Summary Report for the St Georges Basin Flood Study

St Georges Basin Flood Study

59918098 R005

Prepared for
Shoalhaven City Council

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Stantec

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Abbreviations

AEP	Annual Exceedance Probability
ALS	Aerial Laser Survey
ARF	Areal Reduction Factor
ARI	Average Recurrence Interval
ARR87	Australian Rainfall and Runoff 1987 edition
ARR2019	Australian Rainfall and Runoff 2019 edition
BoM	Bureau of Meteorology
DCP	Development Control Plan
DECCW	NSW Department of Land and Water Conservation (now DPE)
DPE	NSW Department of Planning & Environment
FDM	Floodplain Development Manual
FFA	Flood Frequency Analysis
FPL	Flood Planning Level
FRMC	Floodplain Risk Management Committee
FRMP	Floodplain Risk Management Plan
FRMS	Floodplain Risk Management Study
GIS	Geographic Information System
ha	Hectare
IFD	Intensity Frequency Duration
km	Kilometres
km^2	Square kilometres
LEP	Local Environment Plan
LiDAR	Light Detection and Ranging aerial survey
LGA	Local Government Area
m	Metre
m^2	Square metre
m^3	Cubic metre
m^3/s	Cubic metres per second (flow)
mAHD	Metres to Australian Height Datum
mm	Millimetre
m/s	Metres per second (velocity)
NSW	New South Wales
OEH	NSW Office of Environment & Heritage (now DPE)
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
SES	State Emergency Service
SCC	Shoalhaven City Council

Glossary

Annual Exceedance Probability (AEP)	Refers to the probability or risk of a flood of a given size occurring or being exceeded in any given year. A 90% AEP flood has a high probability of occurring or being exceeded each year; it would occur quite often and would be relatively small. A 1%AEP flood has a low probability of occurrence or being exceeded each year; it would be fairly rare but it would be relatively large.
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Recurrence Interval (ARI)	The average or expected value of the periods between exceedances of a given rainfall total accumulated over a given duration. It is implicit in this definition that periods between exceedances are generally random
Cadastre, cadastral base	Information in map or digital form showing the extent and usage of land, including streets, lot boundaries, water courses etc.
Catchment	The area draining to a site. It always relates to a particular location and may include the catchments of tributary streams as well as the main stream.
Creek Rehabilitation	Rehabilitating the natural 'biophysical' (i.e. geomorphic and ecological) functions of the creek.
Design flood	A significant event to be considered in the design process; various works within the floodplain may have different design events. E.g. some roads may be designed to have a 1% AEP flood immunity while other roads may be designed to be overtopped in the 20 year ARI or 5% AEP flood event.
Development	The erection of a building or the carrying out of work; or the use of land or of a building or work; or the subdivision of land.
Discharge	The rate of flow of water measured in terms of volume over time. It is to be distinguished from the speed or velocity of flow, which is a measure of how fast the water is moving rather than how much is moving.
Flash flooding	Flooding which is sudden and often unexpected because it is caused by sudden local heavy rainfall or rainfall in another area. Often defined as flooding which occurs within 6 hours of the rain which causes it.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.
Flood fringe	The remaining area of flood-prone land after floodway and flood storage areas have been defined.
Flood hazard	Potential risk to life and limb caused by flooding.
Flood-prone land	Land susceptible to inundation by the probable maximum flood (PMF) event, i.e. the maximum extent of flood liable land. Floodplain Risk Management Plans encompass all flood-prone land, rather than being restricted to land subject to designated flood events.
Floodplain	Area of land which is subject to inundation by floods up to the probable maximum flood event, i.e. flood prone land.

Floodplain management measures	The full range of techniques available to floodplain managers.
Floodplain management options	The measures which might be feasible for the management of a particular area.
Flood planning area	The area of land below the flood planning level and thus subject to flood related development controls.
Flood planning levels (FPLs)	Flood levels selected for planning purposes, as determined in floodplain management studies and incorporated in floodplain management plans. Selection should be based on an understanding of the full range of flood behaviour and the associated flood risk. It should also take into account the social, economic and ecological consequences associated with floods of different severities. Different FPLs may be appropriate for different categories of land use and for different flood plains. As FPLs do not necessarily extend to the limits of flood prone land (as defined by the probable maximum flood), floodplain management plans may apply to flood prone land beyond the defined FPLs.
Flood storages	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood.
Floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often, but not always, aligned with naturally defined channels. Floodways are areas which, even if only partially blocked, would cause a significant redistribution of flood flow, or significant increase in flood levels. Floodways are often, but not necessarily, areas of deeper flow or areas where higher velocities occur. As for flood storage areas, the extent and behaviour of floodways may change with flood severity. Areas that are benign for small floods may cater for much greater and more hazardous flows during larger floods. Hence, it is necessary to investigate a range of flood sizes before adopting a design flood event to define floodway areas.
Geographical Information Systems (GIS)	A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.
High hazard	Flood conditions that pose a possible danger to personal safety; evacuation by trucks difficult; able-bodied adults would have difficulty wading to safety; potential for significant structural damage to buildings.
Hydraulics	The term given to the study of water flow in a river, channel or pipe, in particular, the evaluation of flow parameters such as stage and velocity.
Hydrograph	A graph that shows how the discharge changes with time at any particular location.
Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.
Low hazard	Flood conditions such that should it be necessary, people and their possessions could be evacuated by trucks; able-bodied adults would have little difficulty wading to safety.
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of the principal watercourses in a catchment. Mainstream flooding generally excludes watercourses constructed with pipes or artificial channels considered as stormwater channels.

Management plan	A document including, as appropriate, both written and diagrammatic information describing how a particular area of land is to be used and managed to achieve defined objectives. It may also include description and discussion of various issues, special features and values of the area, the specific management measures which are to apply and the means and timing by which the plan will be implemented.
Mathematical/computer models	The mathematical representation of the physical processes involved in runoff and stream flow. These models are often run on computers due to the complexity of the mathematical relationships. In this report, the models referred to are mainly involved with rainfall, runoff, pipe and overland stream flow.
Overland Flow	The flow of water over the ground surface either along formal flowpaths such as roads and formed channels, or informal flowpaths along topographic low points and through properties and open space areas. The term overland flow is used interchangeably in this report with “flooding”.
Peak discharge	The maximum discharge occurring during a flood event.
Probable Maximum Flood (PMF)	The flood calculated to be the maximum that is likely to occur.
Probability	A statistical measure of the expected frequency or occurrence of flooding. For a fuller explanation see Annual Exceedance Probability.
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. For this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
Runoff	The amount of rainfall that actually ends up as stream or pipe flow, also known as rainfall excess.
Stage	Equivalent to 'water level'. Both are measured with reference to a specified datum.
Stage hydrograph	A graph that shows how the water level changes with time. It must be referenced to a particular location and datum.
Stormwater flooding	Inundation by local runoff. Stormwater flooding can be caused by local runoff exceeding the capacity of an urban stormwater drainage system or by the backwater effects of mainstream flooding causing the urban stormwater drainage system to overflow.
Topography	A surface which defines the ground level of a chosen area.
TUFLOW	One-dimensional (1D) and two-dimensional (2D) flood and tide simulation software (hydraulic model)
WBNM	Watershed Bounded Network Model – hydrologic runoff routing computer model

* Terminology in this Glossary have been derived or adapted from the NSW Government Floodplain Development Manual, 2005, where available.

1 Introduction

Local councils have lead responsibility for managing flood prone areas, and the State Government assists local council by providing financial and technical support under the Floodplain Management Program.

Council's Central Floodplain Risk Management Committee (the Committee) oversees the Floodplain Management process for the Central Region of the Shoalhaven Local Government Area. The Committee meets as required and includes representatives from Council, the NSW Department of Planning & Environment (DPE), the NSW State Emergency Service (SES), Councillors and local community representatives.

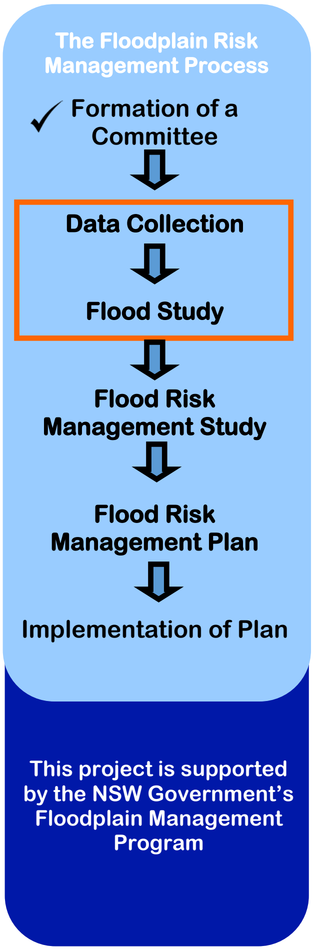
Shoalhaven City Council (Council) engaged Cardno to assist with the preparation of the St Georges Basin Flood Study. Previous flood information available for the catchment was undertaken using older software and methods. Council are taking the opportunity to update the flood models using the latest software and survey information and expanding the model extents to improve the accuracy and currency of the flood information.

The purpose of this Flood Study is to define flood behaviour and flood risk in the St Georges Basin catchment which will subsequently be used in the Floodplain Risk Management Study and Plan to identify and recommend appropriate actions to manage current and future flood risks in the St Georges Basin catchment.

1.1 Study Context

The Floodplain Management process, as described in the NSW Government Floodplain Development Manual (2005), progresses through 6 stages in an iterative process:

- Stage 1 - Formation of a Floodplain Management Committee;
- Stage 2 - Data Collection;
- Stage 3 - Flood Study;
- Stage 4 - Floodplain Risk Management Study (FRMS);
- Stage 5 - Floodplain Risk Management Plan (FRMP); and
- Stage 6 - Implementation of the Floodplain Risk Management Plan.



This project covers Stages 2 to 5 of the Floodplain Management process. The Flood Study report addresses Stage 2 and Stage 3 of the Floodplain Management process.

1.2 Objectives

The objectives of the Flood Study are to:

- Collate and review available flood information for the catchment;
- Develop updated hydrologic and hydraulic models using recent information and software, calibrated and validated to historical events;
- Derive design flood event flows, water levels and other hydraulic parameters through hydraulic modelling;
- Define and document flood risk in the catchment including mapping; and
- Determine impacts of flooding on the community, flood planning levels, flood damages and emergency response considerations.

The completed Flood Study will form the basis of the FRMS&P, which will include identification and analysis of flood risk and the floodplain risk management options assessment.

1.3 Context of This Flood Study Summary Report

The purpose of this Flood Study Summary Report is to provide an abridged version of the Flood Study that outlines the key approach, stages and outcomes of the study in a less technical manner that is more accessible to the community. More detail on each stage and technical description is contained within the full Flood Study report. The Flood Study report details:

- Hydrology model setup;
- Hydraulic model setup;
- Model calibration and validation;
- Design event flood estimation;
- Flood modelling of design events, sensitivity testing and climate change;
- Flood model results and mapping; and
- Flood damages, flood planning and emergency response considerations.

2 Study Area

2.1 Study Area Overview

St Georges Basin is a coastal lagoon and is located immediately south of Jervis Bay draining to the Tasman Sea through the Sussex Inlet channel. There are a number of residential areas around the Basin, along the tributary creeks and the Sussex Inlet Channel, which are listed later. In the past, the land usage around the Basin has undergone significant changes, from a rural community to an urbanised community. The urban area to the north of Badgee Lagoon could historically be isolated from the surrounding areas during larger flood events without being inundated. However a gated flood free access road (FFAR) has recently been constructed to Sussex Inlet Road through the Badgee Urban Release Area. Establishing an alternative evacuation route for the Badgee urban area was a recommended action in the St Georges Basin FRMS&P (2013). It is also notable that Badgee Lagoon connects through the Riviera Keys canal estate to the Sussex Inlet channel. The study area boundary is shown in **Figure 2-1.**

2.2 Catchment Description

The study area comprises of St Georges Basin itself, the Estuary area, Sussex Inlet and upstream residential areas along the tributary creeks. The entire catchment to the ocean covers an area of approximately 358 square kilometres with approximately 10% of the catchment area covered by the Basin itself. The catchment area of the Basin contains a number of creeks including Pats Creek, Home Creek, Wandandian Creek, Tomerong/Cockrow Creek, Cow Creek, Tullarwalla Creek and Worrowing Creek. Wandandian Creek and Tomerong Creek are the largest tributaries along the Basin having catchment areas of 159.3 square kilometres and 42.8 square kilometres, respectively. The upstream end of the catchment rises to an elevation of approximately 650 mAHD and is 24 kilometres away from the Basin. The catchment starts from east of Braidwood Road and follows an easterly direction to the St Georges Basin. The Basin connects to the ocean through the Sussex Inlet Channel and there are no recorded periods of closure of the Basin's entrance.

2.3 Description of Flood Behaviour

Flooding within the study area may occur as a result of a combination of the following factors:

- An elevated Basin level due to intense rain over the total catchment, typically for storm events occurring over multiple days. Flooding is volume driven and the Basin level rises when the rate of inflow to the Basin is greater than the outflow to the ocean. The Sussex Inlet channel and ocean conditions can act as constriction to the rate of outflow;
- Elevated water levels within the individual creeks as a result of intense rain over the local tributary catchments. Flood levels are driven by flow rates and the capacity of the channels. The levels in the creeks may also be affected by an elevated Basin level or by constrictions along their lengths (natural or hydraulic structures such as bridges and culverts). Flood characteristics can be different in these catchments, during localised storm events;
- Overland flow in small local catchments with runoff accumulating in low points. Inadequate local drainage provisions and elevated Basin levels at the outlets of the urban drainage system may compound this problem;
- Elevated ocean levels caused by storm surge (from a low-pressure system) in combination with increased wave activity. This primarily affects the Sussex Inlet area but can also lead to elevated water levels in the Basin. Higher water levels can be observed in Sussex Inlet than in the Basin due to ocean conditions; and
- Local wind conditions generating waves and setup across the fetch of the Basin.

As reported in the St Georges Basin Floodplain Risk Management Study (WMA, 2006), some local residents had reported during the flood study process that during the 1971 flood, levels at the eastern end of the Basin were 0.5m higher than at the western end due to the effects of wind stress across the fetch of the water body.

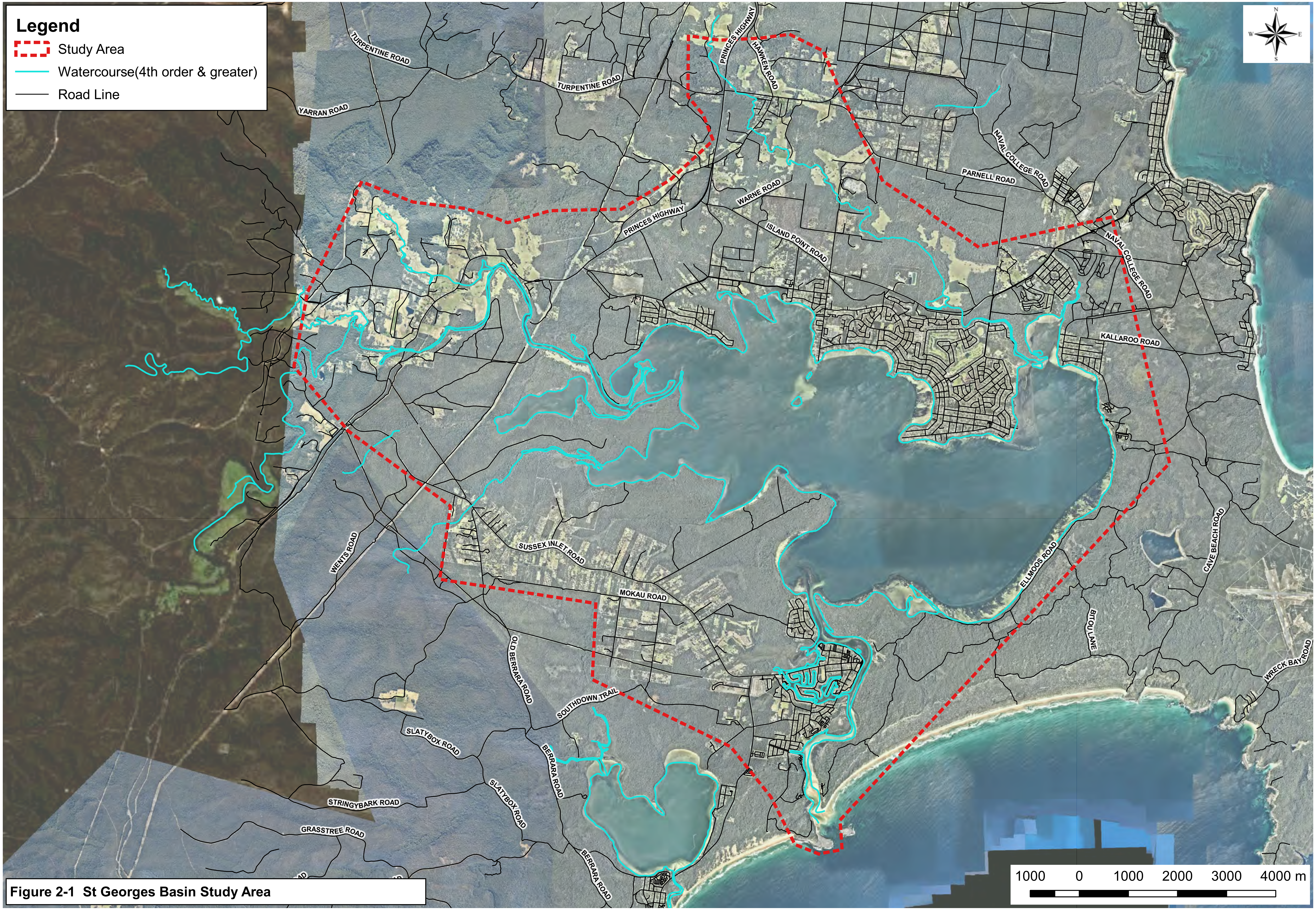


Figure 2-1 St Georges Basin Study Area

3 History of Flooding

A number of instances of flooding have been reported in the St Georges Basin catchment since the 1950's in low lying foreshore areas around the St Georges Basin and Sussex Inlet. The Sussex Inlet and the Sanctuary Point townships in particular can be inundated for a couple of days.

Known significant flood events in the catchment occurred in:

- March 1959;
- October 1959;
- February 1971;
- June 1991; and
- August 2015.

Minor storm events also occurred in:

- May 1953;
- February 1958;
- March 1961;
- March 1975;
- March and October 1976;
- February 1992;
- September 1993;
- April 1994;
- August 1998;
- June 2013;
- June 2016; and
- July and August 2020.

The Island Point Water level gauge in St Georges Basin was installed in July 1991, providing water level records from that time. Although a number of floods are known to have occurred in the 1950's, no water level data is available. The largest event was the February 1971 event with peak basin levels of between 2.21m AHD and 2.7m AHD being reported.

Recently, settlements in this catchment have experienced flooding due to the East Coast Low (ECL) weather systems that took place in August 2015, June 2016 and July/August 2020. A peak water level at St Georges Basin at Island Point Road was recorded as 1.85m AHD during August 2015 flood which is higher than the current 10% AEP flood level estimate (1.68m AHD). The MHL gauge recorded peak water level of 1.46m AHD at Sussex Inlet during the August 2015 flood is higher than the 20% AEP flood level (1.4m AHD), but below the 10% AEP flood level (1.6m AHD). The June 1991 event had similar levels of 1.7 – 1.9 m AHD reported.

A review and ranking of the recorded flood levels within the Basin are provided for each event in **Table 3-1**.

Table 3-1 Ranking of Historical Events

Event	Basin Level	Source	Model	Notes
1971	2.2	St Georges Basin Flood Study (2001)	Yes	Significant changes to ground levels in Sussex Inlet after 1971 which make calibration to this event difficult.
August 2015	1.853	MHL	Yes	Largest storm recorded by the two MHL gauges and event selected for calibration. Event similar magnitude as 1991 event, with better data.
June 1991	1.7 – 1.9	St Georges Basin Flood Study (2001)	No	Variation in recorded levels in close proximity and no levels recorded as being "very good" accuracy. Peak levels only recorded means that the rate of rise and fall cannot be verified.
June 2013	1.418	MHL	Yes	2^{nd} largest event recorded by MHL gauges and event selected for validation.
July 2020	1.353	MHL	No	
August 1998	1.28	MHL	No	Less certainty on bathymetry due to date. No gauge data at Sussex Inlet available.
February 1992	1.18	MHL	No	Similar magnitude to 2016 event.
June 2016	1.171	MHL	No	Flooding event recorded by MHL gauges. Known bathymetry within Sussex Inlet during event due to recent survey.

4 Flood Model Development

4.1 Previous Reports and Studies

A number of previous studies have been conducted within and around the study area. These studies have been reviewed as part of this study to identify relevant information that can inform or be used in this study.

Reports and studies that have been reviewed include:

> Previous Flood Studies of the St Georges Basin;
> Floodplain Risk Management Studies and Plans for the St Georges Basin;
> Coastal Management Plans and Studies;
> Council Policies; and
> Data Collection Reports.

4.2 Available Data

Available data has been reviewed to inform the study, to provide data to setup the hydrological and hydraulic models, and to allow calibration and validation of the models' performance. Where insufficient data was available, additional data was collected such as additional survey and up to date rainfall and water level data.

A more thorough description of available data is provided in the Flood Study. The below list provides a summary of the key data collated for this study:

> Council GIS Database – including Aerial photographs, Cadastre, Drainage, Wastewater, Water and Water Catchments, and Waterways;
> Historical flood photographs;
> Terrain data including Aerial Laser Survey, detailed ground survey and bathymetric survey;
> Hydraulic structure data – bridges, culverts and stormwater drainage structures (survey and GIS database including location, type, inverts and dimensions); and
> Rainfall and Water Level gauge data - within the immediate catchment area there are a number of gauges.

4.3 Community Consultation

Consultation with the community and stakeholders is an important component in the development of a Flood Study and Floodplain Risk Management Study & Plan. Consultation provides an opportunity to collect information from observed flood events, feedback and observations from the community on problem areas and potential floodplain management measures. It also provides a mechanism to inform the community about the current study and flood risk within the study area and seeks to improve their awareness and readiness for dealing with flooding.

Community consultation was undertaken in the form of a questionnaire to obtain information from the community about historical flood observations and to obtain community preferences for different types of flood mitigation options. Relevant stakeholder agencies have been corresponded with to obtain relevant data and flood information for use in the study. Further community consultation will be undertaken in futures stages of the study.

The details and outcomes of community engagement activities to date are provided in the Flood Study.

4.4 Flood Model Development

The study uses two models which have been setup using current industry standards and available data:

> A hydrological model to simulate the conversion of rainfall into runoff to calculate flows within the catchment; and
> A hydraulic model to simulate the flow of water through a catchment and associated waterways to calculate flood characteristics such as water level and velocity of flow.

A Watershed Bounded Network Model (WBNM) hydrologic model was established to represent the St Georges Basin catchment including the Basin characteristics.

The St Georges Basin hydrological model covers an area of approximately 358 square kilometres and was divided into sub-catchments using available terrain data (**Figure 4-1**).

Catchments were assessed for their characteristics such as slope, land use, vegetation cover and impervious areas such as roads and buildings to allow assignment of model parameters reflective of current conditions to each sub-catchment. Appropriate model parameters have been selected through a process of calibration and validation against recorded basin level data from historical events (**Section 4.5**).

The TUFLOW software was used to setup a 2-dimensional hydraulic model to represent the waterways and floodplains within the Study Area including the Basin and Sussex Inlet channel to Tasman Sea along with the lower reaches of the tributaries flowing into the Basin and all floodplain areas (**Figure 4-2**). To define the topography/bathymetry of the study area the model uses ground survey and Aerial Laser Survey data and includes bridges and culverts under roads. The model extends to the ocean where suitable ocean tidal boundaries have been applied.

Appropriate model parameters are applied to different waterways and land use types and these have been selected both through national guidance literature as well as through the calibration process where model results are compared to recorded water levels from historic events.

Flows derived from the hydrological model are applied as inflows to the hydraulic model to assess flood impacts within the study area for a range of storm scenarios.

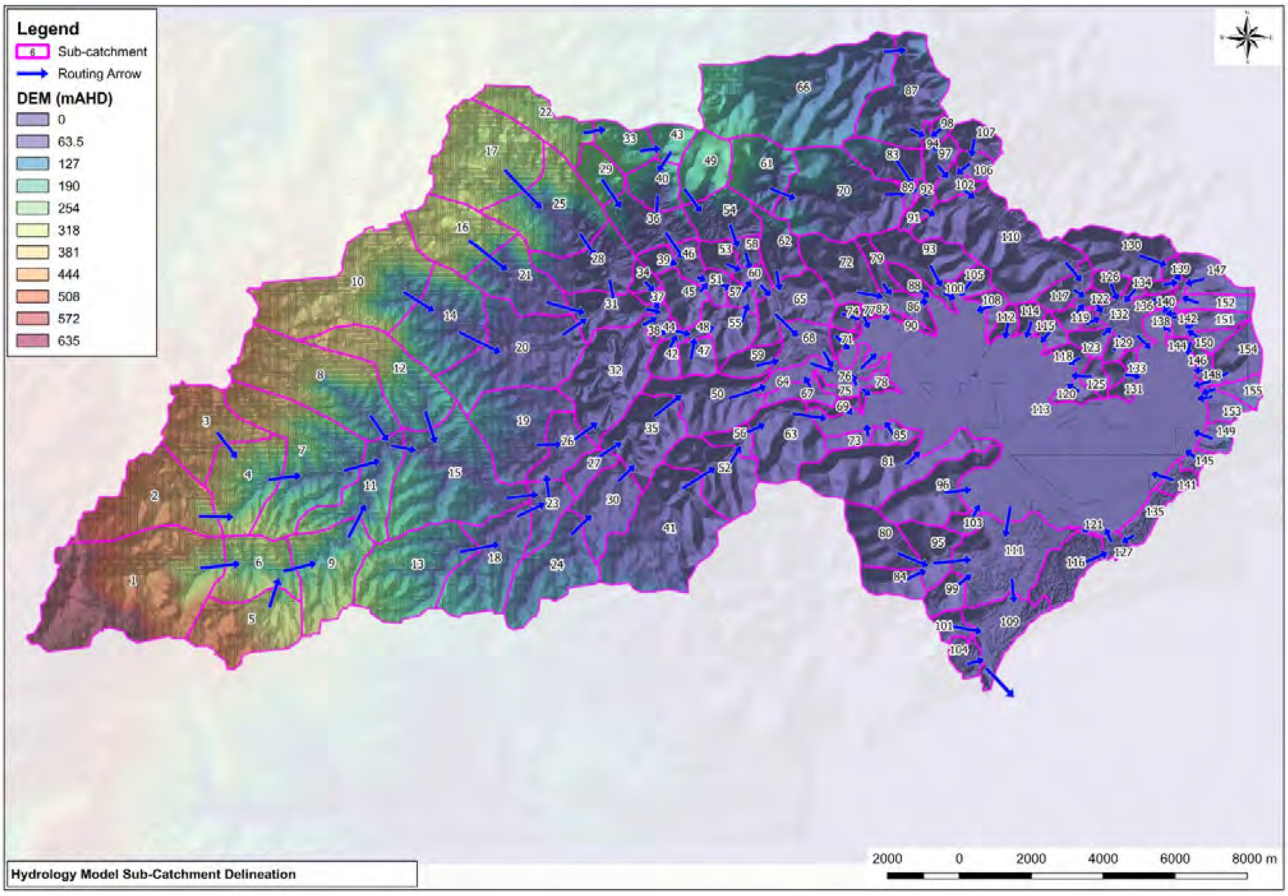


Figure 4-1 St Georges Basin Catchment

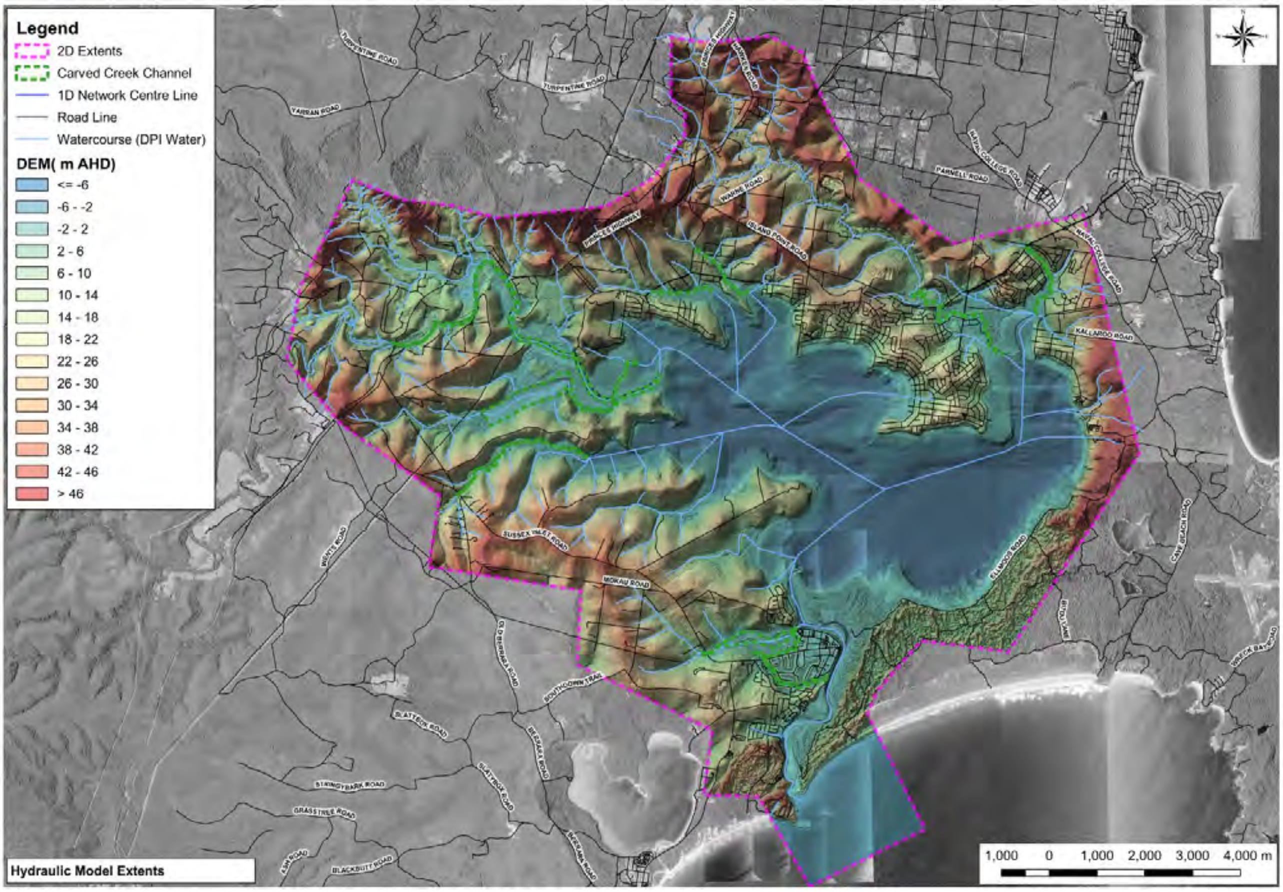


Figure 4-2 Hydraulic Model Extents

4.5 Model Calibration and Validation

Calibration and validation of the hydrologic and hydraulic models is a key component of the Flood Study, as it confirms that the models (developed as described in **Section 4.4**) can reasonably reproduce recorded and observed flood behaviour in the catchment for a range of flood event magnitudes.

Calibration involves the selection and adjustment of model parameters to achieve a good match between modelled behaviour and observed behaviour from water level and flow gauges and community flood observations. Validation involves testing the calibrated model against additional historical measured flood events to ensure that the model performs well across a range of events.

While for major events there are some good flood data from community observations around the Basin and Sussex Inlet, there is limited information available in the tributaries and there are currently only two water level gauges in operation at Island Point in the Basin and in Sussex Inlet. There are no available streamflow gauges to calibrate parameters to match the flow hydrographs in the tributaries.

Hence, the hydrology model cannot be calibrated in isolation. Rainfall data of historical storms was used in WBNM to determine inflows and volumes for the TUFLOW model. Water levels from the TUFLOW model were then compared to historical water level observations and gauge records in order to determine how well the model is calibrated. Various WBNM parameters were tested to achieve the best match between the modelled and recorded water levels.

The August 2015 historical flood event was chosen for calibration as it is the largest recent event and had the greatest availability of reliable data, including gauged flow and level data and community observations. February 1971 and June 2013 storm events were selected for validation.

For the August 2015 calibration event, the overall response of the hydrologic and hydraulic model at the two Manly Hydraulics Laboratory (MHL) water level gauges (**Figure 4-3** and **Figure 4-4**) shows a good correlation with recorded data with peak water levels slightly lower than gauged (100mm lower in the Basin and 55mm lower in Sussex Inlet). A good correlation of peak levels is achieved at the surveyed flood marks and levels/depths reported by the community. The average difference between predicted and surveyed peak levels is calculated to be -0.06m and most values are within +/- 0.11m for the August 2015 storm event.

