planning area must be consistent with the principles of the Floodplain Development Manual 2005 or as*

otherwise determined by a Floodplain Risk Management Study or Plan adopted by the relevant council.

Consistency

9) *A planning proposal may be inconsistent with this direction only if the planning proposal authority can satisfy the Secretary of the Department of Planning, Industry and Environment (or their nominee) that:*
   a) *the planning proposal is in accordance with a floodplain risk management study or plan adopted by the relevant Council in accordance with the principles and guidelines of the Floodplain Development Manual 2005, or*
   b) *where there is no council adopted floodplain risk management study or plan, the planning proposal is consistent with the flood study adopted by the council prepared in accordance with the principles of the Floodplain Development Manual 2005 or*
   c) *the planning proposal is supported by a flood and risk impact assessment accepted by the relevant planning authority and is prepared in accordance with the principles of the Floodplain Development Manual 2005 and consistent with the relevant planning authorities' requirements, or*
   d) *the provisions of the planning proposal that are inconsistent are of minor significance as determined by the relevant planning authority.*

Note: In this direction:

   a) *"flood prone land" "flood storage" "floodway" and "high hazard" have the same meaning as in the Floodplain Development Manual 2005.*
   b) *"flood planning level" "flood behaviour" and "flood planning area" has the same meaning as in the Considering flooding in land use planning guideline 2021.*
   c) *Special flood considerations are outlined in the Considering flooding in land use planning guideline 2021 and an optional clause in the Standard Instrument (Local Environmental Plans) Order 2006.*
   d) *Under the floodplain risk management process outlined in the NSW Government's Floodplain Development Manual 2005, councils may produce a flood study followed by a floodplain risk management study and floodplain risk management plan.*

8.1.3 NSW Flood Prone Land Policy (2005)

The Floodplain Development Manual supports the NSW the NSW Government's Flood Prone Land Policy in its goal of developing sustainable strategies for human occupation and use of floodplains. The manual was primarily written for the use of local governments, providing guidance for the undertaking of flood studies and floodplain risk management plans.

The *Floodplain Development Manual* details the roles and responsibilities of various NSW agencies and includes information on:

- *the preparation of flood studies, floodplain risk management studies and plans;*
- *floodplain risk management options;*
- *flood planning levels and areas;*
- *hydraulic and hazard categorisation; and*
- *emergency response planning.*

8.1.4 Planning Circular PS 21-006

Planning Circular PS 21-006 (14 July 2021) replaces Planning Circular PS 07-003, and acts as an overview of various changes made regarding flood related land use planning and constraints. These changes include:

- An amendment to clause 7A of Schedule 4 to the *Environmental Planning and Assessment Regulation 2000* that requires councils include a notation on section10.7

planning certificates if the land or part of the land is within the flood planning area or between the FPA and the PMF.

- A revised local planning direction regarding flooding issued under section 9.1 of the *Environmental Planning and Assessment Act 1979* which removes the need for exceptional circumstances when applying flood-related residential development controls above the 1% AEP flood level. It also ensures planning proposals consider flood risks and do not permit residential accommodation in high hazard areas and other land uses on flood prone land where the development cannot effectively evacuate, as well as making provision for special flood considerations where councils have chosen to adopt the optional Special flood considerations clause in an LEP.
- Two local environmental plan (LEP) clauses which introduce flood related development controls, namely the Flood Planning and Special Flood Considerations clauses.
- The implementation of a new guideline *Considering Flooding in Land Use Planning (2021)*
- Revoking the *Guideline on Development Controls on Low Flood Risk Areas (2007)*.

8.1.5 Considering Flooding in Land Use Planning (2021)

The NSW Department of Planning, Industry and Environment published the Considering Flood in Land Use Planning guideline in July of 2021 in order to provide advice to councils on flood-related land use planning and outline the two newly introduced Flood Planning and Special Flood Considerations LEP clauses.

The Flood Planning clause is a mandatory provision for local environmental plans, and introduces the Flood Planning Areas (FPAs) category for flood-related development controls, the clause defines:

- Flood Planning Area as *the area of land at or below the flood planning level (FPL)*,
- Flood Planning Level as *a combination of the flood level from the defined flood event (DFE) and freeboard selected for flood risk management purposes*, and
- Defined Flood Event as *the flood event selected as a general standard for the management of flooding to development* (with the manual identifying the 1% AEP flood event, or an equivalent historic flood, as an appropriate starting point for determining the DFE).

This clause allows councils to define multiple FPAs/FPLs when applicable based on factors such as differing flood risks in different catchments as identified through the FRM process, or differing land use types (for example, residential, industrial, commercial developments).

The Special Flood Considerations clause is an optional provision for local environmental plans. It allows for the addition of particular flood risk considerations that must be satisfied to obtain consent for certain types of development that have been identified by councils and the state government as having a higher risk to life and warranting the consideration of the impacts of rarer flood events on land located outside the FPA. The special flood considerations include that the development:

1) *will not affect the safe occupation of and efficient evacuation of people in the event of a flood, and*
2) *incorporates appropriate measures to manage risk to life from flood, and*

will not adversely affect the environment in the event of a flood.

8.1.6 State Environmental Planning Policy 2008 – Exempt and Complying Development Codes

The State Environmental Planning Policy (SEPP) aims to provide streamlined assessment processes for development that complies with specified development standards by providing exempt and complying development codes that have State-wide application. Developments that pose minimal environmental impact do not require development consent.

Part 3A Division 3 Subdivision 9 Section 3A.38 of the SEPP relates to Complying Development n "flood control lots", which must satisfy the following criteria:

1) *Development under this code must not be carried out on any part of a flood control lot, other than a part of the lot that the council or a professional engineer who specialises in hydraulic engineering has certified, for the purposes of the issue of the complying development certificate, as not being any of the following–*
    a) *A flood storage area,*
    b) *A floodway area,*
    c) *A flow path,*
    d) *A high hazard area,*
    e) *A high risk area.*
2) *Development that is carried out under this code on any part of a flood control lot must meet the following requirements–*
    a) *if there is a minimum floor level adopted in a development control plan by the relevant council for the lot, the development must not cause any habitable room in the dwelling house to have a floor level lower than that floor level,*
    b) *any part of the dwelling house or any ancillary development that is erected at or below the flood planning level is constructed of flood compatible material,*
    c) *any part of the dwelling house or any ancillary development that is erected is able to withstand the forces exerted during a flood by water, debris and buoyancy up to the flood planning level (or if an on-site refuge is provided on the lot, the probable maximum flood level),*
    d) *the development must not result in increased flooding elsewhere in the floodplain,*
    e) *the lot must have pedestrian and vehicular access to a readily accessible refuge at a level equal to or higher than the lowest habitable floor level of the dwelling house,*
    f) *vehicular access to the dwelling house will not be inundated by water to a level of more than 0.3m during a 1:100 ARI (average recurrent interval) flood event,*
    g) *the lot must not have any open car parking spaces or carports lower than the level of a 1:20 ARI (average recurrent interval) flood event.*
3) *The requirements under subclause (2)(c) and (d) are satisfied if a joint report by a professional engineer specialising in hydraulic engineering and a professional engineer specialising in civil engineering states that the requirements are satisfied.*

8.2 Local Government Planning Policies

It is important for local Councils to ensure land use and development is compatible with flood risk and does not increase the impact of flooding or the damage to public or private assets associated with flooding.

Environmental planning tools, such as Local Environmental Plans (LEPs) guide planning decisions for local government areas. This is done through zoning and development controls that provide a framework for the way land can be used and developed. Development Control Plans (DCPs) are a planning tool that provides detailed planning and design guidelines to support the planning controls detailed in the LEPs.

LEPs are made under the *Environmental Planning and Assessment Act 1979*. All LEPs should conform to a standard format. This standardisation was initiated by the NSW state government in 2006, through the Standard Instrument LEP program.

8.2.1 Council Formation

Dubbo Regional Council was formed in 2016 as part of the NSW state government's push for Council amalgamations. This local government area encompasses the former City of Dubbo

Council and former Wellington Council. The City of Dubbo Council was located to the north-west and included the City of Dubbo, as well as the Eumungerie, Mogriguy, Brocklehurst, Wongarbon, Toongi and Rawsonville villages. Wellington Council was located to the south-east and included the townships of Wellington, Maryvale, Geurie, North Yeoval, Dripstone, Mumbil, Stuart Town and Euchareena.

The Dubbo Regional Council planning controls, including the LEPs and DCPs are still separated according to the former Council areas. The flood objectives for the City of Dubbo and the Wellington LEPs are very similar; but the objectives, planning approach and controls of the two DCPs vary considerably.

In July of 2021, both the City of Dubbo and Wellington LEPs were amended to replace their previously differing flood planning sections with new, identically worded flood planning clauses as per Standard Instrument (Local Environmental Plans) Amendment (Flood Planning) Order 2021. Section 8.2.2 below outlines the flood planning clause found in both the City of Dubbo LEP and the Wellington LEP. Section 8.2.3 and 8.2.4 below outlines the flood controls specific to the City of Dubbo DCP and the Wellington DCP.

8.2.2 City of Dubbo Local Environmental Plan 2011 and Wellington Local Environment Plan 2012

The City of Dubbo Local Environmental Plan was adopted in November 2011, and the Wellington Local Environmental Plan was adopted in November 2012; with both amended in July 2021. In both of these LEPs, the flood controls are stated in Clause 5.21 of each as follows:

1) *The objectives of this clause are as follows–*
    a) *to minimise the flood risk to life and property associated with the use of land,*
    b) *to allow development on land that is compatible with the flood function and behaviour on the land, taking into account projected changes as a result of climate change,*
    c) *to avoid adverse or cumulative impacts on flood behaviour and the environment,*
    d) *to enable the safe occupation and efficient evacuation of people in the event of a flood.*
2) *Development consent must not be granted to development on land the consent authority considers to be within the flood planning area unless the consent authority is satisfied the development–*
    a) *is compatible with the flood function and behaviour on the land, and*
    b) *will not adversely affect flood behaviour in a way that results in detrimental increases in the potential flood affectation of other development or properties, and*
    c) *will not adversely affect the safe occupation and efficient evacuation of people or exceed the capacity of existing evacuation routes for the surrounding area in the event of a flood, and*
    d) *incorporates appropriate measures to manage risk to life in the event of a flood, and*
    e) *will not adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.*
3) *In deciding whether to grant development consent on land to which this clause applies, the consent authority must consider the following matters–*
    a. *the impact of the development on projected changes to flood behaviour as a result of climate change,*
    b. *the intended design and scale of buildings resulting from the development,*
    c. *whether the development incorporates measures to minimise the risk to life and ensure the safe evacuation of people in the event of a flood,*

d. the potential to modify, relocate or remove buildings resulting from development if the surrounding area is impacted by flooding or coastal erosion.

4) *A word or expression used in this clause has the same meaning as it has in the Considering Flooding in Land Use Planning Guideline unless it is otherwise defined in this clause.*
5) *In this clause–*
   a) *Considering Flooding in Land Use Planning Guideline means the Considering Flooding in Land Use Planning Guideline published on the Department's website on 14 July 2021.*
   b) *flood planning area has the same meaning as it has in the Floodplain Development Manual.*
   c) *Floodplain Development Manual means the Floodplain Development Manual (ISBN 0 7347 5476 0) published by the NSW Government in April 2005.*

8.2.3 City of Dubbo Development Control Plan 2013

The City of Dubbo Development Control Plan was adopted in May 2013 and applies to land which was previously part of City of Dubbo Council. The purpose of this DCP is to provide planning and design guidelines to support the planning controls detailed in the City of Dubbo LEP 2011. Provision 7 of Element 7 of Part 2.1.3 of the DCP relates to flooding in residential development and subdivisions and states that:

- *P7.1 Where residences (new or existing) are proposed in flood-affected areas, these shall be protected from flood waters.*
- *P7.2 Flood-ways are developed in a manner which ensures that there is a low risk of property damage.*
  - *A7.1 Ground floors of residences are located at or above the 'flood planning level' to provide protection to life and property in accordance with the accepted level of risk.*

Element 5 of Part 2.4.8 of the DCP relates to flooding in rural development and subdivisions. The objectives of this section of the DCP are:

- *To manage the floodplain so as to minimise the impact and hazard of flooding to people and the environment and to allow for water distribution to and from flood dependent environments.*

In accordance with this section of the DCP, the performance criteria and associated acceptable solutions are:

- *P1 Development is located away from watercourses and flood-prone land and does not adversely impede the flow of flood waters.*
  - *A1.1 Consultation with Council's Environmental Services Division and local residents regarding available information on previous flood events.*
  - *A1.2 Decommission/relocation of equipment, chemicals, fuel and effluent disposal systems.*
  - *A1.3 Development is located on land above the impact of the 1% AEP flood event.*
- *P2 A Flood Evacuation Plan has been prepared.*
  - *A2.1 A Flood Evacuation Plan is developed for all developments likely to be affected by flooding. The Flood Evacuation Plan should address but not be limited to such things as:*
    - *Identification of flood hazard;*
    - *Flood response times;*
    - *Assembly areas for all persons;*
    - *Means of evacuation;*
    - *Removal of stock and possessions;*
    - *Alternative accommodation; and*

- *Required assistance from emergency services.*

8.2.4 Wellington Development Control Plan 2013

The Wellington Development Control Plan was adopted in July 2013 and applies to land which was previously part of Wellington Council. The purpose of this DCP is to provide planning and design guidelines to support the planning controls detailed in the Wellington LEP 2012.

Part C2 of the DCP relates to Flood Hazard and aims to reduce the impact of flooding and flood liability on individuals, owners and occupiers of flood prone land, as well as minimise risk to human life and damage to property by controlling development on flood prone land. The objectives of this section of the DCP are:

1) *To minimise risk to human life and damage to property by controlling development on flood prone land.*
2) *To ensure that all land uses and essential services are appropriately sited and designed in recognition of all potential floods and inundation.*
3) *To ensure that development on the floodplain or waterway does not adversely affect the amenity or ecology of an area.*
4) *Provide guidelines, for the use and development of land subject to all potential floods in the floodplain or waterway, which reflect the probability of the flood occurring and the potential hazard within different areas.*

In accordance with these objectives, all land within the Wellington Local Government Area is subject to the following development requirements for building in river floodplains:

1) *Generally, Council will exclude all new residential development from land mapped as flood prone. Exception may be granted where the land is an existing lot zoned for urban use and in separate ownership prior to 2012. Council must be satisfied that a safe dwelling site can be provided, ensuring compliance with the requirements of point 7 below.*
2) *Other development only permissible within high flow areas if the development will not change ground levels by more than 300mm (for local drainage purposes) or obstruct flood flows.*
3) *A flood free dwelling site of natural surface at least 1.5 metres above recorded flood level must exist on each new allotment created. The construction of a flood free dwelling site will be permitted only where it can be demonstrated that such work will not have any adverse effects on floodwaters in the locality.*
4) *The development will not unduly restrict or increase the level and flow behaviour of floodwaters and stormwater runoff in the vicinity.*
5) *The development will not exacerbate the consequences of floodwaters flowing on the land with regard to erosion, siltation and destruction of vegetation.*
6) *Council may approve development where filling of flood-prone land is required. A flood study, completed by a suitable qualified engineer, must accompany the development application. The study should substantiate that the proposed development will not alter flood behaviour.*
7) *Additional requirements for buildings on flood prone land:*
    a) *The floor level of any building located on flood-liable land shall be confirmed by Survey Certificate prepared by a Registered Surveyor. The Survey Certificate shall be lodged prior to proceeding with construction above flood level.*
    b) *Where ground level, at any building site, is below Designated Flood level, the structure below flood level shall be constructed from flood-compatible materials and shall be certified by a suitably engineer as being capable of withstanding the floods and conditions likely to occur in the Designated Flood event.*
    c) *All building services shall have outlets, switches, junctions, and any features susceptible to flood damage, sited above the flood planning level.*
    d) *Where a development site has been filled and the finished ground level is less than 0.5m above Recorded Flood level, minimum floor levels shall apply to all*

structures erected on the filled area of 1 metre above recorded level for commercial buildings and 1.5 metres for residential.

e) *Gully traps on all structures shall be a minimum of 0.3m above recorded Flood level.*

Similarly, all land within the Wellington Local Government Area is subject to the following development requirements for building in an unmapped water course:

1) *Controls also apply where development is located in the base of any watercourse or where land is known to be subject to flood and/ or inundation.*
2) *If practicable, where residential land includes unmapped watercourses, development should be placed outside the likely channel of peak flow.*
3) *New subdivisions must demonstrate all dwelling sites are clear of any drainage line.*
4) *Where it is not possible in an existing urban lot to accommodate development outside of the drainage line, physical drainage protection measures may be required such as piping the water course and Council may require an engineering report as to likely cross- section flow in 1/100 Annual Recurrence Level events. A floor level may then be required 500 mm above such level.*

8.2.5 Flooding in Geurie Council Policy 2017

Dubbo Regional Council adopted the Flooding in Geurie Council Policy in March 2017. This policy describes the history and reasons for flooding at Geurie, as well as defining certain flood affectation types, and laying out specific flood controls for development in the area.

The policy lists the surrounding creeks whose catchment areas affect flooding in Geurie; namely Boori Creek, Geurie Creek, Heatherbrae Creek and Limestone Creek. It describes flooding within the Geurie Village to be a result of surface water from these creek catchments, as well as runoff generated within the village.

The policy includes development controls specific to multiple types of flood affectation, including high hazard floodways, low hazard flood fringes, as well as overland flow of floodwater and stormwater. These controls state that:

- Development on land classified as a high hazard floodway is unlikely to be approved by Council, however any development applications for this land type are required to include a detailed flood study and hydraulic analysis prepared by a suitably qualified hydrological engineer.
- Development on land classified as a low hazard flood fringe must have a minimum floor height of 500 mm above the 1% AEP peak flood level. Additionally, any development applications for this land type are required to include a site survey, development plans showing the floor height including details of overland flooding, and details of any boundary or internal fencing.

Additionally, in order to maintain the flow of floodwater and stormwater during a flood event, the following measures are applicable to all development in the Geurie urban area and surrounding lands:

- *Fencing, including boundary fencing shall be provided in a manner so as to not obstruct the flow of water.*
- *Fencing, including boundary fencing shall be provided with an open area at the bottom of the fence (adjacent to the ground level) of no less than 500 mm, to allow for the flow of water.*
- *The 500 mm open area can be provided with netting or another alternative movable component that can be easily opened or moved to allow for the flow of water and debris. Any netting or other suitable component shall be tied or fastened on the downstream side to allow for easy removal prior to, or during a flooding event.*
- *New driveway levels at the road frontage (allotment boundary) should be raised to minimise the level of water entering the property from the roadway to a minimum of 300 mm to enable the level of the adjacent road water table level.*

9 Review of Flood Planning Area and Level

9.1 Overview

Flood Planning Areas (FPA) and Flood Planning Levels (FPL) facilitate future Council assessments of proposed developments. The FPA identifies parcels of land that are subject to Section 10.7 flood-related development controls. The FPL identifies the minimum floor level required for proposed developments on parcels of land classified as within the FPA.

The Floodplain Development Manual recommends that the FPL be based upon the 1% AEP peak flood level plus a freeboard. Typically, a 0.5 m freeboard is applied; although the Manual does allow for a lower freeboard to be applied if local conditions justify doing so. Of further consideration is also the difference between riverine flood behaviour and local overland flood behaviour, with the former typically being the basis on which FPA and FPL methodologies have been developed and applied. Often these differences are seen in how great the difference in peak flood levels are between different magnitude events, whereby riverine flood levels vary to a greater degree between events whereas overland flood levels vary to a much smaller degree. As such, applying the typical freeboard of 0.5 m to overland flood levels can result in an FPL that is significantly greater than the PMF level and areas outside the PMF extent being identified within the FPA.

9.2 Methodology

As the current study investigates both mainstream and overland flooding in the study area, the FPA and FPL has been defined for each flood mechanism.

Mainstream flooding was defined as flooding along the established creek lines (such as Geurie Creek and Boori Creek). The mainstream FPL and FPA extent was classified as areas affected by the 1% AEP mainstream flooding plus 0.5 m freeboard.

Overland flooding was defined as flooding where the 1% AEP peak flood depth was greater than 0.15 m. The overland FPA extent was classified as areas where overland flooding affected 10% or more of the area of a property. The overland FPL was defined as the 1% AEP peak flood level plus a freeboard of 0.3 m.

10 Consequences of Flooding

10.1 Overview

Flood damages (or the consequences of flooding) are typically broken down into four categories; tangible direct, tangible indirect, intangible direct and intangible indirect. Tangible damages are those that can be quantified in a monetary sense, such as the cost of rebuilding a house. Whereas intangible damages are generally difficult to quantify in terms of dollar value, such as the stress placed on families and business owners as a result of flooding. In-direct damages are those damages that occur but are not a direct result of flood waters, for example the loss of business after a flood occurs. This is shown graphically in Chart 10-1.

Chart 10-1: Flood damage representation (Source - UNISDR: Prevention Web, Direct and Indirect Losses, 2014)

The economic impacts, social impacts and heritage impacts as a result of flooding are discussed in the following.

10.2 Economic Impacts

10.2.1 Methodology

There are a number of methods available for calculating tangible, direct flood damages, including; the Rapid Appraisal Method (RAM), ANU FLOOD Method and the depth-damage curves developed by the NSW Government (2007).

The tangible, direct flood damages to residential property were calculated using the depth-damage curves developed by the NSW Government (2007). This method requires a number of parameters to be specified for the catchment, which is discussed in Section 10.2.1.1.

The tangible, direct flood damages to commercial property were calculated using the depth-damage curves from the ANUFLOOD method. This method requires a number of parameters to be specified for the properties, which is discussed in Section 10.2.1.2.

These depth-damage relationships were then intersected with the number of properties affected by above floor flooding (with the floor level estimation discussed in Section 10.2.1.3) and above ground flooding (with the flood level estimation to be the maximum flood level from within a 3m radius of the building for each flood event was then assigned to each building) to estimate the total tangible, direct flood damages within the study area.

The tangible, indirect flood damages to both residential and commercial properties were calculated as 15% of the tangible, direct flood damages.

10.2.1.1 Residential Depth-Damage Relationship

The NSW Government (2007) method calculates the depth-damage relationship based upon a number of parameters, the values and description of which is shown in Table 10-1.

Table 10-1: Residential damage parameters

Input Parameter	Value Adopted	Explanation
Regional Cost Variation Factor	1.08	Costs adjusted based on Rawlinsons (2019) for both Dubbo and Wellington.
Post 2001 Adjustment Factor	1.83	Costs adjusted to account for changes to average weekly earnings since the estimates were calculated in 2001, based on the Australian Bureau of Statistics data from November 2019
Post Flood Inflation Factor	1.3	Ranges from 1.0 to 1.5 (NSW Government, 2007), based on the recommended factor for medium scale impacts on a regional town
Typical House Size	220 m^2	Based upon the digital schematisation of buildings in the study area from the aerial photography.
Typical Duration of Immersion	6 hours	
Building Damage Repair Limitation Factor	0.85	Based on a short duration flood event.
Average Contents Value	$55,000	Based upon the typical house size in the study area.
Contents Damage Repair Limitation Factor	0.9	Based on a long duration flood event.
Typical Table/Bench Height	0.9 m	0.9 m is the default.
Level of Flood Awareness	Low	'Low' is the default.
Effective Warning Time	0 hours	Given the relatively short duration and localised nature of the storm events that cause flooding in the study area, little to no warning time is available.

These input parameters resulted in the following residential depth-damage curves.

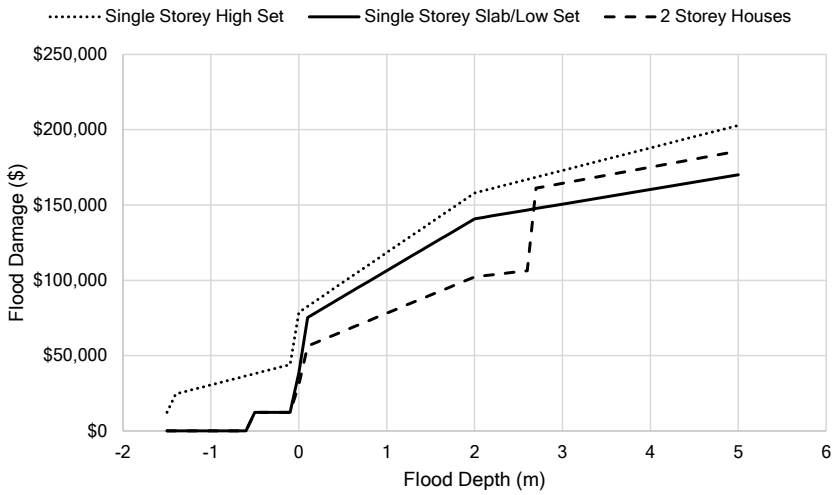
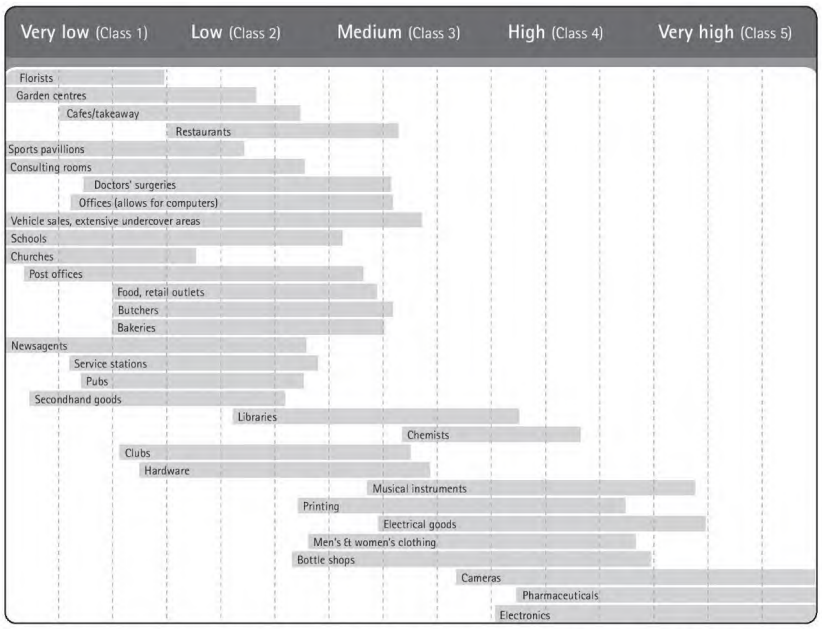


Chart 10-2: Residential depth-damage curves

10.2.1.2 Non- Residential Depth-Damage Relationship

The ANUFLOOD method calculates the depth-damage relationship based upon the size of the commercial property and the commercial usage of the property. The commercial property sizes are classified as either small commercial (less than 186 m2), medium commercial (between 186 m^2 to 650 m^2), or large commercial (greater than 650 m2). The commercial usage is classified as either Class 1 (very low), Class 2 (low), Class 3 (medium), Class 4 (High), or Class 5 (very high); as shown in Chart 10-3.



Reproduced from Centre for Resource and Environmental Studies (Australian National University) 1992, ANUFLOOD: A Field Guide, *prepared by D.I. Smith and M.A. Greenaway, Canberra.*

Chart 10-3: Commercial damage categories based on the commercial usage of the property

Within the Geurie study area it was found that all the commercial properties were within the Class 2 category, with varying commercial property sizes. This resulted in the following commercial depth-damage curves.

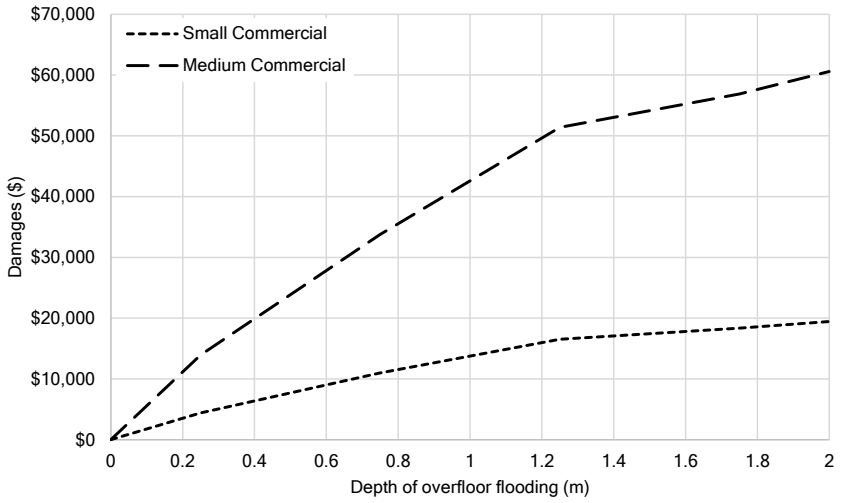


Chart 10-4: Commercial depth-damage curves

10.2.1.3 Floor Level Estimation

Floor levels were estimated using Google Street View and the LiDAR data. Google Street View images were interrogated for each house within the study area to estimate the height above ground level of the lowest habitable floor based upon the entryway door. The estimated floor height above ground level was then intersected with the LiDAR surveyed ground level to produce an estimated floor level. However, buildings identified as sheds were excluded from the assessment.

10.2.2 Residential and Non-Residential Damage Results

The direct damages as a result of flooding have been calculated for each individual flood event (including the 20% AEP, 10% AEP, 5% AEP, 2% AEP, 1% AEP, 0.5% AEP and PMF events). The Average Annual Damages (AAD) and Net Present Value (NPV) of these direct flood damages have also been calculated. AAD is a measure of the average damage due to flooding experienced by an area over a large period of time. This is to account for the different amount of damage caused by different events of varying magnitude (i.e. large, less frequent floods generally cause more damage than small, more frequent floods). The AAD per annum in present terms is then adopted for each year of the NPV of damages estimation (assuming a 50 year economic life).

Table 10-2 details the direct flood damages due to flooding within the study area. From this, the AAD was $202,988 and the NPV was $3,004,377.

Table 10-2: Direct flood damages

Event (AEP)	Affected by Above Ground Flooding	Affected by Above Floor Flooding	Tangible, Direct Damages	Intangible, Direct Damages	Total Direct Damages
PMF					
Residential	109	52	$7,825,925	$1,173,889	$8,999,814
Commercial	15	12	$353,836	$53,075	$406,911
Sub-Total	124	64	$8,179,761	$1,226,964	$9,406,725
0.5% AEP					
Residential	99	19	$3,728,014	$559,202	$4,287,216
Commercial	15	4	$63,132	$9,470	$72,602
Sub-Total	114	23	$3,791,146	$568,672	$4,359,818
1% AEP					
Residential	98	10	$3,255,345	$488,302	$3,743,647
Commercial	15	3	$22,758	$3,414	$26,172
Sub-Total	113	13	$3,278,103	$491,716	$3,769,819
2% AEP					
Residential	95	5	$2,838,482	$425,772	$3,264,254
Commercial	14	3	$22,758	$3,414	$26,172
Sub-Total	109	8	$2,861,240	$429,186	$3,290,426
5% AEP					
Residential	50	-	$1,348,018	$202,203	$1,550,220
Commercial	14	-	$-	$-	$-
Sub-Total	64	-	$1,348,018	$202,203	$1,550,220
10% AEP					
Residential	50	-	$1,340,557	$201,084	$1,541,640
Commercial	12	-	$-	$-	$-
Sub-Total	62	-	$1,340,557	$201,084	$1,541,640
20% AEP					
Residential	50	-	$1,339,065	$200,860	$1,539,924
Commercial	11	-	$-	$-	$-
Sub-Total	61	-	$1,339,065	$200,860	$1,539,924

10.3 Social Impacts

The social impact of flooding was assessed by considering the impact of flood events on key locations of importance to the community. Through analysing flooding behaviours, it was found that Geurie Public School and Geurie Police Station did not experience flooding in any of the events modelled. As the Geurie Waste Depot was outside of the hydraulic extent, the extent of flooding at this location is unknown.

10.4 Heritage Impacts

Through analysing the flood behaviour in relation to non-Indigenous Australian cultural heritage sites, it was found that:

- The Geurie Grandstand was found to experience depths of up to 0.5 m in the 20% AEP flood event, and was fully inundated in the PMF event.
- The Union Church and Hall, the Cobborah Shire Building, Geurie Antiques and the Garden Café all experienced partial flooding of less than 0.15 m in the 20% AEP event.
- The CBC Bank building experienced partial flooding of less than 0.15 m in the 5% AEP event.
- The Garden Café, CBC Bank building and Geurie Antiques experienced flooding of up to 0.3 m in the 2% AEP event.
- The Garden Café, CBC Bank building and Geurie Antiques experienced flooding of up to 0.5 m in the 0.5% AEP event.
- The Cobborah Shire building experienced flooding of up to 0.5 m in the PMF event, while the Garden Café, CBC Bank building and Geurie Antiques experienced flooding of up to 2 m in the PMF event.

Similarly, the flood behaviour in relation to the Indigenous Australian cultural heritage sites was analysed, and it was found that:

- A resource-gathering site and artefact site located to the south of Geurie town, and between Arthurville Road were found to experience flood depths less than 0.15 m in the 20% AEP event, with the artefact site experiencing depths of up to 0.3 m in the PMF event.
- A separate artefact site in the same general location experienced depths of up to 0.5 m in the PMF event.
- Two artefact sites located to the south of Geurie town, along the Eastern bank of Geurie Creek, experienced depths of up to 2 m in the PMF event.

11 Floodplain Risk Management Measures

11.1 Overview

The NSW Floodplain Development Manual (NSW Government, 2005), categorises the modification measures that can be investigated to mitigate the flood risks to a community as:

- Flood Modification Measures - These options aim to reduce flood risk by altering the flood behaviour, such as decreasing flood levels, velocities or extents.
- Property Modification Measures – These options aim to reduce flood risk by altering the existing properties and/or imposing planning controls to future properties.
- Response Modification Measures - These options aim to reduce flood risk by altering the way the community responds to a flood event.

The mitigation measures identified and investigated in this study span the range of mitigation measures (i.e. flood, property and response) and are discussed in the following.

11.2 Options Identified

11.2.1 Potential Flood Modification Measures

11.2.1.1 Option FM01 - Detention basin within Wise Park

This option was for the construction of an open, grassed detention basin in Wise Park. This included excavation of the park grounds to be level with the open concrete-lined channel invert downstream of the detention basin (with battered sides to the base of the detention basin), and re-grassing and landscaping the park. It also includes the construction of an earthen embankment along the northern and eastern edges of the basin. Figure C 1 shows the location and schematisation of this detention basin.

11.2.1.2 Option FM02 - Detention basin under Geurie Tennis Courts

This option involved the construction of an underground detention basin under Geurie Tennis Courts. This included excavation of the tennis courts, installation of a prefabricated detention basin, installation of a 600mm diameter pipe into the detention basin (from Boori Creek, to run along the southern side of Wellington Street) and installation of a 450 mm diameter pipe out of the detention basin (into Boori Creek, upstream of Jennings Street). This option also included the reinstallation of the affected tennis courts. Figure C 2 shows the location and schematisation of this detention basin and pipes.

11.2.1.3 Option FM03 - Detention basin within Tom Culkin Oval

This option was for the construction of an open, grassed detention basin in Tom Culkin Cricket Oval. This included excavation of the park grounds (with battered sides to the base of the detention basin), and re-grassing and landscaping the park. It also included installation of a 600mm diameter pipe into the detention basin (from Boori Creek, to run along the southern side of Wellington Street) and installation of a 450 mm diameter pipe out of the detention basin (into Geurie Creek). Additionally, this option includes the construction of shallow swales along Jennings Street and Severne Street (with a 150mm diameter culvert installed at the intersection of the two streets) to Geurie creek, as well as a small earthen embankment along the southern edge of Jennings Street between Boori Creek and the Severne Street intersection to direct overflow from the detention basin. Figure C 3 shows the location and schematisation of this detention basin and pipes.

11.2.1.4 Option FM04 - Detention basin within 72 Severne Street

This option was for the construction of an open, grassed detention basin within 72 Severne Street. This included excavation of the park grounds (with battered sides to the base of the detention basin), and re-grassing and landscaping the grounds. It also included installation of a 450 mm diameter pipe out of the detention basin (into Geurie Creek). Figure C 4 shows the location and schematisation of this detention basin and pipes.

11.2.1.5 Option FM05 - Detention basin on Geurie Creek upstream of the railway embankment

This option was for the construction of an open, grassed detention basin upstream of the railway embankment. This included the purchase of private property covered by the detention basin, excavation of the grounds (with battered sides to the base of the detention basin), and re-grassing and landscaping the grounds. It also included installation of a 600 mm diameter pipe out of the detention basin (into Geurie Creek). Figure C 5 shows the location and schematisation of this detention basin and pipes.

11.2.1.6 Option FM06 - Cascading detention basins alongside railway

This option involved the construction of five open, grassed cascading detention basins between the Mitchell Highway and the Railway upstream of Wise Park. This included excavation of the area (with battered sides to the base of the detention basin), and re-grassing and landscaping, as well as the construction of a small earthen embankment along the eastern edge of the most downstream detention basin. Figure C 6 shows the location and schematisation of this detention basin.

11.2.1.7 Option FM07 - Additional culverts along Geurie Creek through the railway embankment

This option involved the construction of additional culverts on Geurie Creek under the railway embankment. This included adding an additional 4 culverts to the 6 culvert set to the west and an additional 4 culverts to the 10 culvert set to the east. Figure C 7 shows the location and schematisation of the additional culverts.

11.2.1.8 Option FM08 - Additional culverts along Geurie Creek under the Mitchell Highway

This option involved the construction of 4 additional culverts on Geurie Creek under the Mitchell Highway (2 located to the east and 2 located to the west of the existing culverts). Figure C 8 shows the location and schematisation of the additional culverts.

11.2.1.9 Option FM09 - Construct swales adjacent to the roadway edges

This option involved the construction of swales alongside the urban roadways throughout Geurie. The aim of this option was to capture and divert road runoff, thereby decreasing the volume of flood waters entering residential properties. Figure C 9 shows the location and schematisation of the swales.

11.2.1.10 Option FM10 - Earthen levee along the Mitchell Highway

This option involved the construction of an earthen levee alongside the Mitchell Highway and Mitchell Street, from the Railway intersection to Geurie Creek. It also involves the construction of a secondary earthen levee along the back of several properties on Paxton Street to mitigate against the flood level increase upstream of the Railway. This option also included the installation of a 600mm diameter pipe (to run from the intersection of the Mitchell Highway and Mitchel Street, to Geurie Creek) and the widening of Geurie Creek downstream of the Mitchell Highway. Figure C 10 shows the location and schematisation of this option.

11.2.2 Potential Property Modification Measures

11.2.2.1 Option PM01 - Update development controls

Development controls are often applied so as to protect future development from flood risk and flood damage. These are generally applied through the establishment of development controls within Council's Development Control Plan (DCP) and Section 10.7(2) Planning Certificates issued by Council for individual properties.

This option is to adopt the FPA and FPL determined from this study (discussed in Section 9) into Council's LEP and DCP. This would also involve updating individual property's Section 10.7(2) Planning Certificates accordingly.

11.2.2.2 Option PM02 - Update zoning controls

Updating zoning controls (i.e. re-zoning) is often applied so as to ensure that potential future development does not occur where it would be incompatible with the flood risk profile of the property. As such, this option considered the number of properties affected by the Z5 (high) and Z6 (extreme) flood risk categories, the number of these affected properties that contained an existing building and the current land zoning of these affected properties (previously discussed in Section 6.6.2).

From this it was found that 60 properties were subject to either high or extreme flood risk and of these properties, only 5 contained an existing building. The current land zoning of these affected properties ranged from:

- E2 – Environmental Conservation
- R5 – Large Lot Residential
- RE2 – Private Recreation
- RU1 – Primary Production
- RU5 - Village

Although there is a low chance that the lots identified could be developed, it is recommended that Council undertake consultation with the owners of the lots to understand the current use and to articulate the flood hazard of the land. This consultation will be with a view to inclusion of the lots in Council's strategic planning processes for potential rezoning in the future, having regard to the significant flood hazard and the likely constraints of the land to further development.

11.2.2.3 Option PM03 - Voluntary property purchase

Voluntary purchase is a property modification measure where in council purchases land affected by high flood hazard. Buildings that are purchased are then demolished, and the land is rezoned to a more appropriate classification. This is seen as a last resort option, and is used only when other mitigation options are not feasible in the given area.

DPIE has made available guidelines for voluntary purchase schemes to assist in the determination of whether this modification option is suitable for the area (DPIE, 2020). These guidelines recommend that voluntary purchase is effective in areas where:

- there are highly hazardous flood conditions from riverine or overland flooding and the principal objective is to remove people living in these properties and reduce the risk to life of residents and potential rescuers.
- a property is located within a floodway and the removal of a building may be part of a floodway clearance program that aims to reduce significant impacts on flood behaviour elsewhere in the floodplain by enabling the floodway to more effectively perform its flow conveyance function.
- purchase of a property enables other flood mitigation works (such as channel improvements or levee construction) to be implemented because the property will impede construction or may be adversely affected by the works with impacts not able to be offset.

