Model Development and Calibration Report

Stawell Flood Investigation (C14 2022/23)

Northern Grampians Shire Council

2 December 2024

Document Status

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Cover Image: Cato Park 2022 Flood Event

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ACKNOWLEDGEMENT OF COUNTRY

The Board and employees of Water Technology acknowledge and respect the Aboriginal and Torres Strait Islander Peoples as the Traditional Custodians of Country throughout Australia. We specifically acknowledge the Traditional Custodians of the land on which our offices reside and where we undertake our work. In particular we acknowledge the Jardwadjali and Djab Wurrung Peoples as the Traditional Custodians of the waters and lands on which this this project is based.

We respect the knowledge, skills and lived experiences of Aboriginal and Torres Strait Islander Peoples, who we continue to learn from and collaborate with. We also extend our respect to all First Nations Peoples, their cultures and to their Elders, past and present.

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

2 December 2024

Steven Cobden
Senior Design Engineer
Northern Grampians Shire Council
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Via email: steven.cobden@ngshire.vic.gov.au

Dear Steven,

Stawell Flood Investigation (C14 2022/23)

Please see attached the draft hydraulic model calibration report for the Stawell Flood Investigation. This report forms documentation of the TUFLOW model construction and joint RORB and calibration for the January 2011 and December 2011 events, using information collected during community consultation.

If you have any questions regarding this report don’t hesitate to contact me.

Yours sincerely

Ben Hughes
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WATER TECHNOLOGY PTY LTD

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GLOSSARY

Annual Exceedance Probability (AEP)	Refers to the probability or risk of a flood of a given size occurring or being exceeded in any given year. A 90% AEP flood has a high probability of occurring or being exceeded; 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 was commissioned by Northern Grampians Shire Council (NGSC) to undertake the Stawell Flood Investigation. The investigation covers two study areas; the local Stawell township catchment (including Pleasant Creek) and the Stawell Golf Course catchment to the north of Stawell, as shown in Figure 1-1.

No previous flood studies have been undertaken for either of the study areas. The Mt William Creek Flood Investigation included the Pleasant Creek catchment which covers the southern areas of Stawell. The study utilised RORB hydrologic modelling and TUFLOW two-dimensional hydraulic modelling. Modelling was calibrated to streamflow gauge records, flood frequency analysis and historic flood level data. However, the flood mapping produced only covered a minor part of southeastern Stawell.

In 2021/2022 Water Technology undertook a hydraulic assessment of flooding in Stawell caused by runoff from Big Hill, located in the eastern portion of the town. The study covered most of central Stawell and utilised a direct rainfall on grid (RoG) modelling approach. The model was not calibrated and limited survey data of hydraulic and topographic features was available. The flood study is required to address the uncertainty around flood risk within Stawell and to develop an understanding flooding behaviour to inform future land use, prospective mitigation options and emergency management actions.

The study will produce reliable flood intelligence for use in emergency management situations, assess the current flood impact/exposure in terms of annual average damages caused by flooding in Stawell, investigate structural and non-structural mitigation options, and 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 Stawell Flood Investigation. Each reporting stage is shown below:

- R01 - Data Review and Validation Report – Draft completed 31 October 2023 and final version issued 2 December 2024
  - This report details all the data collated and any gaps in the data required, resulting in further data survey of ground levels and the drainage network.
- **R02 – Model Development and Calibration Report – This report**
  - This report documents the development of the hydraulic models and calibration and validation of the Stawell hydraulic model using the 2011 flood events.
- R03 – Design Modelling Report
- R04 – Flood Intelligence and Warning Report
- R05 – Flood Damages and Mitigation Report
- R06 – Final Summary Report

1.2 Study area

Stawell is in Victoria's Wimmera region on the Western Highway, located approximately 110 km northwest of Ballarat and 140 km southwest of Bendigo. There are no major watercourses within or near the town, instead flood risk is driven by local stormwater runoff from elevated areas east of the town, including Big Hill. The southwestern parts of town are located within the Pleasant Creek catchment. Pleasant Creek originates approximately 8 km south of Stawell at the Black Range, flowing northwest along the Western Highway past southwestern Stawell, before eventually running into Lake Lonsdale, 9 km west of Stawell. The Pleasant Creek catchment upstream of Stawell is approximately 28 km^2 and consists of bushland in the upper reaches and cleared pasture in the lower reaches upstream of Stawell, see Figure 1-2.

