River Clyde Flood Mapping Study

Central Highlands Council

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GHD Pty Ltd | ABN 39 008 488 373

2 Salamanca Square,

Hobart, Tasmania 7000, Australia

T +61 3 6210 0600 | **F** +61 3 8732 7046 | **E** hbamail@ghd.com | **ghd.com**

Executive Summary

The primary objective of the project was to provide informed recommendations to better manage floodwaters which will aid in preparing the community, service providers, and emergency management responses in the event of flooding. The project aligns with the objectives of the National Disaster Risk Reduction Framework and aims to reduce the risk and increase the long-term resilience of the community against disruption or disaster arising from flood.

The flood study, modelling, and mapping included landowner and community consultation to inform the community of flood risk and gain knowledge from the community on key social and physical infrastructure that should be protected or improved in the event of flooding. This will aid in better understanding floods, preparing and responding to them. The study will also assist the council to make informed decisions regarding capital works expenditure, land use planning, and future-proofing rural communities. It will empower the community and reduce the sense of isolation and vulnerability that can be caused during floods or while waiting for flood damage to be repaired.

The project involved partnerships across the three levels of government, private landowners, and the private sector to align with the procedures of the State Emergency Services, council emergency management policies and procedures. Overall, this project will assist to build a more resilient community, build confidence and trust in the council, encourage further investment in the Bothwell township and surrounding areas, and help in better managing floodwaters.

To achieve these objectives, the project team conducted a technical investigation of flood behaviour in the Bothwell township and River Clyde catchments, analysing local flood history and available collected flood data, developing hydrologic and hydraulic models, calibrating, and verifying the models against historic flood events/gauges, and estimating the full range of flood behaviour in the study area.

The study area was focused on the Bothwell township and nearby community at Nant Lane. Potential mitigation measures have been identified for further investigation, which may assist to reduce flood risk in the study area.

This report is subject to, and must be read in conjunction with, the limitations set out in section 1.2 and the assumptions and qualifications contained throughout the Report.

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1. Introduction

Central Highlands Regional Council (Council) has received the financial support from the Australian Government program of Department of Industry, Science, Energy and Resources (the department), to identify flood behaviour through rigorous data collection and modelling to inform investment decisions, infrastructure upgrades, industry development and community education to reduce the financial and social impacts of future flooding.

The grant application objective is to map the River Clyde flood plain in the township of Bothwell and surrounding area. The study shall provide a series of informed recommendations to better manage flood waters. This will better prepare the community, service providers and emergency management responses in the event of flooding.

1.1 Purpose of this report

The purpose of this report is to outline the works undertaken as part of the River Clyde Flood Mapping Study (the Project) including information gathered, land use planning analysis, community consultation, hydrologic analysis and natural values assessment. The assessment of flood management and mitigation options is described.

1.2 Scope and limitations

The scope of the Project included the following:

– Data Collection
– Site Investigation
– Land Use Planning Analysis
– Community Consultation
– Hydrologic & Hydraulic Analysis; and
– Natural Values Analysis.

The following limitations apply to the River Clyde Flood Mapping Project:

– The study is limited to the Bothwell township and River Clyde catchments and may not provide relevant information for other areas.
– The study is based on the available information and data, which may not be complete or accurate.
– The study is limited by the accuracy of the models used and the assumptions made during their development.
– The results of the study should be interpreted in the context of the limitations of the data and models used.
– The study may not reflect the full range of flood behaviour and potential impacts in the study area, particularly in rare and extreme flood events.
– The study includes limited implementation of flood mitigation measures, which may be necessary to reduce flood risk in the study area.

This report has been prepared by GHD for Central Highlands Council and may only be used and relied on by Central Highlands Council for the purpose agreed between GHD and Central Highlands Council as set out in section 1.1 of this report.

GHD otherwise disclaims responsibility to any person other than Central Highlands Council arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section 7 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared the River Clyde Model ("Model") for, and for the benefit and sole use of, Central Highlands Council to support flood risk assessment and must not be used for any other purpose or by any other person.

The Model is a representation only and does not reflect reality in every aspect. The Model contains simplified assumptions to derive a modelled outcome. The actual variables will inevitably be different to those used to prepare the Model. Accordingly, the outputs of the Model cannot be relied upon to represent actual conditions without due consideration of the inherent and expected inaccuracies. Such considerations are beyond GHD's scope.

The information, data and assumptions ("Inputs") used as inputs into the Model are from publicly available sources or provided by or on behalf of the Central Highlands Council, (including possibly through stakeholder engagements). GHD has not independently verified or checked Inputs beyond its agreed scope of work. GHD's scope of work does not include review or update of the Model as further Inputs becomes available.

The Model is limited by the mathematical rules and assumptions that are set out in the Report or included in the Model and by the software environment in which the Model is developed.

The Model is a customised model and not intended to be amended in any form or extracted to other software for amending. Any change made to the Model, other than by GHD, is undertaken on the express understanding that GHD is not responsible, and has no liability, for the changed Model including any outputs.

GHD has prepared this report on the basis of information provided by Central Highlands Council and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

Accessibility of documents

If this report is required to be accessible in any other format, this can be provided by GHD upon request and at an additional cost if necessary.

1.3 Assumptions

Assumptions for the hydrological study of the River Clyde Flood Mapping Project are as follows:

- The flow of the River Clyde is free from significant blockages in the study area.
- The historical flood events and data collected accurately represent the flood behaviour in the study area.
- The flood mapping project assumes that historical flood events and gauges data is an accurate representation of the current flood behaviour in the study area.
- The flood mapping project assumes that no significant changes occur in the study area's physical characteristics during the study period, such as changes in land topography, land use, urbanisation, or deforestation.
- The study assumes that the data collected for the analysis is reliable and sufficient to produce accurate results.

2. Overview

2.1 Flood Study

The study was overseen and guided by Council. Other agencies were also consulted as described in the *Consultation and Engagement Summary Report* (GHD, 2023). For the full *River Clyde Flood Mapping Study Consultation and Engagement Summary* please refer to Appendix H of this report.

This project involved conducting a flood study, which is a comprehensive technical investigation of flood behaviour that provides the main technical foundation for the development of a floodplain risk assessment. It aims to provide an understanding of the full range of flood behaviour and flood hazard in the study area. It involved consideration of the local flood history, available collected flood data, and the development of hydrologic and hydraulic models. The model was verified against historic flood events and gauge data and then extended to estimate the full range of flood behaviour.

The overall project seeks to provide an understanding of, and information on, flood behaviour and associated risk to inform:

– relevant government information systems,
– government and strategic decision makers on flood risk,
– flood risk management and planning for existing and future development, and
– other key stakeholders (including utility providers and the insurance industry) on flood risk.

The outputs of the study will be able to assist by providing a better understanding of the variation in flood behaviour, flood function, flood hazard and flood risk in the study area. This will facilitate information sharing on flood risk across government and with the community.

The study focuses on the River Clyde catchment and the town of Bothwell, with a particular emphasis on the impact of development in the area and the risk of flooding. The study includes consideration of the current land uses in the catchment, the population density, and the plans for future development in the area.

2.2 Study Area

Bothwell is a town located in the Central Highlands of Tasmania. It is situated approximately 66 kilometres south-west of Hobart and 63 kilometres north-east of Launceston. The town is situated on the banks of the River Clyde, which is the main source of water for the town and the surrounding areas.

The major hydrological features in the River Clyde catchment area include two significant storages, Lake Sorell and Lake Crescent, River Clyde tributaries, and the various dams and irrigation infrastructure in the area.

The study area is located in the central part of the River Clyde catchment area, in the vicinity of Bothwell. The extent of the study area can be seen in Figure 1 below.

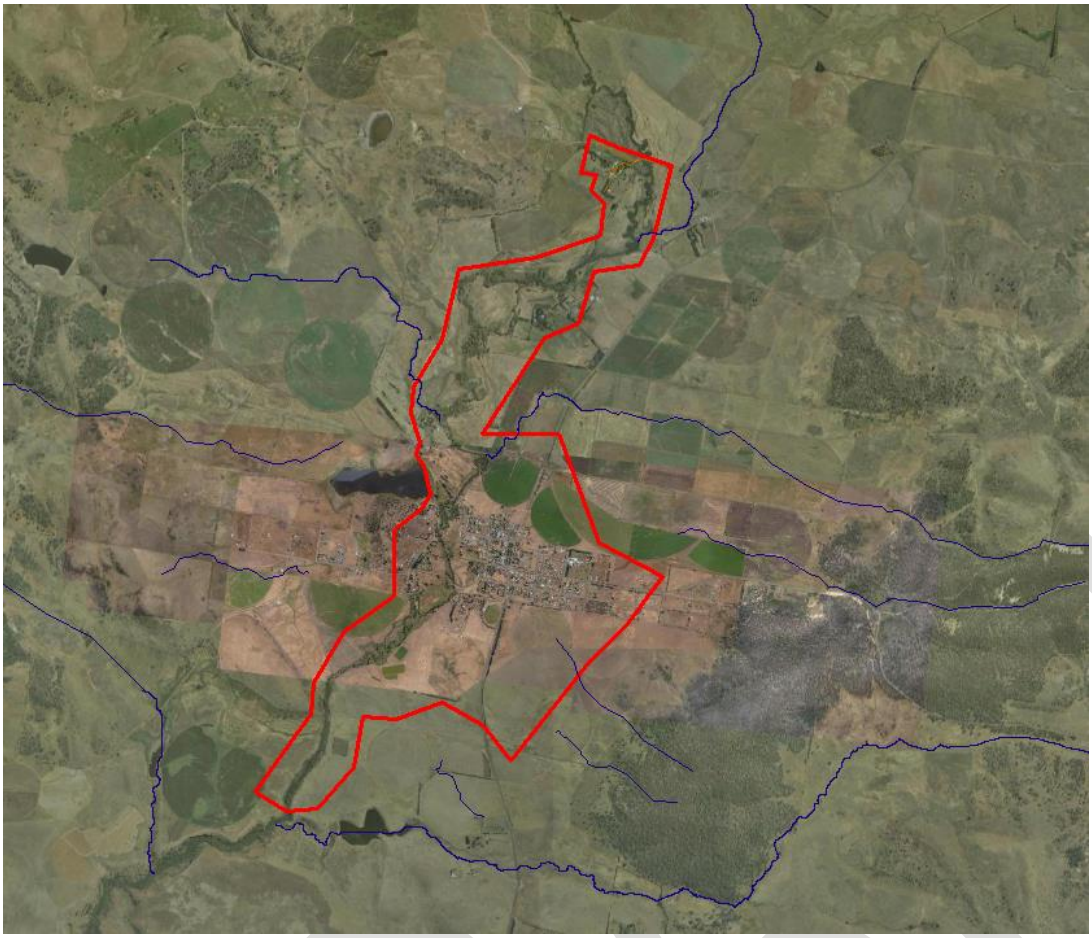


Figure 1 Flood Modelling Area

Flooding has been a major issue in the River Clyde catchment area in the past. Floods in the River Clyde catchment have had significant impacts on local communities, causing damage to infrastructure, homes, and businesses. Some of the most notable flood events in the River Clyde area include:

- 2011 floods: In January 2011, following heavy rainfall the River Clyde catchment experienced severe flooding. The floods caused widespread damage to roads, bridges, and homes, and disrupted essential services such as power and water supplies.
- 1960 floods: The 1960 floods in the River Clyde catchment were caused by heavy rainfall. The floods caused significant damage to homes and infrastructure and disrupted essential services such as power and water supplies.
- 1929 floods: The 1929 floods in the River Clyde catchment were some of the worst in Tasmanian history. The floods caused widespread damage, with the town of Bothwell being particularly affected. Homes, businesses, and bridges were destroyed, and many people were left homeless.
- 1905 flood: Between 30th and 31st of May, floods were recorded at Bothwell, River Clyde;
- 1903 flood: Between 8th and 9th of June, there is heavy flooding in the Clyde and Lachlan rivers. Much of the country around Bothwell, Ratho, and Hamilton is inundated.
- 1901 flood: On 28th of October, the River Clyde floods at Bothwell.
- 1880 flood: between 2nd and 4th of August, flooding about southern Tasmania. At Bothwell, the River Clyde was reported to be at its highest level for some years.
- 1869 flood: January 25th, streets flooded in Bothwell.

The River Clyde catchment area is approximately 1,200 square km in size. The catchment includes the River Clyde, its tributaries, and several lakes and dams. The topography of the headwaters of River Clyde flow from

unglaciated dolerite plateau through the rolling hills and gentle valleys of the midlands. The soils in the area are predominantly deep and fertile, making them ideal for agriculture and other forms of land use.

There are several features that influence flooding in the River Clyde catchment area. These include the high rainfall in the area, the steep terrain, and the narrow valleys that can cause rapid runoff and flash flooding. Additionally, the flat floodplain areas are vulnerable to overflow during periods of heavy rainfall.

Development in the River Clyde catchment area is relatively sparse, with most of the land being used for agriculture or other forms of rural land use. However, there is some development pressure in the area, particularly in the town of Bothwell, where land has been zoned for residential and business purposes. This development pressure is significant as it could impact the natural hydrological systems in the area and increase the risk of damage or harm from flooding.

There are also several flood-dependent ecosystems in the River Clyde catchment area, including wetlands, which play an important role in reducing the impact of flooding by providing areas for water to accumulate and be slowly released. The preservation of these ecosystems is crucial for reducing the risk of flooding in the catchment area.

The River Clyde catchment area and the town of Bothwell are managed by the Central Highlands Council. The catchment is also under the jurisdiction of the River Clyde Trust, which was formed following an Act of Parliament initially passed in 1857. The River Clyde Trust works closely with the local council and other stakeholders to ensure that the area is managed in a sustainable manner.

The population of the River Clyde catchment area is relatively small, with the majority of residents living in the town of Bothwell.

The land uses in the River Clyde catchment area are primarily agricultural, with the majority of the land being used for farming and grazing. There are also some areas of forest and conservation land in the catchment. In the town of Bothwell, there is a mix of residential and commercial land use, with some areas designated for industrial use.

The flood behaviour in the River Clyde catchment area and the town of Bothwell is primarily riverine in nature. The catchment responds rapidly to rainfall, with flash flooding often occurring in the steep upper sections and narrow valleys. The flooding duration can range from a few hours to several days, depending on the severity of the event.

There are several flooding hot spots in the study area, particularly in the town of Bothwell and in low-lying areas near the River Clyde. These areas are subject to riverine flooding during periods of heavy rainfall.

Exacerbating factors for flooding in the study area include blockages in the River Clyde and its tributaries, antecedent conditions, and natural or constructed hydraulic controls, including dams and bridges. Tributary flooding can also coincide with riverine flooding, leading to increased water levels and flood risk in the catchment.

Frequently inundated areas in the catchment include low-lying farmland near the River Clyde, and areas in the town of Bothwell close to the river and its tributaries.

3. Data Collection

Data and information available from previous studies/flood events has been collated and examined. A search for any additional relevant data was performed. A summary of the sources of available data and relevance to the project is included below.

3.1 Sources of Data

The River Clyde catchment area has some history of hydrological data collection, with a variety of data sources available for modelling purposes. Some of the available data includes:

- Hydrological data: This includes daily rainfall data, streamflow data collected by the Bureau of Meteorology and the Department of Primary Industries, Parks, Water, and Environment.
- Geographical data: This includes topographical data, such as digital elevation models, land use maps, and soil type maps. These data are used to support the development of hydrological models and to understand the impact of land use on the catchment.
- Climate data: Climate data, such as daily temperature and rainfall data, are used to understand the climatic patterns in the catchment and to support the development of climate models.
- Management strategies: There is a Draft Amended River Clyde Water Management Plan 2017 (Altering the River Clyde Water Management Plan 2005) available for the River Clyde catchment. This strategy provides a policy relating to preserving water in extreme climatic conditions for environmental, economic and social needs and catchment management strategies.
- Flood history: There is some historical data available on flooding in the River Clyde catchment, including information on flood events, flood damage, and flood management strategies.
- Previous studies: This data is used to support the development of hydraulic models.

The available and compiled data is summarised below, along with organisations and relevant contacts.

Table 1 Summary of previous studies

Study name	Description (one paragraph summary)	Author	Year	Accessible
Stormwater Infrastructure Survey and Assessment of The Bothwell Township for Central Highlands Council	The Central Highlands Council required a Stormwater System Management Plan for the Town of Bothwell. There were no records of existing stormwater infrastructure in Bothwell. The project consultant was required to carry out works in two stages. In Stage A, PDA Surveyors located and surveyed existing stormwater infrastructure, prepared a GIS map of the urban area, reviewed flood studies and mapped stormwater catchments. In Stage B, PDA Surveyors liaised with Council staff, analysed infrastructure in critical areas, and prepared a concept design and construction estimates for proposed upgrading.	PDA Surveyors	2019	Electronic copy of the DRAINS model and report provided by Council
Tasmanian Strategic Flood Map Hydrology Methods Tasmanian Strategic Flood Map Hydrodynamic Methods	The Tasmanian Strategic Flood Mapping Project aimed to help flood-affected communities recover from the 2016 floods by improving the understanding of flood behaviour and increasing the resilience of Tasmanian communities to future floods. The project had targeted outcomes of ensuring that post-flood recovery is informed by updated flood risk information, allocating ownership of flood risk appropriately, enabling flood risk to be included in investment decisions, and allocating responsibility for flood mitigation costs appropriately. The state-wide Strategic Flood Maps are being developed to support flood risk assessment and post-event analysis using	WMA Water	2021	https://d2kpbjo3hey01t.cloudfront.net/uploads/2022/02/Tasmanian-Flood-Map-Project-Hydrology-Methods-Report.pdf https://d2kpbjo3hey01t.cloudfront.net/uploads/2022/03/Hydrodynamic-methods-report-Aug-21.pdf

Study name	Description (one paragraph summary)	Author	Year	Accessible
	the Innovyze ICM software platform, with hydrologic modelling methods developed in two platforms – WMA water's in-house RAFTS modelling framework and ICM. An established, automated approach using the external hydrologic model enabled the efficient calibration of the state-wide hydrologic models. Historical rainfall data were used to calibrate the hydrologic model, and catchment average initial and continuing loss values were calibrated at gauged sites.			
Derwent Catchment Review	Several organisations and agencies initiated the Derwent Catchment Technical Review project to manage water quality and quantity in the Derwent catchment. Previous reviews of water quality issues were integrated with contemporary datasets from the entire catchment to develop conceptual models. The project focused on reviewing existing water quality and stream-flow datasets to identify stressors, data gaps, and requirements for additional monitoring. Conceptual models were developed for waterways impacted by regulation and those with no modification to flow regime. The major outcomes were to assess the adequacy of existing monitoring, identify emergent water quality issues and provide recommendations for an integrated monitoring program for stakeholders.	TasWater Consulting Pty	2011	https://www.derwentestuary.org.au/assets/Derwent_Catchment_Review_2011_Part1.pdf

Table 2 Available and compiled existing data

Data type	Description	Source/agency	Year	Accessible
Historic flood information	TasMap 1:13,542	Thelist.tas.gov.au TASMAP	NA	https://maps.thelist.tas.gov.au/listmap/app/list/map
Hydrologic data Stream water level gauge	Station number: 54.1 Latitude: -42.38 Longitude: 147.00 Number of years: 44.10	TAS - Department of Primary Industries, Parks, Water and Environment		http://www.bom.gov.au/waterdata/
Survey data (Imagery/topographic DEMs)	Aerometrex was commissioned by Department of Primary Industries, Parks, Water and Environment DPIPWE to provide LiDAR coverage over Central Highlands. This project was flown in conjunction with other projects in the region. UDM was commissioned by Council to capture an imagery of high flow of River Clyde.	Derwent Valley 2019_DEM_1m_GDA2020_55 Imagery was obtained on 31 October 2022	2019 2022	https://elevation.fsdf.org.au/
GIS layers	The list databases, including building polygons, road polygons, land use etc.	TheList.tas.gov.com.au		https://maps.thelist.tas.gov.au/listmap/app/list/map

Table 3 Organisations with relevant existing data

Agency/office	Relevant contacts – name, email, phone	Comments
Bureau of Meteorology	Ann Conroy, ann.conroy@bom.gov.au	Rainfall data
SES Tasmania	Lynley Hocking, Lynley.Hocking@ses.tas.gov.au	SES Manning's data

3.2 Digital Elevation Model (DEM) Data

The Digital Elevation Model (DEM) with a 1m resolution was a crucial component of the project area to determine the elevation and bathymetry data. The data was obtained through a cloud-based system called Elvis Elevation and Depth, which provided quick and easy access to the DEM. The DEM was represented as a continuous surface of elevation values using a regular array of z-values, which were referenced to the GDA 2020 Zone 55 datum. The representation was in the form of a grid or raster data set, which made it possible to visualize the topographic surface.

However, the DEM only represented the ground surface and excluded features such as vegetation, trees, shrubs, and human-constructed features like sheds and houses. A high-level review of the original 1m DEM was carried out to ensure that the data quality was sufficient for the flood modelling process. The review was done to identify areas that could cause issues in the modelling process, but the data was found to be of sufficient quality to support the project's objectives.

3.3 Manning's n Data

The State Emergency Service (SES) has provided a statewide Manning's 'n' layer. The data was supplied in a raster format and is based on the methodology outlined in the *Statewide Manning's Layer DocumentationV2.docx*. This documentation outlines the process used to determine the suggested Manning's 'n' values, which were ultimately adopted for the project. The results of this process are presented in Table 4. The data was reviewed and found appropriate for use from both technical and consistency aspects. Adoption of this data has also allowed the modelling team to spend additional time in other aspects of the model without loss of accuracy.

Table 4 Surface-type classes with suggested Manning's-n values

ID	Group	n_2	DESCRIPTION
1	Rural&Forested	0.020	mown or well grazed 0.05 stubble and low undulations
2	Rural&Forested	0.030	mixed areas of slashed/grazed grassland with some shrubs and/or taller grass clumps
3	Rural&Forested	0.040	tall stiff grass with significant areas of clumped shrubs
5	Rural&Forested	0.050	moderate density little underbrush typically easy to walk thru off track
7	Rural&Forested	0.100	High density substantial underbrush and fallen limbs typically cannot walk thru off track
8	Rural&Forested	0.050	Low density mod height shrubs foliage from ground some gaps between
11	Roads	0.020	roads/parking areas - mostly free of parked vehicles
12	Roads	0.035	roads/parking areas - significant number of parked vehicles present
13	Roads	0.035	roads/parking areas - roads with side veg swales - few parked vehicles
16	Residential	0.050	low density typically large blocks with small dwelling footprint significant grassed yard and open fences
17	Residential	0.100	average density some solid fences

ID	Group	n_2	DESCRIPTION
18	Residential	0.200	typically, smaller blocks with large dwelling footprint small yards and frequent solid fences
19	Residential	0.150	where dwelling is modelled as a solid - mostly solid fences perpendicular to flow
23	Commercial	0.100	small building footprint significant paving mostly permeable fences
26	Commercial	0.150	where building is modelled as solid - Stored matl/cars and mostly solid fences perp to flow
27	Commercial	0.040	where building is modelled as solid - mostly free of solid fences and stored matl/cars
28	Industrial	0.050	low density small building footprint significant paving and permeable fences
29	Industrial	0.100	average density 30% footprint some solid fences
34	Waterways	0.011	concrete lined channel
35	Waterways	0.013	flat variable grade sandy bed low undulations no instream vegetation - typically estuary and/or lake
37	Waterways	0.035	uniform bed grade and section little instream vegetation
47	Miscellaneous	1.000	nom 1% permeability modelled as n =100*0.100

3.4 Structures Data

The infrastructure data set was obtained from the PDA Surveyors DRAINS model which was conducted in 2019. The DRAINS data included information about the pipes, pits, manholes, and culvert inlets/outlets in the Bothwell township. The extracted data was then transferred into a GIS data set and imported into InfoWorks ICM.

After a thorough evaluation, the data was found to be of sufficient quality to support the desired analysis and modelling needs.

This data set provided the invert level and pipe diameters of the various pipes and other infrastructure components. Additionally, the data also included important information such as the location, type, and material of the pipes, pits, manholes, and culvert inlets/outlets. This data set is crucial in providing a comprehensive understanding of the drainage infrastructure in the Bothwell township. The invert level and pipe diameter information were used in determining the flow capacity and hydraulic performance of the drainage system.

3.5 Initial and Continuing Losses

In hydrology, initial losses (IL) and continuing losses (CL) are two important parameters used in the rainfall-runoff modelling process. Initial losses represent the amount of rainfall that is lost to infiltration and evaporation before any runoff is generated, while continuing losses represent the amount of water that is lost due to evapotranspiration after runoff has begun. In this study, the initial and continuing losses were extracted from the ARR 2019 data hub and adopted for the modelling process. provides the values of initial and continuing losses for each sub-catchment in the study area. These values were used in the RAFTS runoff-routing model to simulate the runoff generation process and estimate the flow volumes and peak flows for different rainfall events.

Table 5 Initial and Continuing Losses

Land Use	IL (mm)	CL (mm/h)
Impervious	0.0	0.0
Low Density Residential	8.9	3.9
Environmental Management	8.9	3.9
Significant Agricultural	8.9	3.9
Rural Resources	19.9	4.9

Land Use	IL (mm)	CL (mm/h)
Rural Living	0.0	0.0
Community Purpose	8.9	3.9
Village	8.9	3.9
Open Space	19.9	4.9
Recreation	19.9	4.9
Utilities	0.0	0.0

3.6 Building Footprints

In the development of the hydraulic model for this project, the buildings within the study area were not raised on the DEM. This is because the focus was on identifying the areas that are most at risk of flooding and developing appropriate mitigation strategies rather than on accurately modelling every building within the study area rather than introducing a solid obstruction to the flow of water and therefore significantly alter the velocity and direction of the water.

However, it is important to note that the increased height of the buildings can have an impact on flood behaviour. Specifically, the increased height of the buildings can cause an increase in the floodplain extent, meaning that more areas will be affected by floodwaters. Additionally, the increased height of the buildings may also lead to changes in the water depth at specific locations, which can impact the severity of the flood in those areas. Therefore, while the buildings were not raised on the DEM for the purposes of the hydraulic model development, it is important to consider the potential impact of the buildings on flood behaviour and to incorporate this information into any flood mitigation strategies developed as a result of this project.

3.7 Site Visits

During the initial stages of any project, it was critical to gain a comprehensive understanding of the study area. The project team undertook a field inspection of the study area to gain an understanding of the catchment and floodplain features that may influence flood behaviour. This included topography, land use, vegetation cover, and watercourses. The aim of this familiarisation exercise was to identify potential sources of flooding, such as low-lying areas, drainage systems, and infrastructure that could exacerbate flood risk.

In addition, the project team liaised with the local council and landowners to gain a better understanding of flood behaviour, existing flood mitigation controls, and how they operate. This included a visit to Thorpe Farm, where the team liaised with the landowner to understand the current flood mitigation measures in place. This included levees, flood walls, drainage systems, and other infrastructure that is designed to manage flood risk.

The findings from the field inspection and familiarisation exercise informed the development of the hydrologic and hydraulic model. This model enabled the project team to simulate flood behaviour under different scenarios and identify potential interventions that could mitigate flood risk. By incorporating data on existing flood mitigation measures into the model, the team was able to determine the effectiveness of these measures and identify areas for improvement.

Overall, undertaking a field inspection and familiarisation exercise was crucial in the initial stages of a flood management project. It enabled the project team to gain a comprehensive understanding of the study area and identify potential sources of flooding. Incorporating data on existing flood mitigation measures into the hydrologic model enabled the team to determine the effectiveness of these measures and identify opportunities for improvement.

4. Flood Model

4.1 Model Setup

4.1.1 InfoWorks ICM

The hydraulic model was set up using the InfoWorks ICM 2023.1.

InfoWorks ICM is a powerful hydraulic modelling software tool that is widely used in the water industry. It is reasonably user-friendly, and its features enable users to create accurate hydraulic models of complex stormwater systems. The latest version, InfoWorks ICM 2023.1, has several enhancements, including improved modelling of urban network, better visualization of model results, and a more user-friendly interface.

Setting up the hydraulic model using InfoWorks ICM 2023.1 involved creating a digital representation of the stormwater system, defining the hydraulic characteristics of the system components, and running simulations to analyse system behaviour under different scenarios. This included analysing the impact of rainfall events on flood risk.

One of the key advantages of using InfoWorks ICM is its ability to integrate with other software tools, enabling users to import and export data from other sources, including GIS software, AutoCAD and other hydraulic modelling software. This integration makes it easier for users to incorporate different data sources into the model and ensures that the model reflects the most up-to-date information about the stormwater system.

4.1.2 RAFTS Hydrology

The RAFTS model is an ideal choice for the rainfall-runoff modelling required for this project. This non-linear runoff-routing model has been extensively used throughout Australia and has been found to be suitable for both rural and urban catchments. The model works by dividing each sub-catchment into pervious and impervious portions, each of which is treated as a cascading non-linear storage unit with a specific relationship. The sub-catchment parameters for the RAFTS model are inputted by specifying different land use types and their associated surface runoff types. This allows for the model to account for the varying levels of infiltration and runoff depending on the type of land use within the catchment. By using this model, we can accurately simulate the movement of rainfall through the catchment, and how it is transformed into surface runoff, groundwater recharge, and evaporation. The results of this modelling will be critical in assessing the flood risk within the study area and developing appropriate mitigation measures.

4.1.2.1 Catchment Delineation

Catchment delineation is a key step in hydrological modelling as it involves identifying the boundaries of the catchment areas that drain water to a specific point. In this case, the digital elevation model (DEM) data was used to perform catchment delineation using ArcMap software's Hydrology toolset. This toolset is a mathematical algorithm that uses ground elevations and slopes to estimate flow path lengths, directions, and sub-catchment boundaries.

The results of the catchment delineation are presented in **Error! Reference source not found.**, which shows the catchment areas and slope for each catchment. The sub-catchment boundaries resulting from the application of the ArcMap Hydrology toolset are shown in Figure 2. However, the additional manual checks and reviews of the catchment boundaries were carried out during hydraulic model development to verify ArcMap's delineation and to identify any connections to additional sub-catchments through cross-drainage structures.

Hydraulic modelling involves simulating water movement in a catchment area, and accurate catchment delineation is crucial in developing a reliable hydraulic model. The verification of the catchment boundaries through manual checks and reviews helps to ensure that the hydraulic model accurately represents the catchment's actual characteristics. This further enhances the reliability and accuracy of the model, and ultimately the flood risk assessment or management plan that is based on it.

Table 6 Catchment area and slope

Catchment ID	Area (ha)	Slope (m/m)
1	555	0.044
213	4136	0.117
211	1077	0.117
3	6052	0.426
4	2257	0.117
5	8017	0.088
6	5101	0.290
7	28	0.012
8	87	0.068
9	218	0.056
10	314	0.038
212	617	0.041
12	99	0.043
214	492	0.006
215	855	0.006
216	5525	0.076
16	6552	0.111
17	3873	0.140
18	2488	0.033
19	7385	0.192
20	4507	0.231
21	9477	0.176

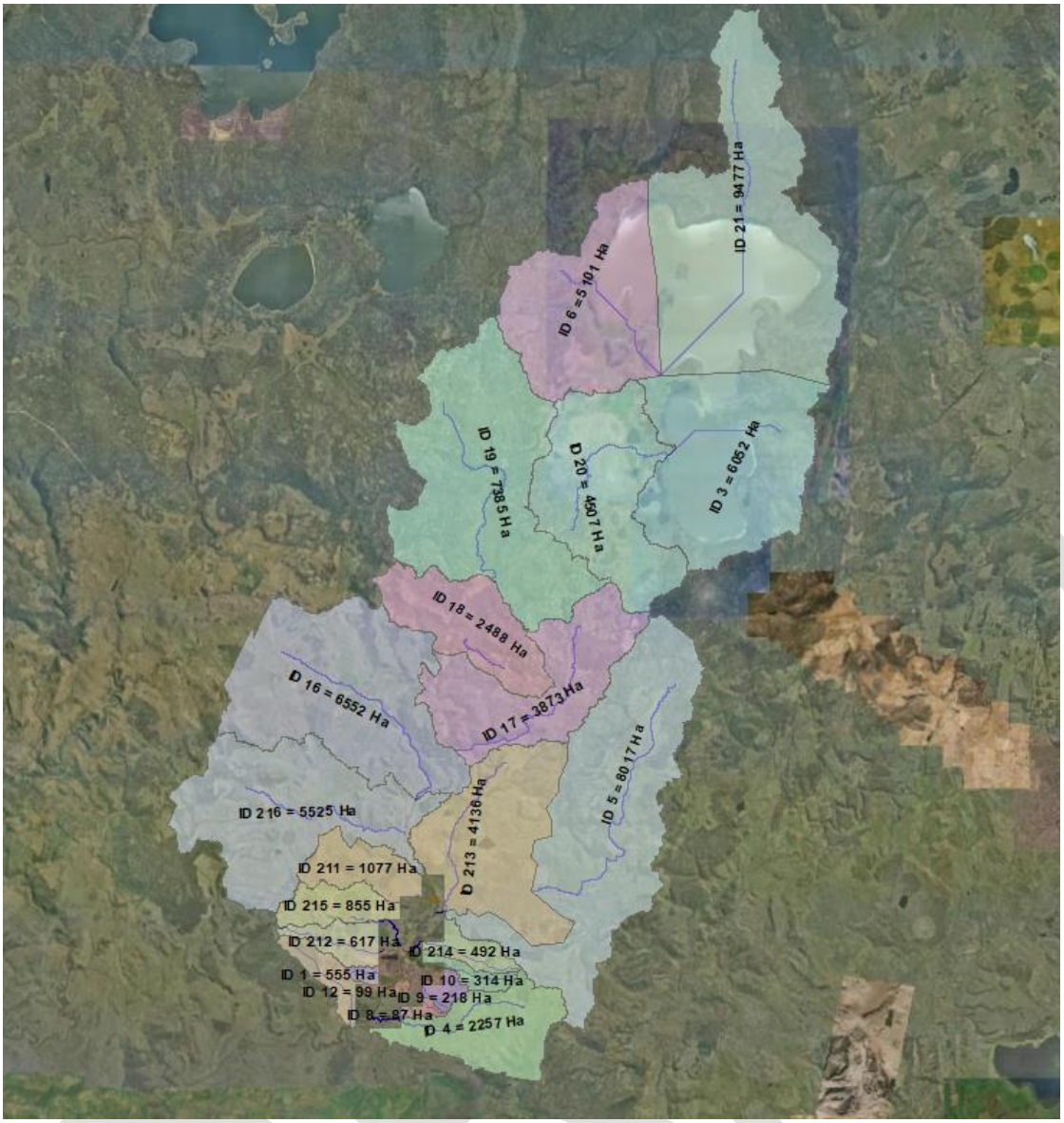


Figure 2 Sub-catchment delineation map

The outflows from the Hydrology model flow directly into the Hydaulic model (refer section 4.1.3 below).

4.1.3 Hydraulic Model

4.1.3.1 Topography

In order to develop an accurate hydraulic model, it is essential to have an accurate representation of the topography of the study area. A Digital Elevation Model (DEM) is a widely used tool for creating a detailed representation of the terrain. In this case, a 1m DEM was adopted to develop the baseline topography for the InfoWorks ICM model.

The review of Elvis's DEM has highlighted no issues within the study area, indicating that the data is of high quality and suitable for use in developing the hydraulic model. This is crucial because any errors or inaccuracies in the topography data could have a significant impact on the model's accuracy and reliability.