Highly hazardous flood conditions were defined using the true hazard categorisation of the 1% AEP flood event (discussed in Section 6.5.1.2). Of the residential buildings identified within the study area, none were determined to have been subjected to highly hazardous flood conditions within the 1% AEP flood event. Therefore voluntary purchase is not proposed for any buildings within the study area.

11.2.3 Potential Response Modification Measures

Given that there is little to no warning time available for flooding in the study area, there is little scope for an effective response modification measure.

11.3 Options Assessment Process

The Floodplain Development Manual (NSW Government, 2005) and the Australian Emergency Management Handbook 7 (AEMI, 2017) recommend that a multi-criteria assessment (MCA) be carried out to assess each of the potential mitigation measures. An MCA considers the economic, social and environmental impacts of the potential mitigation measures. The multi-criteria matrix system that was used for the current assessment is detailed in Table 11-1.

HYDROSPATIAL

Table 11-1: Multi-criteria matrix system

Category	Criteria	Score						
		-3	-2	-1	0	1	2	3
Flood Behaviour (Weighted 3)	Impact on Flood Behaviour	> 100 mm increase or newly flooded	50 to 100 mm increase	< 50 mm increase	No change	< 50 mm decrease	50 to 100 mm decrease	> 100 mm decrease or no longer flooded
Economic (Weighted 2)	Benefit Cost Ratio	< 0.15	0.15 to 0.5	0.5 to 1.0	1.0	1.0 - 1.2	1.2 - 1.5	> 1.5
	Average Annual Damages	>$20,000 increase	$10,000 to $20,000 increase	< $10,000 increase	No Change	< $10,000 decrease	$10,000 to $20,000 decrease	> $20,000 decrease
	Cost of initiating management measure	> $7,500,000	$7,500,000 to $5,000,000	$5,000,000 to $2,500,000	$2,500,000 to $1,000,000	$1,000,000 to $750,000	$750,000 to $500,000	> $500,000
Social (Weighted 1)	Social Disruption (during construction of measure)	Works within 10m of socially significant sites	Works within 20m of socially significant sites	Works within 30m of socially significant sites	No Impact	N/A	N/A	N/A
	Community Support	Strongly Disagree	Moderately Disagree	Minorly Disagree	Neutral	Minorly Agree	Moderately Agree	Strongly Agree
Environmental (Weighted 1)	Contaminated Land Impacts	Works within 10m of known contaminated land sites	Works within 20m of known contaminated land sites	Works within 30m of known contaminated land sites	No Impact	N/A	N/A	N/A
	Biodiversity Impacts	Works within 10m of known biodiversity sites	Works within 20m of known biodiversity sites	Works within 30m of known biodiversity sites	No Impact	N/A	N/A	N/A
	Heritage Impacts	Works within 10m of known heritage sites	Works within 20m of known heritage sites	Works within 30m of known heritage sites	No Impact	N/A	N/A	N/A

11.4 Options Assessment Results

11.4.1 Potential Flood Modification Measures

11.4.1.1 Option FM01 - Detention basin within Wise Park

Flood Behaviour Assessment

Figure D 1 to Figure D 3 shows the flood level impact of this option over a range of flood event magnitudes. From this it was found that this option increased flood levels along Boori Creek, particularly further downstream of the detention basin. However, this option also resulted in partially decreased flooding along Geurie Creek.

Economic Assessment

Table 11-2 details the economic assessment of this option. From this it was found that there was an increase in flood damages across the range of flood events. This was due to the increase in flood levels affecting buildings and properties, whereas the decrease in flood levels affected the open channel area.

Table 11-2: FM01 Economic Assessment

	Event (AEP)	Affected by Above Ground Flooding	Affected by Above Floor Flooding	Tangible, Direct Damages	Intangible, Direct Damages	Total Direct Damages
Before mitigation	PMF	124	64	$8,179,761	$1,226,964	$9,406,726
	0.5% AEP	114	23	$3,791,146	$568,672	$4,359,818
	1% AEP	113	13	$3,278,103	$491,716	$3,769,819
	2% AEP	110	8	$2,861,240	$429,186	$3,290,426
	5% AEP	64	-	$1,348,018	$202,203	$1,550,220
	10% AEP	62	-	$1,340,557	$201,084	$1,541,640
	20% AEP	61	-	$1,339,065	$200,860	$1,539,924
	AAD (before mitigation measure)					$202,988
	NPV (before mitigation measure)					$3,004,377
After Mitigation	PMF	124	64	$8,184,273	$1,227,641	$9,411,914
	0.5% AEP	114	22	$3,791,146	$568,672	$4,359,818
	1% AEP	113	13	$3,278,103	$491,716	$3,769,819
	2% AEP	110	9	$2,903,720	$435,558	$3,339,278
	5% AEP	63	-	$1,349,510	$202,426	$1,551,936
	10% AEP	62	-	$1,348,018	$202,203	$1,550,220
	20% AEP	62	-	$1,345,033	$201,755	$1,546,788
	AAD (after mitigation measure)					$204,173
	AAD Reduction					-$1,185
	NPV (after mitigation measure)					$3,021,915
	NPV Reduction					-$17,538

	Estimated Cost of Mitigation Measure	$191,000
	B/C Ratio	-0.092

Social Assessment

When considering the works necessary to implement flood mitigation option FM01, it was found that these works were not located within a 30 m radius of any structures of social importance.

Heritage Assessment

When considering the works necessary to implement flood mitigation option FM01, the following heritage impact was identified:

- Works to construct the detention basin would come within 10m of the Cobborah Shire Building (former), and are highly likely to impact the heritage structure.

Environmental Assessment

When considering the works necessary to implement flood mitigation option FM01, it was found that these works were not located within a 30 m radius of any areas of environmental significance.

11.4.1.2 Option FM02 - Detention basin under Geurie Tennis Courts

Flood Behaviour Assessment

Figure D 4 to Figure D 6 shows the flood level impact of this option over a range of flood event magnitudes. From this it was found that this option decreased flood levels along Boori Creek, however it also increased flood levels across a small portion of Geurie Creek. The flood level impact (both the decrease and the increase in flood levels) was found to lessen in the larger flood events as the detention basin reached capacity.

Economic Assessment

Table 11-3 details the economic assessment of this option. This resulted in no change to the flood damages calculated for the range of flood events, except for the PMF, as the flood level impacts were relatively limited.

Table 11-3: FM02 Economic Assessment

	Event (AEP)	Affected by Above Ground Flooding	Affected by Above Floor Flooding	Tangible, Direct Damages	Intangible, Direct Damages	Total Direct Damages
Before mitigation	**PMF**	124	64	$8,179,761	$1,226,964	$9,406,726
	0.5% AEP	114	23	$3,791,146	$568,672	$4,359,818
	1% AEP	113	13	$3,278,103	$491,716	$3,769,819
	2% AEP	110	8	$2,861,240	$429,186	$3,290,426
	5% AEP	64	-	$1,348,018	$202,203	$1,550,220
	10% AEP	62	-	$1,340,557	$201,084	$1,541,640
	20% AEP	61	-	$1,339,065	$200,860	$1,539,924
	AAD (before mitigation measure)					$202,988

	NPV (before mitigation measure)					$3,004,377
After Mitigation	PMF	124	64	$8,188,268	$1,228,240	$9,416,508
	0.5% AEP	114	23	$3,791,146	$568,672	$4,359,818
	1% AEP	113	13	$3,278,103	$491,716	$3,769,819
	2% AEP	109	8	$2,861,240	$429,186	$3,290,426
	5% AEP	64	-	$1,348,018	$202,203	$1,550,220
	10% AEP	62	-	$1,340,557	$201,084	$1,541,640
	20% AEP	61	-	$1,339,065	$200,860	$1,539,924
	AAD (after mitigation measure)					$202,997
	AAD Reduction					-$9
	NPV (after mitigation measure)					$3,004,504
	NPV Reduction					-$127
	Estimated Cost of Mitigation Measure					$228,000
	B/C Ratio					-0.001

Social Assessment

When considering the works necessary to implement flood mitigation option FM02, it was found that these works were not located within a 30 m radius of any structures of social importance.

Heritage Assessment

When considering the works necessary to implement flood mitigation option FM02, it was found that these works were not located within a 30 m radius of items of known heritage significance.

Environmental Assessment

When considering the works necessary to implement flood mitigation option FM02, it was found that these works were not located within a 30 m radius of any areas of environmental significance.

11.4.1.3 Option FM03 - Detention basin within Tom Culkin Oval

Flood Behaviour Assessment

Figure D 7 to Figure D 9 shows the flood level impact of this option over a range of flood event magnitudes. From this it was found that this option decreased flood levels along Boori Creek, however it increased flood levels on Jennings Street immediately downstream of the detention basin. This was the result of the detention basin overflowing when full and redirecting flows.

Economic Assessment

Table 11-4 details the economic assessment of this option. From this it was found that there was no change in flood damages in the smaller flood events. However there was a marginal increase in flood damages in the larger flood events due to the redirection of flow causing increases in flood levels on Jennings Street.

Table 11-4: FM03 Economic Assessment

	Event (AEP)	Affected by Above Ground Flooding	Affected by Above Floor Flooding	Tangible, Direct Damages	Intangible, Direct Damages	Total Direct Damages
Before mitigation	PMF	124	64	$8,179,761	$1,226,964	$9,406,726
	0.5% AEP	114	23	$3,791,146	$568,672	$4,359,818
	1% AEP	113	13	$3,278,103	$491,716	$3,769,819
	2% AEP	110	8	$2,861,240	$429,186	$3,290,426
	5% AEP	64	-	$1,348,018	$202,203	$1,550,220
	10% AEP	62	-	$1,340,557	$201,084	$1,541,640
	20% AEP	61	-	$1,339,065	$200,860	$1,539,924
	AAD (before mitigation measure)					$202,988
	NPV (before mitigation measure)					$3,004,377
After Mitigation	PMF	124	64	$8,179,761	$1,226,964	$9,406,725
	0.5% AEP	114	21	$3,786,634	$567,995	$4,354,629
	1% AEP	113	13	$3,304,456	$495,668	$3,800,125
	2% AEP	109	8	$2,862,732	$429,410	$3,292,142
	5% AEP	64	-	$1,348,018	$202,203	$1,550,220
	10% AEP	62	-	$1,340,557	$201,084	$1,541,640
	20% AEP	61	-	$1,339,065	$200,860	$1,539,924
	AAD (after mitigation measure)					$203,112
	AAD Reduction					-$124
	NPV (after mitigation measure)					$3,006,214
	NPV Reduction					-$1,837
	Estimated Cost of Mitigation Measure					$506,000
	B/C Ratio					-0.004

Social Assessment

When considering the works necessary to implement flood mitigation option FM03, it was found that these works were not located within a 30 m radius of any structures of social importance.

Heritage Assessment

When considering the works necessary to implement flood mitigation option FM03, it was found that these works were not located within a 30 m radius of items of known heritage significance.

Environmental Assessment

When considering the works necessary to implement flood mitigation option FM03, it was found that these works were not located within a 30 m radius of any areas of environmental significance.

11.4.1.4 Option FM04 - Detention basin within 72 Severne Street

Flood Behaviour Assessment

Figure D 10 to Figure D 12 shows the flood level impact of this option over a range of flood event magnitudes. From this it was found that this option decreased flood levels along Geurie Creek and Boori Creek. However, as a result of the option there was a small area where the flood level increased on Comobella Road downstream of the detention basin as the overflow from the full detention basin redirects flows.

Economic Assessment

Table 11-5 details the economic assessment of this option. From this it was found that there was no change to flood damages in the smaller flood events, however there was a marginal decrease in flood damages in the larger flood events.

Table 11-5: FM04 Economic Assessment

	Event (AEP)	Affected by Above Ground Flooding	Affected by Above Floor Flooding	Tangible, Direct Damages	Intangible, Direct Damages	Total Direct Damages
Before mitigation	PMF	124	64	$8,179,761	$1,226,964	$9,406,726
	0.5% AEP	114	23	$3,791,146	$568,672	$4,359,818
	1% AEP	113	13	$3,278,103	$491,716	$3,769,819
	2% AEP	110	8	$2,861,240	$429,186	$3,290,426
	5% AEP	64	-	$1,348,018	$202,203	$1,550,220
	10% AEP	62	-	$1,340,557	$201,084	$1,541,640
	20% AEP	61	-	$1,339,065	$200,860	$1,539,924
	AAD (before mitigation measure)					$202,988
	NPV (before mitigation measure)					$3,004,377
After Mitigation	PMF	124	64	$8,175,250	$1,226,287	$9,401,537
	0.5% AEP	114	23	$3,748,428	$562,264	$4,310,693
	1% AEP	113	13	$3,278,103	$491,716	$3,769,819
	2% AEP	109	7	$2,861,240	$429,186	$3,290,426
	5% AEP	64	-	$1,348,018	$202,203	$1,550,220
	10% AEP	62	-	$1,340,557	$201,084	$1,541,640
	20% AEP	61	-	$1,339,065	$200,860	$1,539,924
	AAD (after mitigation measure)					$202,813
	AAD Reduction					$175
	NPV (after mitigation measure)					$3,001,781
	NPV Reduction					$2,596

	Estimated Cost of Mitigation Measure	$1,632,000
	B/C Ratio	0.002

Social Assessment

When considering the works necessary to implement flood mitigation option FM04, it was found that these works were not located within a 30 m radius of any structures of social importance.

Heritage Assessment

When considering the works necessary to implement flood mitigation option FM04, the following heritage impact was identified:

- Works to construct the detention basin would directly impact the Geurie Grandstand.

Environmental Assessment

When considering the works necessary to implement flood mitigation option FM04, the following environmental impacts were identified:

- Construction works for the detention basin would come within 10-20 m of a biodiverse area to the south of Geurie Showground, and has a moderate likelihood of impacting the environment.

11.4.1.5 Option FM05 - Detention basin on Geurie Creek upstream of the railway embankment

Flood Behaviour Assessment

Figure D 13 to Figure D 15 shows the flood level impact of this option over a range of flood event magnitudes. From this it was found that flood levels decreased along Geurie Creek in all flood events. Additionally, in larger flood events, flood levels also decreased along Boori Creek where flood waters would previously spill over after it accumulated to a high enough volume upstream of the railway embankment.

Economic Assessment

Table 11-6 details the economic assessment of this option. This option resulted in decreases in flood damages in larger flood events due to the flood levels predominantly decreasing as a result of this option, with little to no corresponding increase in flood levels.

Table 11-6: FM05 Economic Assessment

	Event (AEP)	Affected by Above Ground Flooding	Affected by Above Floor Flooding	Tangible, Direct Damages	Intangible, Direct Damages	Total Direct Damages
Before mitigation	**PMF**	124	64	$8,179,761	$1,226,964	$9,406,726
	0.5% AEP	114	23	$3,791,146	$568,672	$4,359,818
	1% AEP	113	13	$3,278,103	$491,716	$3,769,819
	2% AEP	110	8	$2,861,240	$429,186	$3,290,426
	5% AEP	64	-	$1,348,018	$202,203	$1,550,220
	10% AEP	62	-	$1,340,557	$201,084	$1,541,640
	20% AEP	61	-	$1,339,065	$200,860	$1,539,924

	AAD (before mitigation measure)					$202,988
	NPV (before mitigation measure)					$3,004,377
After Mitigation	PMF	124	64	$8,170,414	$1,225,562	$9,395,977
	0.5% AEP	114	23	$3,748,428	$562,264	$4,310,693
	1% AEP	113	12	$3,269,597	$490,440	$3,760,037
	2% AEP	108	5	$2,816,620	$422,493	$3,239,113
	5% AEP	64	-	$1,348,018	$202,203	$1,550,220
	10% AEP	62	-	$1,340,557	$201,084	$1,541,640
	20% AEP	61	-	$1,339,065	$200,860	$1,539,924
	AAD (after mitigation measure)					$201,852
	AAD Reduction					$1,136
	NPV (after mitigation measure)					$2,987,557
	NPV Reduction					$16,820
	Estimated Cost of Mitigation Measure					$3,912,000
	B/C Ratio					0.004

Social Assessment

When considering the works necessary to implement flood mitigation option FM05, it was found that these works were not located within a 30 m radius of any structures of social importance.

Heritage Assessment

When considering the works necessary to implement flood mitigation option FM05, it was found that these works were not located within a 30 m radius of items of known heritage significance.

Environmental Assessment

When considering the works necessary to implement flood mitigation option FM05, it was found that these works were not located within a 30 m radius of any areas of environmental significance.

11.4.1.6 Option FM06 - Cascading detention basins alongside railway

Flood Behaviour Assessment

Figure D 16 to Figure D 18 shows the flood level impact of this option over a range of flood event magnitudes. This option resulted in a decrease in flood levels along sections of Boori Creek and Geurie Creek, particularly in larger events. However, flood levels along the Mitchell Highway, between Douglas Street and Mitchell Street increased in all flood events, with additional flood level increases along part of Boori Creek in smaller events.

Economic Assessment

Table 11-7 details the economic assessment of this option. From this it was found that there was a marginal decrease in flood damages in the larger flood events and a slight increase to the flood damages in the smaller flood events.

Table 11-7: FM06 Economic Assessment

	Event (AEP)	Affected by Above Ground Flooding	Affected by Above Floor Flooding	Tangible, Direct Damages	Intangible, Direct Damages	Total Direct Damages
Before mitigation	PMF	124	64	$8,179,761	$1,226,964	$9,406,726
	0.5% AEP	114	23	$3,791,146	$568,672	$4,359,818
	1% AEP	113	13	$3,278,103	$491,716	$3,769,819
	2% AEP	110	8	$2,861,240	$429,186	$3,290,426
	5% AEP	64	-	$1,348,018	$202,203	$1,550,220
	10% AEP	62	-	$1,340,557	$201,084	$1,541,640
	20% AEP	61	-	$1,339,065	$200,860	$1,539,924
	AAD (before mitigation measure)					$202,988
	NPV (before mitigation measure)					$3,004,377
After Mitigation	PMF	124	64	$8,179,761	$1,226,964	$9,406,725
	0.5% AEP	114	22	$3,791,181	$568,677	$4,359,858
	1% AEP	112	13	$3,207,778	$481,167	$3,688,945
	2% AEP	108	8	$2,837,041	$425,556	$3,262,598
	5% AEP	64	1	$1,346,454	$201,968	$1,548,422
	10% AEP	63	1	$1,344,962	$201,744	$1,546,706
	20% AEP	62	-	$1,339,065	$200,860	$1,539,924
	AAD (after mitigation measure)					$202,144
	AAD Reduction					$844
	NPV (after mitigation measure)					$2,991,889
	NPV Reduction					$12,488
	Estimated Cost of Mitigation Measure					$358,000
	B/C Ratio					0.035

Social Assessment

When considering the works necessary to implement flood mitigation option FM06, it was found that these works were not located within a 30 m radius of any structures of social importance.

Heritage Assessment

When considering the works necessary to implement flood mitigation option FM06, it was found that these works were not located within a 30 m radius of items of known heritage significance.

Environmental Assessment

When considering the works necessary to implement flood mitigation option FM06, the following environmental impacts were identified:

- Construction works for the western-most detention basin would come within 20-30 m of a biodiverse area to the north-west of Geurie, along the railway line, and has a low likelihood of impacting the environment.

11.4.1.7 Option FM07 - Additional culverts along Geurie Creek through the railway embankment

Flood Behaviour Assessment

Figure D 19 to Figure D 21 shows the flood level impact of this option over a range of flood event magnitudes. This option resulted in a decrease in flood levels upstream of the railway embankment and an increase in flood levels on Geurie Creek downstream of the railway embankment. Additionally, in larger flood events, flood levels also decreased along Boori Creek where flood waters would previously spill over after it accumulated to a high enough volume upstream of the railway embankment.

Economic Assessment

Table 11-7 details the economic assessment of this option. From this it was found that there was a marginal decrease in flood damages in the larger flood events and no change to the flood damages in the smaller flood events. This was predominantly due to the decrease in flood levels along Boori Creek as a result of this option.

Table 11-8: FM07 Economic Assessment

	Event (AEP)	Affected by Above Ground Flooding	Affected by Above Floor Flooding	Tangible, Direct Damages	Intangible, Direct Damages	Total Direct Damages
Before mitigation	PMF	124	64	$8,179,761	$1,226,964	$9,406,726
	0.5% AEP	114	23	$3,791,146	$568,672	$4,359,818
	1% AEP	113	13	$3,278,103	$491,716	$3,769,819
	2% AEP	110	8	$2,861,240	$429,186	$3,290,426
	5% AEP	64	-	$1,348,018	$202,203	$1,550,220
	10% AEP	62	-	$1,340,557	$201,084	$1,541,640
	20% AEP	61	-	$1,339,065	$200,860	$1,539,924
	AAD (before mitigation measure)					$202,988
	NPV (before mitigation measure)					$3,004,377
After Mitigation	PMF	124	64	$8,162,232	$1,224,335	$9,386,566
	0.5% AEP	114	23	$3,748,428	$562,264	$4,310,693
	1% AEP	113	12	$3,238,733	$485,810	$3,724,543
	2% AEP	108	4	$2,733,602	$410,040	$3,143,642
	5% AEP	64	-	$1,348,018	$202,203	$1,550,220
	10% AEP	62	-	$1,340,557	$201,084	$1,541,640
	20% AEP	61	-	$1,339,065	$200,860	$1,539,924
	AAD (after mitigation measure)					$199,953
	AAD Reduction					$3,035

	NPV (after mitigation measure)	$2,959,453
	NPV Reduction	$44,924
	Estimated Cost of Mitigation Measure	$400,000
	B/C Ratio	0.112

Social Assessment

When considering the works necessary to implement flood mitigation option FM07, it was found that these works were not located within a 30 m radius of any structures of social importance.

Heritage Assessment

When considering the works necessary to implement flood mitigation option FM07, it was found that these works were not located within a 30 m radius of items of known heritage significance.

Environmental Assessment

When considering the works necessary to implement flood mitigation option FM07, it was found that these works were not located within a 30 m radius of any areas of environmental significance.

11.4.1.8 Option FM08 - Additional culverts along Geurie Creek under the Mitchell Highway

Flood Behaviour Assessment

Figure D 22 to Figure D 24 shows the flood level impact of this option over a range of flood event magnitudes. From this it was found that this option had a marginal impact of flood levels, with a small decrease in flood levels on Geurie Creek between the railway embankment and the Mitchell Highway. This was due to the railway embankment being a greater impediment to flow than the Mitchell Highway.

Economic Assessment

Table 11-8 details the economic assessment of this option. From this it was found that was no impact on a majority of the event, with only a marginal impact in the 0.5% AEP and PMF events.

Table 11-9: FM08 Economic Assessment

	Event (AEP)	Affected by Above Ground Flooding	Affected by Above Floor Flooding	Tangible, Direct Damages	Intangible, Direct Damages	Total Direct Damages
Before mitigation	PMF	124	64	$8,179,761	$1,226,964	$9,406,726
	0.5% AEP	114	23	$3,791,146	$568,672	$4,359,818
	1% AEP	113	13	$3,278,103	$491,716	$3,769,819
	2% AEP	110	8	$2,861,240	$429,186	$3,290,426
	5% AEP	64	-	$1,348,018	$202,203	$1,550,220
	10% AEP	62	-	$1,340,557	$201,084	$1,541,640
	20% AEP	61	-	$1,339,065	$200,860	$1,539,924

	AAD (before mitigation measure)					$202,988
	NPV (before mitigation measure)					$3,004,377
After Mitigation	PMF	124	64	$8,183,756	$1,227,563	$9,411,319
	0.5% AEP	114	23	$3,748,428	$562,264	$4,310,693
	1% AEP	113	13	$3,278,103	$491,716	$3,769,819
	2% AEP	109	8	$2,861,240	$429,186	$3,290,426
	5% AEP	64	-	$1,348,018	$202,203	$1,550,220
	10% AEP	62	-	$1,340,557	$201,084	$1,541,640
	20% AEP	61	-	$1,339,065	$200,860	$1,539,924
	AAD (after mitigation measure)					$202,821
	AAD Reduction					$167
	NPV (after mitigation measure)					$3,001,908
	NPV Reduction					$2,469
	Estimated Cost of Mitigation Measure					$162,000
	B/C Ratio					0.015

Social Assessment

When considering the works necessary to implement flood mitigation option FM08, it was found that these works were not located within a 30 m radius of any structures of social importance.

Heritage Assessment

When considering the works necessary to implement flood mitigation option FM08, it was found that these works were not located within a 30 m radius of items of known heritage significance.

Environmental Assessment

When considering the works necessary to implement flood mitigation option FM08, it was found that these works were not located within a 30 m radius of any areas of environmental significance.

11.4.1.9 Option FM09 - Construct swales adjacent to the roadway edges

Flood Behaviour Assessment

Figure D 25 to Figure D 27 shows the flood level impact of this option over a range of flood event magnitudes. From this it was found that this option had a marginal flood level impact, with both small increases and small decreases in flood levels around the roadways within town. This was due to the capacity of the swales to convey flood water being exceeded.

Economic Assessment

Table 11-9 details the economic assessment of this option. From this it was found that there were both marginal increases and decreases in damages throughout the events, ultimately resulting in a decrease in the AAD and NPV values.

Table 11-10: FM09 Economic Assessment

	Event (AEP)	Affected by Above Ground Flooding	Affected by Above Floor Flooding	Tangible, Direct Damages	Intangible, Direct Damages	Total Direct Damages
Before mitigation	PMF	124	64	$8,179,761	$1,226,964	$9,406,726
	0.5% AEP	114	23	$3,791,146	$568,672	$4,359,818
	1% AEP	113	13	$3,278,103	$491,716	$3,769,819
	2% AEP	110	8	$2,861,240	$429,186	$3,290,426
	5% AEP	64	-	$1,348,018	$202,203	$1,550,220
	10% AEP	62	-	$1,340,557	$201,084	$1,541,640
	20% AEP	61	-	$1,339,065	$200,860	$1,539,924
	AAD (before mitigation measure)					$202,988
	NPV (before mitigation measure)					$3,004,377
After Mitigation	PMF	125	63	$8,127,440	$1,219,116	$9,346,556
	0.5% AEP	115	23	$3,835,059	$575,259	$4,410,318
	1% AEP	112	12	$3,264,832	$489,725	$3,754,557
	2% AEP	109	9	$2,819,533	$422,930	$3,242,462
	5% AEP	64	-	$1,349,510	$202,426	$1,551,936
	10% AEP	62	-	$1,340,557	$201,084	$1,541,640
	20% AEP	61	-	$1,339,065	$200,860	$1,539,924
	AAD (after mitigation measure)					$202,272
	AAD Reduction					$716
	NPV (after mitigation measure)					$2,993,771
	NPV Reduction					$10,606
	Estimated Cost of Mitigation Measure					$620,000
	B/C Ratio					0.017

Social Assessment

When considering the works necessary to implement flood mitigation option FM09, it was identified that works to construct the roadside swales would come within 10m of the following socially significant sites, and are highly likely to affect their operation:

- Geurie Public School,
- Geurie Police Station,
- Geurie Union Church, and
- Geurie Masonic Lodge.

Heritage Assessment

When considering the works necessary to implement flood mitigation option FM09, it was identified that works to construct the roadside swales would come within 10m of the following Heritage sites, and are highly likely to affect the sites:

- Union Church and Hall,
- Geurie Public School,
- St Matthew's Anglican Rectory,
- St Matthew's Anglican Church,
- Geurie General Cemetery,
- Geurie War Memorial Hall,
- Cobborah Shire Building (former),
- CBC Bank (former),
- Garden Café/Alladins Cave,
- Geurie Antiques,
- 37 Buckenbah Street,
- Geurie Post Office,
- Geurie Police Station, and
- Holy Name Catholic Church.

Environmental Assessment

When considering the works necessary to implement flood mitigation option FM09, the following environmental impacts were identified:

- Construction of swales would happen directly within a biodiverse area along Fitzroy Street between Geurie Street and Chambers Street, and is highly likely to impact the environment.
- Construction of swales would come within 20-30 m of a biodiverse area adjacent to Geurie Bald Hill Reserve, and has a low likelihood of impacting the environment.

11.4.1.10 Option FM10 - Earthen levee along the Mitchell Highway

Flood Behaviour Assessment

Figure D 28 to Figure D 30 shows the flood level impact of this option over a range of flood event magnitudes. From this it was found that this option resulted in significant flood level decreases in the area downstream of the levee, with significant increases directly along the levee and marginal to moderate increases in levels further upstream of the levee.

Economic Assessment

Table 11-8 details the economic assessment of this option. From this it was found that was a decrease in flood damages in the larger flood events and no change to the flood damages in the smaller flood events.

Table 11-11: FM10 Economic Assessment

	Event (AEP)	Affected by Above Ground Flooding	Affected by Above Floor Flooding	Tangible, Direct Damages	Intangible, Direct Damages	Total Direct Damages
Before mitigation	PMF	124	64	$8,179,761	$1,226,964	$9,406,726
	0.5% AEP	114	23	$3,791,146	$568,672	$4,359,818
	1% AEP	113	13	$3,278,103	$491,716	$3,769,819
	2% AEP	110	8	$2,861,240	$429,186	$3,290,426
	5% AEP	64	-	$1,348,018	$202,203	$1,550,220
	10% AEP	62	-	$1,340,557	$201,084	$1,541,640

	20% AEP	61	-	$1,339,065	$200,860	$1,539,924
	AAD (before mitigation measure)					$202,988
	NPV (before mitigation measure)					$3,004,377
After Mitigation	PMF	124	64	$8,152,559	$1,222,884	$9,375,443
	0.5% AEP	114	12	$3,293,157	$493,974	$3,787,131
	1% AEP	112	7	$2,886,772	$433,061	$3,319,788
	2% AEP	103	1	$2,435,148	$365,272	$2,800,420
	5% AEP	64	-	$1,348,018	$202,203	$1,550,220
	10% AEP	62	-	$1,340,557	$201,084	$1,541,640
	20% AEP	59	-	$1,339,065	$200,860	$1,539,924
	AAD (after mitigation measure)					$188,738
	AAD Reduction					$14,250
	NPV (after mitigation measure)					$2,793,465
	NPV Reduction					$210,912
	Estimated Cost of Mitigation Measure					$536,000
	B/C Ratio					0.393

Social Assessment

When considering the works necessary to implement flood mitigation option FM10, it was found that these works were not located within a 30 m radius of any structures of social importance.

Heritage Assessment

When considering the works necessary to implement flood mitigation option FM10, the following heritage impact was identified:

- Works to construct the earthen levee would come within 30m of 37 Buckenbah Street, and have a low likelihood of affecting the heritage structure.
- Works to install the additional pipes would come within 30m of Geurie Antiques, and have a low likelihood of affecting the heritage structure.
- Works to install the additional pipes would come within 10m of 37 Buckenbah Street and are highly likely to affect the heritage structure.

Environmental Assessment

When considering the works necessary to implement flood mitigation option FM10, it was found that these works were not located within a 30 m radius of any areas of environmental significance.

11.4.2 Potential Property Modification Measures

11.4.2.1 Option PM01 - Update development controls

Flood Behaviour Assessment

As a result of this mitigation option, there was no change to the flood behaviour across the range of flood events.

Social Assessment

Implementation of this option would not affect locations of social importance to the wider community. However, it does have the potential to affect the community on an individual level, based upon their personal circumstances.

Heritage Assessment

Implementation of this option would not affect items of known heritage significance.

Environmental Assessment

Implementation of this option would not affect items of known environmental significance.

11.4.2.2 Option PM02 - Update zoning controls

Flood Behaviour Assessment

As a result of this mitigation option, there was no change to the flood behaviour across the range of flood events

Social Assessment

Implementation of this option would not affect locations of social importance to the wider community. However, it does have the potential to affect the community on an individual level, based upon their personal circumstances.

Heritage Assessment

Implementation of this option would not affect items of known heritage significance.

Environmental Assessment

Implementation of this option would not affect items of known environmental significance.

11.4.3 Summary of Modification Measures Results

Table 11-10 presents the preliminary results of the multi-criteria assessment for all of the above discussed mitigation options. Following consultation with the FRMC and the community, the relative community support factor for each option will be tabulated, and the overall weighted score and ranking calculated.

Table 11-10: Multi-criteria matrix assessment

Option ID	Impact on flood behaviour	Benefit Cost Ratio	Average Annual Damages	Cost of initiating measure	Social disruption	Community support	Contaminated land impacts	Biodiversity impacts	Weighted score	Ranking
FM01	-1	-3	-1	3	0	TBA	0	0	TBA	TBA
FM02	1	-3	-1	3	0	TBA	0	0	TBA	TBA
FM03	0	-3	-1	2	0	TBA	0	0	TBA	TBA
FM04	1	-3	1	0	0	TBA	0	-2	TBA	TBA
FM05	1	-3	1	-1	0	TBA	0	0	TBA	TBA
FM06	0	-3	1	3	0	TBA	0	-1	TBA	TBA
FM07	1	-3	1	3	0	TBA	0	0	TBA	TBA
FM08	0	-3	1	3	0	TBA	0	0	TBA	TBA
FM09	1	-3	1	2	-3	TBA	0	-30	TBA	TBA
FM10	2	-2	2	2	0	TBA	0	0	TBA	TBA
PM01	0	TBA	0	TBA	0	TBA	0	0	TBA	TBA
PM02	0	TBA	0	TBA	0	TBA	0	0	TBA	TBA

12 Floodplain Risk Management Plan

12.1 Recommended Measures

Based upon the multi-criteria assessment of the flood mitigation options, the following options are recommended for implementation:

- PM01 – Update development controls
- PM02 – Update zoning controls
- FM10 – Earthen levee along the Mitchell Highway

12.2 Implementation

Implementing the aforementioned recommended measures requires information on the following details:

- The agency or organisation primarily responsible for project managing the implementation of the measure;
- The financial requirements to implement the measure; and
- The priority for implementation of the measure.

Table 12-1 lists the implementation plan with consideration given to the aforementioned details. The measures identified would require a total capital expenditure of approximately $536,000.

The plan is expected to be executed over a five year timeframe. The scheduling of the works proposed will be dependent upon the financial commitments of the agencies or organisations responsible.

12.3 Maintenance

A floodplain risk management plan is an ongoing procedure, and is not over at the completion of the report.

A management plan should be based on the best knowledge currently available. Therefore, due to key factors of the study area changing over time, such as social, economic, and catchment conditions that may affect flooding behaviours, the management plan should be reassessed periodically. It is advised that plan reassessment take place every five years or following a significant flood event.

Table 12-1: Implementation plan

Measure ID	Measure Description	Responsibility	Cost	Timeframe (Budget Dependent)	Priority
PM01	Update development controls	Council	N/A	Short term (< 2 years)	High
PM02	Update zoning controls	Council	N/A	Medium term (2-5 years)	Medium
FM10	Earthen levee along the Mitchell Highway	Council / DPIE	$536,000	Long term (> 5 years)	Medium

13 References

Ref 1: Australian Emergency Management Institute (2017), *Australian Emergency Management Handbook 7: Managing the Floodplain Best Practice in Flood Risk Management in Australia*, AEMI, Canberra

Ref 2: Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors) (2019), *Australian Rainfall and Runoff: A Guide to Flood Estimation*, Commonwealth of Australia

Ref 3: BMT WBM (2018), *TUFLOW User Manual*

Ref 4: Boyd, M., Rigby, E., VanDrie, R. (2017), *Watershed Bounded Network Model (WBNM) User Guide*

Ref 5: Institute of Engineers, Australia (1987), *Australian Rainfall and Runoff: A Guide to Flood Estimation, Vol. 1*, Editor-in-chief D.H. Pilgrim, Revised Edition 1987 (Reprinted 1998), Barton, ACT

Ref 6: NSW Government (2005), *Floodplain Development Manual: The management of flood liable land*, Department of Infrastructure, Planning and Natural Resources, NSW Government, Sydney

APPENDIX A
GLOSSARY

The following glossary has been extracted from the Australian Emergency Management Handbook 7 (Ref 1).

Annual Exceedance Probability (AEP)	The likelihood of the occurrence 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 flow of 500 m3/s has an AEP of 5%, it means that there is a 5% chance (that is, a one-in-20 chance) of a flow of 500 m3/s or larger occurring in any one year (see also average recurrence interval, flood risk, likelihood of occurrence, probability).
Astronomical tide	The variation in sea level caused by the gravitational effects of (principally) the moon and sun. It includes highest and lowest astronomical tides (HAT and LAT) occur when relative alignment and distance of the sun and moon from the earth are 'optimal'. Water levels approach to within 20 cm of HAT and LAT twice per year around mid-summer and mid-winter 'king tides'.
Australian Height Datum (AHD)	A common national survey height datum as a reference level for defining reduced levels; 0.0 m AHD corresponds approximately to sea level.
Average Annual Damage (AAD)	Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood-prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time. If the damage associated with various annual events is plotted against their probability of occurrence, the AAD is equal to the area under the consequence-probability curve. AAD provides a basis for comparing the economic effectiveness of different management measures (i.e. their ability to reduce the AAD).
Average Recurrence Interval (ARI)	A statistical estimate of the average number of years between the occurrence of a flood of a given size or larger than the selected event. For example, floods with a flow as great as or greater than the 20-year ARI (5% AEP) flood event will occur, on average, once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event (see also annual exceedance probability).
Catchment	The area of land draining to a particular site. It is related to a specific location, and includes the catchment of the main waterway as well as any tributary streams.
Catchment flooding	Flooding due to prolonged or intense rainfall (e.g. severe thunderstorms, monsoonal rains in the tropics, tropical cyclones). Types of catchment flooding include riverine, local overland and groundwater flooding.
Chance	The likelihood of something happening that will have beneficial consequences (e.g. the chance of a win in a lottery). Chance is often thought of as the 'upside of a gamble' (Rowe 1990) (see also risk).
Coastal flooding	Flooding due to tidal or storm-driven coastal events, including storm surges in lower coastal waterways. This can

	be exacerbated by wind-wave generation from storm events.
Consent authority	The authority or agency with the legislative power to determine the outcome of development and building applications.
Consequence	The outcome of an event or situation affecting objectives, expressed qualitatively or quantitatively. Consequences can be adverse (e.g. death or injury to people, damage to property and disruption of the community) or beneficial.
Defined Flood Event (DFE)	The flood event selected for the management of flood hazard to new development. This is generally determined in floodplain management studies and incorporated in floodplain management plans. Selection of DFEs should be based on an understanding of flood behaviour, and the associated likelihood and consequences of flooding. It should also take into account the social, economic, environmental and cultural consequences associated with floods of different severities. Different DFEs may be chosen for the basis for reducing flood risk to different types of development. DFEs do not define the extent of the floodplain, which is defined by the PMF (see also design flood, floodplain and probable maximum flood).
Design flood	The flood event selected for the treatment of existing risk through the implementation of structural mitigation works such as levees. It is the flood event for which the impacts on the community are designed to be limited by the mitigation work. For example, a levee may be designed to exclude a 2% AEP flood, which means that floods rarer than this may breech the structure and impact upon the protected area. In this case, the 2% AEP flood would not equate to the crest level of the levee, because this generally has a freeboard allowance, but it may be the level of the spillway to allow for controlled levee overtopping (see also annual exceedance probability, defined flood event, floodplain, freeboard and probable maximum flood).
Development	Development may be defined in jurisdictional legislation or regulation. This may include erecting a building or carrying out of work, including the placement of fill; the use of land, or a building or work; or the subdivision of land. Infill development refers to the development of vacant blocks of land within an existing subdivision that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development. New development is intensification of use with development of a completely different nature to that associated with the former land use or zoning (e.g. the urban subdivision of an area previously used for rural purposes). New developments generally involve rezoning, and associated consents and approvals. It may require major extensions of existing urban

	services, such as roads, water supply, sewerage and electric power. Redevelopment refers to rebuilding in an existing developed area. For example, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either rezoning or major extensions to urban services.
Ecologically sustainable development	Using, conserving and improving natural resources so that ecological processes on which life depends are maintained, and the total quality of life – now and in the future – can be maintained or increased.
Effective warning time	The effective warning time available to a floodprone community is equal to the time between the delivery of an official warning to prepare for imminent flooding and the loss of evacuation routes due to flooding. The effective warning time is typically used for people to self-evacuate, to move farm equipment, move stock, raise furniture, and transport their possessions.
Existing flood risk	The risk a community is exposed to as a result of its location on the floodplain.
Flash flood	Flood that is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. It is generally not possible to issue detailed flood warnings for flash flooding. However, generalised warnings may be possible. It is often defined as flooding that peaks within six hours of the causative rain.
Flood	Flooding is a natural phenomenon that occurs when water covers land that is normally dry. It may result from coastal or catchment flooding, or a combination of both (see also catchment flooding and coastal flooding).
Flood awareness	An appreciation of the likely effects of flooding, and a knowledge of the relevant flood warning, response and evacuation procedures. In communities with a high degree of flood awareness, the response to flood warnings is prompt and effective. In communities with a low degree of flood awareness, flood warnings are liable to be ignored or misunderstood, and residents are often confused about what they should do, when to evacuate, what to take with them and where it should be taken.
Flood damage	The tangible (direct and indirect) and intangible costs (financial, opportunity costs, clean-up) of flooding. Tangible costs are quantified in monetary terms (e.g. damage to goods and possessions, loss of income or services in the flood aftermath). Intangible damages are difficult to quantify in monetary terms and include the increased levels of physical, emotional and psychological health problems suffered by flood-affected people that are attributed to a flooding episode.

