Data Collation Report

Teesdale Flood Risk Identification Study

Golden Plains Shire

16 May 2023

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Project Details

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Cover Image: Native Hut Creek at Stones Road/Tolson Road

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GLOSSARY OF TERMS

Annual Exceedance Probability (AEP)	Refers to the probability or risk of a flood of a given size occurring or being exceeded in any given year. A 90% AEP flood has a high probability of occurring or being exceeded; it would occur quite often and would be relatively small. A 1% AEP flood has a low probability of occurrence or being exceeded; it would be fairly rare but it would be of extreme magnitude.
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level. Introduced in 1971 to eventually supersede all earlier datums.
Average Recurrence Interval (ARI)	Refers to the average time interval between a given flood magnitude occurring or being exceeded. A 10 year ARI flood is expected to be exceeded on average once every 10 years. A 100 year ARI flood is expected to be exceeded on average once every 100 years. The AEP is the ARI expressed as a percentage.
Cadastre, cadastral base	Information in map or digital form showing the extent and usage of land, including streets, lot boundaries, water courses etc.
Catchment	The area draining to a site. It always relates to a particular location and may include the catchments of tributary streams as well as the main stream.
Design flood	A design flood is a probabilistic or statistical estimate, being generally based on some form of probability analysis of flood or rainfall data. An average recurrence interval or exceedance probability is attributed to the estimate.
Discharge	The rate of flow of water measured in terms of volume over time. It is to be distinguished from the speed or velocity of flow, which is a measure of how fast the water is moving rather than how much is moving.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from elevated sea levels and/or waves overtopping coastline defences.
Flood frequency analysis	A statistical analysis of observed flood magnitudes to determine the probability of a given flood magnitude.
Flood hazard	Potential risk to life and limb caused by flooding. Flood hazard combines the flood depth and velocity.
Floodplain	Area of land which is subject to inundation by floods up to the probable maximum flood event, i.e. flood prone land.

Flood storages	Those parts of the floodplain that are important for the temporary storage, of floodwaters during the passage of a flood.
Geographical information systems (GIS)	A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.
Hydraulics	The term given to the study of water flow in a river, channel or pipe, in particular, the evaluation of flow parameters such as stage and velocity.
Hydrograph	A graph that shows how the discharge changes with time at any particular location.
Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.
Intensity frequency duration (IFD) analysis	Statistical analysis of rainfall, describing the rainfall intensity (mm/hr), frequency (probability measured by the AEP), duration (hrs). This analysis is used to generate design rainfall estimates.
LiDAR	Spot land surface heights collected via aerial light detection and ranging (LiDAR) survey. The spot heights are converted to a gridded digital elevation model dataset for use in modelling and mapping.
Peak flow	The maximum discharge occurring during a flood event.
Probability	A statistical measure of the expected frequency or occurrence of flooding. For a fuller explanation see Average Recurrence Interval.
Probable Maximum Flood	The flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in a particular drainage area.
RORB	A hydrological modelling tool used in this study to calculate the runoff generated from historic and design rainfall events.
Runoff	The amount of rainfall that actually ends up as stream or pipe flow, also known as rainfall excess.
Stage	Equivalent to 'water level'. Both are measured with reference to a specified datum.
Stage hydrograph	A graph that shows how the water level changes with time. It must be referenced to a particular location and datum.
Topography	A surface which defines the ground level of a chosen area.

1 INTRODUCTION

1.1 Overview

Water Technology has been commissioned by Golden Plains Shire Council (Council) to undertake the Teesdale Flood Risk Identification Study. The investigation area covers the Native Hut Creek and tributaries in the township of Teesdale, as shown in Figure 1-1. Teesdale is identified as a Priority Flood Risk Area in the Corangamite Catchment Management Authority (CCMA) Regional Floodplain Management Strategy (CCMA, 2018), which identifies both riverine and flash flood risks for the town and states that "*flooding associated with Native Hut Creek has damaged several residential properties*".

Previous flood investigations covering Teesdale include CCMA investigations undertaken in 2008 and 2019. The 2008 study utilised RORB hydrologic modelling and HEC-RAS one-dimensional hydraulic modelling, while the 2019 study utilised HEC-RAS two-dimensional hydraulic modelling. A regional flood study of the Barwon River catchment which covers the study area was also completed in 2016 (GHD, 2016).

The CCMA modelling completed in 2019 indicates that the current flood mapping which is the basis for the Floodway Overlay (FO) and Land Subject to Inundation Overlay (LSIO) in the Golden Plains Planning Scheme understates the flood hazard in Teesdale. The Flood Risk Identification Study is being carried out to ensure that the planning scheme mapping accurately reflects flood hazard to ensure that growth in Teesdale is managed appropriately into the future. As such, updated flood mapping suitable for inclusion in the Golden Plains Planning Scheme is a key output required from the study.

In addition, the study will produce flood intelligence information for use in emergency management situations, assess the current flood impact/exposure in terms of annual average damages caused by flooding in Teesdale, investigate structural and non-structural mitigation options to reduce damages, investigate and make recommendations for establishing a flood warning system for the town.

This report is one of a series documenting the outcomes of the Teesdale Flood Risk Identification Study. Each reporting stage is shown below:

- **R01 - Data Review and Validation - This Report**
- R02 – Joint Calibration Modelling Report
- R03 – Design Hydrology and Hydraulic Modelling Report
- R04 – Flood Intelligence and Flood Warning Report
- R05 – Flood Damages and Mitigation Assessment Report
- R06 – MFEP Documentation
- R07 – Final Summary Report

The data required for this study has been collated and reviewed. This report documents a summary of the available streamflow, rainfall and topographic data as well as the relevant previous projects and other information relevant to the study. The report also details verification of the available topographic datasets and details the hydrological and hydraulic modelling approach.

Following appointment and project inception, Water Technology engaged surveyors to capture structure details, waterway cross sections and ground levels for the purpose of LiDAR data verification as detailed in the project brief. The data captured is discussed in this report.

1.2 Objectives and Outputs

The Teesdale Flood Risk Identification Study outputs are required to meet several floodplain management objectives as highlighted in the project brief prepared by Golden Plains Shire and Corangamite CMA. The objectives of the investigation are described below:

- Provision of detailed flood mapping for a range of flooding scenarios across the study area.

Collate and review all available data and, through rigorous analysis, determine robust flood levels velocities, depths and extents.

- Update flood data for the township using current best practice modelling techniques and technology.

Produce robust flood mapping and associated documentation for inclusion in the Golden Plains Planning Scheme.

- Support the implementation of the Teesdale Structure Plan.

Update the Municipal Flood Emergency Plan.

1.3 Study Area

Teesdale is located approximately 8.5 km north of Inverleigh and is situated on the banks of Native Hut Creek. The Native Hut Creek catchment begins approximately 22.5 km north of Teesdale near the town of Meredith. The creek meanders south across agricultural land, the vast majority of which has been historically cleared of large vegetation in line with its use as farmland.

The catchment within and upstream of the study area is mostly cleared agricultural land and the main waterway (Native Hut Creek) has several onstream dams of varying size along its alignment. The Native Hut Creek catchment draining to Teesdale is approximately 110 km^2. The entire catchment is located within the Golden Plains municipal area. The study area is focussed on the township of Teesdale and includes the following waterway structures:

- Two large on-stream dams approximately 3km upstream of the township.
  - An indicative assessment of the impact of the upstream dams was completed in R01 – Data Collation and Validation.
- Road crossings, formal or informal, at the following roads:
  - Tolson Road/Stones Road

  Sutherland Street

  - Bannockburn-Shelford Road

  Barkers Road

- Several off-stream dams throughout the town.