Both the hydrologic and hydraulic models in combination have been able to represent the August 2015 flood event hydraulic behaviour reasonably accurately and the models are considered to be well calibrated for use in design flood estimation.

Validation against the June 2013 event showed that the model's representation of the peak level of the June 2013 storm event is generally good and is within 100mm of Island Point gauge in the Basin and matches Sussex Inlet gauge to within approximately 10mm.

Gauge data is not available for the February 1971 event, so modelled results were only compared to surveyed peak flood marks. Overall, the comparison of observed and modelled water levels shows that using the previously calibrated parameters of the August 2015 Calibration Event, a reasonable match with the recorded data is achieved for the February 1971 event. The greatest differences occur around the foreshore of the Basin, which is likely attributed to recorded water levels being affected by wind generated setup leading to water level variations across the Basin. St Georges Basin Flood Study (WMA, 2001) mentioned local residents reported that differences in flood levels of up to 0.5m were observed across the Basin in the February 1971 flood due to the wind stress across the open water body.

The modelled February 1971 flood event levels in the current study are generally higher than previous results in St Georges Basin Flood Study (WMA, 2001). This may be attributed to, for instance, different mechanisms between 2D and 1D hydraulic models used, Sussex Inlet bathymetry differences, and other survey or data differences. As such, it is considered that the current study model is more representative of the current hydraulic state of the study area.

4.6 Wind Wave Setup

St Georges Basin Flood Study (WMA, 2001) mentioned local residents reported that up to 0.5m difference in basin flood levels were observed in the 1971 flood due to the wind stress across the open water body. Wind generated wave setup within St Georges Basin is not considered in the flood model and results presented are a "still water" level. An assessment of wind/wave setup across the Basin has been undertaken for this study and is presented in **Section 6.4**.

4.7 Sensitivity Analysis

Sensitivity analysis is undertaken to assess how sensitive the hydrology and hydraulic model (based on model results) is to variations in different input parameters. When model results only vary within a reasonable range, then that is a further indication that the developed flood model can adequately represent catchment responses to rainfall for flood modelling purposes.

Sensitivity analysis of the following parameters was undertaken to examine the effect that varying model parameters has on results:

> Changes to flow estimates due to changes in hydrological model parameters;
> Changes to channel Mannings Roughness (representation of different surface types resistance to flow);
> Blockage of structures;
> Constricted entrance condition; and
> Alternate tidal boundary condition.

Results of Sensitivity Analysis scenarios are presented in **Appendix H** of the Flood Study as water level difference plots compared with the adopted 1% AEP event peak water levels.

Sensitivity analysis results show that for a 1% AEP, increases in flood levels due to model parameter uncertainties are generally expected to be in the order of 350mm or less. There are only localised impacts due to blockage of structures in the 1% AEP event, while broader flood levels are not sensitive to blockage because structures are submerged and are not acting as the main hydraulic control determining flood levels.

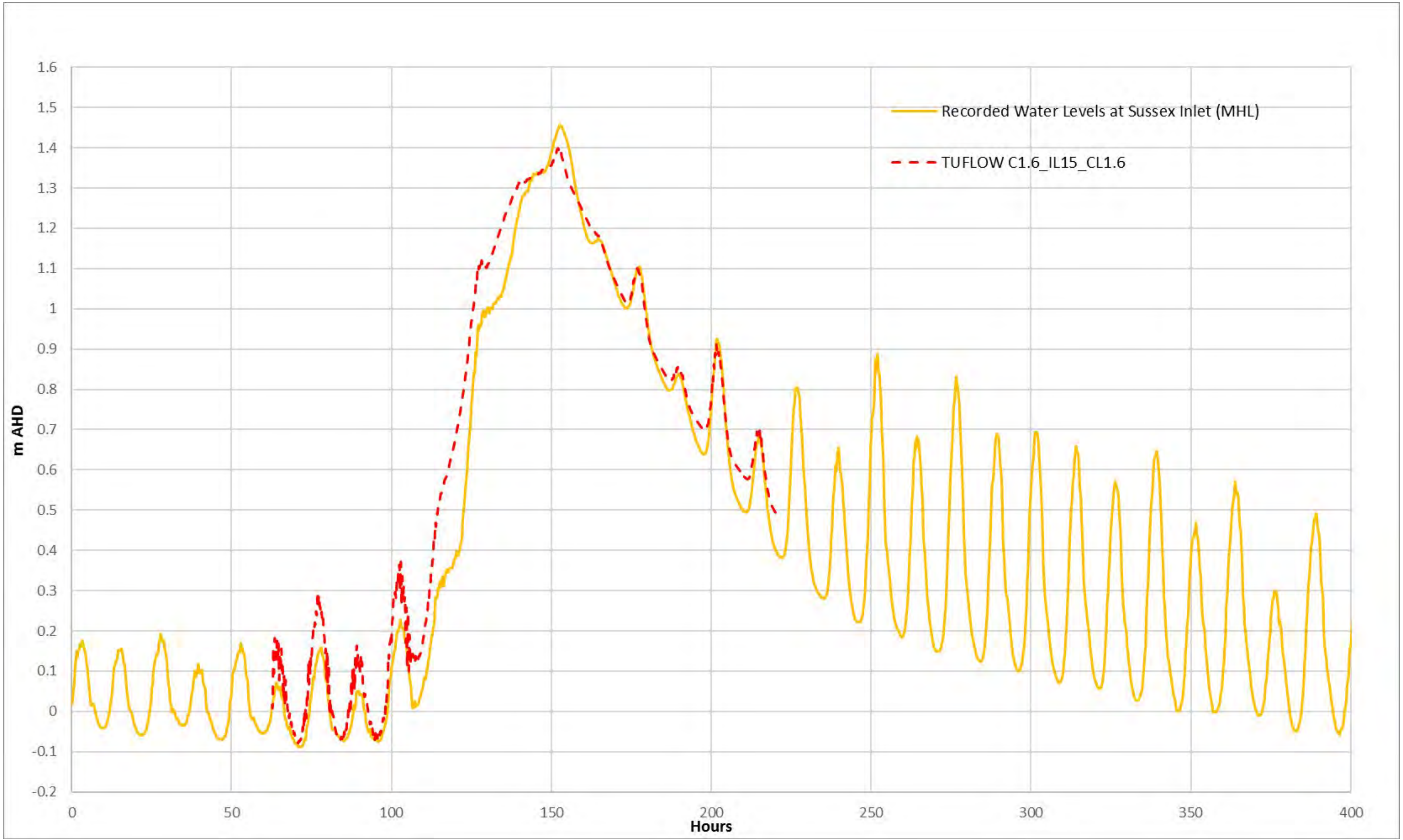


Figure 4-3 Modelled Flood Levels and Recorded MHL Gauge Levels at Sussex Inlet, 2015 Event

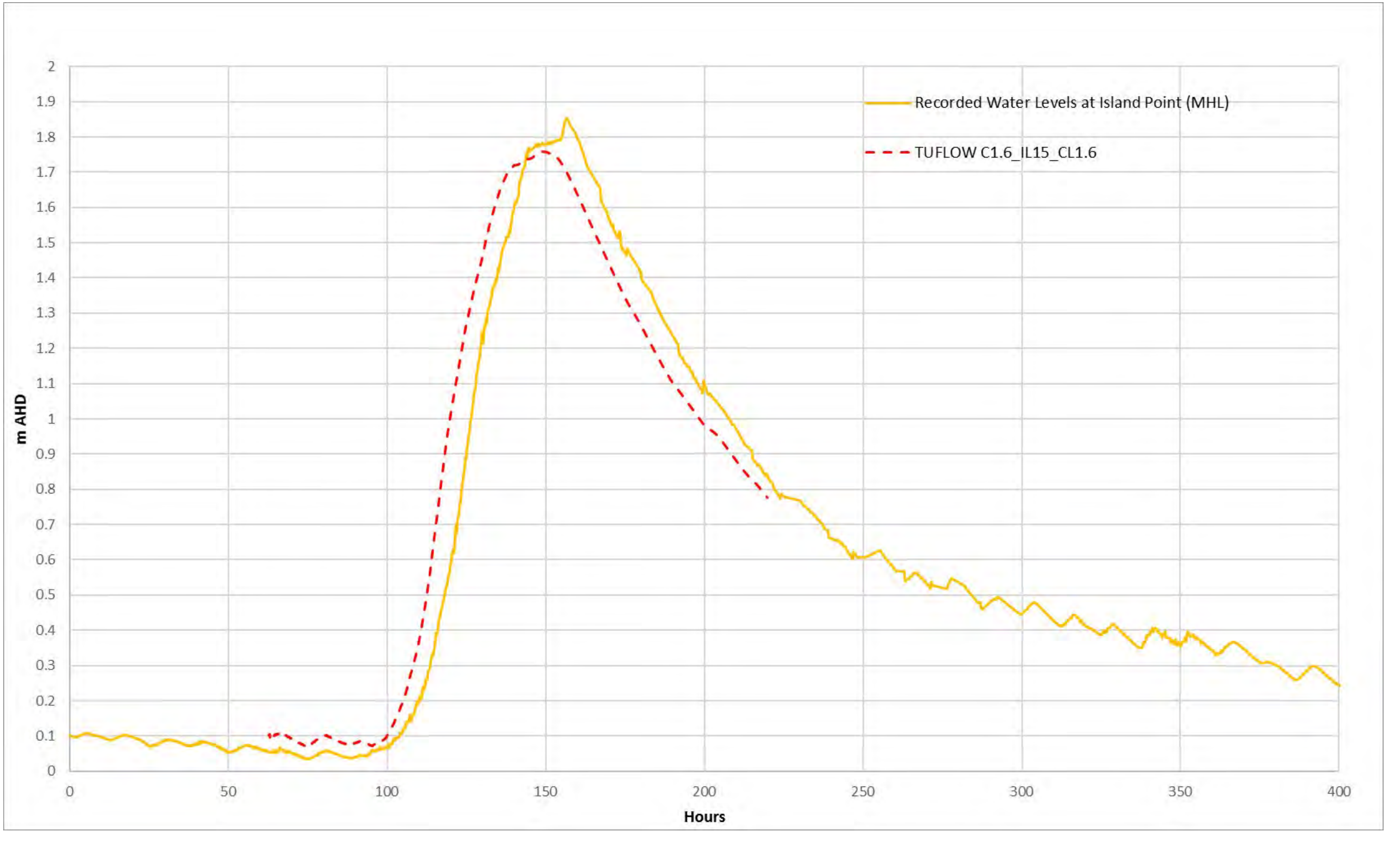


Figure 4-4 Modelled Flood Levels and Recorded MHL Gauge Levels at Island Point, 2015 Event

5 Hydrology – Design Flood Estimation

The calibrated hydrological model of the St Georges Basin catchment has been used for determining design flood event flows in accordance with the current industry standard Australian Rainfall and Runoff 2019 (ARR2019) Guidelines. Data specific to the catchment has been obtained from the ARR Data Hub and Bureau of Meteorology (BoM).

The data was input to the hydrologic model to simulate a range of design events and durations to define flow inputs to the hydraulic model. Design events are defined by an Annual Exceedance Probability (AEP) which is the probability that a flood of a given magnitude will be experienced in any one year. The storm events modelled for the Flood Study include the:

- 20% AEP event
- 10% AEP event;
- 5% AEP event;
- 2% AEP event;
- 1% AEP event;
- 0.2% AEP event; and,
- Probable Maximum Flood (PMF).

For this study the Probable Maximum Flood event is estimated using the Probable Maximum Precipitation (PMP) and rainfall and flows have been derived for both the Generalised Short Duration Method (GSDM) for shorter storm durations relevant to the tributaries and the Generalised Southeast Australia Method (GSAM) for longer duration storms relevant to the Basin and Sussex Inlet.

5.1.1 Design Event Flows

Table 5-1 shows design event flows calculated in the WBNM hydrologic model at key locations within the model Study Area.

Table 5-1 Design event flows from WBNM Hydrology Model at Key Locations

Event	Wandandian Creek	Tullarwalla Creek	Cow Creek	Tomerong Creek	Worrowing Creek
	Flow (m^3/s)	Flow (m^3/s)	Flow (m^3/s)	Flow (m^3/s)	Flow (m^3/s)
20% AEP	358	50	39	117	27
10% AEP	436	63	47	139	36
5% AEP	530	77	57	178	44
2%AEP	699	93	73	215	58
1% AEP	813	110	87	255	69
0.2% AEP	1,137	139	109	328	91
PMP	4,035	499	383	902	200

The flows derived from the WBNM model are used as inflows to the TUFLOW hydraulic model.

6 Model Flood Events

The following sections describe the model scenarios undertaken for the St Georges Basin flood study.

6.1 Modelled Storm Events

The models have been run for the 20%, 10%, 5%, 2%, 1%, 0.2% AEP Storms and the PMF event for Existing, projected 2050 and projected 2100 scenarios.

Suitable ocean boundary conditions for each design event were established in accordance with the *NSW Floodplain Risk Management Guide - Modelling the Interaction of Catchment Flooding and Oceanic Inundation in Coastal Waterways* (NSW OEH, 2015).

6.2 Sea Level Rise

NSW sea level rise planning benchmarks in the *NSW Sea Level Rise Policy Statement (2009)* are an increase above 1990 mean sea levels of 40cm by 2050 and 90cm by 2100. However, this policy was repealed by the NSW Government in 2012 and coastal councils were encouraged to adopt their own sea level rise projections.

Shoalhaven City Council, in partnership with Eurobodalla Shire Council, developed the *South Coast Regional Sea Level Rise Policy and Framework* (Whitehead & Associates, 2014) and Councillors adopted the following sea level rise projections on 10 February 2015:

> 100mm for 2030;
> 230mm for 2050; and
> 360mm for 2100.

These sea level rise projections have been adopted for modelling of the Projected 2050 and Projected 2100 scenarios for the full range of design events. The projected 2050 and projected 2100 scenarios are based on current BoM design event Intensity Frequency Duration (IFD) rainfall data (without projected rainfall increases) and Council's SLR projections of 23cm by 2050 and 36cm by 2100.

The NSW projected 2100 sea level rise of 90cm was also investigated to test sensitivity to a large sea level rise projection.

6.3 Climate Change

It is widely accepted that Climate Change will lead to increases in global temperatures which will lead to increases in the intensity of rainfall along with sea level rise. The NSW Government's Floodplain Development Manual (NSW Government, 2005) requires that flood studies and floodplain risk management studies consider the impact of climate change (rainfall increase and sea level rise) on flood behaviour. This Study has assessed the impacts on flooding of both climate change induced rainfall increases and sea level rise using current industry guidelines.

Climate Change scenarios tested have been adopted from ARR2019 along with consideration of the *OEH Floodplain Risk Management Guides: Modelling the Interaction of Catchment Flooding and Oceanic Inundation in Coastal Waterways* (OEH, 2015) and Practical Consideration of Climate Change (DECC, 2007).

Climate Change predictions are made based on modelling changes to temperature and rainfall in global climate models for various Representative Concentration Pathways (RCPs), which consider projected increases in greenhouse gas concentrations. Temperature and rainfall for low, medium and high carbon emissions scenarios for years up to 2090 for the St Georges Basin catchment are shown in **Table 6-1**.

ARR2019 (Ball et al., 2019) recommends the use of RCP 4.5 and RCP 8.5 values. These values are available as a percentage that the rainfall should be factored by from the ARR Data Hub.

Table 6-1 ARR Data Hub recommended Climate Change Data

Year	RCP 4.5		RCP 8.5	
	Temperature Increase (°C)	Rainfall Increase	Temperature Increase (°C)	Rainfall Increase
2050	1.081	***5.40%***	1.446	***7.30%***
2090	1.496	***7.60%***	3.09	***16.30%***

6.3.2 Climate Change Scenarios

Based on the above considerations, it was decided to run both the rainfall increase with no sea level rise as well as running rainfall increase in combination with the expected corresponding sea level rise for two future scenarios – 2050 and 2090. Both RCP 4.5 and RCP 8.5 rainfall increase has been run for each future scenario for both the 5% AEP and 1% AEP events.

6.4 Wind Wave Setup Assessment

Design event flood levels calculated from hydraulic modelling represent the design 'still' water level in the St Georges Basin. However, the design event flood level applicable around the St Georges Basin foreshore may include the basin 'still' water level and the effect of waves created by wind forces acting across the surface of the Basin.

The size of the waves depends on the length of fetch, depth of water and the speed and duration of wind. Wave runup on the shoreline is influenced by the shore slope and the presence of any structures such as seawalls or revetments. A schematic representation of the wave runup process is shown in **Figure 6-1**.

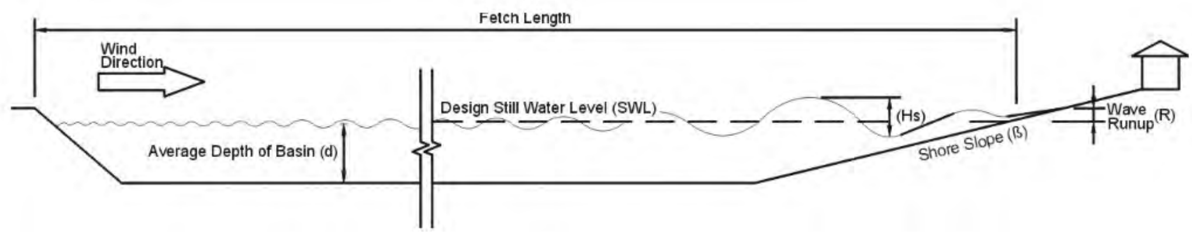


Figure 6-1 Schematic Representation of Wave Runup (WMA, 2001)

Estimated wave heights, wind set-up and indicative wave runup levels have been calculated at three nominated locations around the St Georges Basin foreshore. These sites replicate the locations assessed in the 2001 Flood Study (WMA, 2001) and were considered to represent the worst possible wind frequency/fetch combinations for the existing development areas of Paradise Beach, Island Point and Basin View. Calculations for wave heights, wind set-up and wave run-up are provided in **Appendix K** of the Flood Study.

Results of the assessment are presented in **Section 7.7**.

7 Results and Discussion

During catchment flooding, flows create rising water levels in the tributaries flowing into St Georges Basin as well as Badgee Lagoon/Sussex Inlet. Basin levels begin to rise when the rate of inflow to the Basin is greater than the outflow to the ocean via the Sussex Inlet channel. Outflows from the Basin are controlled by the capacity of the Sussex Inlet channel and then overtop the southern bank of the Basin when levels continue to rise. Flows and flooding in the Sussex Inlet area are driven by the Basin volume, however, there is also complex interaction with ocean conditions (tide levels, barometric setup, waves and entrance conditions) as well as local catchment inflows from Badgee Lagoon which can all compound the flood levels when experienced at the same time. The majority of flooding in the catchment is experienced in Sussex Inlet and around the St Georges Basin foreshore areas.

For short intense storm events, flooding is typically limited to overland flow in urban areas and tributary flooding with only small increases in Basin water levels as the total rainfall volume is insufficient to fill the Basin. Peak Basin levels are experienced during long, steady rainfall events typically occurring over days, where the large rainfall and runoff volume causes elevated Basin levels. Local wind conditions can also affect Basin water levels by generating waves and setup across the fetch of the Basin.

The following sections describe the flood modelling results and processing of results for determining various flood behaviour parameters. Flood maps for the 20%, 10%, 5%, 2%, 1%, 0.2% AEP and PMF design flood events showing peak flood depths, peak flood levels and contours, velocities, hazard and hydraulic categories are provided in **Appendix G** of the Flood Study.

7.1 Summary of Results

Flood levels for the full range of design events corresponding to the key locations in **Figure 7-1** are presented in **Table 7-1**. Flood depth maps for the range of design events are shown in **Figure G01** to **G07** and flood level maps for the 1% AEP and the PMF event are shown in **Figure G12** and **G14** in **Appendix A**.

Flooding in the catchment largely affects Sussex Inlet and the Sanctuary Point area adjacent to Tomerong Creek with flooding of only a small number of properties in the 20% AEP. For events up to the 5% AEP, flows are largely contained within the channel banks of the Sussex Inlet and St Georges Basin tributaries, including Wandandian Creek and Tomerong Creek. However, flood extents change dramatically when flow is out of bank in the 2% AEP event and rarer events, affecting low-lying foreshore areas around St Georges Basin. The PMF affects large areas of the St Georges Basin floodplain as well as the tributaries and overland flow areas.

Flow velocities in the 1% AEP event are generally about 2 m/s within the main channel of the tributaries and about 0.8 m/s over the bank, while velocities are around 1 m/s within the Sussex Inlet channel. Low flow velocities are observed within St Georges Basin due to the water depths. Overland flow velocities across the Study Area are generally limited to less than 1 m/s.

Flow velocities in the Probable Maximum Flood generally vary from 4 to 6 m/s along the tributaries and the Sussex Inlet channel. Flow velocities within tributaries generally vary from 1 to 4 m/s. Most overland flow velocities are expected to be limited to less than 1.5 m/s, with a few localised roadway flows that exceed 3.5 m/s.

7.2 Sea Level Rise

Sea Level Rise predominantly affects Sussex Inlet and the low lying areas around the Basin foreshore. There are no impacts as a result of Seal Level Rise to flood levels in Wandandian Creek beyond the Princes Highway or Tomerong Creek beyond the Wool Road.

NSW Projected 2100 Sea Level Rise (NSW +0.90m) does have slightly more impacts in the Basin (~30mm) and some impacts beyond the Princes Highway and Wool Road.

For Projected 2050 scenario including 0.23m Sea Level Rise and Projected 2100 scenario including 0.36m Sea Level Rise, flood extent maps showing peak flood depths and peak flood levels with contours are provided in **Appendix G** of the Flood Study.

Water level differences compared with existing (no sea level rise) are shown in **Table 7-2** and presented in **Appendix G** of the Flood Study.

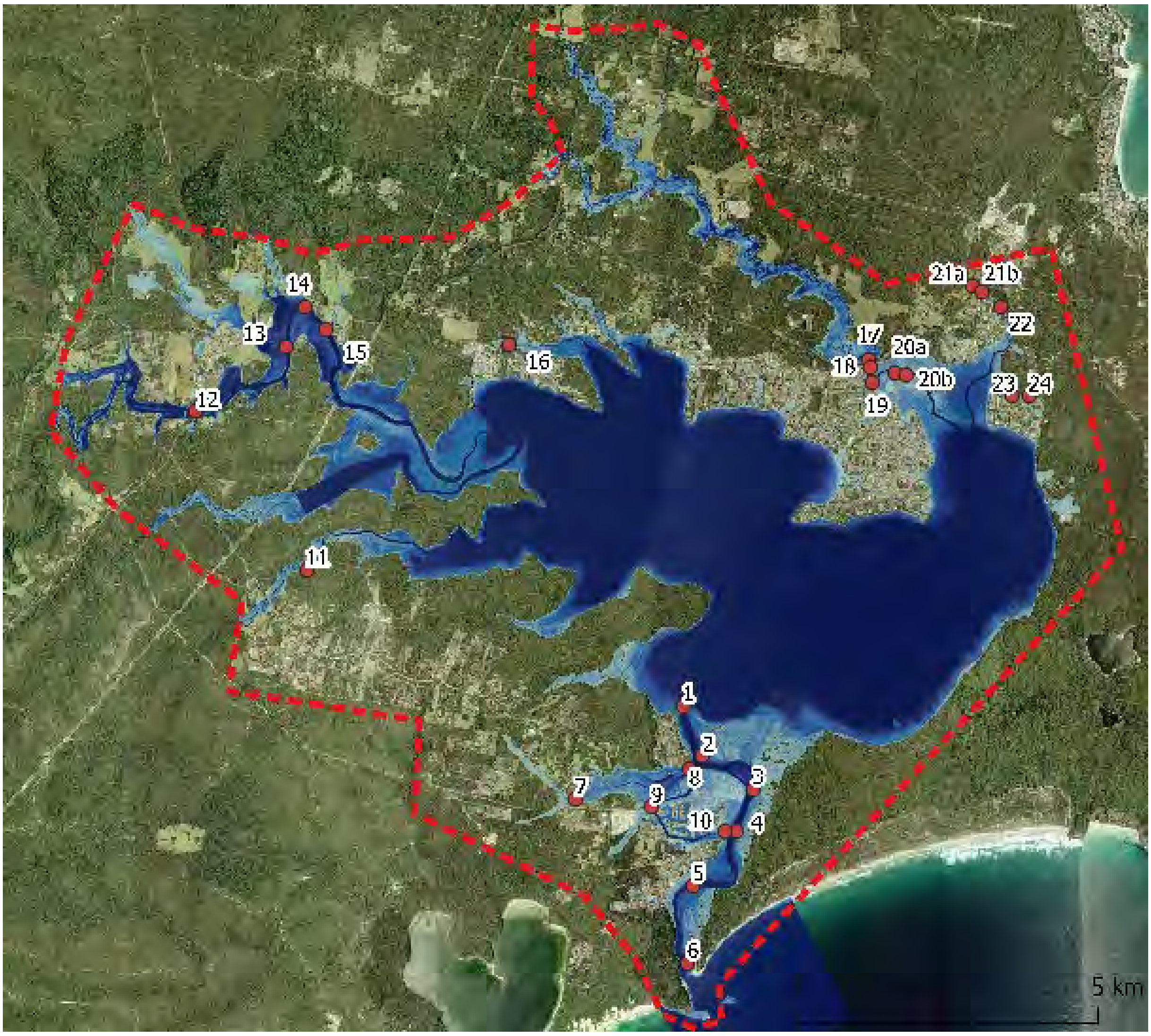


Figure 7-1 Key Locations for Results

Table 7-1 Peak flood level at reference locations for design events – Existing Scenario

ID	Location	Creek	Water Level (mAHD)						
			20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP	PMF
1	Basin	Inlet	1.08	1.30	1.60	2.12	2.30	2.84	5.60
2	Badgee Lagoon Jtn	Inlet	1.07	1.26	1.54	2.08	2.26	2.80	5.55
3	Jacobs Drive	Inlet	1.07	1.24	1.50	2.05	2.23	2.76	5.52
4	Cater Canal	Inlet	1.07	1.22	1.46	2.03	2.19	2.70	5.40
5	Coastal Patrol	Inlet	1.06	1.17	1.35	2.00	2.11	2.53	4.95
6	The Haven	Inlet	1.05	1.08	1.15	1.94	1.99	2.23	3.89
7	D/s Sussex Inlet Rd Bridge	Badgee	2.21	2.35	2.45	2.61	2.82	2.90	5.53
8	U/s Badgee Bridge	Badgee	1.07	1.26	1.53	2.08	2.26	2.79	5.55
9	Jacobs Dr Bridge	Cater	1.07	1.24	1.49	2.05	2.23	2.77	5.53
10	U/s Cater Bridge	Cater	1.07	1.22	1.46	2.03	2.19	2.71	5.43
11	1 km D/s Sussex Inlet Rd	Cow	4.07	4.16	4.26	4.38	4.50	4.76	5.99
12	200 m D/s Princes Highway	Wandandian	6.08	6.33	6.65	7.03	7.32	8.36	11.61
13	Sawmill U/s	Wandandian	3.46	3.75	4.10	4.62	4.82	5.93	9.01
14	Sawmill D/s	Wandandian	3.26	3.58	3.95	4.50	4.71	5.84	8.92
15	Bewong	Wandandian	2.92	3.23	3.59	4.16	4.35	5.50	8.41
16	Wool Rd	Pats	3.90	3.93	3.95	3.98	4.04	4.05	5.60
17	U/s Wool Rd	Home	3.22	3.32	3.53	3.71	3.89	4.44	5.80
18	Wool Rd	Tomerong	2.93	3.01	3.17	3.32	3.44	3.83	5.64
19	Boronia Ave	Tomerong	2.51	2.60	2.75	2.92	3.02	3.39	5.62
20a	U/s Larmer Ave	Tomerong	1.38	1.66	1.97	2.29	2.34	2.87	5.61
20b	D/s Larmer Ave	Tomerong	1.24	1.50	1.82	2.13	2.32	2.85	5.61
21a	U/s Wool Rd	Worrowing	7.53	7.60	7.65	7.73	7.85	7.89	8.31
21b	D/s Wool Rd	Worrowing	5.16	5.30	5.41	5.56	5.77	5.84	6.62
22	Fitzpatrick St	Worrowing	2.34	2.51	2.64	2.85	3.11	3.27	5.61
23	Killarney Rd	Erowal	3.91	3.93	3.93	3.99	4.09	4.09	5.60
24	Kallaroo Rd	Erowal	8.60	8.62	8.62	8.64	8.65	8.65	8.68

Refer to Figure 7-1 for reference locations.

Table 7-2 Sea Level Rise – 1% AEP event water level and water level difference

ID	Location	Creek	1% AEP	SCC 2050 (+0.23m)		SCC 2100 (+0.36m)		NSW 2100 (+0.90m)	
			WL (mAHD)	WL (mAHD)	Diff (m)	WL (mAHD)	Diff (m)	WL (mAHD)	Diff (m)
1	Basin	Inlet	2.3	2.38	0.08	2.44	0.14	2.76	0.46
2	Badgee Lagoon Jtn	Inlet	2.26	2.35	0.09	2.41	0.15	2.75	0.49
3	Jacobs Drive	Inlet	2.23	2.32	0.09	2.39	0.16	2.73	0.50
4	Cater Canal	Inlet	2.19	2.3	0.11	2.37	0.18	2.73	0.54
5	Coastal Patrol	Inlet	2.11	2.25	0.14	2.34	0.23	2.74	0.63
6	The Haven	Inlet	1.99	2.18	0.19	2.3	0.31	2.76	0.77
7	D/s Sussex Inlet Rd Bridge	Badgee	2.82	2.82	0.00	2.82	0.00	2.82	0.00
8	U/s Badgee Bridge	Badgee	2.26	2.35	0.09	2.4	0.14	2.74	0.48
9	Jacobs Dr Bridge	Cater	2.23	2.32	0.09	2.39	0.16	2.74	0.51
10	U/s Cater Bridge	Cater	2.19	2.3	0.11	2.37	0.18	2.73	0.54
11	1 km D/s Sussex Inlet Rd	Cow	4.5	4.5	0.00	4.5	0.00	4.50	0.00
12	200 m D/s Princes Highway	Wandandian	7.32	7.32	0.00	7.32	0.00	7.32	0.00
13	Sawmill U/s	Wandandian	4.82	4.82	0.00	4.82	0.00	4.82	0.00
14	Sawmill D/s	Wandandian	4.71	4.71	0.00	4.71	0.00	4.71	0.00
15	Bewong	Wandandian	4.35	4.35	0.00	4.35	0.00	4.35	0.00
16	Wool Rd	Pats	4.04	4.04	0.00	4.04	0.00	4.04	0.00
17	U/s Wool Rd	Home	3.89	3.89	0.00	3.89	0.00	3.89	0.00
18	Wool Rd	Tomerong	3.44	3.44	0.00	3.44	0.00	3.44	0.00
19	Boronia Ave	Tomerong	3.02	3.02	0.00	3.02	0.00	3.02	0.00
20a	U/s Larmer Ave	Tomerong	2.34	2.41	0.07	2.46	0.12	2.77	0.43
20b	D/s Larmer Ave	Tomerong	2.32	2.4	0.08	2.45	0.13	2.77	0.45
21a	U/s Wool Rd	Worrowing	7.85	7.85	0.00	7.85	0.00	7.85	0.00
21b	D/s Wool Rd	Worrowing	5.77	5.77	0.00	5.77	0.00	5.77	0.00
22	Fitzpatrick St	Worrowing	3.11	3.11	0.00	3.11	0.00	3.11	0.00
23	Killarney Rd	Erowal	4.09	4.09	0.00	4.09	0.00	4.09	0.00
24	Kallaroo Rd	Erowal	8.65	8.65	0.00	8.65	0.00	8.65	0.00

Refer to Figure 7-1 for reference locations.

7.3 Comparison with Previous Flood Study Results

The comparison to the previous 2001 St Georges Basin Flood Study (WMA, 2001) results are presented in **Table 7-3** for the 1% AEP event.

It is noted that water levels are similar to the previous flood study results. It is observed that:

> Water level differences are within +/-50mm in Sussex Inlet and in the Basin;

> Water levels are generally 60 to 200mm higher than the previous flood study in Wandandian Creek; and

> Water level differences are generally within 0 to 40mm in Tomerong Creek.

Locations with greater differences (Sites 7, 11, 12, 17, 22 and 24) can be explained due to the current study using more recent bridge/culvert structure survey and terrain data which may be more accurate in those areas. Further, the use of a 2-dimensional model grid means that all flowpaths follow the terrain and are not assumed or depth averaged across a cross-section as is the case with the previous flood study 1D model.