The topography within the agreed project area is represented as a 2D element mesh model. The mesh is a set of interconnected elements that represent the terrain's surface in a digital format. Water flows according to the hydraulic properties of the land surface, as defined by the 2D topography and roughness. The roughness values are assigned to the mesh elements to represent the land surface's resistance to flow, which affects the velocity and direction of water movement.

By adopting a high-quality DEM data and creating an accurate 2D topography model, the hydraulic model can accurately simulate the water movement in the study area. This enables the development of effective flood management strategies and decision-making processes based on reliable data.

4.1.3.2 Mesh Size

To accurately simulate the behaviour of water in the study area, the project team has decided to apply the rain on grid model to the 2D mesh within the agreed project area. The 2D mesh of elements provides a more detailed overland flow analysis and is generated using the Shewchuk Triangle meshing functionality. Heights at the vertices of the generated mesh elements are calculated by interpolation from the ground model by Elvis DEM. This approach applies rainfall directly to each cell of the 2D mesh model, and after losses are accounted for, the excess rainfall becomes runoff and is routed over 2D surfaces per 2D zone settings.

The 2D surface runoff can flow out of 2D zone boundaries or be captured by 1D elements to enter 1D networks. The InfoWorks ICM software allows for a varying mesh size, and the project team has incorporated mesh sizes ranging from 100 m^2 to 50 m^2 for the model base, and 25 m^2 to 5 m^2 for Township Bothwell and Nant Lane. The proposed mesh cell size is considered suitable to properly represent all the key topographic and land use features of the study area, without significantly impacting the expected simulation run times.

The use of the rain on grid model in the 2D mesh allows for a more accurate representation of how rainfall and runoff behave in the study area, taking into account the land surface's hydraulic properties and roughness values. By applying rainfall directly to each cell of the 2D mesh model, the model can account for spatial variability in rainfall and simulate the movement of runoff over the terrain's surface. The incorporation of varying mesh size ensures that key features are captured within the model, providing a more accurate representation of the study area's behaviour.

Figure 3 Example of various mesh elements within the project area

4.1.3.3 Linear Infrastructure

Linear Infrastructure (pits, pipes, and channels) have been modelled as 1D elements coupled to the 2D hydraulic model. This approach allows flow interchanges between the 1D open channels and underground pipelines and the 2D surface. The hydraulic model elements are shown in Figure 4 - Figure 7.

The 1D conduit network model is used to simulate the hydraulic processes in the stormwater network. The network has been developed to a high level of detail and includes the stormwater drainage conduits, pipes, manholes and pits in the project area that could be identified from the PDA Surveyors DRAINS model provided by Council.

Figure 4 Bothwell Township

Figure 5 Bothwell Bridge

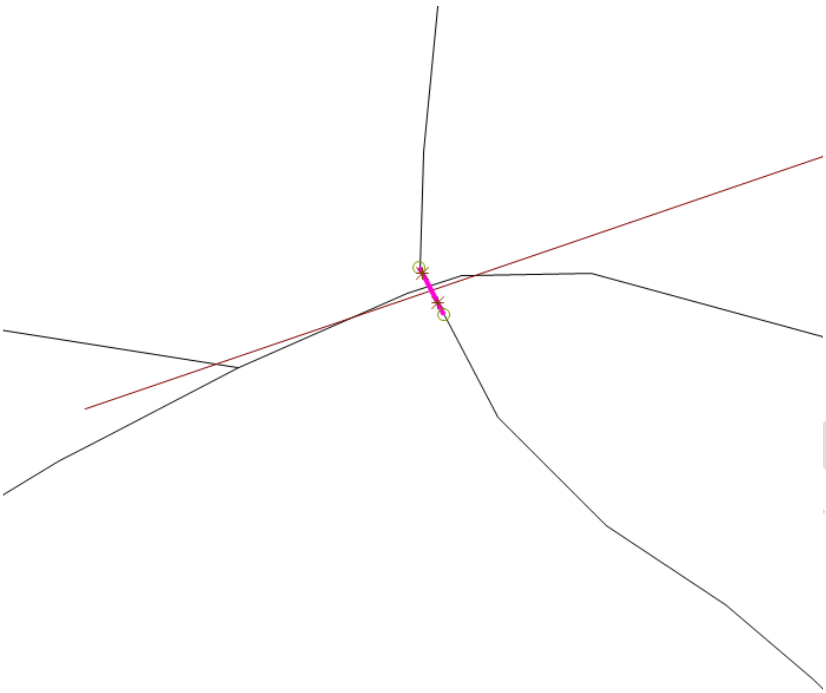


Figure 6 *Nant Lane Bridge*

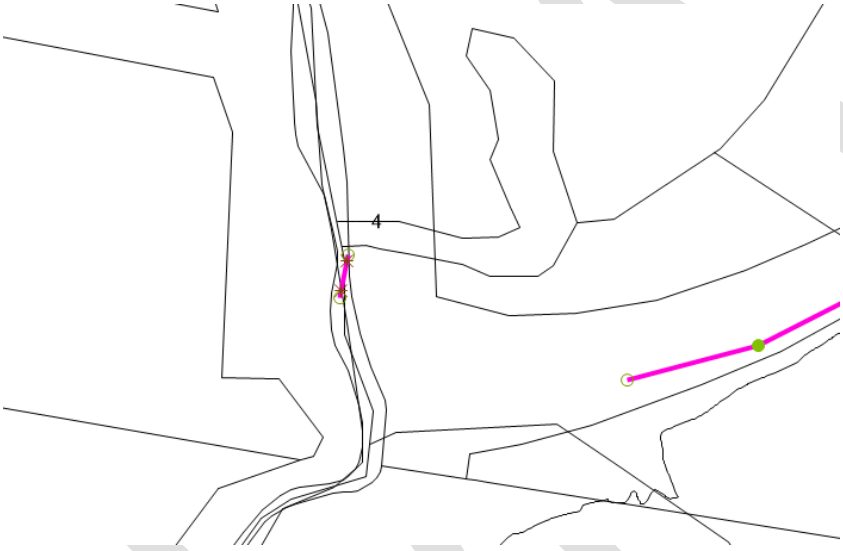


Figure 7 *Arthur Crescent Bridge*

4.1.4 Model Domain Linkages

The River Clyde hydraulic model is a complex system used to simulate the flow of water in the urban and rural domain of River Clyde catchments. It consists of three different model domains, each with their own unique characteristics and properties. The first domain is the 1D conduit network, which includes a network of pipes and conduits that carry water through the system. The second domain is the 1D sub-catchment network, that collect water from the surrounding area and feed it into the 1D conduit network and 2D surface of the model. The third domain is the 2D surface, which represents the surface of the river and the surrounding area.

In this model, flow is transferred between all three domains in all directions, allowing for a comprehensive understanding of how water moves through the system. To model the connections between the conduit network and the open channel, an approach called ‘Outlet 2D’ is used, which specifies the conduit diameter as the width

and height. This method allows the model to convey water between a conduit invert and open channel bed level while remaining stable.

When the conduit network discharges directly into the upstream end of a 1D channel network, a 2D node is used to connect the downstream end of the conduit link to the upstream end of the open channel. In this case, flow across 'Outfall 2D' nodes are calculated using a vortex control with a nominal head discharge relationship.

Finally, when a node is located beneath a road, the nodes 'Flood Type' is set to 'Sealed', preventing the exchange of flow between the 2D model and the 1D pipe network. This allows the model to accurately simulate the effects of road infrastructure on water flow and to predict potential flooding in these areas.

4.2 Design Event Simulations

As per the agreed scope of work, we simulated 1% and 5% AEP events in the hydraulic analysis. The study primarily focused on the overland flow paths, and therefore, the design event analysis was initially focused on durations ranging from 15 minutes to 36 hours. In accordance with the ARR 2019 guidelines, we ran ten temporal patterns per each duration in the hydraulic model. This approach allowed us to account for the variability in rainfall distribution that may occur during a storm event and ensure that the temporal patterns used in the analysis were appropriate for the specific catchments being studied.

Based on the results of this analysis, the critical duration for the area was determined to be a 6-hour storm, with the 6th and 2nd temporal patterns identified as the critical temporal patterns. This information is necessary in developing an effective flood mitigation strategy for the area, as it enables to design infrastructure that can handle the maximum amount of runoff that may occur during a 6-hour storm event. By following the guidelines set out in the ARR 2019 and using a range of temporal patterns in the hydraulic model, we were able to develop an accurate analysis of the catchment's response to rainfall.

The flood inundation extents and depths for 1% and 5% AEP is shown in Appendix A (at the time of peak flood level).

4.3 Sensitivity Tests

The sensitivity tests aimed at estimating the effects of the model parameters on the computed flood levels was performed on the single probability (5% AEP) design event only.

The sensitivity tests on model parameters were performed on one (1) selected critical duration and one (1) selected temporal pattern. The selected critical duration and temporal pattern was 5% AEP 6 hour 2.

As per our proposal, we carried out sensitivity tests on the following model parameters:

– Manning's roughness coefficients: an increase/decrease of ± 20% in the Manning's 'n' roughness coefficients of the hydraulic model.

The initial (IL) and continuing (CL) losses adopted for this study and provided in **Error! Reference source not found.**.

Table 7 ± 20% in the Manning's 'n' roughness coefficients

(ID) Land-use category	Roughness coefficients	Manning's 'n' roughness +20%	Manning's 'n' roughness -20%
1 Rural&Forested	0.020	0.024	0.016
2 Rural&Forested	0.030	0.036	0.024
3 Rural&Forested	0.040	0.048	0.032
5 Rural&Forested	0.050	0.060	0.040
7 Rural&Forested	0.100	0.120	0.080
8 Rural&Forested	0.050	0.060	0.040

(ID) Land-use category	Roughness coefficients	Manning's 'n' roughness +20%	Manning's 'n' roughness -20%
11 Roads	0.020	0.024	0.016
12 Roads	0.035	0.042	0.028
13 Roads	0.020	0.024	0.016
16 Residential	0.030	0.036	0.024
17 Residential	0.040	0.048	0.032
18 Residential	0.050	0.060	0.040
19 Residential	0.100	0.120	0.080
23 Commercial	0.050	0.060	0.040
26 Commercial	0.020	0.024	0.016
27 Commercial	0.035	0.042	0.028
28 Industrial	0.035	0.042	0.028
29 Industrial	0.050	0.060	0.040
34 Waterways	0.100	0.120	0.080
35 Waterways	0.200	0.240	0.160
37 Waterways	0.150	0.180	0.120
47 Miscellaneous	0.100	0.120	0.080

The sensitivity of flood levels to changes in surface Manning's n appeared to be insignificant. The primary reason the flood levels are not significantly different despite the increase/decrease in Manning's n by 20% is due to the rural nature of the model area.

The flood inundation extents and depths for 5% AEP Sensitivity tests are shown in Appendix B (at the time of peak flood level).

4.4 Climate Change

Over the past few decades, global warming has been observed and linked to alterations in the large-scale hydrological cycle, such as changes in atmospheric water vapor content, precipitation patterns, intensity, and extremes, variations in soil moisture and runoff, and an increase in melting snow and ice (Bates et al., 2008). It is increasingly apparent that climate change induced by humans is impacting precipitation extremes and has caused a rise in extreme flooding on a global scale during the 20th century (Trenberth, 2011). The IPCC (2007) and Bates et al. (2008) have reported that these changes in the hydrological cycle will result in more variability in precipitation and increased occurrence of flood events in many areas. The effects of climate change on flooding will influence the intensity, duration, timing, spatial extent, and frequency of extreme weather and climate events, possibly leading to unprecedented events (IPCC, 2012).

In order to assess the impact of climate change on flooding within River Clyde catchments, a simulation was performed using a specific climate change scenario. The scenario involved increasing rainfall intensities due to one selected projection horizon and one gas emission scenario. Specifically, the simulation was carried out with the following parameters: a projection horizon of the year 2090, a gas emission scenario of Representative Concentration Pathway (RCP) of 8.5 (which represents a 16.3% increase), and the application of an increase in rainfall intensity induced by climate change to the 1% AEP scenario. To obtain the necessary climate change factors for the simulation, data was downloaded from the ARR 2019 data hub. These types of simulations are necessary in order to fully understand the potential impact of climate change on flooding, including changes in rainfall intensity, frequency, and duration.

The flood inundation extents and depths for 1% AEP Climate Change is shown in Appendix C (at the time of peak flood level).

4.5 Model Validation

The hydraulic model used for the River Clyde system was validated against historical flood events for which records exist, such as flood extents and impacted properties. This validation process involved adjusting key model parameters, such as Manning's 'n' roughness coefficient and loss rates, within acceptable limits to achieve a level of agreement between the modelled and observed behaviour. To ensure the robustness of the model, a sensitivity analysis on key model parameters was also undertaken by GHD. This analysis allows for a better understanding of the model's sensitivity to variations in the parameters and their impact on the results.

The design event calculated from hydrologic models was compared to the peak flows calculated by stream gauging for the Clyde using a Flood Frequency Analysis. This analysis helps to verify the accuracy of the model by comparing the calculated design event with the recorded peak flows. By comparing the results of the model with the actual historical flood events and the recorded stream gauging data, the hydraulic model's accuracy was evaluated and improved as necessary. Overall, these validation processes ensure that the hydraulic model used for the River Clyde system is robust, accurate, and reliable for predicting potential flooding events and developing effective flood mitigation strategies.

In addition, UDM was engaged to undertake a drone footage of the floodplain after the flooding that occurred on 27 October 2022. The purpose of this survey was to compare the results of the frequent flood event, which happens approximately once every year, with the modelled flood extent generated by the hydraulic model. The results of this comparison showed a high degree of accuracy between the calculated flood extent and the actual footage of the flooded area along the River Clyde. The modelled flood map 63% AEP and the drone aerial picture are shown in Appendix D.

This indicates that the hydraulic model used for the River Clyde system is reliable and can be used to predict the potential flooding extent effectively. The use of drone technology for surveying also highlights the importance of innovative methods for data collection and analysis in modern flood management practices.

4.6 Post-processing of Modelling Results

As per the modelling scope, the direct rainfall hydraulic modelling results were filtered using the ArcGIS software. During the filtering process, depths lower than 0.05 meters were excluded from the map. The purpose of this exclusion was to remove any insignificant information and focus on the areas that had a higher impact from direct rainfall. By removing low-depth areas from the map, the focus was placed on areas where the direct rainfall had a more significant impact. This exclusion of depths lower than 0.05 meters also helped to simplify the map, making it easier to interpret and understand the impact of direct rainfall.

4.7 Flood Hazard

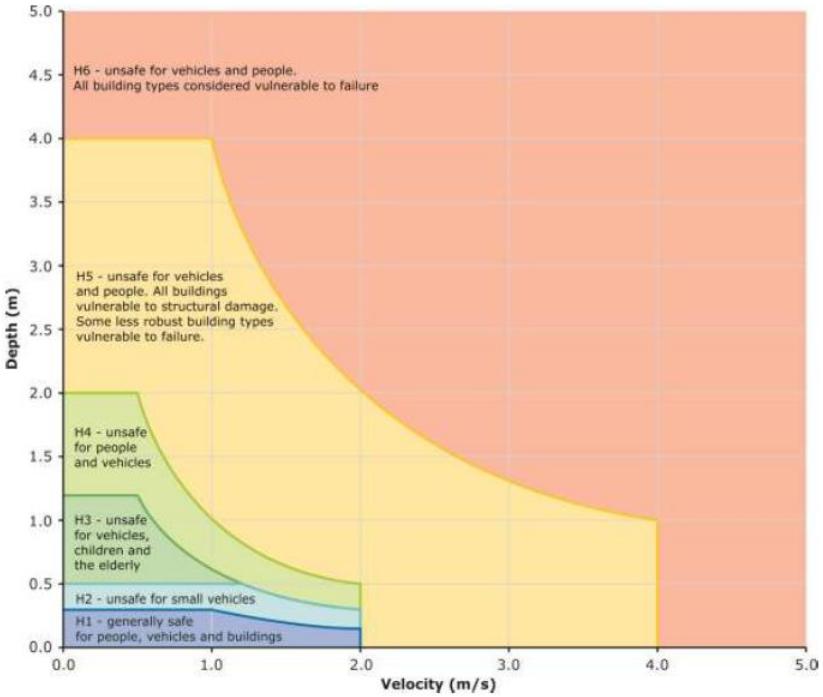
The severity of flooding varies depending on its behaviour, such as extent, depth, velocity, isolation, rate of rise of floodwaters, and duration. To manage flood risk, it is important to understand the potential flood behaviour and identify the relative degree of flood hazard on a floodplain. This section defines flood hazard as the potential loss of life, injury, and economic loss caused by future flood events. It also outlines methods to quantify flood hazard, which can help identify specific flood parameters and benchmark them against thresholds to better understand the danger of flooding to people, buildings, and infrastructure in the community.

The quantification and classification of flood hazard involve considering flood depth and velocity in combination. Understanding the relative degree of hazard and underlying flood behaviour is crucial as different management approaches may be required.

The combined flood hazard curves presented in Figure 8 set hazard thresholds that relate to the vulnerability of the community when interacting with floodwaters. The combined curves are divided into hazard classifications that relate to specific vulnerability thresholds as described in Table 8. Table 9 provides the limits for the classifications provided in Table 8.

A flood hazard map classified against these vulnerability thresholds for the River Clyde floodplain presented in Appendix E.

For full details and additional information on the flood hazard classification, please refer to the *Australian Disaster Resilience Guideline 7-3: Technical flood risk management guideline: Flood hazard, 2014, Australian Institute for Disaster Resilience.*



Source: Australian Disaster Resilience Guideline 7-3:Technical flood risk management guideline: Flood hazard, 2014, Australian Institute for Disaster Resilience.

Figure 8 ***General flood hazard vulnerability curves***

Table 8 ***Combined hazard curves – vulnerability thresholds***

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

Table 9 ***Combined hazard curves – vulnerability thresholds classification limits***

Hazard Vulnerability Classification	Classification limit (D (depth)and V (velocity) in combination) m2/s	Limiting still water depth (D) m	Limiting velocity (V) m/s
H1	D*V ≤ 0.3	0.3	2.0
H2	D*V ≤ 0.6	0.5	2.0
H3	D*V ≤ 0.6	1.2	2.0

Hazard Vulnerability Classification	Classification limit (D (depth)and V (velocity) in combination) m2/s	Limiting still water depth (D) m	Limiting velocity (V) m/s
H4	D*V ≤ 1.0	2.0	2.0
H5	D*V ≤ 4.0	4.0	4.0
H6	D*V > 4.0	-	-

4.8 Flood Model Results

The River Clyde model was run for a number of design rainfall events (discussed in Section 6.2). The flood inundation extents and depths for 1% and 5% AEP are summarised in Table 10, and shown graphically in Appendix A (at the time of peak flood level).

Table 10 Flood modelling summary and results

Rainfall event (AEP)	Design rainfall temporal pattern	Location of the results line	Flow (megalitres/ per day)	Flow (m3/sec)	Time of peak flood level	Peak flood elevation above ground level (m)	Peak flood inundation area (ha) (%) out of total 2D zone area (1286.2 ha)
63.2%	6 hours, ensemble 8	Below Clyde Bridge	2,842.6	32.9	8 hours	1.97	217.2 (16%)
5%	6 hours, ensemble 2	Below Clyde Bridge	19,897.9	230.3	7 hours	2.10	289.5 (22%)
1%	6 hours, ensemble 6	Below Clyde Bridge	28,874.8	334.2	6 hours	2.401871	295.3 (23%)

The overall flooding regime within Bothwell consists of an initial inundation due to rainfall and subsequent catchment inflows from northeast and south side of the residential area. As a result, low-lying areas in the middle section of the residential area gradually experience flooding. The high level of the river also restricts the flow from reaching the discharge locations, further exacerbating the flooding problem.

Based on the model results, it can be concluded that Bothwell township is at a high risk of both river and overland flooding. The police station and fire station area are particularly vulnerable, as the surrounding areas are likely to be inundated in the event of a flood, which could impede emergency response efforts.

Additionally, some water pooling is expected to be in close proximity to the emergency assembly point and ambulance centre, posing a potential threat to emergency services in the area. The model also predicts severe flooding along High Street and Willian Street, as well as full inundation of Arthur Crescent and Nant Lane. The north side of the school grounds is also expected to be at risk of inundation. Private properties along the overland flow path are also deemed to be high-risk flood zones. These properties are located in low-lying areas and are at a high risk of experiencing significant flood damage.

5. Land Use Planning analysis

This section of the report will provide the land use planning analysis for the study area in relation to flooding, flood mitigation and flood mapping.

5.1 Land Use

The study area is defined by two (2) distinct areas. The built township of Bothwell and the farming land that surrounds the township.

Land use is mostly agricultural use outside the township of Bothwell and mixed residential, commercial and community use within the township.

The agricultural use of the land is mixed-use farming for mostly cropping and grazing livestock, which is supported by a residential use.

There is, uniquely, land at 2122 Highland Lakes Road, Bothwell (CT164109/1) which is used for both agriculture and a 9 hole golf course with club house, food services and accommodation. This is unique in that the golf course is located in an intensive agricultural environment and is considered to be the oldest golf course in the southern hemisphere.

Also, in the agricultural area, is a whisky distillery and visitor centre at 254 Nant Lane, Bothwell (CT 151816/1). Within the township of Bothwell, the land is primarily used for residential development, which is comprised of mostly single dwelling housing located on a grid pattern town layout. The residents of the town and surrounding area are supported by community and commercial services such as post office, council chambers, fuel services, food services, open space, school and small industry.

Bothwell is known as an historic township owing to the many colonial buildings, the history of the area and pattern of development. Many of these buildings are still in use and have been maintained and restored over the past 200 years. The town is also part of the “Heartlands” tourism route and is a frequent destination for tourist and visitors.

5.2 Land Development

The study area is, overall, sparsely developed. The agricultural area is defined by expansive cropping, improved pastures and standing vegetation around the River Clyde. There are outbuildings, typically around a dwelling, fencing, dams and other farm infrastructure such as irrigation pipes, irrigators and access tracks. The agricultural area contains public roads including the Lake Highway, Nant Lane, Dennistoun Road, Hollow Tree Road and Meadsfield Road. The Lake Highway is a Category 5 Road under the State Road Hierarchy used primarily as an access road, but also low frequency freight and forestry activities.

The built township of Bothwell is defined by lower density housing on large residential lots on a grid pattern of paved, gravel and unmade roads. There are large sheds and open backyards and small paddocks throughout the town. There are many undeveloped titles which are mostly flat grassed areas. The central business and community area is around Patrick Street, Alexander Street, Market Place and Dalrymple Street. This part of the town is defined by larger buildings. This includes a large sandstone pub, sandstone church, visitor centre, community halls and what is currently the Elders business on the corner of Patrick Street and Queen Street. The roads are wide with grassed nature strips, trees and swale or open drains which is typical for historic colonial towns.

5.3 Zoning

The study area is over 2000ha of land around the township of Bothwell. This land is under the *Tasmanian Planning Scheme – Central Highlands* (the Planning Scheme).

The zoning for the land is shown in Figure 9 and is described as follows:

– The agricultural land, which is most of the study area, is in the Agriculture Zone.

- The Highland Lakes Road, Patrick Street, River Clyde pump station (CT 151816/2), and the TasWater treatment ponds (167794/1) are in the Utilities Zone
- The River Clyde is in the Environmental Management Zone
- The larger rural living lots are either in the Rural Zone or Rural Living Zone
- The small areas of low density living around Barrack Hill are in the Low Density Residential Zone
- The higher density residential, commercial and community areas in the centre of the township of Bothwell are in the Village Zone
- The top of Barrack Hill is in the Open Space Zone
- The Bothwell Recreation Ground is in the Recreation Zone
- The Bothwell District School is in Community Purpose Zone

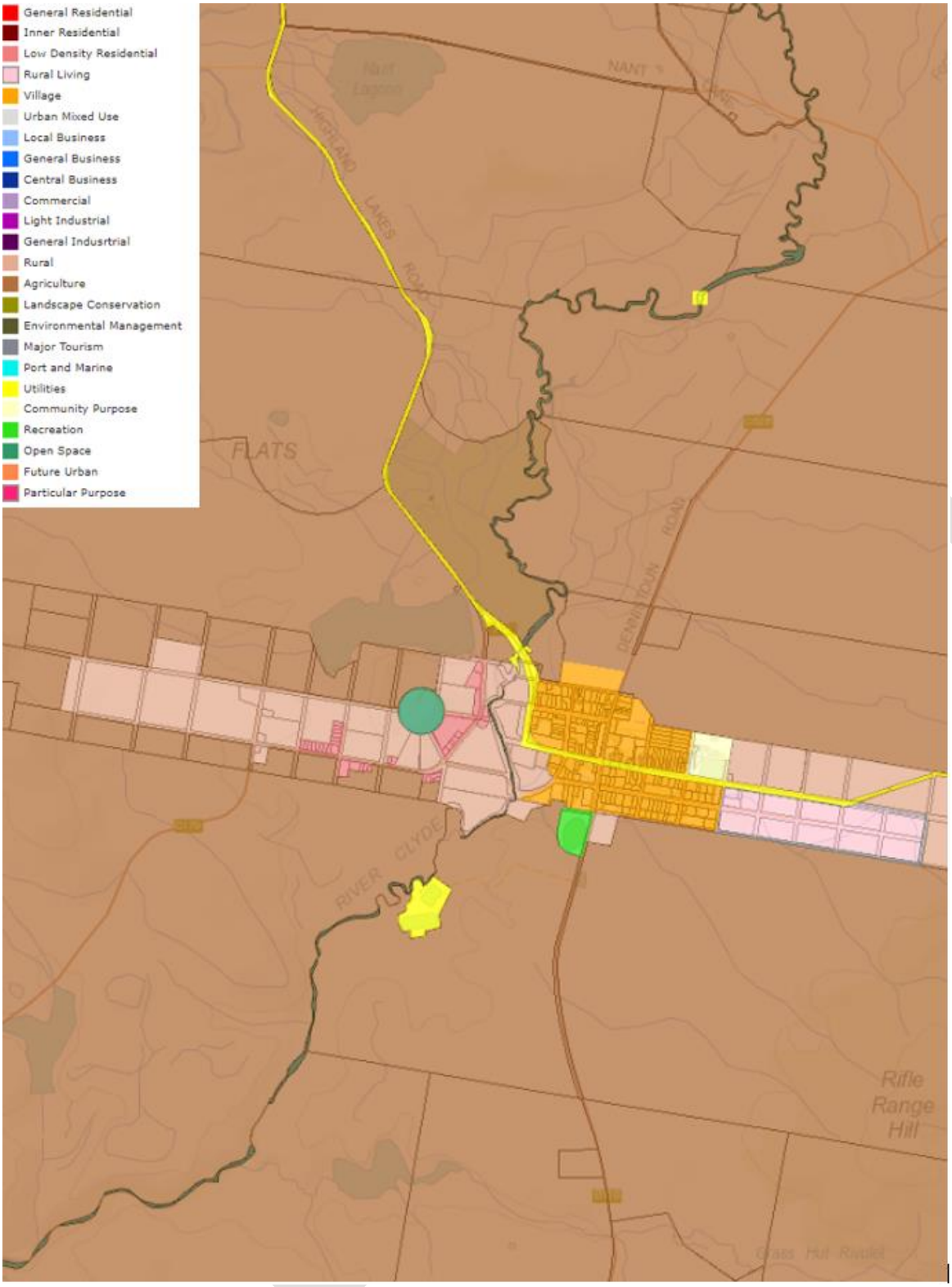


Figure 9 Study Area Zoning Map – Tasmanian Planning Scheme – Central Highlands

Source: LISTMap © State of Tasmania

5.4 Codes and Overlays

The following codes have been mapped as an overlay in the Planning Scheme:

- C4.0 Electricity Transmission Infrastructure Protection Code (Figure 10)

Figure 10 C4.0 Electricity Transmission Infrastructure Protection Code

Source: LISTMap © State of Tasmania

- C6.0 Local Historic Heritage Code (Figure 11)

Figure 11 C6.0 Local Historic Heritage Code

Source: LISTMap © State of Tasmania

- C7.0 Natural Assets Code:
    - Priority Vegetation Overlay (Figure 12

Figure 12 Priority Vegetation Overlay

Source: LISTMap © State of Tasmania

- Waterway and Coastal Protection Area Overlay (Figure 13)

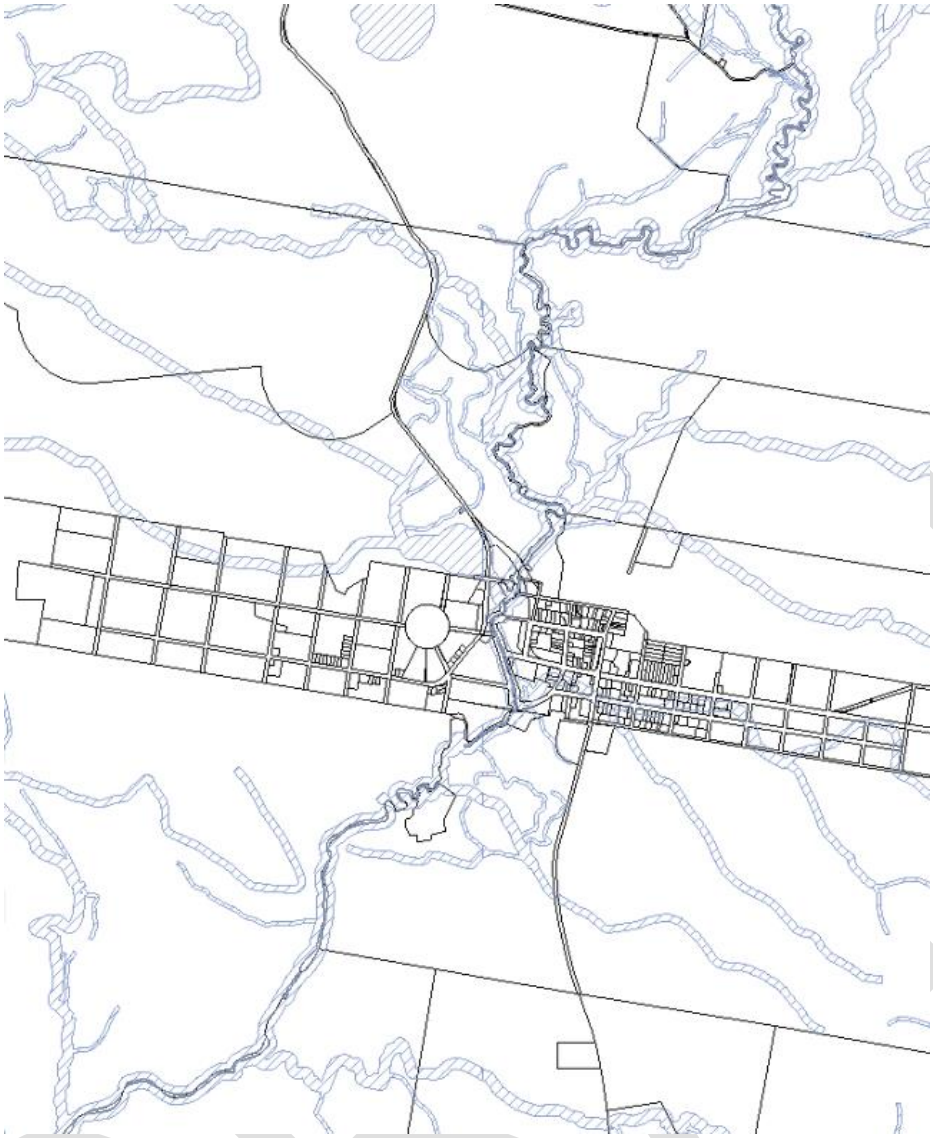


Figure 13 Waterway and Coastal Protection Area Overlay

Source: LISTMap © State of Tasmania

- C13.0 Bushfire-Prone Areas Code (Figure 14)

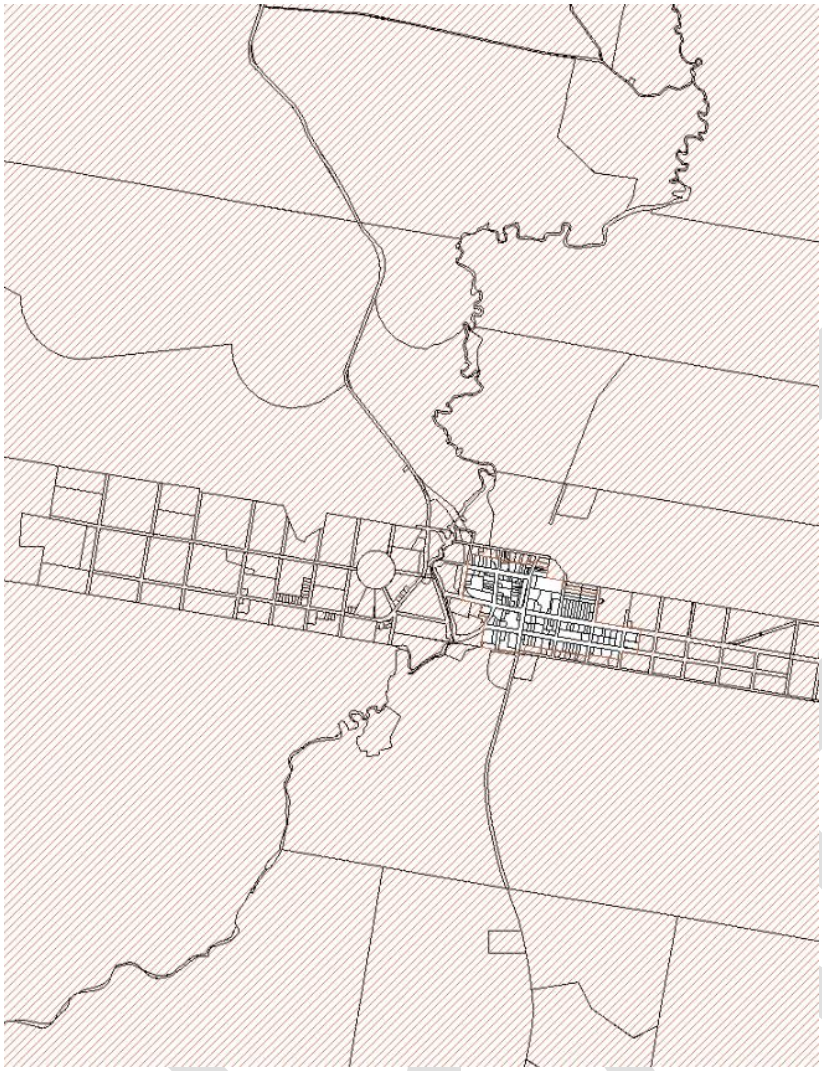


Figure 14 C13.0 Bushfire-Prone Areas Code

Source: LISTMap © State of Tasmania

- C15.0 Landslip Hazard Code (Figure 15)

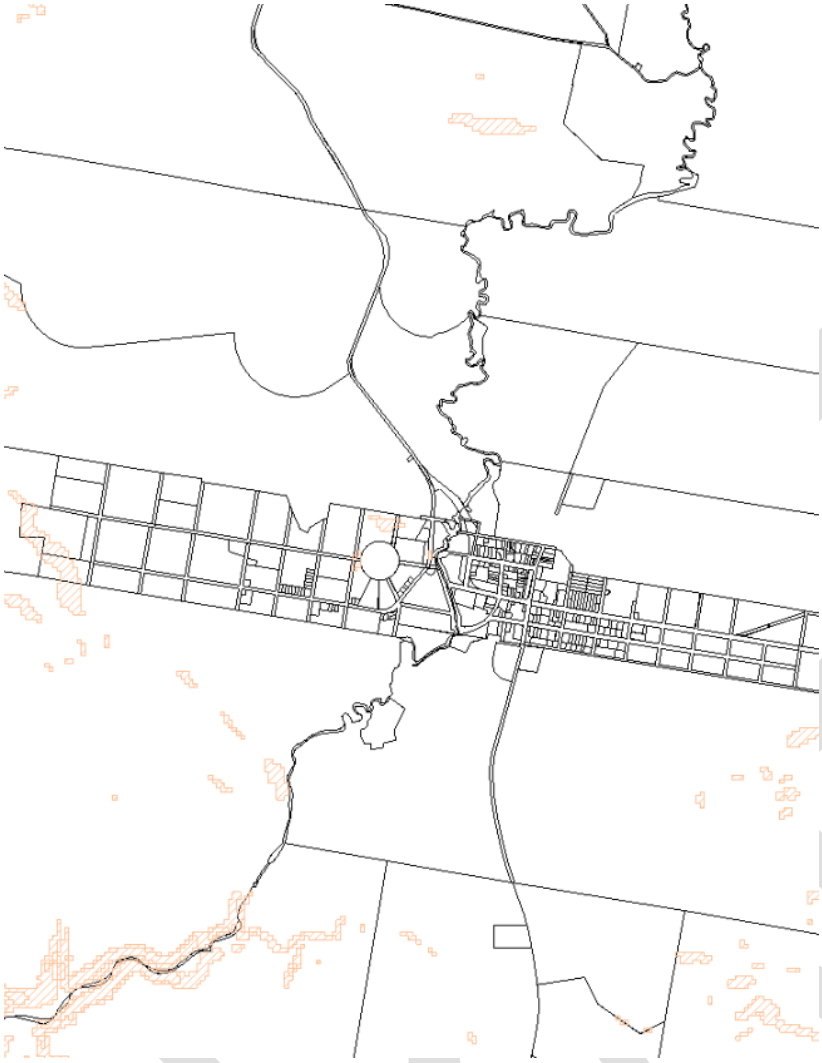


Figure 15 C15.0 Landslip Hazard Code

Source: LISTMap © State of Tasmania

The following codes also apply to use and development of the land, in the study area, but are not mapped as an overlay:

- C1.0 Signs Code
- C2.0 Parking and Sustainable Transport Code
- C3.0 Road and Railway Assets Code
- C5.0 Telecommunications Code
- C9.0 Attenuation Code
- C12.0 Flood-Prone Areas Hazard Code
- C14.0 Potentially Contaminated Land Code (likely but not confirmed)

5.5 Analysis of Codes and Zones

5.5.1 Background

The current zoning of the land reflects both current and intended future use and development of the land based on the available data, characteristics and strategic plans of the Council at the time of preparing and implementing these zones through the *Land Use Planning and Approvals Act 1993* (the Act).