Flood education	Education that raises awareness of the flood problem, to help individuals understand how to manage themselves and their property in response to flood warnings and in a flood event. It invokes a state of flood readiness.
Flood emergency response plan	A step-by-step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of connected emergency operations. The objective is to ensure a coordinated response by all agencies having responsibilities and functions in emergencies.
Flood emergency management	Emergency management is a range of measures to manage risks to communities and the environment. In the flood context, it may include measures to prevent, prepare for, respond to and recover from flooding.
Flood fringe areas	The part of the floodplain where development could be permitted, provided the development is compatible with flood hazard and appropriate building measures to provide an adequate level of flood protection to the development. This is the remaining area affected by flooding after flow conveyance paths and flood storage areas have been defined for a particular event (see also flow conveyance areas and flood storage areas).
Flood hazard	Potential loss of life, injury and economic loss caused by future flood events. The degree of hazard varies with the severity of flooding and is affected by flood behaviour (extent, depth, velocity, isolation, rate of rise of floodwaters, duration), topography and emergency management.
Floodplain	An area of land that is subject to inundation by floods up to and including the probable maximum flood event – that is, flood-prone land.
Floodplain management entity (FME)	The authority or agency with the primary responsibility for directly managing flood risk at a local level.
Floodplain management plan	A management plan developed in accordance with the principles and guidelines in this handbook, usually includes both written and diagrammatic information describing how particular areas of flood-prone land are to be used and managed to achieve defined objectives. It outlines the recommended ways to manage the flood risk associated with the use of the floodplain for various purposes. It represents the considered opinion of the local community and the floodplain management entity on how best to manage the floodplain, including consideration of flood risk in strategic land-use planning to facilitate development of the community. It fosters flood warning, response, evacuation, clean-up and recovery in the onset and aftermath of a flood, and suggests an organisational structure for the integrated management for existing, future and residual flood risks. Plans need to be reviewed regularly to assess progress and to consider the

	consequences of any changed circumstances that have arisen since the last review.
Flood Planning Area (FPA)	The area of land below the flood planning level, and is thus subject to flood-related development controls.
Flood Planning Level (FPL)	The FPL is a combination of the defined flood levels (derived from significant historical flood events or floods of specific annual exceedance probabilities) and freeboards selected for floodplain management purposes, as determined in management studies and incorporated in management plans.
Flood-prone land	Land susceptible to flooding by the probably maximum flood event. Flood-prone land is synonymous with the floodplain. Floodplain management plans should encompass all flood-prone land rather than being restricted to areas affected by defined flood events.
Flood proofing of buildings	A combination of measures incorporated in the design, construction and alteration of individual buildings or structures that are subject to flooding, to reduce structural damage and potentially, in some cases, reduce contents damage.
Flood readiness	An ability to react within the effective warning time (see also flood awareness and flood education).
Flood risk	The potential risk of flooding to people, their social setting, and their built and natural environment. The degree of risk varies with circumstances across the full range of floods. Flood risk is divided into three types – existing, future and residual.
Flood severity	A qualitative indication of the 'size' of a flood and its hazard potential. Severity varies inversely with likelihood of occurrence (i.e. the greater the likelihood of occurrence, the more frequently an event will occur, but the less severe it will be). Reference is often made to major, moderate and minor flooding (see also minor, moderate and major flooding).
Flood storage areas	The parts of the floodplain that are important for temporary storage of floodwaters during a flood passage. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas (see also flow conveyance areas and flood fringe areas).
Flood study	A comprehensive technical investigation of flood behaviour. It defines the nature of flood hazard across the floodplain by providing information on the extent, level and velocity of floodwaters, and on the distribution of flood flows. The flood study forms the basis for subsequent management studies and needs to take into account a full range of flood events up to and including the probable maximum flood.
Flow	The rate of flow of water measured in volume per unit time – for example, cubic metres per second (m3/s). Flow is

	different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).
Flow conveyance areas	Those areas of the floodplain where a significant flow of water occurs during floods. They are often aligned with naturally defined channels. Flow conveyance paths are areas that, even if only partially blocked, would cause a significant redistribution of flood flow or a significant increase in flood levels. They are often, but not necessarily, areas of deeper flow or areas where higher velocities occur, and can also include areas where significant storage of floodwater occurs. Each flood has a flow conveyance area, and the extent and flood behaviour within flow conveyance areas may change with flood severity. This is because areas that are benign for small floods may experience much greater and more hazardous flows during larger floods (see also flood fringe areas and flood storage areas).
Freeboard	The height above the DFE or design flood used, in consideration of local and design factors, to provide reasonable certainty that the risk exposure selected in deciding on a particular DFE or design flood is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels and so on. Freeboard compensates for a range of factors, including wave action, localised hydraulic behaviour and levee settlement, all of which increase water levels or reduce the level of protection provided by levees. Freeboard should not be relied upon to provide protection for flood events larger than the relevant defined flood event of a design flood. Freeboard is included in the flood planning level and therefore used in the derivation of the flood planning area (see also defined flood event, design flood, flood planning area and flood planning level).
Frequency	The measure of likelihood expressed as the number of occurrences of a specified event in a given time. For example, the frequency of occurrence of a 20% annual exceedance probability or five-year average recurrence interval flood event is once every five years on average (see also annual exceedance probability, annual recurrence interval, likelihood and probability).
Future flood risk	The risk that new development within a community is exposed to as a result of developing on the floodplain.
Gauge height	The height of a flood level at a particular gauge site related to a specified datum. The datum may or may not be the AHD (see also Australian height datum).
Habitable room	In a residential situation, a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom. In an industrial or commercial situation, it refers to an area used for offices or to store valuable

	possessions susceptible to flood damage in the event of a flood.
Hazard	A source of potential harm or a situation with a potential to cause loss. In relation to this handbook, the hazard is flooding, which has the potential to cause damage to the community.
Hydraulics	The study of water flow in waterways; in particular, the evaluation of flow parameters such as water level, extent and velocity.
Hydrograph	A graph that shows how the flow or stage (flood level) at any particular location varies with time during a flood.
Hydrologic analysis	The study of the rainfall and runoff process, including the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
Intolerable risk	A risk that, following understanding of the likelihood and consequences of flooding, is so high that it requires consideration of implementation of treatments or actions to improve understanding, avoid, transfer or reduce the risk.
Life-cycle costing	All of the costs associated with the project from the cradle to the grave. This usually includes investigation, design, construction, monitoring, maintenance, asset and performance management and, in some cases, decommissioning of a management measure.
Likelihood	A qualitative description of probability and frequency (see also frequency and probability).
Likelihood of occurrence	The likelihood that a specified event will occur. (With respect to flooding, see also annual exceedance probability and average recurrence interval).
Local overland flooding	Inundation by local runoff on its way to a waterway, rather than overbank flow from a stream, river, estuary, lake or dam. Can be considered synonymous with stormwater flooding.
Loss	Any negative consequence or adverse effect, financial or otherwise.
Mathematical and computer models	The mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.
Merit approach	The merit approach weighs social, economic, ecological and cultural impacts of land-use options for different flood-prone areas, together with flood damage, hazard and behaviour implications, and environmental protection and wellbeing of rivers and floodplains. This approach operates at two levels. At the strategic level, it allows for the consideration of flood hazard and associated social, economic, ecological and cultural issues in formulating statutory planning instruments, and development control plans and policies. At a site specific level, it involves consideration of the best way of

	developing land in consideration of the zonings in a statutory planning instruments, and development control plans and policies.
Minor, moderate and major flooding	These terms are often used in flood warnings to give a general indication of the types of problems expected with a flood.
Probability	A statistical measure of the expected chance of flooding. It is the likelihood of a specific outcome, as measured by the ratio of specific outcomes to the total number of possible outcomes. Probability is expressed as a number between zero and unity, zero indicating an impossible outcome and unity indicating an outcome that is certain. Probabilities are commonly expressed in terms of percentage. For example, the probability of 'throwing a six' on a single roll of a die is one in six, or 0.167 or 16.7% (see also annual exceedance probability).
Probable Maximum Flood (PMF)	The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from PMP and, where applicable, snow melt, coupled with the worst flood-producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood-prone land – that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event, should be addressed in a floodplain risk management study.
Probable Maximum Precipitation (PMP)	The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (WMO 1986). It is the primary input to probable maximum flood estimation.
Rainfall intensity	The rate at which rain falls, typically measured in millimetres per hour (mm/h). Rainfall intensity varies throughout a storm in accordance with the temporal pattern of the storm (see also temporal pattern).
Residual flood risk	The risk a community is exposed to that is not being remedied through established risk treatment processes. In simple terms, for a community, it is the total risk to that community, less any measure in place to reduce that risk. The risk a community is exposed to after treatment measures have been implemented. For a town protected by a levee, the residual flood risk is the consequences of the levee being overtopped by floods larger than the design flood. For an area where flood risk is managed by land-use planning controls, the residual flood risk is the risk associated with the consequences of floods larger than the DFE on the community.

Risk	'The effect of uncertainty on objectives' (ISO31000:2009). NOTE 4 of the definition in ISO31000:2009 also states that 'risk is often expressed in terms of a combination of the consequences of an event (including changes in circumstances) and the associated likelihood of occurrence'. Risk is based upon the consideration of the consequences of the full range of flood behaviour on communities and their social settings, and the natural and built environment (see also likelihood and consequence).
Risk analysis	The systematic use of available information to determine how often specified (flood) events occur and the magnitude of their likely consequences. Flood risk analysis is normally undertaken as part of a floodplain management study, and involves an assessment of flood levels and hazard associated with a range of flood events (see also flood study).
Risk management	The systematic application of management policies, procedures and practices to the tasks of identifying, analysing, assessing, treating and monitoring flood risk. Flood risk management is undertaken as part of a floodplain management plan. The floodplain management plan reflects the adopted means of managing flood risk (see also floodplain management plan).
Riverine flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam. Riverine flooding generally excludes watercourses constructed with pipes or artificial channels considered as stormwater channels.
Runoff	The amount of rainfall that drains into the surface drainage network to become stream flow; also known as rainfall excess.
Stage	Equivalent to water level. Both stage and water level are measured with reference to a specified datum (e.g. the Australian height datum).
Storm surge	The increases in coastal water levels above predicted astronomical tide level (i.e. tidal anomaly) resulting from a range of location dependent factors including the inverted barometer effect, wind and wave setup and astronomical tidal waves, together with any other factors that increase tidal water level (see also astronomical tide, wind set-up and wave set-up).
Stormwater flooding	Is inundation by local runoff caused by heavier than usual rainfall. It can be caused by local runoff exceeding the capacity of an urban stormwater drainage systems, flow overland on the way to waterways or by the backwater effects of mainstream flooding causing urban stormwater drainage systems to overflow (see also local overland flooding).
Temporal pattern	The variation of rainfall intensity with time during a rainfall event.

Tidal anomaly	The difference between recorded storm surge levels and predicted astronomical tide level.
Treatment options	The measures that might be feasible for the treatment of existing, future and residual flood risk at particular locations within the floodplain. Preparation of a treatment plan requires a detailed evaluation of floodplain management options (see also floodplain management plan).
Velocity of floodwater	The speed of floodwaters, measured in metres per second (m/s).
Vulnerability	The degree of susceptibility and resilience of a community, its social setting, and the natural and built environments to flood hazards. Vulnerability is assessed in terms of ability of the community and environment to anticipate, cope and recover from flood events. Flood awareness is an important indicator of vulnerability (see also flood awareness).
Wave set-up	The increase in water levels in coastal waters (within the breaker zone) caused by waves transporting water shorewards. The zone of wave set-up against the shore is balanced by a zone of wave 'set-down' (i.e. reduced water levels) seawards of the breaker zone. Wave setups of 2-4 m could occur during tropical cyclones.
Wind set-up	The increase in water levels in coastal waters caused by the wind driving the water shorewards and 'piling it up' against the shore. Wind set-up can be as high as 10 m in an extreme case, and often exceeds 2-3 m in typical tropical cyclones.

APPENDIX B
EXISTING CATCHMENT CHARACTERISTICS

Please refer to the Geurie Floodplain Risk Management Study and Plan Report Volume 2.

APPENDIX C
POTENTIAL FLOODPLAIN RISK MANAGEMENT MEASURES

Please refer to the Geurie Floodplain Risk Management Study and Plan Report Volume 2.

APPENDIX D
ESTIMATE OF BENEFITS

Please refer to the Geurie Floodplain Risk Management Study and Plan Report Volume 2.

APPENDIX E
ESTIMATE OF COSTS

Please refer to the Geurie Floodplain Risk Management Study and Plan Report Volume 2.

Geurie Floodplain Risk Management Study

Draft Report
Volume 2

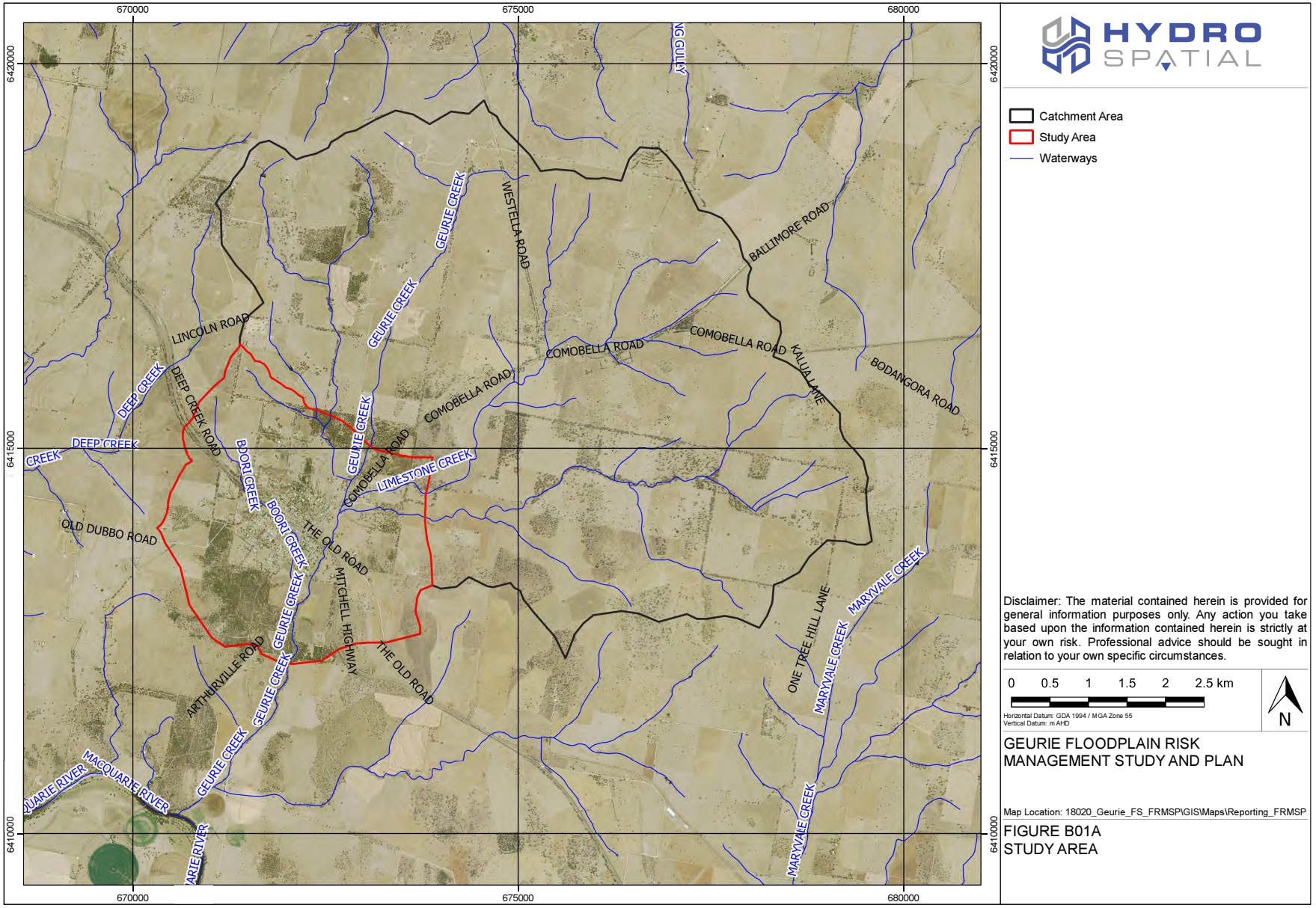
March 2022

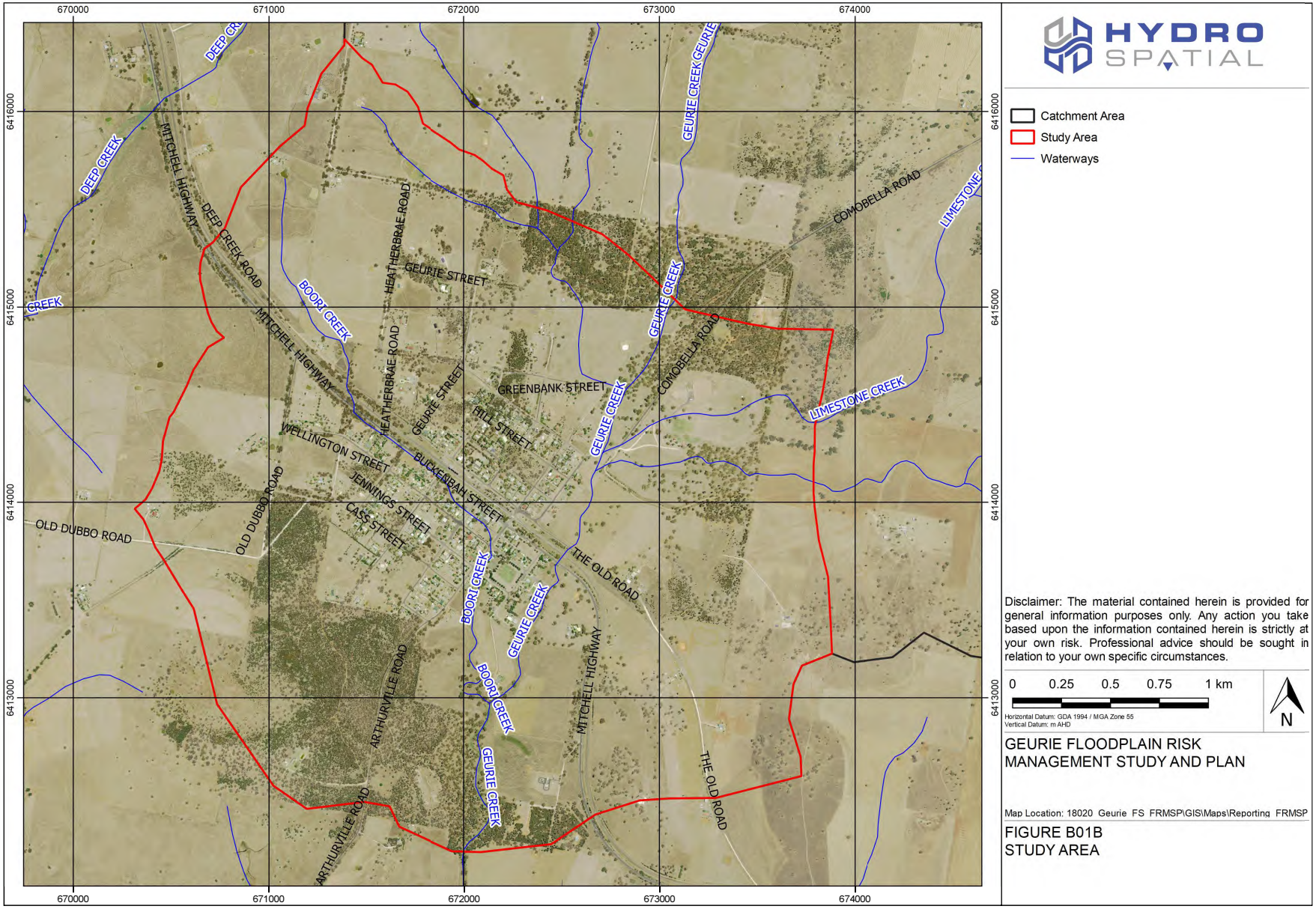
Prepared for
Dubbo Regional Council
PO Box 81
Dubbo, NSW 2830
Email: council@dubbo.nsw.gov.au

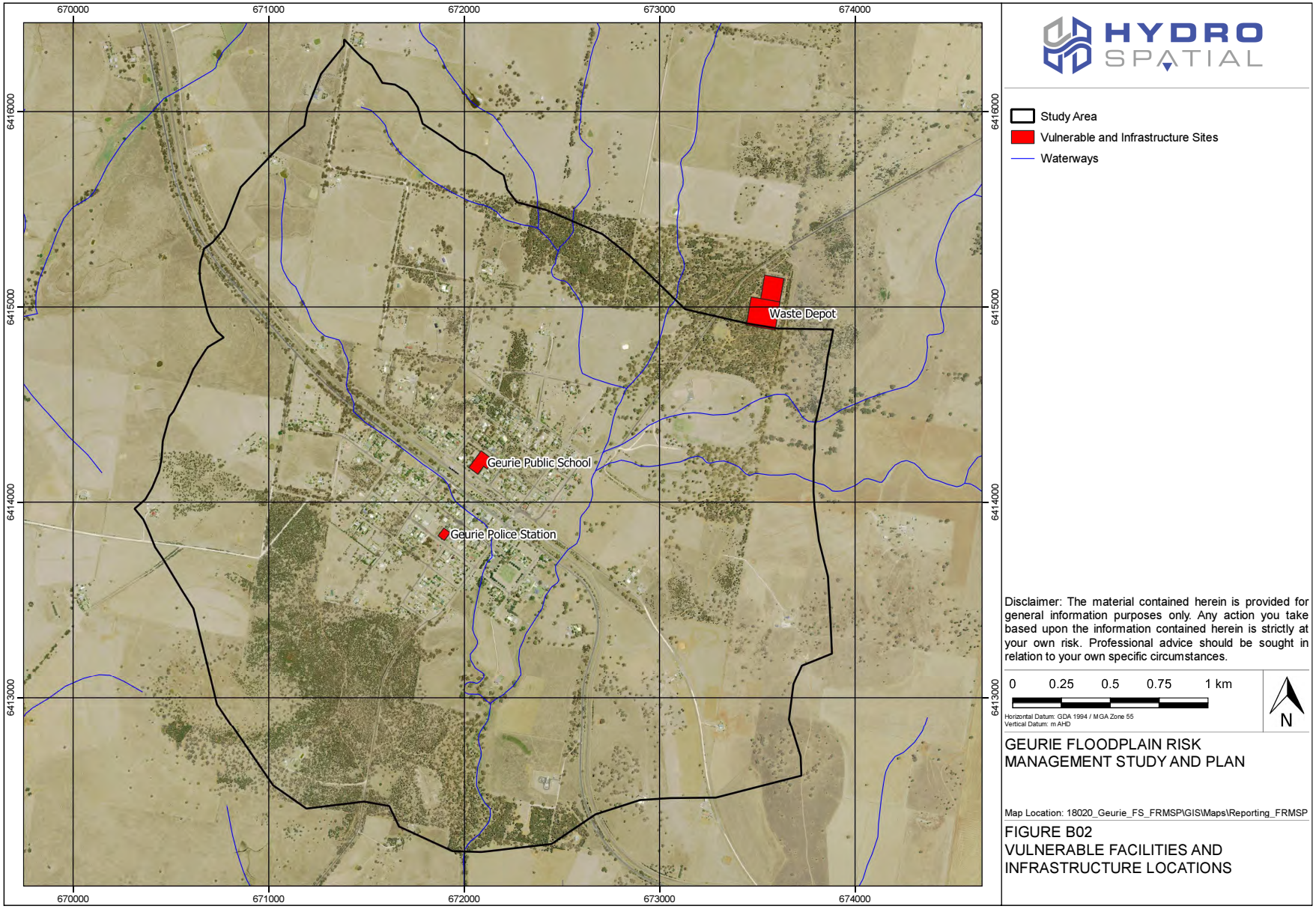
Prepared by
HydroSpatial Pty Ltd
Suite 25, Level 2
104 Bathurst Street
Sydney NSW 2000
Email: info@hydrospatial.com.au

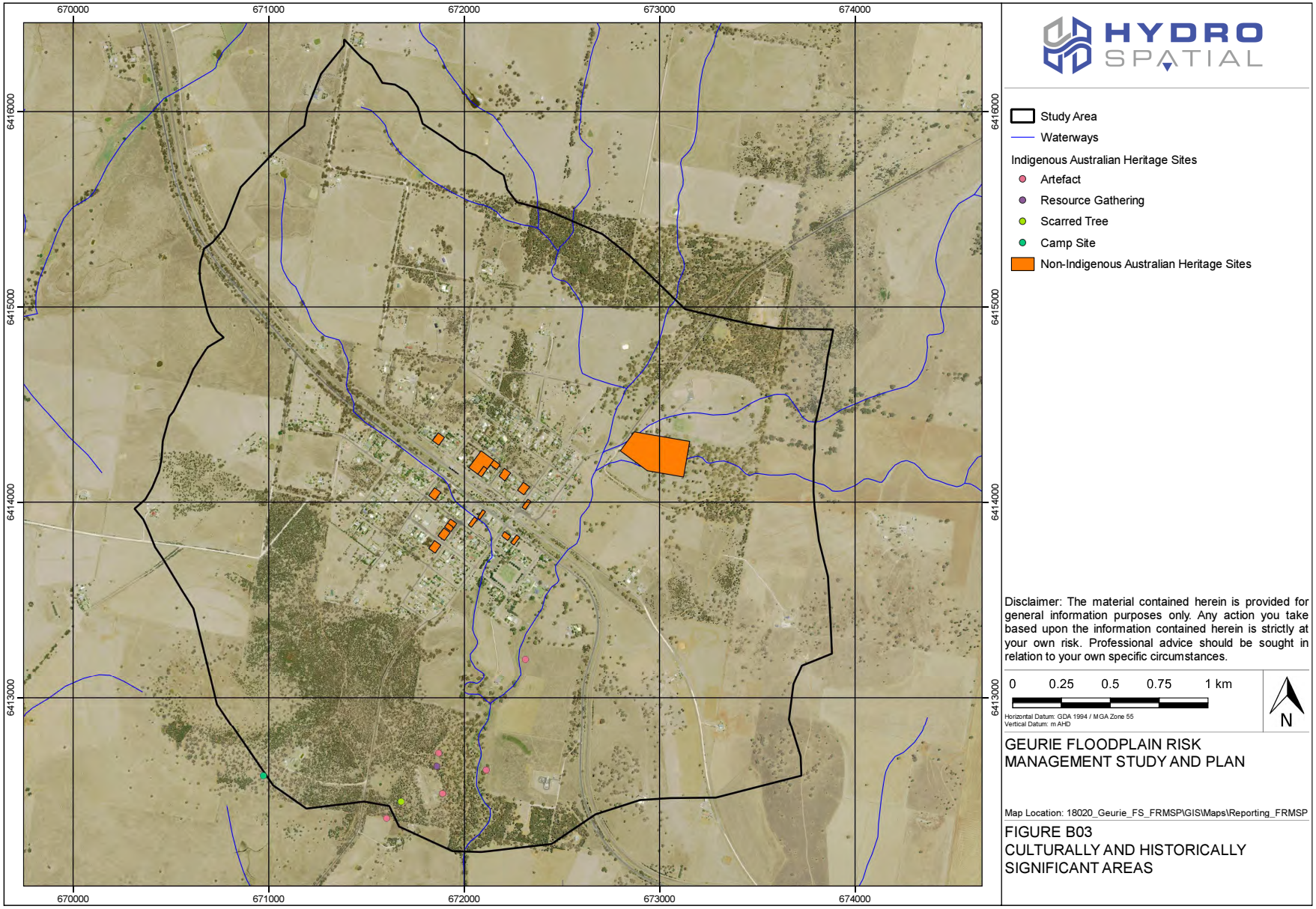
HYDROSPATIAL

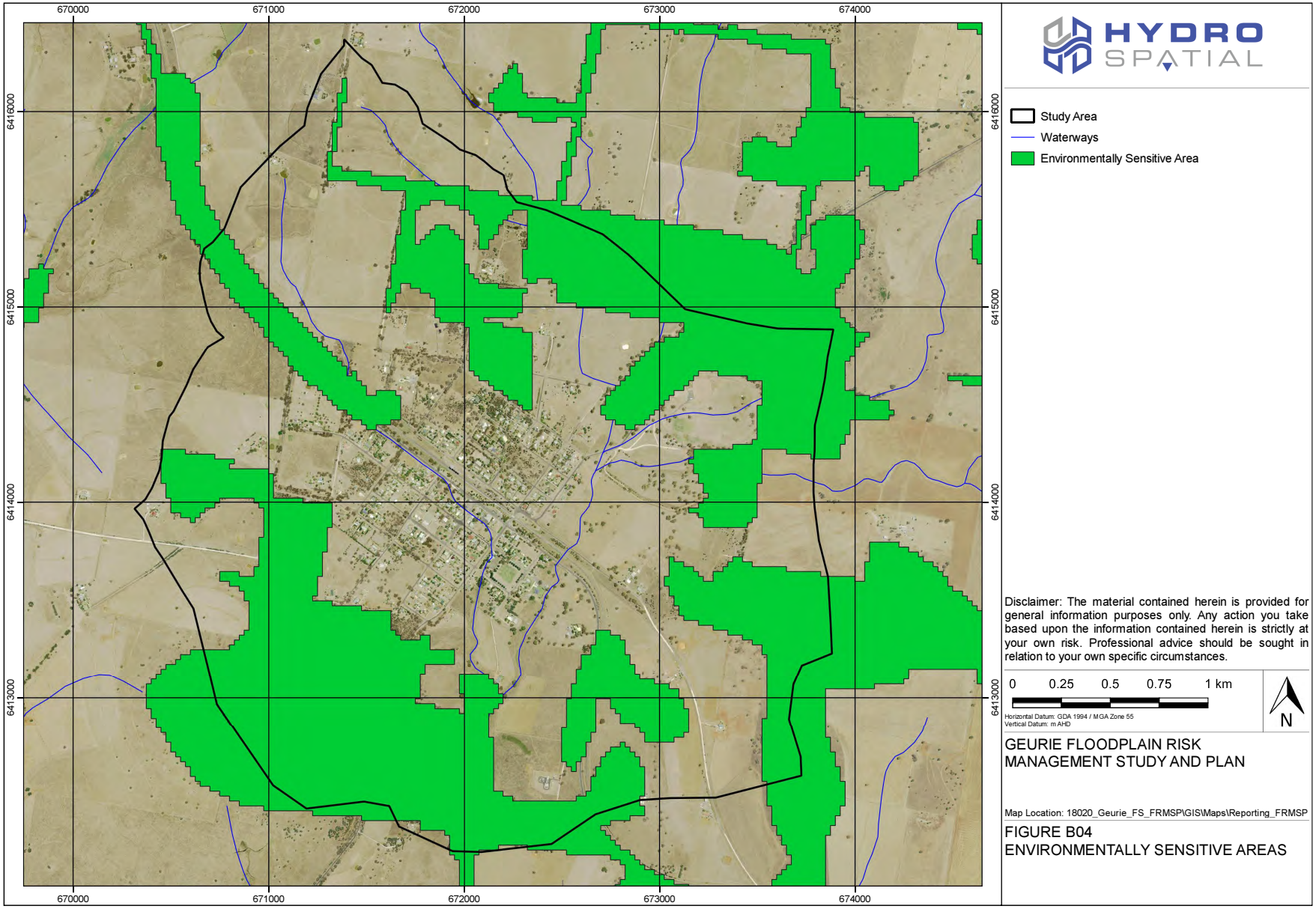
APPENDIX B
EXISTING CATCHMENT CHARACTERISTICS


670000
675000
680000
6420000
6415000
6410000
WESTELLA ROAD
BALLIMORE ROAD
GEURIE CREEK
LINCOLN ROAD
COMOBELLA ROAD
KALUA LANE
BODANGORA ROAD
DEEP CREEK
DEEP CREEK ROAD
BOORI CREEK
LIMESTONE CREEK
OLD DUBBO ROAD
THE OLD ROAD
MITCHELL HIGHWAY
ARTHURVILLE ROAD
ONE TREE HILL LANE
MARYVALE CREEK
MACQUARIE RIVER
Catchment Area
Study Area
Waterways
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.5 1 1.5 2 2.5 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FRMSP
FIGURE B01A
STUDY AREA


670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
DEEP CR
DEEP CREEK
MITCHELL HIGHWAY
DEEP CREEK ROAD
CREEK
BOORI CREEK
HEATHERBRAE ROAD
GEURIE STREET
GEURIE CREEK GEURIE
COMOBELLA ROAD
LIMESTONE
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAH STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
LIMESTONE CREEK
Catchment Area
Study Area
Waterways
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020 Geurie FS FRMSP\GIS\Maps\Reporting FRMSP
FIGURE B01B
STUDY AREA


670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
Waste Depot
Geurie Public School
Geurie Police Station
HYDRO SPATIAL
Study Area
Vulnerable and Infrastructure Sites
Waterways
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FRMSP
FIGURE B02
VULNERABLE FACILITIES AND INFRASTRUCTURE LOCATIONS


670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
HYDRO SPATIAL
Study Area
Waterways
Indigenous Australian Heritage Sites
Artefact
Resource Gathering
Scarred Tree
Camp Site
Non-Indigenous Australian Heritage Sites
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FRMSP
FIGURE B03
CULTURALLY AND HISTORICALLY SIGNIFICANT AREAS


670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
HYDRO SPATIAL
Study Area
Waterways
Environmentally Sensitive Area
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FRMSP
FIGURE B04
ENVIRONMENTALLY SENSITIVE AREAS

HYDRO SPATIAL

Study Area

Structural Capacity

- > 20% AEP
- > 10% AEP
- > 5% AEP
- > 2% AEP
- >1% AEP
- > 0.5% AEP
- > PMF
- < PMF

0 0.25 0.5 0.75 1 km

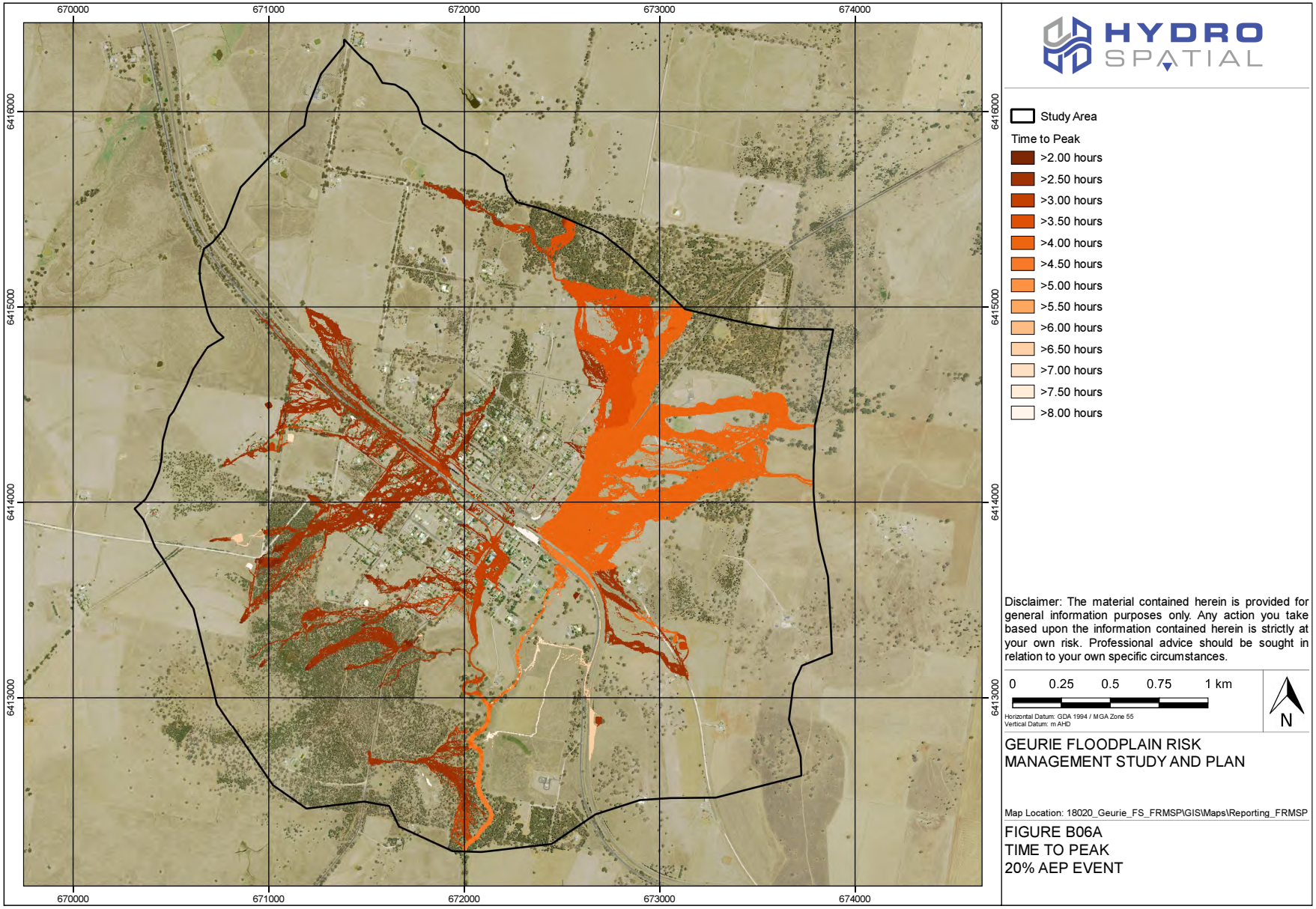
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD

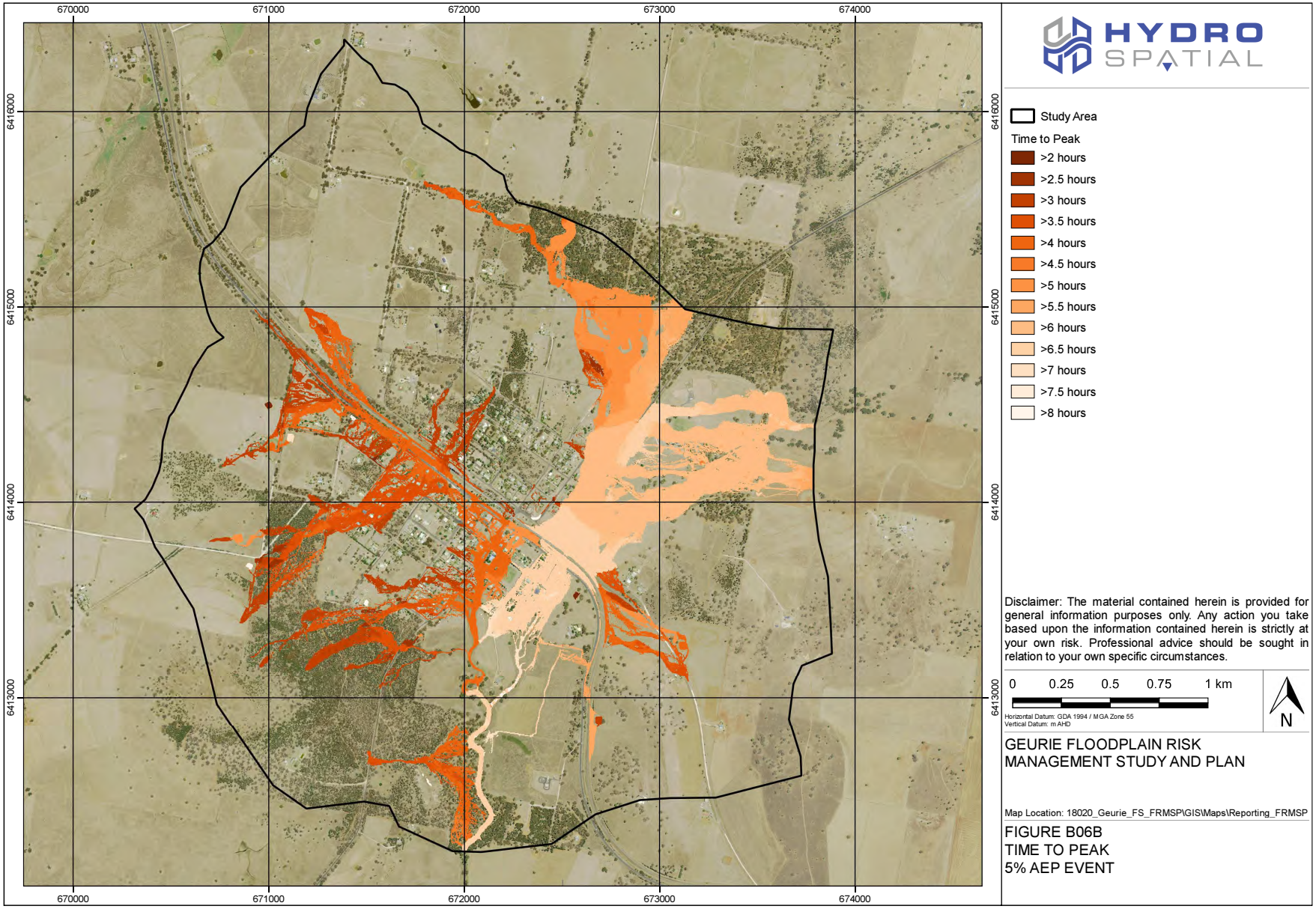
N

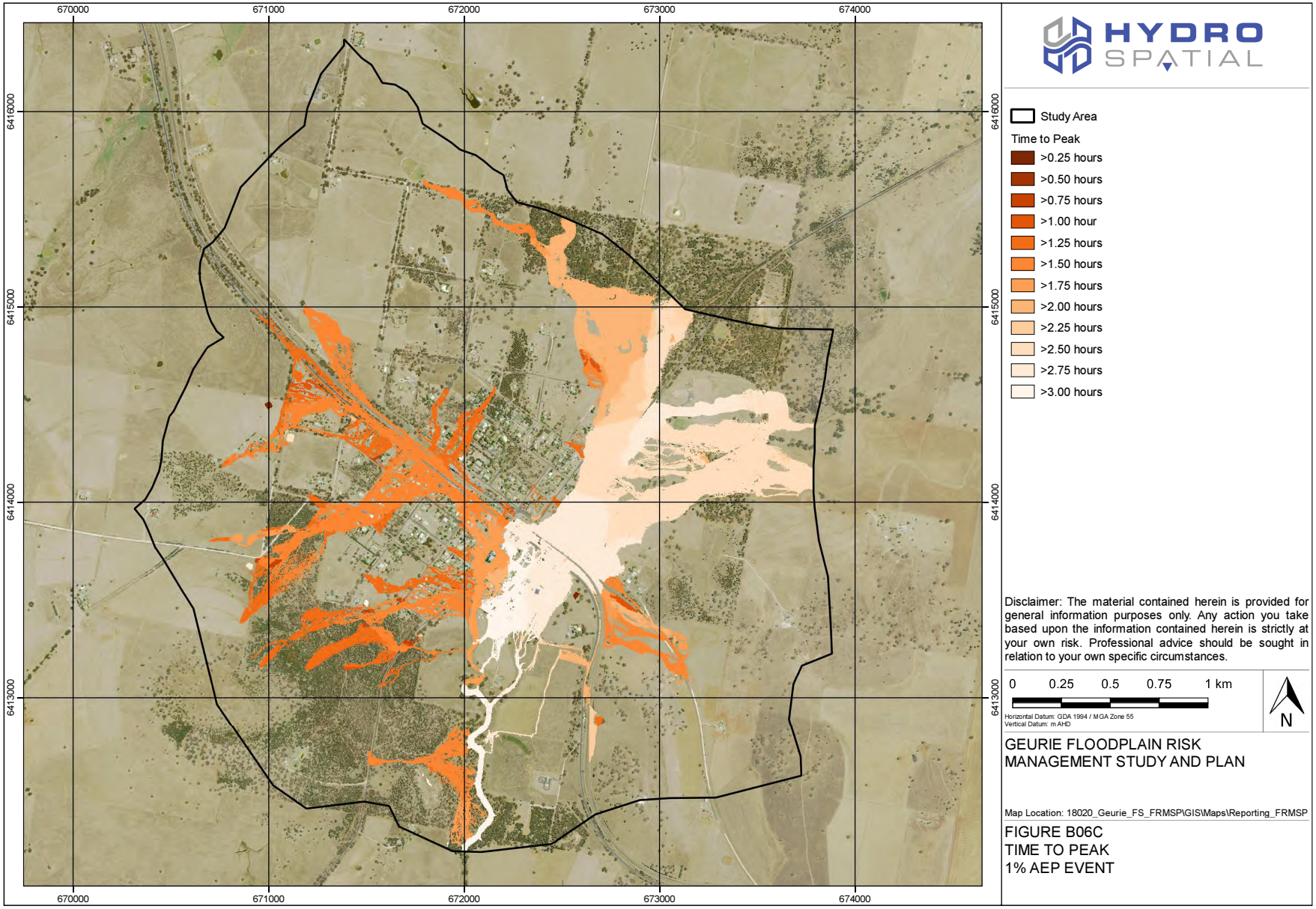
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

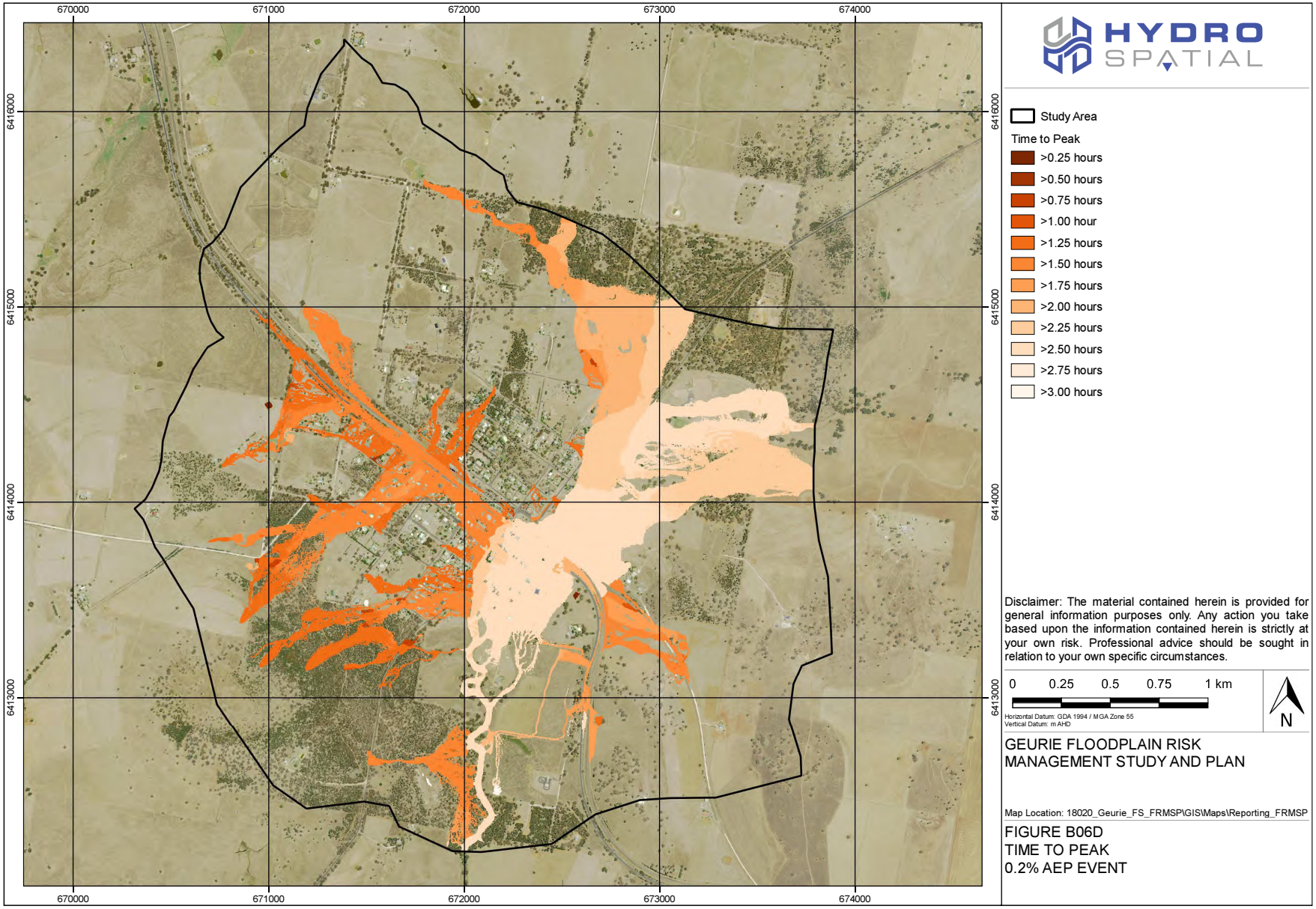
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FRMSP

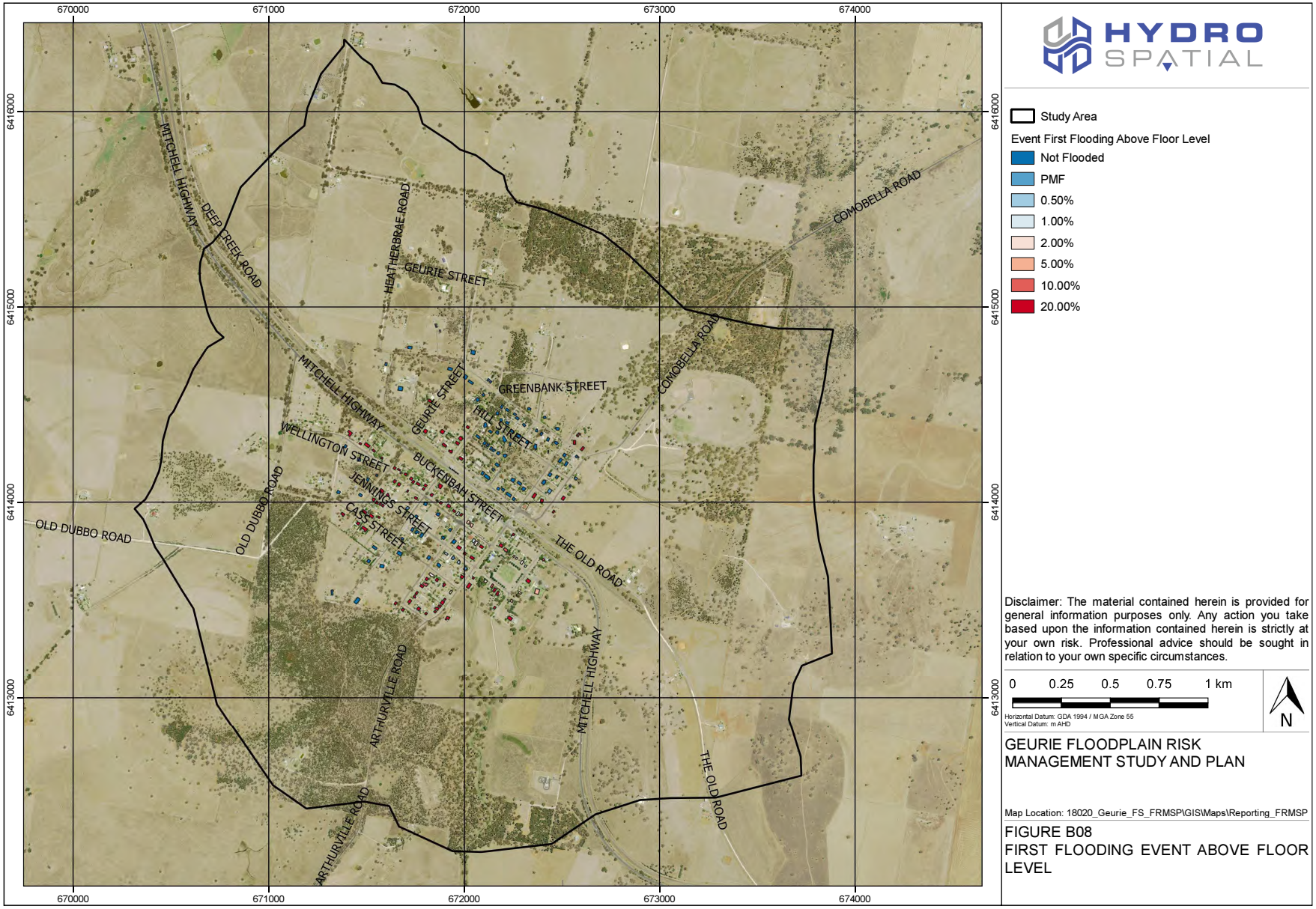
FIGURE B05
BRIDGE AND CULVERT CAPACITY

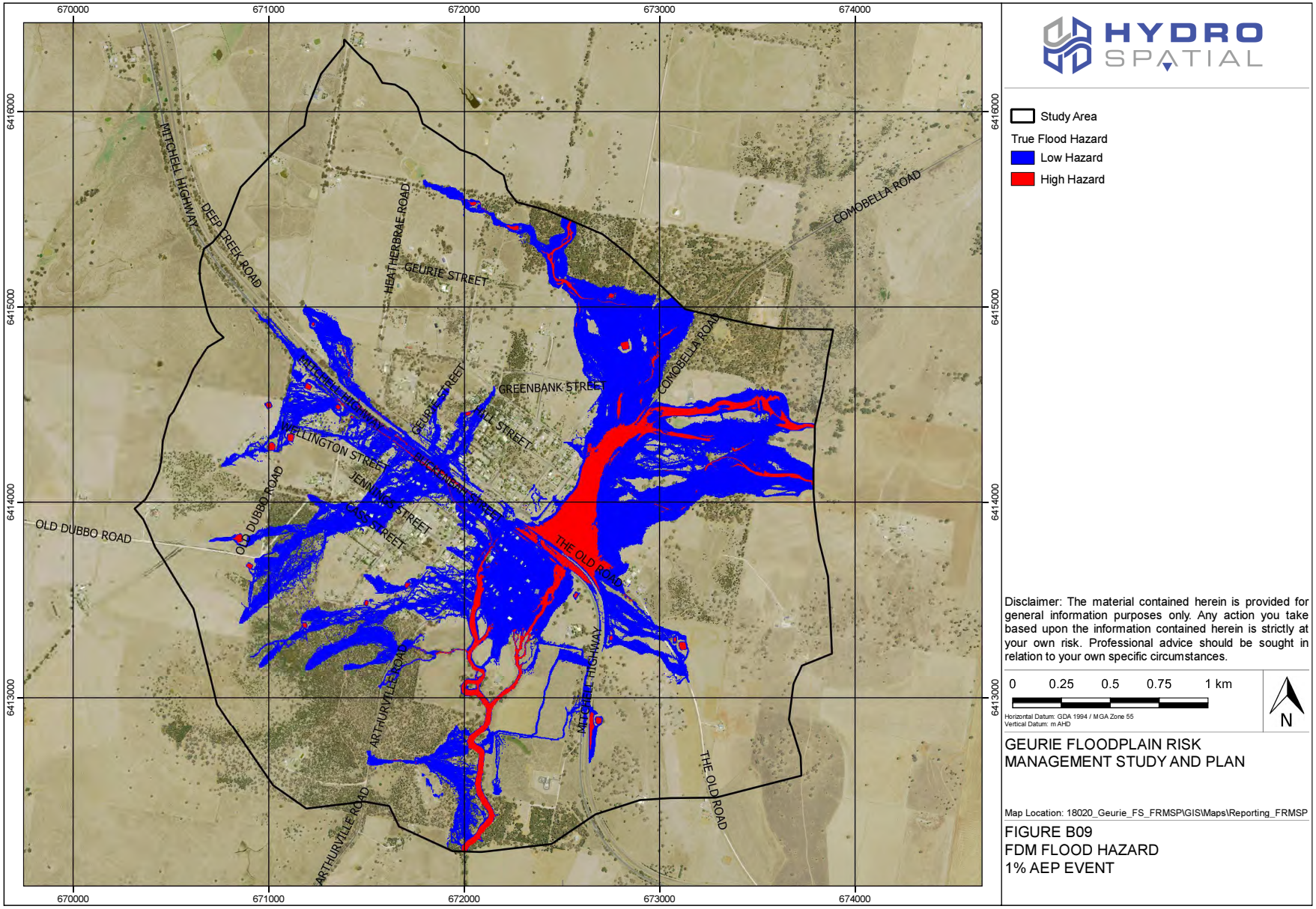

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
HYDRO SPATIAL
Study Area
Time to Peak
>2.00 hours
>2.50 hours
>3.00 hours
>3.50 hours
>4.00 hours
>4.50 hours
>5.00 hours
>5.50 hours
>6.00 hours
>6.50 hours
>7.00 hours
>7.50 hours
>8.00 hours
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FRMSP
FIGURE B06A
TIME TO PEAK
20% AEP EVENT

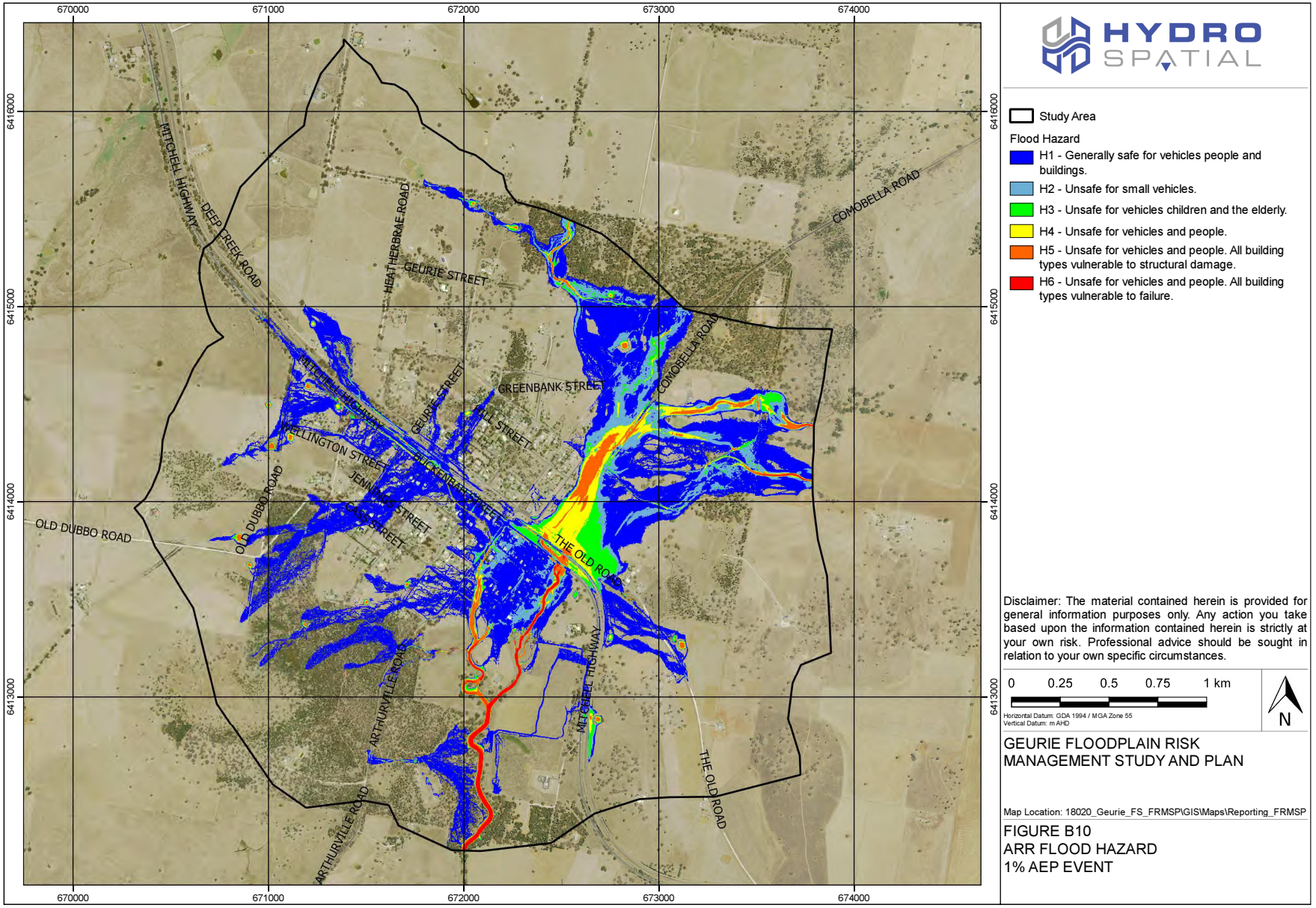

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
HYDRO SPATIAL
Study Area
Time to Peak
>2 hours
>2.5 hours
>3 hours
>3.5 hours
>4 hours
>4.5 hours
>5 hours
>5.5 hours
>6 hours
>6.5 hours
>7 hours
>7.5 hours
>8 hours
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FRMSP
FIGURE B06B
TIME TO PEAK
5% AEP EVENT

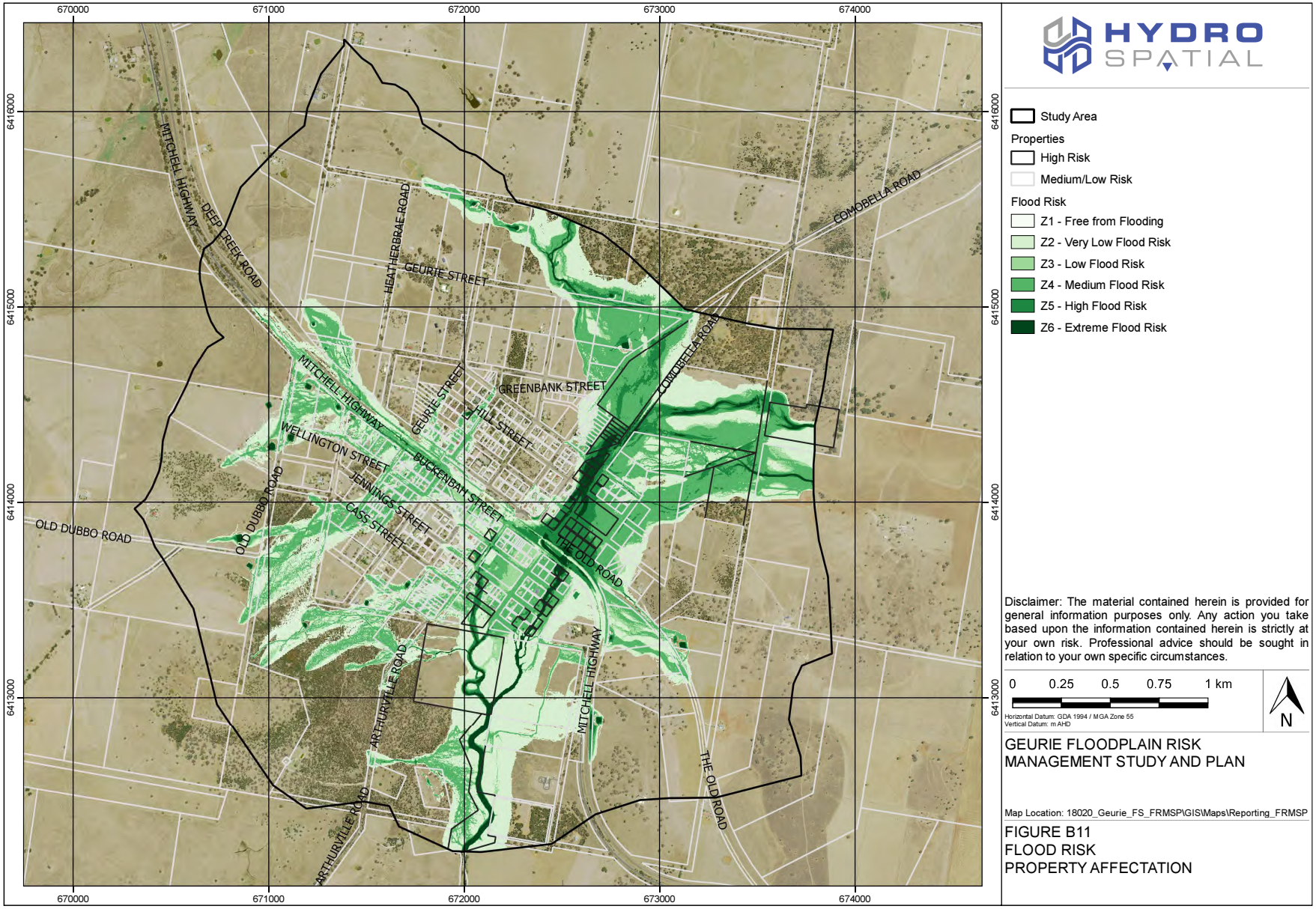

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
HYDRO SPATIAL
Study Area
Time to Peak
>0.25 hours
>0.50 hours
>0.75 hours
>1.00 hour
>1.25 hours
>1.50 hours
>1.75 hours
>2.00 hours
>2.25 hours
>2.50 hours
>2.75 hours
>3.00 hours
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FRMSP
FIGURE B06C
TIME TO PEAK
1% AEP EVENT


670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
HYDRO SPATIAL
Study Area
Time to Peak
>0.25 hours
>0.50 hours
>0.75 hours
>1.00 hour
>1.25 hours
>1.50 hours
>1.75 hours
>2.00 hours
>2.25 hours
>2.50 hours
>2.75 hours
>3.00 hours
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FRMSP
FIGURE B06D
TIME TO PEAK
0.2% AEP EVENT


670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
HYDRO SPATIAL
Study Area
Event First Flooding Above Floor Level
Not Flooded
PMF
0.50%
1.00%
2.00%
5.00%
10.00%
20.00%
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FRMSP
FIGURE B08
FIRST FLOODING EVENT ABOVE FLOOR LEVEL

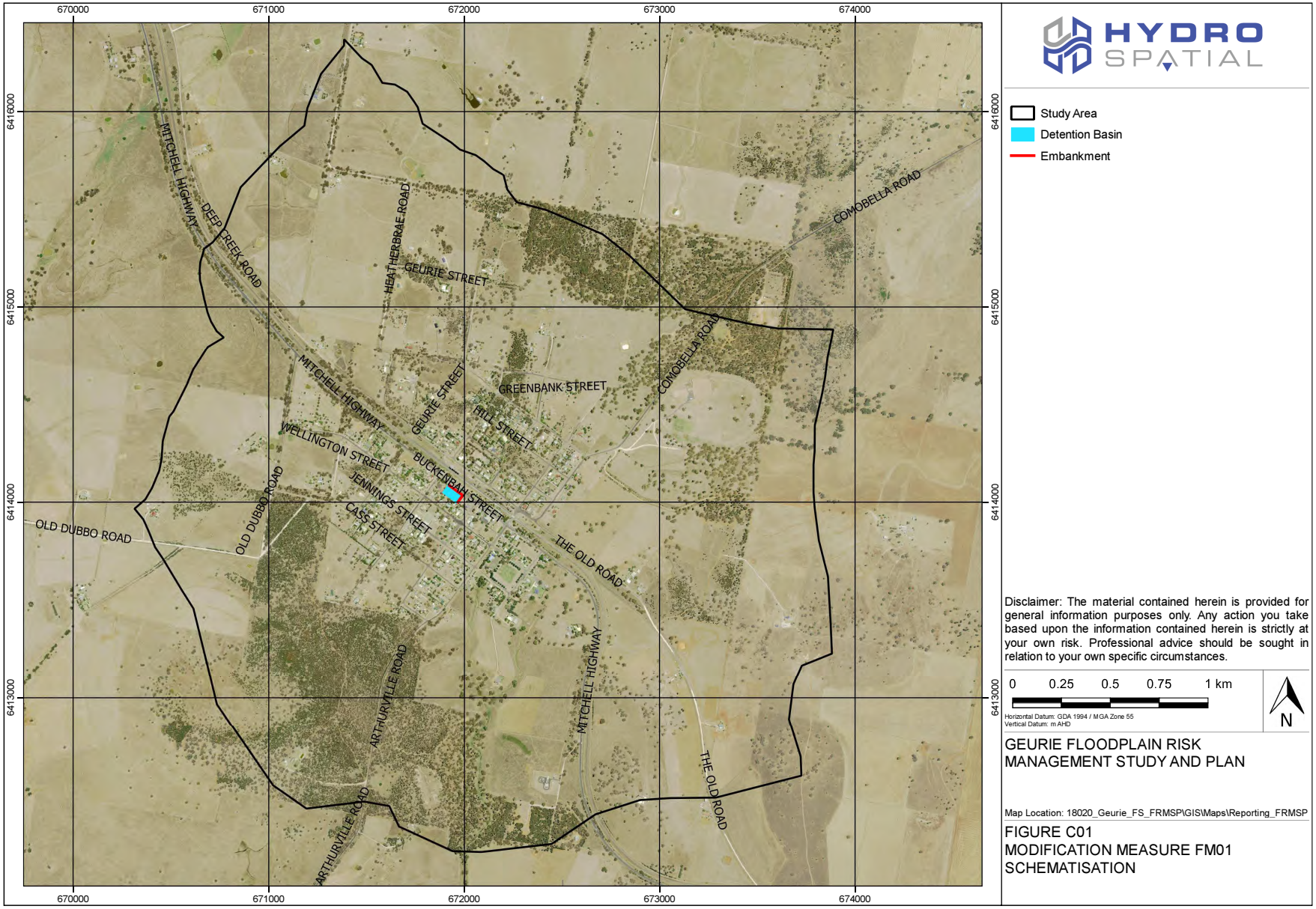

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
WELLINGTON STREET
JENNINGS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Study Area
True Flood Hazard
Low Hazard
High Hazard
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FRMSP
FIGURE B09
FDM FLOOD HAZARD
1% AEP EVENT

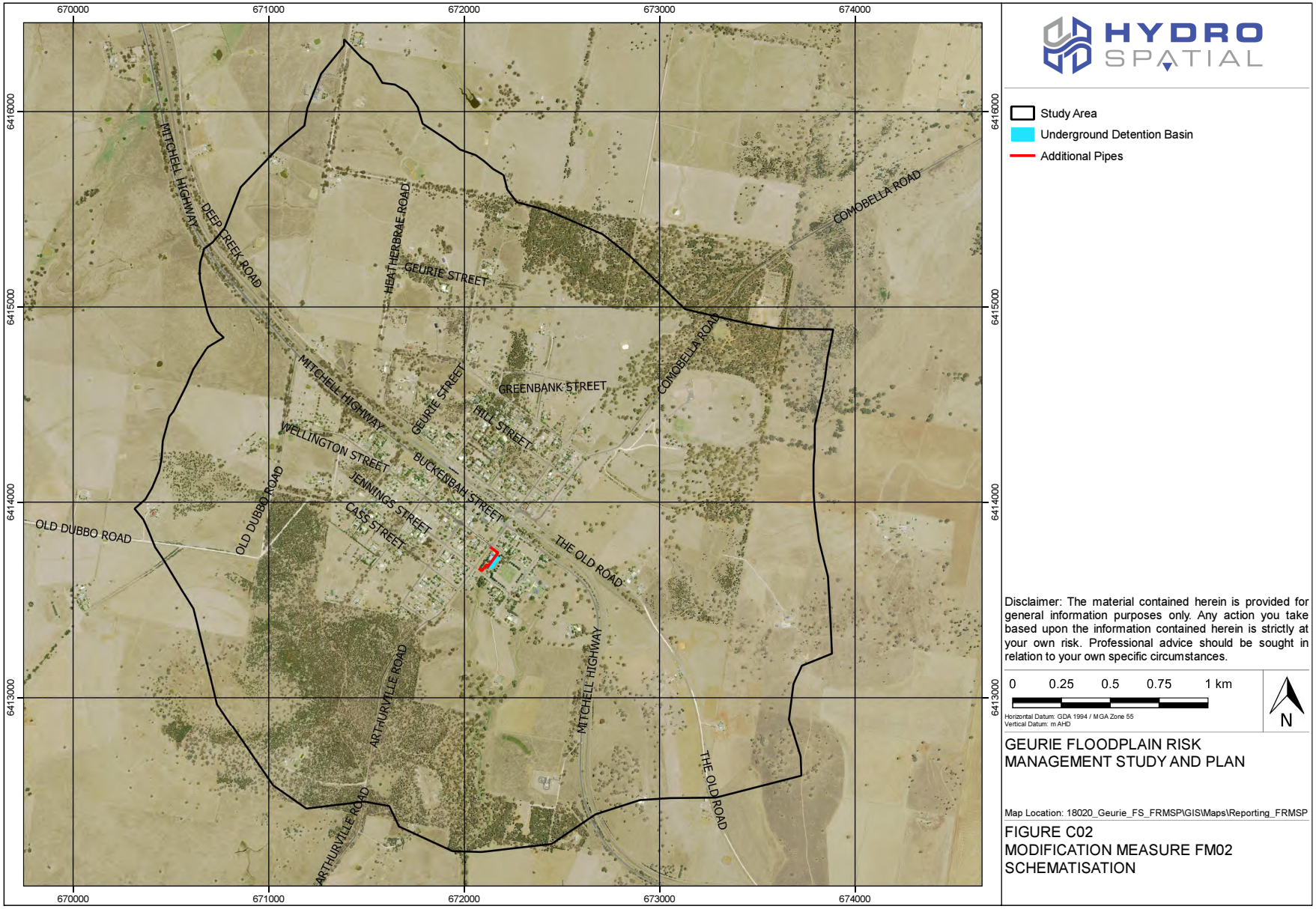

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
WELLINGTON STREET
BUCKINBAH STREET
JENNINGS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Study Area
Flood Hazard
H1 - Generally safe for vehicles people and buildings.
H2 - Unsafe for small vehicles.
H3 - Unsafe for vehicles children and the elderly.
H4 - Unsafe for vehicles and people.
H5 - Unsafe for vehicles and people. All building types vulnerable to structural damage.
H6 - Unsafe for vehicles and people. All building types vulnerable to failure.
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FRMSP
FIGURE B10
ARR FLOOD HAZARD
1% AEP EVENT

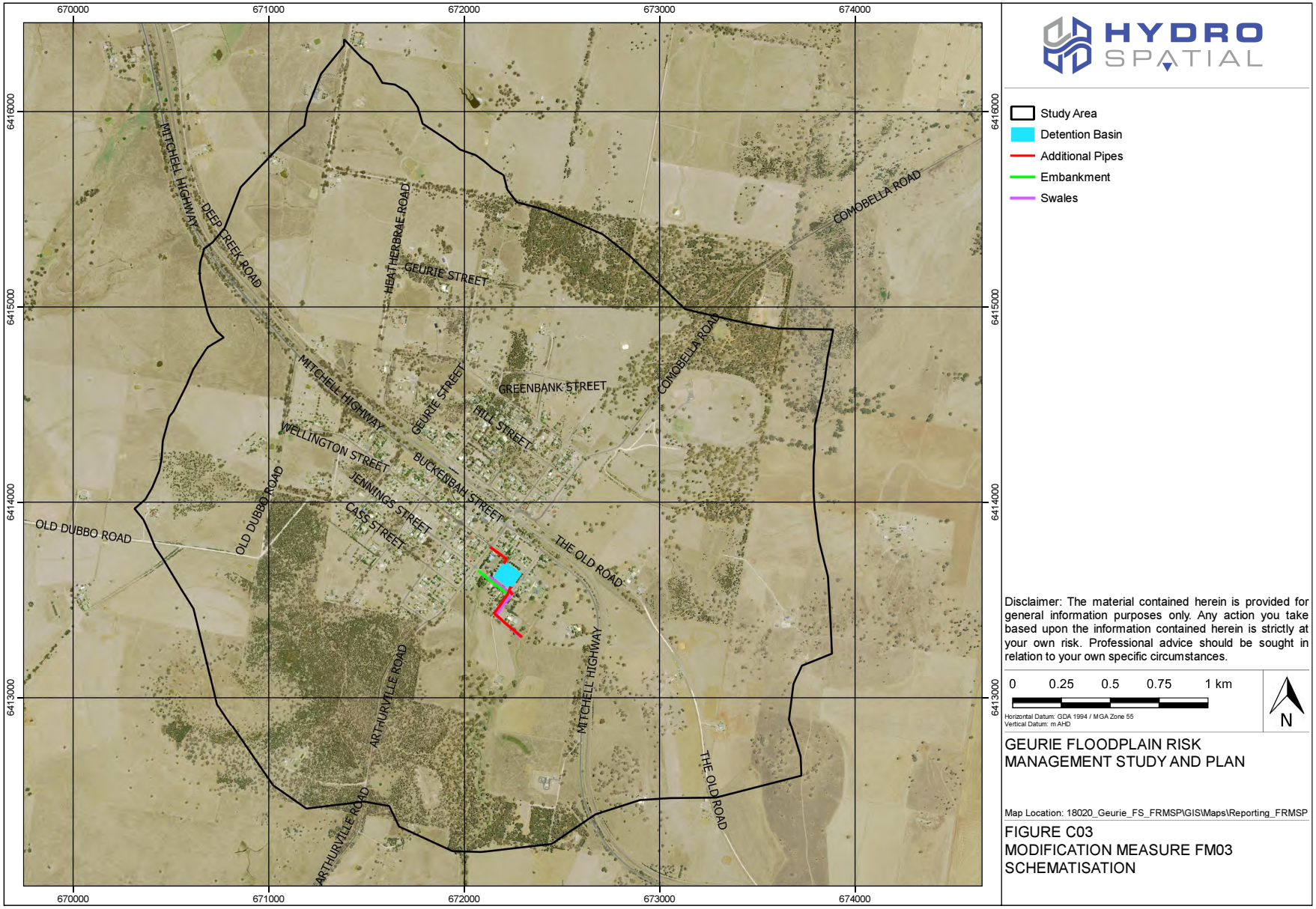

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEATHERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
WELLINGTON STREET
BUCKENBAH STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
HYDRO SPATIAL
Study Area
Properties
High Risk
Medium/Low Risk
Flood Risk
Z1 - Free from Flooding
Z2 - Very Low Flood Risk
Z3 - Low Flood Risk
Z4 - Medium Flood Risk
Z5 - High Flood Risk
Z6 - Extreme Flood Risk
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FRMSP
FIGURE B11
FLOOD RISK
PROPERTY AFFECTATION