Stawell can be separated into two distinct types of potential inundation; short duration stormwater flooding and longer duration riverine flooding from Pleasant Creek, to the southwest of town. While stormwater flooding is the primary driver of damage, Pleasant Creek has still historically caused issues but affects a smaller portion of the population.

The Stawell Golf Course study area is characterised by the Jerrywell Creek catchment. Jerrywell Creek originates on the eastern slope of Big Hill and flows north crossing the Stawell-Avoca Road. Multiple large overland flow paths from the Deep Lead Nature Conservation Reserve feed into the creek before it joins Concongella Creek, and finally the Wimmera River. The Jerrywell Creek catchment within the study area is largely cleared agricultural land with some vegetated areas in the upper reaches, see Figure 1-2.

Stawell has most recently experienced flooding in January and December 2011. While January was of longer duration and larger magnitude, December 2011 was significantly shorter and more intense causing urban flooding.

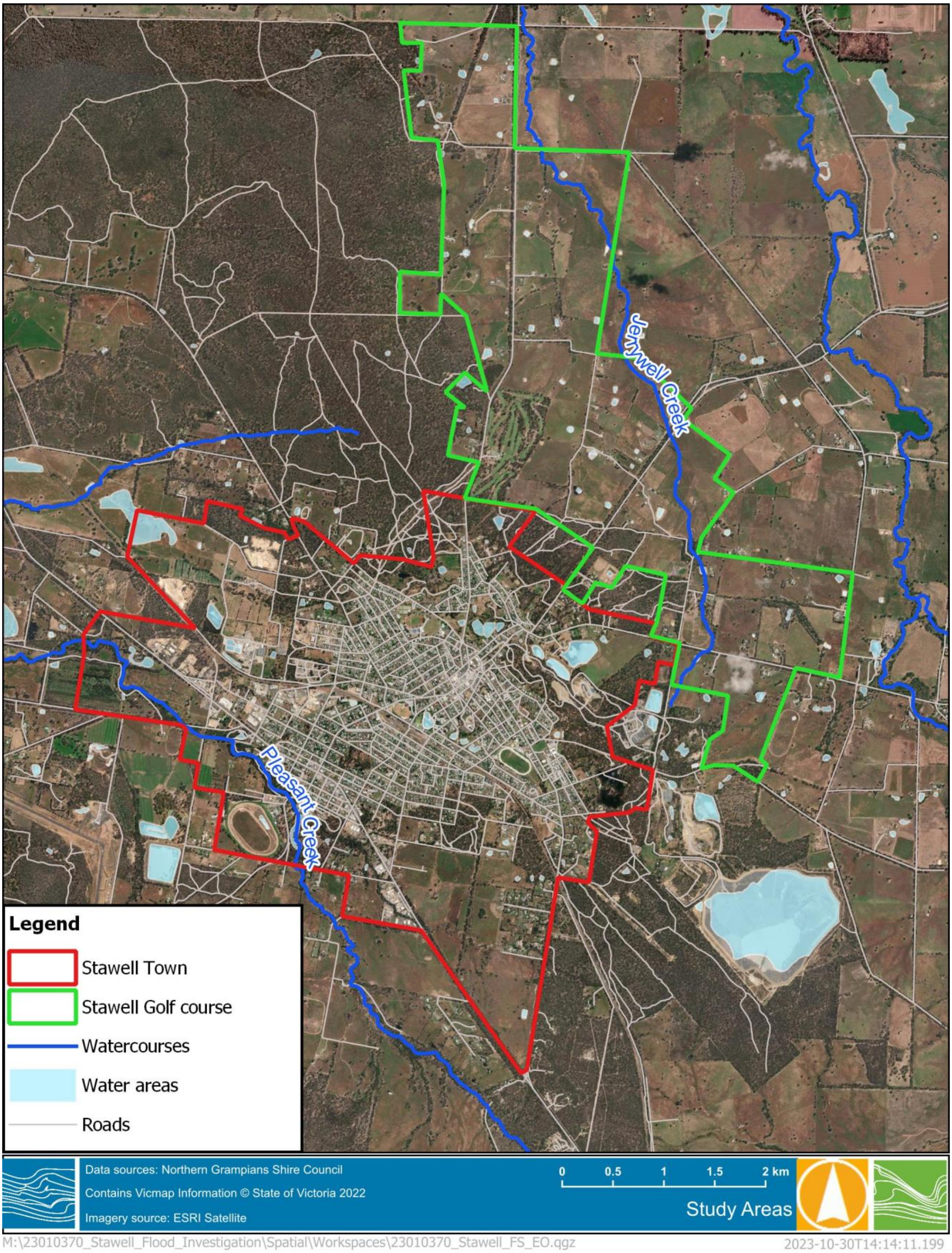

Figure 1-1 Stawell study areas

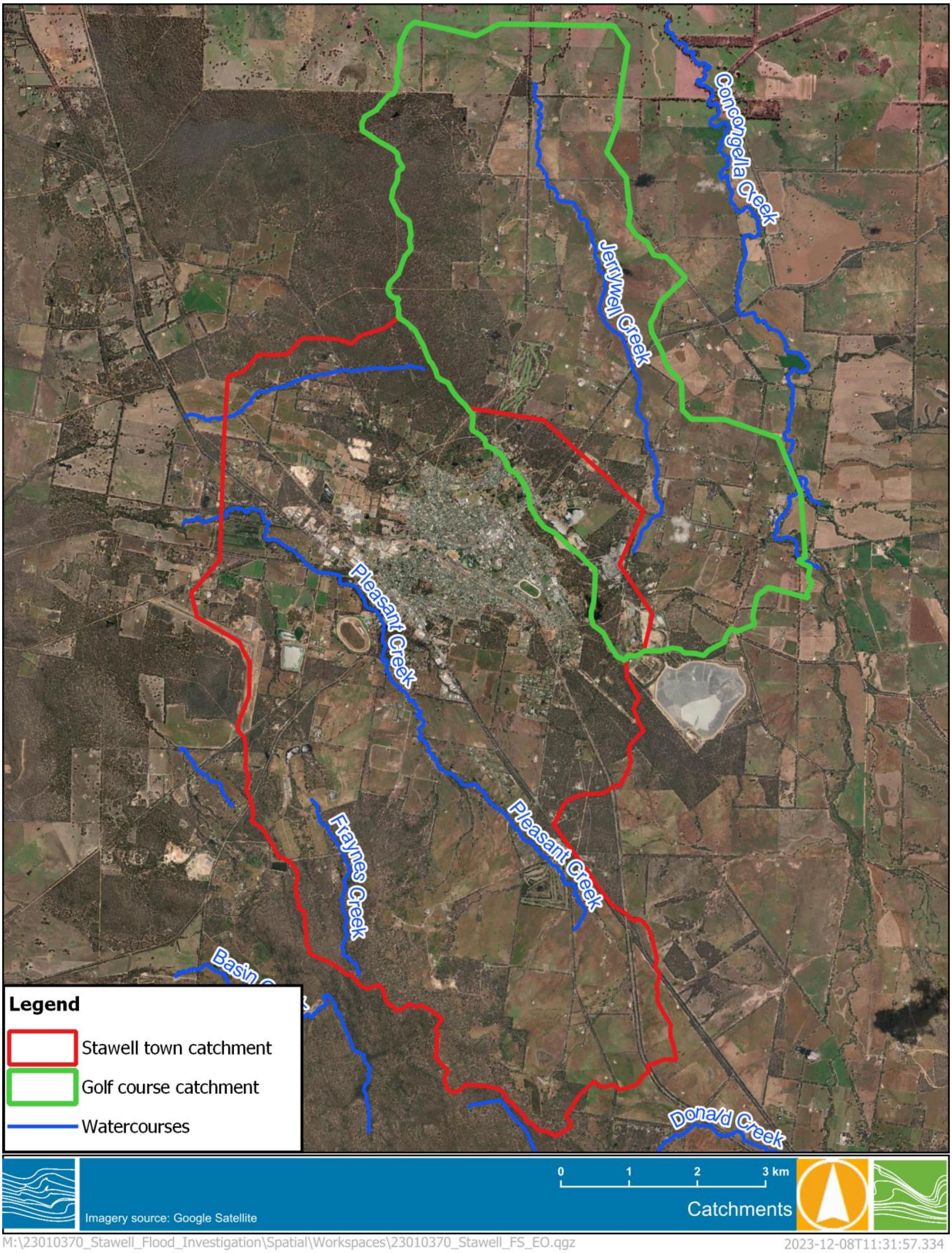

Figure 1-2 Stawell catchments

2 MODEL DEVELOPMENT

2.1 Overview