Most of the current zoning in the Central Highlands Local Government Area (LGA) was converted from the previous zoning under the *Central Highlands Interim Planning Scheme 2015*, which, was also a conversion of zoning under the former *Central Highlands Planning Scheme 1998*. This is relevant to the flood mapping as the zoning that has been applied to the land within the study area, under the current Planning Scheme, has evolved from zoning that has been in place for 25 years. This zoning has, to some extent, had regard to the flooding constraints of the area. This is evident particularly around the River Clyde in the Bothwell township as shown in Figure 16 Figure 9below. Where there is a distinct town boundary between the Rural Zone and the Village and Low Density Residential Zone in the vicinity of the River Clyde flood path. Previous planning schemes have avoided application of higher density development zones such as the residential or commercial zones along the banks of the River Clyde. This has carried through to the current Planning Scheme.

In preparing the current Planning Scheme, through the LPS process, Council did not include a flood-prone area overlay in the mapping. This is simply because Council did not yet have in its possession flood mapping and data that is compliant with the requirements for mapping flood prone areas per the *Guideline No.1 Local Provisions Schedule (LPS): Zone and Code Application,* Tasmanian Planning Commission, June 2018 (Guideline No.1).

Council, per the recommendations of this report will likely initiate an amendment to the LPS to introduce a flood-prone area overlay map to apply the Flood-Prone Areas Code. Council will use the flood modelling from this project to create the map and use the data (including this report) to support the planning scheme amendment process. This is explained in Section 5.7 of this report.

Figure 16 Zoning in vicinity of River Clyde in the Bothwell Township

Source: LISTMap © State of Tasmania

The GHD flood model, created by the flood study, shows that the majority of land within the flood path is within the Rural or Agriculture Zone. The exceptions are:

– The lower lying land in the vicinity of Arthur Crescent, Dalrymple Street and Highland Lakes Road within the Bothwell township which is partly in the Village Zone; and
– Low lying land accessed from Wentworth Street is in the Low Density Residential Zone
– The TasWater treatment ponds and a pump station on the River Clyde (189 Dennistoun Road, CT 106748/1) is in the Utilities Zone.
– The River Clyde reserve is in the Environmental Management Zone.

The Rural and Agriculture Zones are more suitable zones for flood prone areas as compared to those zones listed above. The purpose of the Agriculture Zone is to provide and protect land for agricultural use and development where land is relied upon for livestock, cropping, harvesting and related agricultural use and development. Such land is typically on larger lots and around waterways. It follows that floods and flood paths around waterways are a normal and natural occurrence and land is typically developed to manage and avoid these flood paths where they are known from flood history. The Rural Zone has similar purposes, which is to allow for agricultural land use and development that does not conflict with agricultural land use. Both of these zones are typically applied to land outside of settlements and townships in Tasmania.

The Agriculture Zone and the Rural Zones are very different to residential, community or commercial zones. They do not encourage a high density of development or activities at risk of harm from flooding. Land within these zones is rarely serviced for sewer and does not ordinarily have other infrastructure such as footpaths, sports grounds, local or community businesses and services which may put the public at greater risk of harm from flooding. Much of the land in these zones is open spaces such as pasture or bushland.

The Village Zone, and Low Density Residential Zone encourages higher density of development and are serviced for sewer and water. These zones are allocated to the township of Bothwell with the intention of facilitating residential, commercial and community development and to facilitate growth of the town.

The Utilities Zone is applied to assets and infrastructure or sites intended for future public assets and infrastructure.

The Environmental Management Zone is applied to mostly public reserves to protect and managed conservation values and to allow for compatible use and development that is consistent with the management of such values.

These zones and codes were recently reviewed by Council in preparing and implementing the current *Tasmanian Planning Scheme – Central Highlands*. This came into effect in February 2023. This new scheme replaced the former *Central Highlands Interim Planning Scheme 2015* (Interim Planning Scheme). The new planning scheme is a product of the state legislated roll-out of the *Tasmanian Planning Scheme* which is intended to be a single, state-wide Planning Scheme that will replace all 30 planning schemes in Tasmania.

In implementing this new Planning Scheme, the Central Highlands Council prepared a Local Provisions Schedule (LPS) which provides the maps (zones and overlays) together with a written ordinance that provides the written provisions for the LGA. The local provisions are particular to each LGA and include matters such as provisions for specific area plans, local heritage places and precincts, particular purpose zones and code lists for major roads etc. Councils are able to also include flood prone area overlays in their LPS.

Council now has the opportunity, as a result of the GHD flood study, to review zoning around the River Clyde and to apply the flood prone area overlay map to the LPS. This review will also assist with future strategic plans for Bothwell such as land use and development strategies, master plans and structure plans for the town.

5.5.2 Flood-Prone Areas Hazard Code

The Tasmanian Planning Scheme-Central Highlands includes the Flood-Prone Areas Hazard Code (Code C12.0 of the State Planning Provisions). The purpose of this code, per C 12.1, is:

– To ensure that use or development subject to risk from flood is appropriately located and managed, so that:

  a) people, property and infrastructure are not exposed to an unacceptable level of risk;

  b) future costs associated with options for adaptation, protection, retreat or abandonment of property and infrastructure are minimised; and

  c) it does not increase the risk from flood to other land or public infrastructure.

– To preclude development on land that will unreasonably affect flood flow or be affected by permanent or periodic flood.

Per C12.2, the code applies to development of land within a flood-prone hazard area and for use of land if for a change of use to a new habitable room or building. The identification of a flood-prone hazard area is reliant upon the Planning Authority having in its possession information that demonstrates the land is susceptible to flooding, a report provided by a suitably qualified person or where the land is identified as a flood-prone hazard area in the LPS map overlays. The overlay in the LPS would appear as hatched blue line area on the map as shown in the example given in Figure 17.

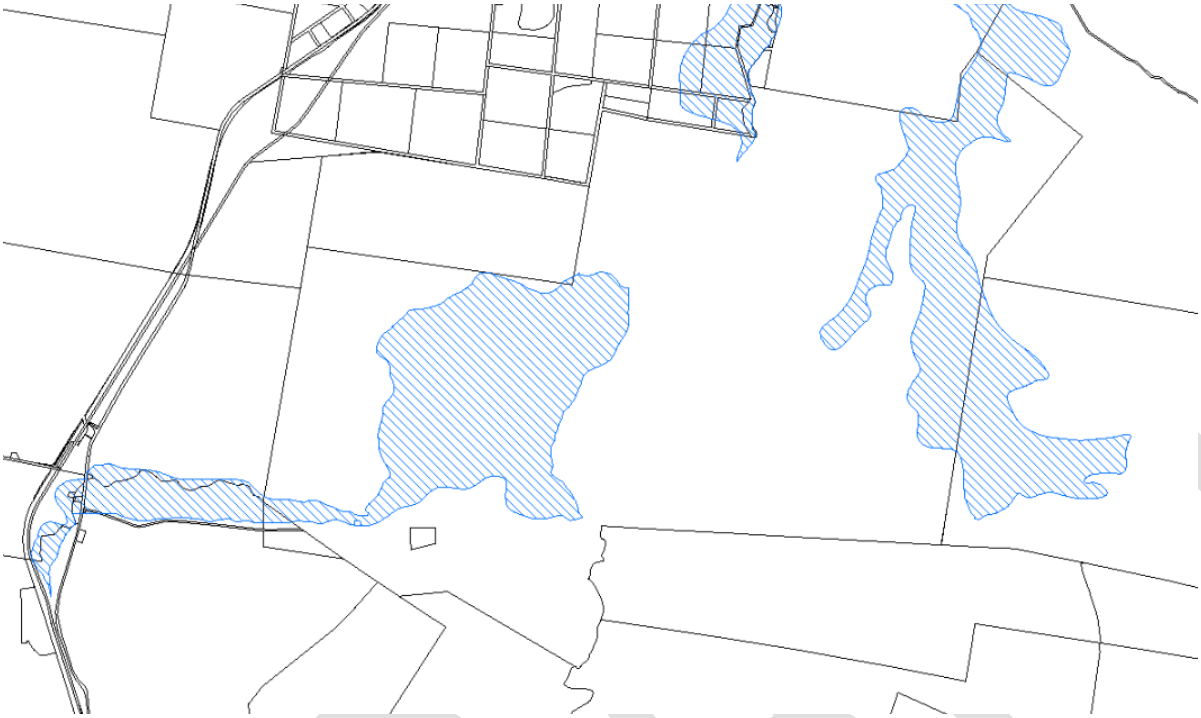


Figure 17 Example of Flood-Prone Area Hazard Overlay Mapping in adjacent Local Government Area

Source: LISTMap © State of Tasmania

The code can be applied to all zones. However, there are a number of exemptions from the code for the following uses or development as provided in C12.4 of the Code:

a) alterations or extensions to an existing building if:

   (i) the site coverage is not increased by more than 20m² from that existing at the effective date; and

   (ii) not for a critical, hazardous, or vulnerable use;

b) use or development of land for:

   (i) Natural and Cultural Values Management;

   (ii) Passive Recreation;

   (iii) Port and Shipping in a proclaimed wharf area;

   (iv) Resource Development, excluding a habitable building;

   (v) minor utilities;

(vi) infrastructure for the generation of hydro-electricity; and

(vii) outbuildings;

c) planting or disturbance of vegetation on existing pasture or crop production land; and

d) consolidation of lots.

The code is used in the assessment of use and development that is not exempt from it per C12.4 and where the use or development is within a flood-prone area per C12.2. The code provides standards for both use and development of land within the flood-prone area. These standards are designed to achieve the purpose statements of the code per C12.1. The standards either require avoidance of the flood-prone area hazard or management of the flood hazard which is supported by expert reporting and recommendations by a suitably qualified engineer.

The full extent of the 1% AEP flood model created by GHD ought to be converted to a flood-prone area hazard overlay in the LPS. This will then achieve clarity and certainty as to where the C12.0 Flood-Prone Areas Hazard Code applies. As currently there is ambiguity and uncertainty as to the extent of flooding in the study area. The Council Planning Authority, landowners and developers ought to be able to establish the extent of flooding through the Planning Scheme overlay mapping.

5.6 Planning Options for Flood Mapping

The GHD flood study provides mapping and data that can be used for assessing and guiding land use and development through the planning system.
The options for Council in applying the Flood Prone-Areas Hazard Code to the study area are provided as follows:

A. Council upload and maintain a copy of the flood mapping report and maps on Council's website where the information is readily accessible at all times to the public. This can then be used for land use and development planning. Council and community can rely upon these maps for the purposes of assessment against the standards of the C12.0 Flood Prone Areas Hazard Code; and/or

B. Council can create their own interactive flood maps online that can be accessed by the public at all times. Council, landowners and developers (and general public) can use this map and software to search property and areas. There are many Councils across Tasmania that have interactive maps such as these, including Glenorchy City Council, Clarence City Council and Kingborough Council; and/or

C. Council create a GIS layer in their current GIS mapping software that can be accessed by Council and copies of specific maps and areas can be provided to the public upon request.

D. In addition to the above Council can, of its own motion, per Section 40D of the *Land Use Planning and Approvals Act 1993* prepare a draft amendment of the LPS to map the flood-prone hazard area overlay. If the amendment is successful through the legislated amendment process then the LPS will be amended to include a flood-prone areas hazard overlay.

All of these options are a means of providing a readily available copy of the flood mapping and data for Council and public in the preparation and assessment of Development Applications. The mapping, per part C12.2 of the Flood-Prone Areas Hazard Code does not need to be applied as an overlay in the LPS in order for the code to apply. Simply by the maps and data being information in the possession of the Council, allows the Planning Authority to make a request for a report, prepared by a suitably qualified person, to determine that a proposed use or development is subject to risk from flood or has the potential to cause increased risk from flood.

There is however significant logic in ensuring the mapping and data is readily available to the public in the preparation of Development Applications, land purchase, land use decisions and strategies. It also aligns with the objectives of the RMPS to encourage public involvement in the planning system.

There are pros and cons to the options for mapping the overlay in the LPS:

– Once the map is applied as an overlay in the LPS then any changes to the flood model or flood extent and behaviour due changes in topography, flood and stormwater mitigation measures and other development, for example, should then require an amendment to the LPS to modify the flood prone areas overlay. This can be problematic for landowners, developers and Council where the code technically applies to the land per the overlay and development applications must then be assessed against the standards of the Code regardless of the existence of flood waters.
– The overlay can also unnecessarily constrain a site for development or dissuade acquisition and purchase of land for future use and development. The issue can ordinarily be resolved through reporting by a suitably qualified person and Council taking a pragmatic approach, however, the requirements of the code can be burdensome for development and landowners where the risk from flood is nil or negligible.

The recommended option is to provide both the mapping and reports to the public through Council's website without delay and to create a GIS layer in their current GIS mapping software. Then initiate an amendment to the LPS through the planning scheme amendment process to map the flood prone areas of the study area.

5.7 Planning Scheme Amendment Process

As described in Section 5.6 above. Council may choose to both provide copies of the flood mapping and reports on Council's website and include a GIS layer on their GIS mapping software. Council may then commence the planning scheme amendment process.

The amendment process can be in the form of the creation of the flood-prone area overlay for the study area only or Council may delay creating the layer pending further flood studies in the Central Highlands and initiate an amendment to multiple areas a single suite of amendments. It is however recommended that Council initiate the amendment with minimal delay as the flood-prone area overlay under the Planning Scheme is typically the data and maps that the public would rely upon in land development, land purchase or land use.

Pending Council acceptance of the mapping and reports by GHD (this project) then Council can initiate the planning scheme amendment process as follows:

1. **Create a Flood-Prone Hazard Areas Code Overlay**
   Council prepare a flood-prone hazard area overlay map that complies with *Guideline No.1*. This Guideline is legislated under Section 8A of the *Land Use Planning and Approvals Act 1993* (the Act) and was intended to be a reference guide for the application for all zones and codes for the preparation of the LPS. An example of the map is provided in Figure 17. The Guideline provides the following requirements in relation to flood prone hazard areas:

Table 11 Exerpt from Guideline No.1

Code	Code Purpose	Code Application Guidelines
C12.0 Flood-Prone Hazard Areas Code Flood-prone areas	The purpose of the Flood-Prone Hazard Areas Code is: C12.1.1 To ensure that use or development subject to risk from flood is appropriately located and managed, so that:	Overview The Flood-Prone Hazard Areas Code is applied by reference to a flood-prone hazard area overlay. There is currently no statewide mapping of land potentially susceptible to flooding risks to

Code	Code Purpose	Code Application Guidelines
 Red 103, Green 169, Blue 207	people, property and infrastructure are not exposed to an unacceptable level of risk; future costs associated with options for adaptation, protection, retreat or abandonment of property and infrastructure are minimised; and it does not increase the risk from flood to other land or public infrastructure. C12.1.2 To preclude development on land that will unreasonably affect flood flow or be affected by permanent or periodic flood.	guide the application of the overlay. Guidelines for applying the Flood-Prone Hazard Area overlay FPHAZ 1 The flood-prone hazard area overlay should be applied to areas known to be prone to flooding, particularly areas known to be within the 1 per cent annual exceedance probability (AEP) level. FPHAZ 2 In determining the extent of the flood-prone hazard area overlay, planning authorities may utilise their own data, including any equivalent overlay contained in an interim planning scheme or section 29 planning scheme for that municipal area, or data from other sources.

Council will need to refine the data set to create this overlay map and should engage the services of a suitably qualified engineer and GIS consultant to generate the final overlay map.

Council will also need to create the amendment instrument (diagram).

2. Report to Council

Council's Planner or Strategic Planner will need to prepare a report to Council per Section 40F of the Act to demonstrate the proposed amendment meets the LPS Criteria. This report will present and support the amendment. Council will need to demonstrate the amendment instrument complies with the Guideline No.1.

3. Public Exhibition and Certification

Council, if satisfied the amendment meets the LPS Criteria, must certify the amendment as meeting the requirements of the Act. Council must then provide to the Tasmanian Planning Commission (TPC) a copy of the certified amendment. Council will then notify the relevant agencies, State Service Agencies and Authorities that the Planning Authority considers may have an interest. The amendment is placed on exhibition for a period of 28 days in accordance with Section 40G and 40H of the Act.

4. Representations and Report

Council, per Section 40K of the Act will need to consider any representations received in a report to the TPC prepared by Council's Planner or Strategic Planner. The report is to contain:

a) a copy of each representation made under section 40J in relation to the draft amendment before the end of the exhibition period in relation to the draft amendment, or, if no such representations were made before the end of the exhibition period, a statement to that effect; and
b) a copy of each representation, made under section 40J in relation to the draft amendment after the end of the exhibition period in relation to the draft amendment, that the planning authority, in its discretion, includes in the report; and
c) a statement of the planning authority's opinion as to the merit of each representation included under paragraph (a) or (b) in the report, including, in particular, as to –

(i) whether the planning authority is of the opinion that the draft amendment ought to be modified to take into account the representation; and
(ii) the effect on the draft amendment, and the LPS to which it relates, as a whole, of implementing the recommendation; and

d) a statement as to whether it is satisfied that the draft amendment of an LPS meets the LPS criteria; and
e) any recommendations in relation to the draft amendment that the planning authority thinks fit.

The report is to be provided to the TPC within 35 days after the end of the public exhibition (or further period as allowed by the TPC).

5. Hearings

As soon as practicable after receiving the report under Section 40K, the TPC may hold hearings under Section 40L in relation to the amendment and the representations received.

The TPC, per Section 40M, is to consider:

a) the report and the draft amendment of an LPS to which it relates; and
b) the information obtained at the hearings; and
c) whether it is satisfied that the draft amendment of an LPS meets the LPS criteria; and
d) whether modifications ought to be made to the draft amendment of an LPS

6. Action and decision by the TPC

The TPC may direct the Planning Authority to modify the amendment, reject or substantially modify the amendment and commence the exhibition and Council assessment process.

If the TPC is otherwise satisfied the amendment meets the LPS Criteria together with those matters listed under Section 40M then the TPC can approve the amendment.

The amendment will come into effect on a specified date after the approval is given.

Once the amendment has come into effect then the “Flood Prone-Area Hazard Overlay” map will be included in the Planning Scheme maps and will be relied upon per C12.2.

The process of preparing an amendment, the Council decision, public exhibition, hearings and the final decision by the TPC can take 6-12 months.

5.7.1 Further Strategic Planning

The GHD flood modelling, together with this report, will provide valuable data that Council can use in the preparation of further strategic plans for the Bothwell township and the surrounding area. Council may rely upon these plans for precinct planning the township of Bothwell and for the allocation of new zones within the township. This will be useful for placemaking, planning open space and for any future residential or commercial areas. In any future structure planning for Bothwell, Council will have regard to the flood model before making recommendations for further growth or development.

This will be particularly relevant for the land around assets such as the Fire Station, Police Station and Council works depot. Stakeholders and Council can make a more informed decision on future development of these sites based on the flood modelling.

Similarly Council, in considering the flood mitigation options, will need to prepare specific outcome focussed objectives that factor the social and physical infrastructure of the town. For example, works to alleviate flooding around the Council Works depot would potentially allow further growth of this site or encourage other compatible services into this area of town.

6. Community Consultation

A Stakeholder and Community Engagement Plan was developed identifying key stakeholders, outlining key messages, activities, project timing and feedback opportunities to support the project objectives. Stakeholder engagement content was prepared to provide information around why the Flood Mapping Study was being undertaken and how it will enable the council to prepare a Stormwater System Management Plan. Content was prepared to inform the community about the Study and invite them to contribute information about flooding.

Two community drop-in sessions were held, coinciding with community events – the Bothwell Bicentennial and Bushfest. Project information was shared and the public were encouraged to share stories and, photographs and to fill out an online survey.

The surveys collected information around flood awareness, emergency planning and impacts. A total of eight survey responses were collected.

Surveys and pop-up sessions were promoted via traditional media, social media, the council website, the Bothwell District High School newsletter, the Highlands Digest, a postcard mailout to every Bothwell post office box holder and posters around the township.

Two stakeholder workshops were held to share project details and gather information from industry, government departments, landowners, residents and business owners. The workshops discussed past flood levels and impacts, and involved a risks, priorities and opportunities analysis. Resulting community feedback from both online and face to face consultation was collated and analysed providing additional data for the Study.

Feedback received from the community consultation identified the following:

- Flood awareness is greater amongst those with lived experience of flooding in the area.
- Landowners who attended the drop-in sessions showed that they had high awareness of flooding and have emergency management plans in place for when flooding occurs.
- Landowners would like to see more willow management in the area with the addition of flood levees to reduce the severity of flooding.
- Although flooding is of concern to the community, it is a lower priority when compared to other extreme weather events such as drought.
- Broadly speaking, the community awareness if flooding is high, though understanding of how they can be better prepared and mitigate the impact of flooding is relatively low. The community may be more inclined to take action to be better prepared with further education and engagement.

A follow up community drop-in session will be held at the completion of the Study to share key findings and recommendations.

For the full *River Clyde Flood Mapping Study Consultation and Engagement Summary* please refer to Appendix H of this report.

7. Consequences of Flooding on the Community

Flooding in the River Clyde catchments, particularly in Bothwell, has significant consequences on people, economy, environment, public administration, and social setting. The following assessment provides insights into these consequences, including historical and anecdotal information, modelling outputs, and flood emergency response planning classifications.

7.1 People

Floods can pose significant risks to people's safety, causing fatalities and injuries. Floodwaters can also cause significant disruptions to people's daily lives, such as evacuations, loss of property, and interruption of basic services like power, water, and communication. Flood warnings and effective emergency response planning can help reduce these risks and protect people's safety.

In terms of the impact of flooding on people, there are specific areas in Bothwell that are of particular concern. One such area is Arthur Crescent, which is vulnerable to flooding due to the existing ground levels. During periods of heavy rain or flooding, the area of Arthur Crescent up to the High Street intersection can become inundated with water, which poses a significant risk to the safety of people if they enter flood waters.

Currently, we understand Council erect signage to limit access to flooded portions of Arthur Crescent. Further measures to reduce the risk of people entering floodwaters in Arthur Crescent such as a permanent boom gate could be considered to prevent people from entering the area and potentially putting themselves in danger.

Another area that is at risk of flooding is Highland Lake Road, which is also located in close proximity to the River Clyde. The flooding of the road verge and the area around Highland Lake Road could lead to difficulties for emergency services to reach people in need, which could be especially dangerous in case of a medical emergency.

7.2 Economy

Floods can have significant economic consequences on the town of Bothwell and its surrounding areas. Floodwaters can damage buildings, roads, bridges, and other infrastructure, leading to costly repairs and reconstruction efforts. In addition, flooding can disrupt business operations, causing loss of income for local businesses and their employees.

During community consultation, landowners indicated that flooding of the River Clyde poses a significant risk to livestock and land infrastructure such as fencing. Loss of livestock and damage to private infrastructure can cause both loss of income and additional financial outlay for repair and replacement to the landowners effected.

Furthermore, flood-related power outages can cause additional economic losses by disrupting production in businesses. The financial burden of flood recovery can be overwhelming for communities, and the long-term economic impact can be felt for years.

7.3 Environment

Flooding can have severe environmental consequences, including the destruction of ecosystems, water pollution, and loss of biodiversity. Floods can also damage agriculture and farming lands, affecting food supply and food security. The assessment of flood risk should take into account the environmental impact of flooding and consider ways to reduce this impact.

Communication with farmers about safe and compliant storage of harmful pesticides and chemicals is essential to prevent contamination of water sources during flood events. To prevent contamination, it is important to educate farmers on the risks of having hazardous materials or substances near flood zones. They should be made aware of the potential consequences of not storing these materials properly and the impact it can have on the environment and human health. This includes ensuring that these materials are stored in a designated area that is

located away from flood zones and is well-ventilated with proper lighting to prevent accidents and spills. Appropriate storage containers, such as chemical storage cabinets, should also be used to prevent leaks and spills. Proper labelling of all containers with clear and accurate information about the contents and associated hazards is also important. Regular inspections of the storage area and containers should be conducted to ensure that they are in good condition and that there are no signs of leaks or damage. The farmers should have an emergency response plan in place in case of a spill or release of hazardous materials. This plan should include clear procedures for containing and cleaning up the spill, as well as contacting emergency services if necessary. By taking proactive measures to store and handle these materials properly, farmers can help to protect the environment and ensure the safety of the surrounding community.

7.4 Public Administration

Effective flood risk management requires coordinated efforts between government agencies, emergency services, and other stakeholders. It is essential to have clear and efficient communication systems and well-established emergency response plans to minimize the effects of flooding on public administration.

In addition to issuing timely and appropriate warnings, clear advice on emergency evacuation centres must be provided. The regional emergency evacuation centre is an essential resource for people forced to evacuate their homes due to flooding. Clear direction and guidance must be provided on the location of the evacuation centre, the services it provides, and how to access it safely.

To ensure a coordinated approach to flood warnings, appropriate communication, direction, and leadership are necessary. This involves collaboration between Council, SES, and other agencies responsible for managing flood risk. Clear lines of communication must be established, and roles and responsibilities must be clearly defined to ensure an effective response to flood events. Effective leadership and direction are essential to ensure that warning systems are fit for purpose, that adequate resources are in place, and that emergency response plans are regularly reviewed and updated. Finally, community education and engagement could be helpful in raising awareness about flood risk and encouraging people to take steps to protect themselves and their property. Flood risk awareness campaigns can help people understand the risks and prepare for floods by taking preventive measures. Community engagement activities, such as workshops, seminars, and training sessions, can help residents learn about the best practices for flood preparedness, such as moving valuables to higher ground and creating evacuation plans. By raising awareness and promoting preparedness, the community can become more resilient to the impact of floods.

7.5 Social Setting

Flooding can have significant impacts on the social fabric of communities. One of the most significant impacts is the displacement of people. When floods occur, homes and communities can be destroyed, leaving people without shelter and forcing them to relocate to safer areas. This displacement can have long-lasting effects on individuals and families, causing emotional and psychological trauma, as well as economic hardship.

In addition to displacement, flooding can also result in the loss of cultural heritage. Communities often have unique cultural and historical sites, such as buildings, monuments, and artifacts, that can be damaged or destroyed during floods. This loss can be devastating to the community's identity and sense of place.

Flooding can also cause damage to community infrastructure, including roads, bridges, and buildings. This damage can disrupt daily life, making it difficult for people to access essential services, such as healthcare and education. It can also be costly to repair, diverting resources away from other community needs.

Another social impact of flooding is the strain it can place on social services, such as emergency response, healthcare, and mental health services. During and after floods, these services can become overwhelmed by the demand for assistance, leading to delays in response times and inadequate support for those in need.

Flooding can also have significant impacts on the social fabric of communities, including the displacement of people, loss of cultural heritage, and damage to community infrastructure. Effective flood risk management requires a community-based approach that takes into account the social and cultural context of the affected area.

To summarise, the following actions Council may need to consider for flood risk management in Bothwell include:

- Implement flood mitigation measures for high-risk areas, such as Arthur Crescent and Highland Lake Road.
- Consider the installation of a boom gate to prevent people from entering flood-prone areas.
- Develop and implement early warning systems and evacuation plans.
- Ensure timely and clear communication of flood warnings through various channels, including radio, television, social media, and mobile devices.
- Encourage residents to take responsibility for their own flood preparedness.
- Assess priority for sandbag distribution and develop a register of vulnerable properties for prompt notification and response.
- Prioritise the distribution of sandbags to high-risk properties to protect the most vulnerable properties first.
- Develop a plan to support local businesses affected by floods by providing financial assistance and resources to help them recover and resume operations.
- Develop a plan to support local farmers and the agricultural sector by offering financial support for crop and livestock losses.
- Educate Bothwell residents and businesses about the importance of reviewing insurance policies to ensure adequate coverage for flood damage.
- Encourage property owners to take responsibility for managing the flood-inundated areas around their properties to reduce the impact of flooding on infrastructure.
- Develop a debris management plan to minimise damage to infrastructure and the effects of flooding caused by debris.
- Educate farmers on safe and compliant storage of hazardous materials and substances to prevent contamination of water sources during floods.
- Coordinating efforts between government agencies, emergency services, and stakeholders to establish clear communication systems and emergency response plans.
- Providing timely and clear warnings and guidance on emergency evacuation centres.
- Establishing clear communication and leadership roles between council, SES, and other agencies responsible for flood risk management.
- Raising community awareness of flood risks and promoting preparedness through education and engagement activities.

8. Mitigation Options

GHD has investigated a range of mitigation options that could be implemented to reduce the impact of flooding in flood-prone areas. As part of this investigation, GHD has considered various infrastructure upgrades that could be implemented to enhance flood protection. The options assessed by GHD consider the available space, existing underground services, and the condition and historical value of the existing infrastructure. Attention has been paid to the options that incorporate the principles of best practice flood management, which recognizes that flooding is a natural process that needs to be integrated into the rural landscape. This approach ensures that flood mitigation measures are sustainable and effective in the long term.

GHD has also conducted a natural values assessment and a land use planning assessment to inform the options and highlight any risks associated with them.

8.1.1 Willow Removal

Willow removal is a flood mitigation option that involves the removal of invasive willow trees from flood-prone areas. Willow trees are known for their ability to grow quickly and form dense stands, which can reduce water flow and increase the risk of flooding. By removing these trees, it is possible to restore natural water flow and increase the capacity of waterways to handle floodwaters. Willow removal is an effective and sustainable solution to reduce the risk of flooding, especially in areas prone to frequent floods. This mitigation option has been widely adopted in many parts of the world, and its benefits have been observed in improved flood protection, increased biodiversity, and enhanced recreational opportunities. This section of the report will explore the benefits of willow removal as a flood mitigation option and its role in improving the resilience of communities to floods.

Willow removal as a flood mitigation option offers several benefits. Firstly, willow removal can help to increase the capacity of rivers and streams to carry water, which can reduce the risk of flooding. By removing willows, the flow of water can be increased, allowing water to move more quickly through the river system. Secondly, willow removal can improve the ecological health of river systems by increasing the amount of sunlight that reaches the riverbed. This can encourage the growth of native plant species, which in turn can provide habitat for a range of aquatic and terrestrial species. Thirdly, removing willows can reduce the amount of sediment that accumulates in rivers and streams, which can improve water quality. Finally, willow removal can help to reduce the risk of damage to infrastructure such as bridges and roads, which can be costly to repair or replace in the event of a flood. Overall, willow removal as a flood mitigation option offers a range of benefits that can help to reduce the impact of flooding and improve the ecological health of river systems.

Furthermore, willow removal can play an important role in improving the resilience of communities to floods. By increasing the capacity of rivers and streams to carry water, willow removal can reduce the risk of flooding in some areas, which can help to protect homes, businesses, and critical infrastructure from damage. This can have a positive impact on the social and economic well-being of communities, as it can reduce the costs associated with flood damage, such as repairs and clean-up efforts. Additionally, by improving the ecological health of river systems, willow removal can help to support the natural services and functions that are important for the well-being of communities. For example, healthy river systems can support fish populations, provide recreational opportunities, and contribute to the overall aesthetic value of an area. By reducing the impact of floods and supporting the ecological health of river systems, willow removal can improve the resilience of communities to the impacts of flooding and help to ensure the long-term sustainability of communities in flood-prone areas.

Careful planning is crucial when it comes to projects for willow control and stream rehabilitation, as it ensures that funds are used efficiently and that long-term outcomes are achieved. This is especially important when undertaking willow control in a single operation, as there may not be sufficient funds available for repeat visits by a works crew and large machinery. A well-planned project should include periodic follow-up to ensure the eradication of willows and prevent re-infestation, as well as the regeneration of native species. A multi-year project that involves gradual willow removal and replacement with native species may be more costly, but it is more likely to succeed in the long term. Prioritising and planning willow removal requires a systematic approach that involves identifying areas of high priority, assessing the scope and complexity of the project, developing a detailed plan and budget, and ensuring that appropriate resources are available to carry out the work. By following a careful planning

process, it is possible to achieve successful outcomes in willow control and stream rehabilitation projects, and to ensure the long-term sustainability of river systems and the communities that depend on them.

The following steps required in prioritising and planning willow removal:

– Scoping the problem: Conduct a thorough survey to identify the distribution and extent of willow trees along the River Clyde and assess the potential threats to natural assets such as native plant species, wildlife habitats, and water quality.
– Determining priorities: Determine the priority areas for willow removal based on the severity of the problem, the level of threat to assets, and the potential benefits of removal.
– Working with the community: Involve the local community in the planning and implementation of the project, including identifying stakeholders, communicating project objectives, and engaging the community in the decision-making process.
– Planning for short-term consequences: Plan for short-term consequences of willow removal such as soil erosion, water flow changes, and potential impacts on recreational activities.
– Willow control/removal: Use appropriate methods for willow control and removal, such as cutting, herbicide application, or a combination of both, while minimising the impact on the environment and ensuring worker safety.
– Revegetation and follow-up: Develop a plan for restoring native plant species and revegetating the area following willow removal to prevent future infestations. Establish a follow-up plan to ensure the success of the restoration efforts.
– Monitoring and evaluation: Establish a monitoring and evaluation plan to assess the effectiveness of the project in achieving its objectives, measure the impact on natural assets, and engage the community in the process.