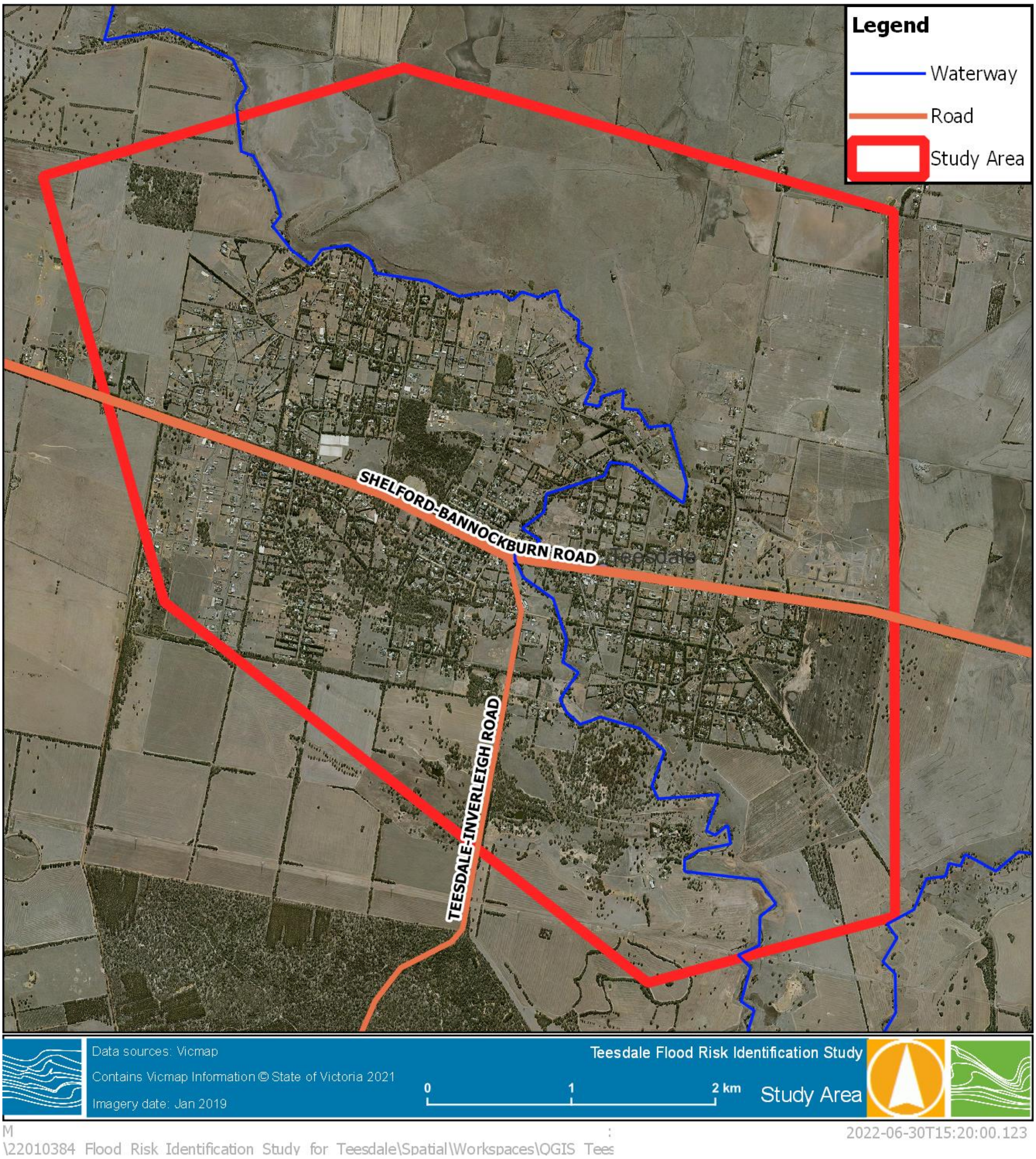


Figure 1-1 Teesdale Flood Risk Identification Study - Study Area

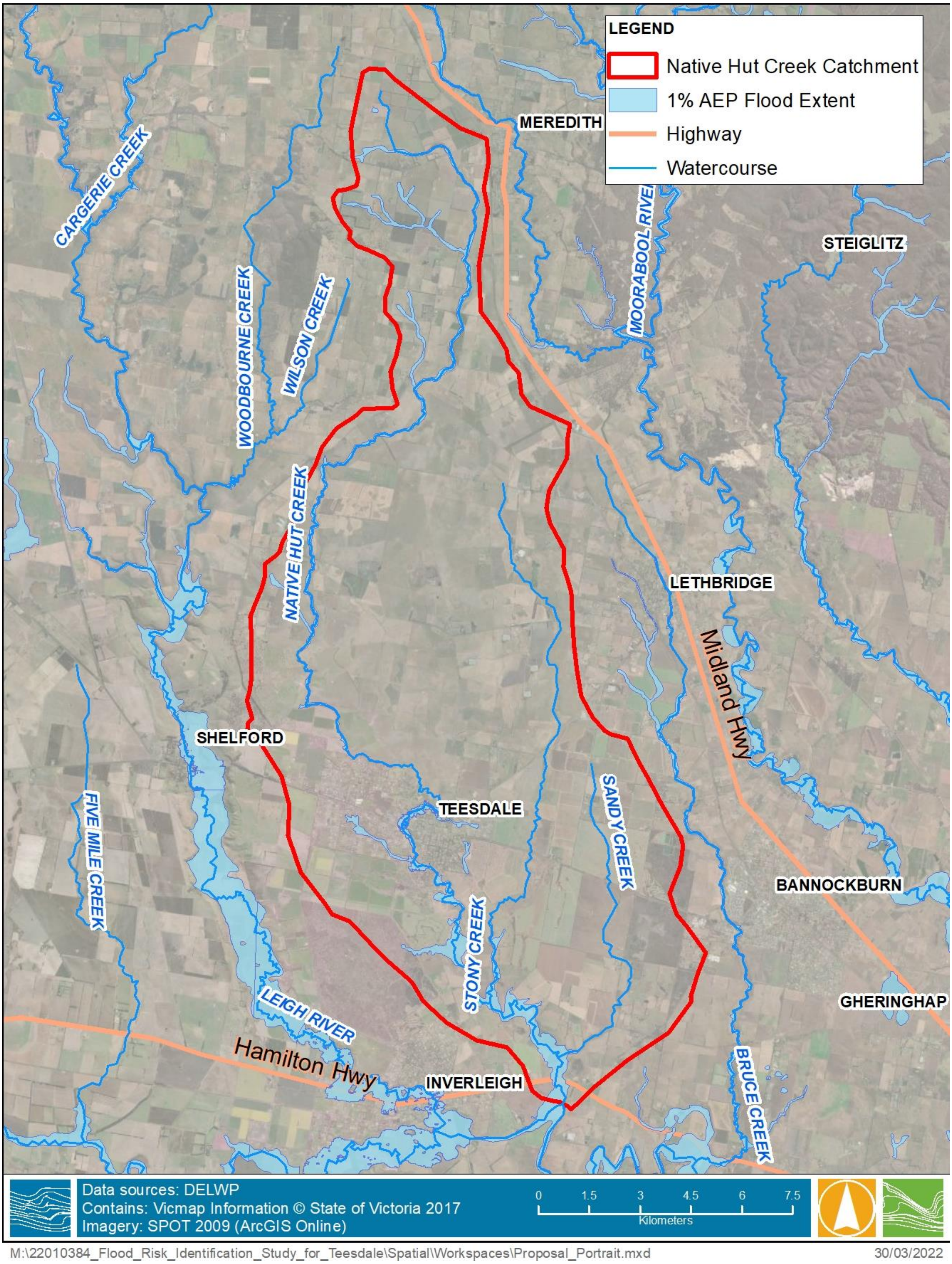


Figure 1-2 Native Hut Creek Catchment

2 DATA SUMMARY

2.1 Previous Studies

The following studies which produced flooding information for Native Hut Creek at Teesdale have been identified as part of the data collation and review:

- Victorian Flood Data Transfer Project (2001)

CCMA Hydrologic and Hydraulic Assessment (2008)

- Regional Flood Mapping – Barwon River, Thompson Creek and Woady Yaloak Creek (2016)

CCMA Updated Hydrologic and Hydraulic Assessment (2019)

A synopsis of each study is given below.

Victorian Flood Data Transfer Project (2001)

The Victorian Flood Data Transfer Project's Golden Plains Shire report was finalised and published in February 2001. The Project's main goal was to produce a *"high quality, consistent and comprehensive Geographic Information System (GIS) layer and hardcopy map products showing a range of flood data for urban and rural floodplains in Victoria"* (Sinclair Knight Merz, 2001). The project produced this data by reviewing available flood data, with no modelling being undertaken for most areas across the municipality including Teesdale. The Golden Plains Shire report states that an 'interpreted' flood extent was available for the Teesdale area in addition to topographic and geologic maps. It is assumed that this interpreted flood extent came from the former State Rivers and Rural Water Commission (SRRWC).

CCMA Hydrologic and Hydraulic Assessment (2008)

The Victorian Flood Data Transfer Project flood extent for Teesdale was superseded by a flood study of Native Hut Creek completed by CCMA in 2008. The CCMA report states that the Victorian Flood Data Transfer Project information is "*known to be inaccurate through Teesdale"* (CCMA, 2008). The CCMA work utilised a RORB hydrological model and HEC-RAS one-dimensional hydraulic model to estimate 1% AEP flood behaviour throughout Teesdale.

Floodplain inundation mapping produced from the HEC-RAS model outputs forms the current flood related overlay mapping in the Golden Plains Planning Scheme.

Regional Flood Mapping – Barwon River, Thompson Creek and Woady Yaloak Creek (2016)

GHD were engaged to undertake the Regional Flood Mapping project by the Department of Environment and Primary Industries (DEPI), now the Department of Environment, Land, Water and Planning (DELWP). The study was delivered in 2016 and utilised RORB hydrological mapping and TUFLOW GPU hydraulic modelling to produce floodplain mapping of the Barwon River catchment, totalling around 3,700 km^2 of catchment area. The modelling was undertaken prior to the release of TUFLOW HPC (Highly Parallelised Compute), which offered significant solver improvements including an upgrade in spatial accuracy from 1st order to 2nd order, and 1D-2D linking capabilities. The study had a number of limitations due to its large spatial coverage, and thus the information and findings produced by the study are subject to a number of qualifications including *"Due to its extensive coverage and consequent low reliability this data is not generally suitable for providing… specific information based on related to flood levels, extents or velocities."*

CCMA Updated Hydrologic and Hydraulic assessment (2019)

In 2019, an updated assessment of flooding in Native Hut Creek was undertaken by Tony Jones of CCMA. The assessment updated the RORB hydrologic modelling, taking advantage of new topographical information and GIS capabilities to better delineate the subareas and reaches of the model. The hydrologic assessment utilised the recommended rainfall Intensity Frequency Duration data and temporal patterns from Australian Rainfall and Runoff 1987.

Flows from the updated hydrologic model were input to a newly developed two-dimensional HEC-RAS hydraulic model of Native Hut Creek and its floodplain. The hydraulic model adopted a uniform Mannings roughness of 0.06 across the creek and floodplain with the exception of the Bannockburn-Shelford Road bridge, which was modelled with a higher roughness of 0.08 to account for the restriction of flows through the structure. Being a two-dimensional hydraulic model, outputs include gridded depth, velocity, water level and the product of depth and velocity.

The two dimensional HEC-RAS model outputs are understood to be the currently adopted "best available information" for flooding in Native Hut Creek through Teesdale and are utilised in assessments of planning referrals and floodplain advice responded to by the Corangamite CMA.

A summary of related studies completed in the Teesdale and Native Hut Creek region are summarised in Table 2-1.

Table 2-1 Flood related studies completed in Teesdale and Native Hut Creek Region

Related Studies	Author	Year
Victorian Flood Data Transfer Project (2001)	DNRE/SKM	2001
Hydrologic and Hydraulic assessment (2008)	CCMA	2008
Regional Flood Mapping – Barwon River, Thompson Creek and Woady Yaloak Creek	GHD	2016
Updated Hydrologic and Hydraulic assessment (2019)	CCMA	2019

2.2 Flood Information

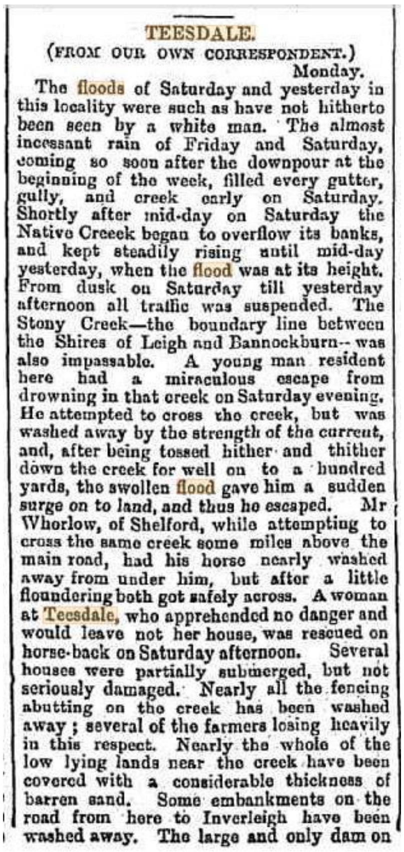
2.2.1 Historical Flood Records

There is no streamflow data available for Native Hut Creek. The 2011, 1995 and 1973 flood events were assessed in the 2016 GHD Regional Study however the assessment of these events was not specific to the Native Hut Creek catchment. These events along with other anecdotal evidence gathered from an initial community consultation meeting form the basis of the known historic flooding in Teesdale.