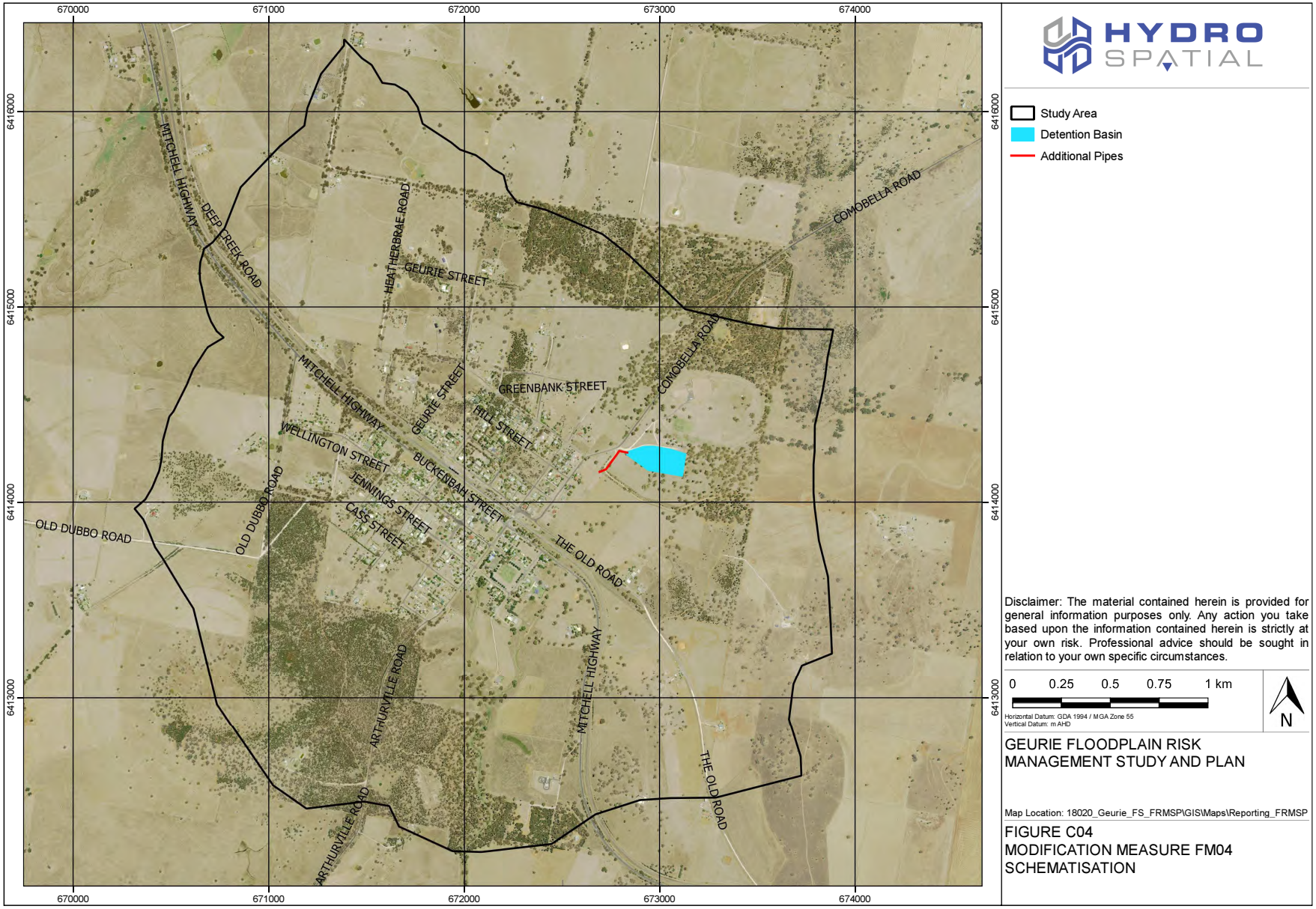
HYDROSPATIAL

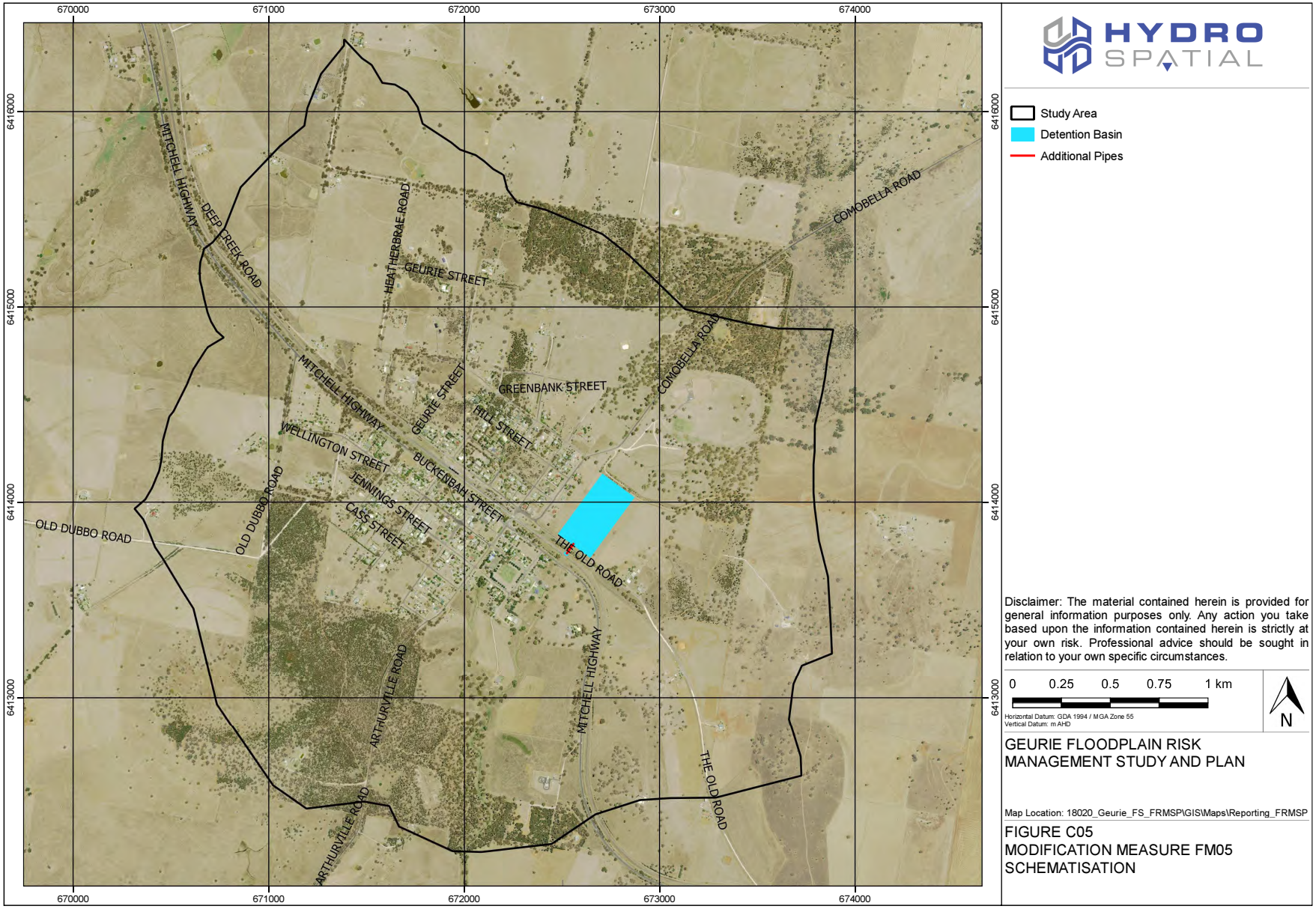
APPENDIX C
POTENTIAL FLOODPLAIN RISK MANAGEMENT MEASURES

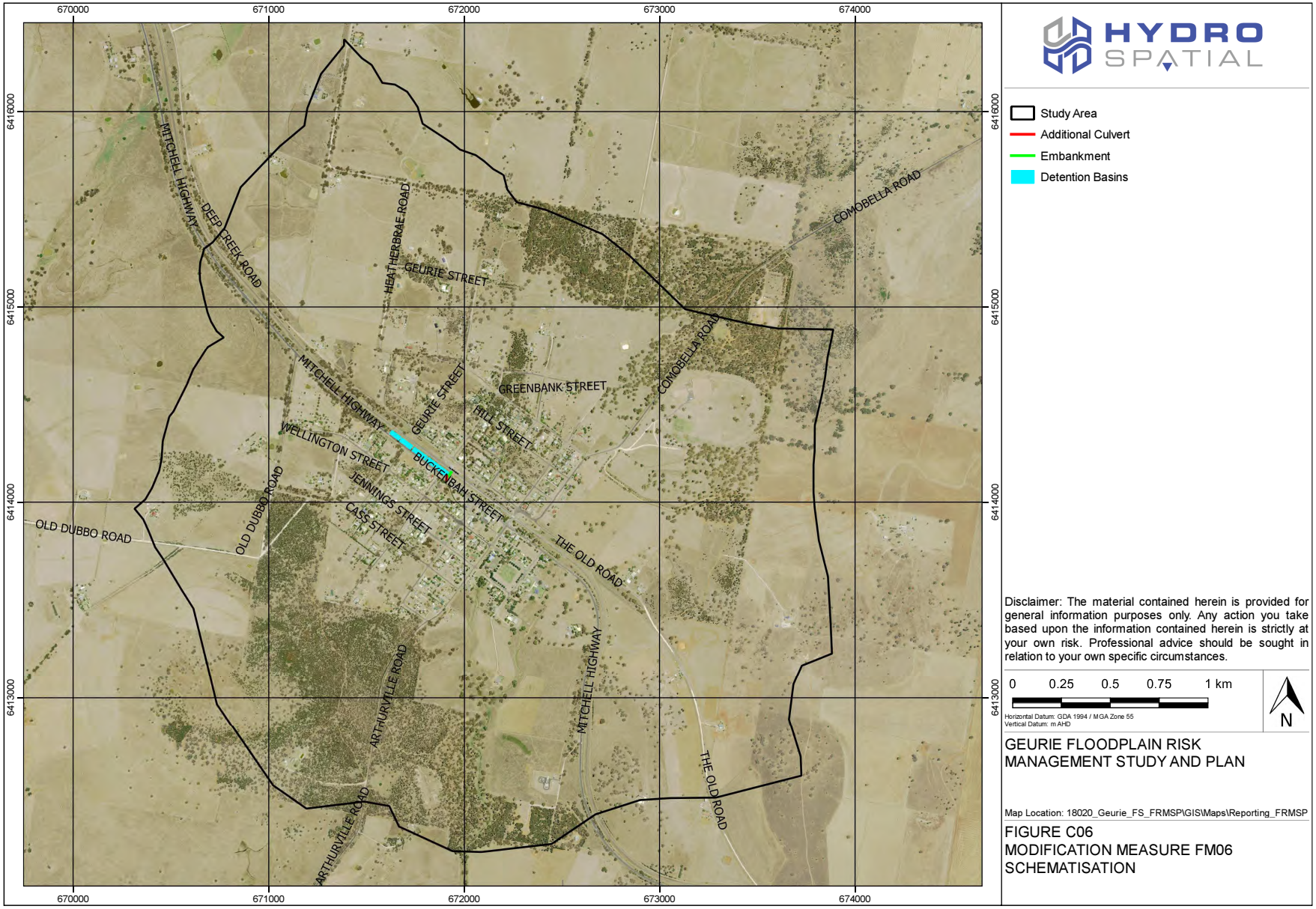

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Study Area
Detention Basin
Embankment
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FRMSP
FIGURE C01
MODIFICATION MEASURE FM01
SCHEMATISATION

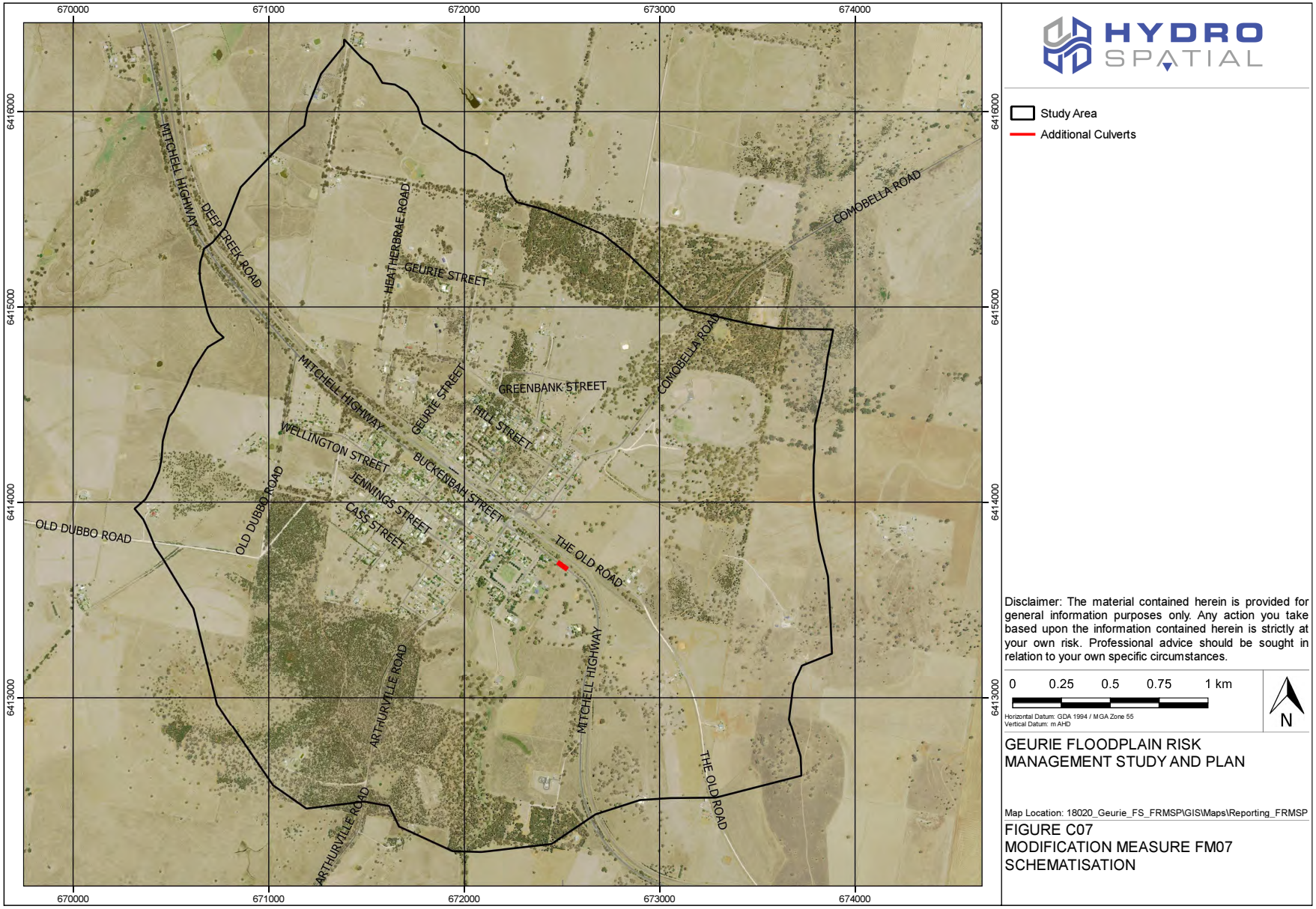

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Study Area
Underground Detention Basin
Additional Pipes
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FRMSP
FIGURE C02
MODIFICATION MEASURE FM02
SCHEMATISATION

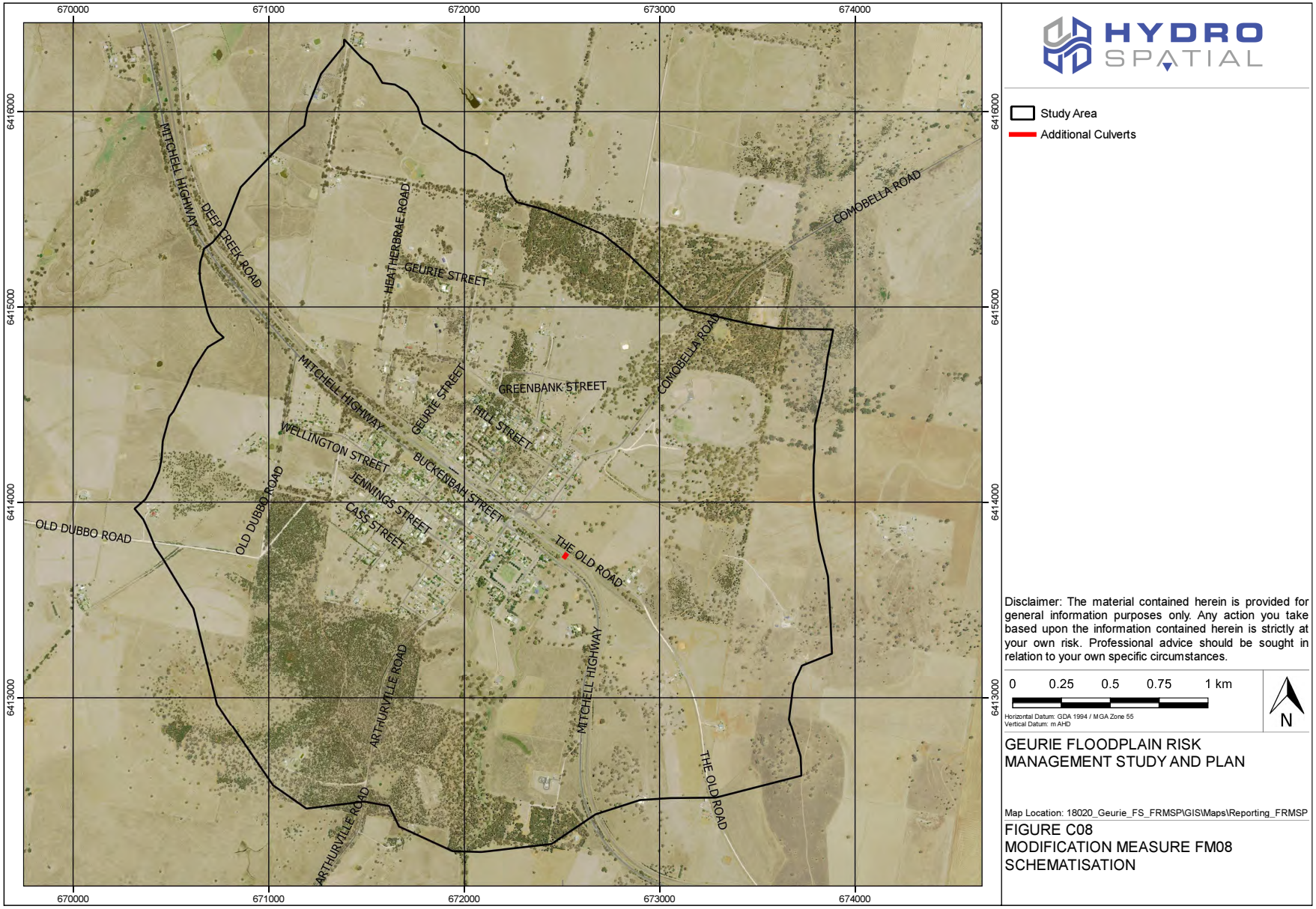

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
MITCHELL HIGHWAY
GEURIE STREET
GREENBANK STREET
COMOBELLA ROAD
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
MITCHELL HIGHWAY
THE OLD ROAD
ARTHURVILLE ROAD
Study Area
Detention Basin
Additional Pipes
Embankment
Swales
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0
0.25
0.5
0.75
1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FRMSP
FIGURE C03
MODIFICATION MEASURE FM03
SCHEMATISATION

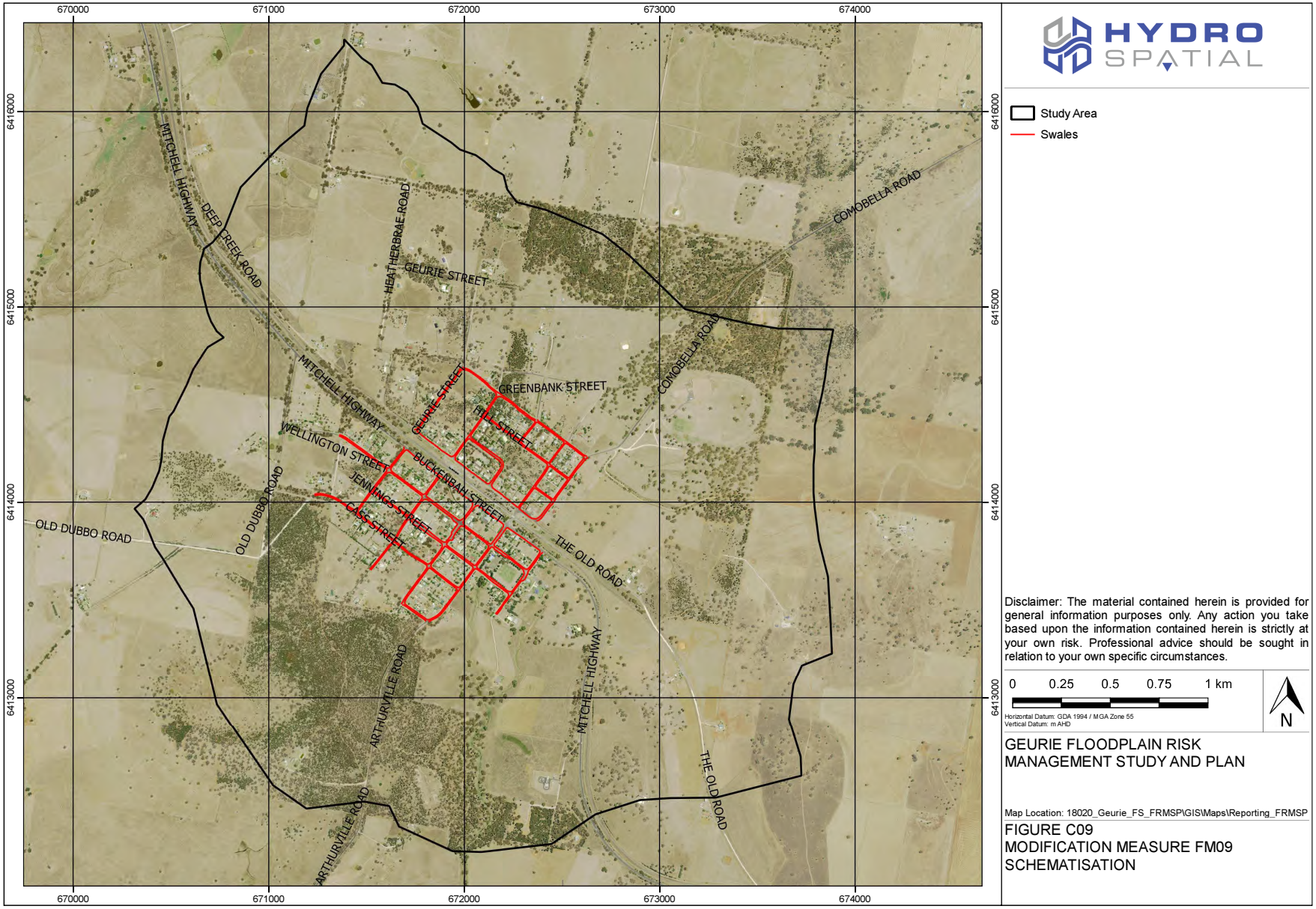

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Study Area
Detention Basin
Additional Pipes
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FRMSP
FIGURE C04
MODIFICATION MEASURE FM04
SCHEMATISATION

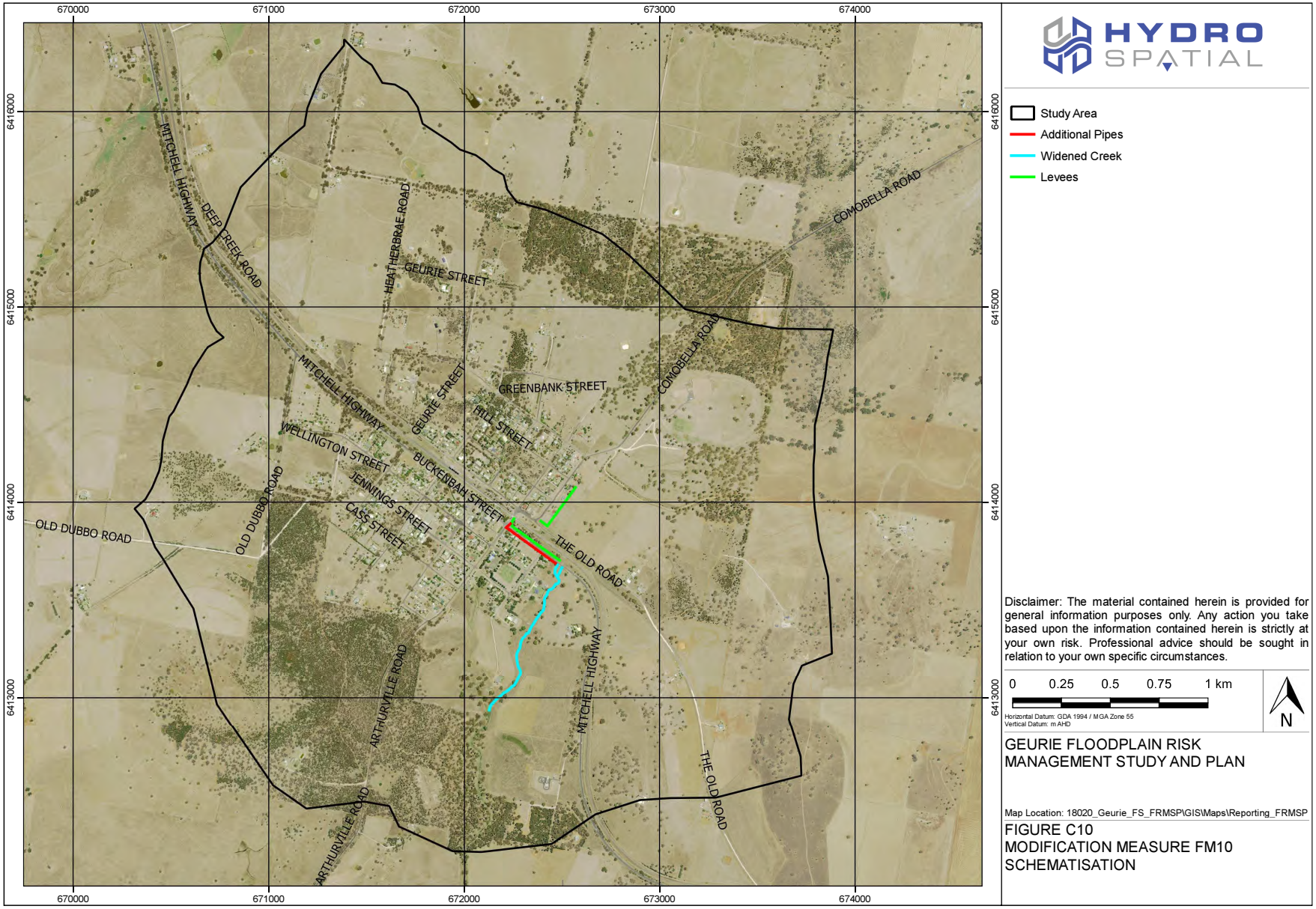

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Study Area
Detention Basin
Additional Pipes
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FRMSP
FIGURE C05
MODIFICATION MEASURE FM05
SCHEMATISATION


670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Study Area
Additional Culvert
Embankment
Detention Basins
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FRMSP
FIGURE C06
MODIFICATION MEASURE FM06
SCHEMATISATION


670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Study Area
Additional Culverts
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FRMSP
FIGURE C07
MODIFICATION MEASURE FM07
SCHEMATISATION

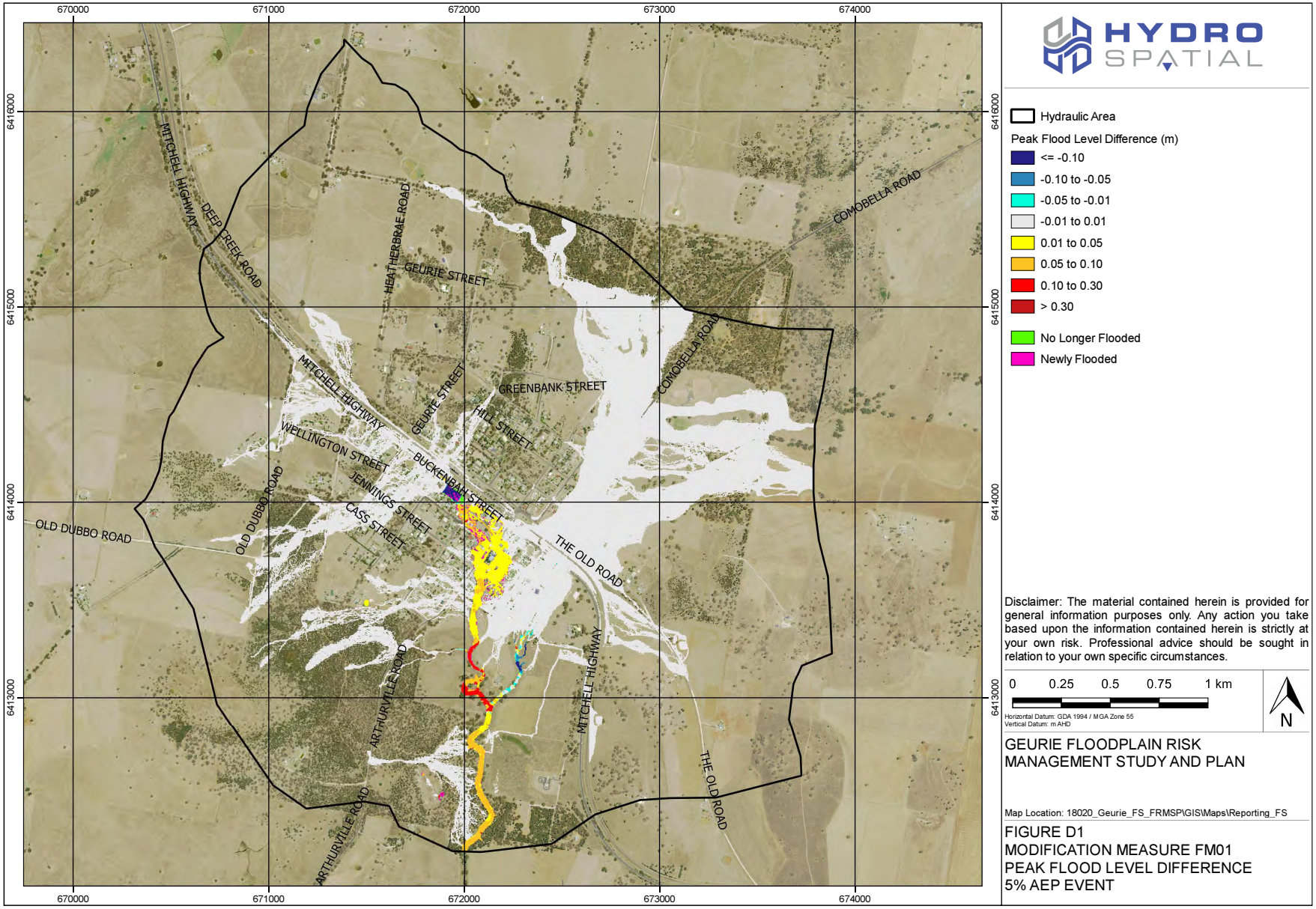

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Study Area
Additional Culverts
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FRMSP
FIGURE C08
MODIFICATION MEASURE FM08
SCHEMATISATION

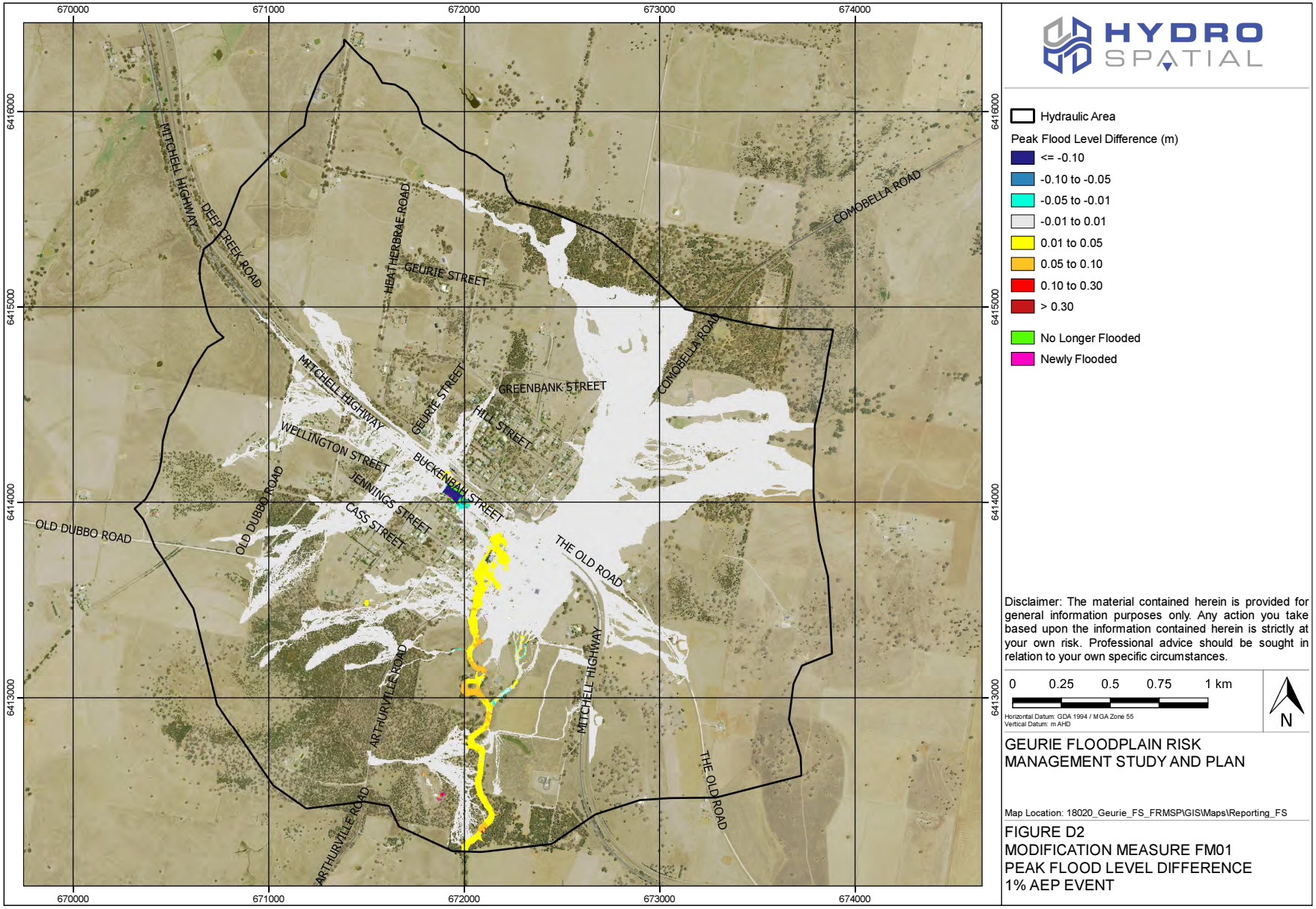

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Study Area
Swales
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FRMSP
FIGURE C09
MODIFICATION MEASURE FM09
SCHEMATISATION

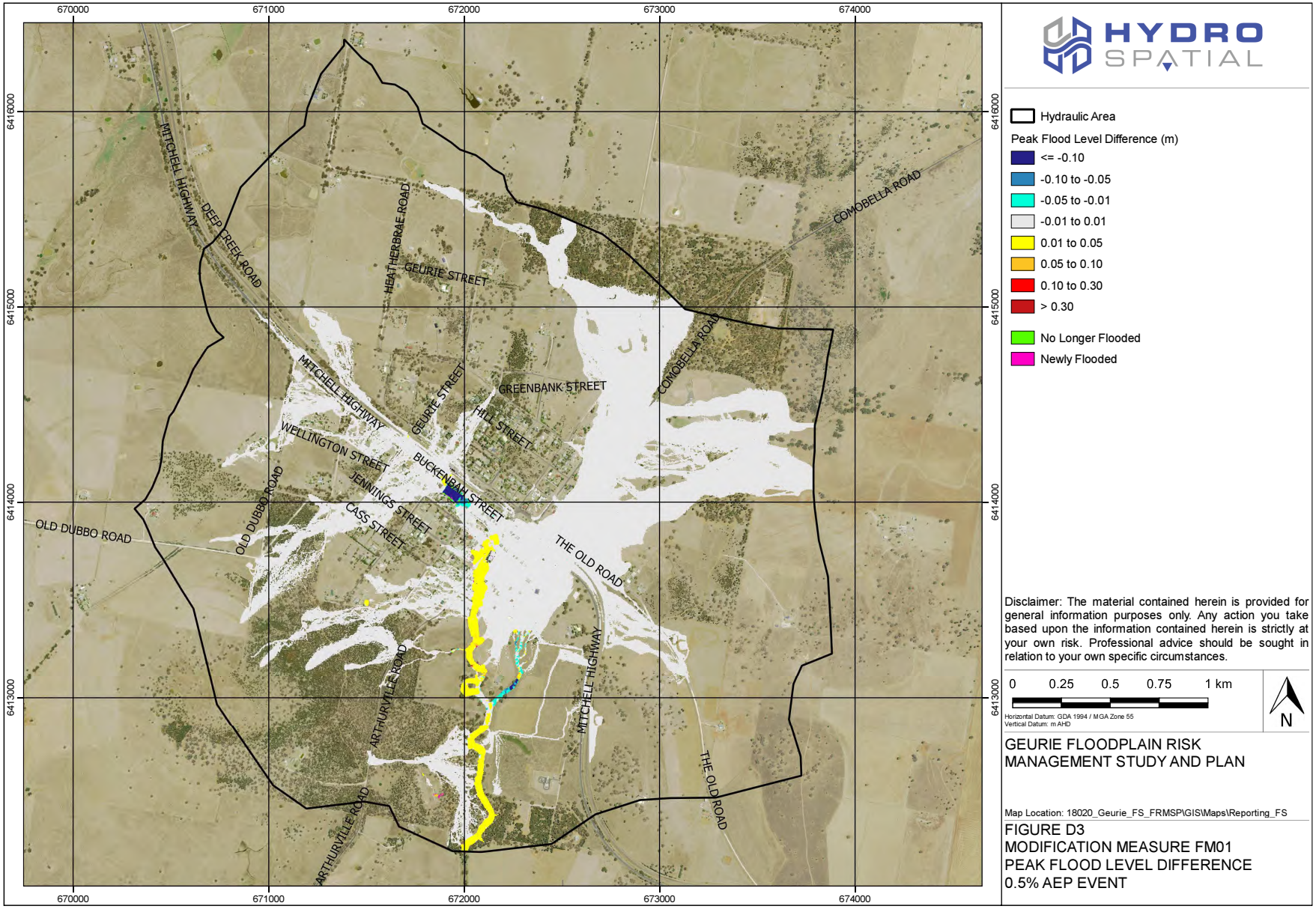

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Study Area
Additional Pipes
Widened Creek
Levees
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FRMSP
FIGURE C10
MODIFICATION MEASURE FM10
SCHEMATISATION