The Pleasant Creek catchment upstream of Stawell is limited in size and there is no clearly defined point of discharge where overland flow enters the Stawell area. Given the relatively dispersed flow paths. It was decided to adopt a direct rainfall on grid (RoG) hydraulic modelling approach for the Stawell Flood Investigation instead of using a separate hydrologic model. This is the most suitable approach for the golf course catchment as well, given its location high up in the Jerrywell Creek catchment. This option was enabled by recent developments in computational capacity which has reduced hydraulic modelling run times.

Two hydraulic models were developed, covering the Pleasant Creek catchment including the Stawell township and the golf course catchment respectively, as depicted in Figure 1-2. The hydraulic model developed during the Big Hill assessment was used as a basis for the current Stawell model. It was expanded and upgraded with the data collected during the data review phase of the project.

The models were built using the TUFLOW HPC hydraulic modelling software. A gridded model was developed per catchment with a direct rainfall boundary applied to represent calibration and design rainfall events. The underground pit and pipe network within the town was incorporated as 1D structures, with the model topography developed and modelled in 2D. Each stage of the model development is detailed below.

2.2 Daily rainfall

Table 2-1 summarises the daily rainfall information available within or near the two study areas, the closest active rainfall gauge being Stawell Aerodrome (079105), located approximately 4 km south of Stawell. There are several other gauges available for this study, however they were excluded from Table 2-1 due to being closed and located outside the study catchments. The rainfall gauge locations are shown in Figure 2-1.

Table 2-1 Daily rainfall gauges

Station Name	Dist. From Stawell	Station No.	Start	End
Stawell Aerodrome	4 km S	079105	1996	Current
Great Western (Seppelt)	16 km SE	079019	1891	Current
Glenorchy	24 km NW	079015	1913	Current
Halls Gap	25 km SW	079074	1958	Current
Morrl Morrl (Valley View)	26 km NW	079032	1902	Current
Moyston (Barton Estate)	30 km S	079050	1906	Current
Ararat Prison	30 km SE	089085	1969	Current
Wartook Reservoir	30 km W	079046	1890	Current
Grampians (Mount William)	30 km SW	079103	2005	Current
Dadswells Bridge	31 km NW	079077	1968	Current
Pomonal	20 km SW	079073	1955	2014
Landsborough	32 km E	079027	1901	2013

2.3 Pluviograph rainfall

The Stawell Aerodrome gauge (079105) also records sub daily rainfall, typically every 6 minutes. This gauge is highlighted in Figure 2-1.