Table 2-2 Historical floods (descriptions as per community anecdotes)

Year	Description of Flooding	Data Available
February 1973	Widespread flooding in the Native Hut Creek and Leigh River, with flooding reported at Inverleigh and Teesdale.	Photographs and descriptions of flooding in Native Hut Creek provided during community consultation session.
November 1995	Significant flooding within the Barwon River catchment (including Barwon River at Inverleigh)	No information available. Understood to not have impacted road closures or houses in Teesdale.
April 2001	Flooding said to overtop the Bannockburn-Shelford Road.	Anecdotal data only available at this stage.
January 2011	Significant flooding on Leigh River including Leigh River at Shelford and Inverleigh.	Minimal information available. Understood to not have impacted road closures or houses in Teesdale. Photos showing flooding remained in channel through Teesdale

In addition to the above events, initial investigations have identified September 1880 as being a flood event which inundated houses in town (see right).


TEESDALE.
(FROM OUR OWN CORRESPONDENT.)
Monday.

The floods of Saturday and yesterday in this locality were such as have not hitherto been seen by a white man. The almost incessant rain of Friday and Saturday, coming so soon after the downpour at the beginning of the week, filled every gutter, gully, and creek early on Saturday. Shortly after mid-day on Saturday the Native Creeck began to overflow its banks, and kept steadily rising until mid-day yesterday, when the flood was at its height. From dusk on Saturday till yesterday afternoon all traffic was suspended. The Stony Creek—the boundary line between the Shires of Leigh and Bannockburn-- was also impassable. A young man resident here had a miraculous escape from drowning in that creek on Saturday evening. He attempted to cross the creek, but was washed away by the strength of the current, and, after being tossed hither and thither down the creek for well on to a hundred yards, the swollen flood gave him a sudden surge on to land, and thus he escaped. Mr Whorlow, of Shelford, while attempting to cross the same creek some miles above the main road, had his horse nearly washed away from under him, but after a little floundering both got safely across. A woman at Teesdale, who apprehended no danger and would leave not her house, was rescued on horse-back on Saturday afternoon. Several houses were partially submerged, but not seriously damaged. Nearly all the fencing abutting on the creek has been washed away; several of the farmers losing heavily in this respect. Nearly the whole of the low lying lands near the creek have been covered with a considerable thickness of barren sand. Some embankments on the road from here to Inverleigh have been washed away. The large and only dam on

2.3 Storages

There are no formal storages within the Native Creek catchment, with any storages limited to farm dams. Two reasonably large dams are located on-line, i.e. the entire Native Hut Creek catchment flows through the dams, approximately 7-7.5km upstream of Teesdale. These farm dams have not been included in the previous CCMA RORB models.

It is understood the storages are privately owned and operated, and thus are unlikely to be operated for flood mitigation purposes. As such, design events will consider the storages to be full at the start of the event.

Notwithstanding the above, the potential impact of the storages on flood behaviour will be investigated as discussed in Section 4.2.3.

The location of the two farm dams is shown in Figure 2-1 and Figure 2-2.

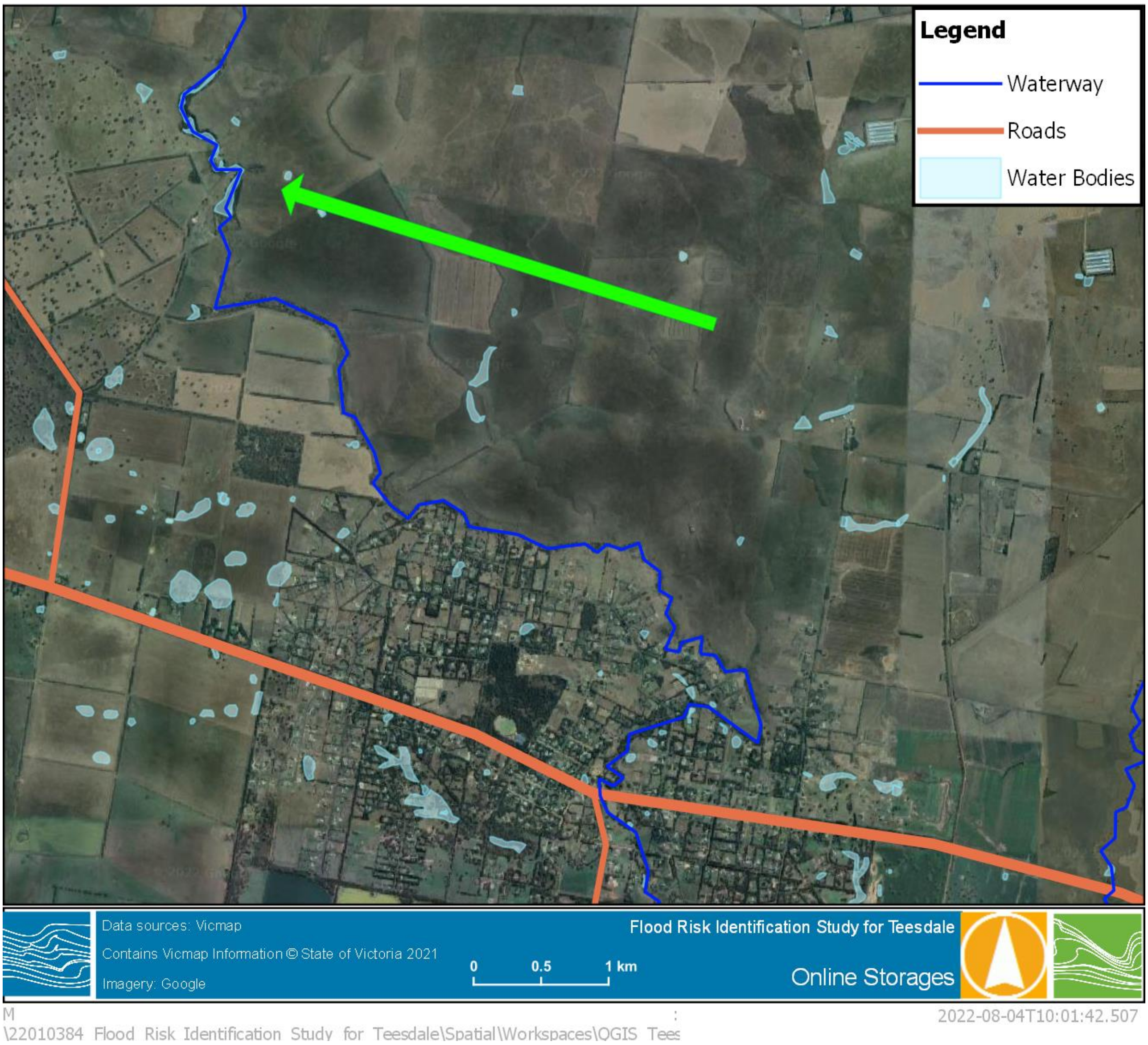


Figure 2-1 Online storages – far view

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Figure 2-2 Online Storages – close view

2.4 Streamflow Data

No streamflow data is available for Native Hut Creek. As identified in Section 2.2, the identification of key flood events is limited to adjacent waterways in the broader catchment. This relies on previous studies including the 2016 Regional Study and the 2018 Inverleigh Flood Study. Streamflow gauges from nearby waterways which may be used to identify broader catchment (Barwon River) flooding are shown in Table 2-3.

Table 2-3 Summary of available streamflow gauges

Station Name	Station No.	Status	Data Type	Period of record available
Leigh River @ Shelford	233213	Active	Instantaneous Flow	1954 to present
Leigh River @ Shelford (Golf Hill)	233248	Inactive	Instantaneous Flow	1994 to 2012
Barwon River @ Pollocksford	233200	Active	Instantaneous Flow	1906 to present*

Station Name	Station No.	Status	Data Type	Period of record available
Moorabool River @ Batesford	232202	Active	Instantaneous Flow	1908 to present**

* Manual daily readings from 1906 to 1922; no records 1922-1969

** Manual daily readings prior to 1959; no records 1922-1944

2.5 Rainfall Data

2.5.1 Overview

Historic daily and sub daily rainfall data is required for the hydrologic and hydraulic model validation. Daily rainfall gauges are used to provide a representation of spatial rainfall variation while sub daily gauges provide a representation of temporal rainfall distribution from historic events.

2.5.2 Daily Rainfall

Table 2-4 summarises the daily rainfall information available within or near the Native Hut Creek catchment. Daily rainfall stations located within the catchment are generally preferred, however the gauges outside of the catchment will be utilised to provide a suitable spatial representation of both event based and average design rainfall. Figure 2-3 displays the location of the daily rainfall gauges.