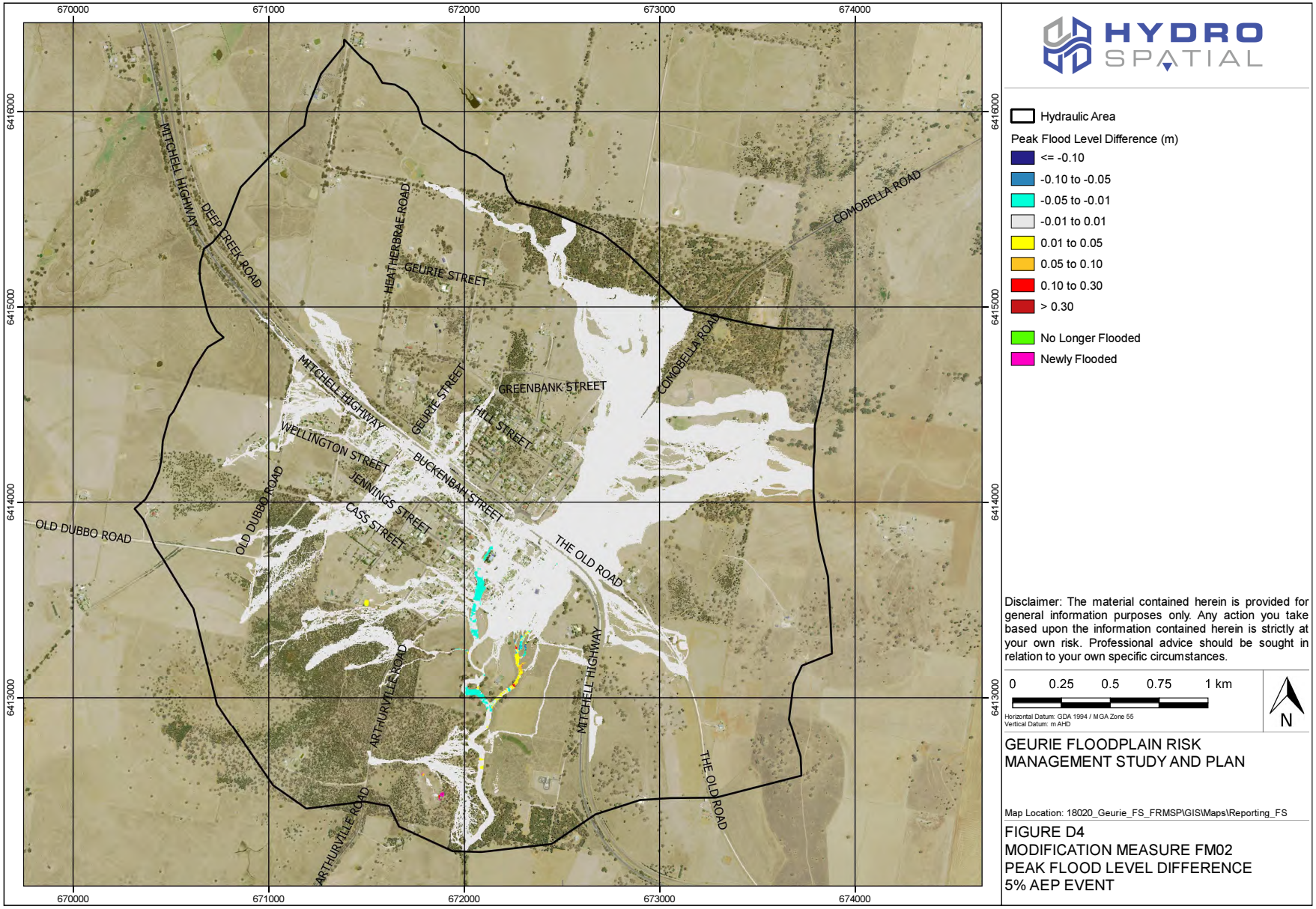
HYDROSPATIAL

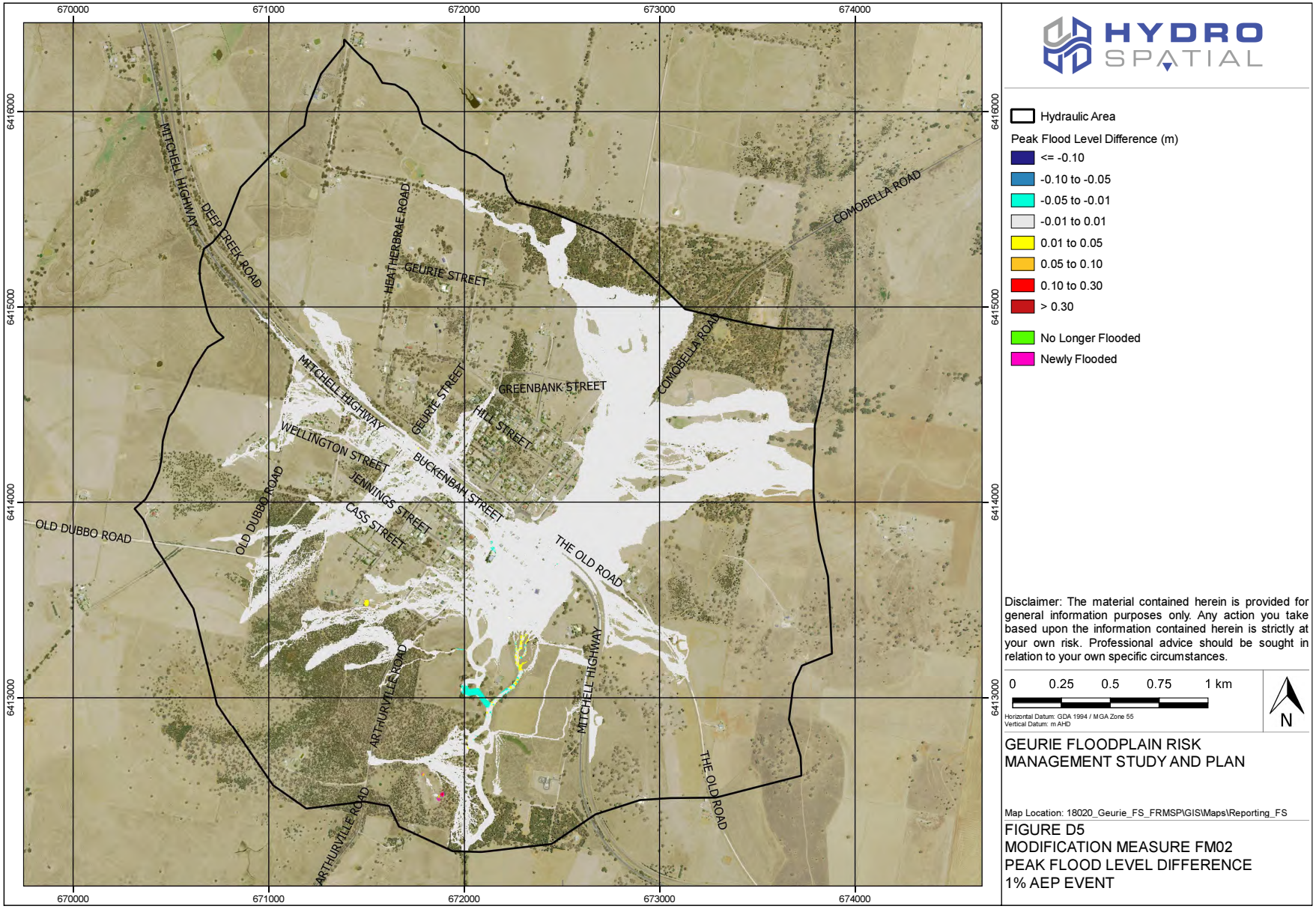
APPENDIX D
ESTIMATE OF BENEFITS

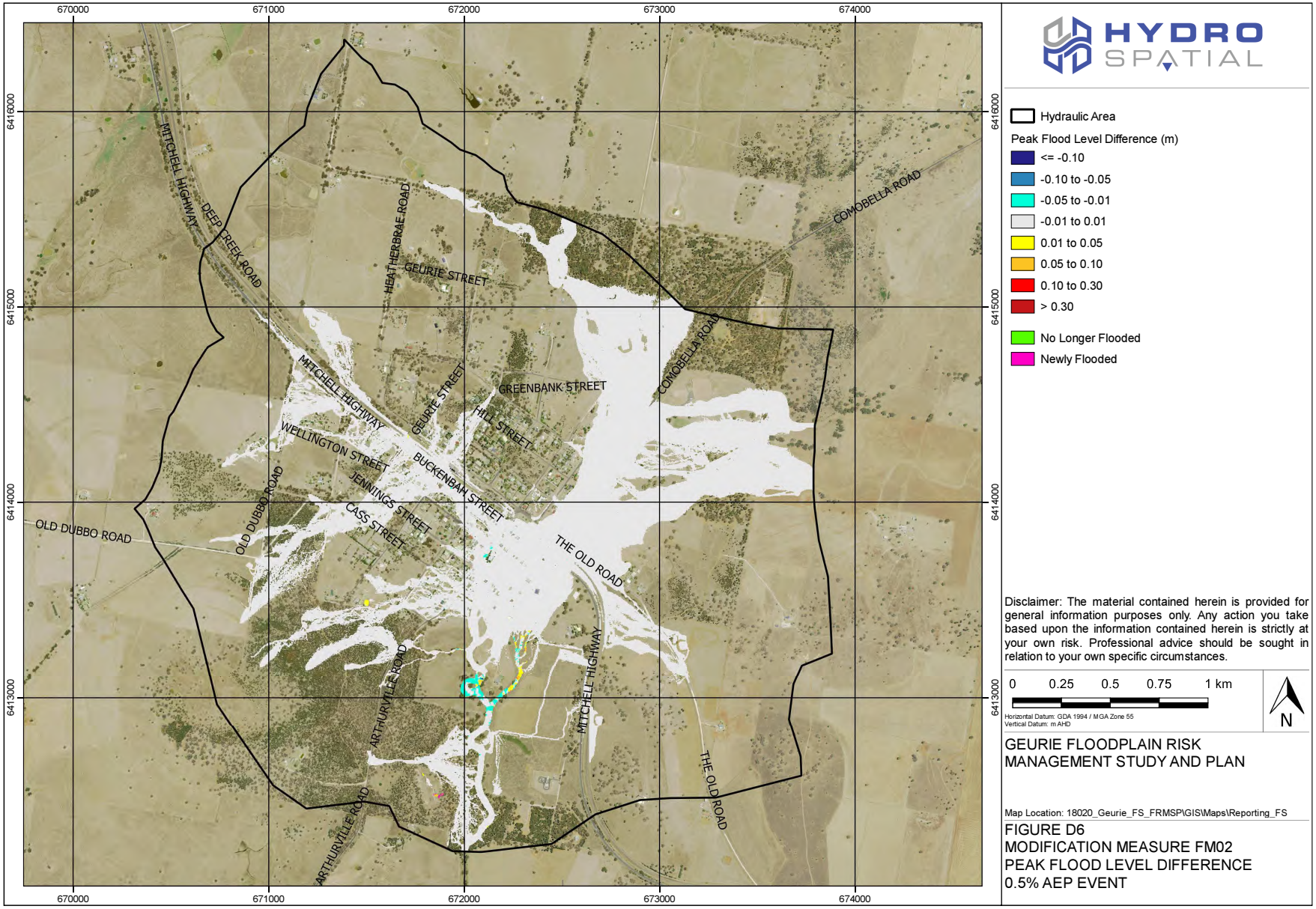

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D1
MODIFICATION MEASURE FM01
PEAK FLOOD LEVEL DIFFERENCE
5% AEP EVENT

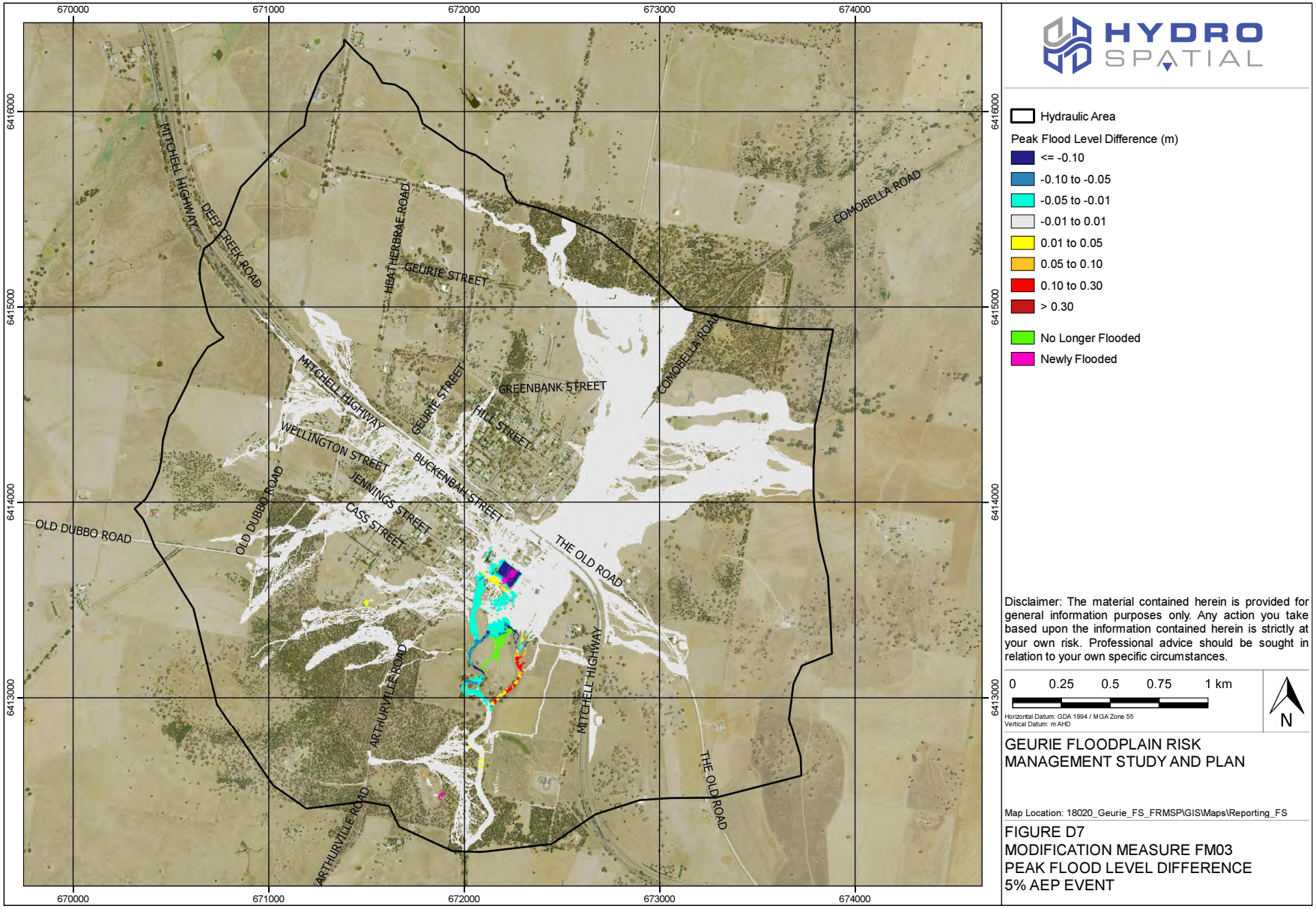

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D2
MODIFICATION MEASURE FM01
PEAK FLOOD LEVEL DIFFERENCE
1% AEP EVENT

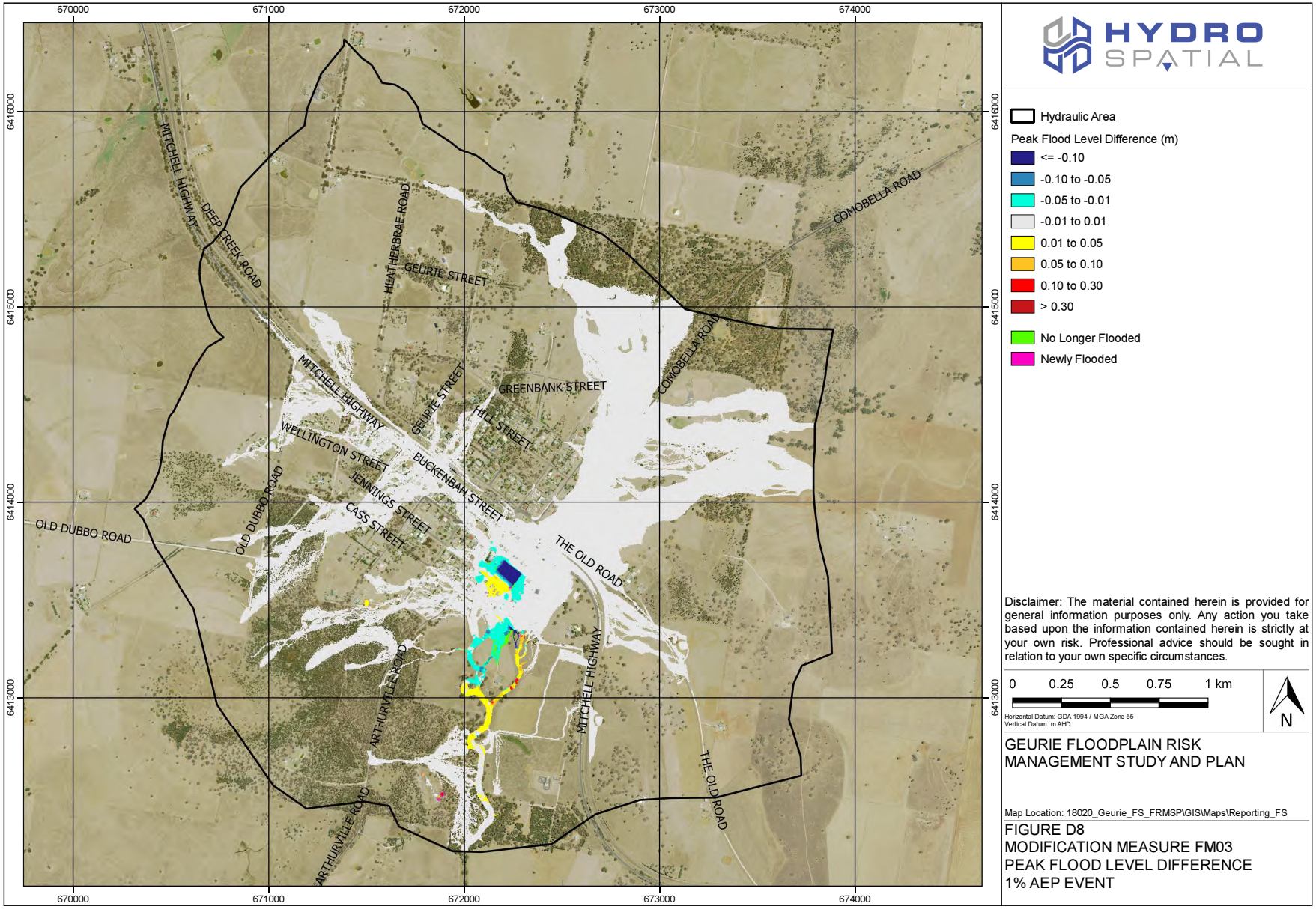

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
MITCHELL HIGHWAY
GEURIE STREET
GREENBANK STREET
COMOBELLA ROAD
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
MITCHELL HIGHWAY
THE OLD ROAD
ARTHURVILLE ROAD
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0
0.25
0.5
0.75
1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D3
MODIFICATION MEASURE FM01
PEAK FLOOD LEVEL DIFFERENCE
0.5% AEP EVENT

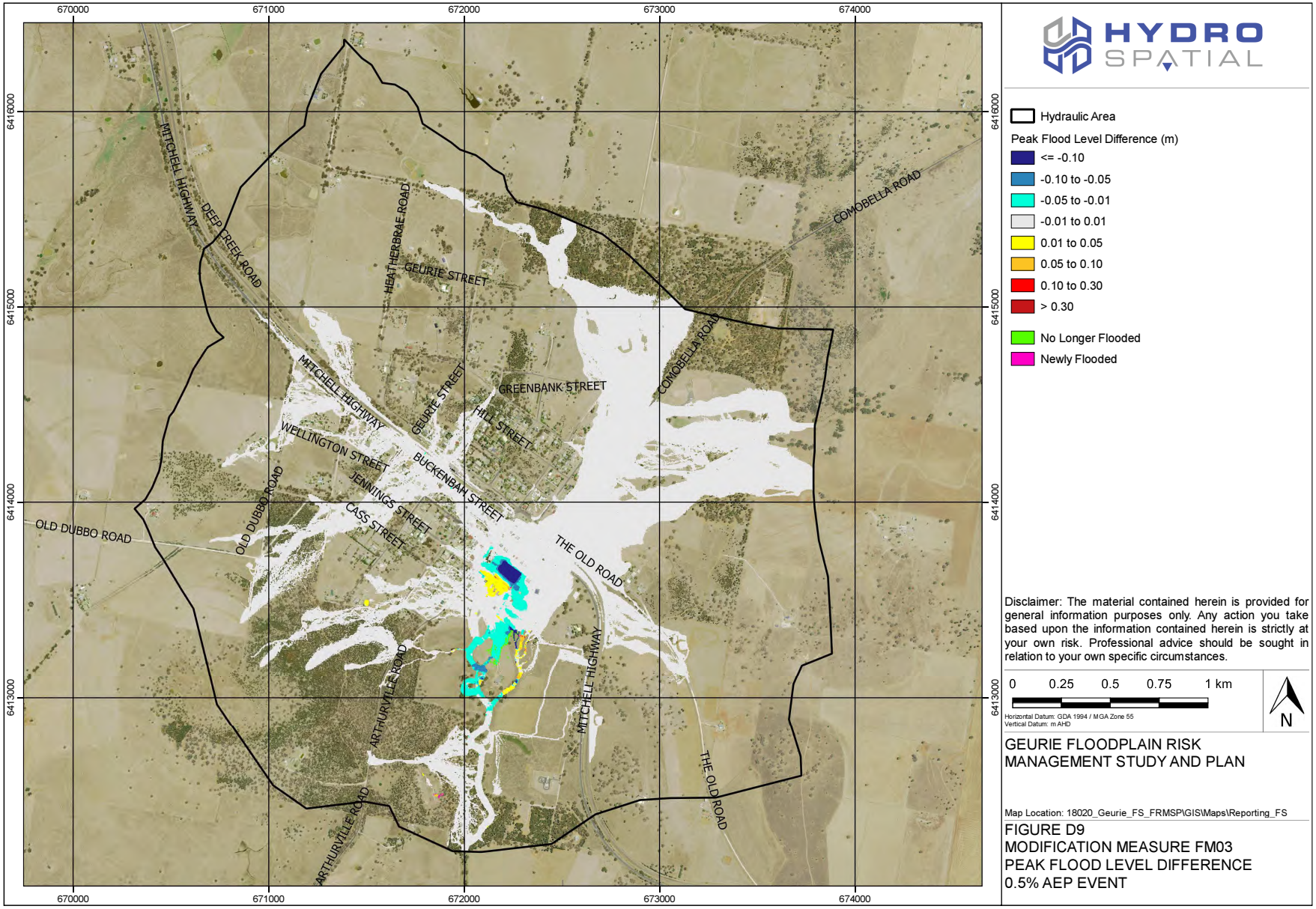

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAM STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D4
MODIFICATION MEASURE FM02
PEAK FLOOD LEVEL DIFFERENCE
5% AEP EVENT

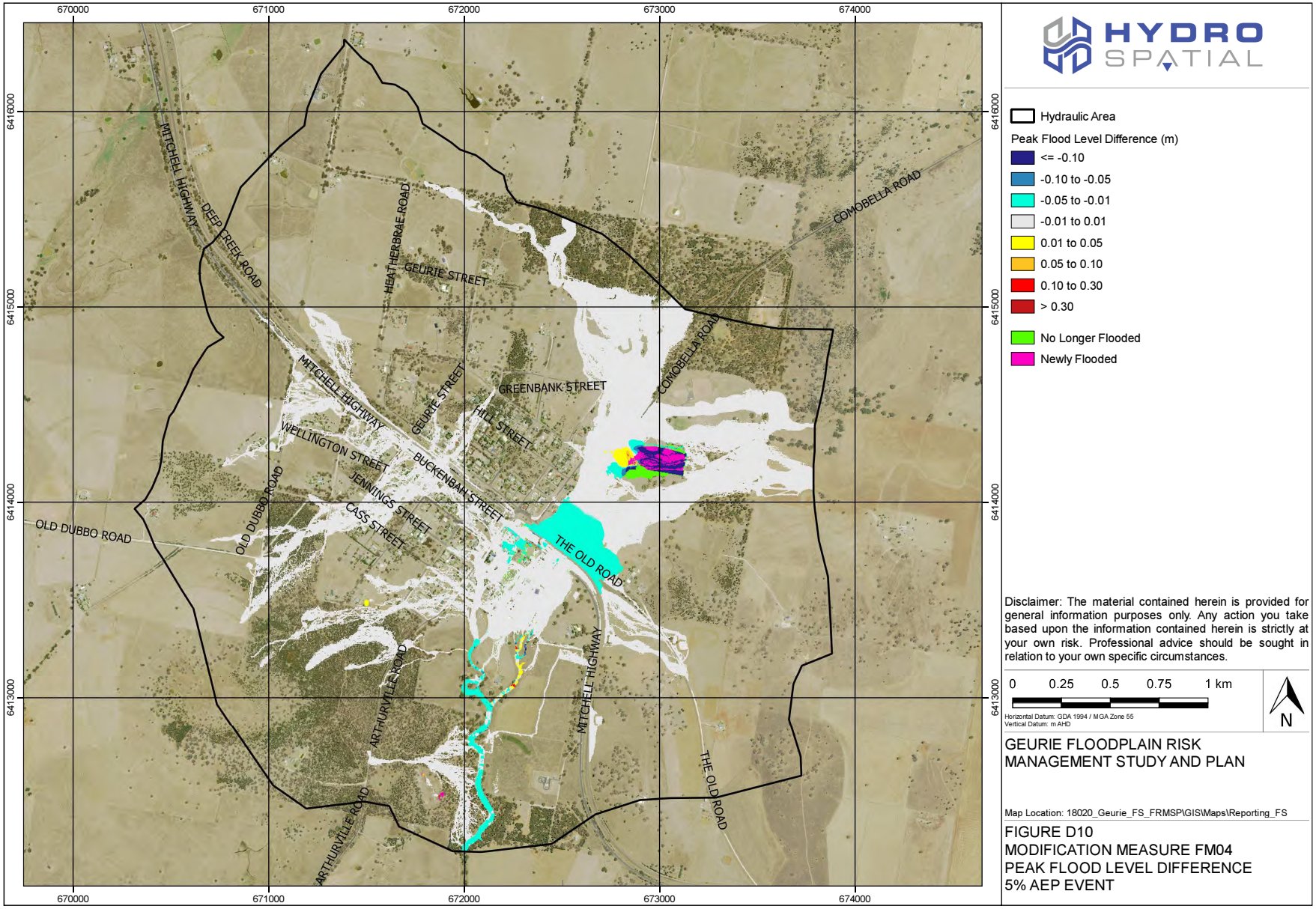

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D5
MODIFICATION MEASURE FM02
PEAK FLOOD LEVEL DIFFERENCE
1% AEP EVENT

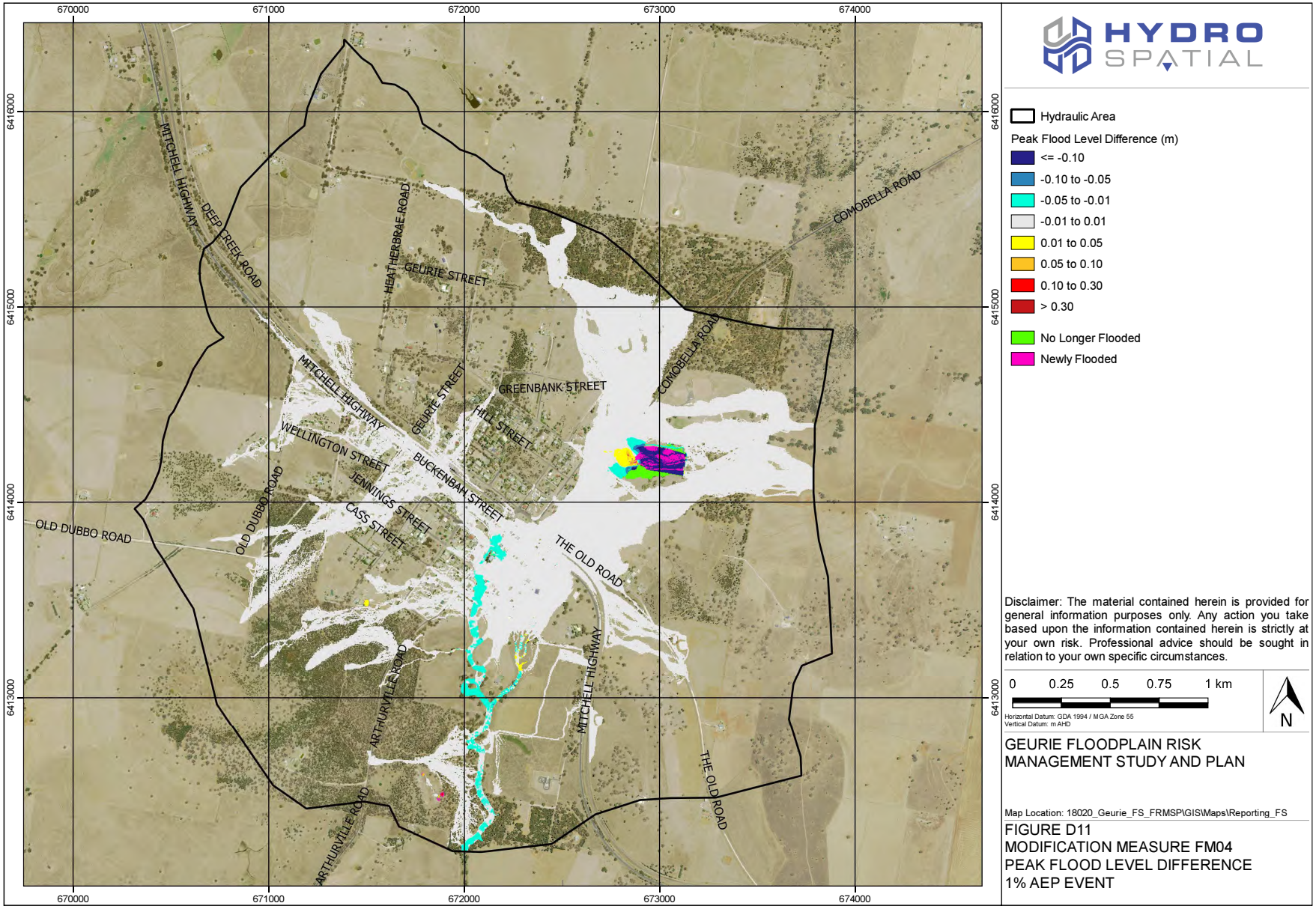

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D6
MODIFICATION MEASURE FM02
PEAK FLOOD LEVEL DIFFERENCE
0.5% AEP EVENT

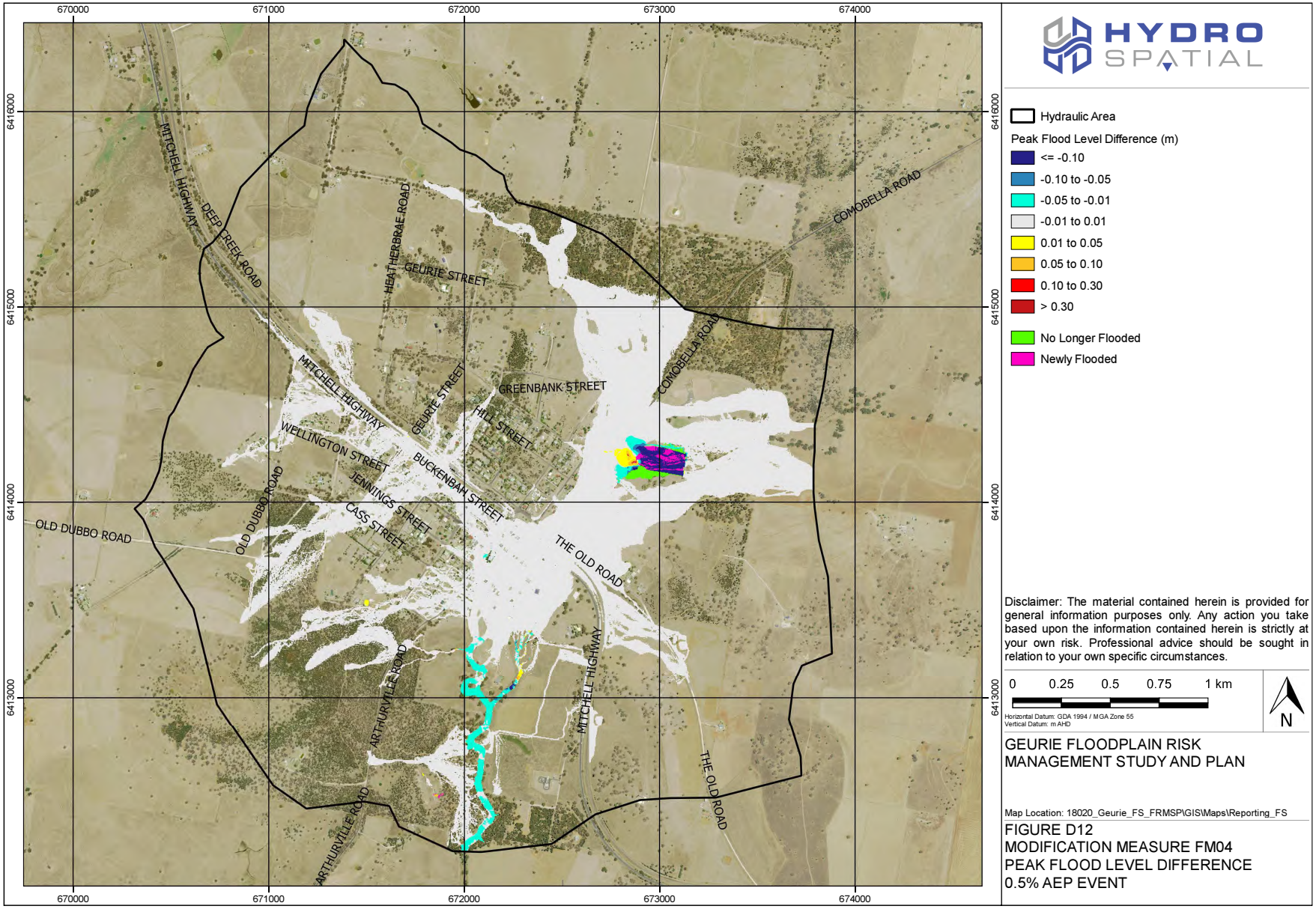

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAM STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
HYDRO SPATIAL
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D7
MODIFICATION MEASURE FM03
PEAK FLOOD LEVEL DIFFERENCE
5% AEP EVENT

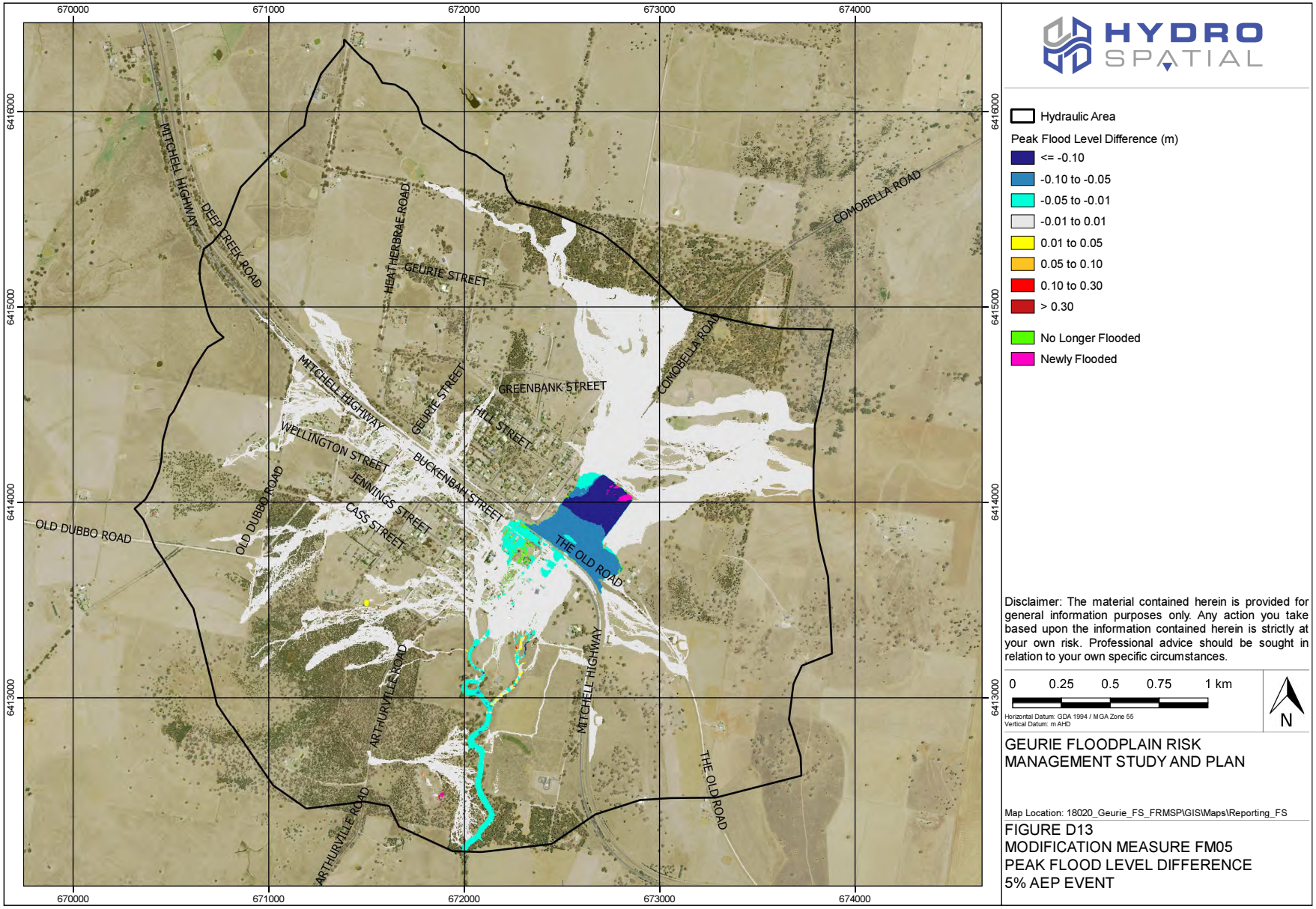

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
HYDRO SPATIAL
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D8
MODIFICATION MEASURE FM03
PEAK FLOOD LEVEL DIFFERENCE
1% AEP EVENT

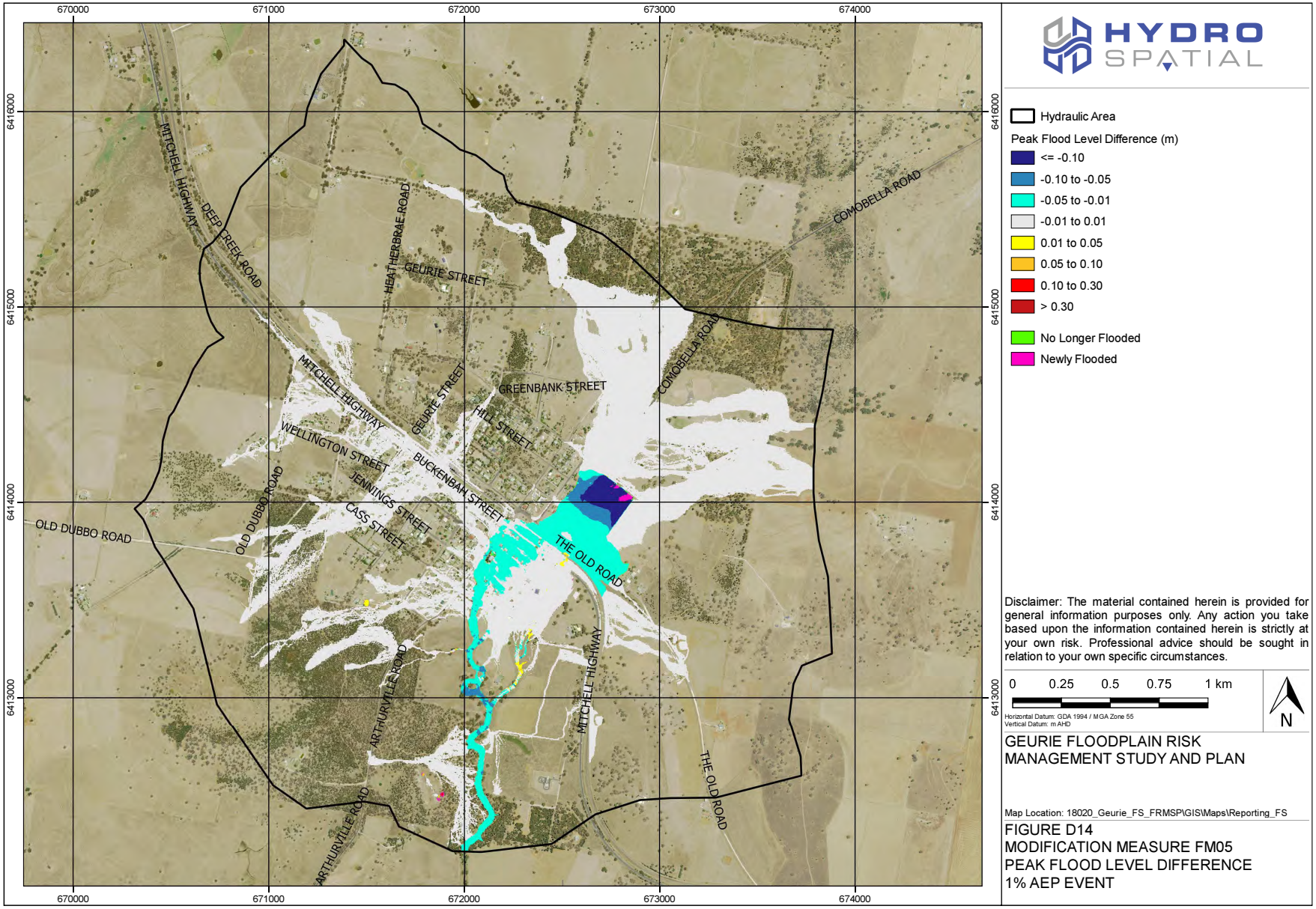

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D9
MODIFICATION MEASURE FM03
PEAK FLOOD LEVEL DIFFERENCE
0.5% AEP EVENT

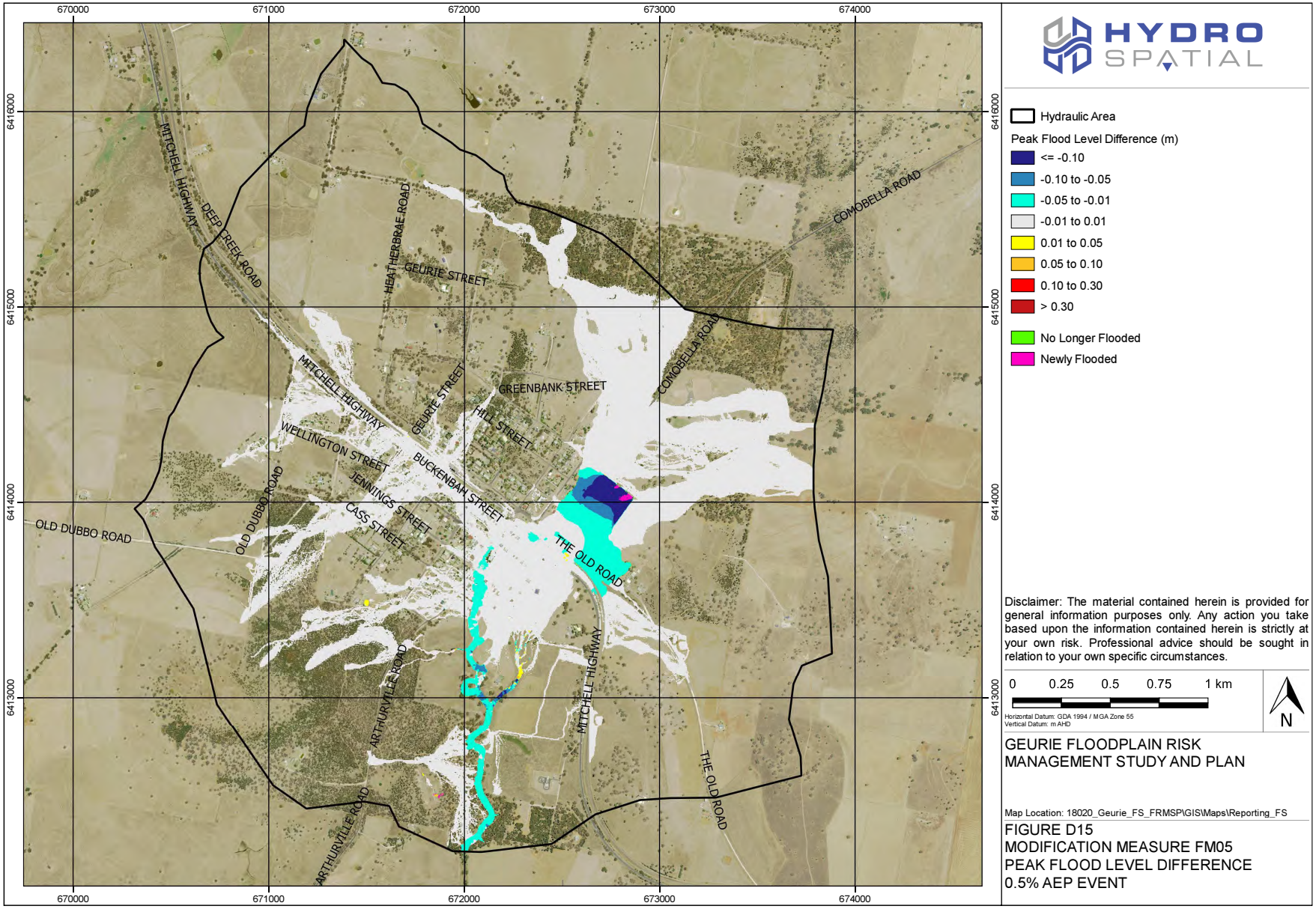

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAM STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
HYDRO SPATIAL
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D10
MODIFICATION MEASURE FM04
PEAK FLOOD LEVEL DIFFERENCE
5% AEP EVENT