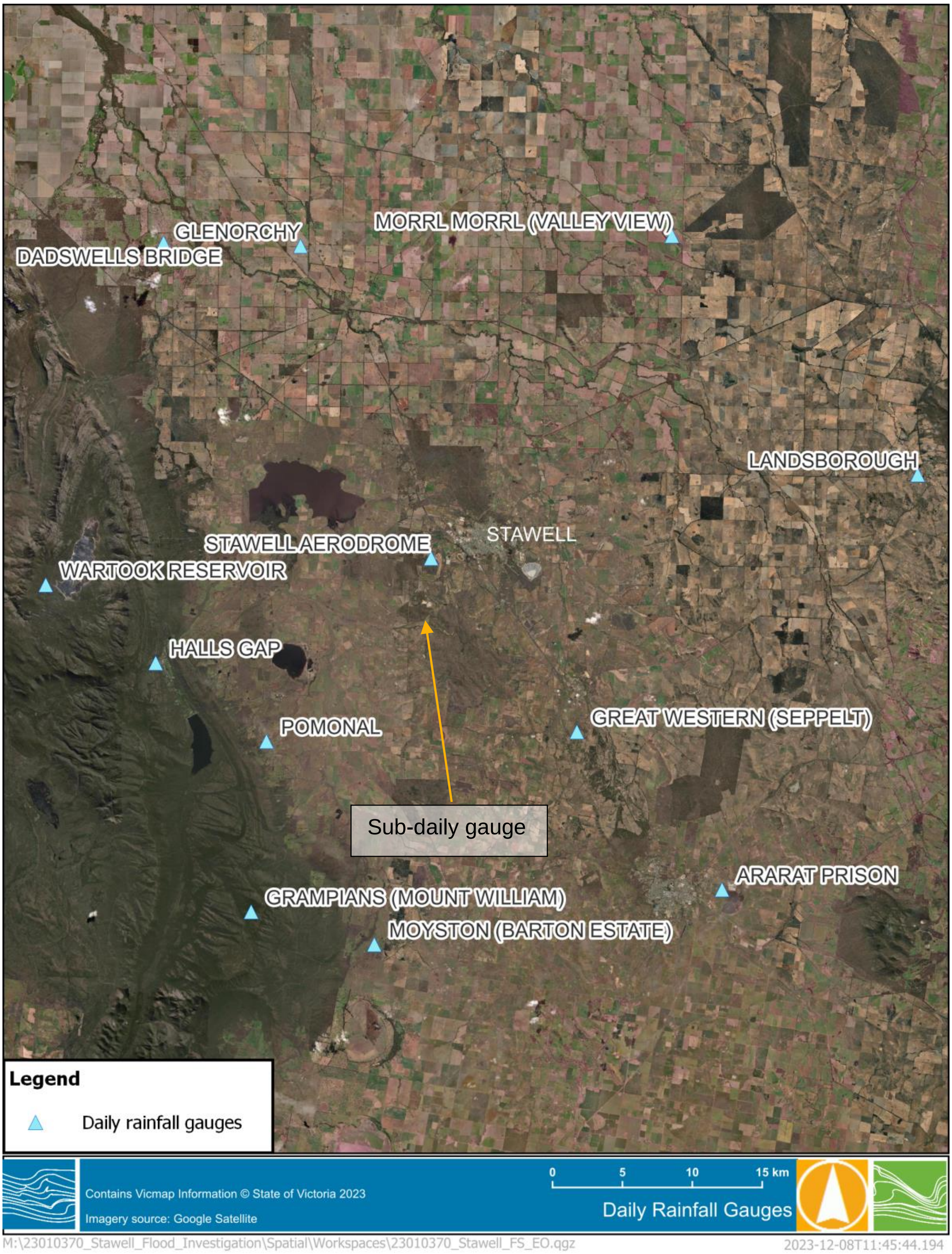

Figure 2-1 Rainfall gauges near the study area

2.4 Model boundaries and extent

Figure 2-2 shows the two hydraulic model extents and applied downstream boundaries. The model extents were determined based on the topography, ensuring the entire upstream catchments were included. The Stawell model extent covers 54 km^2 and the golf course model extent covers 31 km^2.

A single inflow boundary was applied per model, consisting of a polygon of the same extent as the model extent representing the incoming rainfall. For design events a uniform pluviography will be applied across the boundary, while the calibration events used a gridded inflow constructed from rainfall totals from the gauges surrounding Stawell, this is further detailed in Section 3.2.2 and Section 3.3.2.

A flowrate/height tailwater boundary ("HQ" type) was applied at several locations downstream of each study area to allow water flowing out the model with the rate of outflow dictated by the height.

2.5 Model topography

The 2005-2006 GWMWater Wimmera Mallee Pipeline project LiDAR was the only available high-resolution dataset covering the entire study area. The dataset was verified against survey data provided by NGSC and in 2023. Based on the verification, the LiDAR dataset was found to be on average 0.08 m above surveyed levels and it was therefore lowered by 0.08 m prior to being adopted in the model.

The topography representation was further improved by a vast amount of survey data provided by NGSC as listed below:

- Point cloud elevation data captured by drone covering a total of approximately 1 km^2, filtered to only include ground elevation data.
  - This data was rasterised and included in the model in favour of the LiDAR in covered areas.
- Topography survey data for the Norman Castle Reserve dams, Albion Road dam, Grant Street dam, Curtis Street dams, Taylors Gully Park depression, part of the North Park oval, the Stawell Main Drain and a number of bridge obverts.
  - This data was rasterised and included in the model in favour of the LiDAR and the point cloud data in covered areas. The Curtis Street dam walls and North Park Oval southern edge were included as breaklines.

Figure 2-3 and Figure 2-4 show the hydraulic model topography for each model.