Table 7-3 Comparison to previous flood study – 1% AEP water level difference

ID	Location	Creek	Previous Flood Study 1% AEP	Current Study 1% AEP	
			WL (mAHD)	WL (mAHD)	Diff (m)
1	Basin	Inlet	2.35	2.30	-0.05
2	Badgee Lagoon Jtn	Inlet	2.30	2.26	-0.04
3	Jacobs Drive	Inlet	2.26	2.23	-0.03
4	Cater Canal	Inlet	2.18	2.19	0.01
5	Coastal Patrol	Inlet	2.05	2.11	0.06
6	The Haven	Inlet	1.96	1.99	0.03
7	D/s Sussex Inlet Rd Bridge	Badgee	2.30	2.82	0.52
8	U/s Badgee Bridge	Badgee	2.30	2.26	-0.04
9	Jacobs Dr Bridge	Cater	2.30	2.23	-0.07
10	U/s Cater Bridge	Cater	2.26	2.19	-0.07
11	1 km D/s Sussex Inlet Rd	Cow	3.47	4.50	1.03
12	200 m D/s Princes Highway	Wandandian	6.66	7.32	0.66
13	Sawmill U/s	Wandandian	4.7	4.82	0.12
14	Sawmill D/s	Wandandian	4.5	4.71	0.21
15	Bewong	Wandandian	4.29	4.35	0.06
16	Wool Rd	Pats	4.26	4.04	-0.22
17	U/s Wool Rd	Home	2.54	3.89	1.35
18	Wool Rd	Tomerong	3.44	3.44	0.00
19	Boronia Ave	Tomerong	3.02	3.02	0.00
20a	U/s Larmer Ave	Tomerong	2.36	2.34	-0.02
20b	D/s Larmer Ave	Tomerong	2.36	2.32	-0.04
21a	U/s Wool Rd	Worrowing	7.75	7.85	0.10
21b	D/s Wool Rd	Worrowing	5.66	5.77	0.11
22	Fitzpatrick St	Worrowing	2.56	3.11	0.55
23	Killarney Rd	Erowal	4.06	4.09	0.03
24	Kallaroo Rd	Erowal	7.08	8.65	1.57

Refer to Figure 7-1 for reference locations.

It is also noted that different methodologies are used in these two studies:

> Different hydrology data and methods leads to differences in the design flow estimates,
> Different hydraulic models have been used and updated survey data and
> Different tailwater ocean conditions have been adopted - the current study has adopted lower ocean tidal boundary conditions than the previous study in accordance with DPE guidelines.

As discussed in **Section 4.5**, the current study has been calibrated to historical events and provides a good correlation with historical event stage frequency analysis of Basin water levels.

7.4 Flood Hazard

Hazard categorisation developed by the revised ARR manual Book 6: Flood Hydraulics, Section 7.2.7 (Ball et al. 2019) determines hazard through a relationship developed between the depth and velocity of floodwaters using six categories based on the stability of children, adults, the elderly, vehicles and buildings in floodwaters. The ARR2019 hazard curves are shown in **Figure 7-2**.

Hazard mapping for Design Events, Projected 2050 and Projected 2100 scenarios are provided in **Appendix G** of the Flood Study. Flood hazard categories for the 1% AEP and the PMF event are shown in **Figure G22** and **Figure G24** in **Appendix A**.

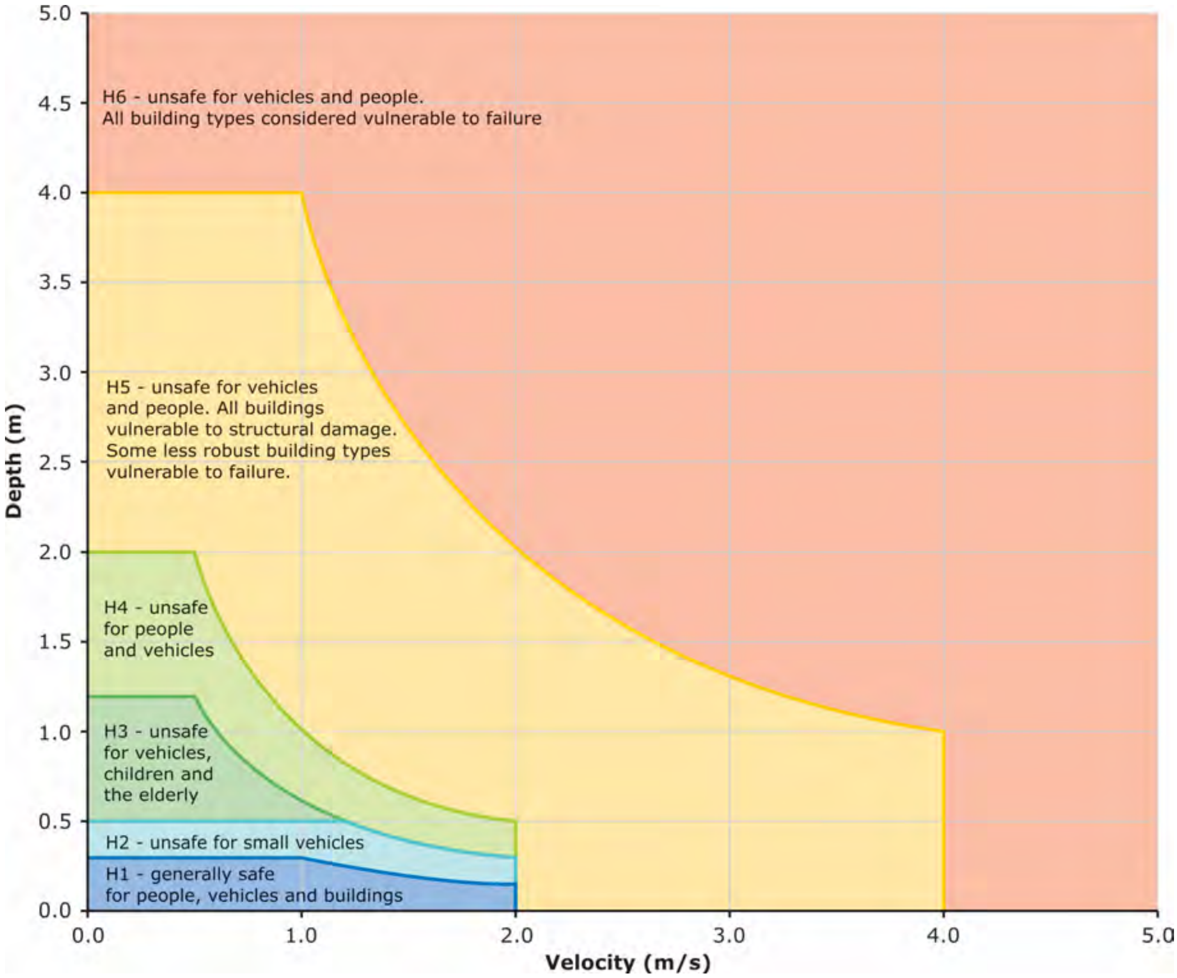


Figure 7-2 Hazard Categories from ARR 2019

Within the St Georges Basin, flood hazard is predominately classed as H6 as a result of the significant depths that occur. The tributaries and Sussex Inlet channel also experience H6 classified hazard due to the high velocities of the concentrated flow. The depths and velocity make flooding hazardous for both pedestrians and vehicles. As a result of the relatively steep banks around the Basin, the fringe of lower hazards is relatively small. That is, the transition from H6 hazard to flood-free occurs very quickly, with little lower hazard flooding occurring in between.

For the tributaries, the hazard mapping shows that 1% AEP H6 hazard areas are largely contained within creek and river systems. Most tributaries are fairly incised, resulting in overbank areas that are classified as H3 hazard or lower. However, H5 hazard is mapped in overbank areas along Wandandian Creek and Tomerong Creek (upstream of Island Point Road).

For most overland flowpaths, a H1 or H2 hazard is expected, and are generally safe for people, larger vehicles and buildings, based on the AR&R hazard categories.

In the PMF, H3 to H6 hazard regions dominate the flood extent, with only the outer flood fringe classed as H1 to H2 hazard. These H5 to H6 hazard regions may impact properties along Wandandian Creek, Tomerong Creek, Tullarwalla Creek, Cow Creek and Worrowing Creek. Other significant areas that are greatly affected by H5 to H6 hazards in the PMF is properties around the basin foreshore, Larmer Avenue near Tomerong Creek, Sussex Inlet area and Sussex Inlet South foreshore areas.

7.5 Climate Change Scenarios

The study also assessed the potential impacts of both Climate Change induced rainfall increases and sea level rise using current recommended ARR2019 values based on global climate modelling. Results of Climate Change scenarios are presented in **Appendix H** of the Flood Study showing water level difference plots compared with the adopted 1% AEP event peak water levels. Difference maps have been derived by subtracting the existing 1% AEP event water surface level from the Climate Change Scenario water surface level.

Peak 1% AEP event water levels for each Climate Change Scenario at reference locations are shown in **Table 7-4** for increased rainfall only and **Table 7-5** for increased rainfall in combination with sea level rise. The tables also show water level difference compared to the adopted 1% AEP peak water levels. Reference locations are shown in **Figure 7-1**.

Increased rainfall due to climate change has the biggest impact in the tributaries as the increased flow in the constrained channel capacity leads to increased water levels. Additional flow volumes from increased rainfall influence Basin levels, while sea level rise impacts the Basin and Sussex Inlet areas.

For the 1% AEP, increased flows due to increased rainfall leads to increases in flood levels in the Basin by up to almost 300mm, and up to 450mm in Wandandian Creek for a 16.3% rainfall increase (2090 RCP 8.5). Increases are generally less than 150mm for all tributaries up to 7.6% rainfall increase (2090 RCP 4.5) with increases typically 150 – 250 mm for the 16.3% rainfall increase.

While for 1% AEP event 2100 projections of increased rainfall (up to 16.3%) and sea level rise (+0.36m) in combination, increases in water level of up to 400mm in the Basin are observed with sea level rise dominating near the entrance (up to 400mm increases). No additional impacts due to sea level rise are expected in the tributaries with increases of typically 150 – 250 mm and up to 450m in Wandandian Creek the result of increased rainfall only.

Table 7-4 Climate Change – 1% AEP Rainfall Increase (Existing sea level) water level difference

ID	Location	1% AEP	CC 2050 RCP4.5		CC 2050 RCP8.5		CC 2090 RCP4.5		CC 2090 RCP8.5	
		WL (mAHD)	WL (mAHD)	Diff (m)	WL (mAHD)	Diff (m)	WL (mAHD)	Diff (m)	WL (mAHD)	Diff (m)
1	Basin	2.30	2.39	0.09	2.43	0.12	2.43	0.13	2.58	0.28
2	Badgee Lagoon Jtn	2.26	2.35	0.09	2.38	0.12	2.39	0.13	2.54	0.27
3	Jacobs Drive	2.23	2.31	0.09	2.35	0.12	2.35	0.12	2.49	0.27
4	Cater Canal	2.19	2.27	0.08	2.30	0.11	2.30	0.11	2.43	0.25
5	Coastal Patrol	2.11	2.17	0.06	2.19	0.08	2.20	0.09	2.30	0.19
6	The Haven	1.99	2.01	0.03	2.02	0.03	2.02	0.04	2.07	0.08
7	D/s Sussex Inlet Rd Bridge	2.68	2.71	0.03	2.72	0.05	2.73	0.05	2.79	0.12
8	U/s Badgee Bridge	2.26	2.35	0.09	2.38	0.12	2.38	0.13	2.53	0.27
9	Jacobs Dr Bridge	2.23	2.31	0.09	2.34	0.12	2.35	0.12	2.49	0.27
10	U/s Cater Bridge	2.19	2.27	0.08	2.30	0.11	2.31	0.11	2.44	0.25
11	1 km D/s Sussex Inlet Rd	4.50	4.54	0.04	4.55	0.05	4.55	0.05	4.61	0.11
12	200 m D/s Princes Highway	7.32	7.47	0.14	7.52	0.19	7.53	0.20	7.76	0.43
13	Sawmill U/s	4.82	4.97	0.15	5.02	0.20	5.03	0.21	5.26	0.44
14	Sawmill D/s	4.71	4.86	0.15	4.91	0.21	4.92	0.21	5.16	0.45
15	Bewong	4.35	4.50	0.15	4.55	0.21	4.56	0.22	4.80	0.45
16	Wool Rd	4.02	4.03	0.01	4.04	0.02	4.04	0.02	4.06	0.04
17	U/s Wool Rd	3.89	3.96	0.07	3.98	0.10	3.99	0.10	4.10	0.22
18	Wool Rd	3.44	3.50	0.05	3.52	0.07	3.52	0.08	3.60	0.16
19	Boronia Ave	3.02	3.07	0.05	3.08	0.07	3.09	0.07	3.16	0.14
20a	U/s Larmer Ave	2.34	2.42	0.09	2.46	0.12	2.46	0.13	2.61	0.27
20b	D/s Larmer Ave	2.32	2.41	0.09	2.45	0.12	2.45	0.13	2.60	0.28
21a	U/s Wool Rd	7.77	7.79	0.02	7.80	0.03	7.80	0.03	7.83	0.07
21b	D/s Wool Rd	5.63	5.67	0.04	5.68	0.05	5.69	0.06	5.75	0.12
22	Fitzpatrick St	2.94	2.99	0.05	3.01	0.07	3.02	0.08	3.10	0.16
23	Killarney Rd	4.09	4.11	0.03	4.12	0.03	4.13	0.04	4.16	0.07
24	Kallaroo Rd	8.65	8.66	0.00	8.66	0.00	8.66	0.00	8.66	0.01

Refer to Figure 7-1 for reference locations.

Table 7-5 Climate Change – 1% AEP Rainfall Increase + SLR water level difference

ID	Location	1% AEP	CC 2050 RCP4.5 + SLR2050 (SCC)		CC 2050 RCP8.5 + SLR2050 (SCC)		CC 2090 RCP4.5 + SLR 2100 (SCC)		CC 2090 RCP8.5 + SLR 2100 (SCC)	
		WL (mAHD)	WL (mAHD)	Diff (m)	WL (mAHD)	Diff (m)	WL (mAHD)	Diff (m)	WL (mAHD)	Diff (m)
1	Basin	2.30	2.47	0.17	2.50	0.20	2.55	0.25	2.68	0.38
2	Badgee Lagoon Jtn	2.26	2.43	0.17	2.46	0.20	2.52	0.26	2.65	0.38
3	Jacobs Drive	2.23	2.40	0.18	2.43	0.20	2.49	0.26	2.62	0.39
4	Cater Canal	2.19	2.37	0.18	2.39	0.21	2.46	0.27	2.57	0.39
5	Coastal Patrol	2.11	2.30	0.19	2.32	0.21	2.40	0.30	2.49	0.38
6	The Haven	1.99	2.20	0.22	2.21	0.22	2.32	0.34	2.36	0.37
7	D/s Sussex Inlet Rd Bridge	2.68	2.71	0.03	2.72	0.05	2.73	0.05	2.79	0.12
8	U/s Badgee Bridge	2.26	2.43	0.17	2.46	0.20	2.51	0.26	2.64	0.38
9	Jacobs Dr Bridge	2.23	2.40	0.18	2.43	0.21	2.49	0.26	2.62	0.39
10	U/s Cater Bridge	2.19	2.37	0.18	2.40	0.21	2.46	0.27	2.58	0.39
11	1 km D/s Sussex Inlet Rd	4.50	4.54	0.04	4.55	0.05	4.55	0.05	4.61	0.11
12	200 m D/s Princes Highway	7.32	7.47	0.14	7.52	0.19	7.53	0.20	7.76	0.43
13	Sawmill U/s	4.82	4.97	0.15	5.02	0.20	5.03	0.21	5.26	0.44
14	Sawmill D/s	4.71	4.86	0.15	4.91	0.21	4.92	0.22	5.16	0.45
15	Bewong	4.35	4.50	0.15	4.55	0.21	4.56	0.22	4.80	0.45
16	Wool Rd	4.02	4.03	0.01	4.04	0.02	4.04	0.02	4.06	0.04
17	U/s Wool Rd	3.89	3.96	0.07	3.98	0.10	3.99	0.10	4.10	0.22
18	Wool Rd	3.44	3.50	0.05	3.52	0.07	3.52	0.08	3.60	0.16
19	Boronia Ave	3.02	3.07	0.05	3.09	0.07	3.09	0.07	3.16	0.14
20a	U/s Larmer Ave	2.34	2.49	0.16	2.52	0.19	2.57	0.24	2.70	0.37
20b	D/s Larmer Ave	2.32	2.48	0.16	2.52	0.19	2.56	0.24	2.70	0.37
21a	U/s Wool Rd	7.77	7.79	0.02	7.80	0.03	7.80	0.03	7.83	0.07
21b	D/s Wool Rd	5.63	5.67	0.04	5.68	0.05	5.69	0.06	5.75	0.12
22	Fitzpatrick St	2.94	2.99	0.05	3.01	0.07	3.02	0.08	3.10	0.16
23	Killarney Rd	4.09	4.11	0.03	4.12	0.03	4.13	0.04	4.16	0.07
24	Kallaroo Rd	8.65	8.66	0.00	8.66	0.00	8.66	0.00	8.66	0.01

Refer to Figure 7-1 for reference locations.

7.6 Validation of design event results

The St Georges Basin has sparse historical observed flood data. The only suitable long term data is the historical water level record in the Basin which has been used to develop a Basin stage frequency analysis from the 1971 event (largest event from 1971 – 2020) and six events that have occurred since 1991 (**Figure 7-3**). This provides a check on flood event estimates up to the 2% AEP event and possibly the 1% AEP event.

To validate the current study ARR2019 design flood event peak basin water levels, a number of design flood event estimates of water levels have been plotted against the Basin stage frequency analysis (**Figure 7-3**) including:

1. Current study ARR2019 Design flood event peak basin water levels (including sensitivity result for 5% AEP event with a 5% ocean tide);
2. Calibration model results versus historical events;
3. 2001 Flood Study Design flood event basin peak water levels (ARR87); and
4. 2013 WMA FRMS&P Climate Change Assessment revised Design flood event basin peak water levels (ARR87) (Revised baseline, no sea level rise).

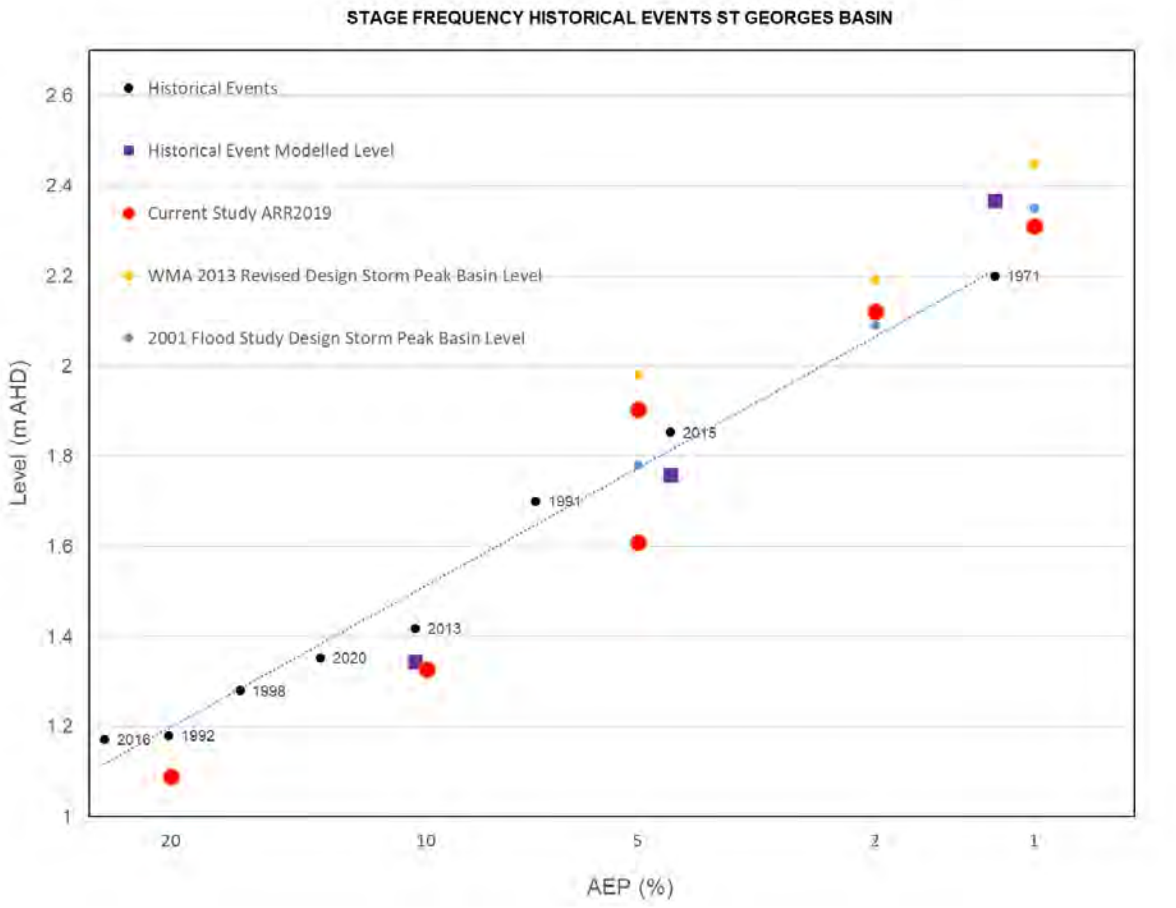


Figure 7-3 Comparison of flood model results with Basin historical event stage frequency analysis

It is noted that the model results reflect the Basin still water level while the historical event records may be affected by wind-wave set-up across the Basin.

The following comments are made regarding the validation:

- The current study ARR2019 modelled water levels follow the same trend as the frequency analysis;
- The 20%, 10% and 5% AEP events are approximately 100mm below expected levels. Similarly for the historical calibration events model results being approximately 50-100mm below recorded levels. This could be explained by a small amount of wind wave set up across the basin at the gauge location;
- The current study ARR2019 results for the 1% and 2% AEP are marginally higher than expected from the frequency analysis;
- The results compare well with the previous 2001 and 2013 flood study results, noting the 2013 results are somewhat higher than suggested by the frequency analysis which is mainly due to the adopted ocean tailwater level; and
- The 5% AEP event results show the effect on basin level adopting a HHWSS tide as per DPE guidelines (lower orange dot) and using a 5% AEP ocean tide (upper orange dot). All previous studies have adopted a higher tailwater level of 1.8m – 2.0m AHD for the 5% AEP, which dominates the basin level.

Results of the current study are therefore consistent with expected results and similar to previous study results, albeit slightly lower which is likely attributable to some wind wave setup across the basin and the adopted ocean tide level. The model is well calibrated to historical events despite the paucity of rainfall and flow data across the catchment.

7.7 Wind Wave Climate

The results for the estimated wave heights, wind set-up and indicative wave runup levels at the three nominated locations within St Georges Basin (described in **Section 6.4**) are shown in **Table 7-6**. Site locations and calculations are shown in **Appendix K** of the Flood Study.

Table 7-6 Calculated wave runup around the Basin foreshore

		Site 1 - Paradise Beach	Site 2 - Island Point	Site 3 - Basin View
Wave Runup	m	0.69	0.42	0.61
Basin Still level	mAHD	2.30	2.30	2.30
Design Basin level	mAHD	3.00	2.75	2.90

Wind setup may be expected to add 50 – 100mm to the basin levels and, while wave runup is site specific dependent on local shoreline slope and structures, indicative calculations show that wave runup between 0.4m to 0.7m may be expected at sites exposed to long wind fetch lengths.

8 Impacts of Flooding on the Community

8.1 Impacts of Flooding

The community within the St Georges Basin catchment is susceptible to flooding, most notably in Sussex Inlet and Sanctuary Point near Tomerong Creek as well as properties around Worrowing waterway and Old Erowal Bay. Properties around the Basin foreshore are typically only impacted in rare events larger than the 1% AEP event. Numbers and types of properties affected and associated damages are presented in **Section 8.3.2**.

Table 8-1 summarises the number of affected properties in areas within the St Georges Basin Catchment. The number of buildings with predicted overfloor flooding for each design flood event has been calculated based on a database of actual surveyed floor levels which has been supplemented with some assumed floor levels based on building type for buildings where the actual floor level was unknown at the time of this Flood Study preparation. The number of buildings with predicted overfloor flooding for each design flood event can be updated as part of the Floodplain Risk Management Study & Plan following the completion of additional floor level survey.

Table 8-1 Flood affected properties by location

Event	20% AEP		10% AEP		5% AEP		2% AEP		1% AEP		0.2% AEP		PMF	
Location	B	Y	B	Y	B	Y	B	Y	B	Y	B	Y	B	Y
Sussex Inlet	2	538	6	627	28	756	200	1025	336	1051	627	1089	1212	1280
Sanctuary Point	13	360	19	411	52	473	92	519	110	539	190	572	627	758
Basin View	0	21	0	21	0	27	0	36	0	38	6	47	42	69
St Georges Basin	2	152	3	159	4	164	5	185	9	187	15	192	149	217
Bewong And Wandandian	0	16	0	18	0	19	1	21	1	23	3	27	42	44
Worrowing Heights & Erowal	1	103	1	120	5	147	17	161	21	165	46	173	148	210
Jervis Bay Territory	0	1	0	1	0	1	1	2	1	2	2	2	2	2
TOTAL	**18**	**1191**	**29**	**1357**	**89**	**1587**	**316**	**1949**	**478**	**2005**	**889**	**2102**	**2222**	**2580**

B – Buildings with overfloor flooding

Y – Yards with flooding

8.1.2 Sussex Inlet

Flows largely remain within the Sussex Inlet channel for flows up to the 20% AEP event, with some minor flooding of properties along River Road between Thora Street and Gordon Street, but there is no overfloor flooding of properties other than the Sussex Inlet Marine Centre at the end of Jacobs Drive. In a 10% AEP event, six properties are affected by overfloor flooding east of River Road and around Wunda Ave. This number increases to 28 in these areas in a 5% AEP as flood depths increase. Extensive overfloor flooding occurs in the 2% AEP with some 200 properties impacted as the Sussex Inlet channel swells to inundate the areas north of Jacobs Drive and east of Sandpiper Way and along Fairview Crescent. Evacuation would become cut off from these areas as Jacobs Drive and River Road become inundated.

More than 335 properties would have overfloor flooding in the 1% AEP and in rarer events up to the PMF, the vast majority of properties in Sussex Inlet are impacted (more than 1200) with the exception of high ground areas north of Badgee Lagoon and west of Merison Road/Lyons Road.

Some properties in Jervis Bay Territory on the eastern side of Sussex Inlet channel are also identified as being impacted in the 2% AEP event.

8.1.3 Sanctuary Point

Sanctuary Point is an area with existing flood risk and damages in frequent events with 13 properties affected in the 20% AEP event, primarily on The Park Drive adjacent to Tomerong Creek upstream of Larmer Avenue bridge. In this area, water backs up behind the Larmer Avenue bridge, inundating properties and bypassing to the south through properties and via channels either side of the oval. As flood depths increase in rarer events, more properties are impacted with 52 properties having over floor flooding in the 5% AEP event. As Basin levels begin to rise, properties on The Park Drive east of Larmer Avenue also become impacted. In a 1% AEP event some 110 properties will become affected, primarily along The Park Drive and Mountain Street.

In general, properties along the foreshore areas of Sanctuary Point remain unaffected by flooding up to at least the 2% AEP event, with a small number of properties expected to have overfloor flooding in the 2% and 1% AEP events in the Paradise Beach foreshore area along Walmer Avenue south of Paradise Beach Road. Modelling indicates there are isolated properties along local overland flowpaths/tributaries that experience overfloor flooding in a 5% AEP event and greater.

In the PMF event, large numbers of properties along the Basin Foreshore and Tomerong Creek will be affected.

8.1.4 Worrowing Heights, Erowal Bay and Old Erowal Bay

Properties in Old Erowal Bay are affected by flooding from the Worrowing Waterway with five properties with overfloor flooding in the 5% AEP event along Prentice Avenue and McGowen Street. The number of impacted properties increases to approximately 20 in the 2% and 1% AEP events. A small number of properties in Erowal Bay also become impacted in the 2% and 1% AEP events along the foreshore areas and along Erowal Creek. Some 150 properties would be affected in the PMF.

8.1.5 Basin Foreshore areas

The foreshore areas around Basin View, St Georges Basin and Wrights Beach remain largely unaffected by flooding up to at least the 2% AEP event, with a small number of properties expected to have overfloor flooding in the 2% and 1% AEP events. Most properties have floor levels above the 0.2% AEP flood level, however, large numbers of properties along the Basin foreshore will be affected in the PMF event. Properties may also be impacted by wind-wave action locally increasing flood levels.

8.1.6 Wandandian and Bewong

Wandandian and Bewong areas will only be impacted in the PMF event with the exception of one property which will experience flooding above floor level in a 2% AEP event.

8.2 Flood Planning Area

The Flood Planning Level (FPL) is a combination of flood levels and freeboards selected for planning purposes to manage risk to properties susceptible to flood risk to life and damage to property. Freeboard is applied to the selected planning flood to account for uncertainties in flood model accuracy, potential increases due to rainfall increases associated with Climate Change and other factors such as impacts of structure blockage or localised water level differences due to wave action.

The FPL is typically defined as the 1% AEP flood event plus 500mm freeboard for most residential and commercial developments.

The Flood Planning Area (FPA) mapping for this study has been determined by adding 500mm freeboard to the 1% AEP flood level and extending the surface laterally to intersect with the adjacent terrain to define the area within the FPL. The FPA has been determined for current day flood results and with Projected 2050 and Projected 2100 sea level rise and RCP8.5 increase in rainfall.

Draft Flood Planning Areas maps are provided in **Figures I02** and **I03** in **Appendix B**.

In determining appropriate FPLs, consideration may be given to ensuring areas sensitive to sea level rise, blockage and Climate Change impacts are fully considered in the Flood Planning Area.

Various hydrological input parameters have been tested to obtain a good correlation with historical flood event behaviour and validation of Basin water levels estimates against a statistical Frequency Analysis of historical Basin water levels during flood events.

Taking into consideration the different flood processes and to simplify the adoption of different flood planning levels and freeboard in different areas, it is recommended to adopt the 1% AEP 2090 Climate Change scenario (RCP8.5 16.3% rainfall increase and 0.36m Sea Level Rise) as the planning flood with a standard 500mm freeboard as the FPL. Thus, for example, a house with a life span of 70 years would have an FPL based on the flood level estimated to be applicable in about 80 years' time.

It is also worth considering adding additional freeboard to properties positioned along the northern foreshore of the Basin including Basin View, Island Point and Paradise Beach to accommodate wind wave setup across Basin. The St Georges Basin Flood Study (WMA, 2001) mentioned local residents reported that differences in flood levels of up to 0.5m were observed across the Basin in the 1971 historical flood due to the wind stress across the open water body. The current study has estimated indicative wave runup of up to 400mm at Island Point, 600mm at Basin View and 700mm at Paradise Beach. While an additional freeboard is recommended, this should be assessed on a site-specific basis using equations presented in **Appendix K** of the Flood Study, as the wave runup potential is dependent on the local foreshore slope and any structures present.

8.3 Flood Damages

The economic impact of flooding can be defined by what is commonly referred to as flood damages. Flood damages are generally categorised as either tangible (direct and indirect) or intangible damage types; these types are summarised in **Table 8-2**.

Table 8-2 Types of Flood Damages

Type of Flood Damage	Description
Direct	Building contents (internal) Structure (building repair and clean) External items (vehicles, contents of sheds etc.)
Indirect	Clean-up (immediate removal of debris) Financial (loss of revenue, extra expenditure) Opportunity (non-provision of public services)
Intangible	Social – increased levels of insecurity, depression, stress General inconvenience in post-flood stage

The direct damage costs, as indicated in **Table 8-2**, are just one component of the entire cost of a flood event. There are also indirect costs. Together, direct and indirect costs are referred to as tangible costs. In addition to tangible costs, there are intangible costs such as social distress. The flood damage values discussed in this report are the tangible damages and do not include an assessment of the intangible costs which are difficult to calculate in economic terms.

A flood damage assessment for the existing catchment conditions has been completed as part of this study.

The assessment is based on damage curves for residential, commercial and industrial properties that relate the depth of flooding on a property to the likely damage cost within the property.

A floor level database was developed by Council (2021) for all the properties within the PMF flood extent and included data from ground level and floor level survey undertaken by Council in 2001. Where survey data was unavailable, the floor level was estimated based on average building heights relative to ground level for different property types such as whether it is slab on ground, on piers, commercial, industrial etc.

To inform the damages analysis, flood level results for the full range of AEP events were assessed to determine the depth of over-floor flooding and over-ground flooding for each flood affected lot.

8.3.2 Total Damages

Flood damages (for each design event) for each property are calculated by using the damage curves described above. The total damage for a design event is determined by adding all the individual property damages for that event. A summary of the total damage incurred for the St Georges Basin catchment is shown in **Table 8-3.**

8.3.3 Average Annual Damage

Average Annual Damage (AAD) attempts to quantify the flood damage that a floodplain would receive on average each year using a probability approach based on the flood damages calculated for each design event. Based on the analysis described above, the total AAD for the St Georges Basin catchment under existing conditions is **$7,062,670**.