By involving the local community throughout the entire process, from planning to monitoring and evaluation, the project will benefit from better ownership and success. The project objectives will ensure that the willow removal is done in a responsible and effective manner, minimizing negative consequences and maximizing benefits for the local environment and community.

In addition to scoping the problem Council will need to consider and allow for statutory approval and landowner consent to inform the scope of works, timeframe and budget. A standalone project plan for the willow weed management should be created as part of the initial planning phase. The *Environmental Best Practice Guidelines 1. Legislative and Policy Requirements for Protecting Waterways and Wetlands when Undertaking Works*, prepared by the Department of Natural Resources Environment Tasmania should be considered as part of the project planning. There are a significant number of legislative requirements that must complied with prior to commencing works within a wetland or watercourse. The *Wetlands and Waterways Works Manual*, developed by the Department of Natural Resources Environment Tasmania and available at **https://nre.tas.gov.au/conservation/flora-of-tasmania/tasmanias-wetlands/wetlands-waterways-works-manual** should be used as a guide through-out the process. An Aboriginal Heritage desktop survey should also be undertaken during the scoping phase of the planning.

The works will however likely be exempt from requiring a permit under *the Land Use Planning and Approvals Act 1993* per Part 4.0 of the Planning Scheme. This is provided in Table 4.4 of the Scheme per clause 4.4.2 and 4.4.3 listed below:

• *4.4.2 landscaping and vegetation management*

Landscaping and vegetation management within a private garden, public garden or park, or within State-reserved land or a council reserve, if:

a. the vegetation is not protected by legislation, a permit condition, an agreement made under section 71 of the Act, or a covenant; or

b. the vegetation is not specifically listed and described as part of a Local Heritage Place or a significant tree in the relevant Local Provisions Schedule,

unless the management is incidental to the general maintenance.

AND

- *4.4.3 vegetation rehabilitation works*

The planting, clearing or modification of vegetation for:

c. soil conservation or rehabilitation works including Landcare activities and the like, provided that ground cover is maintained and erosion is managed;

d. the removal or destruction of declared weeds or environmental weeds listed under a strategy or management plan approved by a council;

e. water quality protection or stream bank stabilisation works approved by the relevant State authority or a council;

f. the implementation of a vegetation management agreement or a natural resource, catchment, coastal, reserve or property management plan or the like, provided the agreement or plan has been endorsed or approved by the relevant State authority or a council; or

g. the implementation of a mining and rehabilitation plan approved under the terms of a permit, an Environment Protection Notice, or rehabilitation works approved under the Mineral Resources Development Act 1995.

High level modelling of a reduction in willow density indicated that willow removal/control would likely reduce the extent of flooding to the River Clyde floodplain during frequent flood events and shown graphically in Appendix G (at the time of peak flood level).

8.1.2 Debris Management

Debris management can also be a major issue following a flood event, particularly if catchment management is lacking. Large amounts of debris can be washed into rivers, including trees and other vegetation from private properties. This can cause significant damage to infrastructure and exacerbate the effects of flooding. It is important to communicate these issues to property owners and encourage them to take responsibility for managing the flood-inundated areas around their properties. This can help to reduce the overall impact of flooding on the local economy and community.

8.1.3 Insurance Policy

In addition, individuals who are unaware of whether they have flood insurance coverage may be faced with unexpected expenses and financial difficulties, adding to the trauma they have already experienced from the flood.

The conflict between flood and storm cover in insurance policies can also contribute to confusion and uncertainty. Storm cover typically refers to damage caused by high winds, hail, and other severe weather conditions, while flood cover is designed to protect against damage caused by rising water levels. However, there may be overlap

between these two types of coverage, and policy language can be complex and difficult to understand. To address these issues, it is important for Bothwell residents and businesses to review their insurance policies carefully and ensure that they have adequate coverage for flood damage. Council can provide some education efforts to help raise awareness of the risks of flooding and the importance of being prepared. By taking proactive steps to mitigate the impact of floods, individuals and businesses can help protect themselves and the local economy from the financial and emotional toll of these disasters.

8.1.4 Infrastructure Upgrade

GHD investigated options for an infrastructure upgrade to minimize flooding in the town of Bothwell. The proposed option was designed to take into consideration the constructability of any new infrastructure required, the available space, existing underground services, historical value, and alignment of the existing infrastructure. The focus was on incorporating best practice flood management principles, recognising that flooding is a natural process that needs to be integrated into the rural landscape rather than ignored or eliminated through feats of engineering. GHD conducted a thorough options assessment that included a natural values assessment and a land use planning assessment to highlight any potential risks and inform the options.

The reduction of release volumes from Lake Crescent was an option that was considered as a potential flood risk management measure. However, this option was ultimately dismissed due to community consultation feedback and concerns about drought conditions. The community expressed their opposition to the idea, and there were concerns that reducing the release volumes could impact irrigation in the area. Additionally, there was a realisation that this measure might not have a significant impact on the overall flood behaviour in the wider River Clyde catchment.

Another potential option that was considered for flood risk management was the construction of in-stream detention basins. However, this option was also dismissed due to several factors. The main concern was the high cost of building and maintaining these basins, which made them economically unfeasible. Additionally, there were potential safety concerns associated with the construction and operation of the basins, such as the risk of erosion and flooding.

This section will explore the option proposed by GHD, its advantages, and its suitability in mitigating flooding in Bothwell.

8.1.4.1 Option 1 - Stormwater Infrastructure Upgrade

It has been determined that Option 1, as proposed by PDA Surveyors, is a viable option for mitigating the flooding issue. This option involves laying a new stormwater pipework along the local overland flow path through the back of the hotel and through No 8 Patrick St and No 4 Patrick St. While this option is expected to effectively convey flow in frequent floods, it is important to note that during high river flows, the proposed option may be ineffective.

During high river flows, it is likely that the downstream levels of the River Clyde will not allow the water to be discharged freely, which could result in backflow and further exacerbate the flooding problem. As such, it is important to consider measures to address this potential issue, such as implementing a valve or other backflow prevention devices at the outlet location. This will ensure that the proposed option remains effective in mitigating flooding during frequent floods, while also addressing the potential issue of backflow during high river flows. Overall, a comprehensive approach to flood management that considers both frequent and extreme flood events, as well as downstream conditions, will be necessary to ensure the long-term effectiveness of any proposed solutions.

The flood inundation extents and depths for 5% AEP is shown graphically in Appendix G (at the time of peak flood level).

8.1.4.2 Option 2 - Open Drainage Channel

Option 2 proposes the construction of an open channel that will convey water from the northeast to the south side of the residential area along Franklin Street and discharging water into the River Clyde. However, it presents some challenges, such as the need for additional measures like culverts and underground infrastructure to ensure safe and efficient conveyance of water. Additionally, the downstream piped section is necessary to accommodate private driveway crossings, which can add complexity to the construction process. Excavation is also a significant undertaking, as the channel will need to be deep enough to handle a significant amount of water. Moreover, constructing the channel against the existing natural ground slope in the upper reaches will require careful planning and execution to ensure that the channel banks are stable. Despite these challenges, Option 2 remains a viable solution for managing water flow in the residential area of Bothwell township.

Additionally, it can be designed to integrate with the existing landscape and infrastructure, ensuring minimal disruption to the surrounding environment. The open channel could also serve as a natural habitat for wildlife, depending on its design and construction.

Two additional upgrades have been considered for the Arthur Crescent and Nant Lane areas. The first option was to upgrade the bridge/crossing, but due to the significant cost compared to the benefits, this option does not appear viable in the short term. As an alternative, the Council should consider implementing safety measures at the crossing to exclude movements during flooding. The second option was to undertake levee works adjacent to the properties, but it is not considered viable due to the significant inundation of the wider area and inflow from the east side of the area.

The flood inundation extents and depths for 5% AEP are shown graphically in Appendix G (at the time of peak flood level).

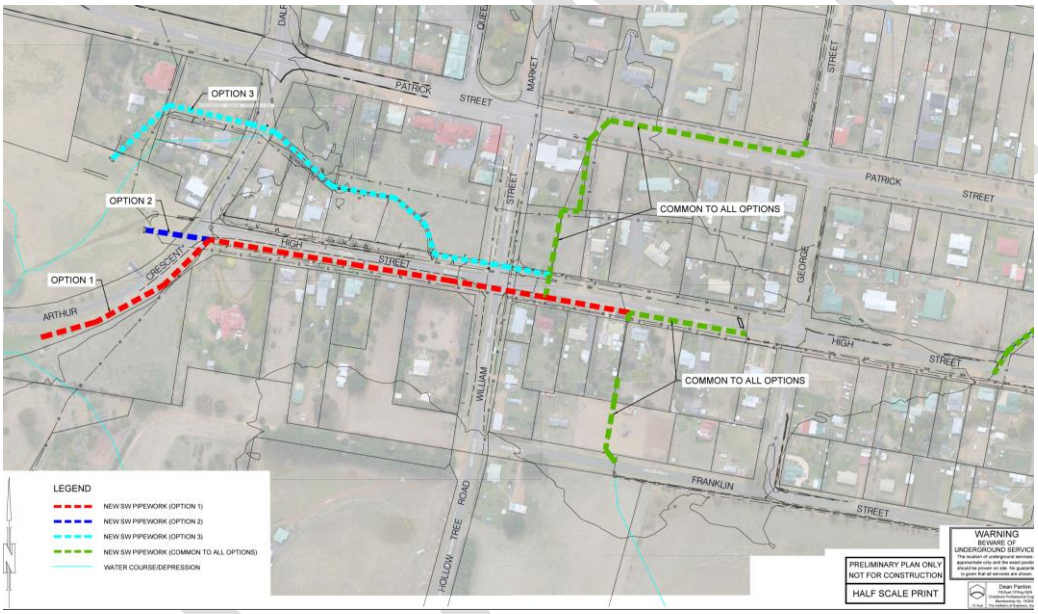


Figure 18 PDA Surveyors Mitigation Options

8.1.5 Land Use Planning Considerations for Infrastructure Options

In considering the infrastructure options for flood and stormwater management, Council will need to factor requirements under the Planning Scheme. This should be undertaken early in the project planning phase as part of a project plan.

The following planning considerations are provided for the options shown in Figure 18:

– Stormwater works such as pipes, open drains/swales, detention or retention basin dam are defined as mostly “Minor Utilities”, however a large detention or retention basin/dam could mean the works are “Utilities” and may require a permit.

– There are six (6) heritage listed places under the *Historic Cultural Heritage Act 1995*. These are 6 High Street, 16-18 High Street, 'Castle Hotel' 14 Patrick Street, 10 Patrick Street, 8 Patrick Street and 4 Patrick Street. Works could be managed through design solutions or avoidance of property or extent of heritage values.
– Works are in the Bothwell Heritage Precinct under the Local Historic Heritage Code.
– There is a small area of Priority Vegetation Overlay under the Natural Assets Code at 2 Franklin Street.
– The area is mixed zones. The use status of works for each zone is provided as follows:
    - Village Zone – likely exempt from requiring a permit as stormwater infrastructure per 4.2.2 of the Planning Scheme
    - Agriculture Zone – likely exempt as stormwater infrastructure per 4.2.2 of Scheme.
    - Rural Living Zone - likely exempt as stormwater infrastructure per 4.2.2 of Scheme
    - Recreation Zone - likely exempt as stormwater infrastructure per 4.2.2 of Scheme
– GHD recommend an Aboriginal Heritage desktop assessment be undertaken during the planning and design phase of the project – particularly closer to the River Clyde.
– Works should and ought to be undertaken within the road reserve where possible.

The infrastructure options are likely exempt from requiring a permit under the Planning Scheme. However further considerations will be required early in the project planning phase.

9. Natural Values Assessment

GHD conducted a desktop based natural values assessment to examine and assess the existing environment within a defined survey area and identify the extent of any environmental values that may constrain the suitability and implementation of any proposed mitigation options (specifically Option 2 as per section 8.1.4.2) for the River Clyde mapping study and flood mitigation strategies.

Environmental constraints assessed include the potential presence of conservation significant vegetation communities, flora species, fauna species and habitat. The desktop assessment collates data from verified publicly available databases, although does not contain any field assessment or site investigation conducted in association with the works. As such, small scale variations in vegetation, flora composition, fauna habitat and general condition of the site are unlikely to be represented in the assessment.

Key recommendations of the desktop assessment include:

- A total of 11 state and/or Commonwealth listed flora species have the potential to or are likely to be located within the survey area.
- A total of seven state and/or Commonwealth listed fauna species (two birds, four mammals & one reptile) are potentially present within the survey area based on previous records, their known habitat preferences and the habitat identified during the desktop assessment.
    - The survey was not considered to provide suitable nesting or denning habitat for the Tasmanian devil, spotted tailed-quoll, Tasmanian wedge-tailed eagle, and Tasmanian masked owl given the lack of representative suitable habitat.
    - Suitable nesting/denning habitat for the eastern quoll, eastern barred bandicoot and the tussock skink may be present within the survey area.
- The survey area intersects with a small area listed as ‘Priority Vegetation’ under the Natural Assets Code of the Central Highlands Local Provisions Schedule and Tasmanian Planning Scheme.
    - According to aerial imagery, the vegetation in this area looks to comprise roadside planted shrubs and trees, however, this will require confirmation.
- Based on the above, prior to the commencement of any construction a natural values survey conducted by a suitably qualified ecologist is recommended to map and record the baseline ecological values within the survey area.
    - It is noted that the majority of the survey area is mapped as modified vegetation in the form of agricultural/pastoral land, house and transport infrastructure and urban areas. However, some threatened flora and/or fauna species are known to inhabit such communities which may provide refugia in a heavily cleared landscape.
    - The survey should aim to target those species (flora and/or fauna) whose suitable habitat was identified as potentially present.
    - Field survey methods should be developed in accordance with the NRE Guidelines for Natural Values Surveys - Terrestrial Development Proposals
    - Flora surveys should ideally be conducted during the spring/early summer flowering period for most Tasmanian flora species as this will increase the likelihood of positive identifications.
        - Where baseline flora surveys identify the likely presence of potential threatened flora species, or some flora species are unable to be identified in the field, additional targeted flora surveys may be required.
- Once the preferred flood mitigation option has been selected, the final project footprint should be determined.
    - This will assist the assessment of the potential impacts of any proposed development and inform the methods and the extent of the proposed survey activities.
- Eleven declared weeds under the Tasmania *Weed Management Act 1999* have been recorded within 500m and 5km of the survey area respectively. Several of which are also known to be Weeds of National Significance (WoNS).

- As such, the proponent should develop and implement a Weed & Hygiene Management Plan (WHMP) to reduce the risk of introduction and spread of invasive flora species as a result of any development.
- The WHMP may be included as part of any Construction Environmental Management Plan (CEMP) developed for the project.

– Once the final project footprint is confirmed, impacts to listed flora, fauna and vegetation communities should be confirmed to inform the need for any relevant permits and approvals.
    - This will be informed by the results of the recommended field survey.

The full desktop assessment can be found in Appendix H of this report

10. Conclusion

This study has investigated the flood levels along River Clyde, resulting from flood inundation caused by the 1% and 5% AEP design flood events and the 1% AEP design flood event with climate change. The study investigated flooding between Nant Lane and the River Clyde Falls, focused on Bothwell township. A hydrological study was conducted using a RAFTS hydrology. A variety of available and collected data was utilised for modelling purposes. This includes hydrological, geographical, climate, management, flood history, and previous study data. The availability of this data has supported the development of hydrological and hydraulic models for the River Clyde catchment area. The compiled data and relevant contacts for organisations have been summarised in this report, providing a useful resource for future research and planning in the area.

The results of the hydrological study show that the critical duration for the catchment was 6 hours for both the current study as well as the climate change scenario. The climate change scenarios analysed project increases in the magnitudes of the 1% AEP flood by 16.3% by the end of the century.

InfoWorks ICM modelling results indicate that the residential area in Bothwell, Arthur Crescent, Williams Street and Nant Lane are likely to flood during frequent and rare rainfall events.

InfoWorks ICM modelling results also indicate that the flood capacity of the stormwater infrastructure within Bothwell is restricted due to the high River Clyde levels.

It is important to note that the results of the study should be interpreted in the context of the limitations of the data and models used. Moreover, the study may not reflect the full range of flood behaviour and potential impacts in the study area, particularly in rare and extreme flood events. A high-level review of potential flood mitigation measures was undertaken with several option identified for potential future investigation and implementation.

11. References

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Bates, B., Evans, J., Green, J., Griesser, A., Jakob, D., Lau, R., Lehmann, E., Leonard, M., Phatak, A., Rafter, T., Seed, A., Westra, S. and Zheng, F. (2015), Development of Intensity-Frequency-Duration Information across Australia - Climate Change Research Plan Project. Report for Institution of Engineers Australia, Australian Rainfall and Runoff Guideline: Project 1. 61p.

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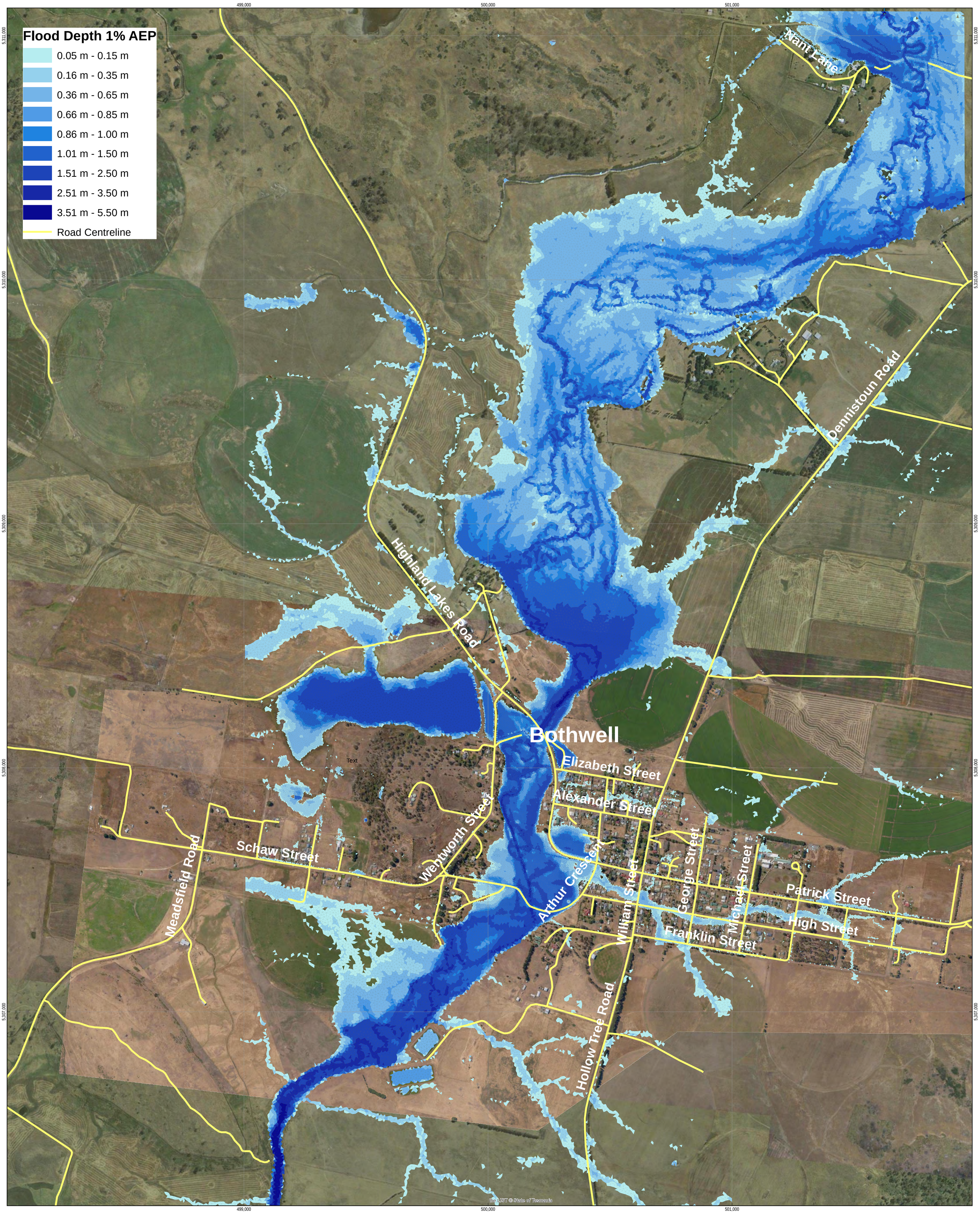
Zheng, F., Westra, S. and Leonard, M. (2015), Opposing local precipitation extremes. Nature Climate Change, 5(5), 389-390, doi: 10.10. 38/nclimate2579, Available at: http://dx.doi.org/10.1038/nclimate2579.

Australian Disaster Resilience Guideline 7-3:Technical flood risk management guideline: Flood hazard, 2014, Australian Institute for Disaster Resilience CC BY-NC

Appendices

Appendix A

Flood Depth Maps 1% and 5% AEP- Project Area, Bothwell, Nant Lane



Paper Size A1

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Central Highlands Council
River Clyde Flood Mappring Study

River Clyde Flood Map 1% AEP

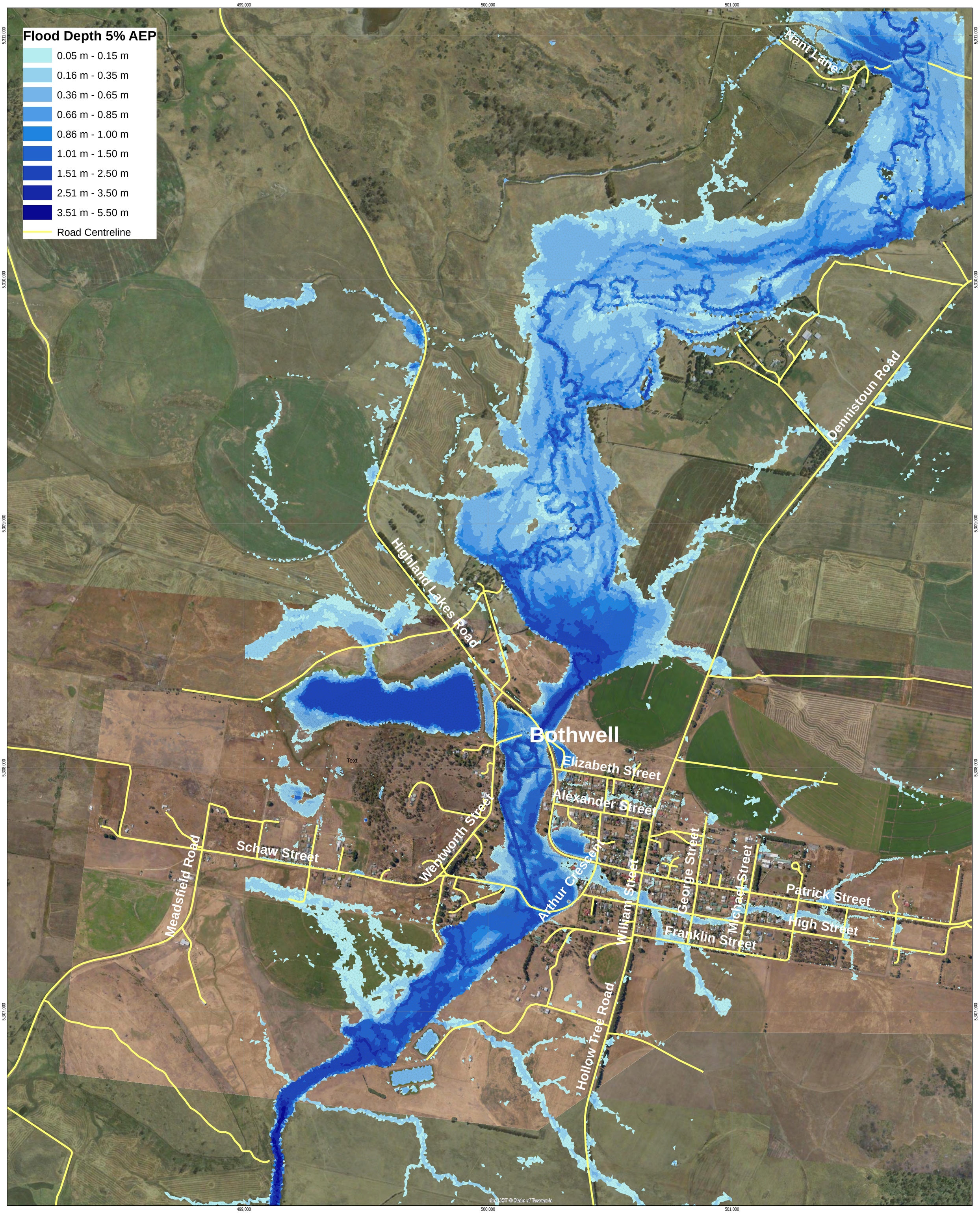
Job Number	12571871
Revision	B
Date	20 Mar 2023

Figure 1

C:\Users\EKISEL~1\AppData\Local\Temp\arcC43D\12571871_001_Clyde_A1_1pct_Rev_B.mxd

2 Salamanca Square, Hobart Tasmania 7000 Australia **T** 61 3 6210 0600 **E** hbamail@ghd.com **W** www.ghd.com

Data source: Roads (LIST), Flood Model (GHD). Created by:ekiseleva



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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Central Highlands Council
River Clyde Flood Mappring Study

River Clyde Flood Map 5% AEP

Job Number	12571871
Revision	B
Date	20 Mar 2023

Figure 2

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2 Salamanca Square, Hobart Tasmania 7000 Australia **T** 61 3 6210 0600 **E** hbamail@ghd.com **W** www.ghd.com

Data source: Roads (LIST), Flood Model (GHD). Created by:ekiseleva

Paper Size A1

0 30 60 120 180 240

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Central Highlands Council
River Clyde Flood Mapping Study

Bothwell Flood Map 1% AEP

Job Number	12571871
Revision	B
Date	09 Mar 2023

Figure 4

C:\Users\EKISEL~1\AppData\Local\Temp\arc1C4A\Bothwell_Map_A1_Willow_removal_2yr.mxd

Data source: Roads (LIST), Flood Model (GHD). Created by:ekiseleva

2 Salamanca Square, Hobart Tasmania 7000 Australia **T** 61 3 6210 0600 **E** hbamail@ghd.com **W** www.ghd.com

499,000 500,000 501,000

5,309,000 5,307,000

Highland Lakes Road
Wentworth Street
Adelaide Street
Barrack Street
Elizabeth Street
Alexander Street
Dennistoun Road
Queen Street
Market Place
George Street
Keeling Road
Schaw Street
Logan Street
Arthur Crescent
William Street
Michael Street
Mary Street
Patrick Street
High Street
Franklin Street
Hollow Tree Road

Flood Depth 5% AEP

- 0.05 m - 0.15 m
- 0.16 m - 0.35 m
- 0.36 m - 0.65 m
- 0.66 m - 0.85 m
- 0.86 m - 1.00 m
- 1.01 m - 1.50 m
- 1.51 m - 2.50 m
- 2.51 m - 3.50 m
- 3.51 m - 5.50 m
- Road Centreline
- Property Boundary

DRAFT

Paper Size A1

0 30 60 120 180 240

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Central Highlands Council
River Clyde Flood Mappring Study
Bothwell Flood Map 5% AEP

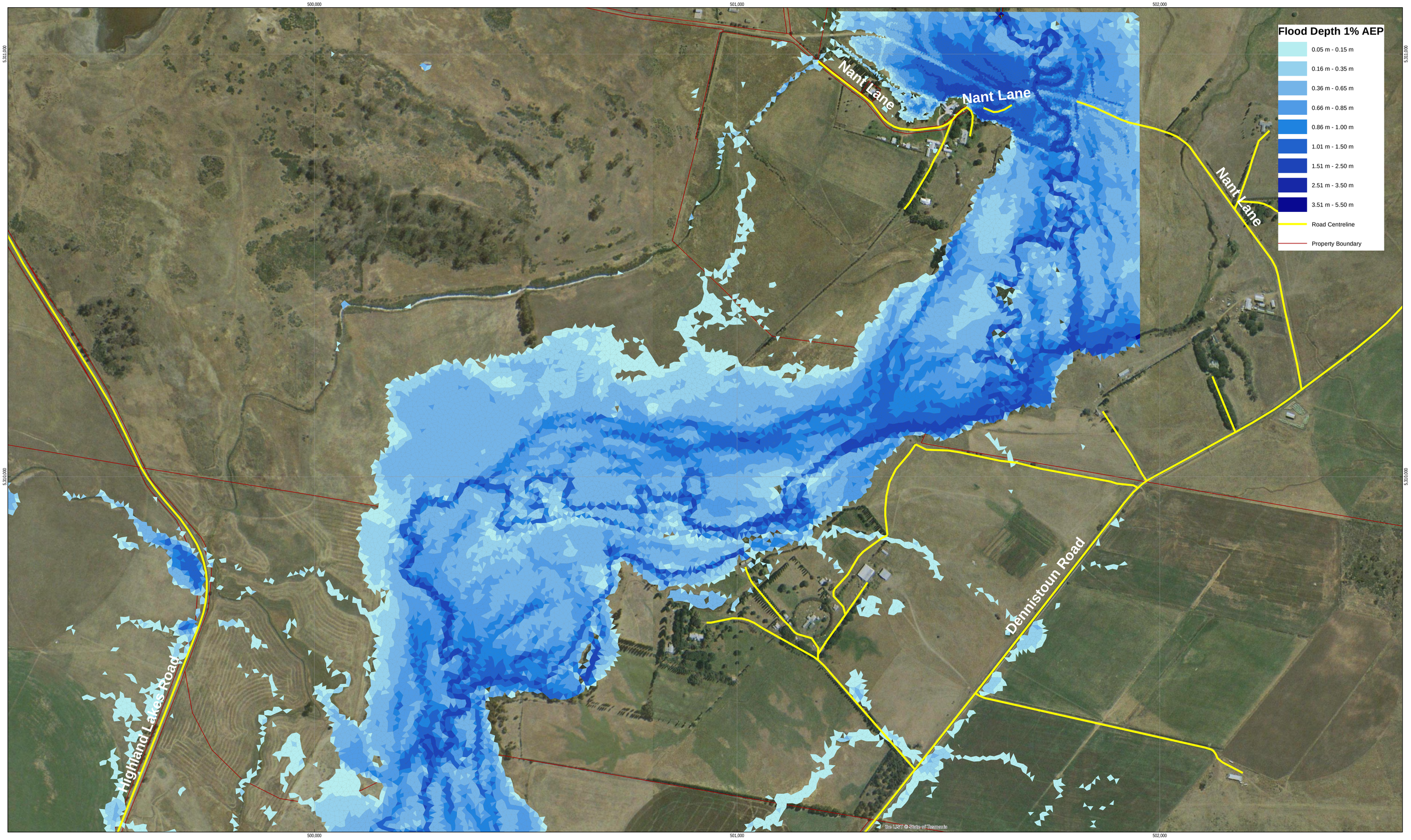
Job Number	12571871
Revision	B
Date	09 Mar 2023

Figure 5

C:\Users\EKISEL~1\AppData\Local\Temp\arcCE4\12571871_005_Bothwell_A1_5pct_Rev_B.mxd

Data source: Roads (LIST), Flood Model (GHD). Created by:ekiseleva

2 Salamanca Square, Hobart Tasmania 7000 Australia **T** 61 3 6210 0600 **E** hbamail@ghd.com **W** www.ghd.com



Paper Size A1

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Central Highlands Council

River Clyde Flood Mappring Study

Nant Lane Flood Map 1% AEP

Job Number	12571871
Revision	B
Date	20 Mar 2023

Figure 7

C:\Users\EKISEL~1\AppData\Local\Temp\arc3969\12571871_007_Nant_L_A1_1pct_Rev_B.mxd

Data source: Roads (LIST), Flood Model (GHD). Created by:ekiseleva

2 Salamanca Square, Hobart Tasmania 7000 Australia **T** 61 3 6210 0600 **E** hbamail@ghd.com **W** www.ghd.com

500,000
501,000
502,000
5,311,000
5,310,000

Nant Lane
Nant Lane
Nant Lane
Dennistoun Road
Highland Lakes Road

Flood Depth 5% AEP

- 0.05 m - 0.15 m
- 0.16 m - 0.35 m
- 0.36 m - 0.65 m
- 0.66 m - 0.85 m
- 0.86 m - 1.00 m
- 1.01 m - 1.50 m
- 1.51 m - 2.50 m
- 2.51 m - 3.50 m
- 3.51 m - 5.50 m
- Road Centreline
- Property Boundary

Paper Size A1

0 37.5 75 150 225 300

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Central Highlands Council
River Clyde Flood Mappring Study

Nant Lane Flood Map 5% AEP

Job Number	12571871
Revision	B
Date	20 Mar 2023

Figure 8

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Data source: Roads (LIST), Flood Model (GHD). Created by:ekiseleva

2 Salamanca Square, Hobart Tasmania 7000 Australia **T** 61 3 6210 0600 **E** hbamail@ghd.com **W** www.ghd.com

Appendix B

Flood Depth Map 1% and 5% AEP – Sensetivity Test

Flood Depth 5% AEP

- 0.05 m - 0.15 m
- 0.16 m - 0.35 m
- 0.36 m - 0.65 m
- 0.66 m - 0.85 m
- 0.86 m - 1.00 m
- 1.01 m - 1.50 m
- 1.51 m - 2.50 m
- 2.51 m - 3.50 m
- 3.51 m - 5.50 m
- Road Centreline

499,000 500,000 501,000

5,311,000 5,310,000 5,309,000 5,308,000 5,307,000

Avant Lane
Dennistoun Road
Highland Lakes Road
Bothwell
Elizabeth Street
Alexander Street
Wentworth Street
Arthur Crescent
William Street
George Street
Michael Street
Patrick Street
High Street
Franklin Street
Schaw Street
Meadsfield Road
Hollow Tree Road
P
F
A
EMP
S
Text

the LIST © State of Tasmania

Paper Size A1

0 70 140 280 420 560

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Central Highlands Council
River Clyde Flood Mappring Study