Table 2-4 Daily rainfall station information

Station Name	Station No.	Start	End
Bannockburn	87009	1898	Current
Meredith	87042	1887	Current
Meredith (Darra)	87043	1875	Current
Meredith (Wattle Vale)	87044	1905	1971
Shelford	87059	1887	2009
Teesdale	87092	1883	1914
Teesdale	87120	1968	1979
Lethbridge (Glenmoor)	87123	1968	2006
Shelford (Leigh River)	87132	1954	1982
Sheoaks*	87168	1990	Current
Inverleigh	89041	1940	1974
Leigh River @ Mount Mercer	89104	1956	Current

(*Sheoaks also provides sub-daily (6-minute) pluviography information)

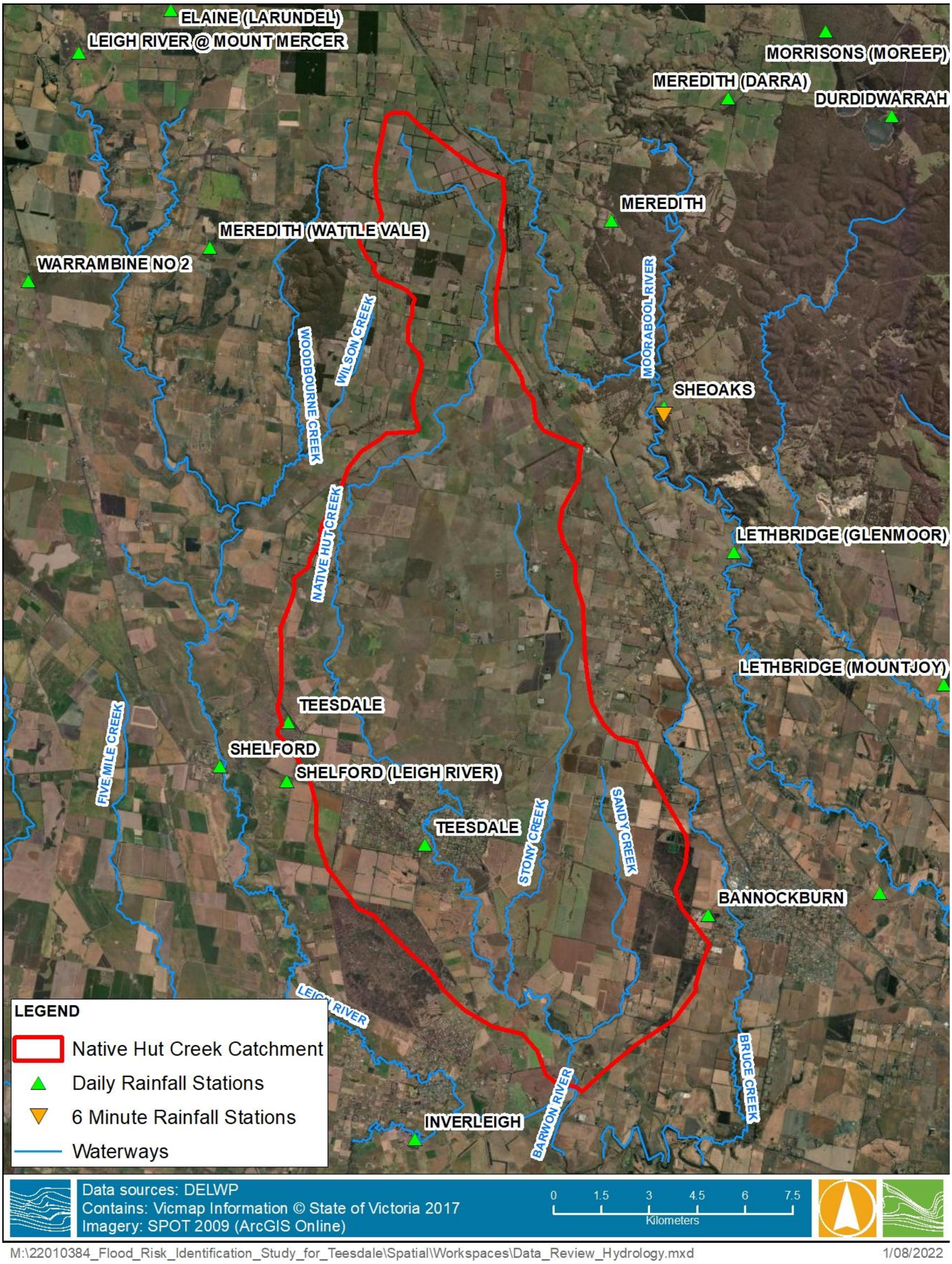

Figure 2-3 Daily Rainfall station in Native Hut Creek catchment

2.5.3 Sub-Daily Rainfall

There are no sub-daily rainfall stations within the Native Hut Creek catchment. The locations of nearby current and closed sub-daily rainfall stations are shown in Figure 2-4. The nearest sub-daily catchment is Sheoaks, approximately 14.5 km northeast of Teesdale. Multiple sub-daily stations are available to the east of the catchment in more populated areas near Geelong and Lara, while to the west of the catchment stations are available at Colac and Ballarat.

Figure 2-4 Pluviograph stations near Native Hut Creek Catchment

2.6 Road and Drainage Infrastructure

Within the project area, there are several road structures on Native Hut Creek and several minor culverts on ephemeral tributaries/drainage lines within the town. These structures are listed in Table 2-5 and are highlighted in Figure 2-5, with numbers assigned to the crossings to provide a reference between the table and location as in Figure 2-5. A site visit was carried out on 4th August 2022 and all relevant road crossings along Native Hut Creek were visited with structure measurements taken, as shown in Table 2-5. Feature survey was also undertaken at three structures to both increase the accuracy of the modelling and be used as a basis for LiDAR verification (discussed further in Section 2.7.2).

Table 2-5 Native Hut Creek and Teesdale Drainage structures

Crossing (number)	Owner	Data collected/provided	Structure description / measurements
Bannockburn-Shelford Road	VicRoads	Feature survey of structure captured as part of project	Bridge
Stones Road/Tolson Road	Golden Plains Shire	Feature survey of structure captured as part of project; design plans provided	Bridge
Barker Street	Golden Plains Shire	Feature survey of structure captured as part of project	2x box culverts
Teesdale – Inverleigh Road (1)	Golden Plains Shire	Site Visit to measure structure, invert to be set from LiDAR	600 x 600mm box culvert, bluestone construction
Jollys Road (2)	Golden Plains Shire	Site Visit to measure structure, invert to be set from LiDAR	600 x 600mm box culvert, bluestone construction
Learmonth Street (3)	Golden Plains Shire	Site Visit to measure structure, invert to be set from LiDAR	300mm RCP
Learmonth St (4)	Golden Plains Shire	Site Visit to measure structure, invert to be set from LiDAR	2x 300mm RCP
Bruce Street (5)	Golden Plains Shire	Site Visit to measure structure, invert to be set from LiDAR	300mm RCP, partially buried
Sutherland Street (6)	Golden Plains Shire	Site Visit to measure structure, invert to be set from LiDAR	Walkway through waterway, no culvert or pipe present
Teesdale – Inverleigh Road (7)	Golden Plains Shire	Site Visit to measure structure, invert to be set from LiDAR	450mmm RCP west side (Mercer Street) 375mm RCP east side (Turtle Bend path)
Teesdale – Inverleigh Road (8)	Golden Plains Shire	Site Visit to measure structure, invert to be set from LiDAR	Culvert submerged, unable to measure

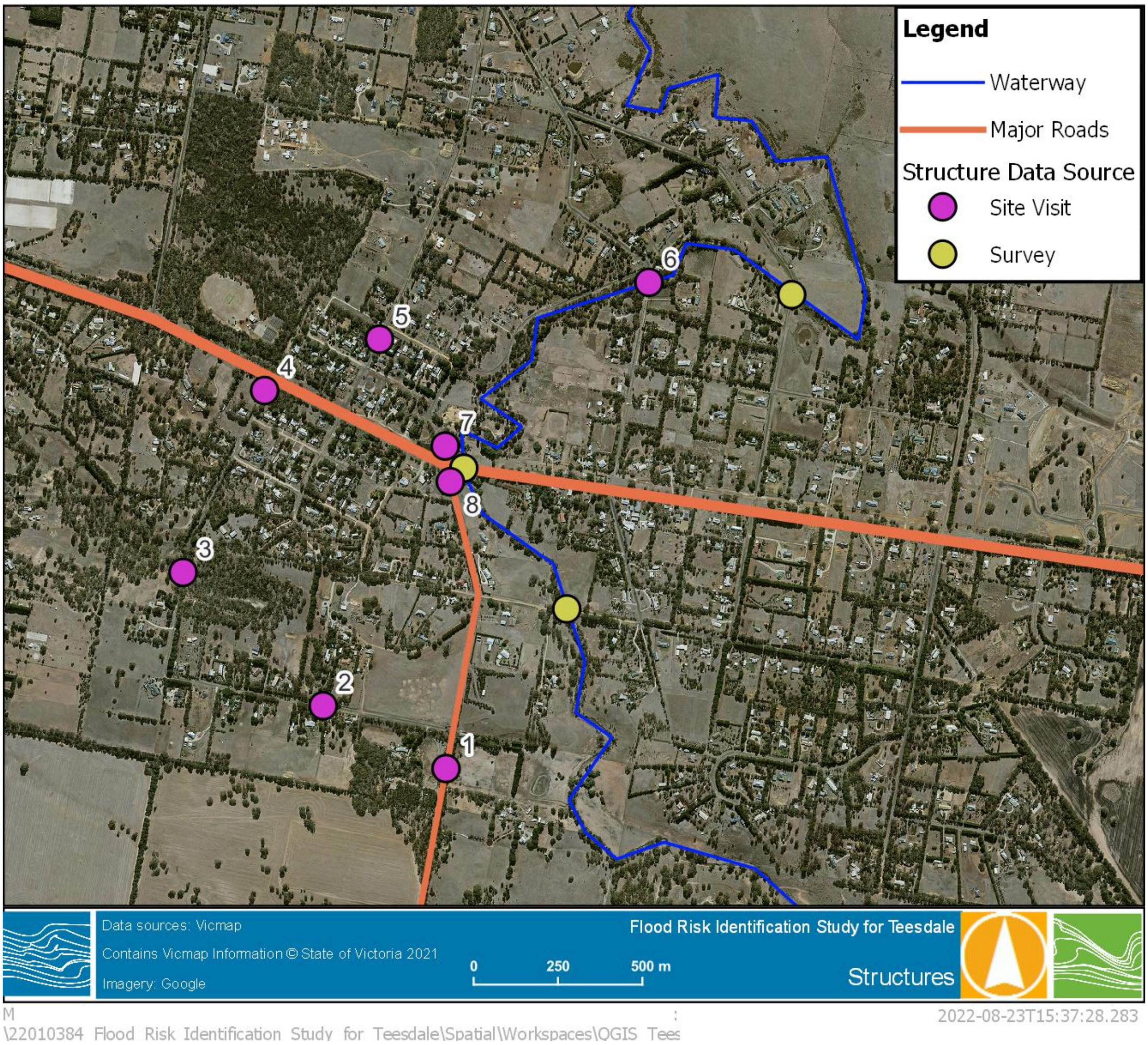

Figure 2-5 Location of key structures within model extent

2.7 Topography and Survey Data

2.7.1 LiDAR Data

An initial assessment of the spatial coverage of available LiDAR data datasets was undertaken during the data review phase. Four key datasets were available, these were as follows:

- 2021 Golden Plains LiDAR (GPS/DELWP)
  - This LiDAR was flown as part of the DELWP CIP program, the data is available as a 50cm DEM and covers the entire catchment and is the most recent data captured.
- 2014 Geelong-Anakie-Teesdale
  - This is a 1m DEM covers the south-east of the study extent and the Township of Teesdale. It overlaps with ISC LiDAR and the 2021 data.
- 2010 Index of Stream Condition (ISC) captured by Fugro

  - This is an 1m DEM covers the river systems Native Hut Creek. It has been noted through numerous studies there is generally a systematic 305mm error in this data which was found in the 2013 Skipton Flood Investigation.
- 2008 Corangamite CMA
  - This is a 5m DEM covers the study extent and broader Native Hut Creek catchment. This data was captured as part of the National Action Plan for Salinity and Water Quality.