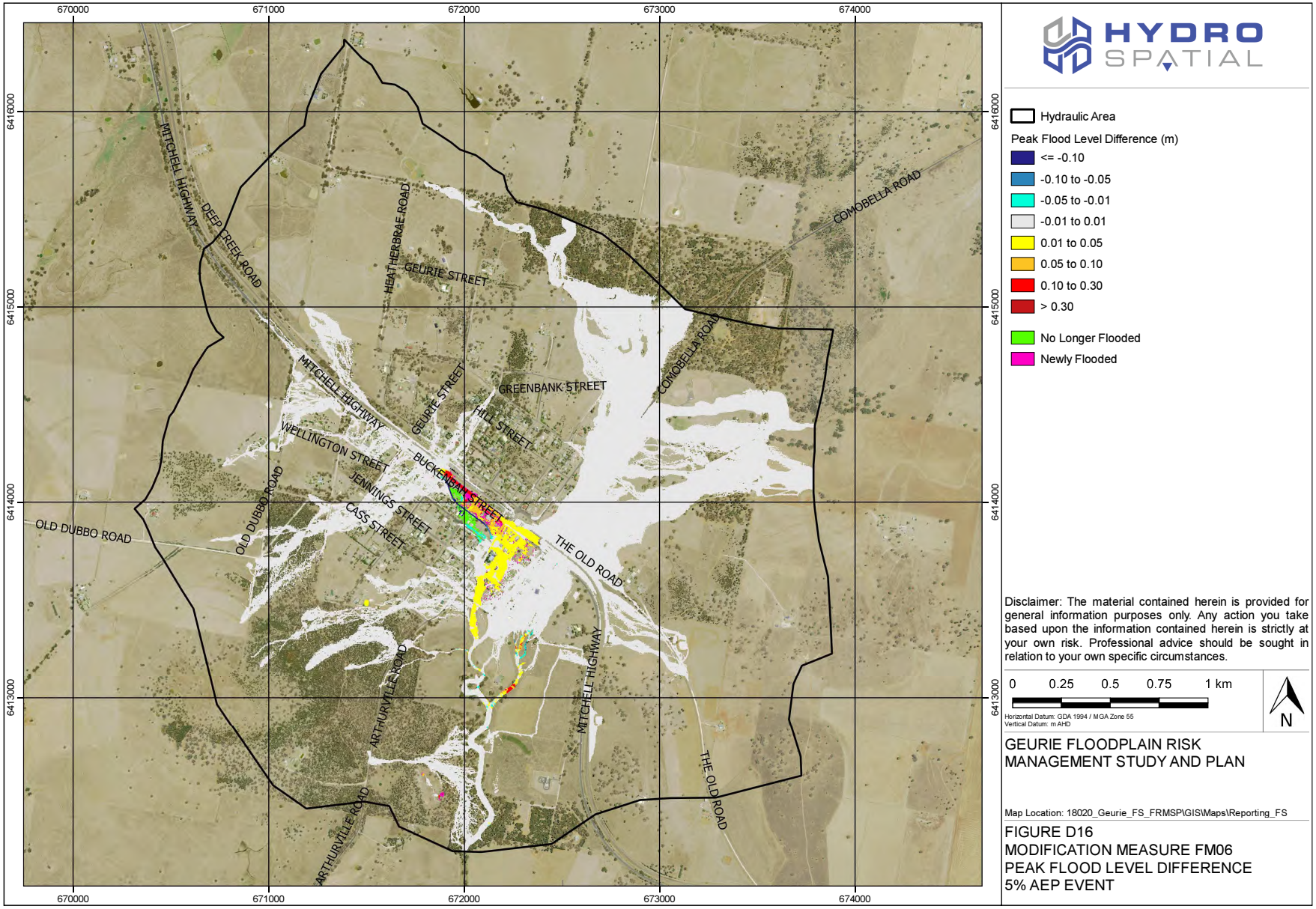

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D11
MODIFICATION MEASURE FM04
PEAK FLOOD LEVEL DIFFERENCE
1% AEP EVENT

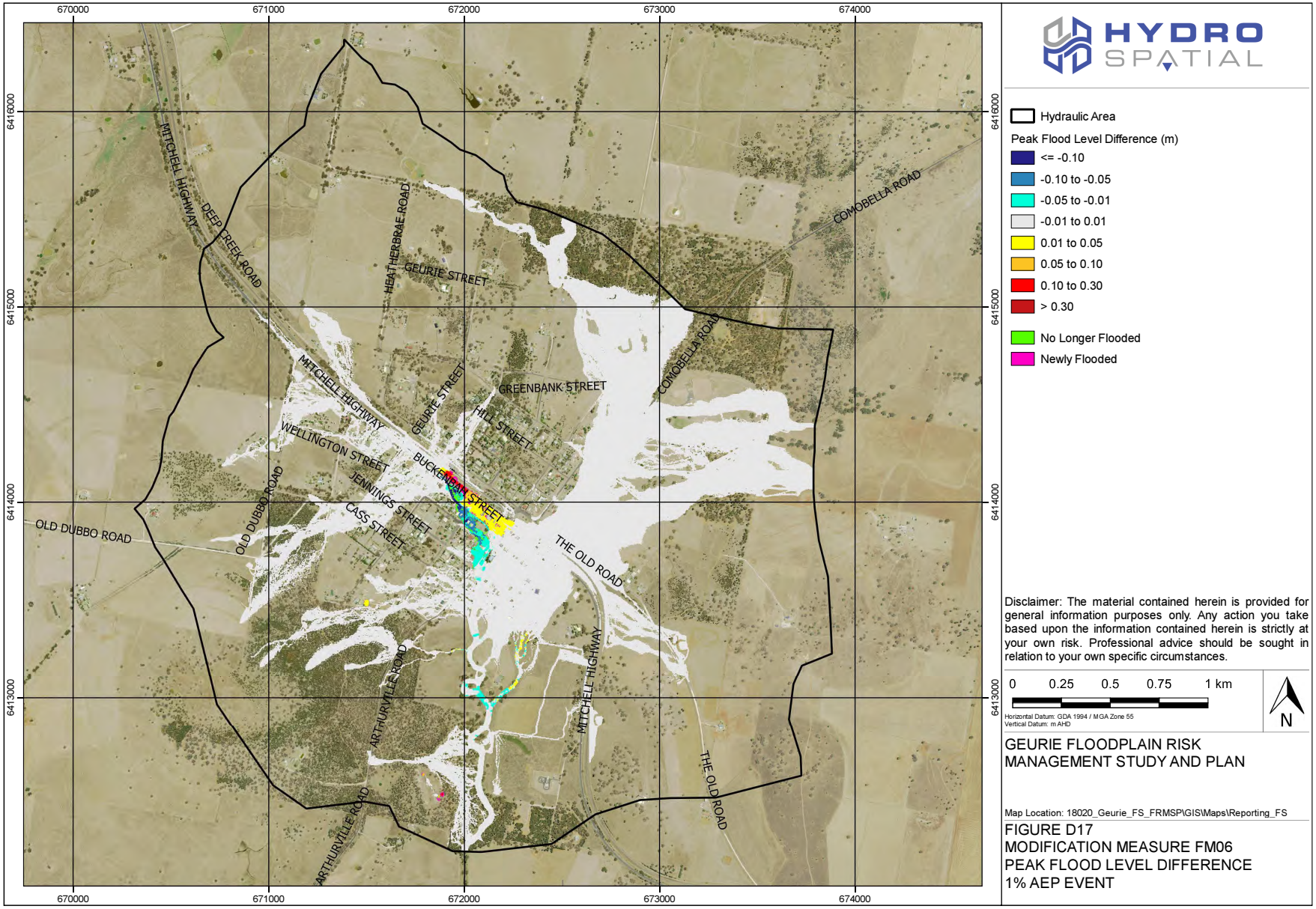

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEATHERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
HYDRO SPATIAL
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D12
MODIFICATION MEASURE FM04
PEAK FLOOD LEVEL DIFFERENCE
0.5% AEP EVENT

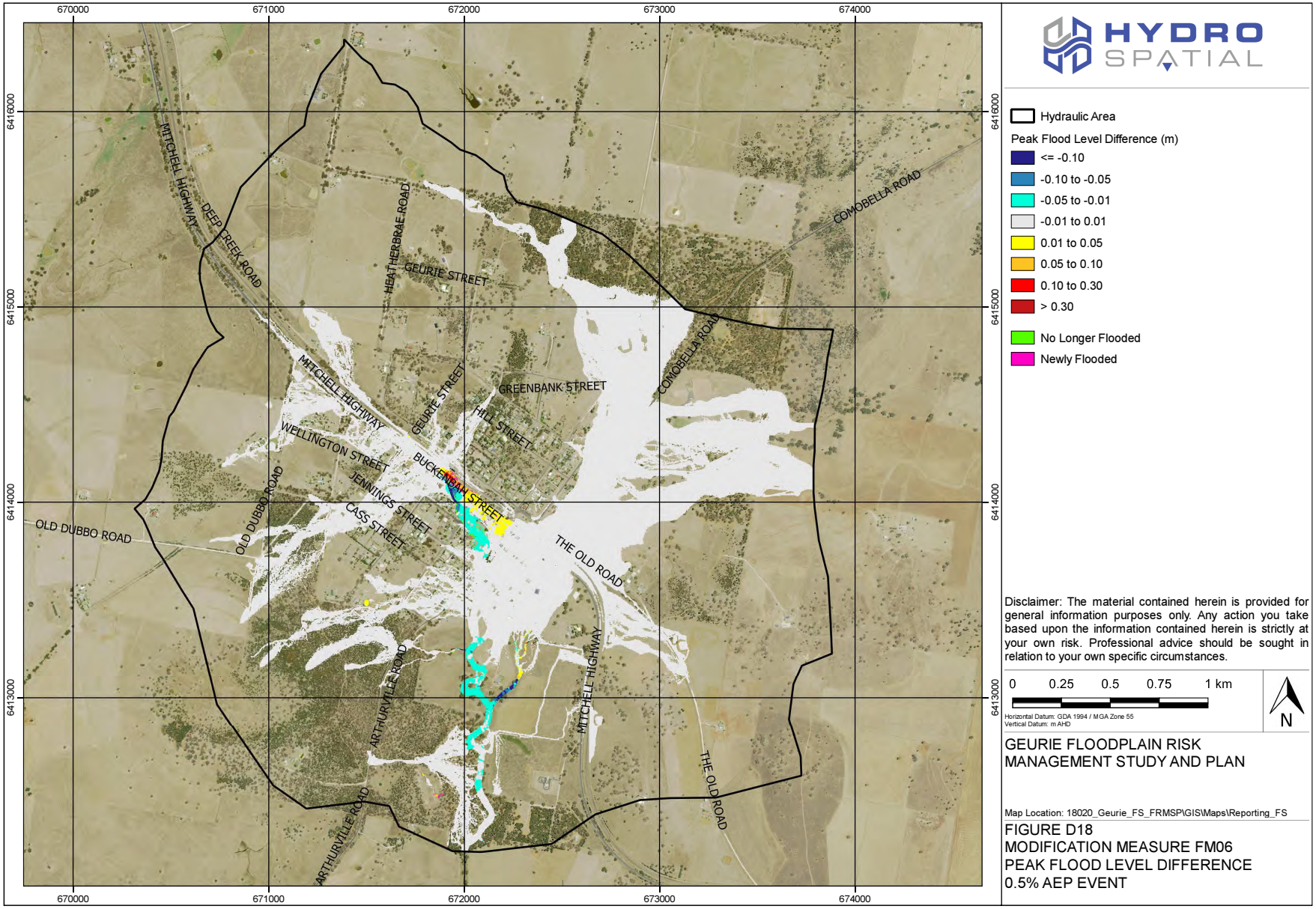

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAM STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D13
MODIFICATION MEASURE FM05
PEAK FLOOD LEVEL DIFFERENCE
5% AEP EVENT

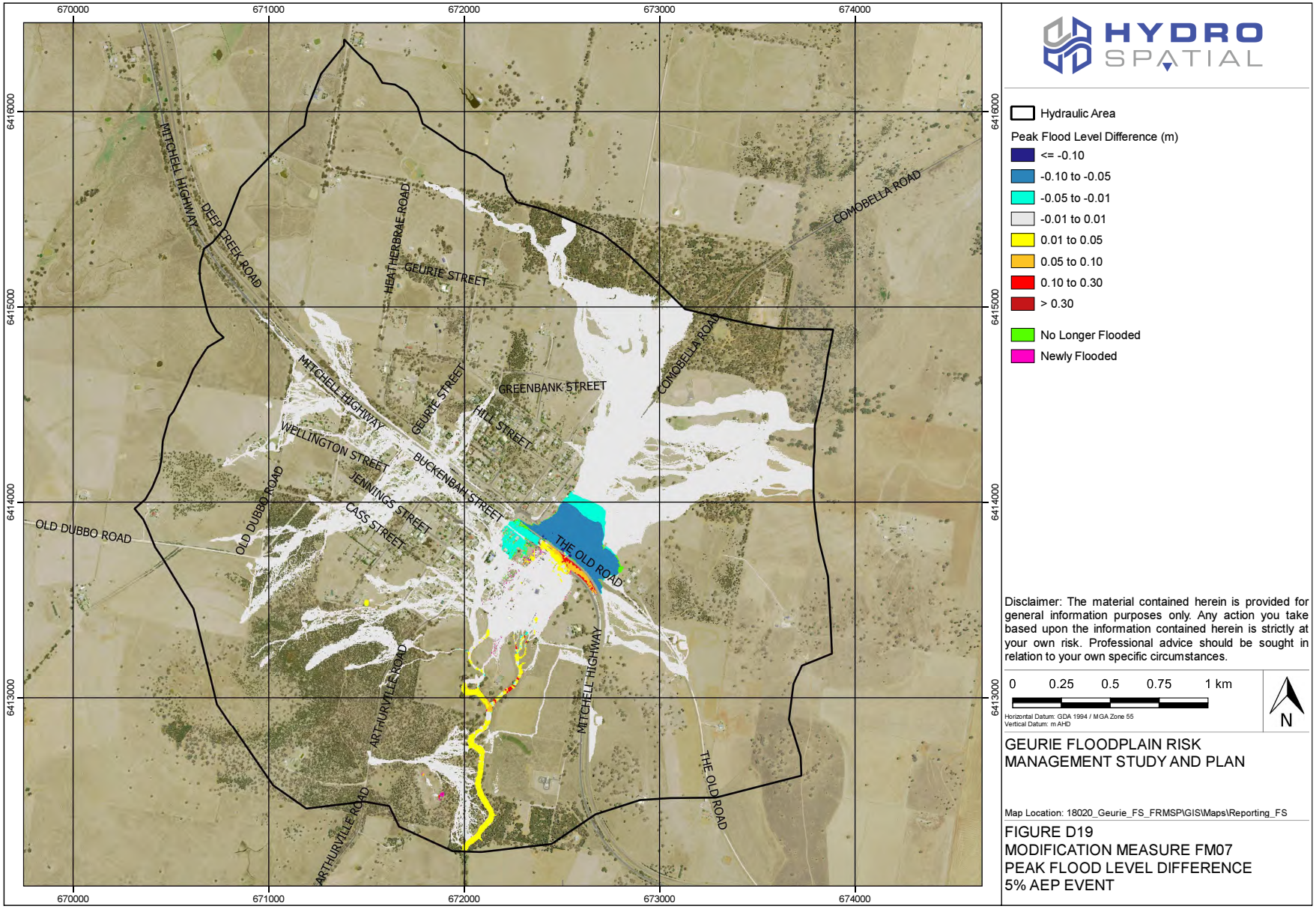

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEATHERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D14
MODIFICATION MEASURE FM05
PEAK FLOOD LEVEL DIFFERENCE
1% AEP EVENT

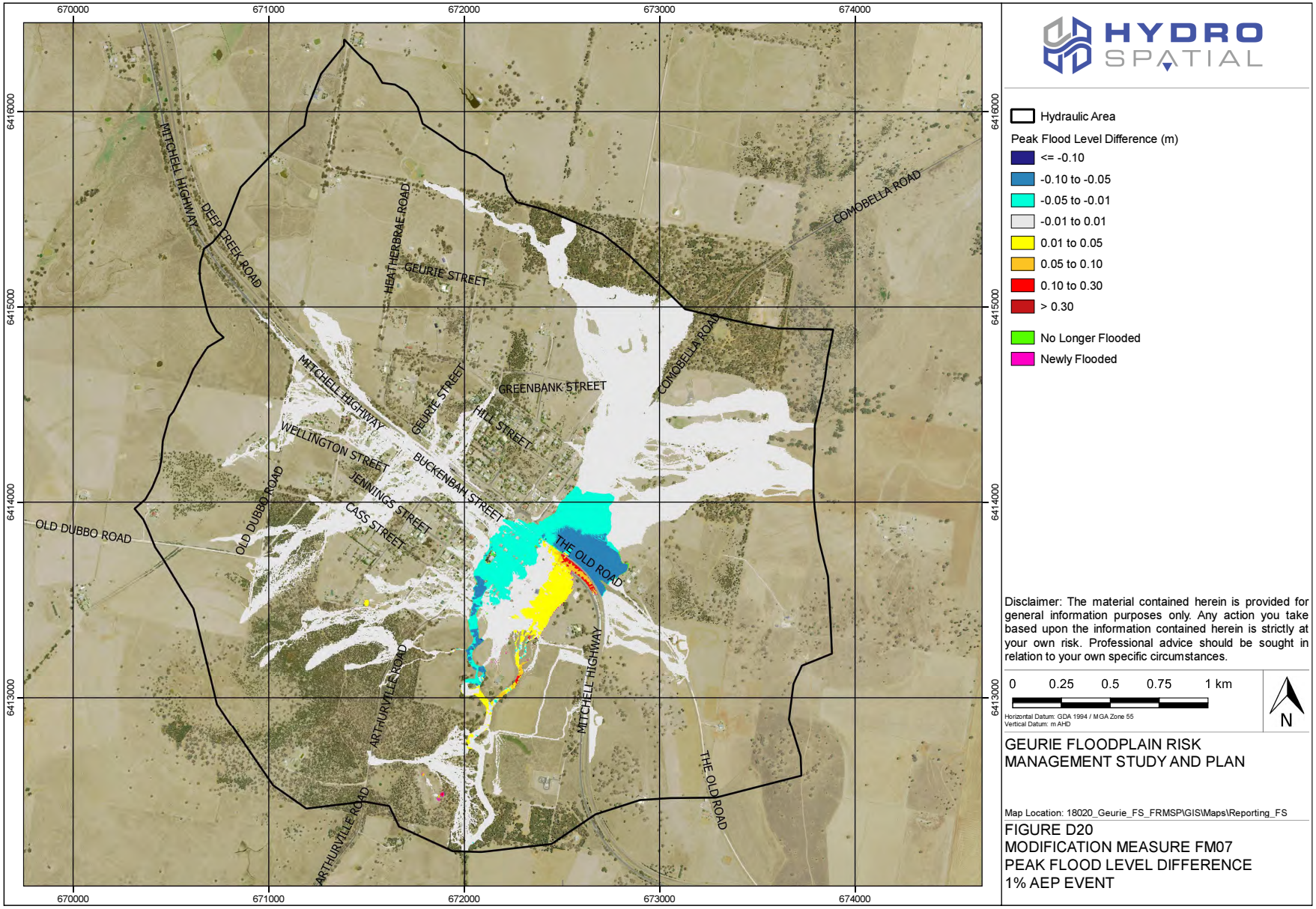

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEATHERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D15
MODIFICATION MEASURE FM05
PEAK FLOOD LEVEL DIFFERENCE
0.5% AEP EVENT

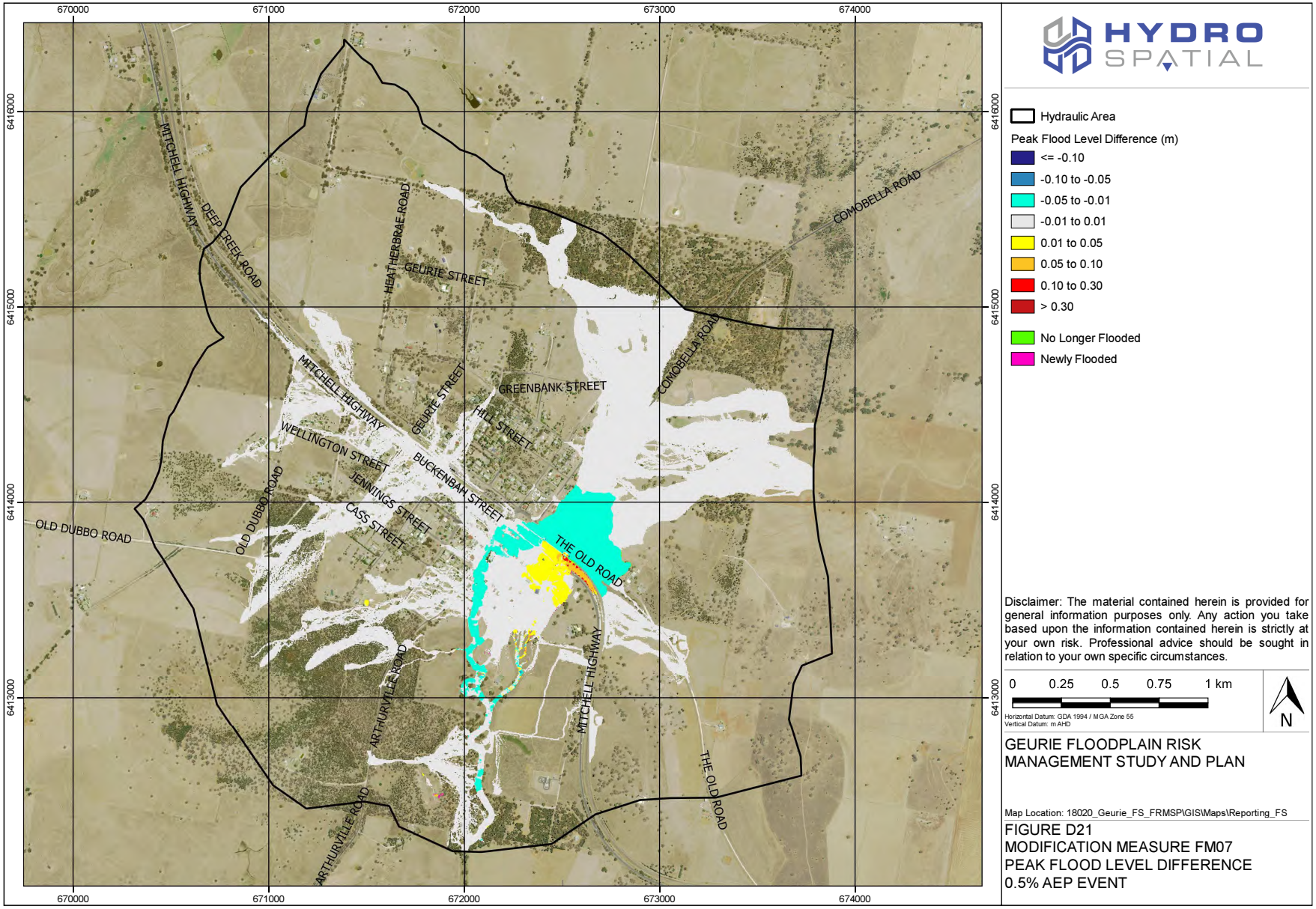

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKINGHAM STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D16
MODIFICATION MEASURE FM06
PEAK FLOOD LEVEL DIFFERENCE
5% AEP EVENT

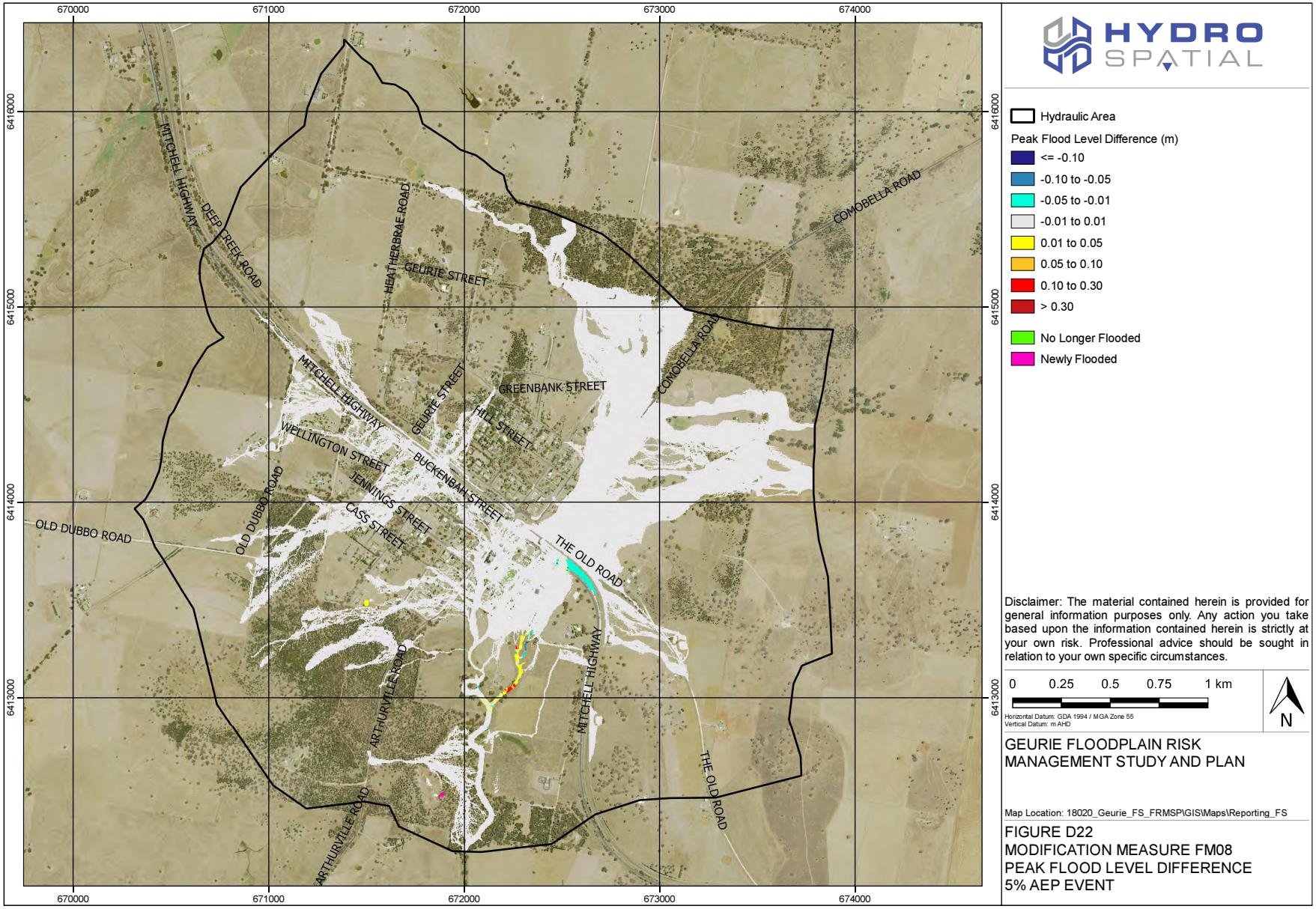

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKINGHAM STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D17
MODIFICATION MEASURE FM06
PEAK FLOOD LEVEL DIFFERENCE
1% AEP EVENT

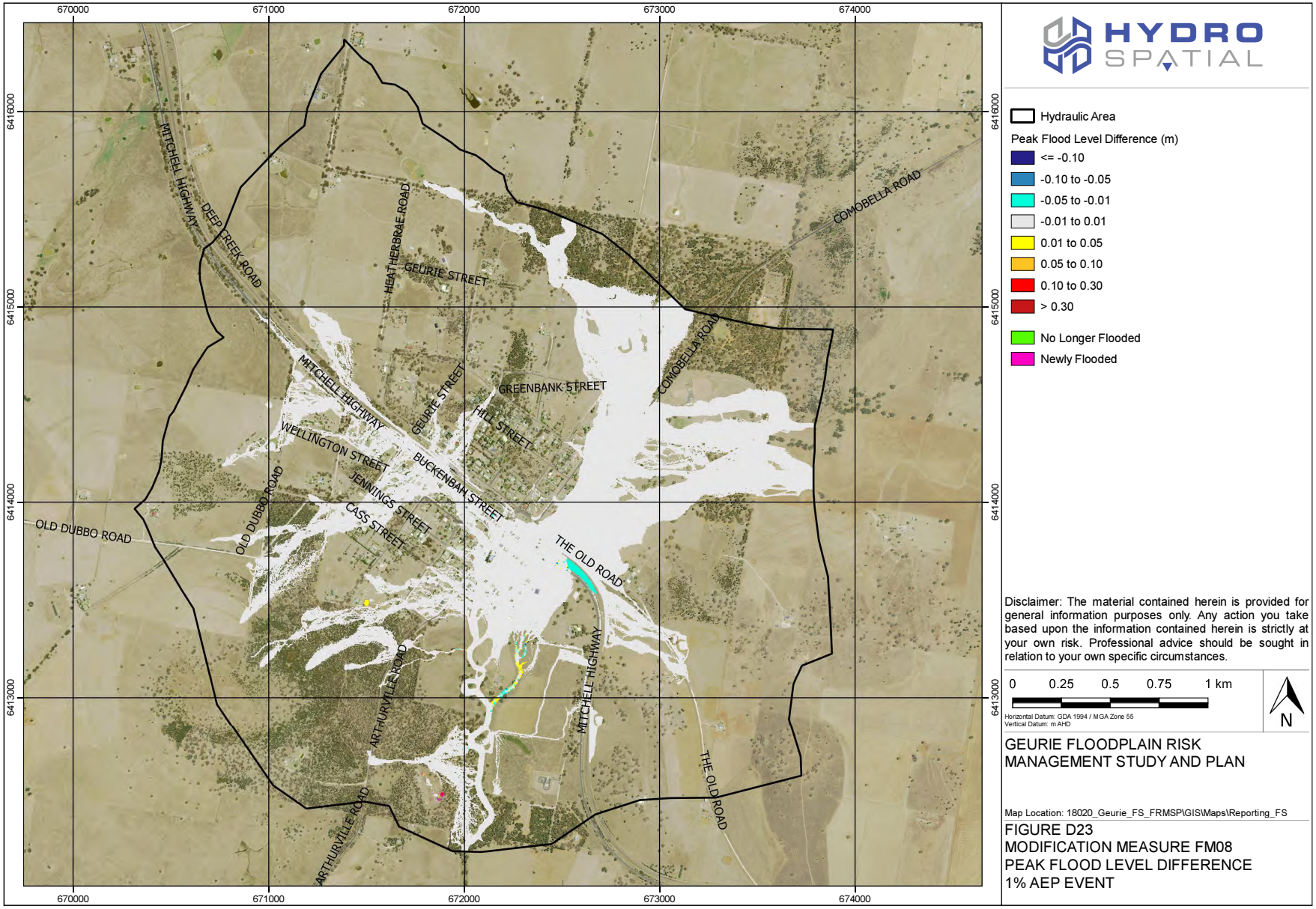

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKINGHAM STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D18
MODIFICATION MEASURE FM06
PEAK FLOOD LEVEL DIFFERENCE
0.5% AEP EVENT

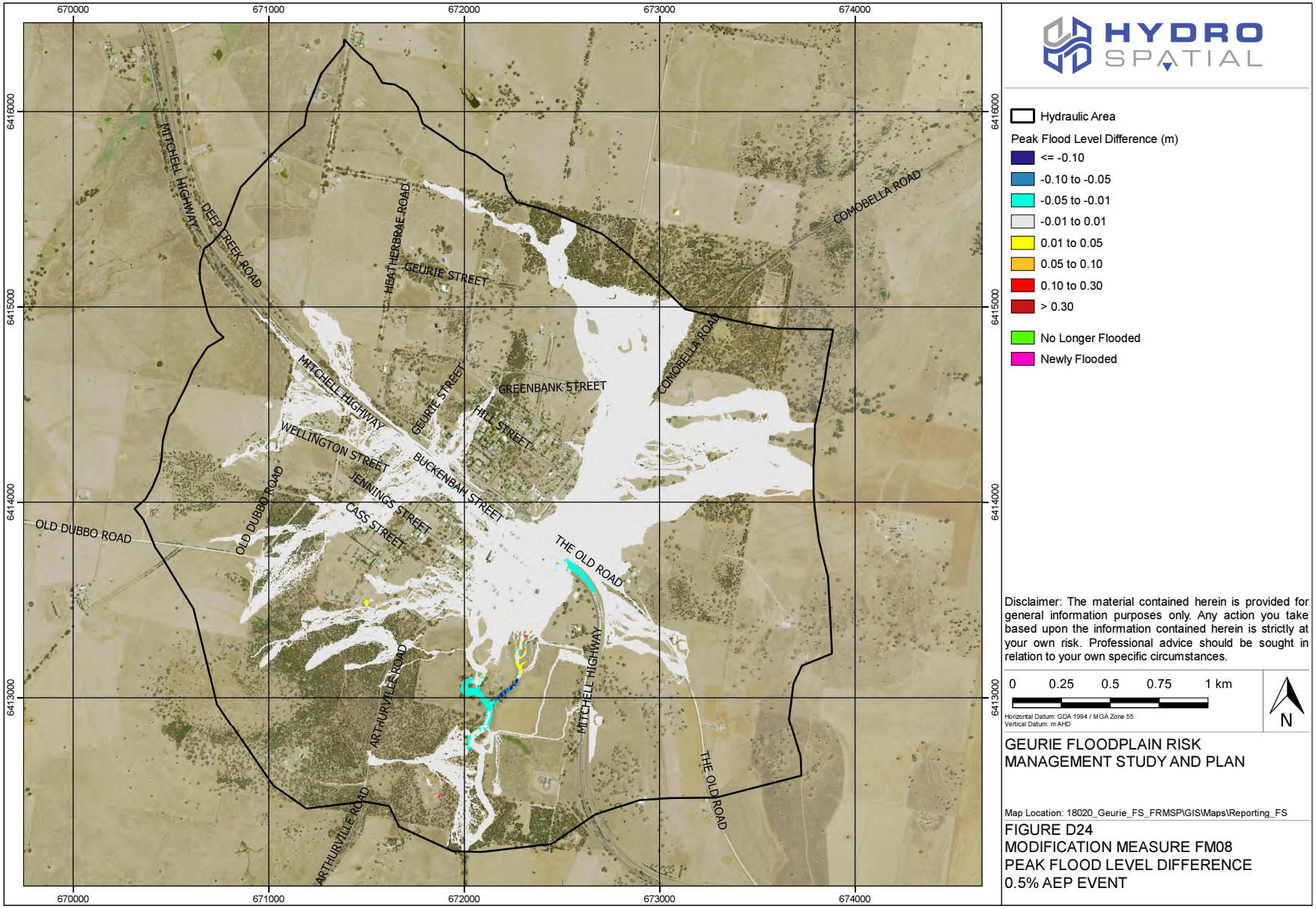

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEATHERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAM STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D19
MODIFICATION MEASURE FM07
PEAK FLOOD LEVEL DIFFERENCE
5% AEP EVENT

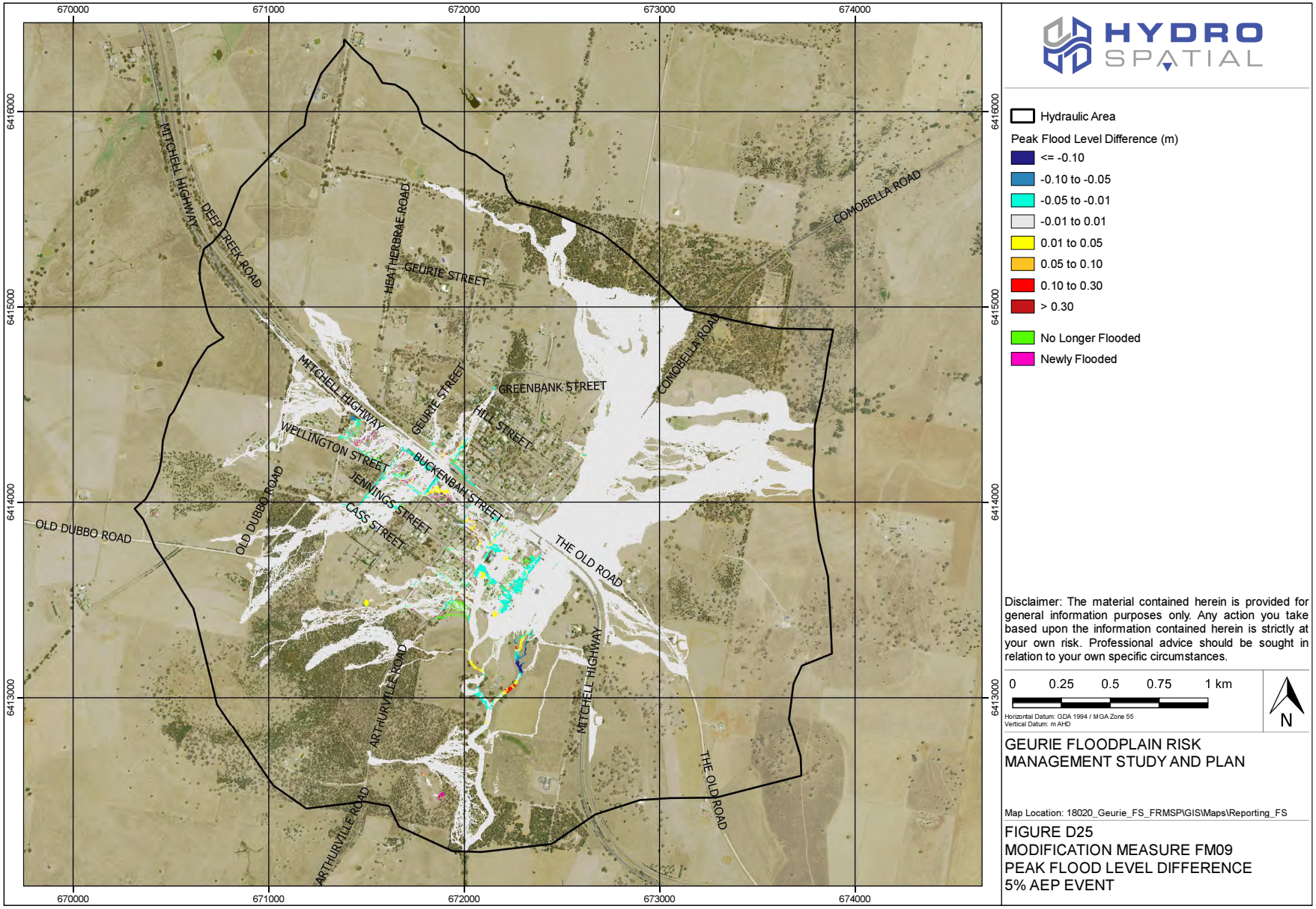

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
HYDRO SPATIAL
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D20
MODIFICATION MEASURE FM07
PEAK FLOOD LEVEL DIFFERENCE
1% AEP EVENT

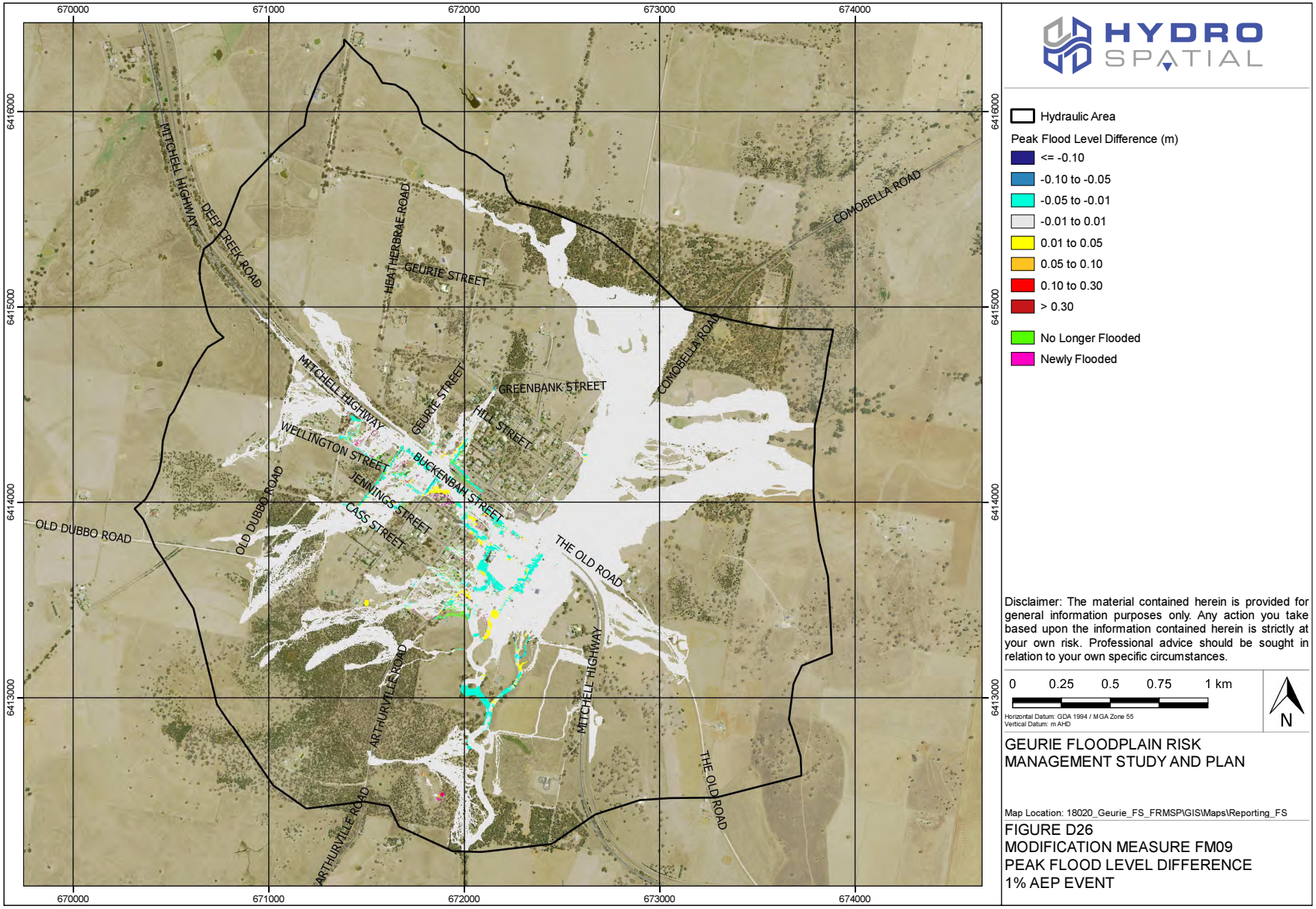

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D21
MODIFICATION MEASURE FM07
PEAK FLOOD LEVEL DIFFERENCE
0.5% AEP EVENT