Table 8-3 Flood Damages Assessment Summary

Property Type	Properties with Overfloor Flooding	Average Overfloor Flooding Depth (m)	Maximum Overfloor Flooding Depth (m)	Properties with Overground Flooding	Total Damage ($May 2021)	
PMF						
Residential	2,135	2.23	4.70	2,490	$	396,550,255
Commercial	80	3.04	4.76	83	$	10,661,710
Industrial	7	2.36	3.27	7	$	1,255,295
Total	**2,222**			**2,580**	**$**	**408,467,260**
0.2% AEP						
Residential	818	0.57	1.95	2,018	$	116,356,990
Commercial	67	0.68	2.00	77	$	6,471,375
Industrial	4	0.55	0.91	7	$	336,290
Total	**889**			**2,102**	**$**	**123,164,655**
1% AEP						
Residential	428	0.34	1.41	1922	$	60,250,510
Commercial	49	0.29	1.48	76	$	2,558,975
Industrial	1	0.53	0.53	7	$	97,200
Total	**478**			**2005**	**$**	**62,906,680**
2% AEP						
Residential	286	0.30	1.22	1,867	$	43,584,815
Commercial	29	0.25	1.31	75	$	1,600,610
Industrial	1	0.41	0.41	7	$	86,590
Total	**316**			**1,949**	**$**	**45,272,010**
5% AEP						
Residential	83	0.17	0.71	1,550	$	16,380,375
Commercial	5	0.20	0.75	30	$	281,170
Industrial	1	0.26	0.26	7	$	70,815
Total	**89**			**1,587**	**$**	**16,732,355**
10% AEP						
Residential	27	0.13	0.41	1,327	$	9,095,305
Commercial	1	0.50	0.50	23	$	159,830
Industrial	1	0.10	0.10	7	$	46,630
Total	**29**			**1,537**	**$**	**9,301,770**
20% AEP						
Residential	16	0.13	0.31	1,166	$	6,961,050
Commercial	1	0.33	0.33	18	$	129,205
Industrial	1	0.02	0.02	7	$	26,430
Total	**18**			**1,191**	**$**	**7,116,680**

9 Conclusion

This Flood Study has developed hydrological and hydraulic models that have been successfully calibrated; with a combined calibration/validation to three historical events. Design flood estimates have been validated against a Flood Frequency Analysis of observed annual peak St Georges Basin flood levels to provide confidence in the modelled design event Basin level estimates. As such, the models can be used with confidence in assessing design flood behaviour.

The study uses the current industry standard methods and guidelines in flood estimation using Australian Rainfall and Runoff 2019 and a series of DPE floodplain management guidelines to define flood behaviour in the St Georges Basin area for a range of representative design flood events.

The 1% AEP design flood levels in the current Flood Study are similar to those derived from the previous 2001 flood study modelling that Council has adopted. Differences are explained by the use of updated data and ARR2019 methods in the current study along with differences in model setup and more up-to-date survey and catchment conditions.

The models have been run for the 20%, 10%, 5%, 2%, 1%, 0.2% AEP storms and Probable Maximum Flood (PMF) event for the existing, Projected 2050 and Projected 2100 scenarios and flood levels, depths and velocities mapped. Provisional hazard, hazard, hydraulic categories and combined hazard and hydraulic categories have also been mapped.

Assessment of the impacts of rainfall increases and sea level rise due to climate change was undertaken along with assessment of tidal inundation and sensitivity to various model parameters.

The report also provides guidance on the adoption of Flood Planning Levels and Emergency Response parameters for use in planning and by the NSW SES.

The study will be used by Council and various stakeholders to inform flood planning and emergency management in the Study Area. The outputs of the Flood Study will provide information on current and future flood risk which is important for increasing community awareness and for building resilience.

9.1 Next Stage in Floodplain Risk Management Process

The following steps will be undertaken now that a draft Flood Study has been completed:

- Present to the Floodplain Risk Management Committee;
- Undertake public exhibition and community consultation for the draft Flood Study;
- Complete the Final Flood Study based on feedback from the public exhibition and community consultation phase;
- Undertake flood modification options assessment; and
- Develop Floodplain Risk Management Study and Plan.

The Floodplain Risk Management Study will provide an understanding of potential emergency response, planning and flood modification measures for managing flood risk in the catchment, benefit cost analysis and development of the Floodplain Risk Management Plan.

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APPENDIX

A

KEY FLOOD MAPS

Figure List:

Existing 20% AEP Flood Depth

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary

Flood Depth (m)

- 0.00 to 0.10
- 0.10 to 0.30
- 0.30 to 0.50
- 0.50 to 0.70
- 0.70 to 1.00
- 1.00 to 1.50
- > 1.50

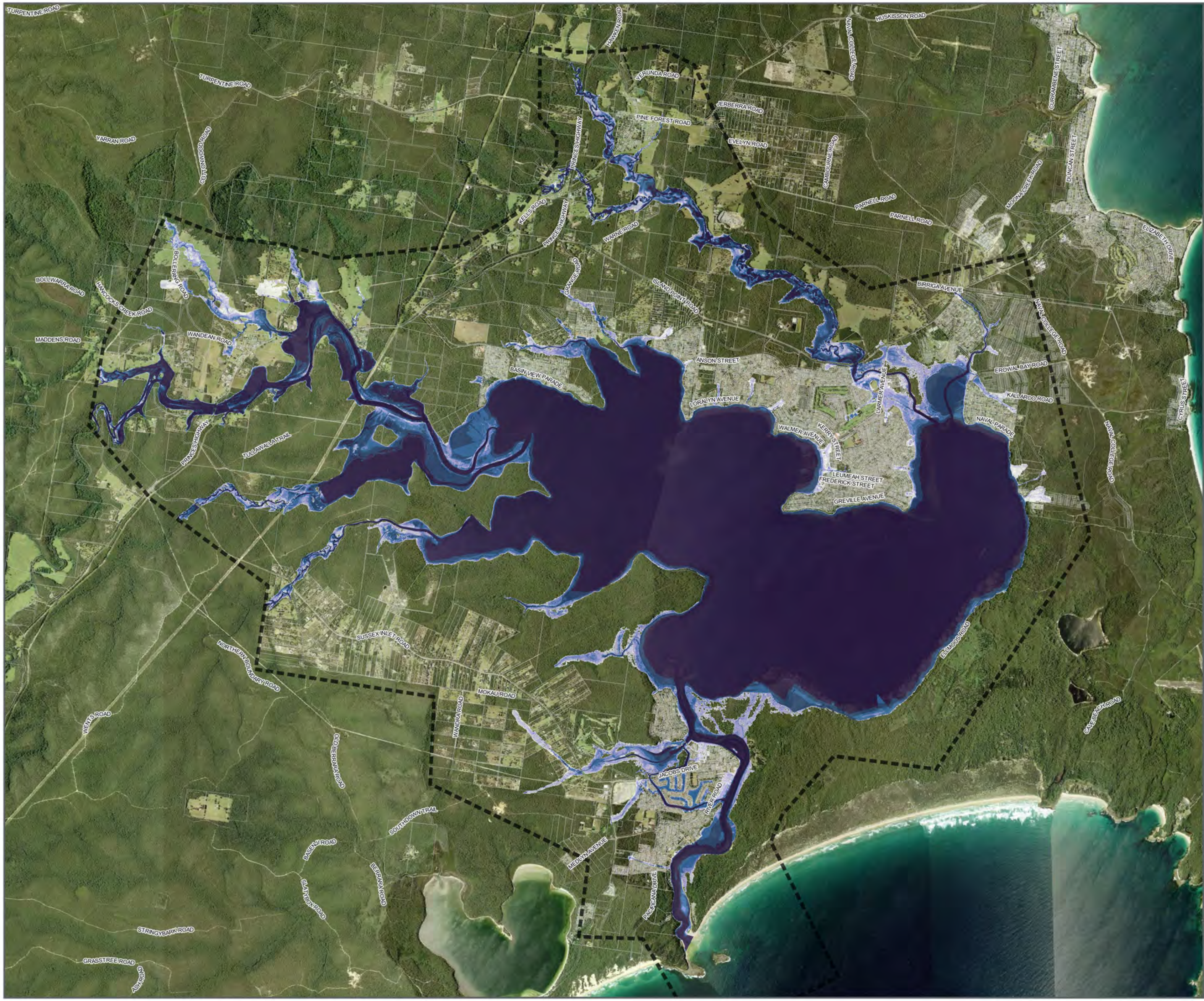
FIGURE G01

1:65,000 Scale at A3

0 700 1,400 2,100 2,800 3,500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Existing 10% AEP Flood Depth

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary

Flood Depth (m)

- 0.00 to 0.10
- 0.10 to 0.30
- 0.30 to 0.50
- 0.50 to 0.70
- 0.70 to 1.00
- 1.00 to 1.50
- > 1.50

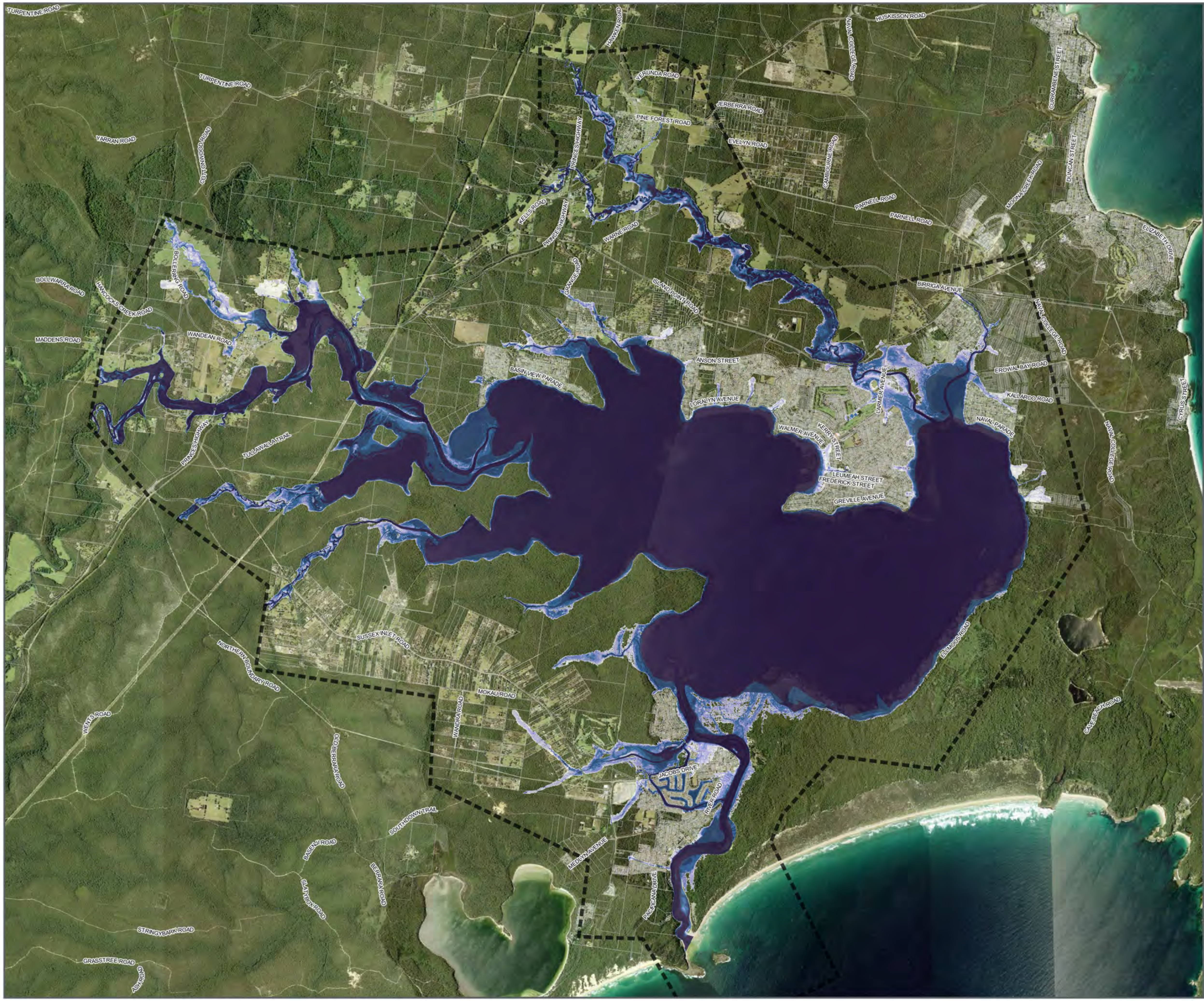
FIGURE G02

1:65,000 Scale at A3

0 700 1,400 2,100 2,800 3,500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Existing 5% AEP Flood Depth

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary

Flood Depth (m)

- 0.00 to 0.10
- 0.10 to 0.30
- 0.30 to 0.50
- 0.50 to 0.70
- 0.70 to 1.00
- 1.00 to 1.50
- > 1.50

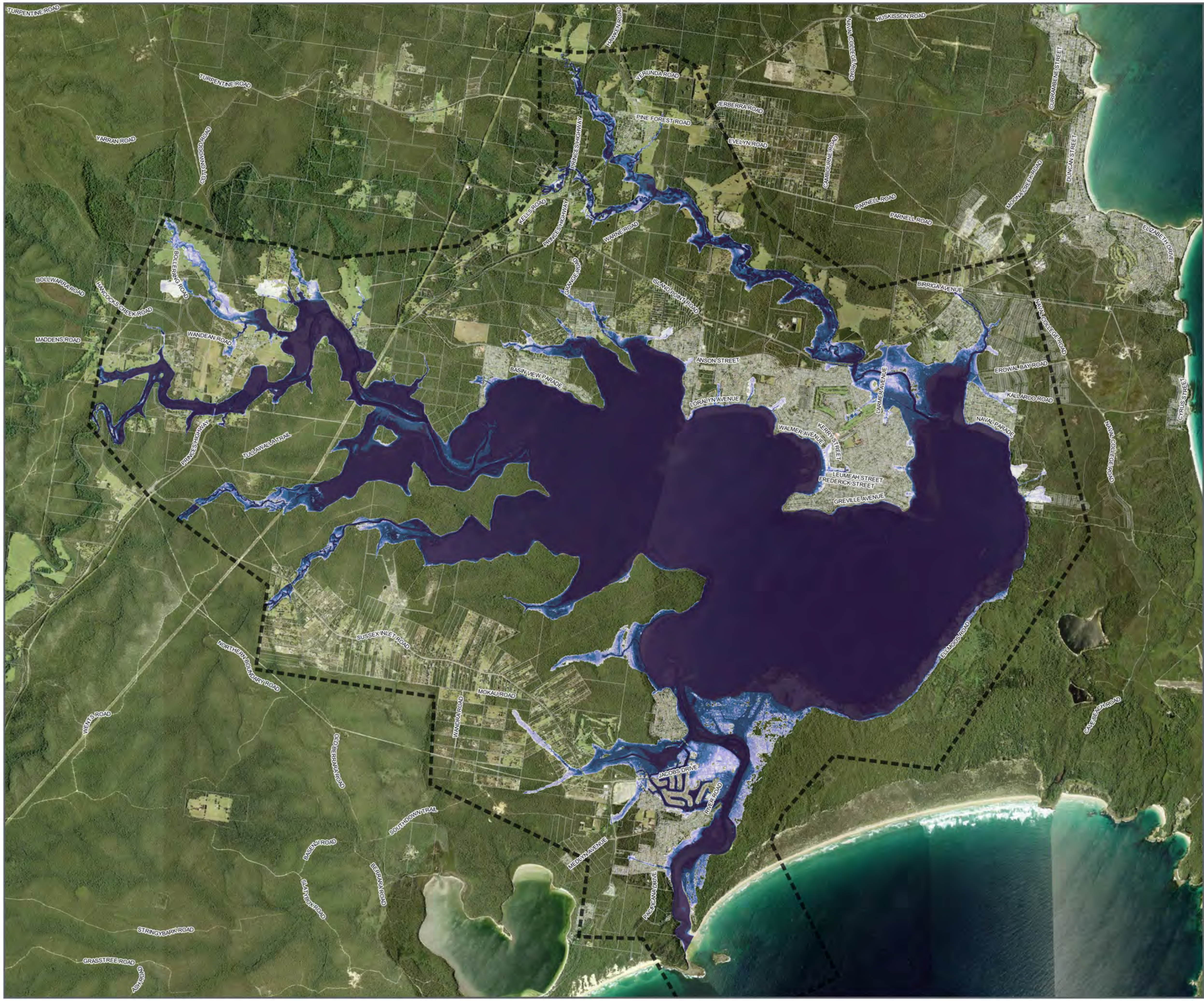
FIGURE G03

1:65,000 Scale at A3

0 700 1,400 2,100 2,800 3,500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Existing 2% AEP Flood Depth

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary

Flood Depth (m)

- 0.00 to 0.10
- 0.10 to 0.30
- 0.30 to 0.50
- 0.50 to 0.70
- 0.70 to 1.00
- 1.00 to 1.50
- > 1.50

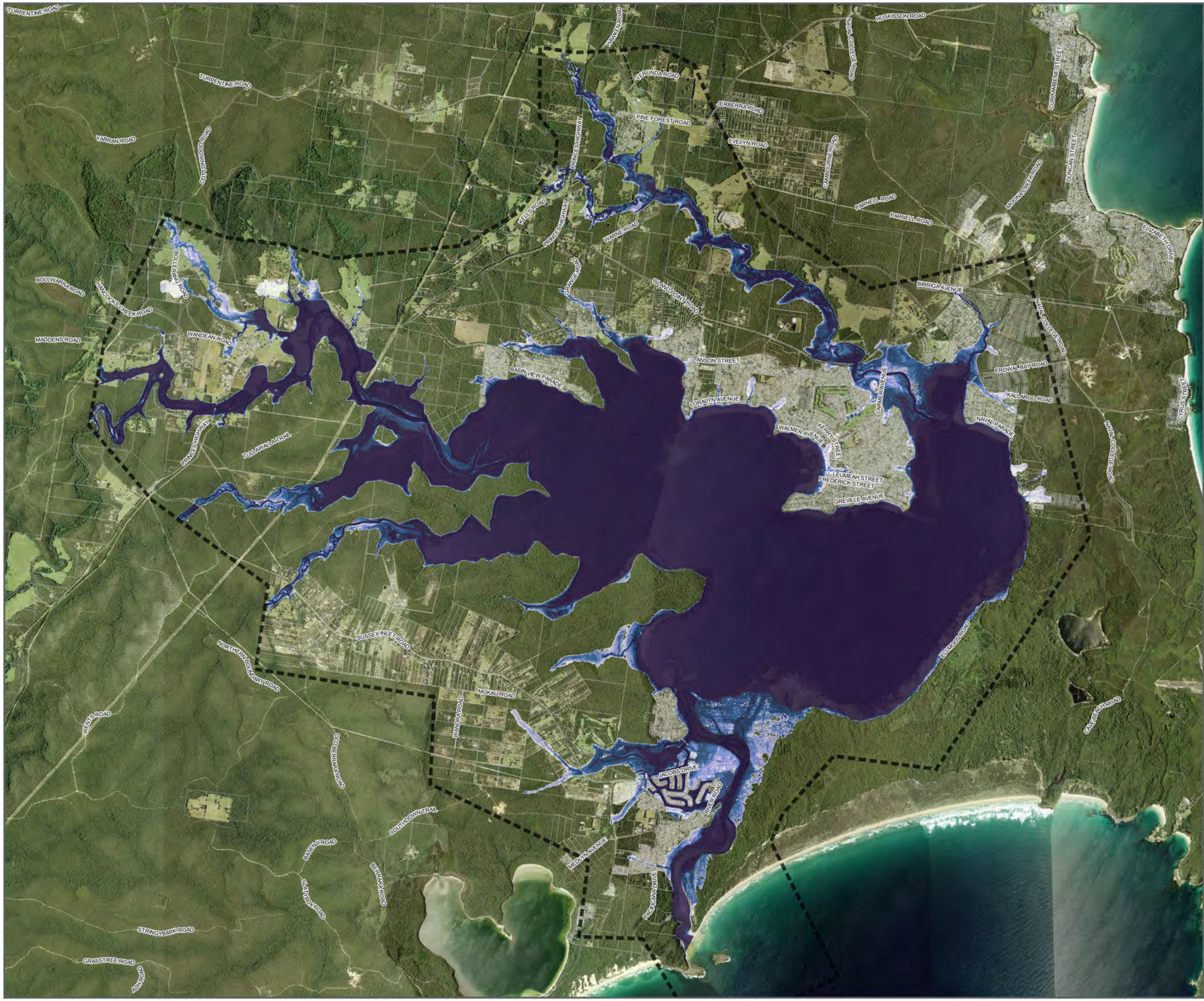
FIGURE G04

1:65,000 Scale at A3

0 700 1,400 2,100 2,800 3,500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Existing 1% AEP Flood Depth

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary

Flood Depth (m)

- 0.00 to 0.10
- 0.10 to 0.30
- 0.30 to 0.50
- 0.50 to 0.70
- 0.70 to 1.00
- 1.00 to 1.50
- > 1.50

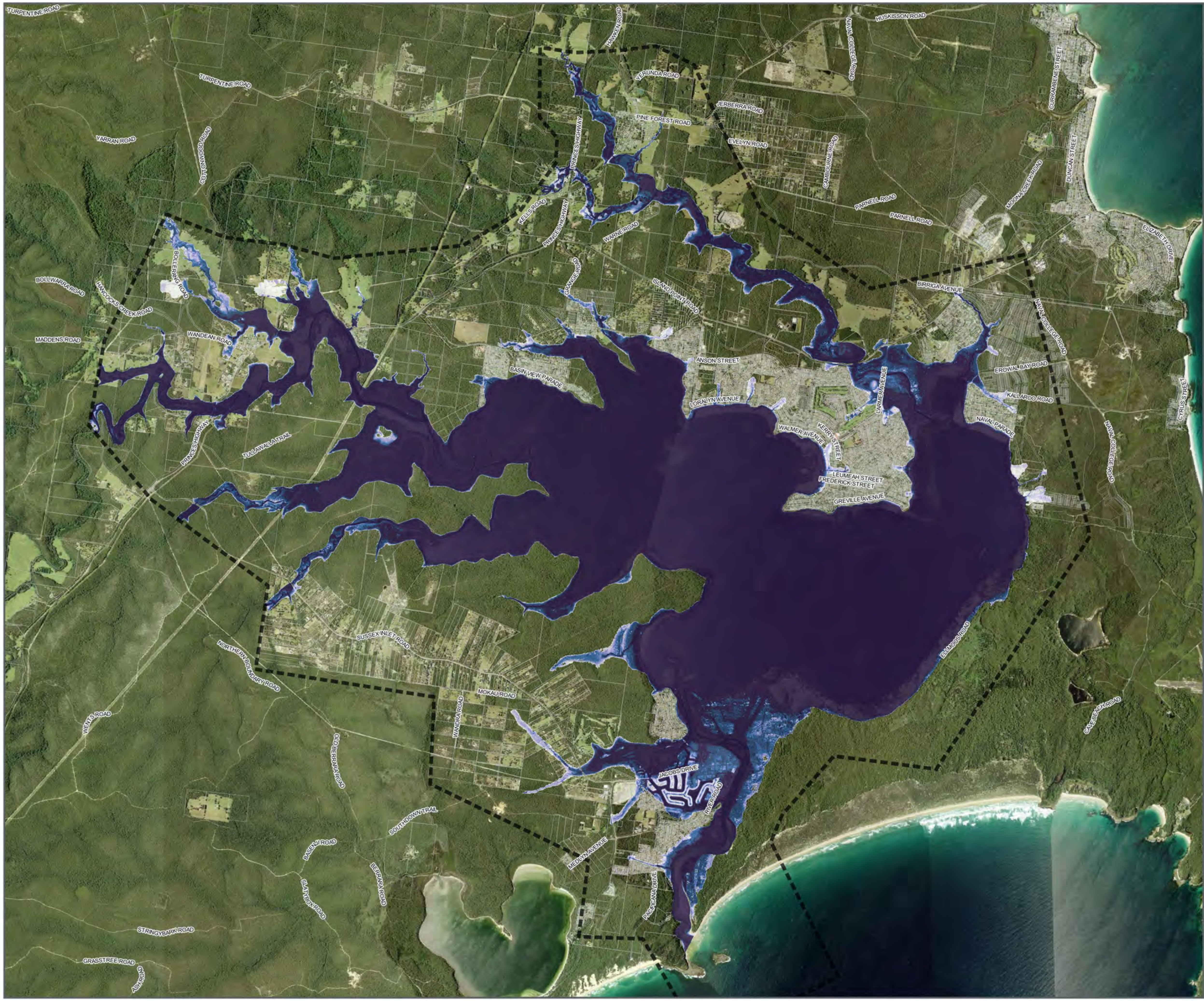
FIGURE G05

1:65,000 Scale at A3

0 700 1,400 2,100 2,800 3,500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Existing 0.2% AEP Flood Depth

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary

Flood Depth (m)

- 0.00 to 0.10
- 0.10 to 0.30
- 0.30 to 0.50
- 0.50 to 0.70
- 0.70 to 1.00
- 1.00 to 1.50
- > 1.50

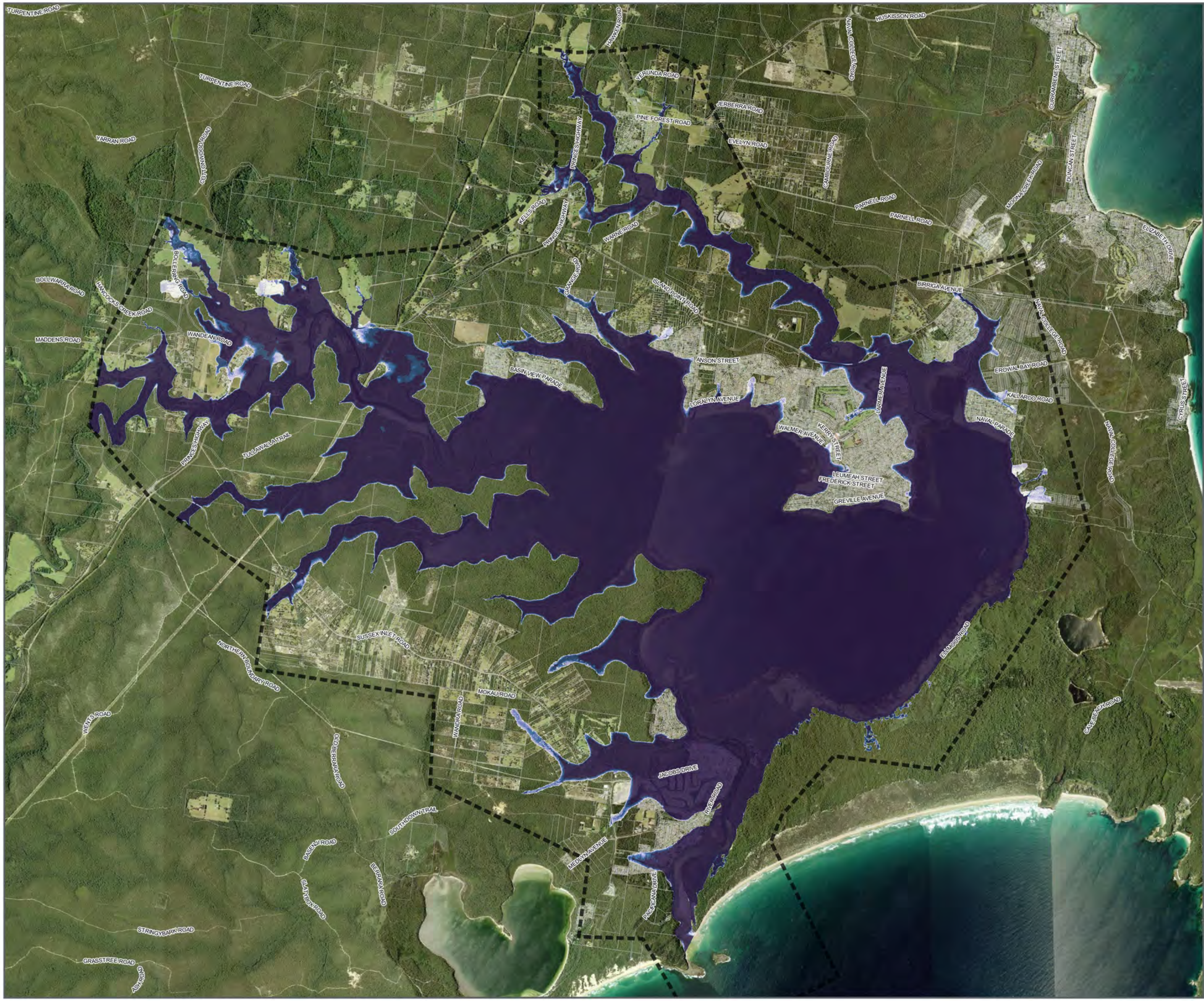
FIGURE G06

1:65,000 Scale at A3

0 700 1,400 2,100 2,800 3,500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Existing PMF Flood Depth

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary

Flood Depth (m)

- 0.00 to 0.10
- 0.10 to 0.30
- 0.30 to 0.50
- 0.50 to 0.70
- 0.70 to 1.00
- 1.00 to 1.50
- > 1.50

FIGURE G07

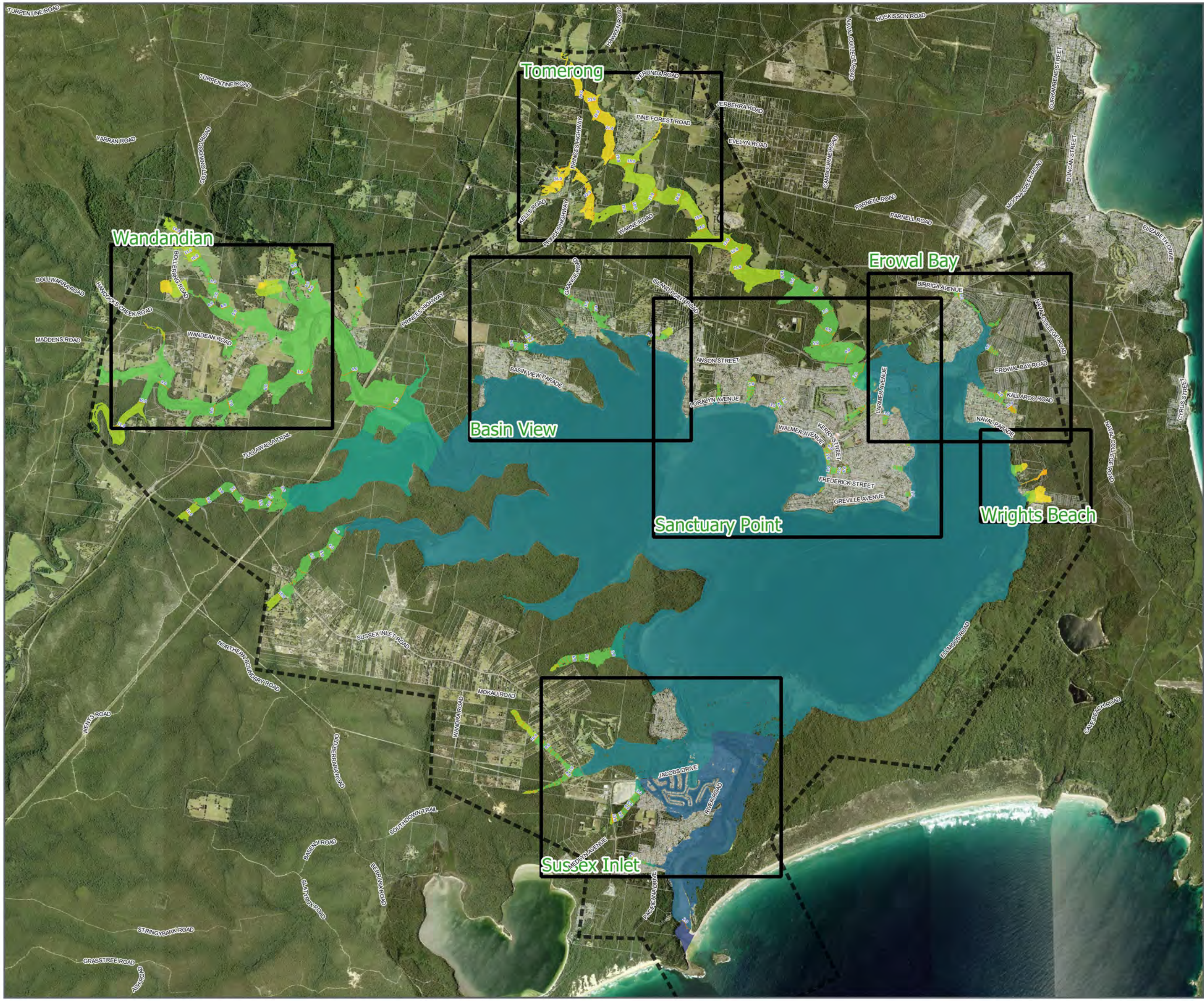
1:65,000 Scale at A3

0 700 1,400 2,100 2,800 3,500 m

N

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Existing 1% AEP Water Level Overview

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Water Level Contours (1.0m)

Water Level (m AHD)

- <= 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3 - 10
- 10 - 20
- > 20