Table 2-6 outlines the metadata information of the available LiDAR datasets used in this project. The GPS/DELWP LiDAR dataset, being the most recently captured data, is intended to be the main data source for the project as suggested in the request for quote. Before adopting the GPS/DELWP LiDAR, verification and comparison to other available datasets has been undertaken to ensure it is fit for purpose.

Table 2-6 Available Datasets

Dataset	Name	Source	Capture Date	Vertical Accuracy	Resolution
GPS/DELWP LiDAR	2021 Golden Plains LiDAR	LiDAR	2021	±0.15m	0.5m grid
CHW_LiDAR	Geelong-Anakie-Teesdale	LiDAR	2014	±0.15m	1m grid
ISC_LiDAR	2009-10 Victorian State Wide Rivers LiDAR Project – Corangamite CMA	LiDAR	2009 – 2010	±0.2m	1m grid
Corangamite_LiDAR	2007-08 South-West Region LiDAR – Corangamite	LiDAR	2006 – 2008	±0.5m	5m grid

2.7.2 LiDAR Verification

Topography data is the major source of data used in the project and was verified in order to ensure the hydraulic model can accurately replicate flood behaviour within the study area. This is critical in ensuring that model outputs, particularly peak water surface elevations, are accurate.

The capture of ground survey at three locations within the study area was commissioned to assist with verification of the available LiDAR datasets (Figure 2-6). The survey consisted of transects along the crest of roadways shown in Figure 2-6. Each transect is approximately 100 m in length with a spot height every 5 metres. The transect results compared with available LiDAR datasets are presented in Table 2-7.

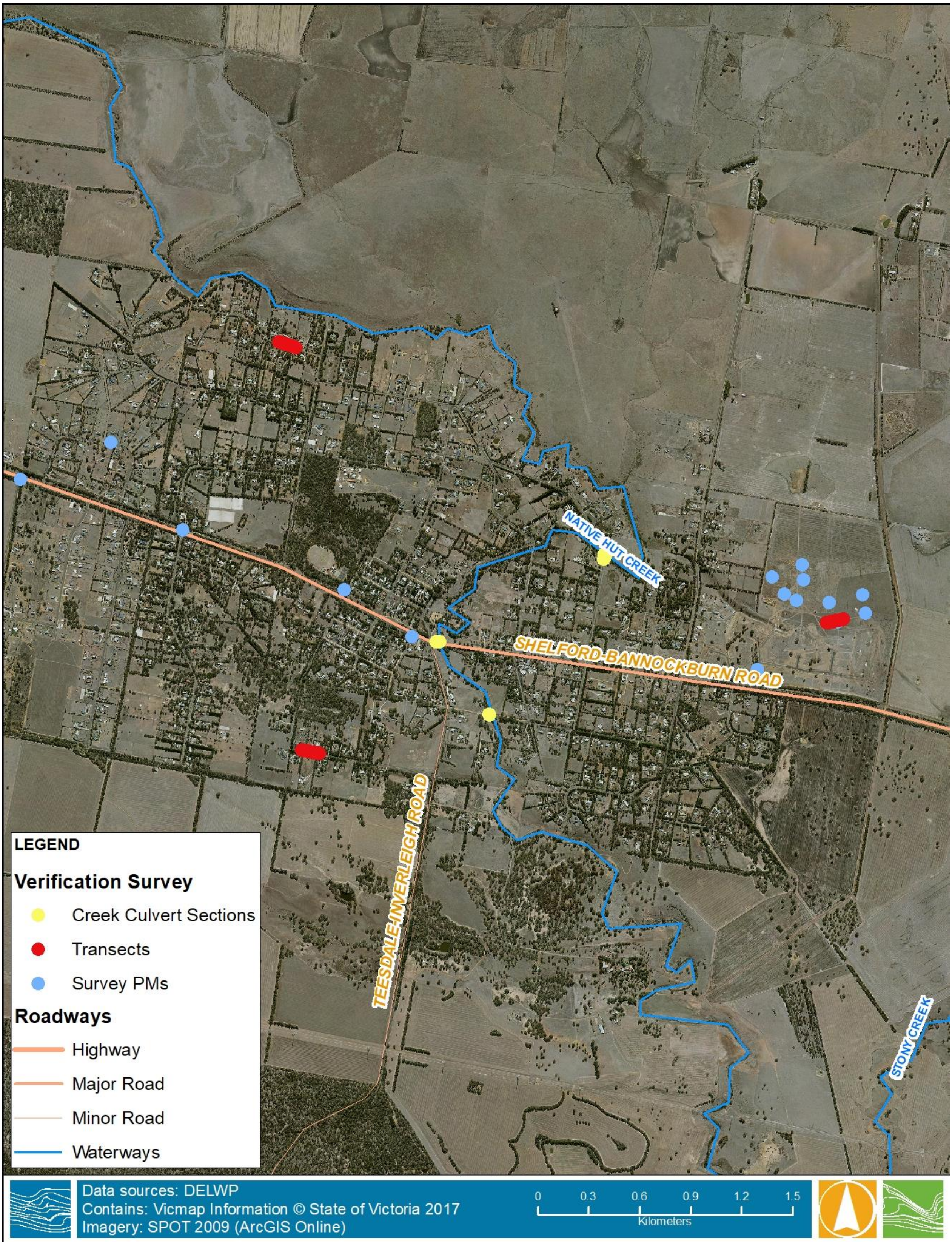

Figure 2-6 Verification Survey

The 2021 Golden Plains LiDAR was verified by comparison to surveyed road transects (captured at three road crossings). Comparison to cross section survey was completed in two ways; on a point by point basis to create a statistical distribution of the differences and as transects to get a visual comparison of the reliability of the data.

63 surveyed crest points were available across the road transects, each of the surveyed levels was compared to the level determined in the LiDAR data and the difference between the two calculated. The levels were plotted against the survey for the three transects shown in Figure 2-8 – Figure 2-10. Of the 63 points compared, 60 were within 0.05m. The average difference across the three transects is less than 2cm as shown in Figure 2-7 and Table 2-7. This shows a high degree of accuracy and indicates the LiDAR is suitable for use in the development of the Digital Elevation Model (DEM) for the hydraulic model.

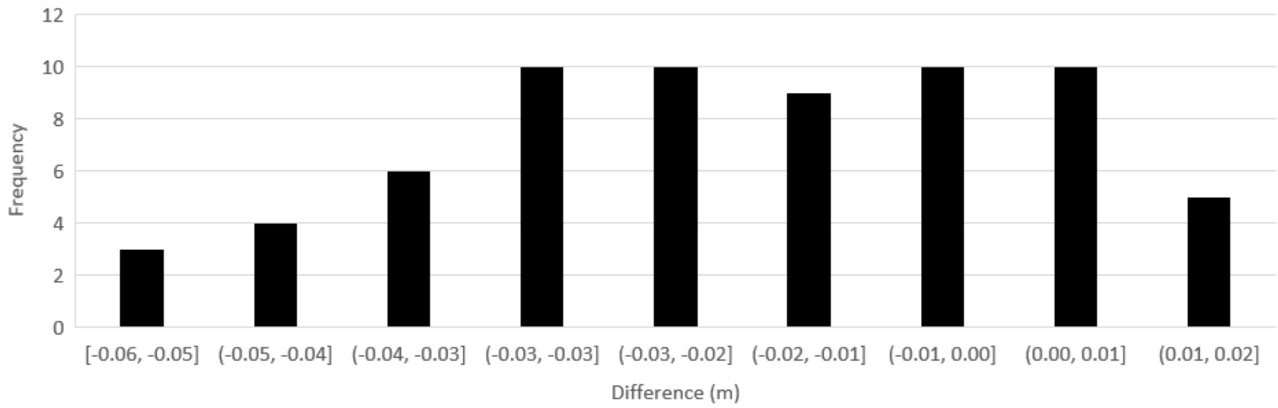

Figure 2-7 Distribution of survey and LiDAR comparison

Table 2-7 Field Survey – Road Transect LiDAR Comparison

Transect	Number of Points	Minimum Difference	Maximum Difference	Average Difference	Standard Deviation
1- River Dr, Teesdale	21	-0.055	0.010	-0.026	0.016
2- Jollys Rd, Teesdale	21	-0.058	-0.002	-0.025	0.015
3- Rocklea Rd, Teesdale	21	-0.032	0.016	-0.004	0.012
Total	63	-0.058	0.016	-0.018	0.018