River Clyde Flood Map 5% AEP Surface Roughness Increase

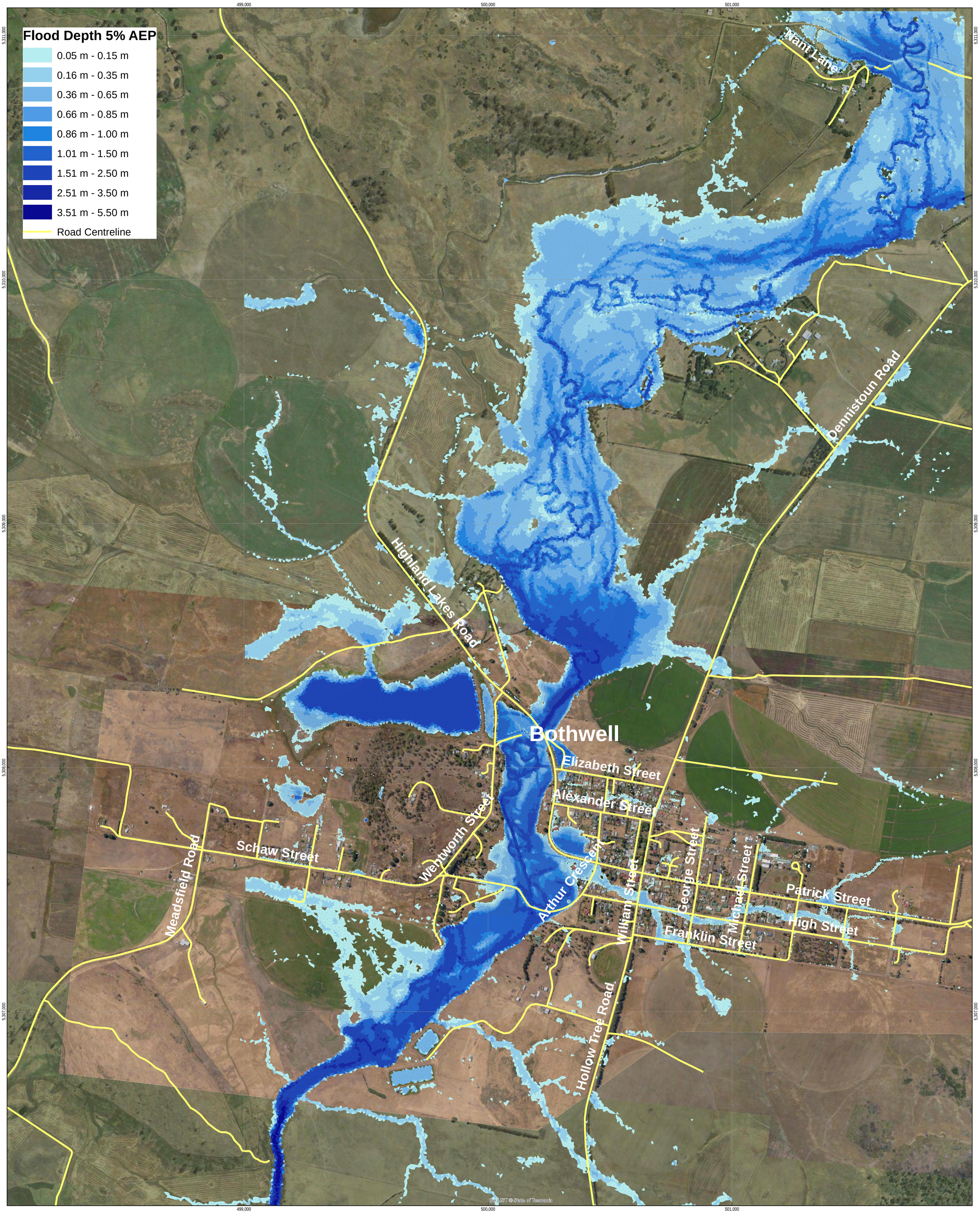
Job Number	12571871
Revision	B
Date	20 Mar 2023

Figure 12

C:\Users\EKISEL~1\AppData\Local\Temp\arc7918\12571871_012_Clyde_Roughness_+20_A1_5pct_Rev_B.mxd

2 Salamanca Square, Hobart Tasmania 7000 Australia **T** 61 3 6210 0600 **E** hbamail@ghd.com **W** www.ghd.com

Data source: Roads (LIST), Flood Model (GHD). Created by:ekiseleva



Paper Size A1

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Central Highlands Council
River Clyde Flood Mappring Study

River Clyde Flood Map 5% AEP Surface Roughness Decrease

Job Number 12571871
Revision B
Date 20 Mar 2023

Figure 13

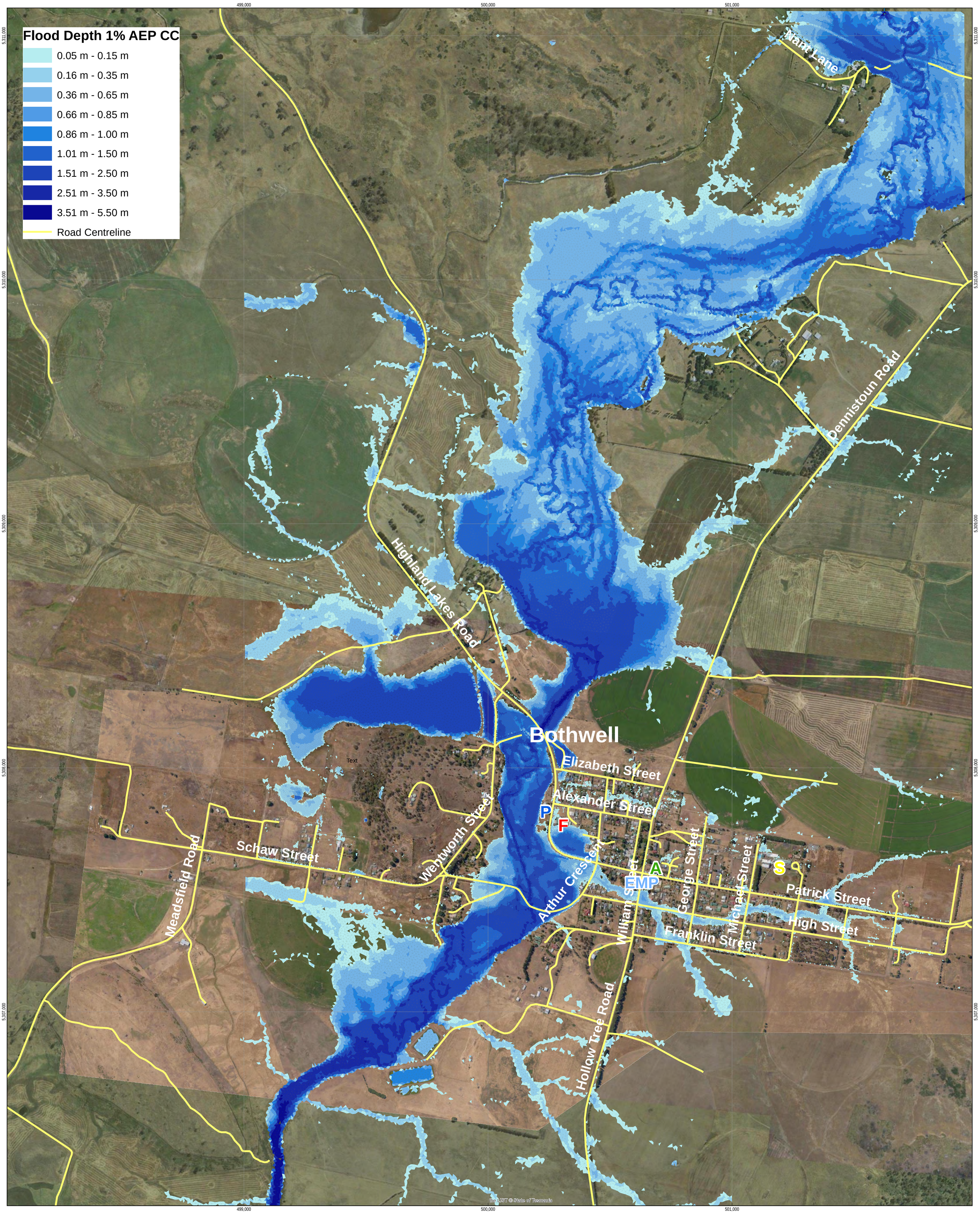
C:\Users\EKISEL~1\AppData\Local\Temp\arc800D\12571871_013_Clyde_Roughness_-20_A1_5pct_Rev_B.mxd

2 Salamanca Square, Hobart Tasmania 7000 Australia **T** 61 3 6210 0600 **E** hbamail@ghd.com **W** www.ghd.com

Data source: Roads (LIST), Flood Model (GHD). Created by:ekiseleva

Appendix C

Flood Depth Map 1% AEP - Climate Change



Paper Size A1

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Central Highlands Council
River Clyde Flood Mappring Study

River Clyde Flood Map 1% AEP Climate Change

Job Number	12571871
Revision	B
Date	20 Mar 2023

Figure 10

C:\Users\EKISEL~1\AppData\Local\Temp\arc5F75\12571871_010_Clyde_A1_1pctCC_Rev_B.mxd

2 Salamanca Square, Hobart Tasmania 7000 Australia **T** 61 3 6210 0600 **E** hbamail@ghd.com **W** www.ghd.com

Data source: Roads (LIST), Flood Model (GHD). Created by:ekiseleva

Appendix D

Aerial Imaging and 63% AEP Flood Map

Flood Depth 63% AEP

- 0.05 m - 0.15 m
- 0.16 m - 0.35 m
- 0.36 m - 0.65 m
- 0.66 m - 0.85 m
- 0.86 m - 1.00 m
- 1.01 m - 1.50 m
- 1.51 m - 2.50 m
- 2.51 m - 3.50 m
- 3.51 m - 5.50 m
- Road Centreline

499,000 500,000 501,000

5,311,000 5,310,000 5,309,000 5,308,000 5,307,000

Nant Lane
Dennistoun Road
Highland Lakes Road
Bothwell
Elizabeth Street
Alexander Street
Wentworth Street
Arthur Crescent
William Street
George Street
Michael Street
Patrick Street
High Street
Franklin Street
Text

Paper Size A1

0 70 140 280 420 560

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Central Highlands Council
River Clyde Flood Mappring Study

River Clyde Flood Map 63% AEP

Job Number 12571871
Revision B
Date 20 Mar 2023

Figure 3

C:\Users\EKISEL~1\AppData\Local\Temp\arc1BEE\12571871_003_Clyde_A1_63pct_Rev_B.mxd

2 Salamanca Square, Hobart Tasmania 7000 Australia **T** 61 3 6210 0600 **E** hbamail@ghd.com **W** www.ghd.com

Data source: Aerial (UDM Group), Roads (LIST), Flood Model (GHD). Created by:ekiseleva

499,000
500,000
501,000
502,000
5,311,000
5,310,000
5,309,000
5,308,000
5,307,000

Road Centreline

Nant Lane
Nant Lane
Highland Lakes Road
Dennistoun Road
Bothwell
Text
Elizabeth Street
Alexander Street
Wentworth Street
Arthur Crescent
William Street
George Street
Michael Street
Frankun Street
High Street
Patrick Street
Highland Lakes Road
Bchaw Street

Paper Size A1

0 70 140 280 420 560

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Central Highlands Council
River Clyde Flood Mappring Study

River Clyde Drone Aerial Image (UDM Group)

Job Number 12571871
Revision B
Date 20 Mar 2023

Figure 11

C:\Users\EKISEL~1\AppData\Local\Temp\arc757E\12571871_011_Clyde_A1_Drone_Aerial_Rev_B.mxd
2 Salamanca Square, Hobart Tasmania 7000 Australia **T** 61 3 6210 0600 **E** hbamail@ghd.com **W** www.ghd.com

Data source: Aerial (UDM Group), Roads (LIST). Created by:ekiseleva

499,000 500,000 501,000

5,308,000 5,307,000

Flood Depth 63% AEP
- 0.05 m - 0.15 m
- 0.16 m - 0.35 m
- 0.36 m - 0.65 m
- 0.66 m - 0.85 m
- 0.86 m - 1.00 m
- 1.01 m - 1.50 m
- 1.51 m - 2.50 m
- 2.51 m - 3.50 m
- 3.51 m - 5.50 m
- Road Centreline
- Property Boundary

Highland Lakes Road
Wentworth Street
Adelaide Street
Barrack Street
Elizabeth Street
Alexander Street
Dennistoun Road
Queen Street
Market Place
George Street
Keeling Road
Schaw Street
Logan Street
Arthur Crescent
William Street
Michael Street
Mary Street
Patrick Street
High Street
Franklin Street
Hollow Tree Road

DRAFT

the LIST © State of Tasmania

Paper Size A1

0 30 60 120 180 240

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Central Highlands Council
River Clyde Flood Mappring Study
Bothwell Flood Map 63% AEP

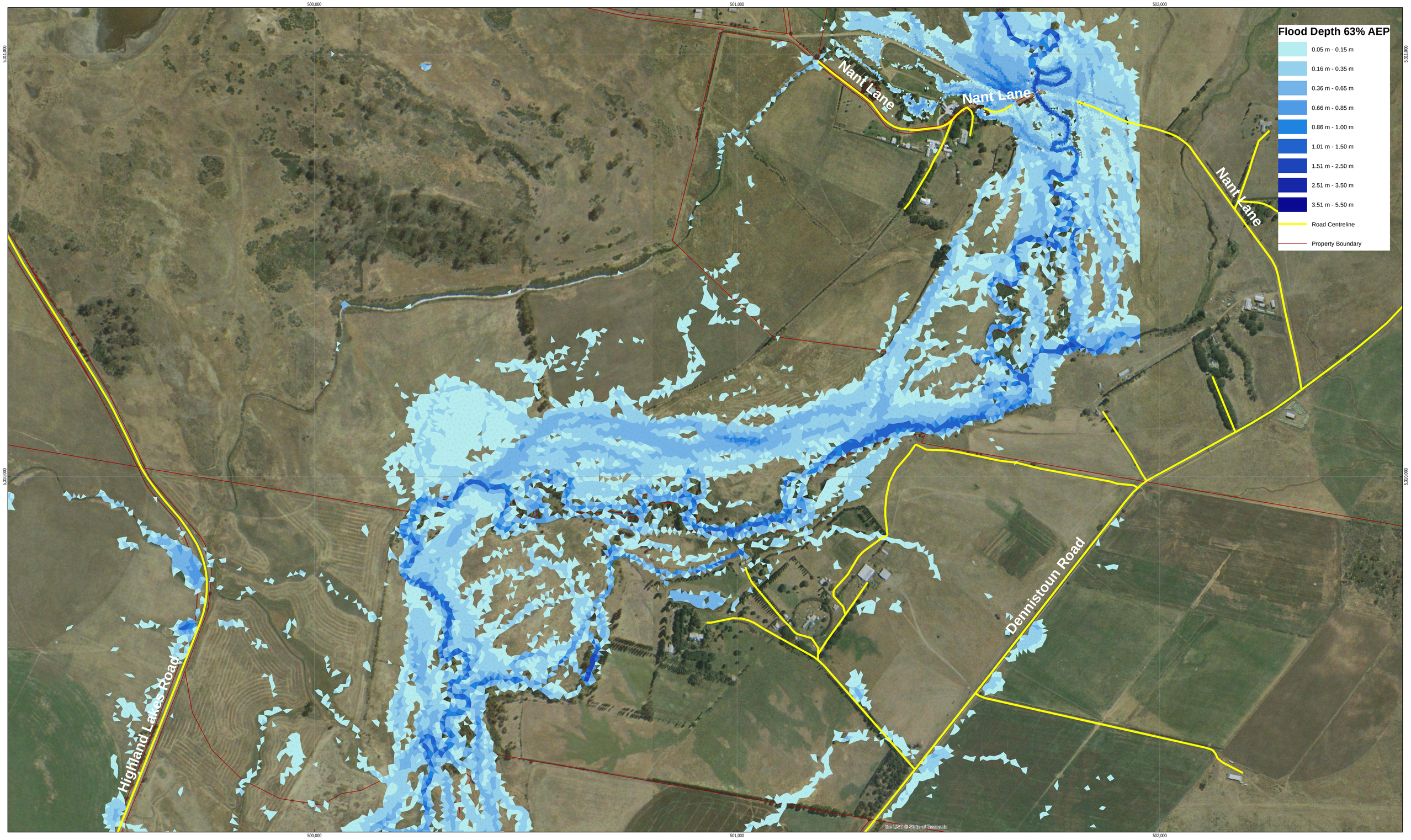
Job Number	12571871
Revision	B
Date	20 Mar 2023

Figure 6

C:\Users\EKISEL~1\AppData\Local\Temp\arc362D\12571871_006_Bothwell_A1_63pct_Rev_B.mxd

Data source: Roads (LIST), Flood Model (GHD). Created by:ekiseleva

2 Salamanca Square, Hobart Tasmania 7000 Australia **T** 61 3 6210 0600 **E** hbamail@ghd.com **W** www.ghd.com



Paper Size A1

0 37.5 75 150 225 300

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Central Highlands Council

River Clyde Flood Mappring Study

Nant Lane Flood Map 63% AEP

Job Number	12571871
Revision	B
Date	20 Mar 2023

Figure 9

C:\Users\EKISEL~1\AppData\Local\Temp\arc821A\12571871_009_Nant_L_A1_63pct_Rev_B.mxd

Data source: Roads (LIST), Flood Model (GHD). Created by:ekiseleva

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Appendix E

Flood Hazard Maps 1% and 5% AEP

Flood Hazard 1% AEP

- H1
- H2
- H3
- H4
- H5
- H6
- Road Centreline

499,000 500,000 501,000

5,311,000 5,310,000 5,309,000 5,308,000 5,307,000

Nant Lane
Dennistoun Road
Highland Lakes Road
Bothwell
Elizabeth Street
Alexander Street
Wentworth Street
Arthur Crescent
William Street
George Street
Michael Street
Patrick Street
High Street
Franklin Street
Hollow Tree Road
Schaw Street
Meadsfield Road
Text

the LIST © State of Tasmania

Paper Size A1

0 70 140 280 420 560

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Central Highlands Council
River Clyde Flood Mappring Study

River Clyde Flood Hazard Map 1% AEP

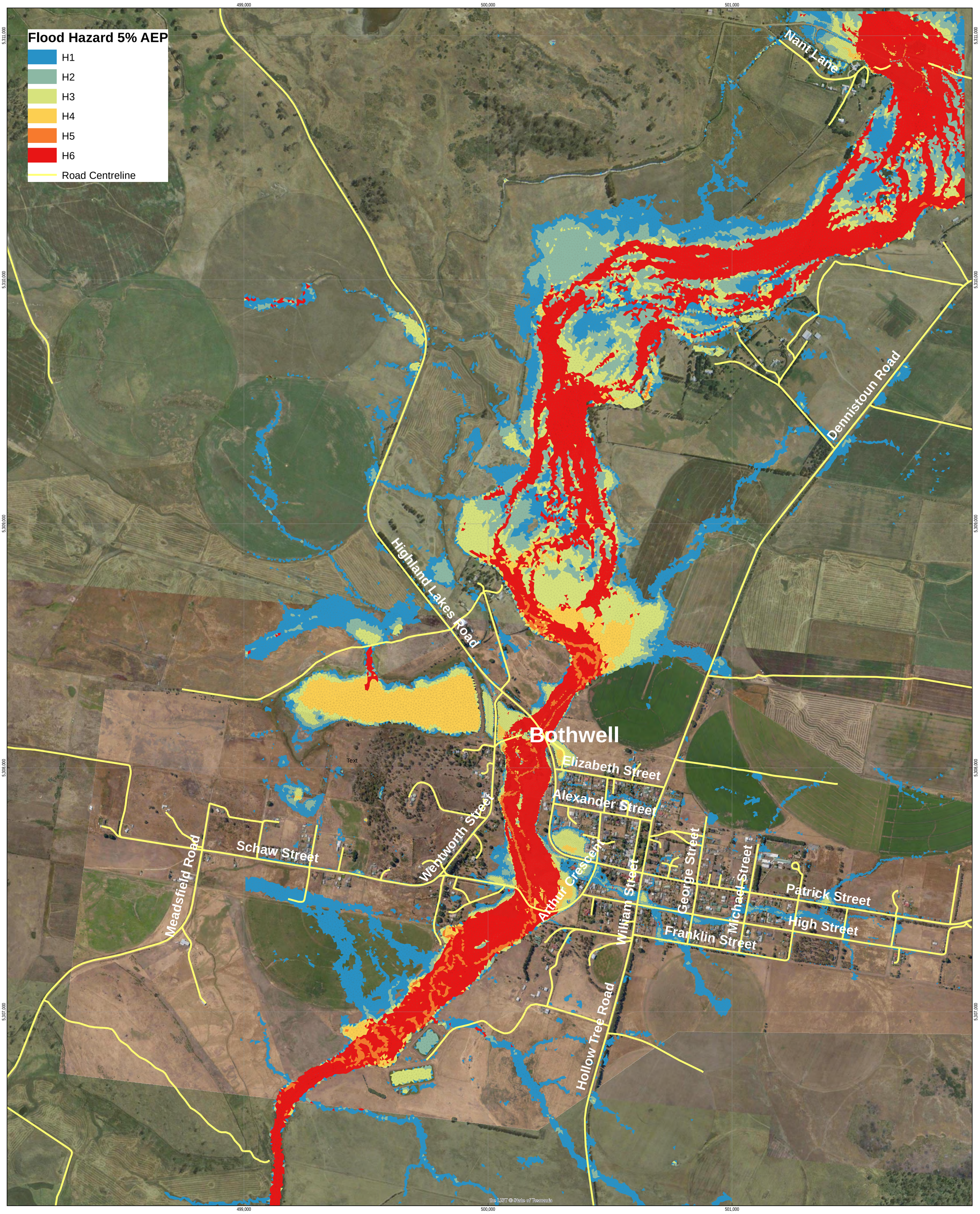
Job Number	12571871
Revision	B
Date	20 Mar 2023

Figure 14

C:\Users\EKISEL~1\AppData\Local\Temp\arc8647\12571871_014_Clyde_Hazard_A1_1pct_Rev_B.mxd

2 Salamanca Square, Hobart Tasmania 7000 Australia **T** 61 3 6210 0600 **E** hbamail@ghd.com **W** www.ghd.com

Data source: Roads (LIST), Flood Model (GHD). Created by:ekiseleva



Paper Size A1

0 70 140 280 420 560

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Central Highlands Council
River Clyde Flood Mappring Study

River Clyde Flood Hazard Map 5% AEP

Job Number	12571871
Revision	B
Date	21 Mar 2023

Figure 15

C:\Users\EKISEL~1\AppData\Local\Temp\arcA37\12571871_015_Clyde_Hazard_A1_5pct_Rev_B.mxd

2 Salamanca Square, Hobart Tasmania 7000 Australia **T** 61 3 6210 0600 **E** hbamail@ghd.com **W** www.ghd.com

Data source: Roads (LIST), Flood Model (GHD). Created by:ekiseleva

499,000 500,000 501,000

5,308,000 5,307,000

Flood Hazard 1% AEP
- H1
- H2
- H3
- H4
- H5
- H6
- Road Centreline
- Property Boundary

Highland Lakes Road
Wentworth Street
Adelaide Street
Barrack Street
Elizabeth Street
Alexander Street
Dennistoun Road
Keeling Road
Schaw Street
Logan Street
Arthur Crescent
Queen Street
Market Place
George Street
William Street
Michael Street
Mary Street
Patrick Street
High Street
Franklin Street
Hollow Tree Road

the LIST © State of Tasmania

Paper Size A1

0 30 60 120 180 240
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Central Highlands Council
River Clyde Flood Mapping Study
Bothwell Flood Hazard Map 1% AEP

Job Number	12571871
Revision	B
Date	21 Mar 2023

Figure 16

C:\Users\EKISEL~1\AppData\Local\Temp\arc4CF8\12571871_016_Bothwell_Hazard_A1_1pct_Rev_B.mxd

Data source: Roads (LIST), Flood Model (GHD). Created by:ekiseleva

2 Salamanca Square, Hobart Tasmania 7000 Australia **T** 61 3 6210 0600 **E** hbamail@ghd.com **W** www.ghd.com

499,000 500,000 501,000

5,308,000 5,307,000

Highland Lakes Road
Wentworth Street
Adelaide Street
Barrack Street
Elizabeth Street
Alexander Street
Dennistoun Road
Keeling Road
Schaw Street
Logan Street
Arthur Crescent
Queen Street
Market Place
George Street
William Street
Michael Street
Mary Street
Patrick Street
High Street
Franklin Street
Hollow Tree Road

Flood Hazard 5% AEP

- H1
- H2
- H3
- H4
- H5
- H6
- Road Centreline
- Property Boundary

499,000 500,000 501,000

Paper Size A1

0 30 60 120 180 240

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Central Highlands Council
River Clyde Flood Mappring Study

Bothwell Flood Hazard Map 5% AEP

Job Number	12571871
Revision	B
Date	21 Mar 2023

Figure 17

C:\Users\EKISEL~1\AppData\Local\Temp\arc5073\12571871_017_Bothwell_Hazard_A1_5pct_Rev_B.mxd

Data source: Roads (LIST), Flood Model (GHD). Created by:ekiseleva

2 Salamanca Square, Hobart Tasmania 7000 Australia **T** 61 3 6210 0600 **E** hbamail@ghd.com **W** www.ghd.com

500,000 501,000 502,000

5,311,000 5,310,000

Nant Lane

Nant Lane

Nant Lane

Highland Lakes Road

Dennistoun Road

Flood Hazard 1% AEP

- H1
- H2
- H3
- H4
- H5
- H6
- Road Centreline
- Property Boundary

Paper Size A1

0 37.5 75 150 225 300

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Central Highlands Council

River Clyde Flood Mappring Study

Nant Lane Flood Hazard Map 1% AEP

Job Number	12571871
Revision	B
Date	21 Mar 2023

Figure 18

C:\Users\EKISEL~1\AppData\Local\Temp\arc540D\12571871_018_Nant_Hazard_A1_1pct_Rev_B.mxd

Data source: Roads (LIST), Flood Model (GHD). Created by:ekiseleva

2 Salamanca Square, Hobart Tasmania 7000 Australia **T** 61 3 6210 0600 **E** hbamail@ghd.com **W** www.ghd.com

500,000 501,000 502,000

5,311,000

5,310,000

Nant Lane

Nant Lane

Nant Lane

Dennistoun Road

Highland Lakes Road

Flood Hazard 5% AEP

- H1
- H2
- H3
- H4
- H5
- H6
- Road Centreline
- Property Boundary

Paper Size A1

0 37.5 75 150 225 300

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Central Highlands Council

River Clyde Flood Mappring Study

Nant Lane Flood Hazard Map 5% AEP

Job Number	12571871
Revision	B
Date	21 Mar 2023

Figure 19

C:\Users\EKISEL~1\AppData\Local\Temp\arc8B0B\12571871_019_Nant_Hazard_A1_5pct_Rev_B.mxd

Data source: Roads (LIST), Flood Model (GHD). Created by:ekiseleva

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Appendix F

Consultation and Engagement Summary

River Clyde Flood Mapping Study

Consultation and Engagement Summary

Central Highlands Council

4 April 2023

→ **The Power of Commitment**

Project name		River Clyde Flood Mapping Study					
Document title		River Clyde Flood Mapping Study | Consultation and Engagement Summary					
Project number		12571871					
File name		12571871-RPT-A-River Clyde Flood Mapping Study Consultation and Engagement Summary DRAFT A .docx					
Status Code	**Revision**	**Author**	**Reviewer**		**Approved for issue**		
			Name	**Signature**	**Name**	**Signature**	**Date**
S3	A	Annalise Rees Robyn Hall	Michael Ulph				
[Status code]							
[Status code]							
[Status code]							
[Status code]							

GHD Pty Ltd ABN 39 008 488 373

2 Salamanca Square

Hobart, TAS 7000, Australia

T 03 6210 0600 | **F** +61 3 8732 7046 | **E** hbamail@ghd.com | **ghd.com**

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1. Introduction

The Central Highlands Council's flood map for the township of Bothwell was developed over 50 years ago. The town and surrounding districts have experienced several large flood events since that time, resulting in major infrastructure damage, property loss, destruction of crops, loss of livestock, and health impacts owing to waterborne diseases which have negatively impacted the social fabric of the community.

The Central Highlands Council sought funding through the Australian Government's *Preparing Australian Communities* program to undertake a River Clyde Flood Mapping Study (the Study). The Study collected data to better predict the likelihood and location of future flood events to improve decision making around land use, and future development. The Study also identifies the most effective mitigation measures that can be taken to reduce the negative impacts of flood events such as damage to major infrastructure and property, agricultural productivity losses and activity, and risks to public health.

The Council is seeking to gain a better understanding of flood behaviour, extent, likely water levels, velocities and depths within the study area to develop a *Stormwater System Management Plan* that will improve emergency management planning and the response to flood events.

An important part of the Study has been engaging with stakeholders, including government departments, industry, landowners, businesses and residents to gather important historical flooding information and gain an understanding of community priorities, awareness and perception of flood risk. The information that the Study provides aids Council to identify potential mitigation options that address community priorities and reduce the negative impacts of future flood events.

1.1 Purpose of this report

The purpose of this report is to capture and summarise the activities undertaken, and feedback received from stakeholders and community members in relation to the River Clyde Flood Study project community engagement scope.

1.2 Scope and limitations

The scope of this project included:

- Undertake a workshop with Council members
- Consultation with landowners
- Preparation of materials for and attendance at public information sessions
- Meetings with business owners and utility/infrastructure
- Development of communication materials for website, Facebook, newsletters
- Development of Consultation and Engagement Summary (this report)

This report: has been prepared by GHD for Central Highlands Council and may only be used and relied on by Central Highlands Council for the purpose agreed between GHD and Central Highlands Council as set out in section 1.1 of this report.

GHD otherwise disclaims responsibility to any person other than Central Highlands Council arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

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The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

Accessibility of documents

If this report is required to be accessible in any other format, this can be provided by GHD upon request and at an additional cost if necessary.

GHD has prepared this report on the basis of information provided by Central Highlands Council and others who provided information to GHD (including Government authorities, community members and landowners), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

1.3 Assumptions

In preparing this report the following assumptions have been made:

- Feedback and information provided through engagement sessions and online surveys is true and correct;
- Opportunities for feedback have reached a substantial portion of the community (distribution via multiple avenues) and therefore the number of responses received reflects the communities understanding and/or interest in the issue

2. Stakeholder engagement summary

Engagement activities for this Study focused on gathering information from stakeholders and community about past flood behaviour and impacts, key priorities and concerns and sharing information to increase community awareness and preparedness for flood events.

2.1 Consultation objectives

The engagement objectives for this project were to:

- gather valuable local insight and knowledge about the history of flooding in the area by involving the community who have lived experience
- better understand the community's main concerns and priority areas for dealing with flooding events
- increase the community's awareness of the risk of flooding within the study area by educating and informing them about flood risk
- improve public perception of the risk and impacts of flooding to encourage proactive behaviours
- discuss flood mitigation measures with the community to increase preparedness for flooding events.

This process was an opportunity for Council to involve the community in a discussion around the impacts of flooding and inform the community of flood risks to improve measures to reduce the negative impacts of flooding in the area.

2.2 Summary of consultation

A Stakeholder and Community Engagement Plan was developed identifying key stakeholders, outlining key messages, activities, project timing and feedback opportunities to support the project objectives. Stakeholder engagement content was prepared to provide information around why the Flood Mapping Study was being undertaken and how it will enable the council to prepare a Stormwater System Management Plan. Content was prepared to inform the community about the Study and invite them to contribute information about flooding.

Two community drop-in sessions were held coinciding with community events – the Bothwell Bicentennial and Bushfest. Project information was shared and the public were encouraged to share stories and photographs and to fill out an online survey.

The surveys collected information around flood awareness, emergency planning and impacts. A total of eight survey responses were collected.

Surveys and pop-up sessions were promoted via traditional media, social media, the council website, the Bothwell District High School newsletter, the Highlands Digest, a postcard mailout to every Bothwell post office box holder and posters around the township.

Two stakeholder workshops were held to share project details and gather information from industry, government departments, landowners, residents and business owners. The workshops discussed past flood levels and impacts, and involved a risks, priorities and opportunities analysis. Resulting community feedback from both online and face to face consultation was collated and analysed providing additional data for the Study.

A summary of the stakeholder engagement activities and outputs can be seen in the table following.

2.3 Stakeholder engagement activities

Table 1 Stakeholder engagement activities summary

Activity	Description/output
Survey	Questions on prior flood history and impacts, emergency planning, flood awareness and level of risk perception.
Public poster	Posters around Bothwell township sharing project information, survey link and advertising community drop-in sessions. Please refer to Figure 1
Project postcard	300 postcards sent to all Bothwell post office box holders sharing project information, survey link and advertising community drop-in sessions. Please refer to Figure 2
Community Pop Up Sessions	Three community sessions to share project detail, gather historical flood information and share key findings of the Study: Bothwell Bicentennial – 15 October 2022 Landowner Meeting at Bothwell town hall – 27 October 2022 Bushfest – 19 November 2022
Photographs/Stories	Past flood information gathered from community
Newsletter	Sent to Bothwell District School, Highlands Digest to share project information, survey link and advertising community drop-in sessions.
Online stakeholder workshop	Workshop attended by representatives from the Department of Natural Resources and Environment, TasWater, Derwent Catchment Project, Inland Fisheries and Heritage Tasmania to share project information, gather historical flood data and undertake a risks, priorities, and opportunities analysis
Face to face stakeholder workshop	Workshop at the Bothwell Town Hall attended by landowners, residents, and business owners to share project information, gather historical flood data and undertake a risks, priorities and opportunities analysis
Media	Media release to newsprint media and radio
Webpage	Project information page on the Central Highlands Council website
Email	participate@ghd.com email address used to capture feedback
Phone number	62100662 phone number used to capture feedback

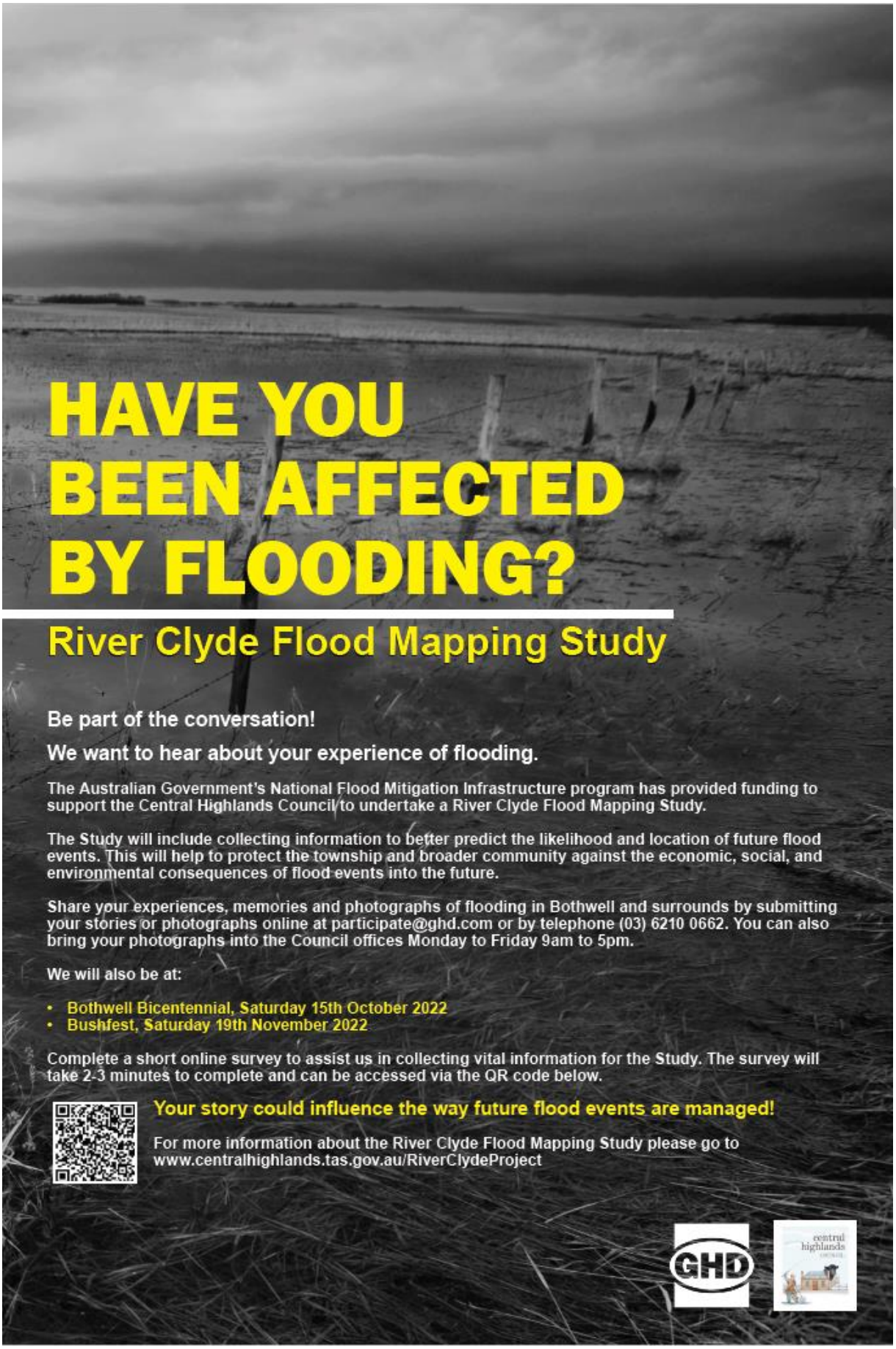


Figure 1 ***Public Poster***

Figure 2 *Project postcard*

3. Survey results

3.1 What is the perception of flood risk within the Study area?

Based on the survey results, the majority of respondents have experienced flooding in the past. The results show that six out of the seven respondents who answered the question regarding where they reside, live less than one kilometre away from the River Clyde. Five of the respondents also work less than one kilometre away from the river.