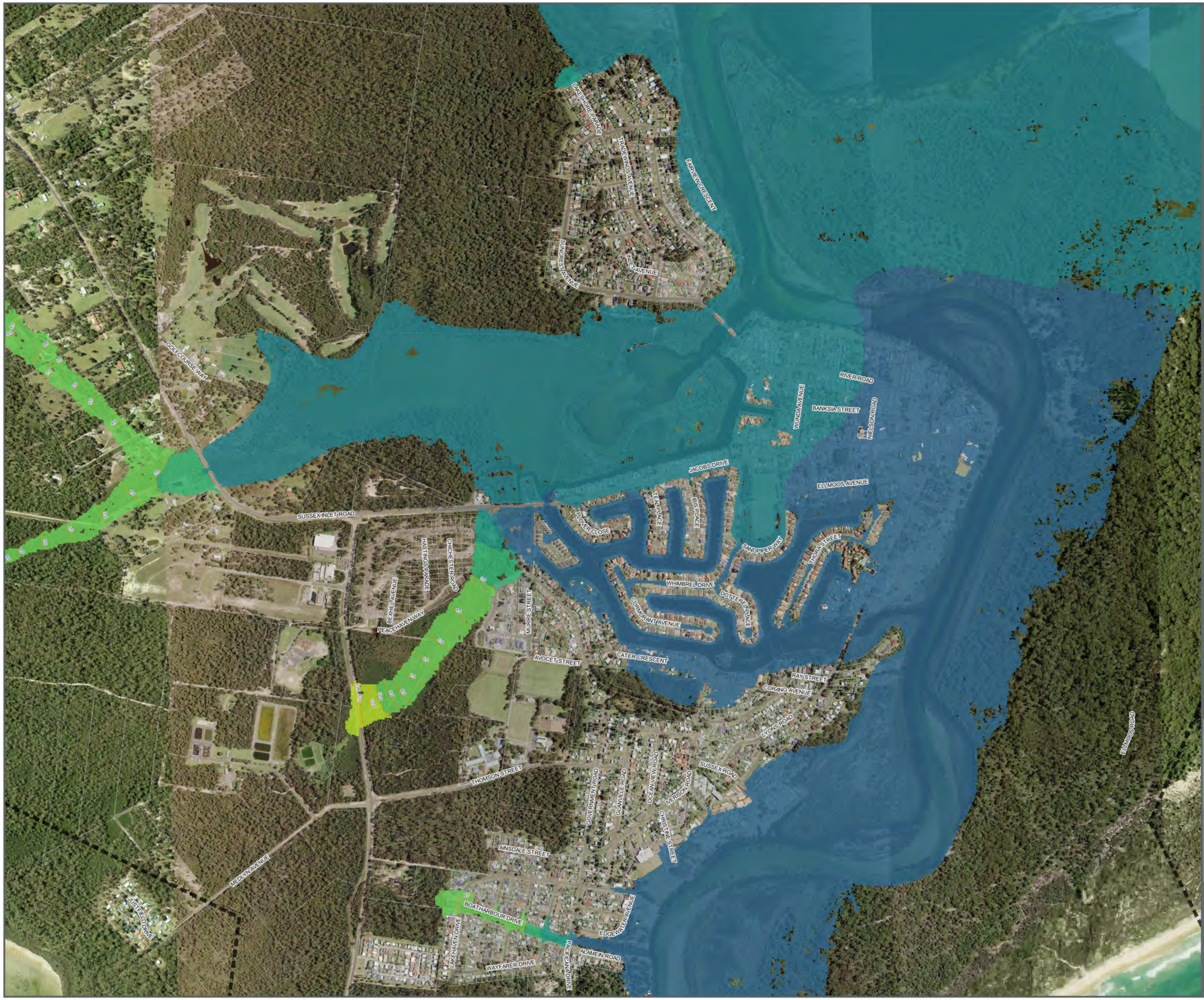
FIGURE G12

1:65,000 Scale at A3

0 700 1,400 2,100 2,800 3,500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Existing 1% AEP Water Level Sussex Inlet

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Water Level Contours (1.0m)

Water Level (m AHD)

- <= 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3 - 10
- 10 - 20
- > 20

FIGURE G12.1

1:13,000 Scale at A3

0 100 200 300 400 500 m

N

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz

Existing 1% AEP Water Level Basin View

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Water Level Contours (1.0m)

Water Level (m AHD)

- <= 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3 - 10
- 10 - 20
- > 20

FIGURE G12.2

1:12,000 Scale at A3

0 100 200 300 400 500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz

Existing 1% AEP Water Level Sanctuary Point

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Water Level Contours (1.0m)

Water Level (m AHD)

- <= 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3 - 10
- 10 - 20
- > 20

FIGURE G12.3

1:15,600 Scale at A3

0 100 200 300 400 500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz

Existing
1% AEP Water Level
Erowal Bay

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Water Level Contours (1.0m)

Water Level (m AHD)

- <= 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3 - 10
- 10 - 20
- > 20

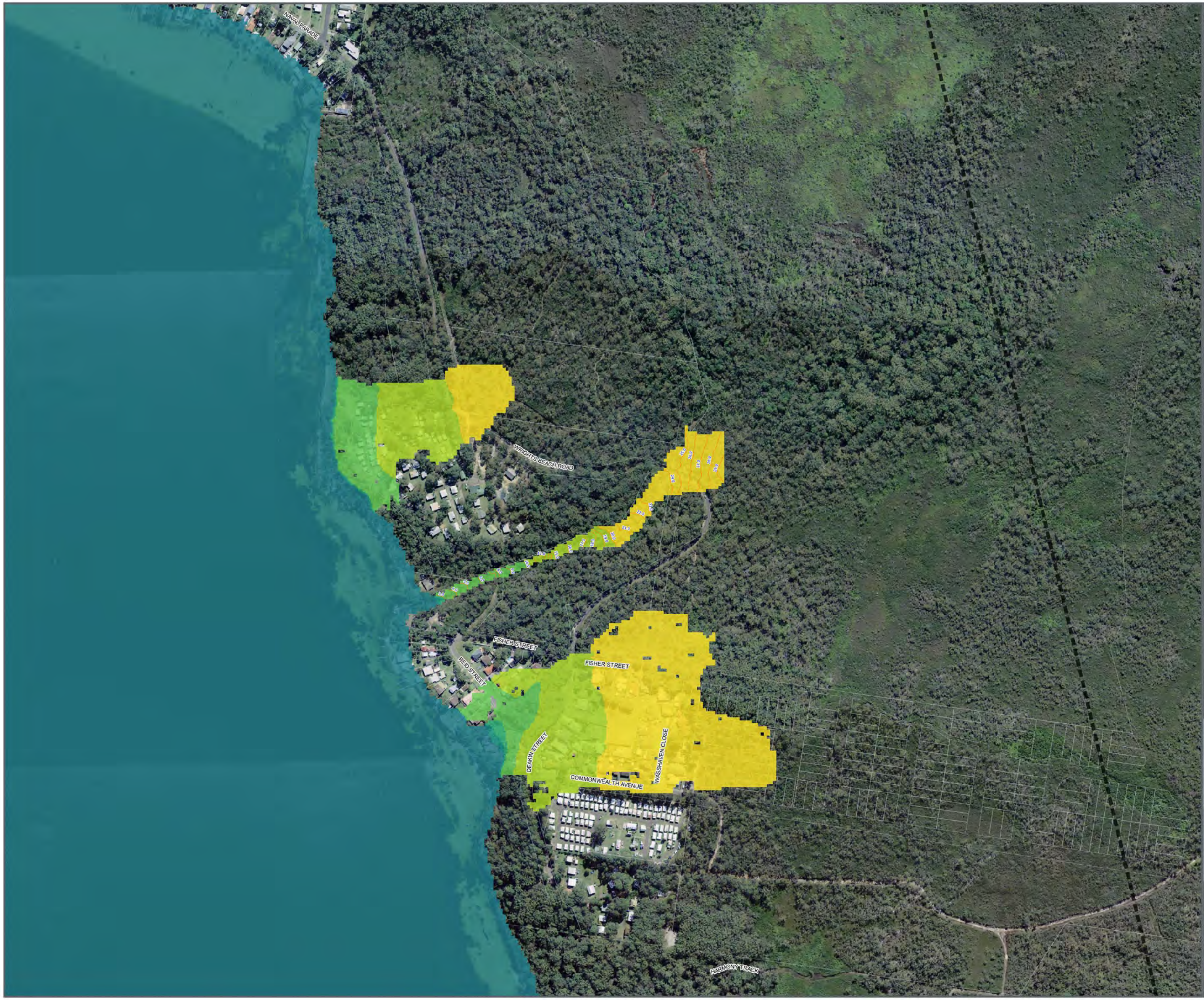
FIGURE G12.4

1:11,000 Scale at A3

0 100 200 300 400 500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Existing
1% AEP Water Level
Wrights Beach

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Water Level Contours (1.0m)

Water Level (m AHD)

- <= 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3 - 10
- 10 - 20
- > 20

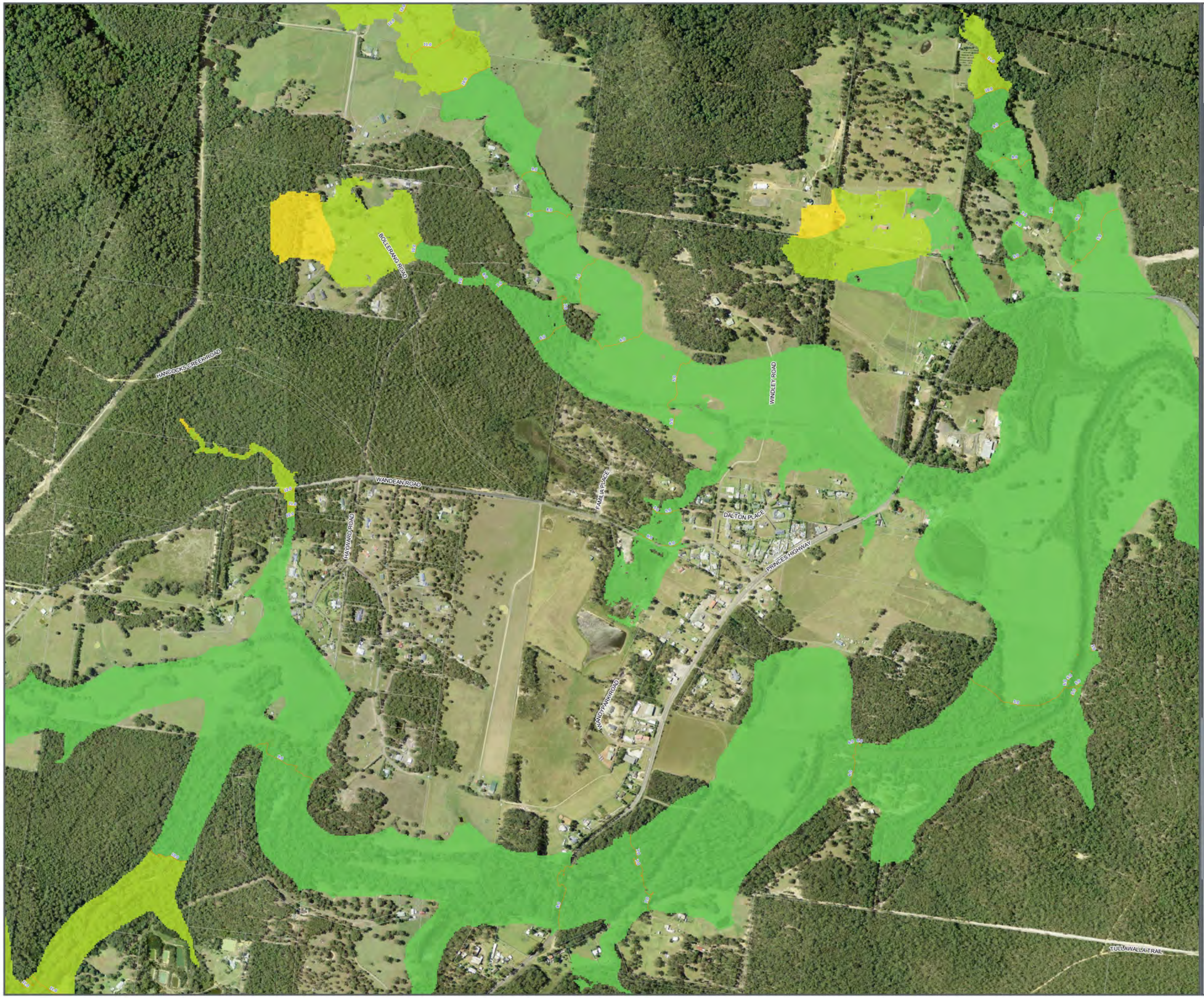
FIGURE G12.5

1:6,000 Scale at A3

0 70 140 210 280 350 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Existing
1% AEP Water Level
Wandandian

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Water Level Contours (1.0m)

Water Level (m AHD)

- <= 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3 - 10
- 10 - 20
- > 20

FIGURE G12.6

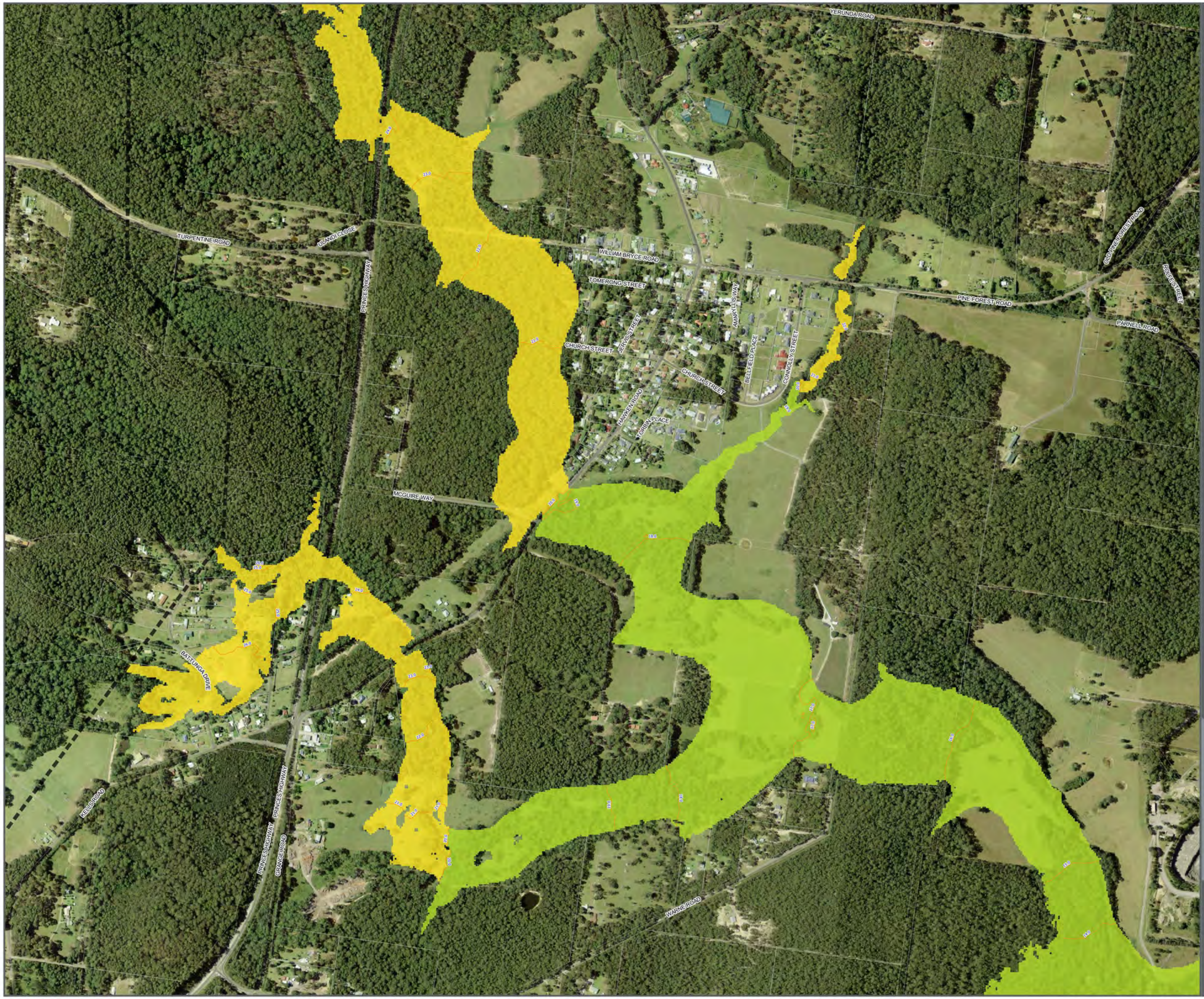
1:12,000 Scale at A3

0 100 200 300 400 500 m

N

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Existing 1% AEP Water Level Tomerong

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Water Level Contours (1.0m)

Water Level (m AHD)

- <= 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3 - 10
- 10 - 20
- > 20

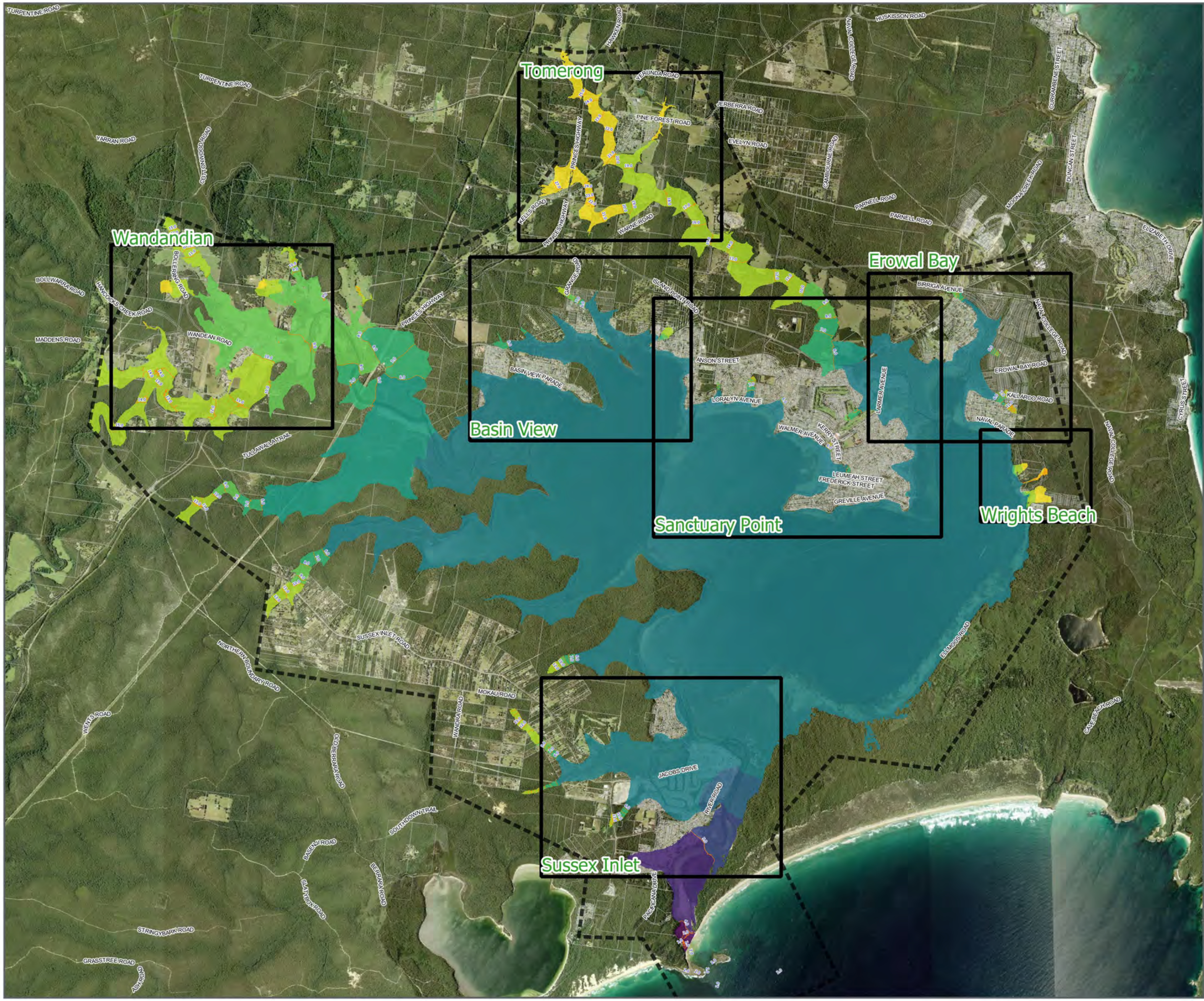
FIGURE G12.7

1:11,000 Scale at A3

0 100 200 300 400 500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Existing PMF Water Level Overview

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Water Level Contours (1.0m)

Water Level (m AHD)

- <= 4
- 4 - 5
- 5 - 5.25
- 5.25 - 5.5
- 5.5 - 5.75
- 5.75 - 6
- 6 - 8
- 8 - 10
- 10 - 20
- > 20

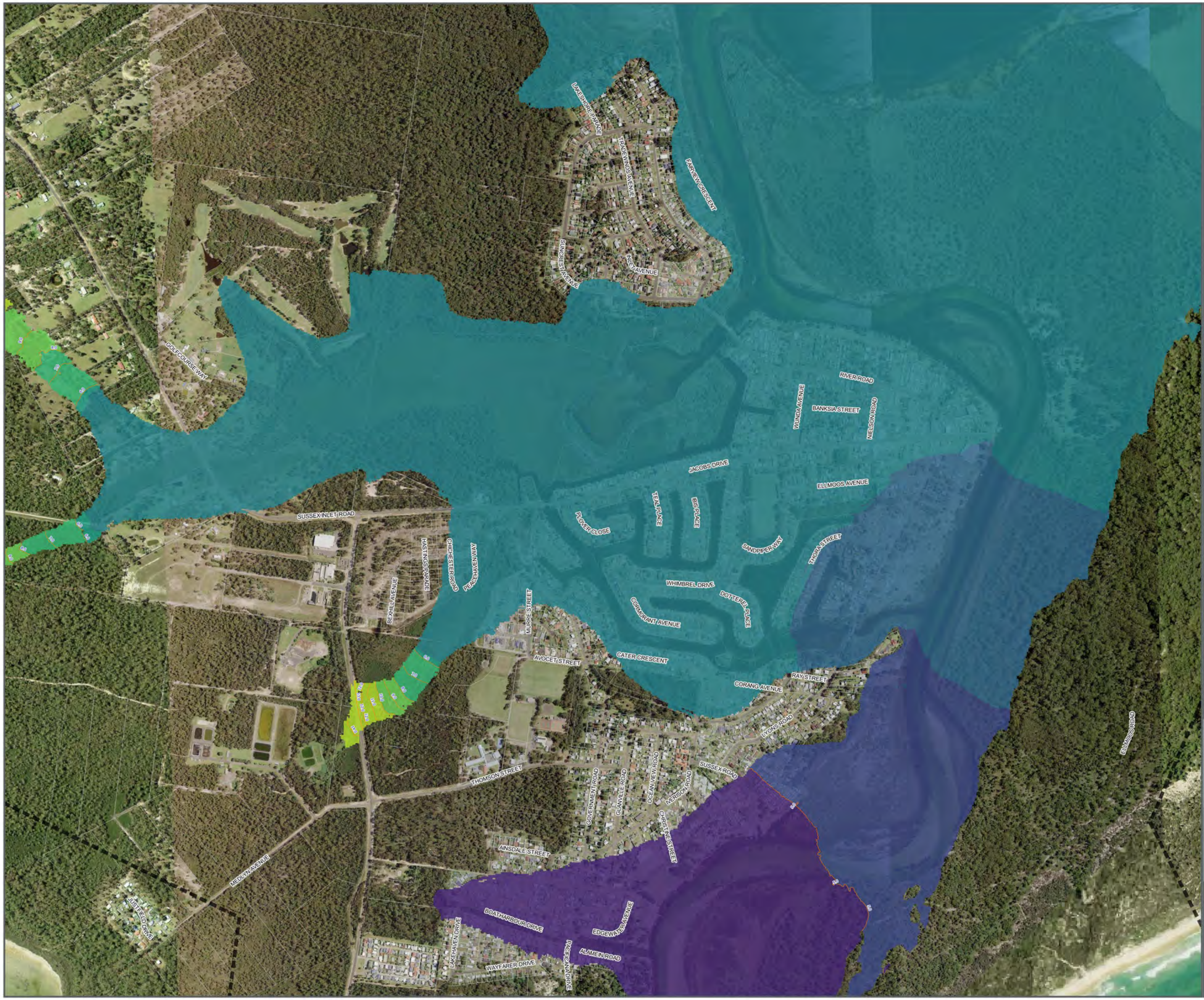
FIGURE G14

1:65,000 Scale at A3

0 700 1,400 2,100 2,800 3,500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Existing PMF Water Level Sussex Inlet

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Water Level Contours (1.0m)

Water Level (m AHD)

- <= 4
- 4 - 5
- 5 - 5.25
- 5.25 - 5.5
- 5.5 - 5.75
- 5.75 - 6
- 6 - 8
- 8 - 10
- 10 - 20
- > 20

FIGURE G14.1

1:13,000 Scale at A3

0 100 200 300 400 500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz

Existing PMF Water Level Basin View

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Water Level Contours (1.0m)

Water Level (m AHD)

- <= 4
- 4 - 5
- 5 - 5.25
- 5.25 - 5.5
- 5.5 - 5.75
- 5.75 - 6
- 6 - 8
- 8 - 10
- 10 - 20
- > 20

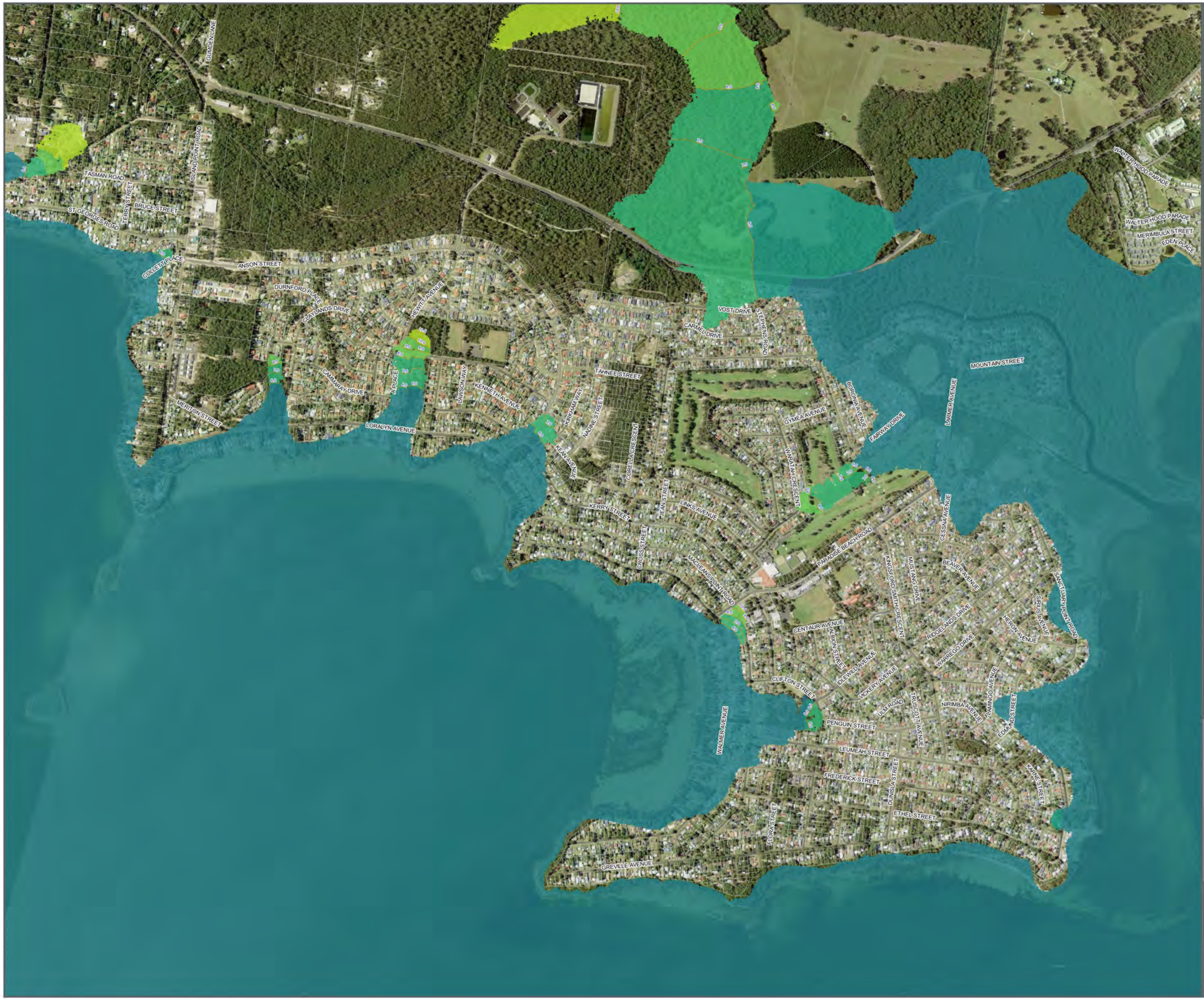
FIGURE G14.2

1:12,000 Scale at A3

0 100 200 300 400 500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Existing PMF Water Level Sanctuary Point

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Water Level Contours (1.0m)

Water Level (m AHD)

- <= 4
- 4 - 5
- 5 - 5.25
- 5.25 - 5.5
- 5.5 - 5.75
- 5.75 - 6
- 6 - 8
- 8 - 10
- 10 - 20
- > 20

FIGURE G14.3

1:15,600 Scale at A3

0 100 200 300 400 500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz

Existing PMF Water Level Erowal Bay

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Water Level Contours (1.0m)

Water Level (m AHD)

- <= 4
- 4 - 5
- 5 - 5.25
- 5.25 - 5.5
- 5.5 - 5.75
- 5.75 - 6
- 6 - 8
- 8 - 10
- 10 - 20
- > 20

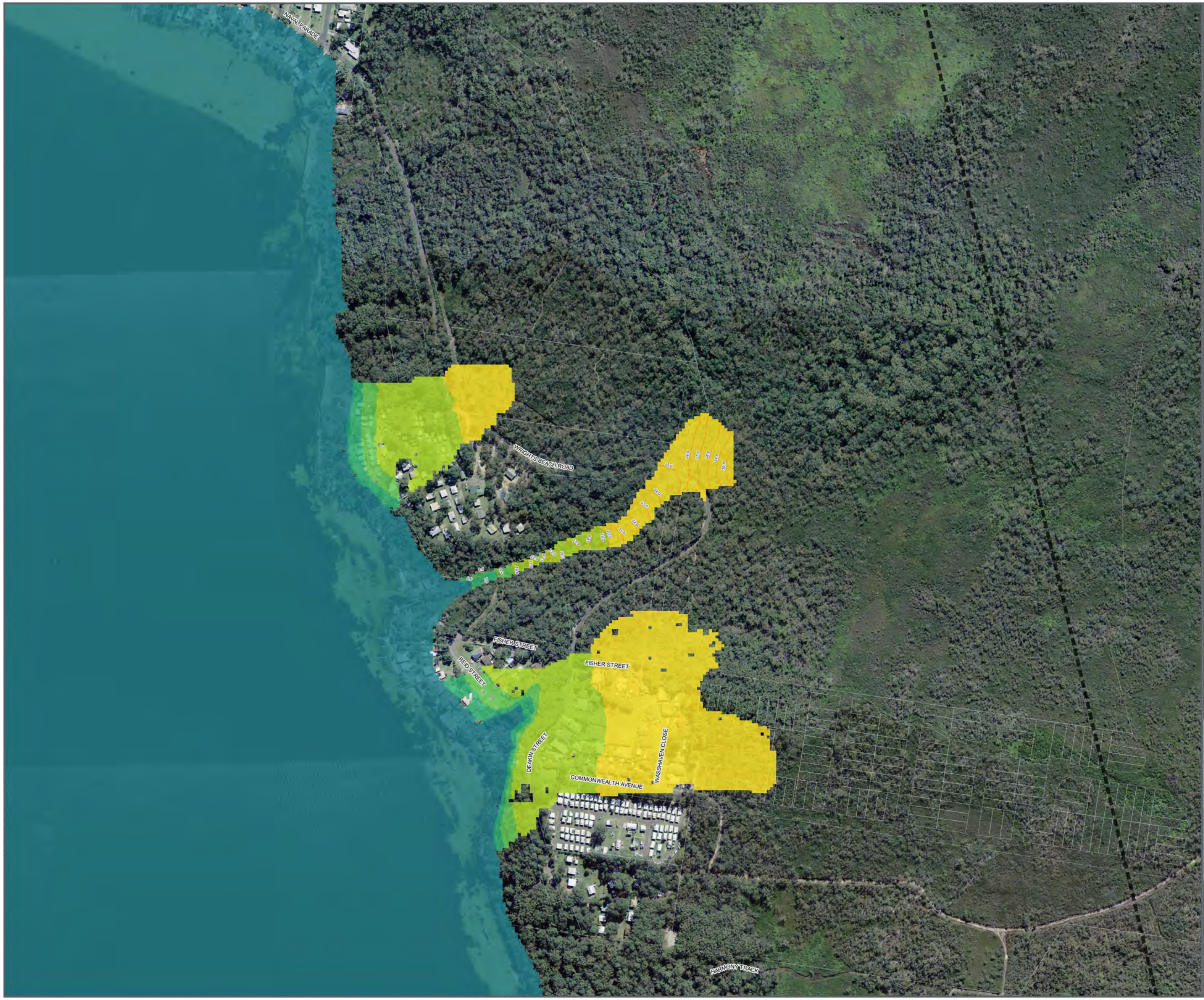
FIGURE G14.4

1:11,000 Scale at A3

0 100 200 300 400 500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Existing PMF Water Level Wrights Beach