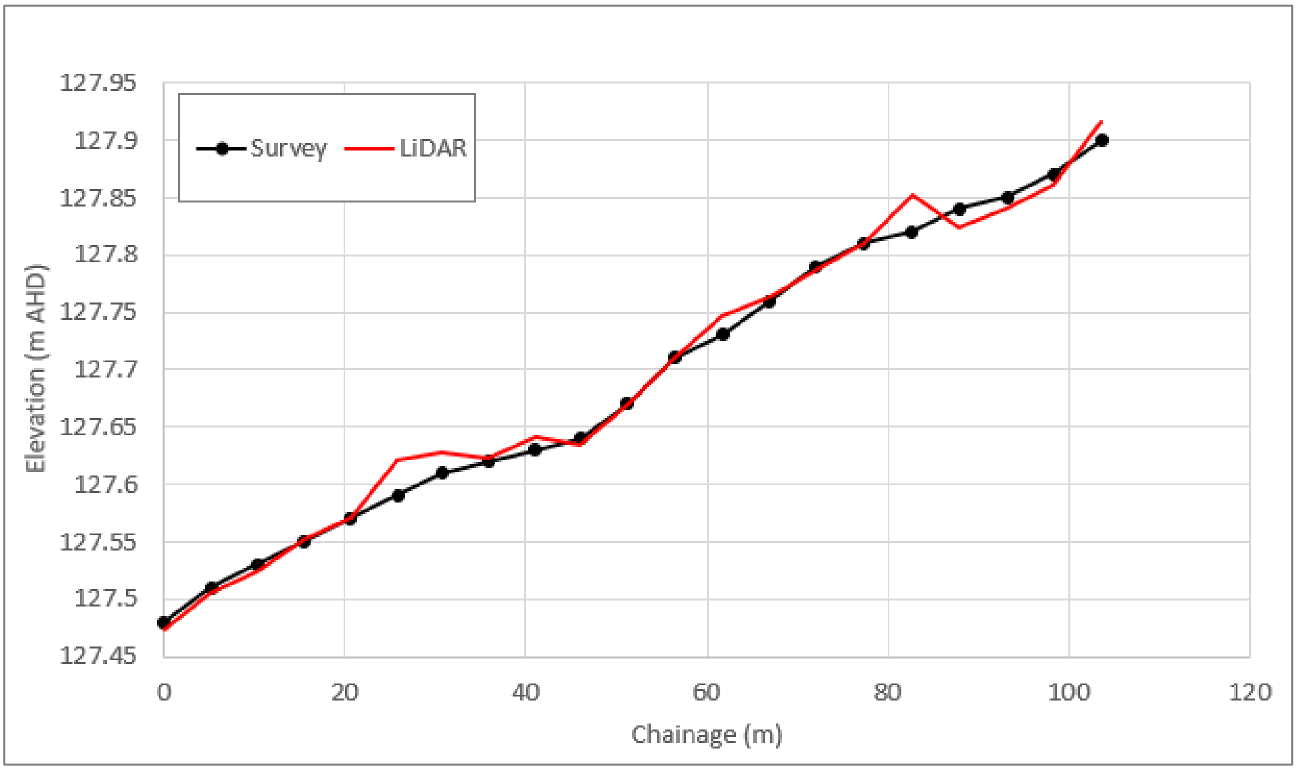

Figure 2-8 Rocklea Road – LiDAR verification

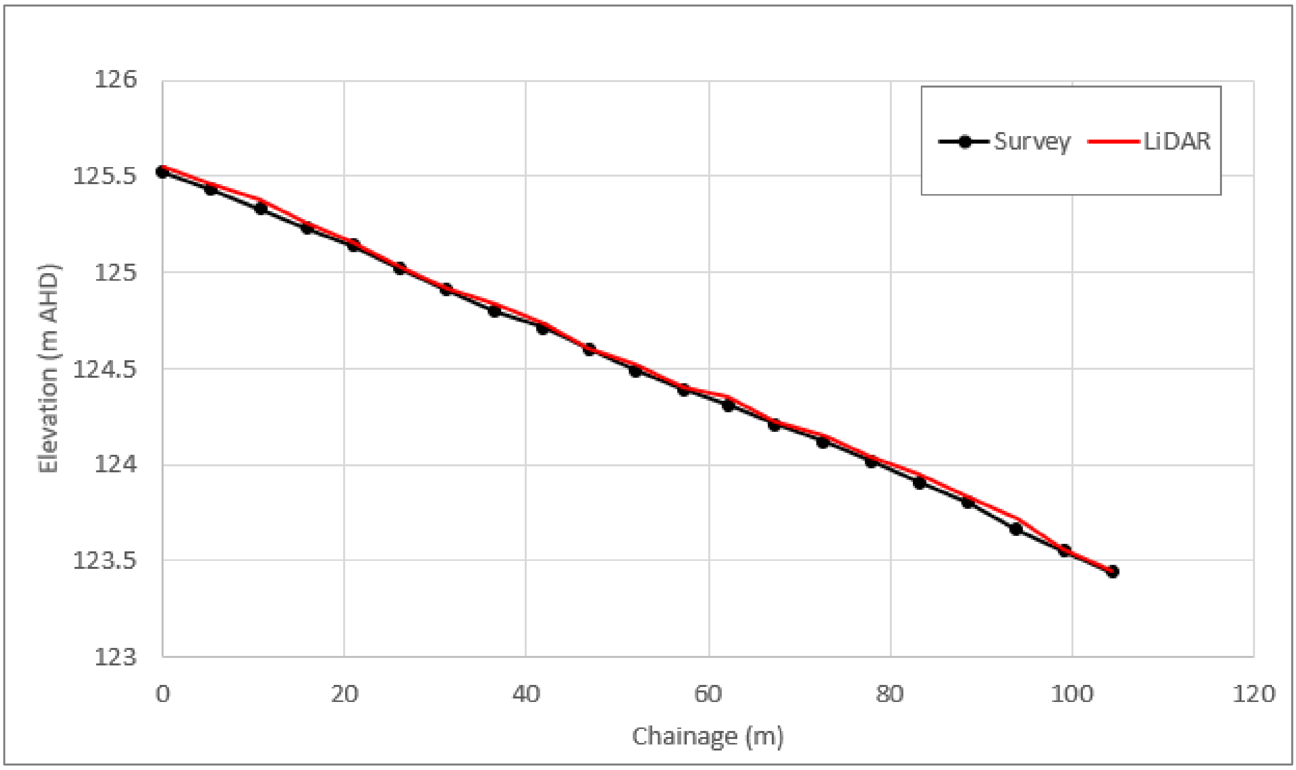

Figure 2-9 Jollys Road – LiDAR verification

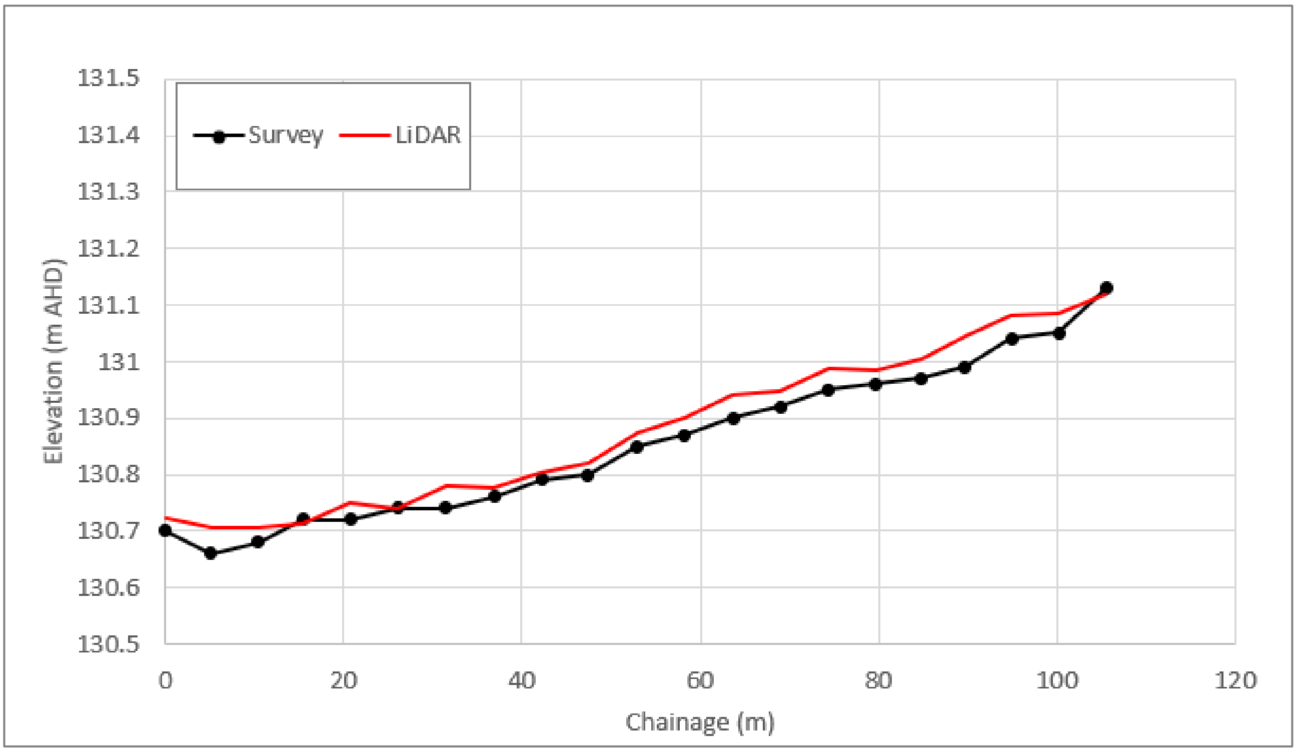

Figure 2-10 Sutherlands Road – LiDAR verification

2.7.3 LiDAR Comparison

Comparison between the 2021 Golden Plains LiDAR, the 2014 Geelong-Anakie LiDAR and the 2009-10 ISC data was made using the following calculations:

2021 Golden Plains LiDAR – 2014 Geelong-Anakie LiDAR

2021 Golden Plains LiDAR – 2009-10 Index of Stream Condition LiDAR

The result showed positive values where the 2021 LiDAR was higher and negative values where the 2014 & 2010 was higher. The comparison was made for the township of Teesdale where LiDAR was available from both required datasets, as shown in Figure 2-11 and Figure 2-12. The calculation determined a mean difference in the datasets of 0.192m between the 2021 and 2014 data and -0.081m between the 2021 and 2009/10 data.

A standout feature of the comparison between the 2021 and 2010 LiDAR is the vertical banding of errors, with the margin of error generally increasing in the easterly direction until a new 'band' begins. It is suspected, but not confirmed, that the bands are a result of data processing, with data having been collected in north/south flight paths. It is noted that the 2010 ISC LiDAR dataset has known accuracy issues, based on previous assessments of the data.