When asked what they thought the likelihood of flooding would be in the area, six respondents said they were almost certain that flooding would take place while two answered that it would be unlikely. Six respondents also provided information about where they had experienced flooding, most indicating that it had taken place on their property. Three experienced flooding levels of less than a metre, however the other three had experienced flood levels of more than a metre.

3.2 What are some examples of associated impacts of flooding?

Examples collected from the survey show the associated impacts of flooding are

- Damages or loss of infrastructure, assets and or utilities
- Impacts to future developments or land use
- Disruptions to access roads to critical services
- Loss of productivity (agriculture and or manufacturing)
- Loss of income, customers, and services
- Increased insurance premiums

Both ‘damages or loss of infrastructure, assets and or utilities’ and ‘disruptions to access roads to critical services’ were chosen by four respondents. Three respondents indicated that impacts of flooding had been minor however there were no responses which indicated that there had been zero impact.

3.3 What are some examples of concerns/priorities around flooding?

Examples of the concerns and priorities of flooding collected in the survey are:

- Damages or loss of infrastructure, assets and or utilities
- Damages or loss of historical buildings or sites
- Impacts to future developments or land use
- Impacts to access roads to critical services
- Reduced productivity (agriculture and or manufacturing)
- Impacts to unemployment and employees
- Health impacts such as stress, anxiety and or wellbeing.

3.4 Level of flooding preparedness within the study area?

The Survey shows that while the majority of respondents know who to call in the case of an emergency, the same majority do not currently have a flood emergency plan in place. Only two respondents out of eight identified what actions they would take to prevent the impacts of flooding on their property.

All survey respondents have indicated that they would like to receive more information about the River Clyde Flood Mapping Study.

3.5 How would people like to receive information about flooding?

Examples collected from the survey results show:

- Websites, apps and online (chosen by four respondents)
- Police, SES, TasFire Service and Bureau of Meteorology and the Central Highlands Council (chosen by four respondents)
- Radio (chosen by two respondents)
- Social media (chosen by two respondents)
- Word of mouth through friends, neighbours, or family (chosen by two respondents).

When asked how they would like to receive future information about flooding six respondents chose websites, apps and online, three respondents chose radio, a further three chose T.V. and just one chose social media.

3.6 Profile of respondents

Gender

Table 2 Gender profile of respondents

Gender	Age Under 18	18-25	26-35	36-50	51-65	66+	Total
Woman							
Man				2	2	4	8
Non-binary							
Prefer not to say							

Where respondents reside

Bothwell township (central within 1km of town)	4
Bothwell township (outskirts 2-5kms from town)	1
River Clyde valley (north of Bothwell)	1
River Clyde valley (south of Bothwell)	0
Other	1

Where people work

Bothwell township (central within 1km of town)	2
Bothwell township (outskirts 2-5kms from town)	1
River Clyde valley (north of Bothwell)	0
River Clyde valley (south of Bothwell)	1
Other	2

Length of time lived/worked/visited Bothwell

Less than a month	0
Less than 1 year	0
1-5 years	3
5-10 years	0
10-20 years	3
20+ years	2

Distance of residence from river

Less than 1km	6
2-5kms	0
5-10kms	0
More than 10kms	1

Perceived likelihood of flooding

Past experience of flooding

Past experience of flooding

Table 3 Respondent experience of flooding

ID	Response
1	*Our property has been inundated at ground level on four occasions in two and a half years. Once in 2019, twice in 2020 and once in 2021.*
2	*Annually*
3	*Several times a year*
4	*November 2016, 2021, 2023*
5	*Every second year*
6	*More or less every winter, sometimes other seasons (e.g., this year, 2022)*

Location of past flooding

Table 4 Location of past flooding experience

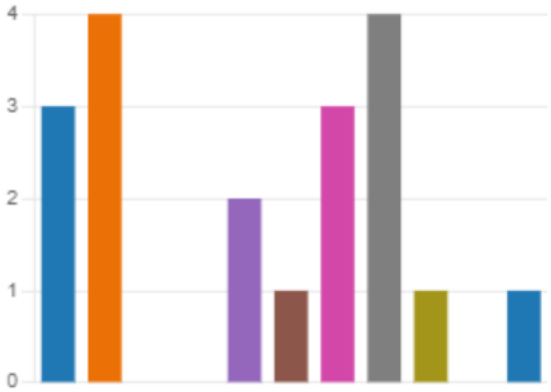
ID	Response
1	*P*atrick Street
2	*Farmland south of Bothwell*
3	*In the vicinity of* Alexander Bridge Nant Lane
4	*Nant*
5	*All over our farm*
6	*On the eastern* boundary of our property

Level of flooding

Less than 10cm	0
10-30cm in height	0
30-50cm	2
50-100cm	1
More than 1m	3

Impact of flooding

Minor impact	3
Damage/loss of infrastructure/assets/property	4
Damage/loss of buildings/historical locations	0
Interruption of services (power, water, telephone)	0
Future development/land use	2
Loss of income/customers/services	1
Loss of productivity (agriculture/manufacturing)	3
Disruption to access/roads to critical services	4
Increase to insurance premiums	1
No impact	0
Other	1

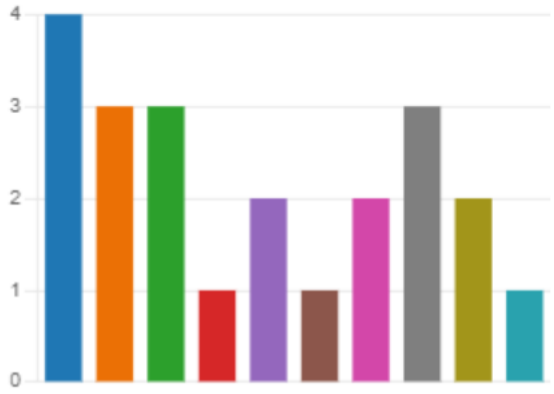


Whether there is a level of concern around flooding

Yes	5
No	3

Areas of concern

Damage/loss of infrastructure/assets/property	4
Damage/loss of buildings/historical locations	3
Future development/land use	3
Loss of tourism income/visitors	1
Reduced productivity (agriculture/manufacturing)	2
Access to locations visited for business/leisure	1
Impact upon employment and employees	2
Access/roads to critical services	3
Anxiety, stress, health and my well-being	2
Other	1



Level of preparation for future flooding

Very prepared	1
Somewhat prepared	4
Neither prepared nor unprepared	3
Somewhat unprepared	0
Very unprepared	0

Flood mitigation actions taken

Table 5 Flood mitigation actions by respondents

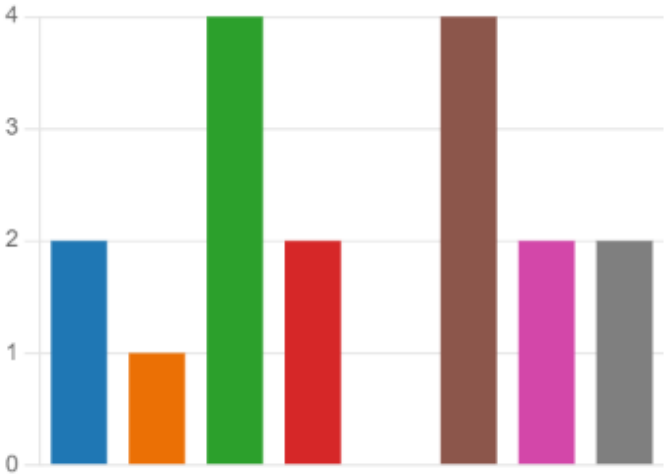
ID	Response
1	*Paddock and* fencing design, moving livestock away from affected areas when flooding is imminent
2	*Pumps high. Don't have stock or crops on the marshes. Stop water flowing around irrigation channel*

Emergency flood plan

Yes	6
No	2

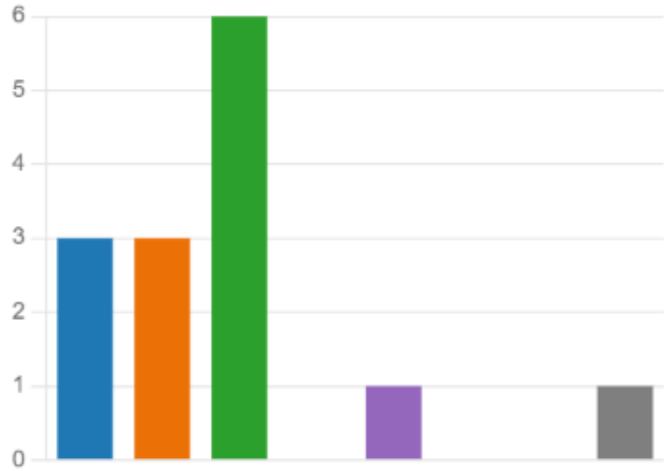
Current source of flood information

Radio	2
TV	1
Websites, apps, online	4
Social media	2
Newspaper	0
Police, SES, TasFire Service, BOM, Council	4
Friends, neighbours, family	2
Other	2



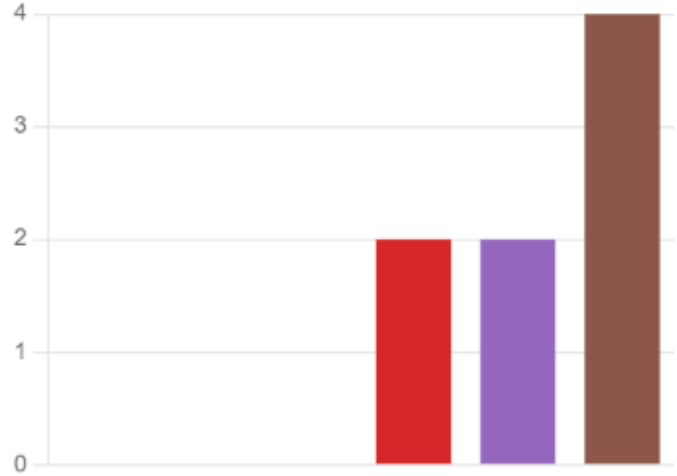
Preferred source of flood information

Radio	3
TV	3
Website, apps, online	6
Printed brochure	0
Social media	1
Newspaper	0
Community newsletter	0
Other	1



Age

Under 18 years	0
18-25	0
26-35	0
36-50	2
51-65	2
66+	4



4. Community engagement and findings

4.1 Bothwell Bicentennial

On Saturday 15 October 2022 the GHD Stakeholder Engagement team, attended the Bothwell Bicentennial to talk to the community about past flooding events and raise awareness of the project. Most members of the community were approachable and willing to talk about their experiences of flooding.

The majority of local community members that were engaged with suggested that the GHD team visit the 1960 flood marker located on Patrick Street. Many had stories that indicated that this was the worst flooding they had experienced in the area.

Attendance for the event was mostly made up of people from outside of the flood mapping area and visitors from other towns. However, amongst the visitors were people who had previously lived in the area. GHD engaged with one woman who grew up just outside of the flood mapping area but would travel down to Hobart to attend boarding school. She recounted that there would be occasions in which the area where she lived would be so badly flooded, she wouldn't be able to visit home as the bus service couldn't run.

Additionally, GHD engaged with the Country Women's Association (CWA) Tasmania at the Bothwell Bicentennial. A couple of members who had also grown up in the area when the 1960 flood occurred spoke of how the town was divided by the flood waters and boats were used to deliver goods to people on each side of the river.

Figure 3 1960 flood marker

Figure 4 Flooding at Croakers Alley (15 October 2022)

Another member of the public at the Bicentennial was able to show GHD photos of flooding on his property and in the centre of town during December 2021. Unfortunately, he did not pass on his photos to the project team as indicated, but the conversation provided insight into the level of impact on the community.

4.2 Government stakeholders' workshop

On Wednesday 26 October 2022, GHD provided a project briefing and ran a risk workshop with the following key stakeholders:

- TasWater (TW)
- The Derwent Catchment Project (DCP)
- Department of Natural Resources & Environment (DNRE)
- State Emergency Service of Tasmania (SES)
- Heritage Tasmania (HT).

The workshop was an opportunity for the above groups to provide input on potential risks, impacts and mitigation measures.

A summary of the perceived risks and opportunities from each group are as follows:

– **TasWater** – the pump at Arthurs Crescent is raised so there is minimal risk of impact due to flooding, however access to the pump during flooding can be an issue. The sewage ponds further down the river are also low risk.

– **Derwent Catchment Project** - would like willow management to be taken into consideration as part of any mitigation measures, with upstream management critical. They expressed that there is no point clearing willows downstream from the flood mapping area without upstream action also. DCP indicated it would be useful to talk to landowners and find out which areas they consider to be choke points and additionally, find out what they are doing on their land to assist with willow management.

– **Department of Natural Resources and Environment** - advised that there are works happening to put a flood levee on the Dennistoun property opposite former Councillor, Anthony Archer's dam, with a levee extended down to Fordell Creek. The levee is proposed to have an embankment and some benching of the river to provide additional flood capacity, although this work is just outside of the flood mapping area. Previous levees built in this area were washed away by the 2016 floods.

– **State Emergency Service** - the main concerns raised by the SES are the impact on residential areas and concerns for those in the community who may not have a flood emergency plan in place. The SES's 'Storm and Flood Ready' program draws upon previous flood studies and focusses on creating more flood resilient properties. The SES are working with the Red Cross to implement this plan. The SES has shown a particular interest in the River Clyde Flood Mapping Study as they want to see more community protection plans integrated into flood mapping studies.

– **Heritage Tasmania** – presented where heritage buildings and sites are located within the study area.

4.3 Drop-in session for landowners

On Thursday the 27 October 2022, GHD invited landowners from the flood mapping study area to the Bothwell Town Hall to discuss the project's objectives and gather information. GHD presented preliminary flood maps and requested feedback. The ten Landowners in attendance were predominantly made up of farmers and residents who had all experienced flooding within the Study area.

Landowners were prompt to inform GHD of factors that impact flooding in the area, the most raised factor being willow management. Some landowners recalled that due to the lack of willow management south of the flood mapping area they have experienced flooding despite a lack of rainfall.

There was a distinct divide in the room with regard to what year the flooding was worse, 1960 or 2016. In 1960, one landowner recalled that the flooding had come up to the windowsills of the houses along Arthur Crescent and the Jordan River Bridge was washed away. The same landowner also recounted stories of a flying fox being used to send supplies to those on either side of the river.

Landowners were forthcoming with their concerns, detail about the impacts and measures they would like to see put in place for flood mitigation.

Critical assets and sites

The landowners' main areas and sites of concern during flooding are as follows:

- Housing / residential areas
- Farmland
- Old Brewery house as it sits on stone foundations, Thorp Mill, the Golf Course, and the Maid's House
- Sewage Treatment Ponds
- Health centres and accessing essential services
- Access roads.

I**mpacts**

Landowners identified the below impacts:

- Damage to roads as a result of flooding
- Loss of productivity on farmland
- Impacts to crops due to topsoil erosion
- Damage to infrastructure
- Flood damage impacting existing security measures
- Flood debris clean up, especially around fencing, trees and vegetation
- Clean up costs, time and logistics
- Potential for landslides and power failure.

Flood mitigation

Landowners recalled the previous flood mitigation measures taking place:

- The Central Highland Council spent $680,000 on fixing the drainage around Bothwell
- Around 25 years ago willows were removed using excavation through 10 metres of the river's channel.

Landowners suggested that flood levees and willow management should be put in place as future flood mitigation measures.

Emergency management

Landowners expressed that they would like flood warnings included for the River Clyde from the Bureau of Meteorology, as this is where they get the majority of their information when planning for major weather events. They believe landowners along the River Ouse also experience the same issues.

Figure 5 River Clyde flooding 27 October 2022

Figure 6 Arthurs Crescent 27 October 2022

4.4 Bushfest

On Saturday 19 November 2022 GHD attended Bushfest, to again raise awareness of the project amongst community members and gather information about flooding in the area. Like the Bothwell Bicentennial, attendance was largely made up of visitors to the area. However, GHD was able to talk to members of the Trout Fishing Guides Association, including the President who provided insight into the affects flooding has on the water quality of the River Clyde, and the negative impacts that poor river management has had on fishing in the area.

The Trout Fishing Guide Association representatives were surprised to find out that the Central Highlands Council were driving the Flood Mapping Study and indicated they have previously felt let down by council and Inland Fisheries when trying to bring attention to river management in the past. This perception may explain the Association's absence at the stakeholder workshops.

While not from Bothwell or the flood mapping area, visitors that GHD spoke to at Bushfest provided further insights into the level of awareness about flooding in the area. One particular member of the public was adamant that the area was not prone to flooding, despite several areas of the town experiencing visible flooding at the time. One vendor who had travelled down from the north of Tasmania was pleased to see that the Council were taking a proactive approach to improving flood awareness as she was personally dealing with the impacts of flooding to her home as a result of the October 2022 floods in north-west Tasmania.

5. Community feedback

Community feedback around flood risk and awareness indicated that community members are aware of flood events happening in the area, even if they are not directly impacted. However, based on the survey results and community members who spoke with our Stakeholder Engagement officers, there is limited community interest when it comes to taking action to assist with the prevention of flooding.

Landowners taking part in the workshops indicated that although flooding is of concern that it is not a major priority in comparison to other extreme weather events such as drought. Landowners intimated that access to water is an important resource that they do not want restricted. Proposed flood mitigation measures will need to take this into consideration.

The low number of responses received for the online survey despite the post card drop to all Bothwell post boxes, school newsletter, Highlands Digest notification, workshops, community drop-in sessions and posters displayed around town suggests that community interest in flooding is low. Responses received suggest that flood awareness is greater amongst those with lived experience of flooding. Based on the responses received, the survey also suggests that those who took part are most likely to be farmers as flood mitigation methods selected were prioritised around livestock and crops.

Landowners who attended the drop-in session on the 27 October 2022 showed that they have a high awareness of flooding and have emergency management plans in place for when flooding events occur. They expressed that they would like to see more willow management in the area with the addition of flood levees to help prevent the severity of floods. Moreover, they would like to see flood warnings for the River Clyde included in alerts by the Bureau of Meteorology.

Broadly speaking, the engagement feedback received suggests that community awareness of flooding is high, however community understanding of how they can be better prepared and mitigate the impact of flooding is low. The community may be more inclined to take action to be better prepared with further education and engagement.

Some people have shown concern that the Flood Mapping Study will affect their insurance premiums.

6. Next steps

Based upon survey responses, feedback received at stakeholder workshops and community drop-in sessions it is suggested that the community would benefit from further engagement and education around how they can be better prepared. This may be most effective if targeted at younger members of the community, including working with students and teachers at Bothwell District High School.

The Derwent Catchment Project indicated that combining environmental education and flood mitigation programs can be very effective for encouraging positive community action. They suggested that working with Landcare to educate about willow control and broader river management practices would be advantageous to any mitigation measures the Council decide to take forward.

The SES would like to support the council by developing a draft community protection plan and are an important stakeholder to include with any community engagement moving forward.

Once the *Stormwater System Management Plan* is complete and flood mitigation measures have been determined it would be beneficial share next steps with key stakeholders and community to demonstrate how community feedback has informed decision making, emergency planning and management for future flooding events.

Appendix A

Landowner photos

Figure 7 *Credit: Landowner, Robert Cassidy – Looking southeast from Mount Adelaide, 19 October 2021*

Figure 8 *Credit: Landowner, Robert Cassidy – Looking southeast from Mount Adelaide, 19 October 2021*

Figure 9 *Credit: Landowner, Robert Cassidy – Ariel view of Bothwell surrounding areas in flood*

Figure 10 *Credit: Landowner, David Dyson*

Figure 11 *Credit: Landowner, David Dyson*

Figure 12 *Credit: Landowner, David Dyson*

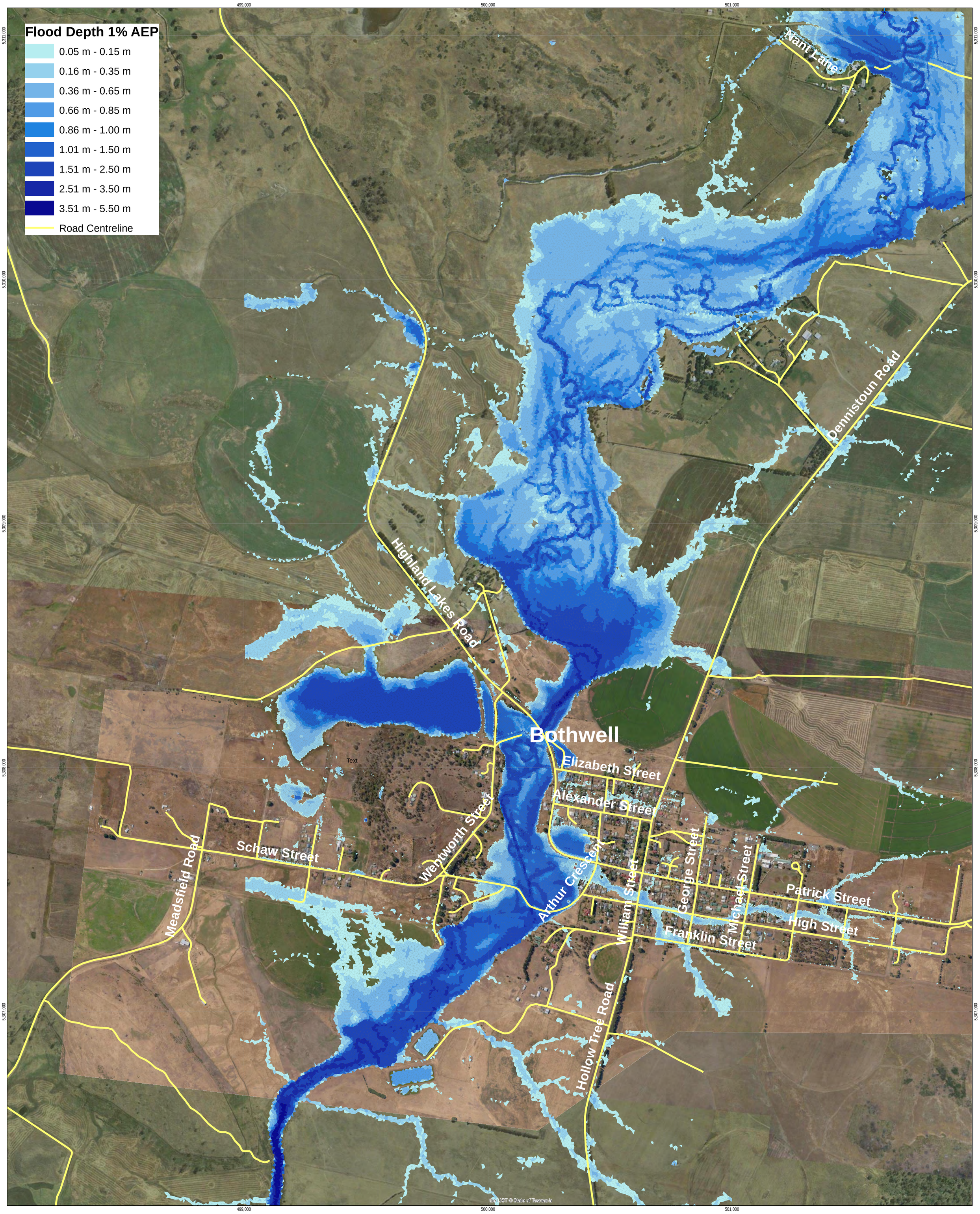
Figure 13 *Credit: Landowner, David Dyson*

Figure 14 *Credit: Landowner, David Dyson*


THIS PLAQUE MARKS
THE LEVEL
OF FLOOD WATERS
ON THE NIGHT OF
22ND APRIL
1960.
FLOOD LEVEL

Appendix G

Flood Depth Maps 5% AEP- Mitigation Options



Paper Size A1

0 70 140 280 420 560

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Central Highlands Council
River Clyde Flood Mappring Study

River Clyde Flood Map 1% AEP Willow Removal

Job Number	12571871
Revision	B
Date	21 Mar 2023

Figure 22

C:\Users\EKISEL~1\AppData\Local\Temp\arc8704\12571871_022_Clyde_Willow_Removal_A1_1pct_Rev_B.mxd

2 Salamanca Square, Hobart Tasmania 7000 Australia **T** 61 3 6210 0600 **E** hbamail@ghd.com **W** www.ghd.com

Data source: Roads (LIST), Flood Model (GHD). Created by:ekiseleva

Flood Depth 63% AEP

- 0.05 m - 0.15 m
- 0.16 m - 0.35 m
- 0.36 m - 0.65 m
- 0.66 m - 0.85 m
- 0.86 m - 1.00 m
- 1.01 m - 1.50 m
- 1.51 m - 2.50 m
- 2.51 m - 3.50 m
- 3.51 m - 5.50 m
- Road Centreline

499,000 500,000 501,000

5,311,000 5,310,000 5,309,000 5,308,000 5,307,000

Avant Lane
Dennistoun Road
Highland Lakes Road
Bothwell
Elizabeth Street
Alexander Street
Wentworth Street
Arthur Crescent
William Street
George Street
Michael Street
Patrick Street
High Street
Franklin Street
Schaw Street
Meadsfield Road
Hollow Tree Road
Text

the LIST © State of Tasmania

Paper Size A1

0 70 140 280 420 560

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Central Highlands Council
River Clyde Flood Mappring Study

River Clyde Flood Map 63% AEP Willow Removal

Job Number	12571871
Revision	B
Date	21 Mar 2023

Figure 23

C:\Users\EKISEL~1\AppData\Local\Temp\arc8F41\12571871_023_Clyde_Willow_Removal_A1_63pct_Rev_B.mxd

2 Salamanca Square, Hobart Tasmania 7000 Australia **T** 61 3 6210 0600 **E** hbamail@ghd.com **W** www.ghd.com

Data source: Roads (LIST), Flood Model (GHD). Created by:ekiseleva

499,000
500,000
501,000
5,308,000
5,307,000

Flood Depth 5% AEP
- 0.05 m - 0.15 m
- 0.16 m - 0.35 m
- 0.36 m - 0.65 m
- 0.66 m - 0.85 m
- 0.86 m - 1.00 m
- 1.01 m - 1.50 m
- 1.51 m - 2.50 m
- 2.51 m - 3.50 m
- 3.51 m - 5.50 m
- Road Centreline
- Property Boundary

Highland Lakes Road
Wentworth Street
Adelaide Street
Keeling Road
Schaw Street
Logan Street
Barrack Street
Elizabeth Street
Alexander Street
Queen Street
Market Place
Arthur Crescent
William Street
Hollow Tree Road
Dennistoun Road
George Street
Michael Street
Mary Street
Patrick Street
High Street
Franklin Street

the LIST © State of Tasmania

Paper Size A1

0 30 60 120 180 240
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Central Highlands Council
River Clyde Flood Mappring Study
Bothwell Flood Map 5% AEP Mitigation Option 1

Job Number	12571871
Revision	B
Date	21 Mar 2023

Figure 20

C:\Users\EKISEL~1\AppData\Local\Temp\arc836A\12571871_020_Bothwell_Mitig_Option1_A1_5pct_Rev_B.mxd

Data source: Roads (LIST), Flood Model (GHD). Created by:ekiseleva

2 Salamanca Square, Hobart Tasmania 7000 Australia **T** 61 3 6210 0600 **E** hbamail@ghd.com **W** www.ghd.com

499,000
500,000
501,000
5,308,000
5,307,000

Highland Lakes Road
Wentworth Street
Adelaide Street
Barrack Street
Elizabeth Street
Alexander Street
Dennistoun Road
Keeling Road
Schaw Street
Logan Street
Arthur Crescent
Queen Street
Market Place
George Street
William Street
Mitchell Street
Mary Street
Patrick Street
High Street
Franklin Street
Hollow Tree Road

Flood Depth 5% AEP

- 0.05 m - 0.15 m
- 0.16 m - 0.35 m
- 0.36 m - 0.65 m
- 0.66 m - 0.85 m
- 0.86 m - 1.00 m
- 1.01 m - 1.50 m
- 1.51 m - 2.50 m
- 2.51 m - 3.50 m
- 3.51 m - 5.50 m
- Mitigation Option Area
- Pipe
- Pit
- Open Channel
- Road Centreline
- Property Boundary

Paper Size A1

0 30 60 120 180 240

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Central Highlands Council
River Clyde Flood Mappring Study

Bothwell Flood Map 5% AEP
Mitigation Option 2 - Open Channel

Job Number	12571871
Revision	B
Date	21 Mar 2023

Figure 21

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Data source: Roads (LIST), Flood Model (GHD). Created by:ekiseleva

2 Salamanca Square, Hobart Tasmania 7000 Australia **T** 61 3 6210 0600 **E** hbamail@ghd.com **W** www.ghd.com

Appendix H

Natural Values Desktop Assessment

River Clyde Mapping Study

Desktop Assessment

Central Highlands Council

04 April 2023

→ **The Power of Commitment**

Project name		River Clyde Flood Mapping Study					
Document title		River Clyde Mapping Study | Desktop Assessment					
Project number		12571871					
File name		12571871_REP_River Clyde Mapping Study_Desktop Assessment.docx					
Status Code	**Revision**	**Author**	**Reviewer**		**Approved for issue**		
			Name	**Signature**	**Name**	**Signature**	**Date**
S3	A	Mickey Dwyer	Nick Priest		Ed Gruber		
[Status code]							
[Status code]							
[Status code]							
[Status code]							

GHD Pty Ltd | ABN 39 008 488 373

2 Salamanca Square,

Hobart, Tasmania 7000, Australia

T +61 3 6210 0600 | **F** +61 3 8732 7046 | **E** hbamail@ghd.com | **ghd.com**

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1. Introduction

1.1 Purpose of this report

As part of the River Clyde Flood Study, the Central Highlands Council and GHD are investigating potential mitigation options to reduce the risk of flooding on the River Clyde. The purpose of this report is to examine and assess the existing environment within the survey area and identify the extent of any environmental values that may constrain the suitability and implementation of any proposed mitigation options for the River Clyde mapping study and flood mitigation strategies. Potential constraints assessed include conservation significant vegetation communities, flora species, fauna species and habitat.

The scope of work covered in this report included a desktop assessment aiming to interrogate all relevant databases (e.g. Natural Values Atlas [NVA] and Protected Matters Search Tool [PMST]) to identify any threatened flora, fauna or vegetation communities that may potentially occur within, or near the survey area and help inform the impact assessment and any additional .

Information obtained during the desktop assessment was used to develop this report, including:

– Outlining potential impacts of the proposed works on ecological values.
– An evaluation of the proposed works against relevant ecological policy and legislation.
– Provision of recommendations to minimise impacts of the proposed works on ecological values.

1.2 Scope and limitations

This report: has been prepared by GHD for Central Highlands Council and may only be used and relied on by Central Highlands Council for the purpose agreed between GHD and Central Highlands Council as set out in section 1.1 of this report.

GHD otherwise disclaims responsibility to any person other than Central Highlands Council arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section(s) 1.3 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

Accessibility of documents

If this report is required to be accessible in any other format, this can be provided by GHD upon request and at an additional cost if necessary.

1.3 Assumptions

The following assumptions should be noted when considering the results and recommendations outlined in this report:

– the desktop assessment collates data from verified publicly available databases
– no field assessment or site investigation was conducted in association with the works outlined in this report
– small scale variations in vegetation, flora composition, fauna habitat and general condition of the site are unlikely to be represented in the modelled mapping

2. Background

2.1 Project Description

GHD Pty Ltd (GHD) was engaged by the Central Highlands Council to undertake a flood study of the River Clyde for the township of Bothwell.

The Clyde River rises in the reservoirs of Lake Sorell and Lake Crescent, near Interlaken and flows generally west by south, through the settlements of Bothwell and Hamilton, joined by nine minor tributaries before reaching its mouth and emptying into the River Derwent at Lake Meadowbank. The river drains a catchment area of 1,120 km sq in an agricultural region of Tasmania and descends 744 metres over its 97 km course.

The River Clyde flood mapping aims to provide Council with a better understanding of the flood behaviour, set to establish the flooding extent, water levels, velocities, depths within the study area, which will ultimately inform a revised floodplain management strategy within the study area, improve the community's understanding of flood risk/hazard of the River Clyde floodplain (to guide land use planning and development) and recommend a flood risk management strategy for the floodplain , emergency response planning and increase community awareness of flood risk.

As part of the project, GHD has developed an options analysis for flood management and mitigation measures, including any required staging whilst taking into consideration the constructability of any new infrastructure. The options analysis required the provision a natural values assessment and a land use planning assessment to inform the options and highlight any risks in the options.

2.1.1 Willow Removal

Driven through GHD discussions with Central Highlands Council, willow (*Salix spp.)* tree removal has been proposed as a flood mitigation option that involves the removal of invasive willow trees from flood-prone areas. Willow trees are known for their ability to grow quickly and form dense stands, which can reduce water flow and increase the risk of flooding. By removing these trees, it is possible to restore natural water flow and increase the capacity of waterways to handle floodwaters.

Willow removal as a flood mitigation option offers several benefits. Firstly, willow removal can help to increase the capacity of rivers and streams to carry water, which can reduce the risk of flooding. By removing willows, the flow of water can be increased, allowing water to move more quickly through the river system. Secondly, willow removal can improve the ecological health of river systems by increasing the amount of sunlight that reaches the riverbed. This can encourage the growth of native plant species, which in turn can provide habitat for a range of aquatic and terrestrial species. Thirdly, removing willows can reduce the amount of sediment that accumulates in rivers and streams, which can improve water quality. Finally, willow removal can help to reduce the risk of damage to infrastructure such as bridges and roads, which can be costly to repair or replace in the event of a flood. Overall, willow removal as a flood mitigation option offers a range of benefits that can help to reduce the impact of flooding and improve the ecological health of river systems.

For the purposes of this report, willow removal is discussed as a management option in relation to the potential environmental impact as a result e.g. sedimentation, removal of habitat, etc.

2.2 Survey Area

For the purpose of this report, the 'survey area' is defined as the area outlined in Figure 2, extending from the intersection of Patrick Street & Mary Street, southward towards High Street and Franklin Street, and west the River Clyde. The survey was calculated to cover approximately 19.75 ha. This area covers several properties including private freehold land, road reserve, crown land and council land and encompasses the potential siting of flood mitigation options. The cadastral parcels intersected by the survey area are outlined in the table below.