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Water Level Contours (1.0m)

Water Level (m AHD)

- <= 4
- 4 - 5
- 5 - 5.25
- 5.25 - 5.5
- 5.5 - 5.75
- 5.75 - 6
- 6 - 8
- 8 - 10
- 10 - 20
- > 20

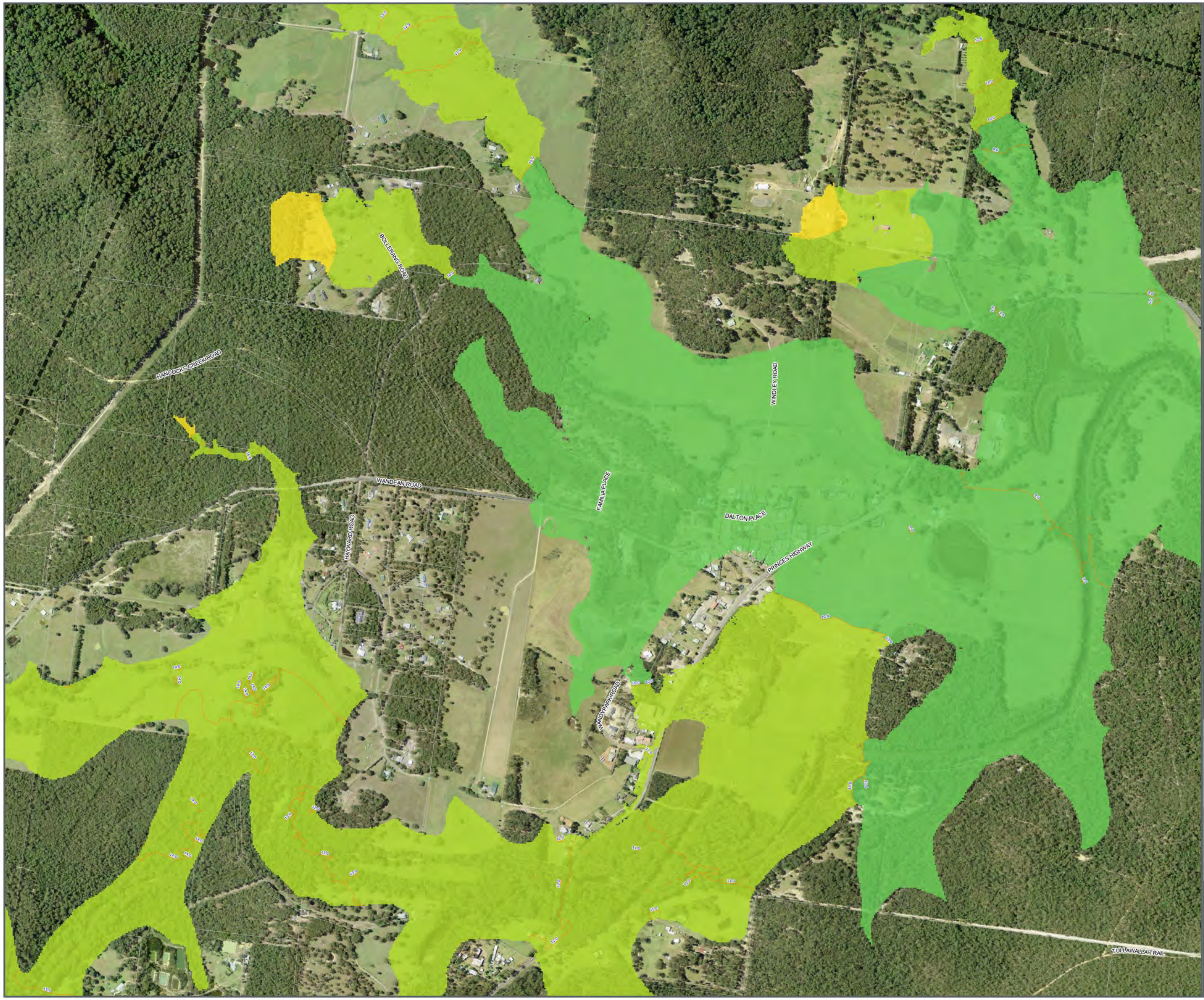
FIGURE G14.5

1:6,000 Scale at A3

0 70 140 210 280 350 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Existing PMF Water Level Wandandian

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Water Level Contours (1.0m)

Water Level (m AHD)

- <= 4
- 4 - 5
- 5 - 5.25
- 5.25 - 5.5
- 5.5 - 5.75
- 5.75 - 6
- 6 - 8
- 8 - 10
- 10 - 20
- > 20

FIGURE G14.6

1:12,000 Scale at A3

0 100 200 300 400 500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz

Existing PMF Water Level Tomerong

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Water Level Contours (1.0m)

Water Level (m AHD)

- <= 4
- 4 - 5
- 5 - 5.25
- 5.25 - 5.5
- 5.5 - 5.75
- 5.75 - 6
- 6 - 8
- 8 - 10
- 10 - 20
- > 20

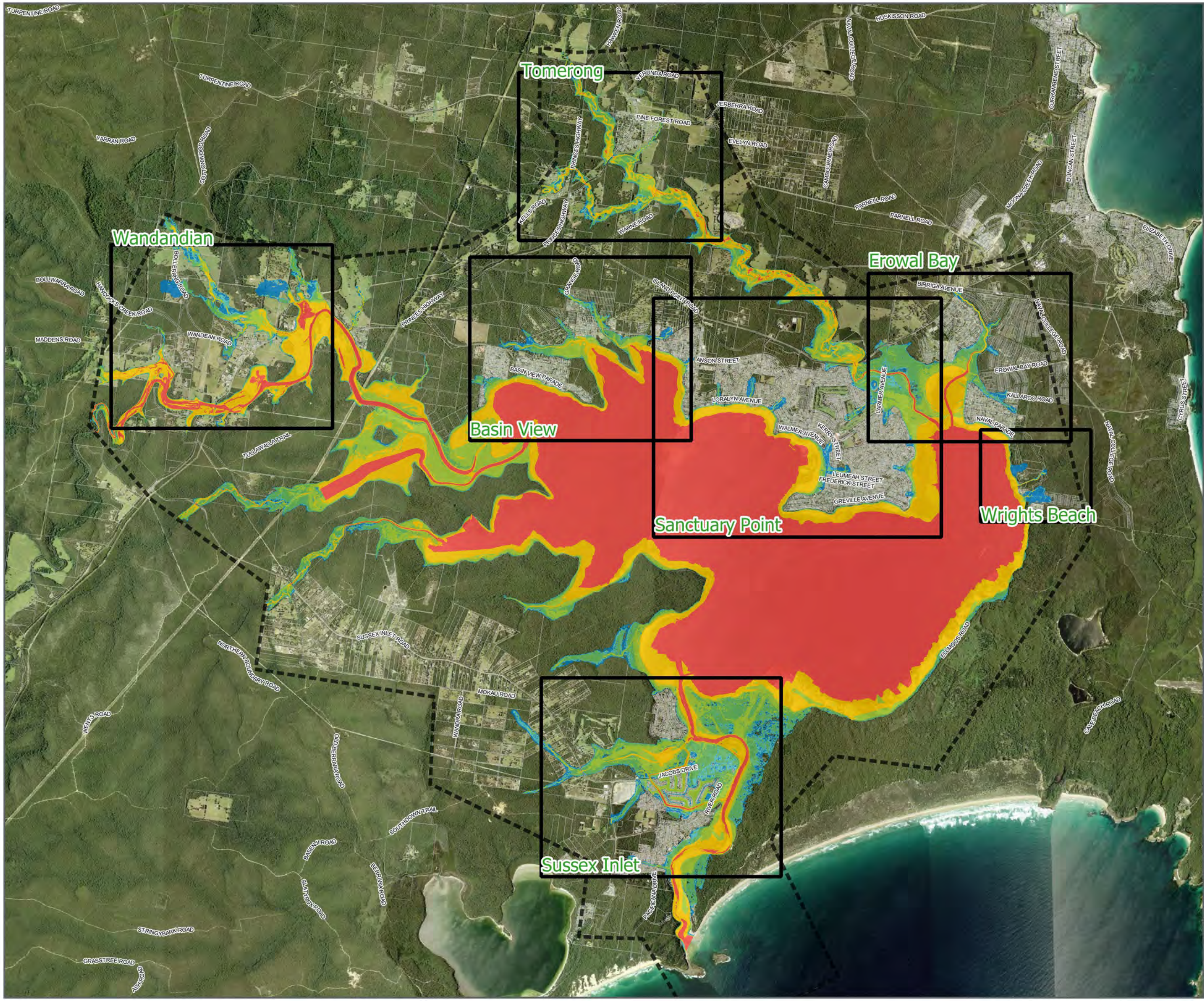
FIGURE G14.7

1:11,000 Scale at A3

0 100 200 300 400 500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Existing 1% AEP Hazard Overview

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary

Hazard (AEMI H1-H6)

- 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 buildings vulnerable to structural damage. Some less robust buildings subject to failure.
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.

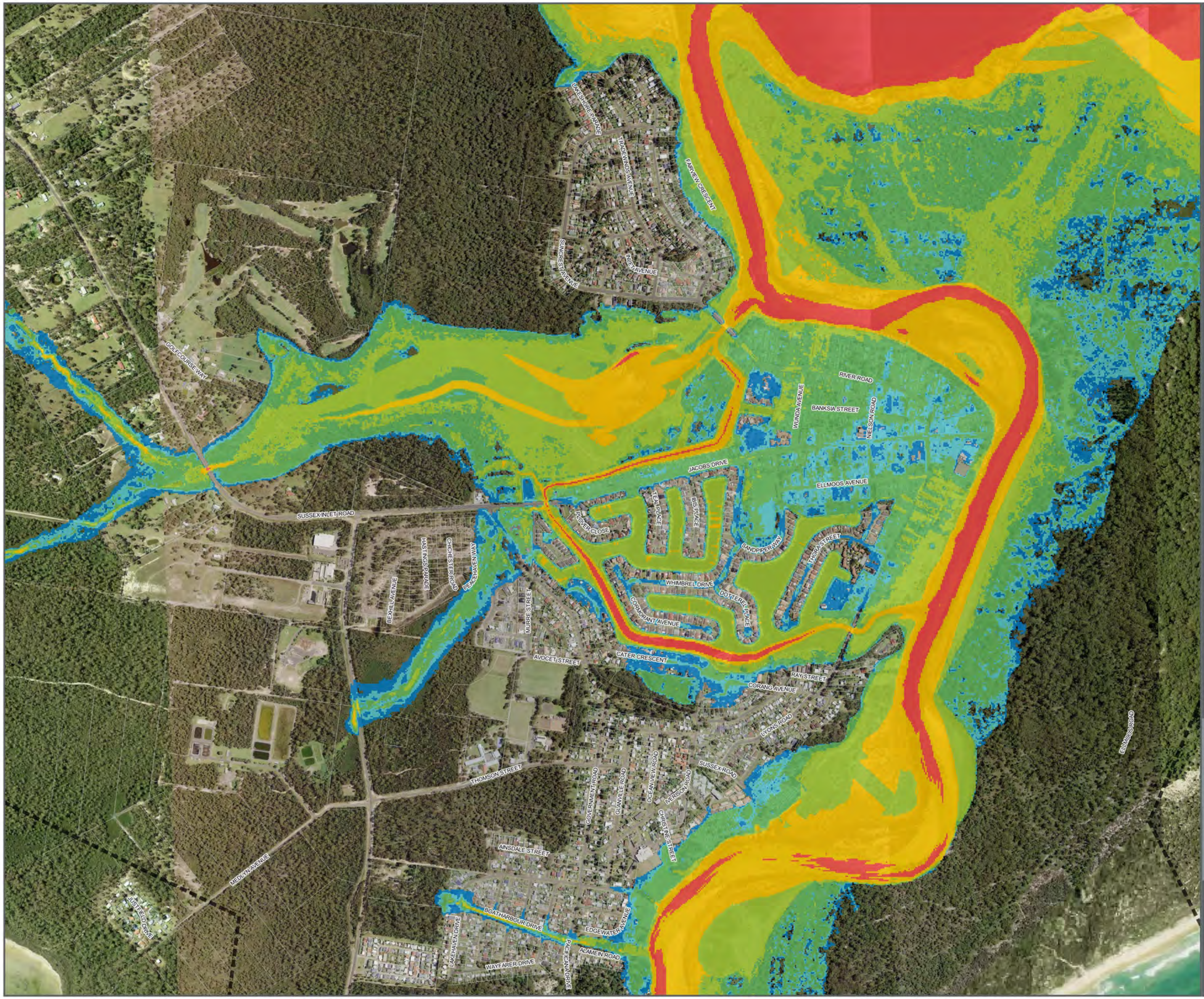
FIGURE G22

1:65,000 Scale at A3

0 700 1,400 2,100 2,800 3,500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Existing 1% AEP Hazard Sussex Inlet

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary

Hazard (AEMI H1-H6)

- 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 buildings vulnerable to structural damage. Some less robust buildings subject to failure.
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.

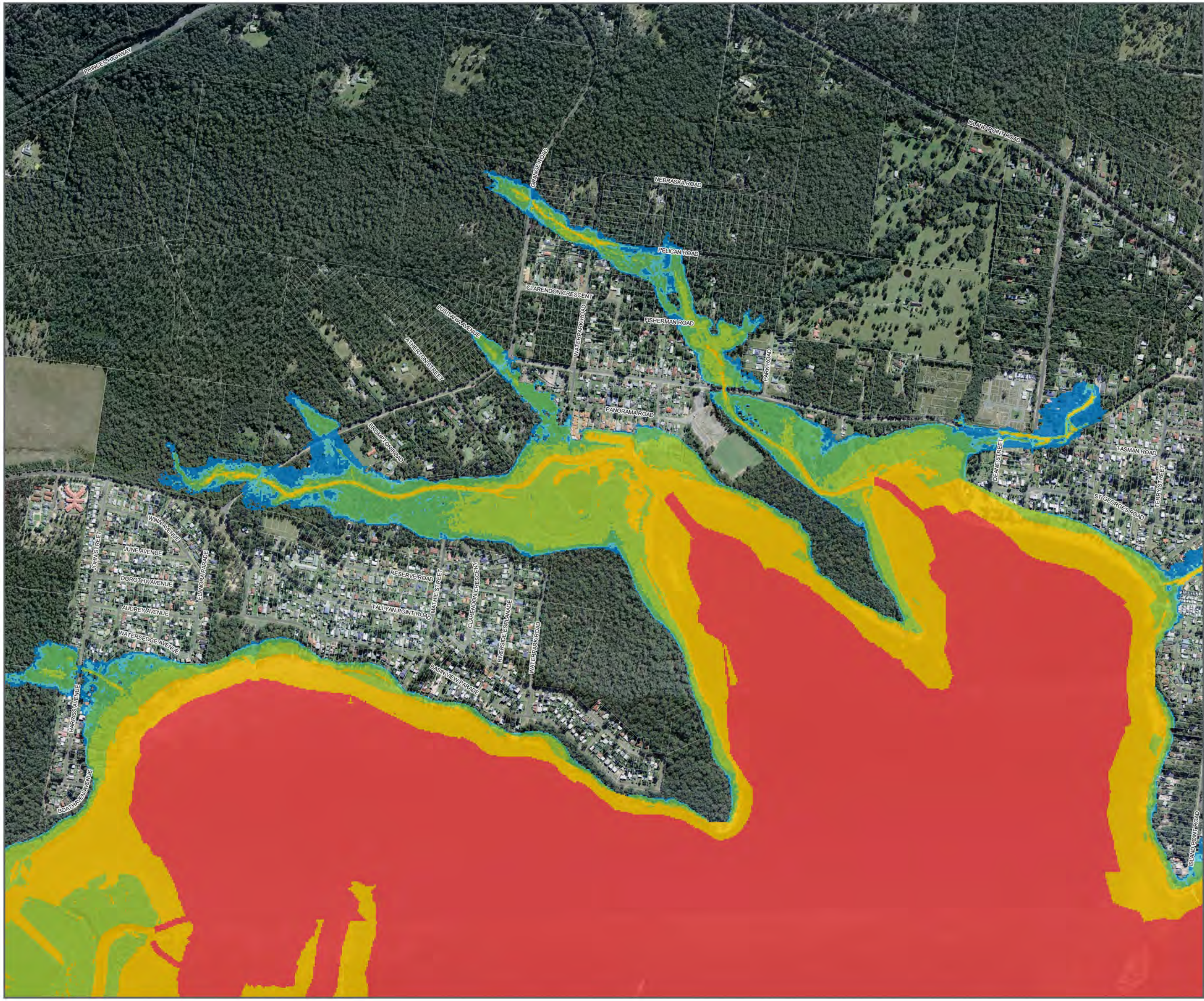
FIGURE G22.1

1:13,000 Scale at A3

0 100 200 300 400 500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Existing
1% AEP Hazard
Basin View

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary

Hazard (AEMI H1-H6)

- 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 buildings vulnerable to structural damage. Some less robust buildings subject to failure.
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.

FIGURE G22.2

1:12,000 Scale at A3

0 100 200 300 400 500 m

N

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz

Existing 1% AEP Hazard Sanctuary Point

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary

Hazard (AEMI H1-H6)

- 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 buildings vulnerable to structural damage. Some less robust buildings subject to failure.
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.

FIGURE G22.3

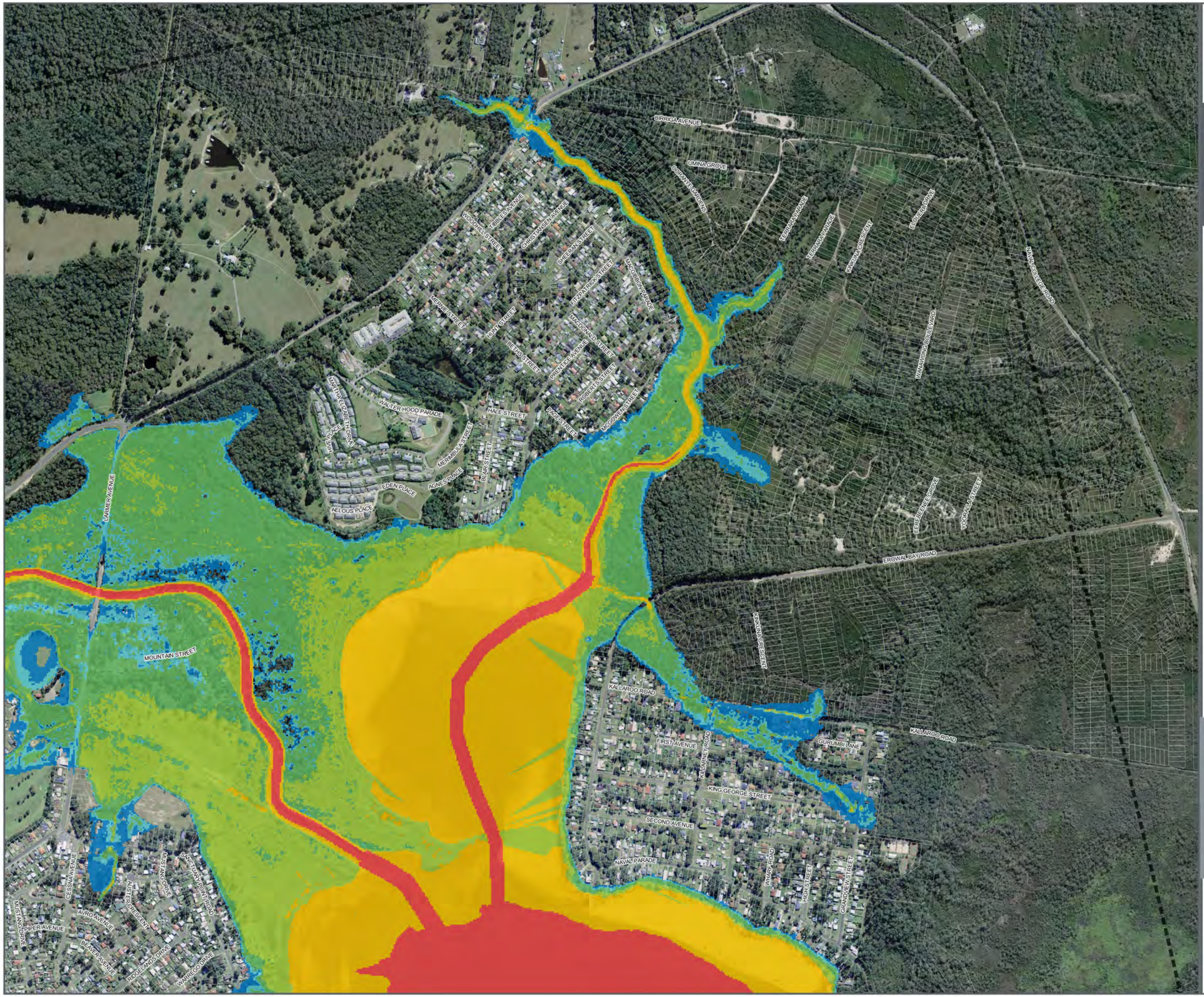
1:15,600 Scale at A3

0 100 200 300 400 500 m

N

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Existing 1% AEP Hazard Erowal Bay

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary

Hazard (AEMI H1-H6)

- 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 buildings vulnerable to structural damage. Some less robust buildings subject to failure.
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.

FIGURE G22.4

1:11,000 Scale at A3

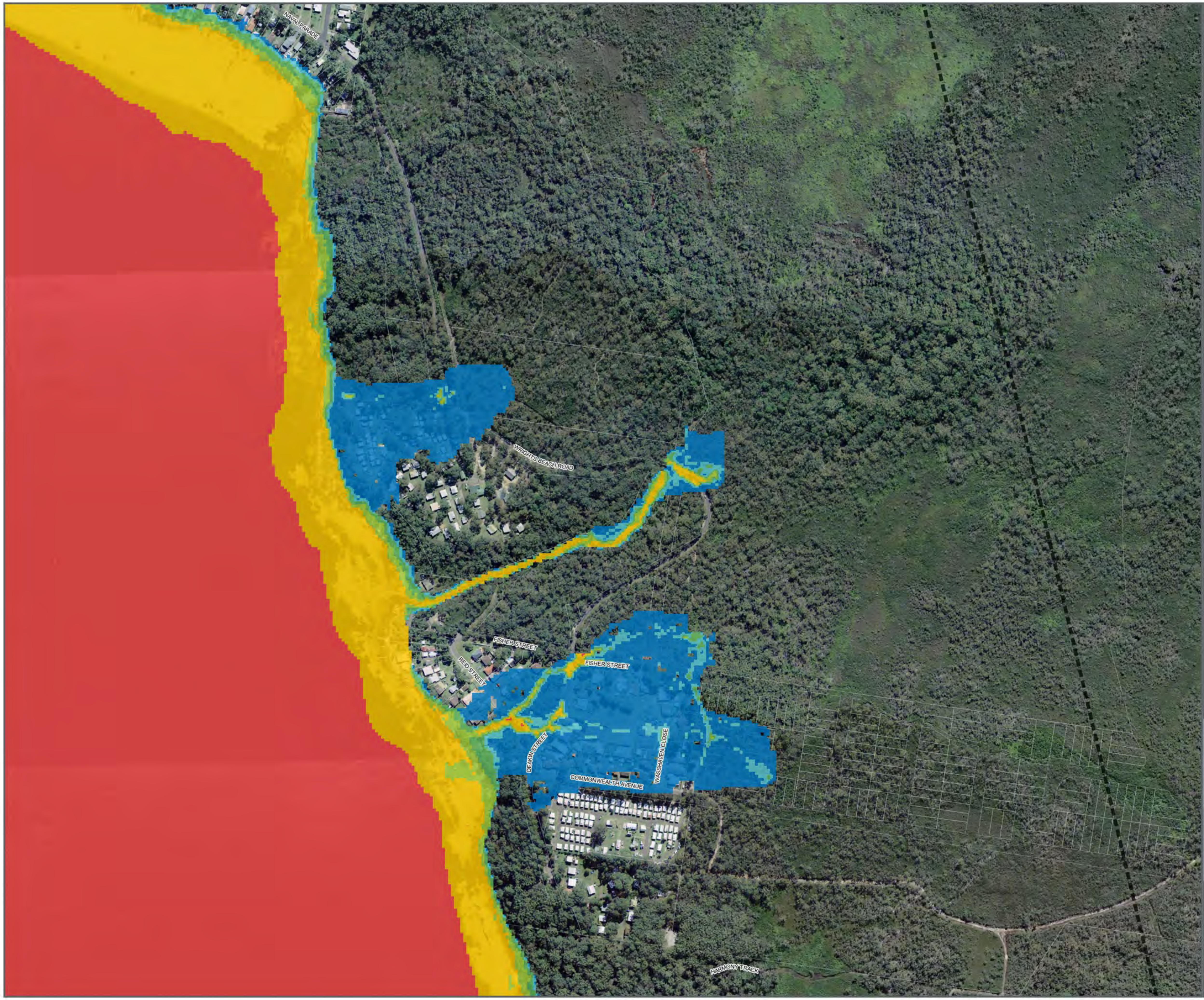
0 100 200 300 400 500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz

Existing
1% AEP Hazard
Wrights Beach

St Georges Basin Flood Study



Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary

Hazard (AEMI H1-H6)

- 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 buildings vulnerable to structural damage. Some less robust buildings subject to failure.
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.

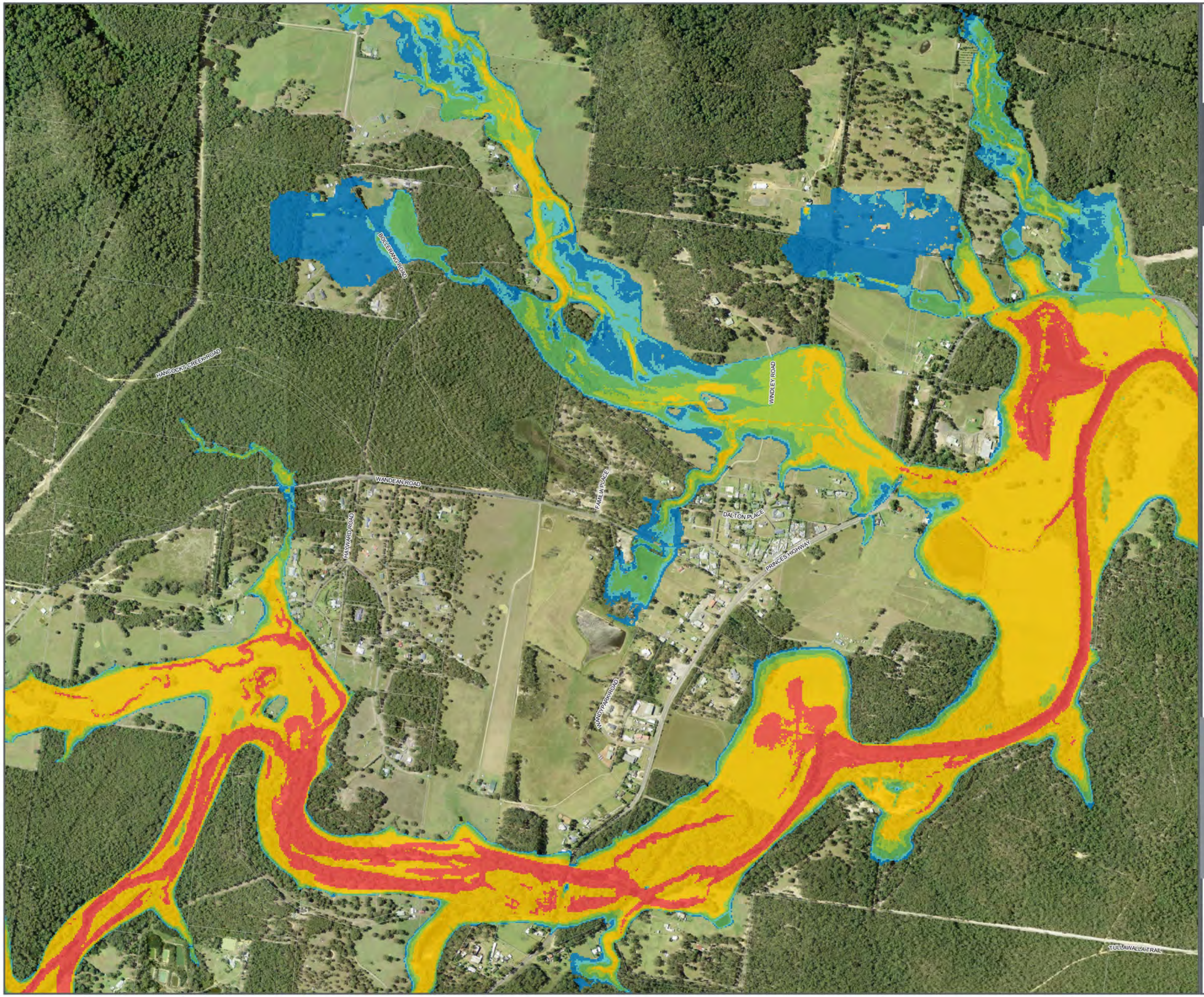
FIGURE G22.5

1:6,000 Scale at A3

0 70 140 210 280 350 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Existing 1% AEP Hazard Wandandian

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary

Hazard (AEMI H1-H6)

- 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 buildings vulnerable to structural damage. Some less robust buildings subject to failure.
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.

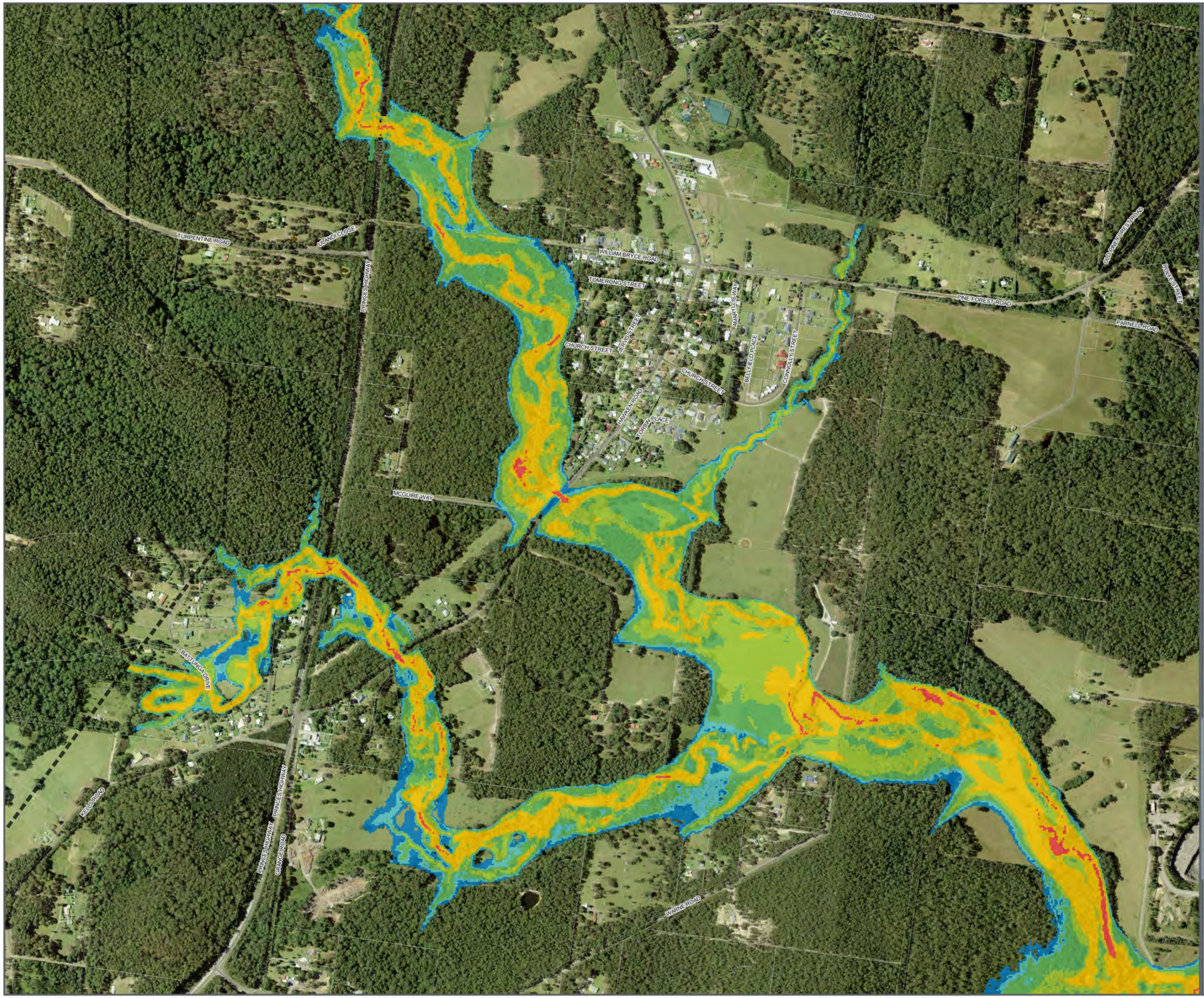
FIGURE G22.6

1:12,000 Scale at A3

0 100 200 300 400 500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Existing 1% AEP Hazard Tomerong

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary

Hazard (AEMI H1-H6)

- 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 buildings vulnerable to structural damage. Some less robust buildings subject to failure.
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.