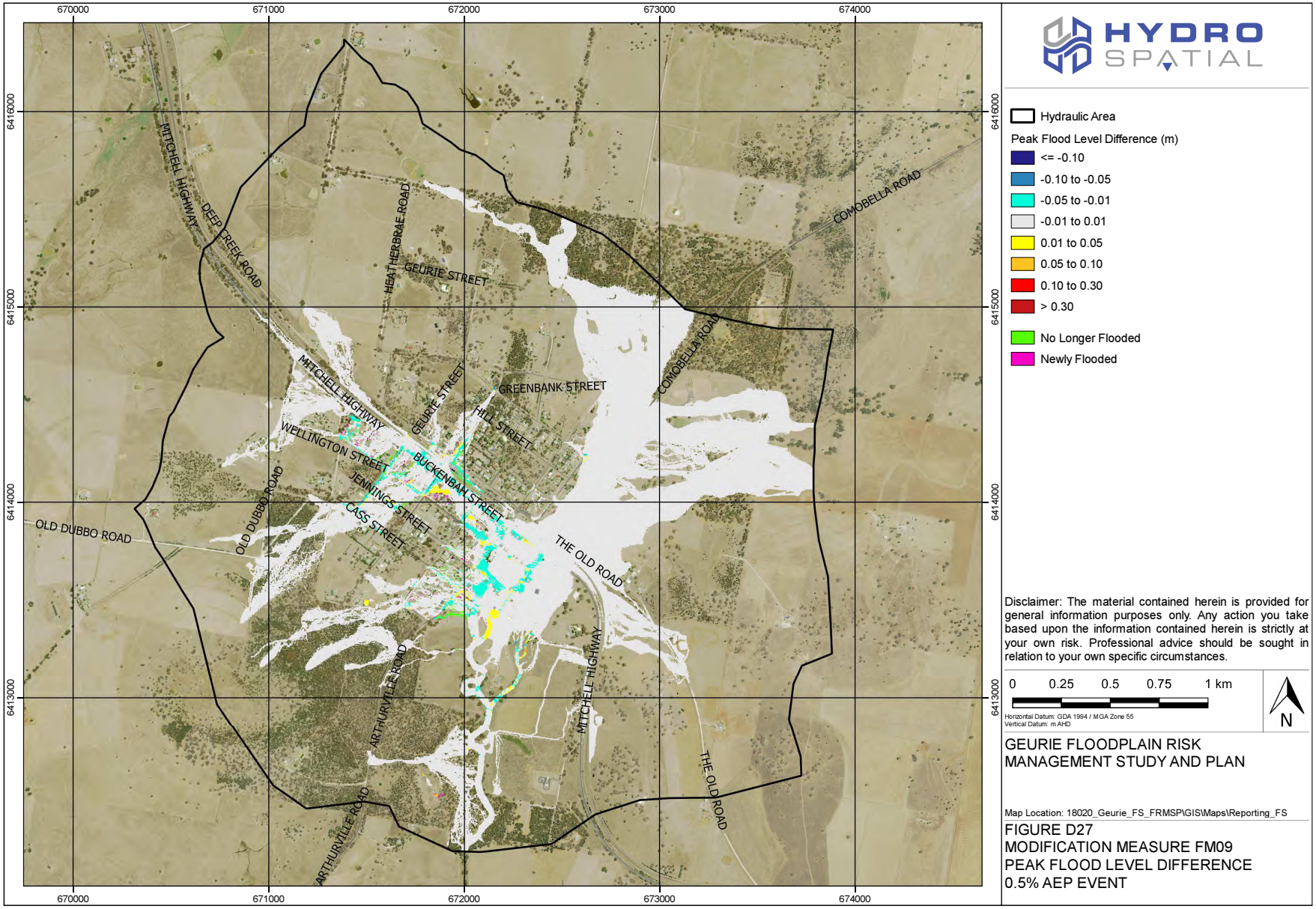

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAM STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D22
MODIFICATION MEASURE FM08
PEAK FLOOD LEVEL DIFFERENCE
5% AEP EVENT

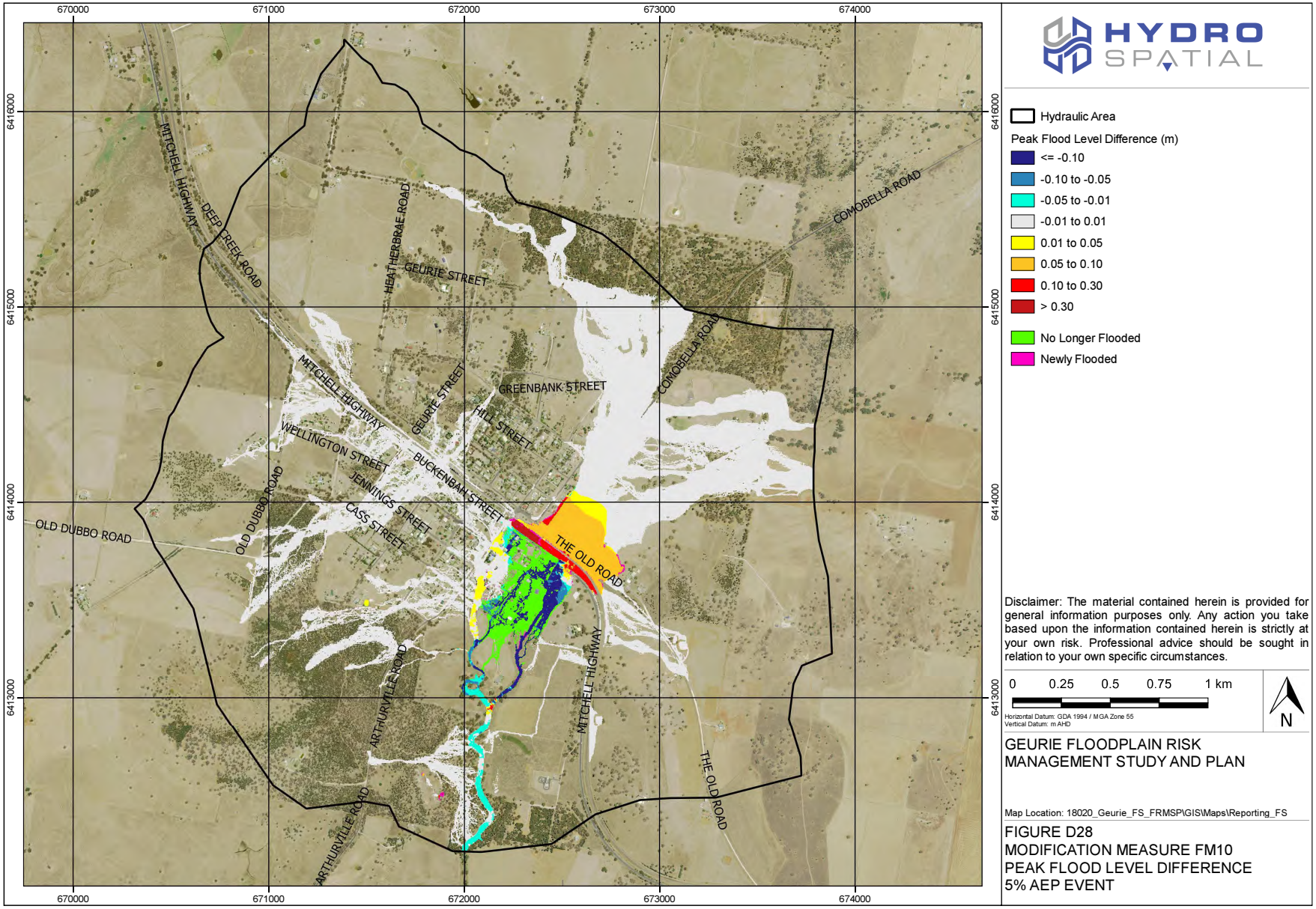

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D23
MODIFICATION MEASURE FM08
PEAK FLOOD LEVEL DIFFERENCE
1% AEP EVENT

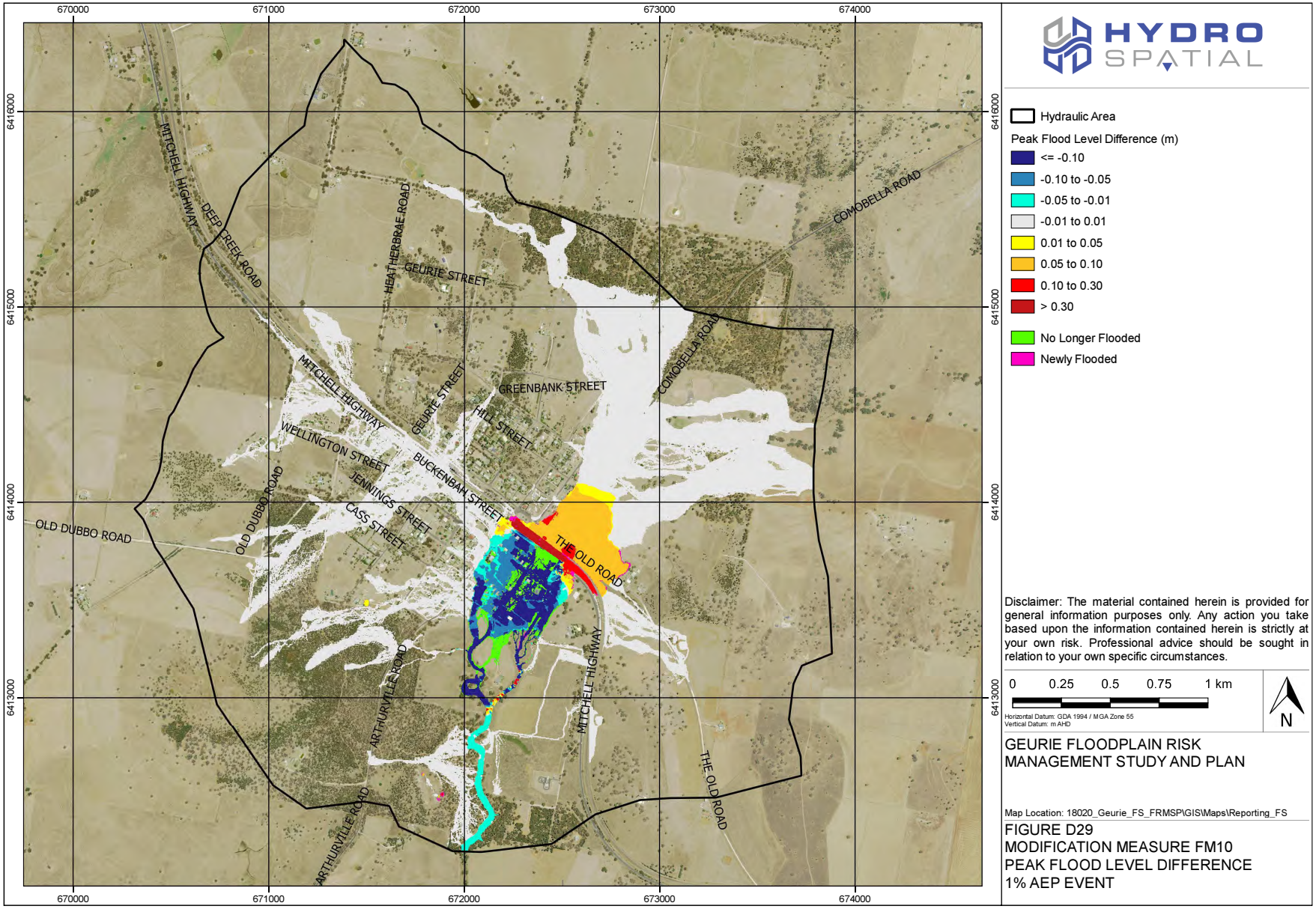

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEATHERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D24
MODIFICATION MEASURE FM08
PEAK FLOOD LEVEL DIFFERENCE
0.5% AEP EVENT

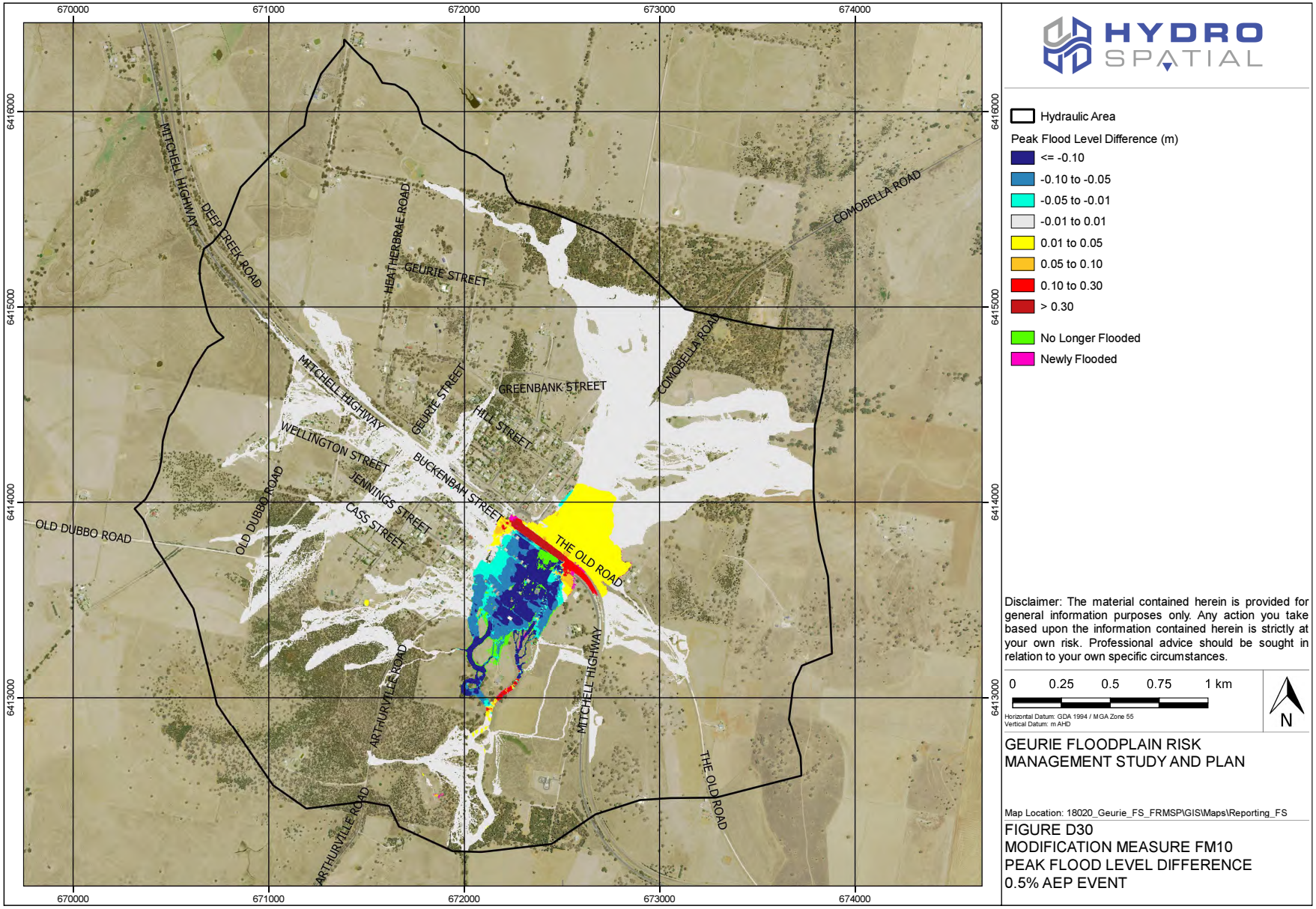

670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEATHERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAM STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
HYDRO SPATIAL
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D25
MODIFICATION MEASURE FM09
PEAK FLOOD LEVEL DIFFERENCE
5% AEP EVENT


670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
MITCHELL HIGHWAY
GEURIE STREET
GREENBANK STREET
COMOBELLA ROAD
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
MITCHELL HIGHWAY
THE OLD ROAD
ARTHURVILLE ROAD
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0
0.25
0.5
0.75
1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D26
MODIFICATION MEASURE FM09
PEAK FLOOD LEVEL DIFFERENCE
1% AEP EVENT


670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEATHERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D27
MODIFICATION MEASURE FM09
PEAK FLOOD LEVEL DIFFERENCE
0.5% AEP EVENT


670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
MITCHELL HIGHWAY
GEURIE STREET
GREENBANK STREET
COMOBELLA ROAD
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
MITCHELL HIGHWAY
THE OLD ROAD
ARTHURVILLE ROAD
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0
0.25
0.5
0.75
1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D28
MODIFICATION MEASURE FM10
PEAK FLOOD LEVEL DIFFERENCE
5% AEP EVENT


670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEAT HERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D29
MODIFICATION MEASURE FM10
PEAK FLOOD LEVEL DIFFERENCE
1% AEP EVENT


670000
671000
672000
673000
674000
6416000
6415000
6414000
6413000
MITCHELL HIGHWAY
DEEP CREEK ROAD
HEATHERBRAE ROAD
GEURIE STREET
COMOBELLA ROAD
GREENBANK STREET
HILL STREET
WELLINGTON STREET
BUCKENBAN STREET
JENNINGS STREET
CASS STREET
OLD DUBBO ROAD
THE OLD ROAD
ARTHURVILLE ROAD
Hydraulic Area
Peak Flood Level Difference (m)
<= -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.30
> 0.30
No Longer Flooded
Newly Flooded
Disclaimer: The material contained herein is provided for general information purposes only. Any action you take based upon the information contained herein is strictly at your own risk. Professional advice should be sought in relation to your own specific circumstances.
0 0.25 0.5 0.75 1 km
Horizontal Datum: GDA 1994 / MGA Zone 55
Vertical Datum: m AHD
N
GEURIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Map Location: 18020_Geurie_FS_FRMSP\GIS\Maps\Reporting_FS
FIGURE D30
MODIFICATION MEASURE FM10
PEAK FLOOD LEVEL DIFFERENCE
0.5% AEP EVENT

HYDROSPATIAL

APPENDIX E
ESTIMATE OF COSTS

HYDROSPATIAL

E.1 Flood Modification Measures

E.1.1 FM01 - Detention basin within Wise Park

Item Number	Description of works	Quantity	Unit	Rate	Cost
1.0	GENERAL AND PRELIMINARIES				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item		
1.2	Provision of sediment & erosion control	1	item		
1.3	Construction setout & survey	1	item		
1.4	Work as executed survey & documentation	1	item		
1.5	Geotechnical supervision, testing & certification	1	item		
	SUBTOTAL				$15,033.54
2.0	DEMOLITION, CLEARING AND GRUBBING				
2.1	Clearing & grubbing	4375.51	sq.m	$0.59	$2,581.55
2.2	Strip topsoil & stockpile for re-use	2625.31	cu.m	$3.67	$9,638.36
2.3	Excavate clay layer	3709.69	cu.m	$3.67	$13,619.48
2.4	Dispose of excess topsoil and clay	5065.89	cu.m	$1.22	$6,199.51
	SUBTOTAL				$32,038.90
3.0	EARTHWORKS				
3.1	Level clay footing	4375.51	sq.m	$3.60	$15,751.84
3.2	Place and compact backfill	1058.27	cu.m	$8.20	$8,677.77
	SUBTOTAL				$24,429.61
4.0	MINOR LANDSCAPING				
4.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)	4375.51	sq.m	$10.00	$43,755.10
	SUBTOTAL				$43,755.10
	CONSTRUCTION SUBTOTAL				$115,257.16
6.0	CONTINGENCIES				
6.1	50% construction cost				$57,628.58
	CONSTRUCTION TOTAL, excluding GST				**$172,885.74**
	GST				**$17,288.57**
	CONSTRUCTON TOTAL, including GST				**$190,174.31**
	CONSTRUCTION TOTAL, rounded				**$191,000.00**

* General and preliminary work subtotal was calculated as 15% of the construction value (excluding contingencies).

HYDROSPATIAL

E.1.2 FM02 - Detention basin under Geurie Tennis Courts

Item Number	Description of works	Quantity	Unit	Rate	Cost
1.0	GENERAL AND PRELIMINARIES				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item		
1.2	Provision of sediment & erosion control	1	item		
1.3	Construction setout & survey	1	item		
1.4	Work as executed survey & documentation	1	item		
1.5	Geotechnical supervision, testing & certification	1	item		
	SUBTOTAL*				$17,945.72
2.0	DEMOLITION, CLEARING AND GRUBBING				
2.1	Demolish tennis courts	2	item	$15,000.00	$30,000.00
2.2	Strip topsoil & stockpile for re-use	1178.2767	cu.m	$3.67	$4,325.84
2.3	Excavate clay layer	1900.8	cu.m	$3.67	$6,978.46
2.4	Dispose of excess topsoil and clay	2764.8	cu.m	$1.22	$3,383.50
	SUBTOTAL				$44,687.80
3.0	EARTHWORKS				
3.1	Level clay footing	1900.8	cu.m	$3.60	$6,842.88
3.2	Place and compact backfill	276.48	cu.m	$8.20	$2,267.14
	SUBTOTAL				$6,842.88
4.0	PIPES				
4.1	Install pipe system	125.989	m	$110.45	$13,915.49
	SUBTOTAL				$13,915.49
5.0	DETENTION BASIN				
5.1	Install detention tank	2764.8	L	$2.50	$6,912.00
	SUBTOTAL				$6,912.00
6.0	TENNIS COURTS				
6.1	Install tennis hard court	2	item	$15,000.00	$30,000.00
	SUBTOTAL				$30,000.00
7.0	MINOR LANDSCAPING				
7.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)	1728	sq.m	$10.00	$17,280.00
	SUBTOTAL				$17,280.00
	CONSTRUCTION SUBTOTAL				$137,583.89
8.0	CONTINGENCIES				
8.1	50% construction cost				$68,791.94

HYDROSPATIAL

Item Number	Description of works	Quantity	Unit	Rate	Cost
	CONSTRUCTION TOTAL, excluding GST				$206,375.83
	GST				$20,637.58
	CONSTRUCTON TOTAL, including GST				$227,013.42
	CONSTRUCTION TOTAL, rounded				$228,000.00

* General and preliminary work subtotal was calculated as 15% of the construction value (excluding contingencies).

HYDROSPATIAL

E.1.3 FM03 - Detention basin within Tom Culkin Oval

Item Number	Description of works	Quantity	Unit	Rate	Cost
1.0	GENERAL AND PRELIMINARIES				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item		
1.2	Provision of sediment & erosion control	1	item		
1.3	Construction setout & survey	1	item		
1.4	Work as executed survey & documentation	1	item		
1.5	Geotechnical supervision, testing & certification	1	item		
	SUBTOTAL				$39,502.58
2.0	DEMOLITION, CLEARING AND GRUBBING				
2.1	Clearing & grubbing	10603.44	sq.m	$0.59	$6,256.03
2.2	Strip topsoil & stockpile for re-use	6562.94	cu.m	$3.67	$24,094.72
2.3	Demolish asphalt and gravel layers	1.1	m	$9.00	$9.90
2.4	Excavate clay layer	4157.11	cu.m	$3.67	$15,262.10
2.5	Dispose of excess topsoil and clay	9052.31	cu.m	$1.22	$11,078.01
	SUBTOTAL				$56,700.76
3.0	PIPES				
3.1	Install pipe system	470.87	m	$110.45	$52,008.03
	SUBTOTAL				$52,008.03
4.0	ROAD CONSTRUCTION				
4.1	Lay subbase	12.48	sq.m	$129.00	$1,609.47
4.2	Lay asphalt	12.48	sq.m	$100.00	$1,247.65
4.3	Seal road	12.48	sq.m	$26.70	$333.12
	SUBTOTAL				$3,190.24
5.0	EARTHWORKS				
5.1	Build embankment clay layer	6.75	cu.m	$4.43	$29.91
5.2	Level clay footing	10368.00	sq.m	$3.60	$37,324.80
5.3	Place and compact backfill	948.32	cu.m	$8.20	$7,776.21
	SUBTOTAL				$45,130.91
6.0	CRICKET PITCH				
6.1	Install cricket pitch	60	sq.m	$55.00	$3,300.00
6.2	Lay turf grass	8740.00	sq.m	$0.67	$5,830.80
	SUBTOTAL				$9,130.80
7.0	MINOR LANDSCAPING				

HYDROSPATIAL

Item Number	Description of works	Quantity	Unit	Rate	Cost
7.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)	10368	sq.m	$10.00	$103,680.00
	SUBTOTAL				$103,680.00
	CONSTRUCTION SUBTOTAL				$306,153.08
8.0	CONTINGENCIES				
8.1	50% construction cost				$153,076.54
	CONSTRUCTION TOTAL, excluding GST				**$459,229.63**
	GST				**$45,922.96**
	CONSTRUCTON TOTAL, including GST				**$505,152.59**
	CONSTRUCTION TOTAL, rounded				**$506,000.00**

* General and preliminary work subtotal was calculated as 15% of the construction value (excluding contingencies).

E.1.4 FM04 - Detention basin within 72 Severne Street

ITEM NO.	DESCRIPTION OF WORK	QUANTITY	UNIT	RATE	COST
1.0	GENERAL AND PRELIMINARIES				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item		
1.2	Provision of sediment & erosion control	1	item		
1.3	Construction setout & survey	1	item		
1.4	Work as executed survey & documentation	1	item		
1.5	Geotechnical supervision, testing & certification	1	item		
	SUBTOTAL				$128,986.40
2.0	DEMOLITION, CLEARING AND GRUBBING				
2.1	Clearing & grubbing	31371.83	sq.m	$0.59	$18,509.38
2.2	Strip topsoil & stockpile for re-use	18823.10	cu.m	$3.67	$69,105.78
2.3	Excavate clay layer	55011.14	cu.m	$3.67	$201,963.99
2.4	Dispose of excess topsoil and clay	70249.81	cu.m	$1.22	$85,970.05
	SUBTOTAL				$375,549.21
3.0	PIPES				
3.1	Install pipe system	234.50	m	$110.45	$25,899.97
	SUBTOTAL				$25,899.97
4.0	EARTHWORKS				
4.1	Level clay footing	31254.59	sq.m	$3.60	$112,516.51
4.2	Place and compact backfill	4072.91	cu.m	$8.20	$33,397.83
	SUBTOTAL				$145,914.33
5.0	MINOR LANDSCAPING				
5.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)	31254.59	sq.m	$10.00	$312,545.85
	SUBTOTAL				$312,545.85
	CONSTRUCTION SUBTOTAL				$988,895.77
6.0	CONTINGENCIES				
6.1	50% construction cost				$494,447.88
	CONSTRUCTION TOTAL, excluding GST				**$1,483,343.65**
	GST				**$148,334.37**
	CONSTRUCTON TOTAL, including GST				**$1,631,678.02**
	CONSTRUCTION TOTAL, rounded				**$1,632,000.00**

* General and preliminary work subtotal was calculated as 15% of the construction value (excluding contingencies).

HYDROSPATIAL

E.1.5 FM05 - Detention basin on Geurie Creek upstream of the railway embankment

Item Number	Description of works	Quantity	Unit	Rate	Cost
1.0	GENERAL AND PRELIMINARIES				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item		
1.2	Provision of sediment & erosion control	1	item		
1.3	Construction setout & survey	1	item		
1.4	Work as executed survey & documentation	1	item		
1.5	Geotechnical supervision, testing & certification	1	item		
	SUBTOTAL				$309,182.93
2.0	PROPERTY PURCHASE				
2.1	Purchase of Existing Properties			Pending property valuation	
	SUBTOTAL				
3.0	DEMOLITION, CLEARING AND GRUBBING				
3.1	Clearing & grubbing	76324.32	sq.m	$0.59	$45,031.35
3.2	Strip topsoil & stockpile for re-use	45794.59	cu.m	$3.67	$168,127.00
3.3	Excavate clay layer	131148.95	cu.m	$3.67	$481,490.90
3.4	Dispose of excess topsoil and clay	164985.92	cu.m	$1.22	$201,905.84
	SUBTOTAL				$896,555.08
4.0	PIPES				
4.1	Install pipe system	64.01	m	$110.45	$7,069.35
	SUBTOTAL				$7,069.35
5.0	EARTHWORKS				
5.1	Level clay footing	76292.32	sq.m	$3.60	$274,652.34
5.2	Place and compact backfill	14636.54	cu.m	$8.20	$120,019.60
	SUBTOTAL				$394,671.94
6.0	MINOR LANDSCAPING				
6.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)	76292.32	sq.m	$10.00	$762,923.17
	SUBTOTAL				$762,923.17
	CONSTRUCTION SUBTOTAL				$2,370,402.48
7.0	CONTINGENCIES				
7.1	50% construction cost				$1,185,201.24
	CONSTRUCTION TOTAL, excluding GST				**$3,555,603.72**
	GST				**$355,560.37**
	CONSTRUCTON TOTAL, including GST				**$3,911,164.09**

Item Number	Description of works	Quantity	Unit	Rate	Cost
	CONSTRUCTION TOTAL, rounded				$3,912,000.00

* General and preliminary work subtotal was calculated as 15% of the construction value (excluding contingencies).

HYDROSPATIAL

E.1.6 FM06 - Cascading detention basins alongside railway

Item Number	Description of works	Quantity	Unit	Rate	Cost
1.0	GENERAL AND PRELIMINARIES				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item		
1.2	Provision of sediment & erosion control	1	item		
1.3	Construction setout & survey	1	item		
1.4	Work as executed survey & documentation	1	item		
1.5	Geotechnical supervision, testing & certification	1	item		
	SUBTOTAL				$28,225.78
2.0	DEMOLITION, CLEARING AND GRUBBING				
2.1	Clearing & grubbing	7706.15	sq.m	$0.59	$4,546.63
2.2	Strip topsoil & stockpile for re-use	4065.81	cu.m	$3.67	$14,926.93
2.3	Demolish asphalt and gravel layers	2	m	$9.00	$18.00
2.4	Dispose of excess topsoil	2148.22	cu.m	$1.22	$2,628.94
	SUBTOTAL				$22,120.50
3.0	PIPES				
3.1	Install pipe system	18.16	m	$110.45	$2,005.99
	SUBTOTAL				$2,005.99
4.0	ROAD CONSTRUCTION				
4.1	Lay subbase	20	sq.m	$129.00	$2,580.00
4.2	Lay asphalt	20	sq.m	$100.00	$2,000.00
4.3	Seal road	20	sq.m	$26.70	$534.00
	SUBTOTAL				$5,114.00
5.0	EARTHWORKS				
5.2	Level clay footing	7601.88	sq.m	$3.60	$27,366.77
5.1	Build embankment clay layer	61.02	cu.m	$4.43	$270.32
5.3	Place and compact backfill	7490.48	cu.m	$8.20	$61,421.90
	SUBTOTAL				$89,058.98
6.0	MINOR LANDSCAPING				
6.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)	7498.64	sq.m	$10.00	$74,986.37
	SUBTOTAL				$74,986.37
	CONSTRUCTION SUBTOTAL				$216,397.62
7.0	CONTINGENCIES				
7.1	50% construction cost				$108,198.81

HYDROSPATIAL

Item Number	Description of works	Quantity	Unit	Rate	Cost
	CONSTRUCTION TOTAL, excluding GST				$324,596.44
	GST				$32,459.64
	CONSTRUCTON TOTAL, including GST				$357,056.08
	CONSTRUCTION TOTAL, rounded				$358,000.00

HYDROSPATIAL

E.1.7 FM07 – Additional culverts along Geurie Creek through the railway embankment

Item Number	Description of works	Quantity	Unit	Rate	Cost
1.0	GENERAL AND PRELIMINARIES				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item		
1.2	Construction setout & survey	1	item		
1.3	Work as executed survey & documentation	1	item		
1.4	Geotechnical supervision, testing & certification	1	item		
	SUBTOTAL				$31,479.66
2.0	DEMOLITION, CLEARING AND GRUBBING				
2.1	Clearing & grubbing	58.56	sq.m	$4.50	$263.52
2.2	Demolish track and gravel	25.62	m	$18.00	$461.16
2.3	Strip topsoil & stockpile for re-use	58.56	sq.m	$3.67	$214.99
2.4	Excavate clay layer	72.03	cu.m	$3.67	$264.44
2.5	Dispose of excess topsoil and clay	85.73184	cu.m	$1.22	$104.92
	SUBTOTAL				$724.68
3.0	CULVERTS				
3.1	Installation of additional culverts	7.32	m	$26,755.00	$195,846.60
	SUBTOTAL				$195,846.60
4.0	RAIL CONSTRUCTION				
4.1	Reconstruct track	25.62	m	$496.00	$12,707.52
	SUBTOTAL				$12,707.52
5.0	MINOR LANDSCAPING				
5.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)	58.56	sq.m	$10.00	$585.60
	SUBTOTAL				$585.60
	CONSTRUCTION SUBTOTAL				$241,344.06
6.0	CONTINGENCIES				
6.1	50% construction cost				$120,672.03
	CONSTRUCTION TOTAL, excluding GST				**$362,016.09**
	GST				**$36,201.61**
	CONSTRUCTON TOTAL, including GST				**$398,217.70**
	CONSTRUCTION TOTAL, rounded				**$400,000.00**

* General and preliminary work subtotal was calculated as 15% of the construction value (excluding contingencies).

HYDROSPATIAL

E.1.8 FM08 – Additional culverts along Geurie Creek under the Mitchell Highway

Item Number	Description of works	Quantity	Unit	Rate	Cost
1.0	GENERAL AND PRELIMINARIES				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item		
1.2	Construction setout & survey	1	item		
1.3	Work as executed survey & documentation	1	item		
1.4	Geotechnical supervision, testing & certification	1	item		
	SUBTOTAL				$12,737.30
2.0	DEMOLITION, CLEARING AND GRUBBING				
2.1	Clearing & grubbing	145.92	sq.m	$4.50	$656.64
2.2	Demolish asphalt and gravel layers	12.16	m	$9.00	$109.44
2.3	Strip topsoil & stockpile for re-use	145.92	sq.m	$3.67	$535.72
2.4	Excavate clay layer	87.552	cu.m	$3.67	$321.43
2.5	Dispose of excess topsoil and clay	0.96	cu.m	$1.22	$1.17
	SUBTOTAL				$1,624.41
3.0	CULVERTS				
3.1	Installation of additional culverts	4	item	$11,130.00	$44,520.00
	SUBTOTAL				$44,520.00
4.0	ROAD CONSTRUCTION				
4.1	Lay subbase	145.92	sq.m	$129.00	$18,823.68
4.2	Lay asphalt	145.92	sq.m	$100.00	$14,592.00
4.3	Seal road	145.92	sq.m	$26.70	$3,896.06
	SUBTOTAL				$37,311.74
5.0	MINOR LANDSCAPING				
5.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)	145.92	sq.m	$10.00	$1,459.20
	SUBTOTAL				$1,459.20
	CONSTRUCTION SUBTOTAL				$97,652.65
6.0	CONTINGENCIES				
6.1	50% construction cost				$48,826.33
	CONSTRUCTION TOTAL, excluding GST				**$146,478.98**
	GST				**$14,647.90**
	CONSTRUCTON TOTAL, including GST				**$161,126.88**
	CONSTRUCTION TOTAL, rounded				**$162,000.00**

* General and preliminary work subtotal was calculated as 15% of the construction value (excluding contingencies).

HYDROSPATIAL

E.1.9 FM09 – Construct swales adjacent to the roadway edges

Item Number	Description of works	Quantity	Unit	Rate	Cost
1.0	GENERAL AND PRELIMINARIES				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item		
1.2	Provision of sediment & erosion control	1	item		
1.3	Construction setout & survey	1	item		
1.4	Work as executed survey & documentation	1	item		
1.5	Geotechnical supervision, testing & certification	1	item		
	SUBTOTAL				$48,473.17
2.0	DEMOLITION, CLEARING AND GRUBBING				
2.1	Clearing & grubbing	19344.14	sq.m	$0.59	$11,413.04
2.2	Strip topsoil & stockpile for re-use	5803.24	cu.m	$3.67	$21,305.61
2.3	Dispose of excess topsoil	2900.00	cu.m	$1.22	$3,548.95
	SUBTOTAL				$36,267.60
3.0	EARTHWORKS				
3.1	Level soil footing	19344.14	sq.m	$3.60	$69,638.90
3.2	Place and compact backfill	2903.24	cu.m	$8.20	$23,806.58
	SUBTOTAL				$93,445.49
4.0	MINOR LANDSCAPING				
4.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)	19344.14	sq.m	$10.00	$193,441.40
	SUBTOTAL				$193,441.40
	CONSTRUCTION SUBTOTAL				$371,627.66
5.0	CONTINGENCIES				
5.1	50% construction cost				$185,813.83
	CONSTRUCTION TOTAL, excluding GST				**$557,441.50**
	GST				**$55,744.15**
	CONSTRUCTON TOTAL, including GST				**$613,185.65**
	CONSTRUCTION TOTAL, rounded				**$620,000.00**

* General and preliminary work subtotal was calculated as 15% of the construction value (excluding contingencies).

HYDROSPATIAL

E.1.10 FM10 - Earthen Levee along the Mitchell Highway

Item Number	Description of works	Quantity	Unit	Rate	Cost
1.0	GENERAL AND PRELIMINARIES				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item		
1.2	Provision of sediment & erosion control	1	item		
1.3	Construction setout & survey	1	item		
1.4	Work as executed survey & documentation	1	item		
1.5	Geotechnical supervision, testing & certification	1	item		
	SUBTOTAL				$42,334.00
2.0	DEMOLITION, CLEARING AND GRUBBING				
2.1	Clearing & grubbing	3338.43	sq.m	$0.59	$1,969.67
2.2	Strip topsoil & stockpile for re-use	143.04	cu.m	$3.67	$525.13
2.3	Demolish asphalt and gravel layers	25	m	$9.00	$225.00
	SUBTOTAL				$2,719.80
3.0	CULVERTS				
3.1	Installation of additional culverts	338.545	m	$110.45	$37,392.30
	SUBTOTAL				$37,392.30
4.0	Creek Widening				
4.1	Clearing & grubbing	14356.035	m	$0.59	$8,470.06
4.2	Excavate clay layer	20431.557	cu.m	$1.22	$25,003.65
	SUBTOTAL				$33,473.71
5.0	ROAD CONSTRUCTION				
5.1	Lay subbase	16.25	sq.m	$129.00	$2,096.25
5.2	Lay asphalt	16.25	sq.m	$100.00	$1,625.00
5.3	Seal road	16.25	sq.m	$26.70	$433.88
	SUBTOTAL				$4,155.13
6.0	EARTHWORKS				
6.1	Level soil footing	3322.18	sq.m	$3.60	$11,959.85
6.2	Build embankment clay layer	20431.56	cu.m	$4.43	$90,511.80
6.3	Place and compact backfill	11.05	cu.m	$8.20	$90.58
	SUBTOTAL				$102,562.22
7.0	MINOR LANDSCAPING				
7.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)	17694.46	sq.m	$10.00	$176,944.64
	SUBTOTAL				$176,944.64

HYDROSPATIAL

Item Number	Description of works	Quantity	Unit	Rate	Cost
	CONSTRUCTION SUBTOTAL				$324,560.67
8.0	CONTINGENCIES				
8.1	50% construction cost				$162,280.33
	CONSTRUCTION TOTAL, excluding GST				**$486,841.00**
	GST				**$48,684.10**
	CONSTRUCTON TOTAL, including GST				**$535,525.10**
	CONSTRUCTION TOTAL, rounded				**$536,000.00**