Table 1 Summary of cadastral parcels intersected by the survey area

CID	Volume	Folio	PID	Cadastre Parcel Type	Land Tenure
964877	16898	1	5013329	Private Parcel	Freehold Title
964908	93962	2	5012609	Private Parcel	Freehold Title
964912	135485	2	2033826	Private Parcel	Freehold Title
964917	15903	1	5012924	Private Parcel	Freehold Title
964928	205924	1	7114078	Private Parcel	Freehold Title
964953	18	4642	5012270	Private Parcel	Freehold Title
964959	226153	10	5012270	Private Parcel	Freehold Title
964961	107602	15	5012385	Private Parcel	Freehold Title
964963	22912	14	5012238	Private Parcel	Freehold Title
964964	228128	1	5012422	Private Parcel	Freehold Title
964965	44848	1	7680897	Private Parcel	Freehold Title
964967	44848	2	1555307	Private Parcel	Freehold Title
964969	213687	4	1555307	Private Parcel	Freehold Title
964971	232397	1	5012828	Private Parcel	Freehold Title
964972	13327	4	7271487	Private Parcel	Freehold Title
964974	216377	1	5012414	Private Parcel	Freehold Title
964975	233761	1	5012262	Private Parcel	Freehold Title
1109762	18586	1	5011593	Private Parcel	Freehold Title
1109763	220354	8	5012625	Private Parcel	Freehold Title
1192725	124600	1	1745282	Private Parcel	Freehold Title
1193585		0	0	Road (type unknown)	Unknown
1198216	126980	1	1805046	Private Parcel	Freehold Title
1319988		0	0	Road (type unknown)	Unknown
1321616	150194	1	5013310	Department of Education	Crown Land
1323732		0	0	Road (type unknown)	Unknown
1370279	15903	3	0	LGA Subdivision Road	Freehold Title
1370280	15903	2	0	LGA Subdivision Road	Freehold Title
1401636	161435	1	5010486	Local Government Authority	Council
1436016	166515	1	3257215	Private Parcel	Freehold Title
1463805	167795	1	3361565	Private Parcel	Freehold Title

Descriptions for the headings from the above table are as follows:

– CID: Cadastral Persistent Identifier; the unique database identifier for each cadastral polygon

– Volume: The registered number for a volume (plan) which together with the folio forms the Folio of the Register (sometimes referred to as Certificate of Title)

– Folio: The registered number for a folio (lot) which together with the volume forms the Folio of the Register (sometimes referred to as Certificate of Title)

– PID: The unique Property Identification number relating to a (live) current rateable property. Property information is maintained against the PID in the VISTAS valuation property database

– Cadastre Parcel Type: The description for the primary classification of a cadastral area

– Land Tenure: The description for the Tenure Type – a broad tenure classification i.e. Private, Crown, Commonwealth, Local Government

2.3 Vegetation

The survey area was mapped to intersect two TASVEG[1] communities, both representing modified land. These communities are outlined in the table below.

Table 2 Summary of the TASVEG communities mapped within the survey area

TASVEG Community	TASVEG Code	Description	Area (ha)
Agricultural land	FAG	Agricultural land (FAG) includes exotic grassland pastures and croplands. The pastures are dominated by mixtures of exotic temperate grasses and clovers. Crops range from common temperate vegetables and orchard fruits and nuts through to crops	14.03
Urban areas	FUR	Urban areas (FUR) include urban and suburban landscapes. These areas are largely or wholly devoid of vegetation apart from areas such as suburban gardens, street trees and parks.	5.72

2.4 Climate

The nearest Bureau of Meteorology weather station of similar geographical setting capturing current weather data is the Ouse Fire Station. The mean annual maximum and minimum temperature for that station is 18.4°C and 5.6°C (1998-2022), while the mean annual rainfall is 522.6mm for the same time period (see Figure 1). The prevailing wind at 9am at this station is north-west to north (from 8776 observations).

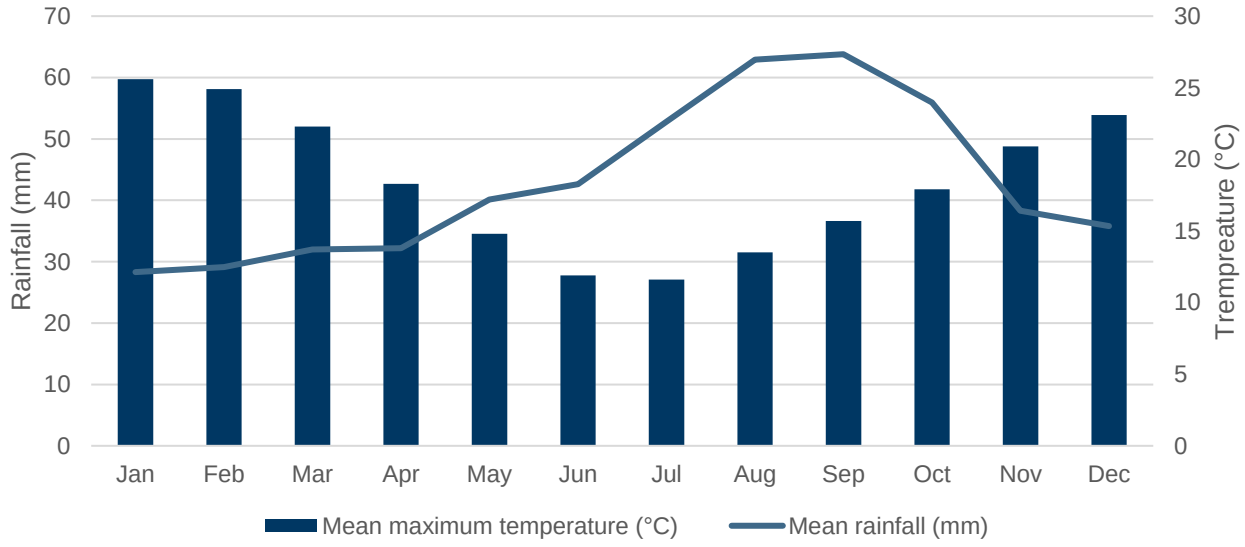

Figure 1 Mean rainfall and mean maximum temperature data from Bureau of Meteorology (BOM) monitoring site at the Ouse Fire Station for the period 1998 - 2022

2.5 IBRA Region

The survey area is located within the Tasmanian Southeast Interim Biogeographic Regionalisation for Australia (IBRA) region (TSE01), described as 'Subhumid cool to subhumid warm coastal plains on a highly indented coastline, bordered inland by low mountain ranges formed from Jurassic dolerite and Permo-Triassic sediments. Soils predominantly clay to sandy loams. Vegetation is predominantly dry sclerophyll forest, with patches of wet sclerophyll forest, relict rainforest, coastal heath and dry coniferous forest. Extensive areas have been converted to improved pasture and cropland. Land use is primarily agriculture (grazing) and forestry.'[2]

[1] Kitchener & Harris 2013
[2] Environment Australia 2000

2.6 Soils and Geology

According to the Reconnaissance Soil Map Series of Tasmania[3] from LISTmap, the survey area is mapped on 'Undifferentiated soils developed on Quaternary alluvium'. As such, an exact soil classification is unknown. The underlying geology of the site is mapped as:

Table 3 Summary of underlying geology mapped to intersect the survey area

Geology Symbol	Description
Qh	Sand gravel and mud of alluvial, lacustrine and littoral origin
Tb	Basalt (tholeiitic to alkalic) and related pyroclastic rocks
Q	Undifferentiated Quaternary sediments
Ts	Dominantly non-marine sequences of gravel, sand, silt, clay and regolith
R	Undifferentiated Triassic fluviolacustrine sequences of sandstone, siltstone and mudstone.

Given the historical modifications and land uses (e.g. pastoral activities, development, etc) within the survey area, a range of sub-surface geological classifications may be present across the survey area including basalt, sandstone, mudstone and siltstone.

[3] Spanswick & Kidd 2001

Figure 2 *Survey area overview*

3. Methods

3.1 Background Research

The primary data sources accessed during the background research included:

– The Natural Values Atlas (NVA) database[4] – which is the most authoritative repository of information on natural values in Tasmania. A NVA Report will identify threatened fauna and flora records within 500 m and 5000 m from the edge of the survey area. The report will also provide lists of TASVEG vegetation communities, geoconservation sites listed on the Tasmanian Geoconservation Database for any site or area within the State;

– The *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* PMST[5] – which provides a PMST Report that identifies any matters listed under the EPBC Act within a 5000 m buffer around the survey area;

– The Land Information System Tasmania (LIST) database[6] – a web-based repository of the State's comprehensive spatial data resources including property and land title information, satellite imagery, topographic maps, geological maps and natural values data; and

– The Department of Natural Resources and Environment (NRE) website – which contains links to biological and ecological information on many of the State's threatened species as well as biosecurity and invasive species information.

– The Tasmanian Threatened Species Link – contains management and conservation advice on Tasmania's threatened species, including species-specific information on survey periods, habitat, activities most likely to cause an impact, and links to DPIPWE note sheets and species recovery plans[7].

Further literature review in relation to key threatened fauna known to utilise the survey area was also undertaken, and a complete reference list is provided at the end of this report.

3.2 Desktop Assessment

A detailed desktop assessment was undertaken to identify any potential matters of conservation significance and to assess the need for any field surveys required at the site.

The desktop assessment was informed by the Tasmanian Natural Values Atlas (NVA) and the Commonwealth Protected Matters Search Tool (PMST). A buffer distance of 500 m and 5 km was used for database searches and is considered appropriate for detecting conservation significant species in the 'Tasmanian South East' Interim Biogeographic Regionalisation for Australia (IBRA) regions. The likelihood of occurrence was determined for all conservation significant vegetation communities identified, using categories outlined in the table below.

Table 4 Categories of likelihood of occurrence for conservation significant vegetation communities

Likelihood Category	Assessment
Present	Individuals recorded within the survey area during the field assessment or any previous assessment within the boundaries of the survey area
Possible	Suitable habitat occurs within the survey area
Unlikely	Suitable habitat unlikely to occur within the survey area, or suitable habitat substantially modified, or suitable habitat present but species not recorded for over 50 years within 5 km of the survey area

The likelihood of occurrence was determined for all conservation significant flora and fauna species identified, using categories outlined in the table below.

[4] BCB 2012
[5] Australian Government 2020
[6] Service Tasmania 2020
[7] TSS 2021

Table 5 Categories of likelihood of occurrence was determined for all conservation significant flora and fauna species

Likelihood Category	Assessment
Present	Individuals recorded within the survey area during the field assessment or any previous assessment within the boundaries of survey area
Possible	Suitable habitat occurs or is likely to occur within the survey area
Unlikely	Suitable habitat unlikely to occur within the survey area, or suitable habitat substantially modified, or suitable habitat present but species not recorded for over 50 years within 5km of the site
Highly Unlikely	No suitable habitat present within the survey area, and individuals not recorded within the survey area during current or any previous assessment

3.3 Nomenclature and Assessment of Significance

All plants are identified in accordance with *A Census of the Vascular Plants of Tasmania*[8]. Flora and fauna conservation significance was determined in accordance with the Tasmanian *Threatened Species Protection Act 1995* (TSP Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The vegetation mapping of the survey area was identified in accordance with the most current TASVEG 4.0 mapping from LISTmap. Conservation significance of vegetation communities was assessed in accordance with the TASVEG 4.0 and *Regional Forestry Agreement* (RFA) classification and associated criteria[9]. Conservation significance of other ecological communities was determined in accordance with the Commonwealth EPBC Act.

Significance of impacts on Matters of National Environmental Significance (MNES) were assessed in accordance with the Australian Government's Significant Impact Guidelines[10].

4. Results

4.1 Vegetation Communities

The results of the NVA report (Appendix B) identified ten vegetation communities within 1000 m of the survey area. Of those, one threatened community is listed as threatened under the Tasmanian NC Act. The PMST report (Appendix C) identified four Commonwealth listed Threatened Ecological Communities (TEC).

Of these five communities, the likelihood assessment indicated none of the threatened communities have the potential to be impacted by these works as they are not mapped within the survey area.

Table 6 Summary of protected vegetation communities identified by the NVA and the PMST within 1 km and 5 km of the survey area and an assessment of their likelihood.

Community Name	Source	Tasmanian Status – NC Act	Commonwealth Status – EPBC Act	Likelihood
Alpine Sphagnum Bogs and Associated Fens	PMST	-	Endangered	Unlikely – no mapped occurrences of this community within the survey area.
Lowland Native Grasslands of Tasmania	PMST	-	Critically endangered	Unlikely – no mapped occurrences of this community within the survey area.

[8] Baker & de Salas 2016
[9] DPIPWE 2014
[10] DotE 2013

Community Name	Source	Tasmanian Status – NC Act	Commonwealth Status – EPBC Act	Likelihood
Tasmanian white gum (*Eucalyptus viminalis*) wet forest	PMST	Threatened	Critically endangered	Unlikely – community absent within 1000 m of survey area.
Tasmanian Forests and Woodlands dominated by black gum or Brookers gum (*Eucalyptus ovata/ E. brookeriana*)	PMST	Threatened	Critically endangered	Unlikely – community absent within 1000 m of survey area.
Eucalyptus tenuiramis forest and woodland on sediments	NVA	Threatened	-	Unlikely – community not mapped within the survey area.

4.2 Threatened Flora

Based on the results of the NVA report (Appendix B), a total of 201 state listed flora from 21 species have been previously recorded within 5 km of the survey area. Four of those species are also listed under the Commonwealth EPBC Act, including *Barbarea australis* (riverbed wintercress), *Glycine latrobeana* (clover glycine), *Lepidium hyssopifolium* (soft peppercress) and *Leucochrysum albicans subsp. tricolor* (grassland paperdaisy). The most abundant species, *L. hyssopifolium*, has been recorded 107 times within 5 km with the nearest record located 62 m from the survey area.

According to the PMST report (Appendix B), 12 EPBC listed flora species, or their habitat have the potential to occur within the survey area. Combining the NVA and PMST indicates a total of 28 state and/or Commonwealth listed flora species with the potential to occur in the survey area. The results of the likelihood analysis indicated one species was considered likely to occur, ten species were possible, 16 were unlikely and one species highly unlikely. Species likelihoods were assessed based on the known habitat preferences for each species and the likely vegetation, habitat, soils and landforms present based on the available information.

Table 7 Summary of threatened flora species identified from within 5 km based on the results from the NVA and PMST

Species Name	Common Name	Source	TSP Act	EPBC Act	Suitable Habitat	Likelihood
Acacia axillaris	Midlands mimosa	PMST	v	VU	Mainly confined to riparian habitats such as dense riparian scrub and associated floodplains but also extends to paddocks and open grassy forests in frost hollows and areas of poor drainage, but also occasionally occurs on rocky slopes (there is a somewhat anomalous population on the mid-slopes of Mt Barrow in the north-east). All populations are strongly associated with dolerite soils. Records outside the core of the range (e.g. Prosser River, Broad River, River Clyde) need to be treated carefully as they may represent the more recently described *Acacia derwentiana*.	Unlikely – some suitable habitat may be present, albeit likely sub-optimal and on the fringes of the survey area.
Acacia siculiformis	dagger wattle	NVA	r		Found near watercourses (e.g. dense shrubby riparian scrubs along major rivers in the Midlands	Unlikely – some suitable habitat may be present

Species Name	Common Name	Source	TSP Act	EPBC Act	Suitable Habitat	Likelihood
					and surrounding uplands) and in dry sclerophyll forest. It is often associated with rocky dolerite sites. Care needs to be taken with outlier records not supported by herbarium specimens.	at the western extent of the survey area, albeit likely sub-optimal.
Anogramma leptophylla	annual fern	NVA	v		Grows in shallow soil layers over rock, on exposed or semi-exposed outcrops in dry or damp sclerophyll forest. Plants are mostly found on rock ledges, often on, or just inside, the drip line of the overhead rock-face. The substrate is variable, including dolerite, basalt and sandstone.	Unlikely – no suitable habitat present within the survey area.
Asperula scoparia subsp. scoparia	prickly woodruff	NVA	r		Widespread in Tasmania and is mainly found in native grasslands and grassy forests, often on fertile substrates such as dolerite-derived soils. Forested sites are usually dominated by *Eucalyptus globulus* and *E. viminalis* (lower elevations) and *E. delegatensis* (higher elevations).	Possible – some suitable habitat may be present within the survey area.
Austrostipa bigeniculata	doublejointed speargrass	NVA	r		Found mainly in the southeast and Midlands in open woodlands and grasslands.	Unlikely – some suitable habitat may be present, albeit likely degraded or modified through historic pastoral activities or development.
Barbarea australis	riverbed wintercress	NVA, PMST	e	EN	Riparian species found near river margins, creek beds and along flood channels. It tends to favour the slower reaches and has not been found on steeper sections of rivers. Juveniles predominantly occur on flood deposits of silt, and gravel deposited as point bars and at the margins of base flows, or more occasionally or between large cobbles on sites frequently disturbed by fluvial processes; however, few plants in these open habitats make it to maturity. Flowering plants tend to occur in protected niches, which can include relatively coarse surrounding vegetation like bracken. Some of the sites are a considerable distance from the river, in flood channels scoured by previous flood action, exposing river pebbles. Most populations are in the Central Highlands, but other populations occur in the northeast and upland areas in the central north.	Unlikely – some suitable habitat may be present, albeit likely sub-optimal and on the fringes of the survey area.

Species Name	Common Name	Source	TSP Act	EPBC Act	Suitable Habitat	Likelihood
Brachyscome rigidula	cutleaf daisy	NVA	v		Found in the Midlands, East Coast and in parts of the eastern Central Highlands of Tasmania, where it occurs in rough pasture, grassland and grassy woodland on dry rocky hills and flats. Has been observed in pasture and agricultural areas known to be grazed.	Possible - some suitable habitat may be present, albeit likely degraded or modified through historic pastoral activities or development.
Caladenia anthracina	black-tipped spider-orchid	PMST	e	CR	Restricted distribution in the Powranna/Campbelltown/Ross area, occurring in grassy woodland with *Acacia dealbata* (silver wattle) and bracken on well-drained sandy soil. Two historical sites from the Derwent Valley are presumed extinct.	Unlikely – some suitable habitat may be present, albeit likely degraded or modified through historic pastoral activities or development.
Calocephalus lacteus	milky beautyheads	NVA	r		Occurs in open, dry sites in lowland areas of eastern and northern Tasmania and on lower altitudes of the Central Plateau. It requires bare ground for recruitment and may benefit from disturbance. It is often found on roadsides and beside tracks.	Possible – some suitable habitat may be present, albeit likely degraded or modified through historic pastoral activities or development.
Colobanthus curtisiae	Curtis' colobanth	PMST	r	VU	Occurs in lowland grasslands and grassy woodlands but is also prevalent on rocky outcrops and margins of forest on dolerite on the Central Highlands (including disturbed sites such as log landings and snig tracks).	Unlikely – some suitable habitat may be present, albeit likely degraded or modified through historic pastoral activities or development. No previous records within 5km.
Cryptandra amara	pretty pearlflower	NVA	e		Grows in some of the driest areas of the State and is typically associated with fertile rocky substrates (e.g., basalt). Its habitat ranges from near riparian rockplates to grasslands or grassy woodlands.	Unlikely – some suitable habitat may be present, albeit likely degraded or modified through historic pastoral activities or development.
Dianella amoena	grassland flax-lilly	PMST	r	EN	Occurs mainly in the northern and southern Midlands, where it grows in native grasslands and grassy woodlands. Has been previously observed within roadsides and verges, open pasture under grazing pressure.	Possible - some suitable habitat may be present, albeit likely degraded or modified through historic pastoral activities or development. Survey area within the western range of the species

Species Name	Common Name	Source	TSP Act	EPBC Act	Suitable Habitat	Likelihood
						indicating possible presence.
Discaria pubescens	spiky anchorplant	NVA	e		Found sporadically in the Midlands and more abundantly in drier parts of the Central Highlands. It grows on sandy or gravelly soil, in basalt talus slopes and clefts amongst fractured dolerite rocks and flood channels. Many sites are in rough pasture, and it also grows on roadsides. Recent collections indicate the species is occasionally associated with sandstone outcrops.	Possible – some suitable habitat may be present, albeit likely degraded or modified through historic pastoral activities or development.
Glycine latrobeana	clover glycine	NVA, PMST	v	VU	Occurs in a range of habitats, geologies and vegetation types. Soils are usually fertile but can be sandy when adjacent to or overlaying fertile soils. The species mainly occurs on flats and undulating terrain over a wide geographical range, including near-coastal environments, the Midlands, and the Central Plateau. It mainly occurs in grassy/heathy forests and woodlands and native grasslands.	Possible – some suitable habitat may be present, albeit likely degraded or modified through historic pastoral activities or development.
Lepidium hyssopifolium	soft peppercress	NVA, PMST	e	EN	Known from the growth suppression zone beneath large trees in grassy woodlands and grasslands (e.g. over-mature black wattles and isolated eucalypts in rough pasture). *Lepidium hyssopifolium* is now found primarily under large exotic trees on roadsides and home yards on farms. It occurs in the eastern part of Tasmania between sea-level to 500 metres above sea level in dry, warm and fertile areas on flat ground on weakly acid to alkaline soils derived from a range of rock types. It can also occur on frequently slashed grassy/weedy roadside verges where shade trees are absent.	Likely – suitable habitat present within the survey area and 107 records within 5km. Nearest record located <70m from the study area.
Leptorhynchos elongatus	lanky buttons	NVA	e		Occurs on Tertiary basalt or Quaternary sediments in *Themeda triandra* (kangaroo grass) grassland, as well as open grassy shrubland. It is extant at cemeteries in Bothwell and Jericho, an area of grassland in the Northern Midlands, and at a higher elevation site at Liawenee Moor on the Central Plateau.	Unlikely – some suitable habitat may be present, albeit likely degraded or modified through historic pastoral activities or development.
Leucochrysum albicans subsp. tricolor	grassland paperdaisy	NVA, PMST	e	EN	Occurs in the west and on the Central Plateau and the Midlands, mostly on basalt soils in open grassland. This species would have originally occupied *Eucalyptus pauciflora* woodland and tussock	Unlikely – only one record from 1911 within 5km and not recorded since. Some suitable habitat

Species Name	Common Name	Source	TSP Act	EPBC Act	Suitable Habitat	Likelihood
					grassland, though most of this habitat is now converted to improved pasture or cropland.	may be present, albeit likely degraded through historic pastoral activities or development.
Pellaea calidirupium	hotrock fern	NVA	r		Found in inland, rocky habitats in areas of low to moderate rainfall predominantly in the eastern half of Tasmania. It grows in crevices and on ledges on exposed or semi-exposed rock outcrops. A large sterile colony occurs on the bare summit of Casaveen Bluff (east of York Plains), while nearby, on a tributary of the Little Swanport River plants grow under more favourable conditions on a rock ledge within the protection of a rock gully.	Unlikely – suitable habitat unlikely to be present, and only one record within 5km from 1993.
Pseudocephalozia paludicola	alpine leafy liverwort	PMST		VU	Occurs on wet ground in subalpine grassland in the west of the State and on its central and eastern mountains. Species of *Pseudocephalozia* mostly occur on permanently damp mineral soil or over peat and are frequently found in moorland and sphagnous areas.	Highly Unlikely – suitable habitat not likely present in the survey area and no records within 40km.
Pterostylis commutata	Midland greenhood	PMST	e	CR	Restricted to Tasmania's Midlands, where it occurs in native grassland and *Eucalyptus pauciflora* grassy woodland on well-drained sandy soils and basalt loams.	Unlikely – outside of the known range of the species and suitable habitat not likely present in survey area.
Pterostylis ziegeleri	grassland greenhood, Cape Portland greenhood	PMST	v	VU	Occurs in the State's south, east and north, with an outlying occurrence in the north-west. In coastal areas, the species occurs on the slopes of low stabilised sand dunes and in grassy dune swales, while in the Midlands it grows in native grassland or grassy woodland on well-drained clay loams derived from basalt.	Unlikely – some suitable habitat may be present, however likely substantially modified. Additionally, no previous records from within 25km.
Rhodanthe anthemoides	chamomile sunray	NVA	r		Occurs in montane grasslands, heath and heathy scrub in central and north-western Tasmania.	Unlikely – some suitable habitat may be present, however likely converted to pasture or residential land.
Scleranthus fasciculatus	spreading knawel	NVA	v		Only recorded from a few locations in the Midlands and south-east. The vegetation at most of the sites is *Poa* grassland/grassy woodland. Appears to need gaps between the tussock spaces for its survival and both fire and stock grazing maintain the openness it requires. Often found in areas protected from	Possible - some suitable habitat may be present, albeit likely degraded or modified through historic pastoral activities or development.

Species Name	Common Name	Source	TSP Act	EPBC Act	Suitable Habitat	Likelihood
					grazing such as fallen trees and branches.	
Vittadinia burbidgeae	smooth new-holland-daisy	NVA	r		Known to occur from native grassland and grassy woodland. Can also occupy cleared or disturbed areas where it can be an early establishing species. Often observed from roadsides, verges and other disturbed sites.	Possible - some suitable habitat may be present, albeit likely degraded or modified through historic pastoral activities or development.
Vittadinia cuneata var. cuneata	fuzzy new-holland-daisy	NVA	r		Known to occur from native grassland and grassy woodland. Can also occupy cleared or disturbed areas where it can be an early establishing species. Often observed from roadsides, verges and other disturbed sites.	Possible - some suitable habitat may be present, albeit likely degraded or modified through historic pastoral activities or development.
Vittadinia gracilis	woolly new-holland-daisy	NVA	r		Known to occur from native grassland and grassy woodland. Can also occupy cleared or disturbed areas where it can be an early establishing species. Often observed from roadsides, verges and other disturbed sites.	Possible - some suitable habitat may be present, albeit likely degraded or modified through historic pastoral activities or development.
Westringia angustifolia	narrowleaf westringia	NVA	r		Occurs mainly in mid elevations, always on dolerite (but can be close to dolerite-sediment contact zones), in dry to wet sclerophyll forest on broad ridges, slopes and dense riparian shrubberies.	Unlikely – suitable habitat unlikely to be present.
Xerochrysum palustre	swamp everlasting, swamp paper daisy	PMST	v	VU	Scattered distribution with populations in the north-east, east coast, Central Highlands and Midlands, all below about 700 m elevation. It occurs in wetlands, grassy to sedgy wet heathlands and extends to associated heathy *Eucalyptus ovata* woodlands. Sites are usually inundated for part of the year.	Unlikely – suitable habitat unlikely to be present.

Note: Likelihood of occurrence of threatened flora is assessed on a 4-tier scale:

1. Present - individuals recorded within the survey area during the field assessment or any previous assessment within the boundaries of survey area;
2. Possible - suitable habitat occurs within the survey area;
3. Unlikely - suitable habitat unlikely to occur within the survey area, or suitable habitat substantially modified, or suitable habitat present but species not recorded for over 50 years within 5km of the site;
4. Highly unlikely - no suitable habitat present within the survey area, and individuals not recorded within the survey area during current or any previous assessment.

4.3 Threatened Fauna

The results of the NVA report (Appendix B) indicated a total of 66 threatened fauna individuals from six species have been previously recorded within 5 km of the survey area. Several of those species have been recorded from

within the survey area including *Aquila audax subsp. fleayi* (Tasmanian wedge-tailed eagle), *Neophema chrysogaster* (orange-bellied parrot) and *Perameles gunnii* (Eastern barred bandicoot).

The results of the PMST report (Appendix C) identified 14 EPBC listed fauna species, or their habitat have the potential to occur within the survey area. This included seven birds, one fish, one amphibian, one invertebrate and four mammals.

The combined results of the PMST and NVA indicated a total of 15 state and/or Commonwealth listed flora species potentially occurring within the survey area. The results of the likelihood analysis indicated two species were considered as present within the survey area given previous records, four species were considered possible to occur within the survey area, seven were unlikely and three species highly unlikely. Species likelihoods were assessed based on the known habitat preferences for each species and the likely vegetation, habitat and landforms present based on the available information.

An additional reptile species, *Pseudemoia pagenstecheri* - tussock skink (TSP: vulnerable / EPBC: -) was considered for assessment. As per the table below, the species habitat includes medium to long grass tussocks in open grasslands where trees are absent or sparse. Relevant literature indicates the species may be present where vegetation consists of a grassy ground layer. The species is known from widely scattered locations, ranging from The Domain near Hobart, through the lowland Midlands, extending to higher elevations near Cradle Mountain, and a single island in Bass Strait. The survey area is located within the known range of the species, suggesting species presence is possible where suitable habitat exists.

Table 8 Summary of threatened fauna species identified from within 5 km based on the results from the NVA and PMST

Species Name	Common Name	Source	TSP Act	EPBC Act	Habitat	Likelihood
Amphibians						
Litoria raniformis	Green and gold frog	PMST	V	VU	Breeding habitat for the Green and Gold Frog includes the following elements: still or slow-moving water bodies (lagoons, lakes, farm dams, ponds, irrigation channels, swamps, and slow-moving sections of rivers and streams); the species prefers the shallow part of lagoons (to approx. 1.5m) with a complex vegetation structure, often containing vegetation communities dominated by emergent plants such as water ribbons (*Triglochin*) and spikerush (*Eleocharis*), and submerged plants such as watermilfoil (*Myriophyllum*), marsh-flower (*Villarsia*), and pondweed (*Potamogeton*); however, other plant communities can also form suitable breeding habitat.	Unlikely – suitable habitat no mapped within the survey area and no known records within 5 km.
Birds						
Aquila audax subsp. fleayi	Tasmanian wedge-tailed eagle	NVA, PMST	E	EN	Nesting habitat includes the following elements: patches of mature (including old-growth) forest, or forest with mature/old-growth elements, normally greater than 10 ha in area; nest trees usually tall (25-75 m), large and robust mature eucalypts, generally taller than the canopy; nests are often constructed in the tallest and largest tree at a site, and usually located within the canopy even when the nest tree is taller; nests typically occur on the lee (sheltered) aspect of the site (or where hills shelter an otherwise	Present – species may be observed within the survey area in a transient nature, however, highly unlikely to nest or breed given the lack of remnant forested patches containing suitable nesting trees/habitat. Previous sighting of the species

Species Name	Common Name	Source	TSP Act	EPBC Act	Habitat	Likelihood
					exposed site), with the nest situated below the ridge level for protection from prevailing winds.	within the survey area, however details unknown (e.g. observer, date, etc)
Calidris ferruginea	Curlew sandpiper	PMST		CR	In Australia, curlew sandpipers mainly occur on intertidal mudflats in sheltered coastal areas, such as estuaries, bays, inlets and lagoons, and also around non-tidal swamps, lakes and lagoons near the coast, and ponds in saltworks and sewage farms. They are also recorded inland, though less often, including around ephemeral and permanent lakes, dams, waterholes and bore drains, usually with bare edges of mud or sand. They occur in both fresh and brackish waters. Occasionally they are recorded around floodwaters.	Unlikely – no suitable habitat mapped within the survey area and the species has not been recorded within 50km of the survey area.
Hirundapus caudacutus	White-throated needletail	PMST		VU	In Australia, the white-throated needletail can occur over most types of habitat, although they are recorded most often above wooded areas, including open forest and rainforest, and may also fly below the canopy between trees or in clearings. When flying above farmland, they are more often recorded above partly cleared pasture, plantations or remnant vegetation at the edge of paddocks. In coastal areas, they have been observed flying over sandy beaches or mudflats, and often around coastal cliffs and other areas with prominent updraughts, such as ridges and sand-dunes. The species roosts in trees amongst dense foliage in the canopy or in hollows.	Unlikely – the species may be observed flying over the site, however, no roosting habitat is mapped within the survey area. No previous records mapped within 5km of the survey area.
Lathamus discolor	Swift parrot	PMST	E	CR	Habitat includes flowering Tasmanian blue gum and black gums (foraging habitat) and any eucalypt forest containing hollow-bearing trees (nesting habitat). Hollow-bearing trees are typically large and old with dead limbs or branches and at least some visible hollows.	Highly Unlikely – no suitable foraging or breeding habitat mapped within the survey area, and no previous records mapped within 5km. Species may be observed flying over the survey area, however would only be transiting through.
Neophema chrysogaster	Orange-bellied parrot	NVA	E	CR	The known breeding range of the Orange-bellied parrot is mostly confined to near-coastal areas of south-west Tasmania between Birchs Inlet in Macquarie Harbour,	Highly Unlikely – not within the known breeding or foraging range of the species and

Species Name	Common Name	Source	TSP Act	EPBC Act	Habitat	Likelihood
					and Louisa Bay on the southern coast. Most breeding activity occurs within 20 km of Melaleuca and 5 km of Birchs Inlet. Non-breeding (migratory) habitat for Orange-bellied Parrot includes the following elements: dunes, heathland, coastal grasslands, saltmarsh and pasture; on King Island, the species favours saltmarsh dominated by Beaded Glasswort *Sarcocornia quinqueflora*, flanked by tall dense Swamp Paperbark *Melaleuca ericifolia* forest. Nesting habitat for Orange-bellied parrot includes the following elements: a mosaic of eucalypt forest, rainforest, and extensive fire dependant moorland and sedgeland plains, intersected by wooded creeks, rivers and estuaries; nesting occurs predominantly in the hollows of live Smithton Peppermint, *Eucalyptus nitida* in patches of forest.	no suitable habitat present within the survey area.
Numenius madagascariensis	Eastern curlew, far eastern curlew	PMST	E	CR	During the non-breeding season in Australia, the eastern curlew is most commonly associated with sheltered coasts, especially estuaries, bays, harbours, inlets and coastal lagoons, with large intertidal mudflats or sandflats, often with beds of seagrass (Zosteraceae). Occasionally, the species occurs on ocean beaches (often near estuaries), and coral reefs, rock platforms, or rocky islets. The birds are often recorded among saltmarsh and on mudflats fringed by mangroves, and sometimes within the mangroves. The birds are also found in coastal saltworks and sewage farms.	Unlikely – no suitable habitat mapped within the survey area and the species has not been recorded within 50 km of the survey area.
Pterodroma leucoptera leucoptera	Gould's petrel, Australian Gould's petrel	PMST		EN	Gould's Petrel breeds on Cabbage Tree Island, 1.4 km offshore from Port Stephens, NSW. This 30 ha island was thought to be the sole breeding locality for this species, but a few nesting birds were discovered on nearby Boondelbah Island in 1995. The non-breeding range and feeding areas of Gould's Petrel is unknown, but it appears that the species forages predominantly within the Tasman Sea. Beach washed specimens and sightings at sea extend as far north as the Queensland border and as far west	Highly Unlikely – no suitable habitat within the survey area, and no previous records within 5 km.