FIGURE G22.7

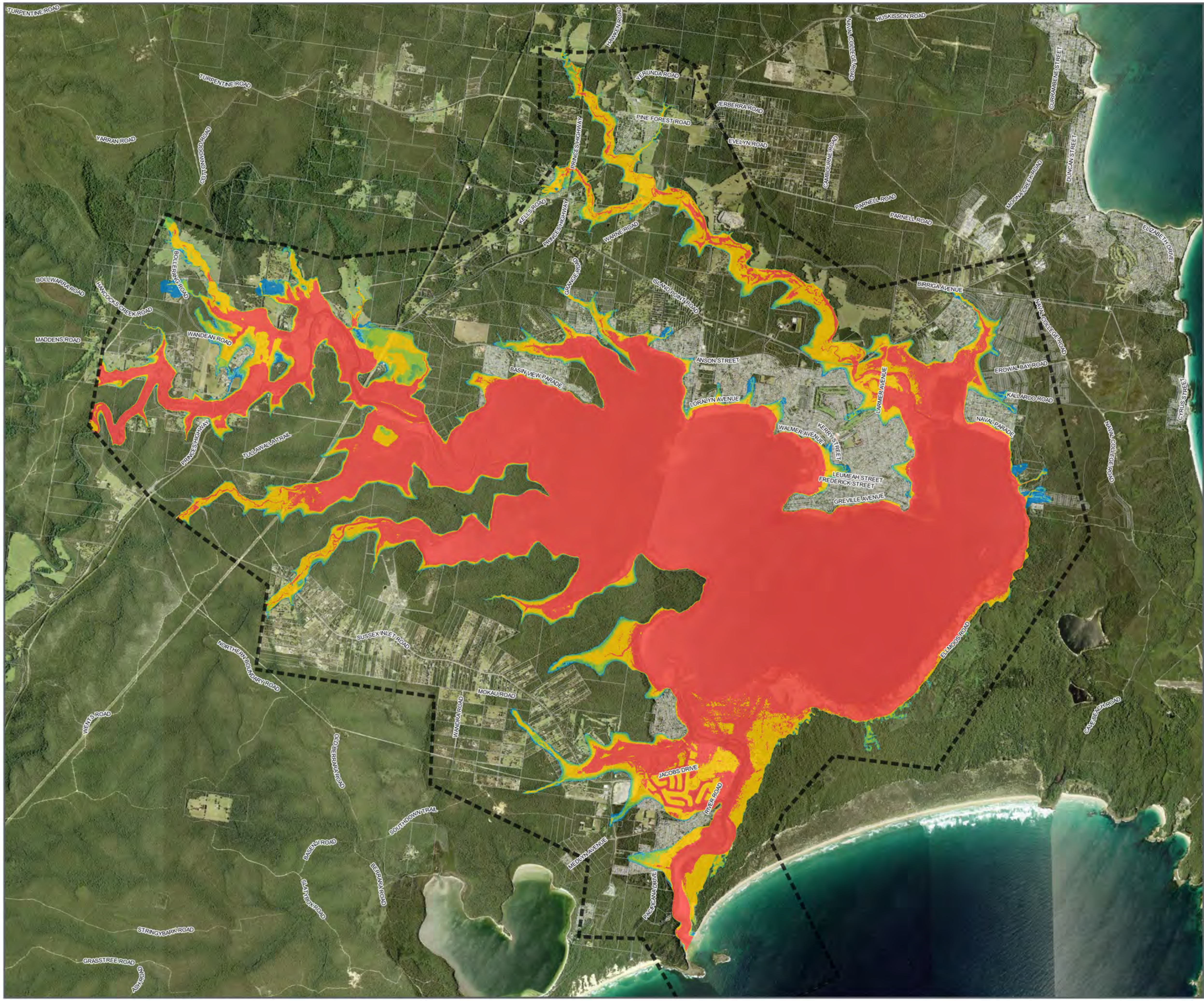
1:11,000 Scale at A3

0 100 200 300 400 500 m

N

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Existing PMF Hazard

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary

Hazard (AEMI H1-H6)

- 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 buildings vulnerable to structural damage. Some less robust buildings subject to failure.
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.

FIGURE G24

1:65,000 Scale at A3

0 700 1,400 2,100 2,800 3,500 m

Cardno

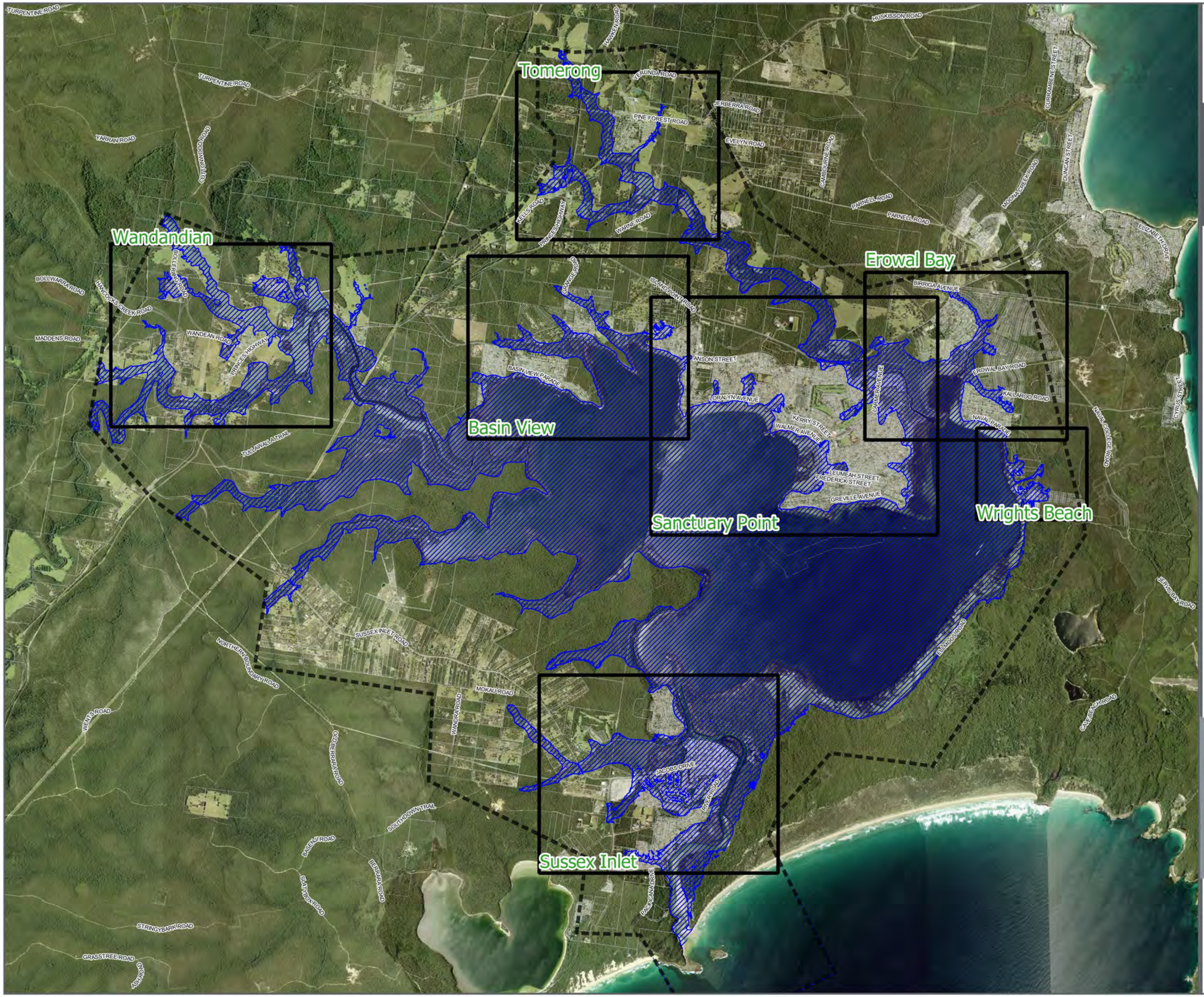
Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2021-11-29| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz

APPENDIX

B

FLOOD PLANNING AREA MAPS

Figure List:



Existing Flood Planning Area Overview

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Flood Planning Area

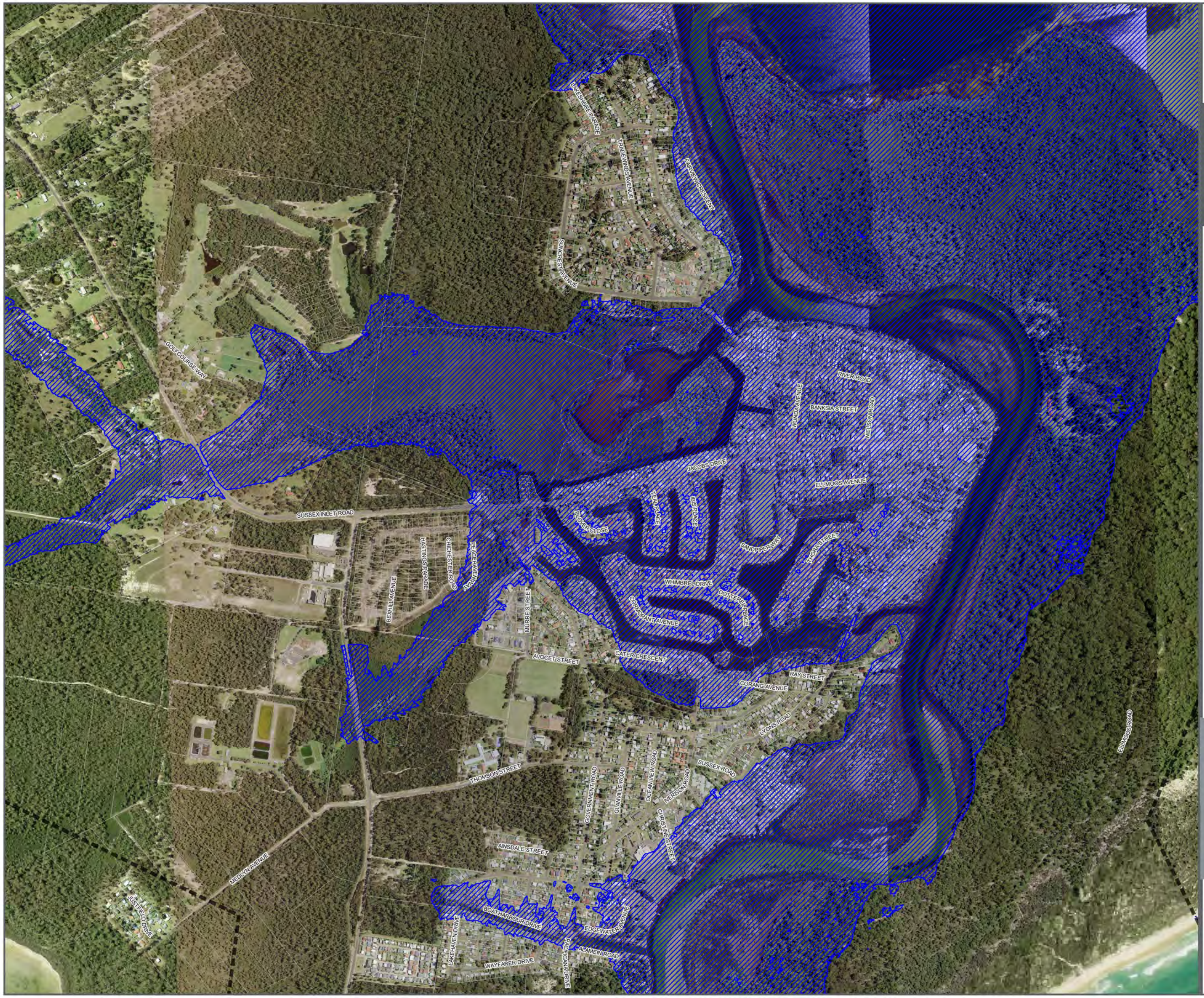
FIGURE I01

1:65,000 Scale at A3

0 700 1,400 2,100 2,800 3,500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2022-9-15| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Existing Flood Planning Area Sussex Inlet

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Flood Planning Area

FIGURE I01.1

1:13,000 Scale at A3

0 100 200 300 400 500 m

N

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2022-9-15| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz

Existing Flood Planning Area Basin View

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Flood Planning Area

FIGURE I01.2

1:12,000 Scale at A3

0 100 200 300 400 500 m

N

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2022-9-15| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz

Existing Flood Planning Area Sanctuary Point

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Flood Planning Area

FIGURE I01.3

1:15,600 Scale at A3

0 100 200 300 400 500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2022-9-15| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz

Existing Flood Planning Area Erowal Bay

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Flood Planning Area

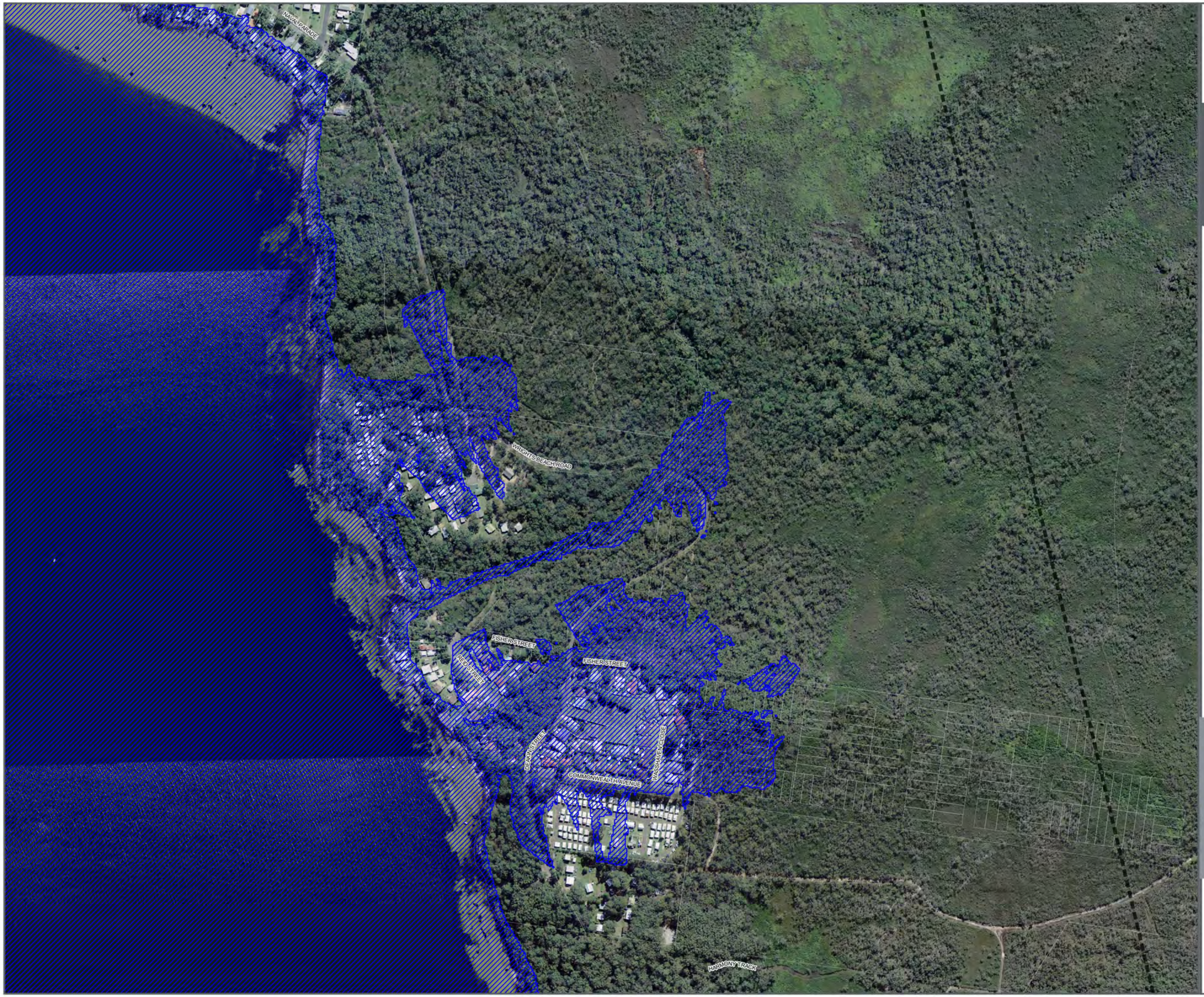
FIGURE I01.4

1:11,000 Scale at A3

0 100 200 300 400 500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2022-9-15| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Existing Flood Planning Area Wrights Beach

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Flood Planning Area

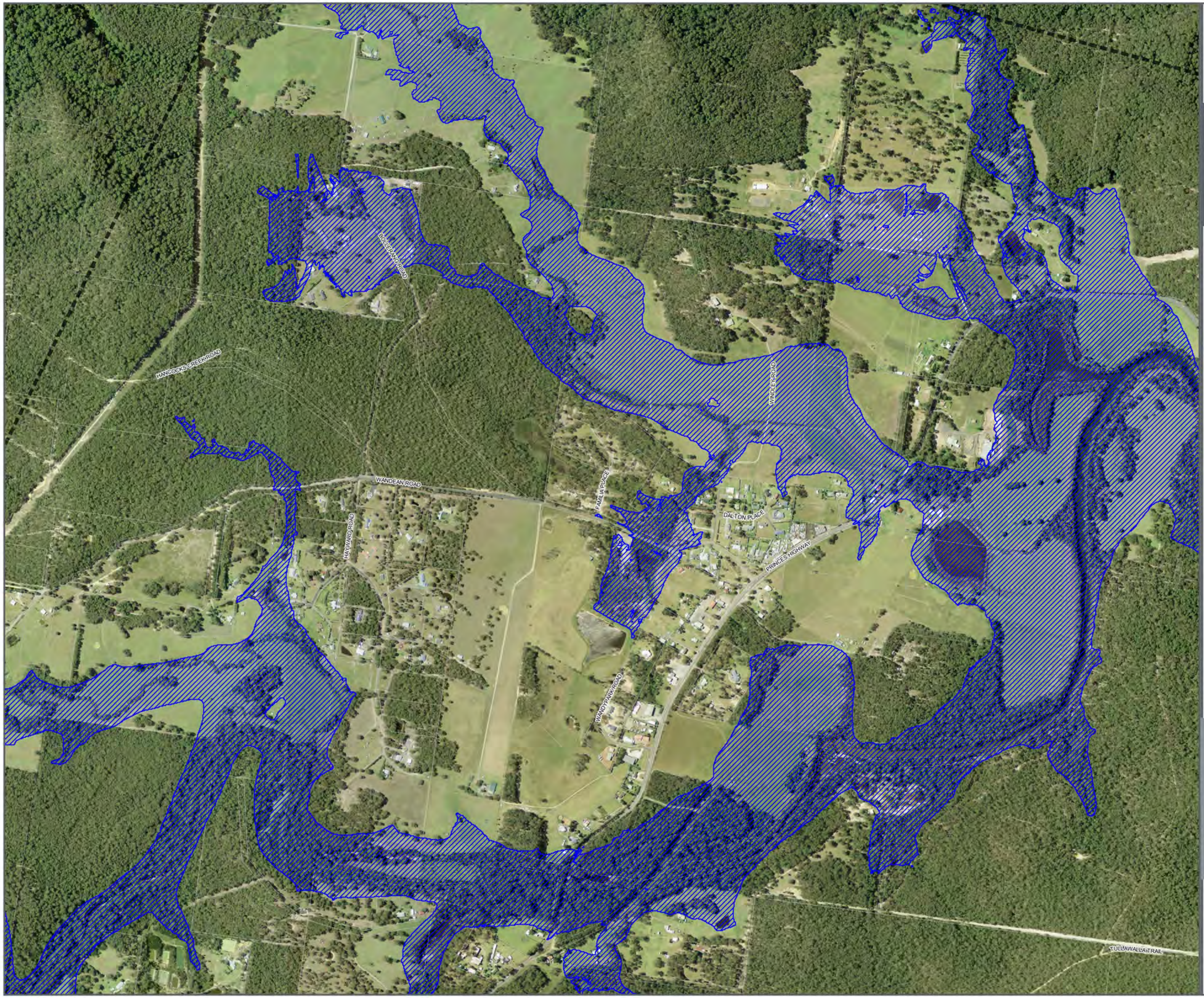
FIGURE I01.5

1:6,000 Scale at A3

0 70 140 210 280 350 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2022-9-15| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Existing
Flood Planning Area
Wandandian

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Flood Planning Area

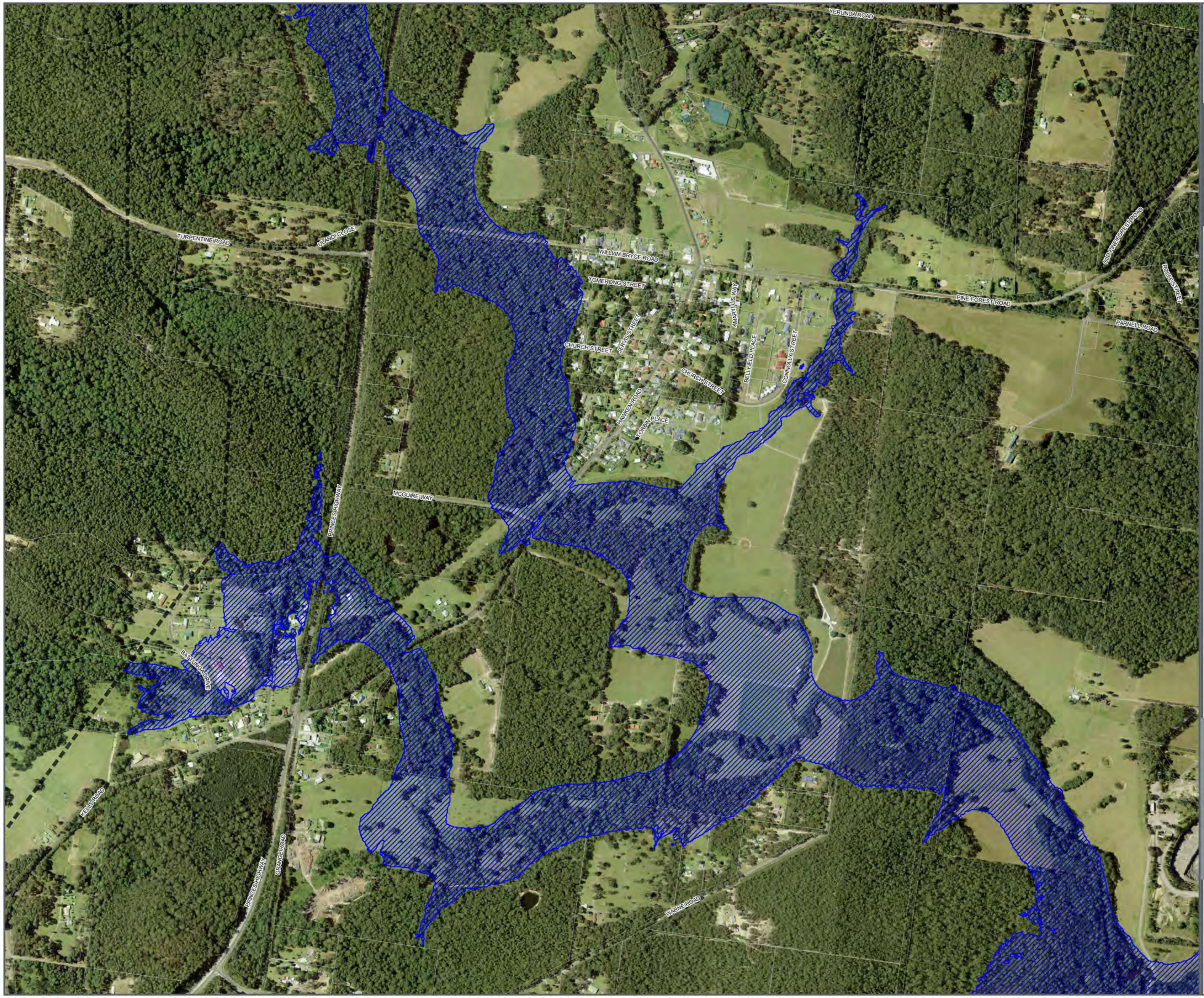
FIGURE I01.6

1:12,000 Scale at A3

0 100 200 300 400 500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2022-9-15| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Existing Flood Planning Area Tomerong

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Flood Planning Area

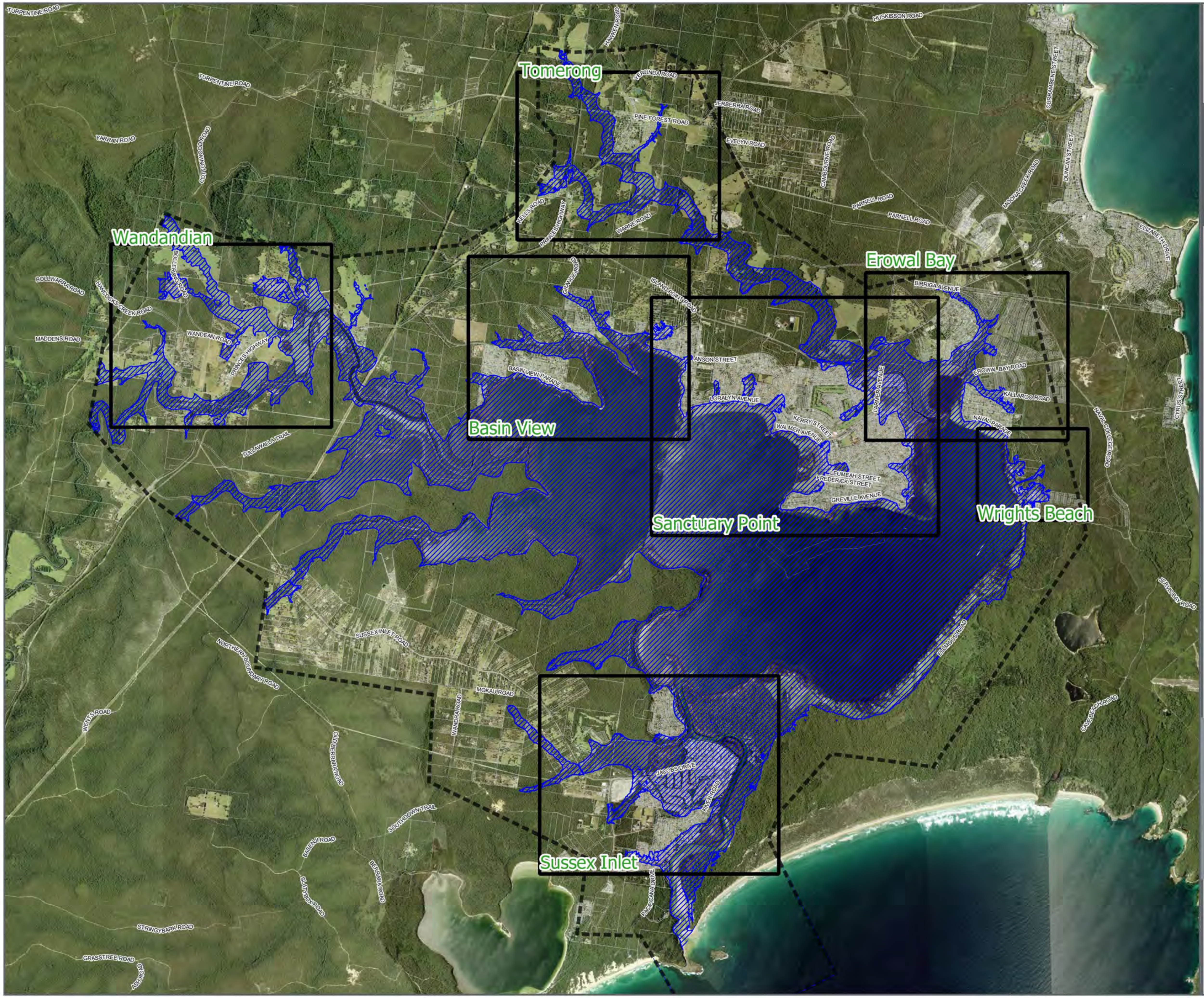
FIGURE I01.7

1:11,000 Scale at A3

0 100 200 300 400 500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2022-9-15| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Projected 2050 Flood Planning Area Overview

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Flood Planning Area

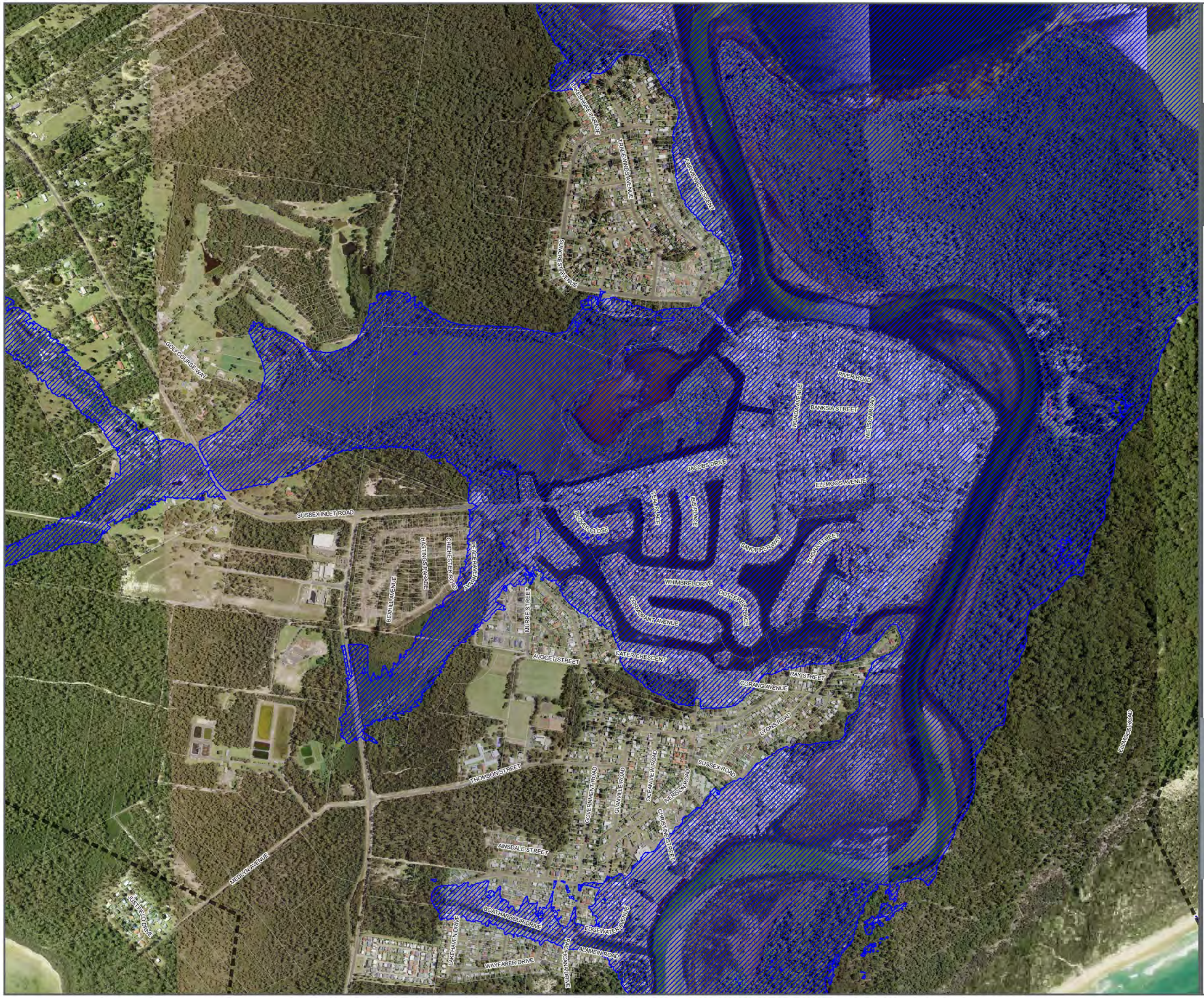
FIGURE I02

1:65,000 Scale at A3

0 700 1,400 2,100 2,800 3,500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2022-9-15| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Projected 2050 Flood Planning Area Sussex Inlet