It is also noted that the 2021 LiDAR is, in general, consistently higher than the 2014 data. It was initially suspected that seasonality could be factor in this result, as the 2021 LiDAR was captured in June, when pasture is expected to be grown to a greater height than the 2014 dataset which was flown in February. While this does appear to be a factor in some locations, for example the large area northeast of the town centre, it is noted that most roads are also showing consistently higher results in the 2021 dataset. Sealed roads are not affected by seasonal vegetation growth, therefore it is concluded that seasonality is not a significant influence in the result. Given the extremely close agreement between the 2021 LiDAR and field survey observations as detailed above, a recommendation of this report is to adopt the use of the *Golden Plains 2021 LiDAR* dataset for the DEM in the hydraulic model build.

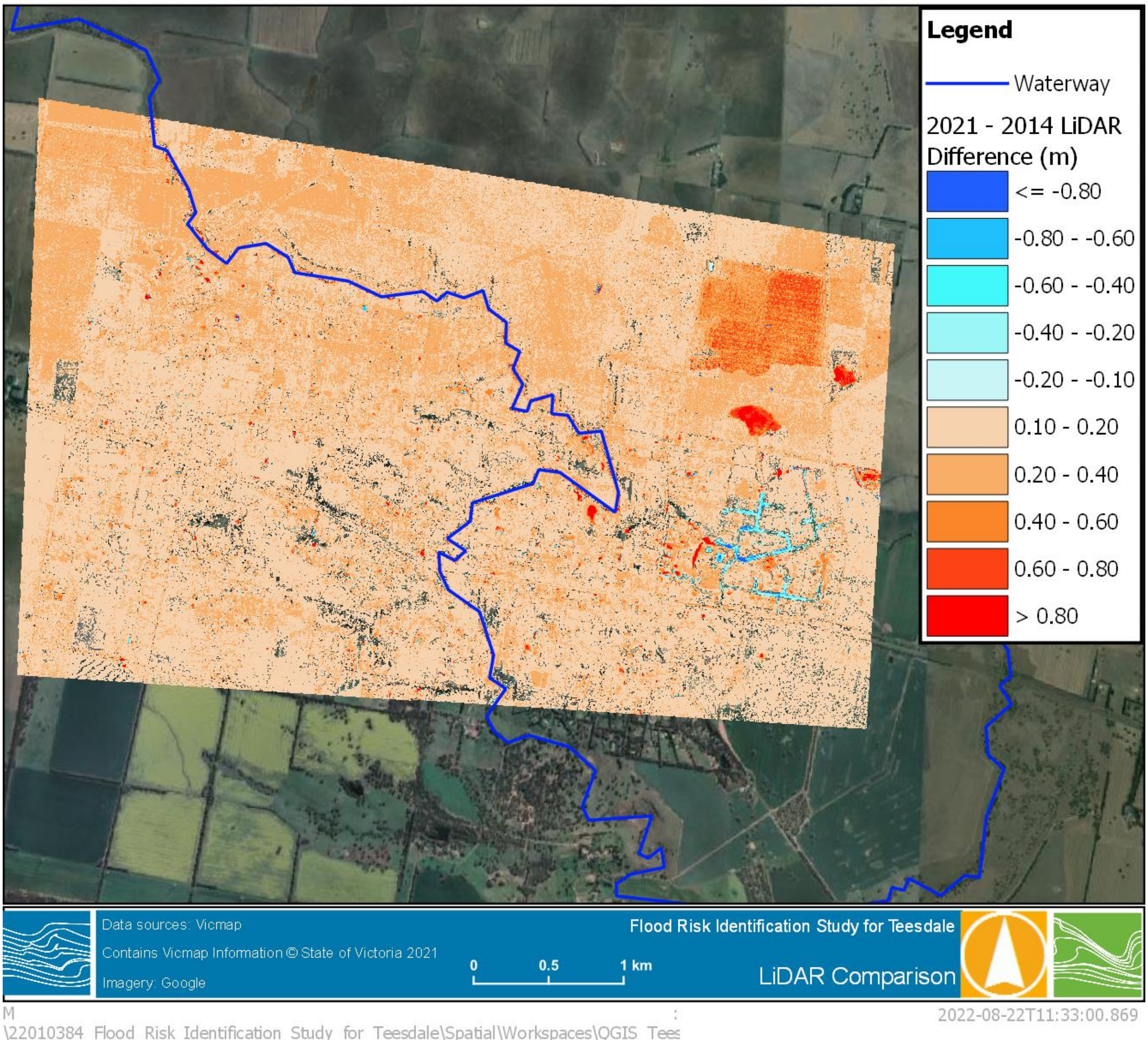

Figure 2-11 Comparison Between 2021 and 2014 LiDAR Datasets (± 0.1m not shown)

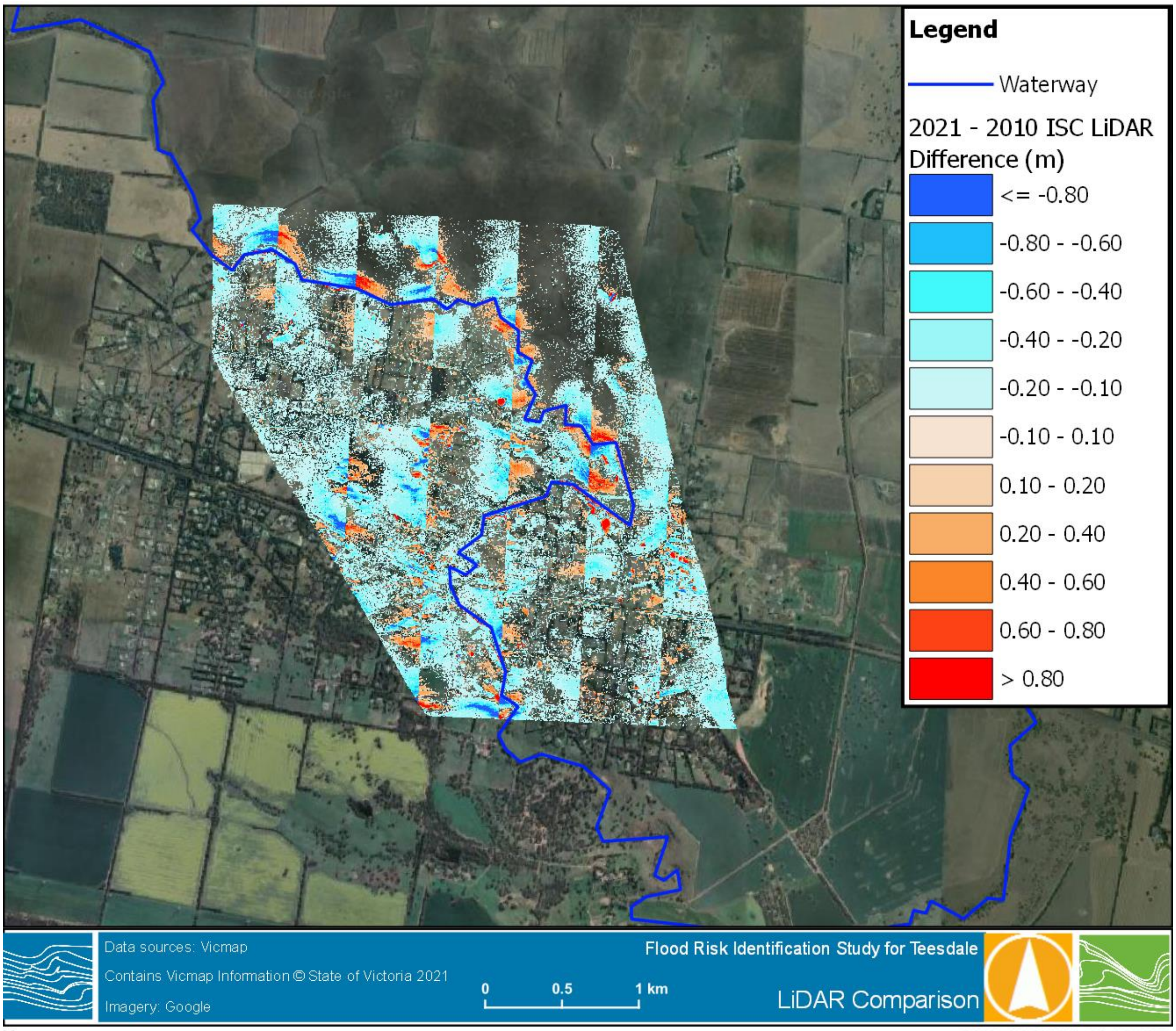

Figure 2-12 Comparison Between 2021 and 2010 LiDAR Datasets

2.7.4 Floor Level Survey

No floor level survey data was available along Native Hut Creek or within Teesdale. To determine the potential floor level survey requirements, preliminary 0.5% AEP modelling with a buffer of 250 metres will be used to highlight buildings at risk of inundation. This is to be discussed at a later stage of the project and recommendations provided in a standalone memorandum (Floor Level Survey Requirements).

2.8 Teesdale Structure Plan

The Teesdale Structure Plan was completed in 2020 and is the guiding strategy for future growth within the township. The Plan identifies a future Planning Scheme Amendment to take place upon completion of the Native Hut Creek Flood Study (i.e. this study). The plan identifies infill subdivision and the “North East Precinct” as the main sources of additional residential land within the town.

3 COMMUNITY CONSULTATION

Community consultation is a key component of any flood investigation. Meaningful consultation helps to ensure that local knowledge is captured and feeds into the study, which is immeasurably valuable in an area such as Teesdale where no formal flood data such as gauged stream levels or recorded flood heights exists.

The first community consultation session was held on the 4th August 2022 at the Teesdale Community Hall. Approximately 20 attendees shared information regarding inundation in the town from both stormwater and riverine catchment sources with Golden Plains Shire, VicSES and Water Technology officers. The majority of concerns raised at the session related to infill and greenfield subdivision and associated increased flows in local drainage, however, information regarding historical riverine flooding of Native Hut Creek was shared.

Information gathered during the session is summarised below:

- Teesdale has experienced recent notable flood events in 1973, 2001 and 2011.

The 1973 event was significant, with widespread overbank flooding and overtopping of Bridge Street (Bannockburn-Shelford Road).

  - Photocopies of photographs of the 1973 event were brought to the session, taken from Pantics Road and showing inundation of entire paddocks.

- An event in 1990 was noted, however this did not cause impacts and did not overtop the road.

An event in 2001 resulted in overtopping of Bridge Road for several hours.