Species Name	Common Name	Source	TSP Act	EPBC Act	Habitat	Likelihood
					as Eyre on the Western Australian south coast.	
Tyto novaehollandiae subsp. castanops	Tasmanian masked owl	NVA, PMST	E	VU	Habitat for the Tasmanian Masked Owl includes the following elements: foraging habitat - a diverse range of forest, woodland and non-forest vegetation including agricultural and forest mosaics; nesting habitat - eucalypt forests and woodlands containing old growth trees with suitable hollows for nesting/roosting, but will also nest in isolated old growth trees with suitable hollows. This species requires a mosaic of forest and open areas for foraging and large old-growth hollow-bearing trees for nests. The core range covers all habitat below 600 m a.s.l, but significant habitat is dry forest with mature habitat elements within that range. Forests with relatively open understoreys, particularly when these habitats adjoin areas of open or cleared land, are particularly favoured	Possible – species may be observed within the survey area in a transient nature, however, highly unlikely to nest or breed given the lack of remnant forested patches containing suitable nesting trees/habitat.
Fish						
Prototroctes maraena	Australian grayling	PMST	V	VU	Habitat for the Australian Grayling includes the following elements: adult Australian Grayling inhabit and breed in rivers and streams, usually in cool waters often with alternating pool and riffle zones; larvae and juveniles inhabit estuaries and coastal seas, although their precise habitat requirements are poorly known.	Unlikely – no suitable habitat mapped within the survey area.
Invertebrates						
Oreixenica ptunarra	Ptunarra Brown, Ptunarra Brown, Butterfly, Ptunarra xenica	PMST	V	EN	Endemic to Tasmania and restricted to five areas of the state: the Midlands, Steppes, Northwest Plains, Eastern Highlands and the Central Plateau. It is generally a montane to alpine species being restricted to sites above 400 m. It does not extend into the lowland plains of the Midlands, where it may be too warm for the butterfly and where it is too dry for its food plant to flourish. Throughout its range the Ptunarra brown butterfly is found in areas where there is a significant cover of *Poa* tussock. Some apparently excellent sites do not carry butterflies and this may be due to the history of the site. It is possible that the species has been eradicated from the western Central Plateau by a European history of over-firing and overgrazing. The preferred habitat	Unlikely – survey area located below the topographic range limit for the species (>400m ASL).

Species Name	Common Name	Source	TSP Act	EPBC Act	Habitat	Likelihood
					ranges from *Poa* tussock grassland to *Hakea microcarpa* grassy shrubland to *Eucalyptus* grassy open woodland.	
Mammals						
Dasyurus maculatus	Spotted-tailed quoll	NVA, PMST	R	VU	Spotted-tailed quolls can be found in numerous types of vegetation. However, forest elements such as rainforest, and wet and dry eucalypt forest are important components of their habitat. They can also be found in non-forest vegetation types such as coastal scrub and heath, and pastoral areas. This wide range of vegetation types are generally characterised by relatively high and predictable seasonal rainfall.	Possible – individuals of the species may be present area for foraging purposes (e.g. carcasses, small mammals), however no suitable denning habitat mapped within the survey area. 2 records from within 5 km, both located in forested areas of remnant vegetation.
Dasyurus viverrinus	eastern quoll	PMST		EN	The species' distribution is associated with areas of low rainfall and cold winter minimum temperatures. Within this distribution, it is found in a range of vegetation types including open grassland (including farmland), tussock grassland, grassy woodland, dry eucalypt forest, coastal scrub and alpine heathland, but is typically absent from large tracts of wet eucalypt forest and rainforest. Dens in burrows, hollow log or rock crevice.	Possible - individuals of the species may be present in area for foraging purposes (e.g. carcasses, insects, etc.). Some suitable denning habitat may be present in the survey area. No previous records mapped within 5 km of the survey area.
Perameles gunnii	eastern barred bandicoot	NVA, PMST		VU	Habitat for the eastern barred bandicoot includes the following elements: within agricultural districts, mosaic habitats of pasture and remnant native forest, often with a significant amount of cover provided by dense-growing weeds such as gorse, blackberry, blackthorn, rose briar, etc; small remnant populations may occur in remnant native grassland and grassy woodland; all records occur below 950 altitude.	Present – previously recorded within the survey area. Individuals may be present within the survey area for foraging or nesting purposes. Three records within 5 km, all from 1987.
Sarcophilus harrisii	Tasmanian devil	NVA, PMST	E	EN	Habitat includes the following elements contained across an area of several square kilometres: denning habitat for daytime shelter (e.g. dense vegetation, hollow logs, burrows or caves), open forests and woodlands are preferred, while devils are less commonly found in tall or dense wet forests; hunting habitat (open understorey mixed with patches of dense vegetation); breeding den habitat (areas of well-drained soil or sheltered overhangs	Possible - individuals of the species may be present area for foraging purposes (e.g. carcasses, small mammals), however no suitable denning habitat mapped within the survey area.

Species Name	Common Name	Source	TSP Act	EPBC Act	Habitat	Likelihood
					such as cliffs, rocky outcrops, knolls, caves and earth banks, free from risk of flooding; windrows and log piles may also be used).	
Reptiles						
Pseudemoia pagenstecheri	Tussock skink	-	V		Known from treeless tussock grassland and grassy open woodland at virtually any elevation where suitable habitat is present; typical habitat in the warmer lowland part of the range is native grassland dominated by *Poa labillardierei (*tussock grass) and species of *Rytidosperma* (wallaby grasses), *Themeda triandra* (kangaroo grass) and *Microlaena stipoides* (weeping grass).	Possible – survey area located within the known range of the species and some suitable habitat may be present, albeit likely degraded through historic pastoral activities or development.

Note: Likelihood of occurrence of threatened flora is assessed on a 4-tier scale:

1. Present - individuals recorded within the survey area during the field assessment or any previous assessment within the boundaries of survey area;
2. Possible - suitable habitat occurs within the survey area;
3. Unlikely - suitable habitat unlikely to occur within the survey area, or suitable habitat substantially modified, or suitable habitat present but species not recorded for over 50 years within 5km of the site;
4. Highly unlikely - no suitable habitat present within the survey area, and individuals not recorded within the survey area during current or any previous assessment.

4.4 Raptors

According to the NVA report, *Aquila audax subsp. fleayi* (Tasmanian wedge-tailed eagle) and *Falco cenchroides* (nankeen kestrel) have been previously sighted within 500 m of the survey area. Additionally, three wedge-tailed eagle (ID – 1096, 2222, 2524) and one *Falco peregrinus* (peregrine falcon) nest (ID – 266) have been identified within 5 km of the survey area. All mapped eagle nests are located greater than 1000 m from the survey area.

4.5 Weeds and Pathogens

According to the NVA report (Appendix B), one and eleven Declared weeds, pursuant to the Tasmanian *Weed Management Act 1999* (WM Act), have been recorded within 500 m and 5000 m, respectively. These include:

– *Carduus pycnocephalus* – slender thistle
– *Carduus tenuiflorus* – winged thistle
– *Cirsium arvense var. arvense* – creeping thistle
– *Cytisus scoparius* – English broom
– *Elodea canadensis* – Canadian pondweed
– *Erica Lusitanica* – Spanish heath
– *Genista monspessulana* – Montpellier broom/canary broom
– *Marrubium vulgare* – white horehound
– *Salix x fragilis var. fragilis* – crack willow
– *Salix x rubens* – basket willow
– *Ulex europaeus* – gorse

Several of those species, including *U. europeaus, C. scoparius, G. monspessulana* & *Salix spp.,* are listed as Weeds of National Significance (WoNS). Under the WM Act, landowners have a responsibility to control and manage declared weeds on their property in accordance with the relevant statutory weed management plan.

5. Threatening Processes

The TSP Act defines a threatening process as any action which poses a threat to the natural survival of any native taxon of flora or fauna. The Tasmanian *Threatened Species Strategy 2000*, prepared under the TSP Act, has identified six threatening processes as having the greatest impact on Tasmania's native flora and fauna:

– Native vegetation clearance
– Pests, weeds and diseases
– Degradation of water systems
– Inappropriate use of fire
– Bycatch and illegal harvesting
– Impacts of livestock

The Commonwealth EPBC Act also provides for the identification and listing of key threatening processes. A threatening process is defined under the EPBC Act as a key threatening process if it threatens or may threaten the survival, abundance or evolutionary development of a native species or ecological community. The implications of listed key threatening processes are different for each state and territory. Those currently listed under the EPBC Act (and relevant to this project) are shown in the table below.

Table 9 Summary of listed Key Threatening Processes under the EPBC Act

Listed Key Threatening Process
Aggressive exclusion of birds from potential woodland and forest habitat by over-abundant noisy miners (*Manorina melanocephala*)
Competition and land degradation by rabbits
Competition and land degradation by unmanaged goats
Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*)
Infection of amphibians with chytrid fungus resulting in chytridiomycosis
Land clearance
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants
Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases
Novel biota and their impact on biodiversity
Predation by European red fox
Predation by feral cats
Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs
Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species

Ecological values, such as those outlined in section 4 of this document, may be adversely affected by threatening processes. Key threatening processes potentially present within the survey area have been outlined below, and those relating more specifically to any proposed developments associated with this project (e.g. introduction of invasive flora) are discussed in Section 5.

5.1 Invasive Species

5.1.1 Invasive Flora

Key Threatening Process: Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants; Novel biota and their impact on biodiversity.

Eleven species listed as declared weeds under the Tasmanian *Weed Management Act 1999*, including eight Weeds of National Significance (WONS), have been previously recorded or are predicted to occur within 5 km of the survey area.

The NVA Report also identified two additional priority weeds (not listed as a declared weed) that have been recorded within 5 km of the survey area; *Tradescantia fluminensis* (wandering creeper) and *Verbascum thapsus* (great mullein).

5.1.2 Invasive Fauna

Key Threatening Process: Competition and land degradation by rabbits; Predation by European red fox; Predation by feral cats

The NVA report (Appendix B) did not identify any known species of biosecurity risk within 1000 m of the survey area, however, it's expected that feral cats and rabbits would be present in the local area given the abundance of open pasture, the proximity to residential properties and the likely abundance of prey in the form of native and invasive small mammals (e.g. bandicoots, rats, mice etc.).

5.2 Pathogen Infestation/s

Key Threatening Process: Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*); Infection of amphibians with chytrid fungus resulting in chytridiomycosis.

Phytophthora cinnamomi (root rot fungus or cinnamon fungus) is an introduced pathogen that attacks the roots of over 130 Tasmanian plant species. It can change the structure and composition of vegetation, and reduce plant species diversity and resources, with resultant flow-on effects to fauna. As such, it is the only pathogen listed as a 'threatening process' on the EPBC Act. *Phytophthora cinnamomi* can be introduced to an area by spores carried on vehicles and machinery, with human activities primarily responsible for introducing the pathogen into new areas. Once established, it can spread rapidly by water transport, root-to-root infection and animal digging, and is impossible to eradicate[11].

Given the relatively low rainfall of the survey area, it's likely that *P. cinnamomi* is unable to spread and affect any present flora species.

Additional plant and fauna pathogens known from Tasmania include myrtle wilt (*Chalara australis*), myrtle rust (*Austropuccinia psidii*) and chytrid fungus (*Batrachochytrium dendrobatidisi*). Myrtle wilt and myrtle rust are not expected to impact ecological values in the survey area as given their relevant host species and/or known habitat are not mapped within the survey area. Chytrid fungus has the potential to impact on any local frog populations, however, the majority of the survey area is expected to be free of standing water bodies. As such, any impacts would be short-lived and not pose an ongoing threat the local species.

[11] FPA 2009

6. Potential Impacts

6.1 Vegetation Communities

According to TASVEG 4.0, none of the mapped vegetation communities within the survey area represent a threatened community under either state or Commonwealth legislation. As such, impacts to any known threatened vegetation communities were considered highly unlikely as a result of the proposed development.

6.2 Threatened Flora

According to the available databases, the closest threatened flora observations are known from 62 m north-west of the survey area. This record consisted of *Lepidium hyssopifolium* (soft peppercress). This species is listed as Endangered under both the TSP Act and EPBC Act.

Based on the results of the desktop assessment, a total of 11 state and/or Commonwealth listed flora species have the potential to be located within the survey area. These species include:

– *Asperula scoparia subsp. scoparia* - prickly woodruff (TSP: rare / EPBC: -)
– *Brachyscome rigidula* - cutleaf daisy (TSP: vulnerable / EPBC: -)
– *Calocephalus lacteus* - milky beautyheads (TSP: rare / EPBC: -)
– *Dianella amoena* - grassland flax-lilly (TSP: rare / EPBC: endangered)
– *Discaria pubescens* - spiky anchorplant (TSP: endangered / EPBC: -)
– *Glycine latrobeana* - clover glycine (TSP: vulnerable / EPBC: vulnerable)
– *Lepidium hyssopifolium* - soft peppercress (TSP: endangered / EPBC: endangered)
– *Scleranthus fasciculatus* - spreading knawel (TSP: vulnerable / EPBC: -)
– *Vittadinia burbidgeae* - smooth new-holland-daisy (TSP: rare / EPBC: -)
– *Vittadinia cuneata var. cuneata* - fuzzy new-holland-daisy (TSP: rare / EPBC: -)
– *Vittadinia gracilis* - woolly new-holland-daisy (TSP: rare / EPBC: -)

Given the known range and preferred habitat of the above flora species, the results of this desktop assessment are unable to definitively determine the potential presence and subsequent impacts to some flora species. As such, a number of the threatened flora species may be present in the survey area given the nearby records of the species. Therefore, a flora survey should be conducted to identify the presence/absence of any threatened flora species and assess any potential impacts.

Several of the above species are listed under the EPBC Act indicating their conservation significance on a national scale. Where impacts and/or removal of these species is possible, a referral to the Commonwealth Minister for Environment and the Department of Climate Change, Environment, Energy & Water (DCCEEW) may be required.

6.3 Threatened Fauna

Based on the results of the desktop assessment, a total of seven state and/or Commonwealth listed fauna species (two birds, four mammals & one reptile) are potentially present within the survey area based on previous records, their known habitat preferences and the habitat identified during the desktop assessment. These species include:

– *Aquila audax subsp. fleayi* - Tasmanian wedge-tailed eagle (TSP: endangered / EPBC: Endangered)
– *Dasyurus maculatus maculatus* – spotted-tailed quoll (TSP: rare / EPBC: Vulnerable)
– *Dasyurus viverrinus* - eastern quoll (TSP: - / EPBC: Endangered)
– *Perameles gunnii gunnii* - eastern barred bandicoot (TSP: - / EPBC: Vulnerable)
– *Pseudemoia pagenstecheri* - tussock skink (TSP: vulnerable / EPBC: -)
– *Sarcophilus harrisii* - Tasmanian devil (TSP: endangered / EPBC: Endangered)
– *Tyto novaehollandiae subsp. castanops* - Tasmanian masked owl (TSP: endangered / EPBC: Vulnerable)

Four of the above threatened species have the potential to be present within the survey area given the abundance of generalised foraging habitat (e.g. open pasture, roadsides, roadkill carcasses, etc.). These species include the Tasmanian devil, spotted tailed-quoll, Tasmanian wedge-tailed eagle, and Tasmanian masked owl. All of these species are conservation significant carnivorous species with site specific habitat requirements for nesting or denning. The survey was not considered to provide suitable nesting or denning habitat for those species given the lack of representative suitable habitat. Given the lack of suitable nesting/denning/breeding habitat for these carnivorous species, any individuals or populations in proximity of the survey area would likely be in very low abundances and any proposed flood mitigation options are not likely to impact on significant habitat for those species.

However, those species are known to forage across a broad range of landscapes, vegetation types and landforms. As such, it's possible these species may be present throughout the survey area, however, their presence would likely be brief in duration, more likely for transit or foraging purposes. Additionally, the foraging resources within the survey are likely to remain accessible post construction. As such, those species (Tasmanian devil, spotted tailed-quoll, Tasmanian wedge-tailed eagle, and Tasmanian masked owl) were not considered for further assessment.

Of those species listed above, suitable nesting/denning habitat for the eastern quoll, eastern barred bandicoot and the tussock skink may be present within the survey area, and as such those species are discussed further below.

6.3.1 Eastern Quoll

The eastern quoll (*D. viverrinus*) is widespread in Tasmania and was previously widespread in mainland south-eastern Australia, including New South Wales, Victoria and eastern South Australia[12]. The species is considered extinct on the mainland, with the last confirmed mainland sighting at Vaucluse (NSW) in 1963. The species is now restricted to Tasmania, occurring in most parts of Tasmania, but is recorded infrequently in the wetter western third of the state.

The species' distribution is associated with areas of low rainfall and cold winter minimum temperatures[13] [14]. Within this distribution, the species is known from a range of vegetation types including open grassland (including farmland), tussock grassland, grassy woodland, dry eucalypt forest, coastal scrub and alpine heathland, but is typically absent from large tracts of wet eucalypt forest and rainforest[15] [16] [17].

According to the NVA database, no records of the species have been recorded within 5km and a total of 23 records within 20km. The survey area is located within the known range of the species and within the core range of the species according to the FPA.

The species is commonly associated with dry grassland and forest mosaics which are bounded by agricultural land, particularly where pasture grubs are common[18] [19] [13]. The species is known to nest in dens made under rocks, in underground burrows or fallen logs[12], but anecdotal evidence suggests the species may nest in man-made structures.

Threats to the eastern quoll are outlined in the below:

– predation by feral cats
– disease
– climate change
– predation by red foxes
– non-target poisoning associated with 1080
– non-target poisoning associated with rodent control
– predation by dogs
– road mortality

[12] TSSC 2015
[13] Fancourt 2015
[14] Fancourt et al. 2015a
[15] Rounsevell et al. 1991
[16] Taylor & Comfort 1993
[17] Fancourt et al. 2015b
[18] Blackhall 1980
[19] Godsell 1983

The majority of the survey area is mapped as agricultural land (FAG) with urban areas (FUR - e.g. residential property/dwellings). Elements of optimal denning habitat (e.g. large tracts of remnant open grassland or woodland containing fallen trees, rock piles or underground burrows) are unlikely to be available within the survey area given the mapped TASVEG communities and historical modifications (e.g. pastoral activities, grazing, residential developments, clearing, roadside maintenance). As such, it is considered the survey area is likely to provide sub-optimal or low-quality denning habitat for the eastern quoll. Higher quality denning habitat may be available in the large remnant forest patches (mapped as *Eucalyptus tenuiramis* forest and woodland on sediments - DTO) located approx. 1-2 km to the west.

Non-developed portions of the survey area may provide access to foraging habitat with abundant access to agricultural invertebrate pests (e.g. cockchafer beetles, southern army worms and corbie grubs)[18] [19] [20]. Access to the foraging habitat (e.g. open pasture) within the survey area is likely to remain post the implementation of any flood mitigation measures.

As such, the implementation of the proposed development is unlikely to generate a significant impact to the eastern quoll. To further mitigate against any risk of impacts to the species, the proponent should conduct pre-clearance surveys to ensure the development footprint is free of any suitable denning structures that may be utilised by any present eastern quolls.

6.3.2 Eastern Barred Bandicoot

The eastern barred bandicoot (*P. gunnii gunnii*) was previously widely distributed in northern, central and south-eastern Tasmania, however, it has now declined in the central part of this range in the Midlands region[21] [22] [23]. The species is now most abundant in the south-eastern quarter of the state with lower numbers in the north-eastern and north-western coastal regions and least abundant in the midland and eastern coastal areas[21] [24]. According to the FPA range boundaries, the survey area is located near the northern-western extent of the core range of the species distribution in Tasmania.

The known threats to the species include:

– clearing of habitat, in particular loss of ground cover
– overgrazing
– urban development
– predation by feral cats (*Felis catus*) and dogs (*Canis familiaris*)

The species occurs in open habitats including woodlands and open forests with a grassy understorey, and native and exotic grasslands[21], and requires understorey plants to provide shelter, nest sites and food[25]. Suitable native plants which form a dense ground cover include saggs *(Lomandra* and *Lepidosperma sp.)*, *Gahnia* species and species of *Acacia, Grevillia, Hakea* and *Correa*, whereas invasive flora including gorse and blackberries also provide shelter for bandicoots. According to the FPA, significant habitat for the eastern barred bandicoot is dense tussock grass, sagg, sedge, swords, piles of coarse woody debris and denser patches of low shrubs (especially those that are densely branched close to the ground providing shelter)[26]. Therefore, the survey area is unlikely to represent significant habitat for the species due to the mapped TASVEG communities and historical modifications (e.g. pastoral activities, grazing, residential developments, clearing, roadside maintenance).

The species is known to feed on earthworms and invertebrates (including pasture pests like corbie grubs) and plant material, such as underground fungi and berries[27]. As such, the majority of the survey area is likely to provide suitable foraging habitat for the species, albeit sub-optimal (given the lack of refugia) and in the form of open pasture/grassland. Access to foraging habitat (e.g. open pasture) within the survey area is likely to remain post the implementation of any flood mitigation measures.

[20] Jones & Barmuta 1998
[21] Hocking 1990
[22] Robinson et al. 1991
[23] Mallick et al. 1998
[24] Mallick et al. 1997
[25] Parks and Wildlife Service Tasmania 2007
[26] FPA 2021
[27] Bryant & Jackson 1999

Given the above, the implementation of any proposed flood mitigation measures is unlikely to significantly impact on the eastern barred bandicoot. To further mitigate against any risk of impacts to the species, the proponent should conduct pre-clearance surveys to ensure the development footprint is free of any suitable nesting/burrow structures that may be utilised by any present individuals.

6.3.3 Tussock Skink

The tussock skink (*P. pagenstecheri*) is a ground-dwelling lizard, occurring in grassland and grassy woodland habitats at a range of elevations[28]. Potential habitat for the tussock skink is described as grassland and grassy woodland (including rough pasture with paddock trees) at virtually any elevation, generally with a greater than 20% cover of native grass species, especially where medium to tall tussocks are present[26]. According to the FPA species range boundaries, the survey area is within the potential range of the tussock skink. The core range of the species is restricted to 550 m buffer areas around the previous records[26].

Suitable habitat features in the warmer lowland part of the range includes native grassland dominated by *Poa labillardierei* (tussock grass) and species of *Rytidosperma* (wallaby grasses), *Themeda triandra* (kangaroo grass) and *Microlaena stipoides* (weeping grass). Records of the species in Tasmania are located in small, disconnected patches of habitat in the Midlands, inland near Cradle Mountain and the eastern Bass Strait islands[28].

According to the NVA, two previous records of the species are located 12 km south, both from 2009. These records are listed as species sightings and located in areas of open pasture mapped as 'agricultural land' (FAG)[1], suggesting the species may persist in rough pasture known to be anthropogenically modified. Two additional records are located 29 km (recorded in 2010) and 32 km south-west (recorded in 2000). This confirms previous research suggesting the vegetation structure of grasslands appears more important for tussock skinks than the floristic composition e.g. individuals are recorded relatively regularly in invasive species dominant grassland vegetation[29].

Given the above, the survey area may provide some suitable habitat for the species, although its unlikely to represent optimal habitat given the mapped TASVEG communities and historical modifications (e.g. pastoral activities, grazing, residential developments, clearing, roadside maintenance). A definitive assessment of the potential impacts is unable to be determined from the desktop level given the unknown potential for the presence of the species within the survey area. As such, a field survey is recommended to identify the presence/absence of any suitable habitat for the tussock skink, identify the presence/absence of any individuals and assess any potential impacts relating to the implementation of any proposed flood mitigation options.

6.4 Weeds and Pathogens

Given the previous records of declared weeds and/or WoNS within or near the survey area, the proponent should develop and implement a Weed & Hygiene Management Plan (WHMP). The data collected during a field survey should inform the location, density and abundance of any significant weeds present within the survey area that require active management.

This documentation should include:

– Control of weeds prior to construction where appropriate
– Washdown and inspection of vehicles, machinery and boots before leaving/entering the site to avoid transporting viable plant materials or large clods of soil
– Washdown to be conducted in accordance with the *Tasmanian Washdown Guidelines for Weed and Disease Control*[30]
– Control of material brought onto the site, to make sure it is free from weed seeds or diseases

Weed control in or near aquatic habitat, or areas of poor drainage, must consider the potential presence of frogs and/or other aquatic species, with manual removal preferable. Otherwise, low-toxicity non-residual herbicides registered as suitable for watercourses (e.g. Roundup Bioactive®) may be appropriate for use in a targeted manner such as spot spraying. Care also needs to be taken in order to avoid impacting any native flora species

[28] TSS 2023
[29] Turner 2012
[30] DPIPWE 2004

during weed control works; make sure that such works are undertaken by an appropriately qualified person with the ability to accurately distinguish the relevant weed species from any native flora.

6.4.1 Willow Removal

As per section 2.1.1, a component of the overall project proposes the woody weed removal specifically targeting willow species (*Salix spp.*). This works will require the removal of relatively large and established trees from the banks of the River Clyde. Worldwide, there are over 330 accepted willow species with over 170 accepted hybrids[31]. Relevant species may include *S. cinerea*, crack willow (*S. fragilis var. fragilis*), basket willow (*S. x rubens*) and black willow (*S. nigra*).

As per the Tasmanian *Weed Management Act 1999* and the relevant statutory Weed Management Plan, willow species (*S. alba var. vitellina, S. matsudana, S. X pendulina var. pendulina, S. X sepulcralis var. chrysocoma, S. X rubens*) the Central Highlands municipality is listed under Zone A. Eradication is the most appropriate management objective for Zone A municipalities which have little or no prohibited willow, or when a credible plan for eradicating existing infestations is being developed and implemented. The ultimate management outcome for Zone A municipalities is achieving and maintaining the total absence of prohibited willow from within municipal boundaries.

Willow control can be dangerous, and if done poorly, may result in additional localised environmental damage. Chemical treatment is the most effective method for killing mature willows, with an adaptive approach incorporating physical and mechanical removal where necessary. The proponent should develop a Woody Weed Management Plan aimed to effectively control and remove targeted willow populations along the River Clyde. GHD can assist in the development of this plan and should be guided by the relevant resources including the Willow – *Salix spp.* Weed Management Guide found on the Department of Natural Resources and Environment Tasmania (DNRET) website, the Willows - Weed Management Plan as per the WM Act, the Weed and Disease Planning and Hygiene Guidelines[32], Tasmanian Washdown Guidelines for Weed and Disease Control[33], Waterways & Wetlands Works Manual - Environmental Best Practice Guidelines[34] and the Waterways & Wetlands - Works Manual[35]. Where required, the Invasive Species Branch of DNRET should be contacted for advice.

In order to reduce the risk of sedimentation and localised impacts to waterways and fauna habitat, all woody weed removal should be guided by sediment and erosion mitigation measures.

6.5 Legislative Implications

6.5.1 Tasmanian *Threatened Species Protection Act 1995*

Threatened flora and fauna listed under this Act are protected under section 51, whereby a permit would be required to 'take, keep, trade in or process' any listed species. Under this Act, any unauthorised activities which may impact on those species listed under the Act would be considered an offence.

Given the desktop assessment has determined several state listed flora and/or fauna species may be present, a field survey should be conducted to confirm the presence absence of those species and/or their habitat.

6.5.2 Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

Under the Commonwealth EPBC Act, an action will require approval from the minister if the action has, will have, or is likely to have, a significant impact on a matter of national environmental significance (MNES). MNES considered under the EPBC Act include listed migratory species, Ramsar wetlands of international importance, Commonwealth marine environment, world heritage properties, national heritage places, the Great Barrier Reef

[31] DSEWPC 2007
[32] DPIPWE 2017
[33] DPIPWE 2004
[34] DPIPWE 2003
[35] DPIWE 2003

Marine Park, nuclear actions and a water resource, in relation to coal seam gas development and large coal mining development.

Where an action is likely to have a significant impact on a matter protected under the EPBC Act, the proponent may be required to refer the proposed action to the Department of Climate Change, Environment, Energy and Water (DCCEEW) for assessment.

Based on the information outlined in section 6, the proposed development has the potential to impact on eastern quolls and eastern barred bandicoots, both of which are listed under the EPBC Act.

The DCCEEW provides a *Significant Impact Guidelines* policy statement[36] to determine if referral to the department is required. The *Guidelines* consider a "significant impact" to comprise loss that is likely to lead to a long-term decrease in the size of an important population of a species ; reduce the area of occupancy of an important population ; fragment an existing important population into two or more; adversely affect habitat critical to the survival of a species; disrupt the breeding cycle of an important population ; modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline ; result in invasive species that are harmful to a threatened species becoming established in the threatened species' habitat ; introduce disease that may cause the species to decline ; or interfere substantially with the recovery of the species.

Where field surveys identify the presence of individuals or habitat for any MNES, a significant impact test should be conducted by the proponent once the final project footprint of any proposed mitigation works and the associated impacts has been determined.

6.5.3 Tasmanian *Nature Conservation Act 2002*

Schedule 3A of the Act lists vegetation types classified as threatened within Tasmania. The survey area does not support any such vegetation types.

6.5.4 Tasmanian *Weed Management Act 1999*

Under the Tasmanian Weed Management (WM) Act, landowners have obligations to control and manage declared weed species in accordance with the relevant species statutory management plans. As per section 4.5, one and eleven declared weeds have been recorded within 500 m and 5000 m respectively. Therefore, the field survey will inform the need for weed control activities in accordance with the WM Act.

6.5.5 Tasmanian *Land Use Planning and Approvals Act 1993*

The applicable planning scheme for the survey area is the Tasmanian Planning Scheme under the Central Highlands Local Provisions Schedule. Note that the following should not be considered a detailed interpretation of the provisions of the *Scheme* or constitute legal advice and may not necessarily align to the views of Central Highlands Council.

The survey area intersects several zones including rural, utilities, rural living Zone A, village, agriculture, recreation and community purpose. Additionally, the survey area covers several codes including:

– Local Historical Heritage Code - Local heritage precinct
– Natural Assets Code – Priority vegetation & waterway and coastal protection area
– Bushfire-Prone Areas Code - Bushfire-prone areas

The overall project footprints of the proposed flood mitigation options should be finalised prior to assessment against any of the codes or zones under the relevant planning scheme.

[36] CofA 2013

6.5.6 Tasmanian *Forest Practices Act 1985* and associated *Forest Practices Regulations 2017*

The Act provides the following definition of the concept of "clearing": *clearing of trees* means the removal of trees by – (a) clearing, cutting, pushing or otherwise removing; or (b) destroying the trees in any way. The Act provides the following definition of the concept of "trees": *trees* means – (a) any woody plants with a height or potential height of 5 metres or more, whether or not living, dead, standing or fallen, that are – (i) native to Tasmania; or (ii) introduced into Tasmania and used for the processing or harvesting of timber; and (b) tree ferns [where *tree fern* means a plant of the species *Dicksonia antarctica*].

Within the survey area, the vegetation is mapped as agricultural and urban areas. As such, it's unlikely the trees within this area are native and are more likely planted. As such, it is considered unlikely that a Forest Practices Plan (FPP) is required.

7. Recommendations

7.1 Further Assessments

As discussed in section 6.2 and 6.3.3, a natural values survey by a suitably qualified ecologist is recommended to map and record the baseline ecological values within the survey area. The aim of the proposed survey will be to:

- Ground truth the results of the desktop assessment
- Identify and record the local vegetation communities according to the TASVEG 4.0[1] descriptions
- Identify evidence of any conservation significant flora, fauna or communities that were not detected during the desktop assessment
- Identify any present threatened flora species with a specific focus on those flora species identified in section 6.2
- Identify any present threatened fauna species and/or their habitat with a particular focus on *P. pagenstecheri* (tussock skink)
- Identify any key threatening processes within the survey area, including but not limited to the presence of weeds and invasive fauna species.
- Assess the impacts of the implementation of the proposed flood mitigation measures on any present significant natural values
- Identify any potential additional relevant legislative approvals related to the implementation of the proposed flood mitigation measures

Field survey methods should be developed in accordance with the NRE *Guidelines for Natural Values Surveys - Terrestrial Development Proposals*[37]. Flora surveys should ideally be conducted during the spring/early summer flowering period for most Tasmanian flora species as this will increase the likelihood of positive identifications. Some species may be identified without reproductive material (flowers/seeds), however, conducting surveys during the optimal flowering period will increase the likelihood of observing all present species, including those annual species (e.g. those which only occur ephemerally). Where baseline flora surveys identify the likely presence of potential threatened flora species, or some flora species are unable to be identified in the field, additional targeted flora surveys may be required.

Fauna survey methods should be developed to target the relevant species, including the tussock skink. Baseline surveys should aim to identify and assess any potentially suitable habitat for the tussock skink. Where suitable habitat is identified, targeted surveys may be required including pitfall trapping and use of temporary artificial habitat (e.g. tiles placed amongst tussock grass) to identify the presence/absence of any individuals within the habitat.

[37] NCH 2021

7.2 Finalise Project Footprint

Once the preferred flood mitigation option has been selected, the final project footprint should be determined. The project footprint should aim to avoid or minimise impacts to any ecological values as identified during the desktop assessment and any field surveys conducted over the area. The following recommendations should be incorporated to the design:

– Development should be directed to degraded areas (e.g. where exotic species dominate the vegetation composition, where there are no suitable habitat features e.g. logs, rock piles)
– Any remnant native vegetation potentially providing habitat for threatened flora and fauna species, and impacts to these habitats should be avoided
– Utilise current tracks for routing access road(s)
– Similarly, project design should make sure that drainage and vegetation is not altered to the detriment of any local flora and fauna species

All of the above avoidance measures should be informed by the survey activities proposed under section 7.1.

7.3 Additional Documentation

As per section 6.4, a WHMP should be developed to control and manage any populations of declared and un-declared weeds within and in close proximity to the survey, including the willow removal a discussed under section 6.4.1. All weed management activities should be informed by the survey activities proposed under section 7.1.

Woody weed removal should be guided by the development sediment and erosion control measures with the aim to limit the risk of impacts to freshwater habitat on the River Clyde. Sediment and erosion control measures to limit the risk of impacts to freshwater habitat may include:

– Location and amount of ground disturbance (see Ground Disturbance, Retain Vegetation)
– Initial and final contours
– Location of watercourses and surface drainage
– Location of roads, drains, buildings and other public and private assets
– Location of significant natural values (e.g. environmental values listed under the *Threatened Species Protection Act 1995* or *Nature Conservation Act 2002*)
– A table identifying the likely potential sources of sediment and their potential impact, risk level and the proposed mitigation measure
– Location of all proposed temporary drainage control measures (temporary drainage control measures)
– Location of vegetation to be retained and removed, including within the area to be inundated
– Location of material stockpiles
– Location and details of all proposed erosion control measures. (e.g. erosion control mats and blankets, drainage control measures, retain vegetation, revegetation and limit ground disturbance, dust control)
– Location and details of all proposed sediment control measures. (e.g. sediment fences & fibre rolls, erosion control mats and blankets, sediment basins and instream sediment control techniques)
– A statement of who is responsible for establishing and maintaining all erosion and sediment control measures
– The installation and un-installation sequence of the different sediment and erosion controls
– The maintenance program of the sediment and erosion controls
– Where required, revegetation of disturbed areas to establish a mix of native understory species including reeds, sedges, shrubs and trees

7.3.1 Significant Impact Test

As per section 6.5.2, where field surveys indicate any MNES are likely to be present, the proponent should conduct a self-assessment in accordance with the *Guidelines.* The self-assessment will assess the project against the ‘significant impact criteria’ to determine if a significant impact is likely and the project requires referral. It should

be noted that a self-assessment is only required where MNES (or habitat for a specific MNES) are identified and have the potential to be impacted.

7.4 Permits and Approvals

Once the final project options and subsequent footprint is confirmed, the likely impacts to listed flora, fauna and vegetation communities should be confirmed to inform the need for any relevant permits and approvals.

Where any threatened flora have the potential to be impacted as a result of the roadworks, a permit to take under the *Threatened Species Protection Act 1995* may be required. Additionally, a permit may be required where any products of wildlife (e.g. burrows, nests, dens) are proposed to be removed as part of the works.

Where a self-assessment determine impacts to MNES are likely, a referral to Commonwealth Minister and DCCEEW will be required. If the Minister decides the action is likely to have a significant impact on a MNES, then the project is a 'controlled action' and will require approval under the EPBC Act. However, should the Minister determine the action unlikely to have a significant impact on any MNES, the project is not a 'controlled action' and will not require approval under the EPBC Act.

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Appendices

Appendix A

Maps & Figures

Appendix B

NVA Report

Appendix C

PMST Report

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The Power of Commitment