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Flood Planning Area

FIGURE I02.1

1:13,000 Scale at A3

0 100 200 300 400 500 m

N

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2022-9-15| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz

Projected 2050 Flood Planning Area Basin View

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Flood Planning Area

FIGURE I02.2

1:12,000 Scale at A3

0 100 200 300 400 500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2022-9-15| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz

Projected 2050 Flood Planning Area Sanctuary Point

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Flood Planning Area

FIGURE I02.3

1:15,600 Scale at A3

0 100 200 300 400 500 m

N

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2022-9-15| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz

Projected 2050 Flood Planning Area Erowal Bay

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Flood Planning Area

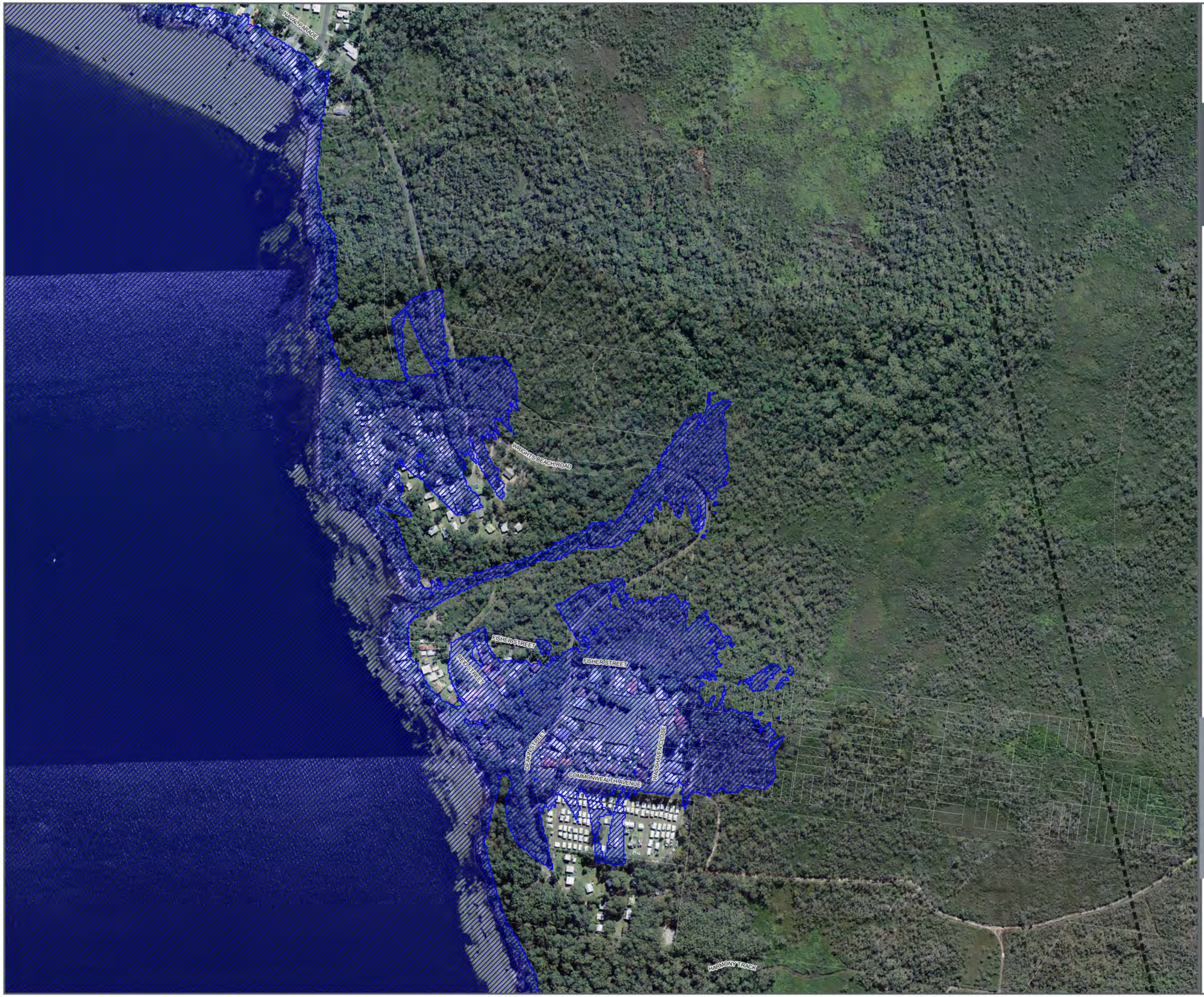
FIGURE I02.4

1:11,000 Scale at A3

0 100 200 300 400 500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2022-9-15| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Projected 2050 Flood Planning Area Wrights Beach

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Flood Planning Area

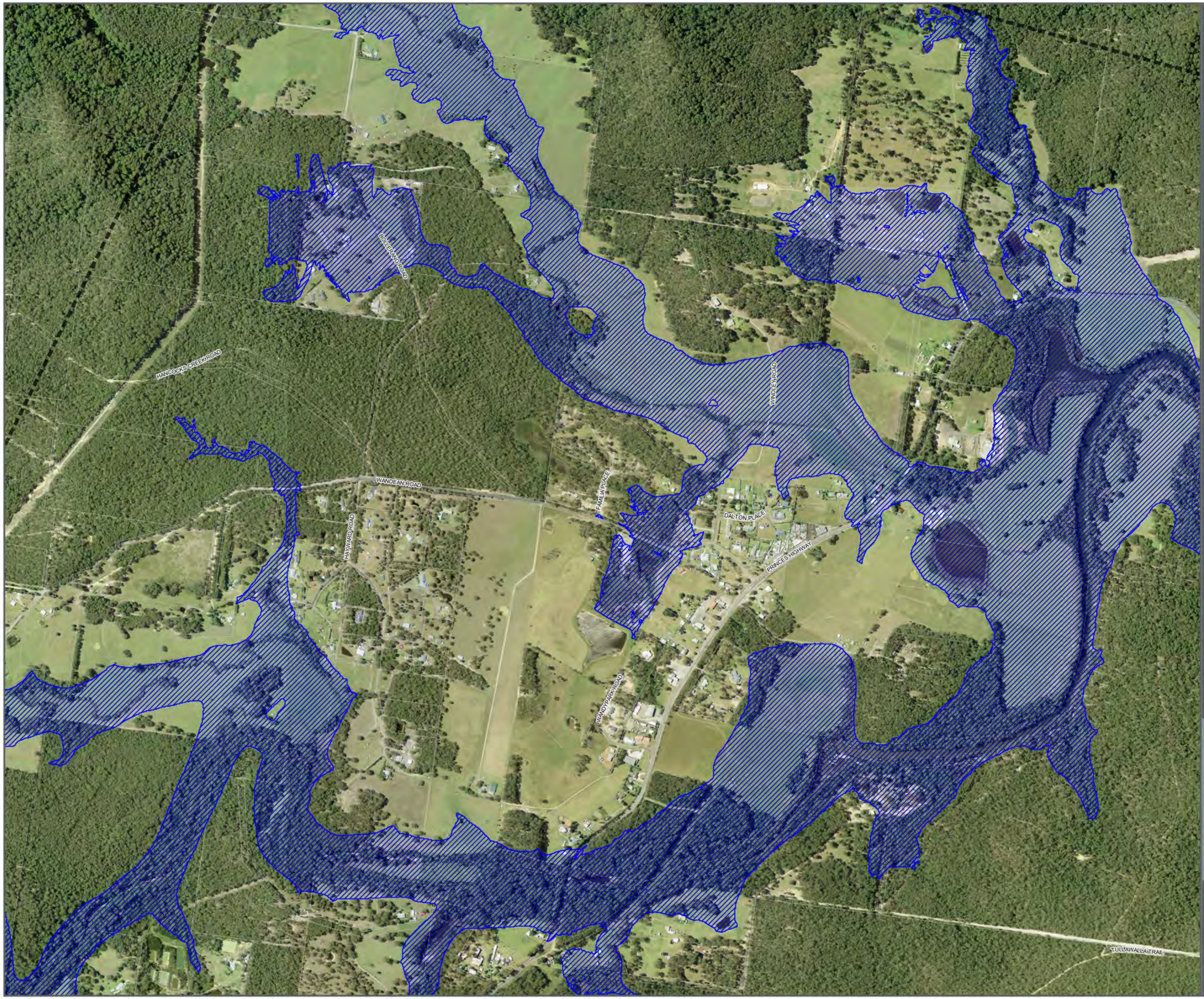
FIGURE I02.5

1:6,000 Scale at A3

0 70 140 210 280 350 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2022-9-15| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Projected 2050 Flood Planning Area Wandandian

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Flood Planning Area

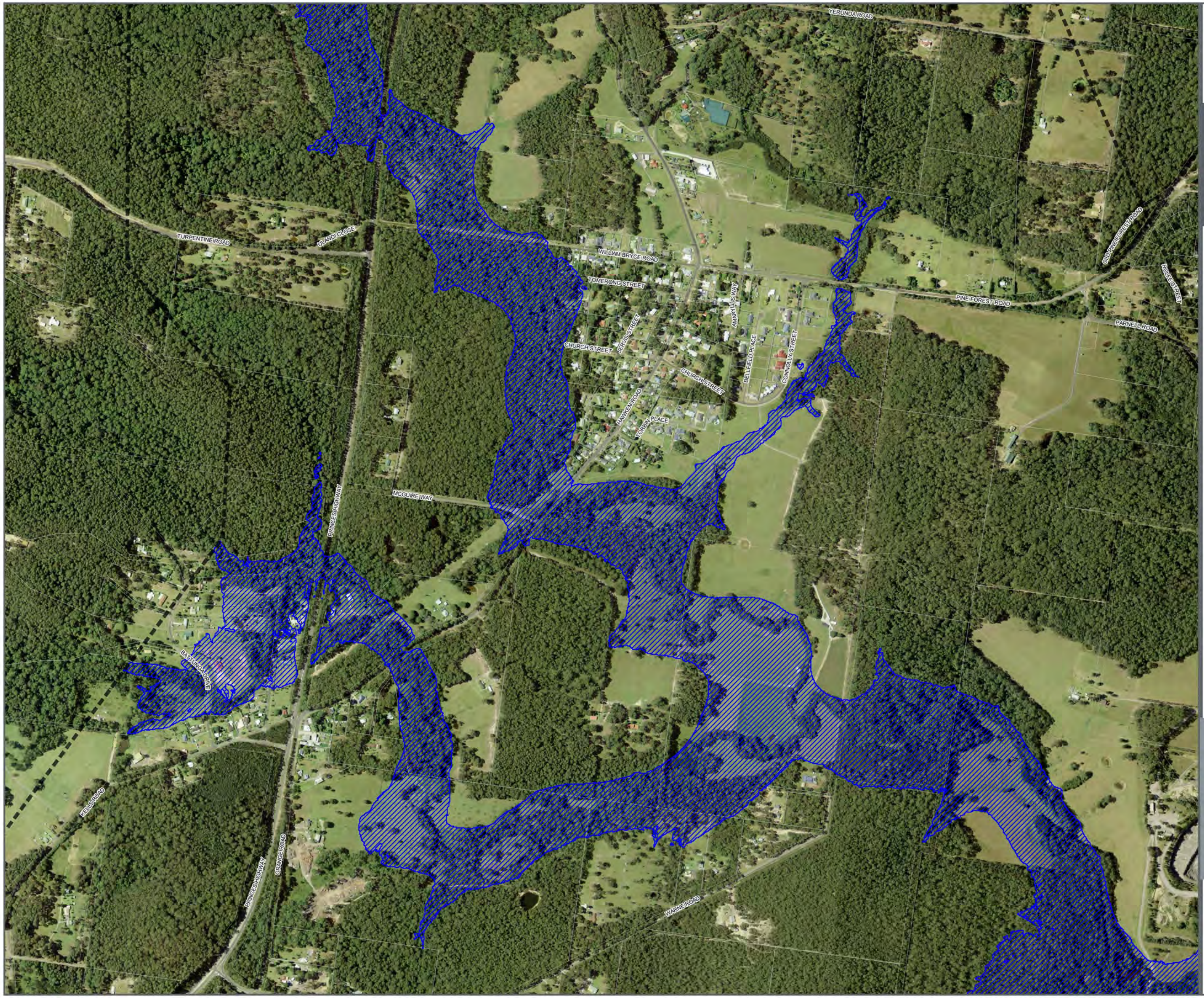
FIGURE I02.6

1:12,000 Scale at A3

0 100 200 300 400 500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2022-9-15| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Projected 2050 Flood Planning Area Tomerong

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Flood Planning Area

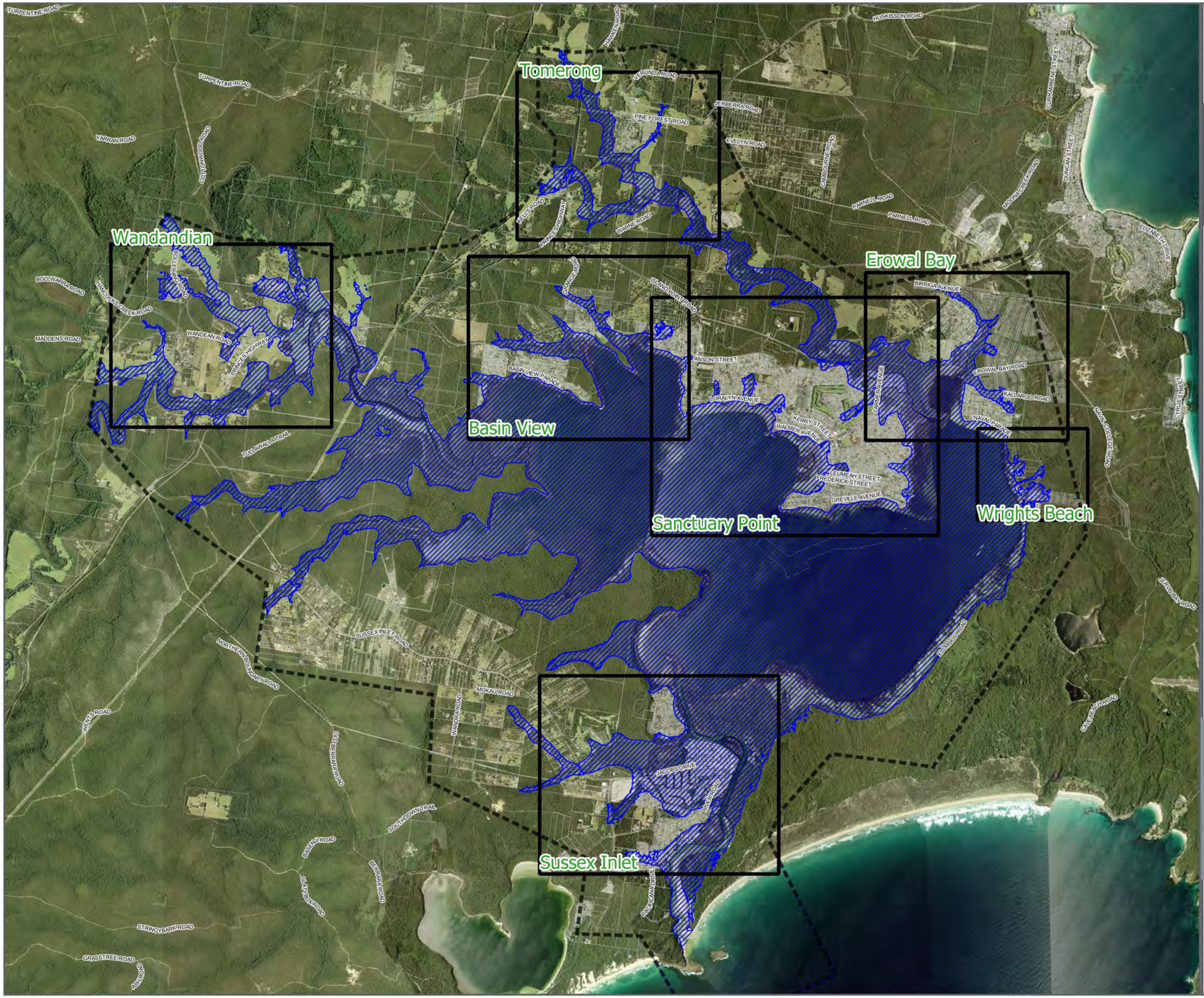
FIGURE I02.7

1:11,000 Scale at A3

0 100 200 300 400 500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2022-9-15| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Projected 2100 Flood Planning Area Overview

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Flood Planning Area

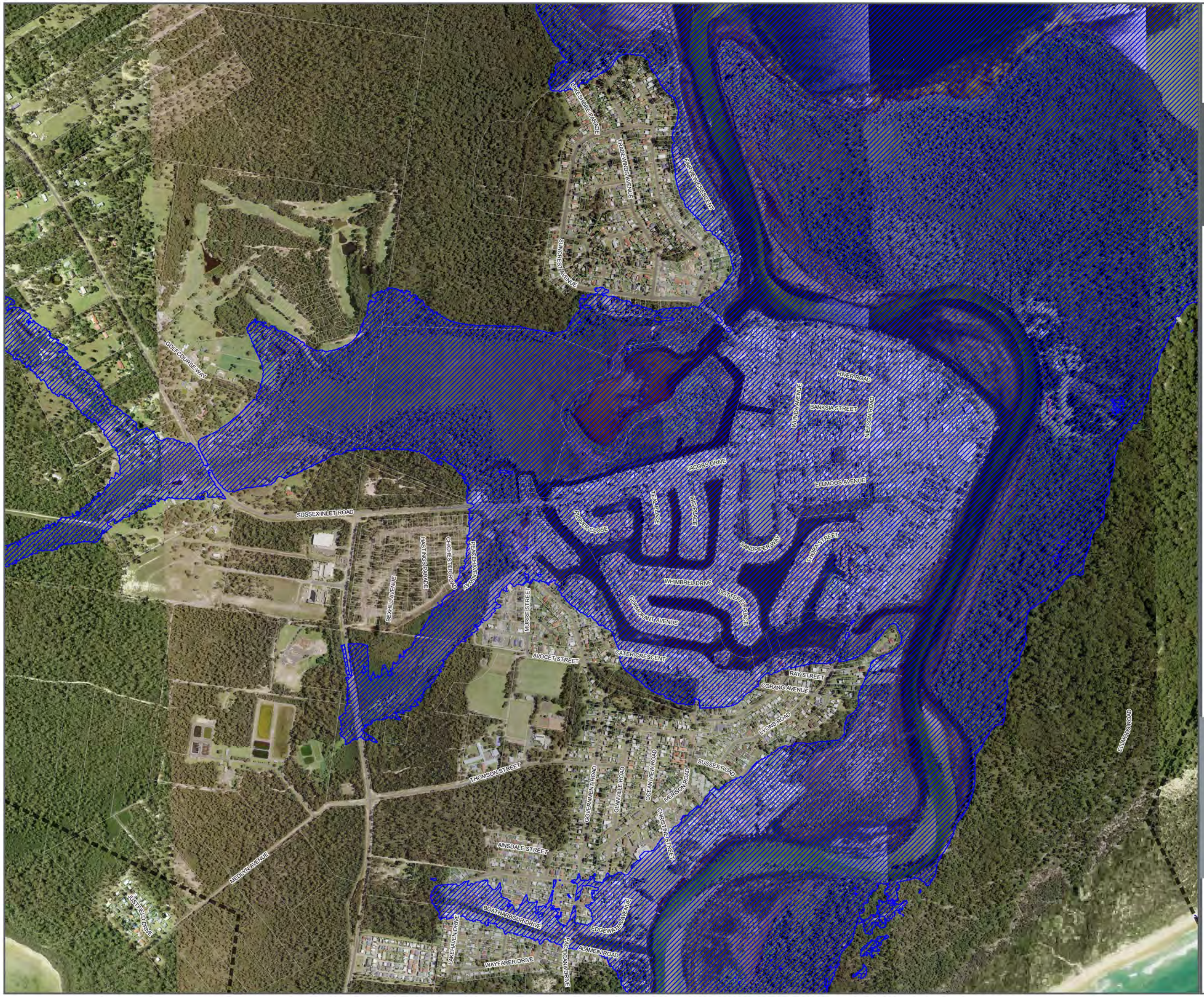
FIGURE I03

1:65,000 Scale at A3

0 700 1,400 2,100 2,800 3,500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2022-9-15| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Projected 2100 Flood Planning Area Sussex Inlet

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Flood Planning Area

FIGURE I03.1

1:13,000 Scale at A3

0 100 200 300 400 500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2022-9-15| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz

Projected 2100 Flood Planning Area Basin View

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Flood Planning Area

FIGURE I03.2

1:12,000 Scale at A3

0 100 200 300 400 500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2022-9-15| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz

Projected 2100 Flood Planning Area Sanctuary Point

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Flood Planning Area

FIGURE I03.3

1:15,600 Scale at A3

0 100 200 300 400 500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2022-9-15| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz

Projected 2100 Flood Planning Area Erowal Bay

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Flood Planning Area

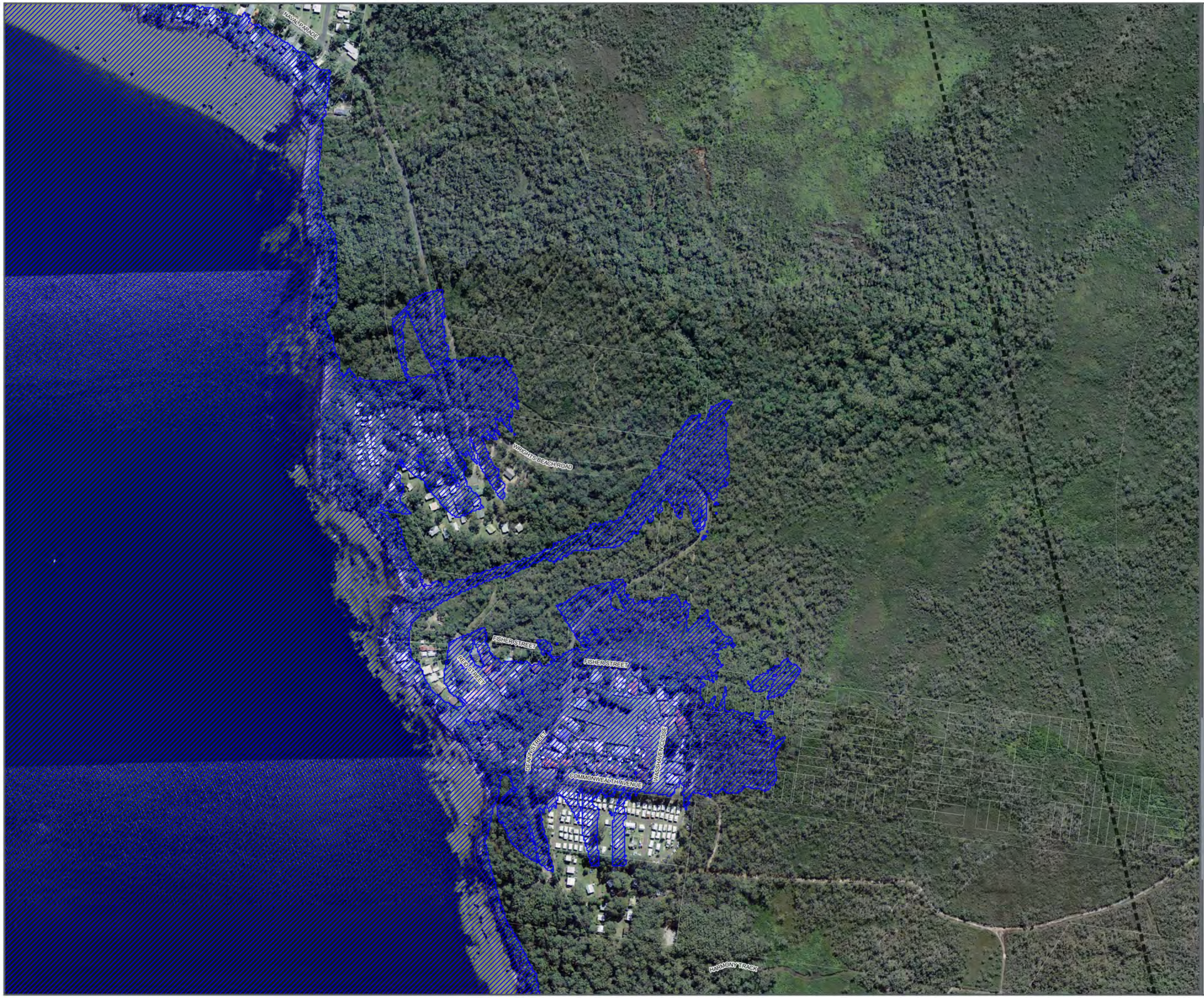
FIGURE I03.4

1:11,000 Scale at A3

0 100 200 300 400 500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2022-9-15| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Projected 2100 Flood Planning Area Wrights Beach

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Flood Planning Area

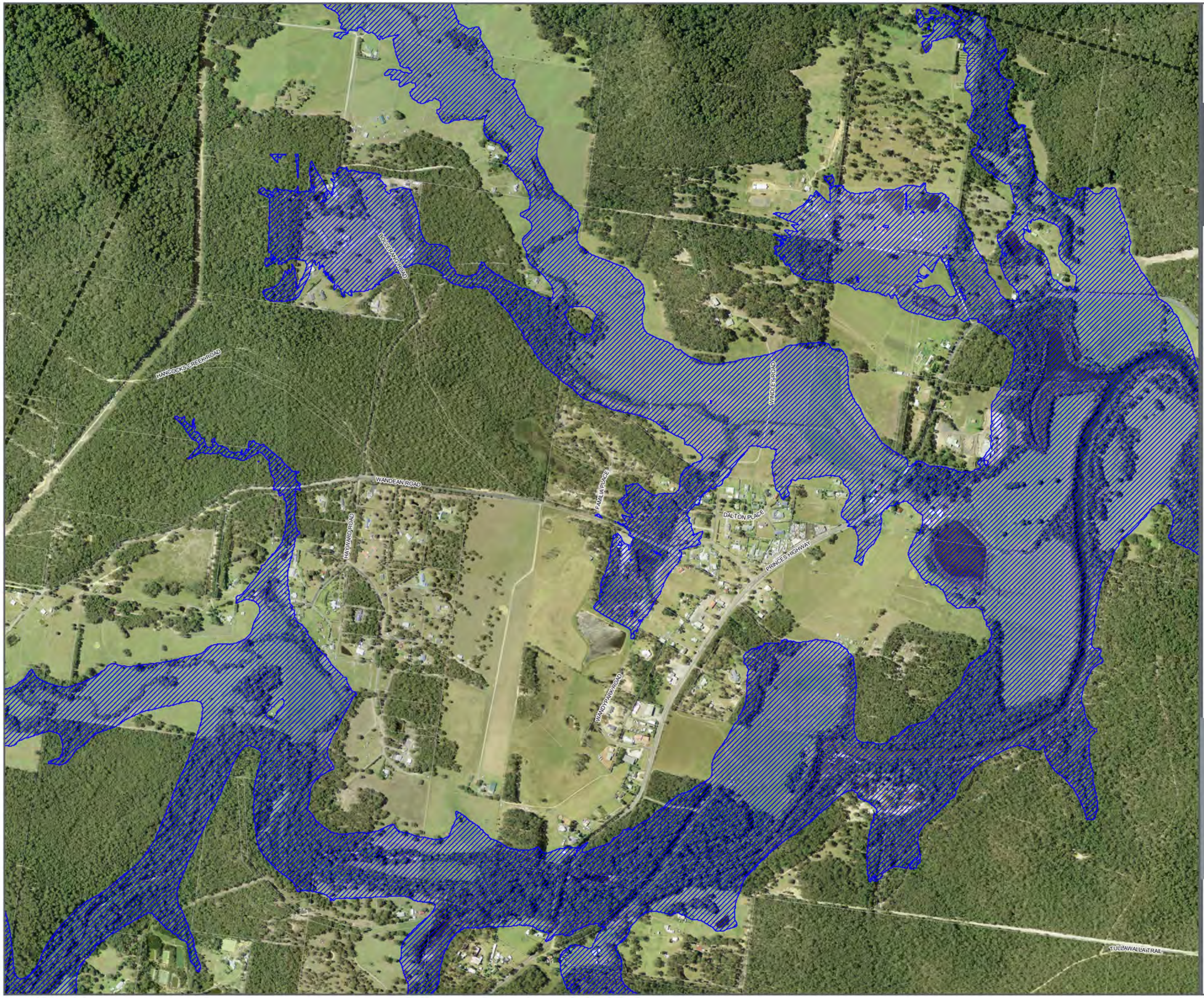
FIGURE I03.5

1:6,000 Scale at A3

0 70 140 210 280 350 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2022-9-15| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Projected 2100 Flood Planning Area Wandandian

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Flood Planning Area

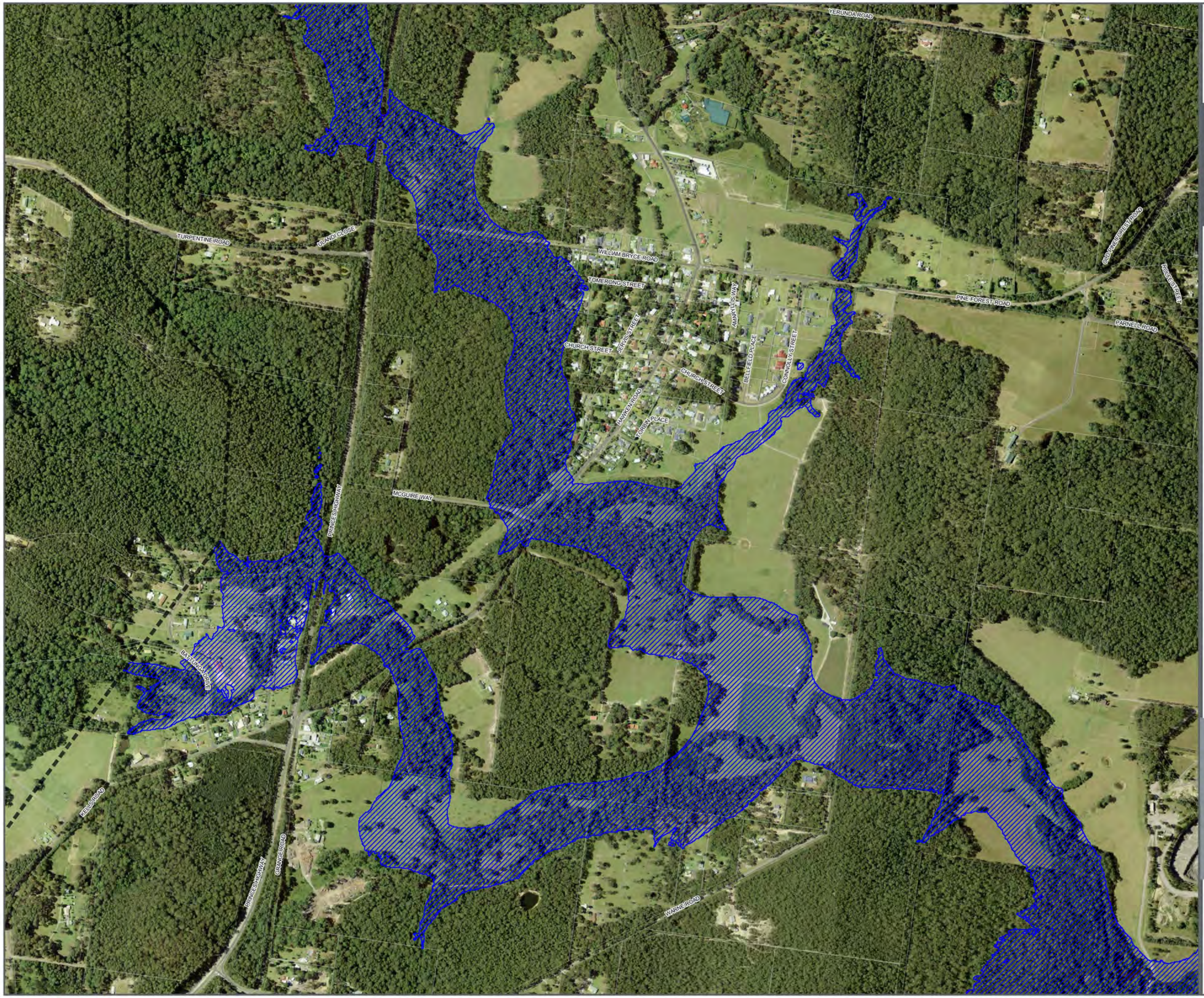
FIGURE I03.6

1:12,000 Scale at A3

0 100 200 300 400 500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2022-9-15| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz



Projected 2100 Flood Planning Area Tomerong

St Georges Basin Flood Study

Legend

- Cadastre (NSW Spatial Services, 2019)
- Hydraulic Model Boundary
- Flood Planning Area

FIGURE I03.7

1:11,000 Scale at A3

0 100 200 300 400 500 m

Cardno

Map Produced by Cardno NSW/ACT Pty LTD (NatW&E)
Date: 2022-9-15| Project: 59918099
Coordinate System: MGA Zone 56
Map: 59918099_SGB_Flood_Maps_v2.qgz