  - Initial analysis of rainfall data suggests this was likely around 24/25 April 2001.

- There was a significant flow event in 2011, however it was contained within the banks for the majority of the town with no reported damage or impact.

Flooding in the mid twentieth century (understood to be in the 1950's) forced the relocation of the towns sporting oval to its current location.

In addition to the information gathered during the session, key contacts and names were shared for further follow up.

Figure 3-1 Community Consultation at the Teesdale Community Hall (4/8/2022)

4 HYDROLOGICAL AND HYDRAULIC MODELLING METHODOLOGY

4.1 Model Revision and Development

Water Technology propose to undertake the hydrology model build utilising RORB software and the existing RORB model for Native Hut Creek developed by the CCMA and construct a new 1D-2D hydraulic model using TUFLOW HPC. A review of the RORB model will be undertaken to ensure its suitability for use in the study, specifically ensuring the approach is in line with the recommendations of the latest *Australian Rainfall and Runoff (ARR2019),* a significant improvement in the design modelling approach of ARR1987. Specific improvements in the approach include:

- 2016 Intensity – Frequency – Duration (IFD) data developed by the Bureau of Meteorology (BoM);

10 different temporal patterns available for every design event;

- Updated areal reduction factors;

Latest growth factors developed by the BoM for durations of 24 hours and greater;

- Modified approach for estimating rainfalls up to an AEP of 1 in 2000 for short durations; the growth factors are anchored on the 1% AEP estimates from the BoM rather than the 2% AEP, giving a higher reliability of the 1% AEP IFD data.

This section will detail the methodology for the hydrology revision and hydraulic model builds, calibration and design modelling for the Teesdale area.

4.2 Hydrological Modelling

4.2.1 RORB Model Revision and Modification

The existing RORB model once reviewed, will be calibrated/validated for three events (likely 2011, 2001 and 1973). We will use the parameters from the existing CCMA and GHD models as a starting point for the calibration of the Native Hut Creek catchment as there is no streamflow gauge available within the study area to calibrate to. We may be able to utilise the Barwon River at Pollocksford gauge to gain an understanding of expected timing of historic events, however the impact of Native Hut Creek at this gauge is likely to be relatively minor compared to flows from the remainder of the Barwon/Leigh River catchments.

4.2.2 Hydrological Modelling Validation (Historic and Design)

A K_C parameter value will be adopted for design model runs based on the historical calibration values. The design loss values will be compared with kc equation values as well as values adopted in nearby studies.

RORB will be run for the design events using the ensemble approach for a range of durations and AEPs. The new RORB hydrograph selector tool will be used to extract the model hydrographs. The new tool has been built into RORB and completes a similar process to that which Water Technology has been applying to recent flood studies manually. This allows the user to select the most appropriate hydrograph from the ensemble series to apply for design purposes. It will select the critical duration and temporal pattern which produces the median peak flow of the 10 temporal patterns for each AEP.

The above approach will be undertaken for all key locations in the model, including hydraulic model inflow boundary locations and key sites (i.e. waterway structure locations). The critical durations and temporal pattern combinations will then be selected for hydraulic modelling.

Monte Carlo Simulation will also be used to verify design flow estimates from the ensemble approach. This is considered to be a necessary check because in some cases the peak flows for the events around the median peak flow may vary considerably, so the selection of temporal pattern above or below the median peak flow can have a large influence on peak flow in these situations. In many situations though, the ensemble peak flows are reasonably close without a huge spread, and the peak flow adopted from the median is not significantly sensitive to this assumption.

4.2.3 Consideration of Storages

The potential impact of the two online storages discussed in section 2.3 has been investigated by considering the potential volume provided by the storages and comparing this to the rising limb of design hydrographs in frequent events. An example calculation based on an estimate of available storage in the dams from LiDAR and the design hydrograph output for a 1% AEP event from the CCMA RORB model is presented in Figure 4-1 below. This highlights the minimal storage available when compared to the overall hydrograph volume and indicates there is likely to be minimal impact whether the dams are full or empty at the time of a large flood event.

In minor events the storage may have an impact on flood behaviour for Teesdale. Design modelling will adopt the conservative approach of assuming the storages are full however this should be considered as part of the broader antecedent conditions.

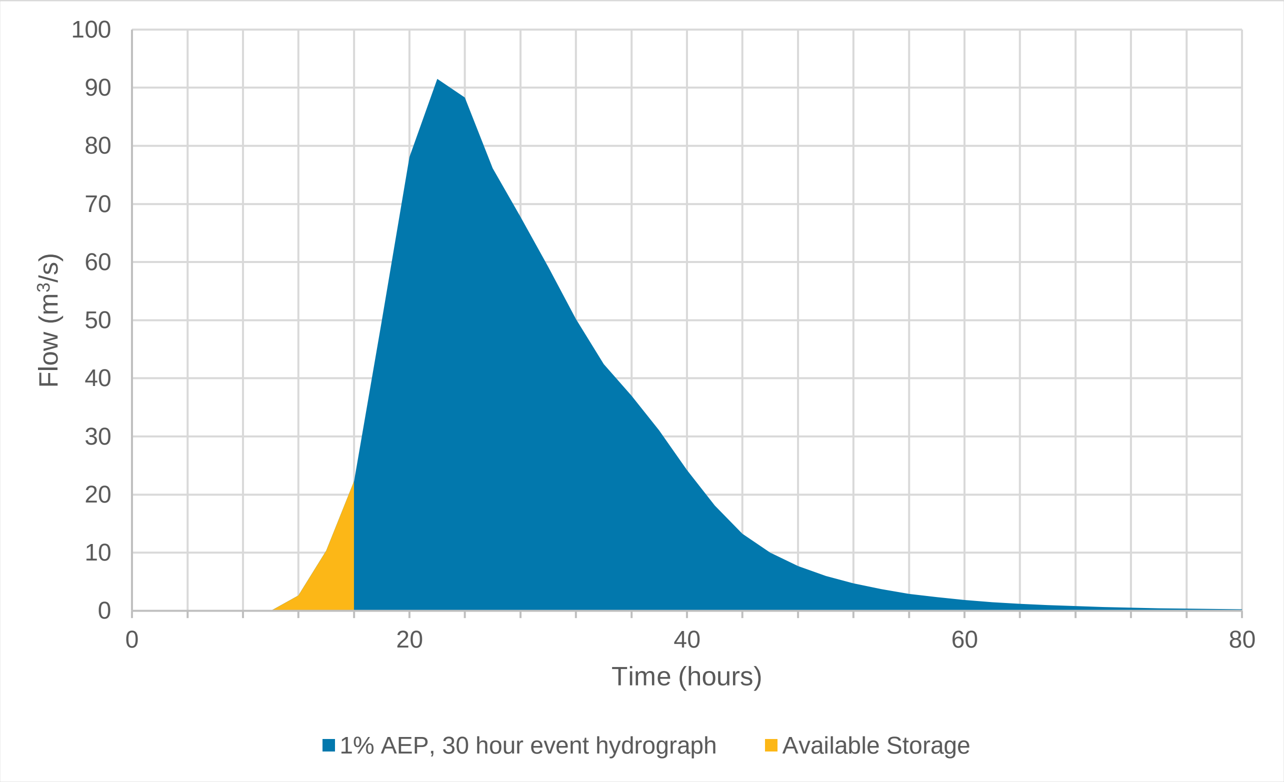

Figure 4-1: Example storage vs hydrograph volume comparison

4.3 Hydraulic Modelling

4.3.1 Hydraulic Model Development

A new hydraulic model of the Teesdale township and Native Hut Creek (and minor tributaries) floodplain will be produced for this investigation. TUFLOW (HPC) has been selected for the hydraulic modelling package.

Key bridges, culverts and pipes will be included in the TUFLOW hydraulic model as detailed 1D structures or layered 2D flow constrictions.

Major inflow boundaries will be applied at the upstream extent of the model on Native Hut Creek, two minor tributaries to the north of Teesdale as well as several minor runoff locations within Teesdale. For sub-catchment inflows along the major waterways not associated with a defined tributary, distributed source area inflow points are to be applied directly to the centre of Native Hut Creek close to the centroid of the RORB sub-areas.

Water Technology's spatial team will also develop a detailed roughness map using a remote sensing technique which will allow for most of the floodplain features to be accurately captured in the model. This is supplemented with VicMap layers to represent roads and residential/commercial properties. This technique can represent clumps of trees and provides a more comprehensive land use roughness map for traditional hand digitising or using planning layers to determine model roughness layers. A series of industry standard roughness values will be applied to the various roughness types identified by this technique.

The downstream boundary will be located approximately 2 km downstream of Teesdale township and will utilise a TUFLOW 2D HQ boundary which will allow the water to leave the model without having to set a boundary level. This approach will allow the downstream boundary to have no influence on the model within the model domain. Hence, sensitivity analysis will not be required on the 2D downstream boundary.

4.3.2 Hydraulic Model Validation

As identified earlier, there is minimal historic survey or flood marks to calibrate to, therefore a pseudo hydrology/hydraulic validation process will be undertaken based on the three historic flood events and the draft 1% AEP flood mapping. This will be presented at a later community meeting and also discussed with the CCMA and GPS.

4.4 Design Event Modelling

Design flood hydrographs for the 20%, 10%, 5%, 2%, 1%, 0.5% and 0.2% Annual Exceedance Probabilities (AEP) flood events, and the Probable Maximum Flood (PMF) at key inflow locations to the hydraulic model will be derived using the calibrated RORB model and appropriate design modelling parameters.

5 SUMMARY AND NEXT STEPS

The data captured as part of the data collation and review process has shown to be suitable for the Teesdale Flood Risk Identification Investigation. Despite there being no streamflow data at Teesdale or along Native Hut Creek to undertake a calibration process, it is hoped that adjacent catchment streamflow gauges and community input will provide suitable data to undertake a validation of the hydrology and hydraulic model results.

There are no outstanding data gaps, however further information on historical flooding in the town would provide rigour and increase confidence in the model validation.

The LiDAR validation survey data captured has shown the 2021 LiDAR meets the accuracy expectations and provides suitable representation of the ground surface for the hydraulic modelling.

Next steps in the project include:

- Hydrology Review

Hydraulic Model Refinement

- Hydrology/Hydraulic Validation

Community Consultation (round 2)

- Design Modelling

Floor Level Survey Capture

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