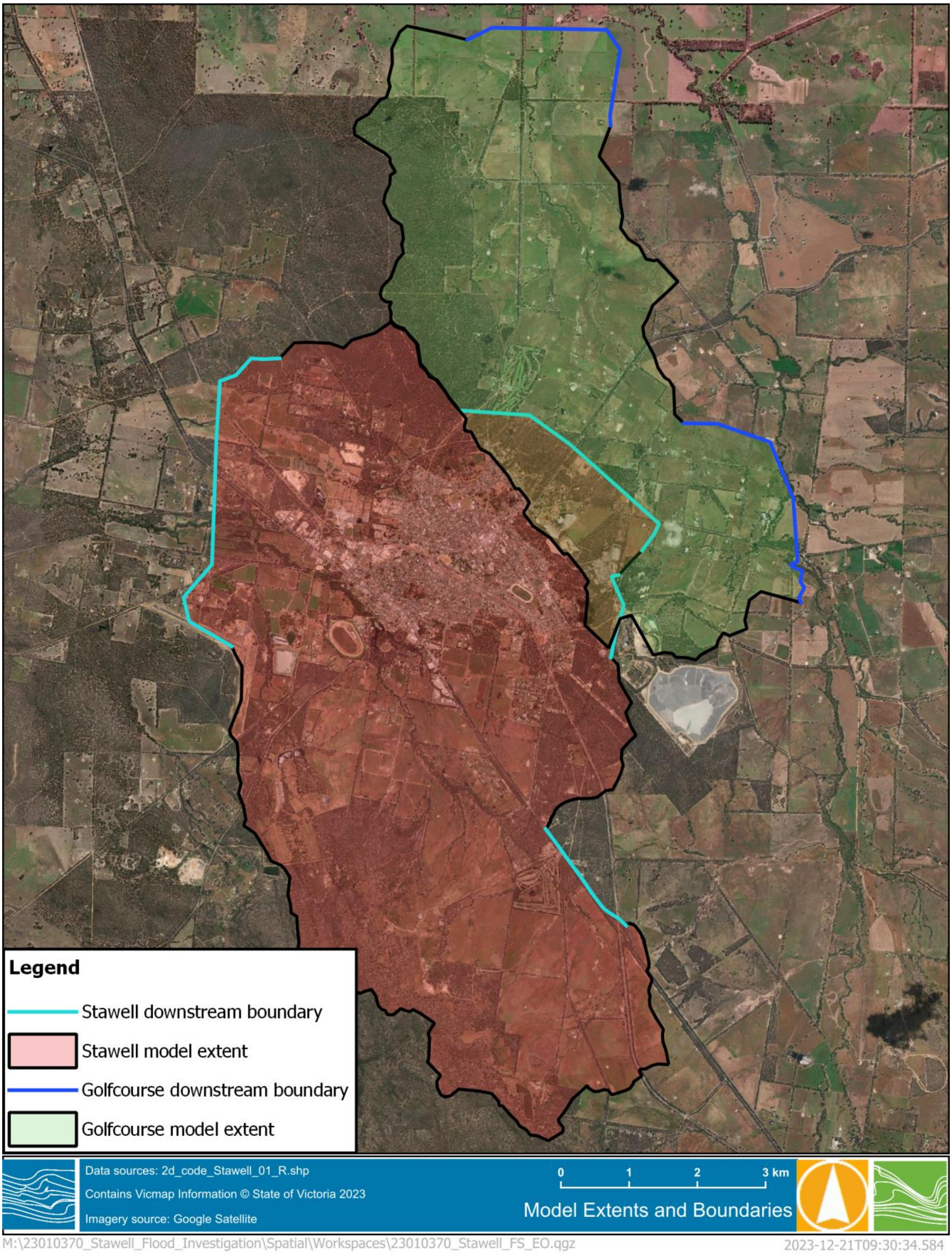

Figure 2-2 Hydraulic model extents and downstream boundaries

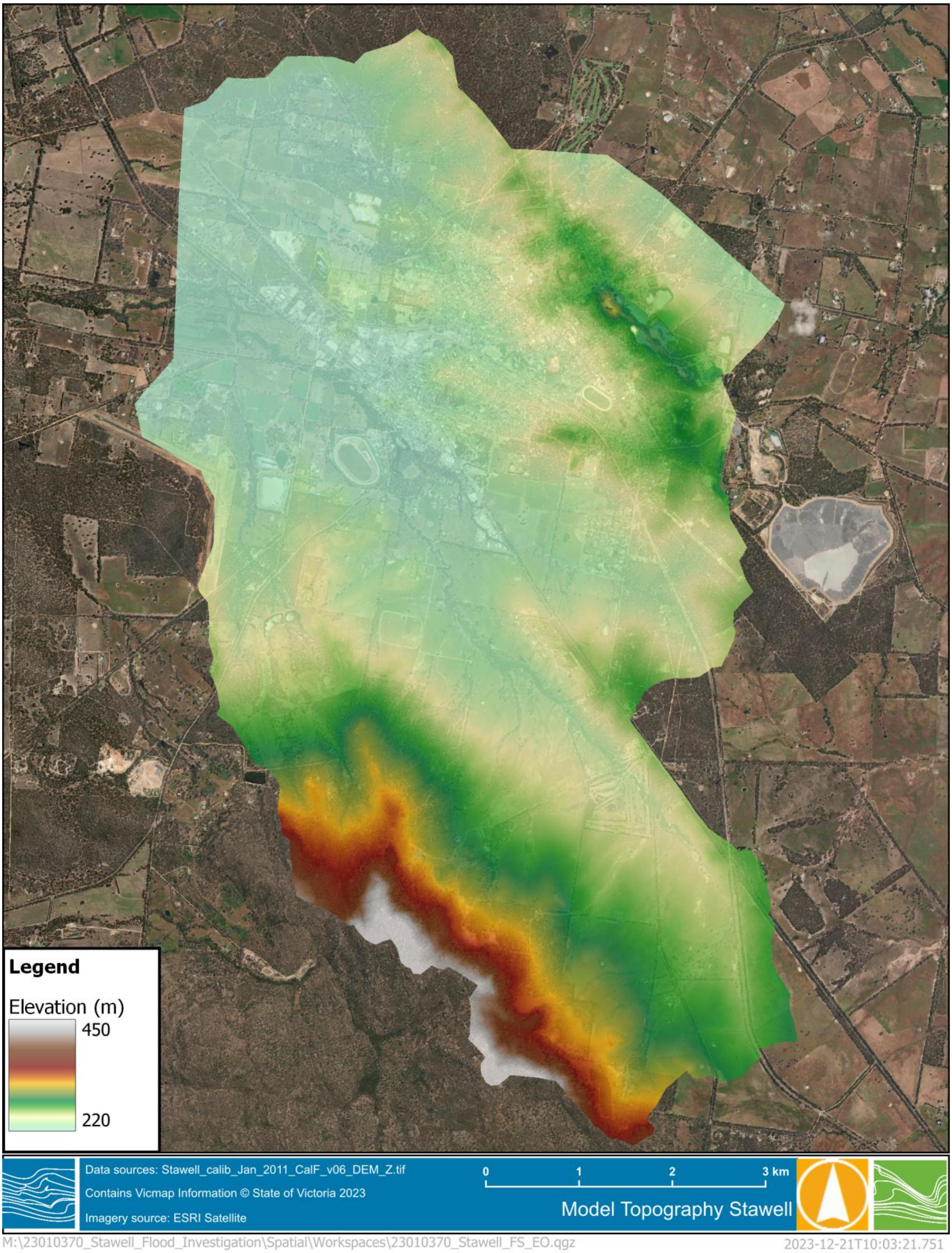

Figure 2-3 Stawell model topography

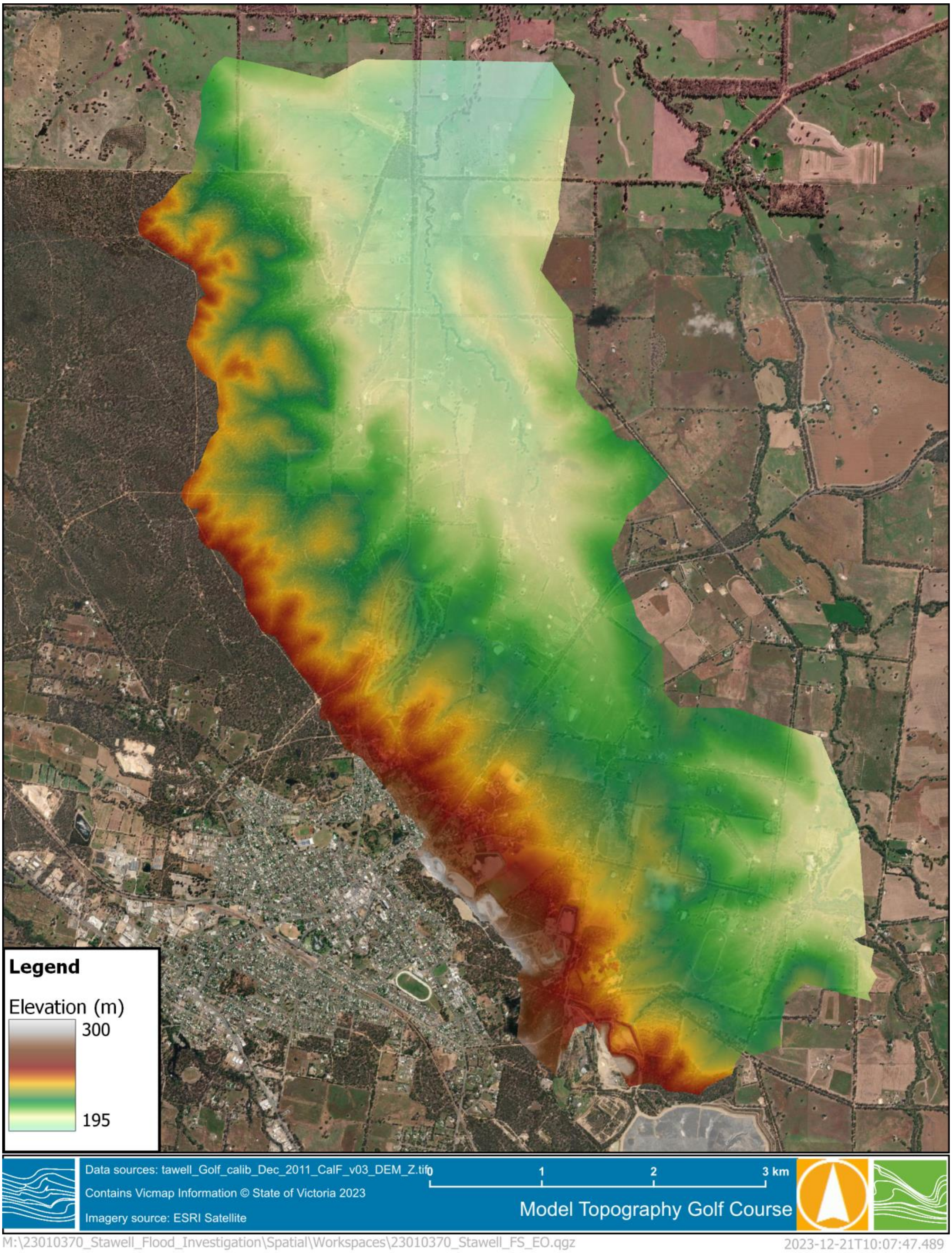

Figure 2-4 Stawell Golf Course model topography

2.6 Hydraulic roughness and rainfall losses

Hydraulic roughness within the 2D model was expressed as roughness coefficient Manning's 'n'. Manning's 'n' was estimated using aerial imagery and land use classifications generalised by the NGSC Planning Scheme layers. Initially, hydraulic roughness coefficients were adopted using industry standard values representing the river channel and floodplain cover, then adjusted as required during model calibration. Rainfall initial and continuing loss were initially adopted based on ARR2019 recommendations and nearby studies and adjusted as required during model calibration.

The adopted hydraulic roughness coefficients and rainfall losses are summarised in Table 2-2. Figure 2-5 shows a map of the adopted roughness values.

Table 2-2 Land use types and Manning's 'n' values

Land use	Roughness coefficient (Manning's 'n')	Initial loss (mm)	Continuing loss (mm/hr)
Open space, minimal vegetation	0.04	20	4
Open space, moderate vegetation	0.08	20	4
Built-up and residential areas – high density (buildings modelled separately)	0.10	20	3
Built-up and residential areas – low density (buildings modelled separately)	0.05	20	3
Building footprints	0.40	3	1
Commercial/industrial areas	0.30	2	0.5
Car park/pavement/roads	0.02	1	0.5
Railway	0.125	2	1
Open water	0.02	0	0

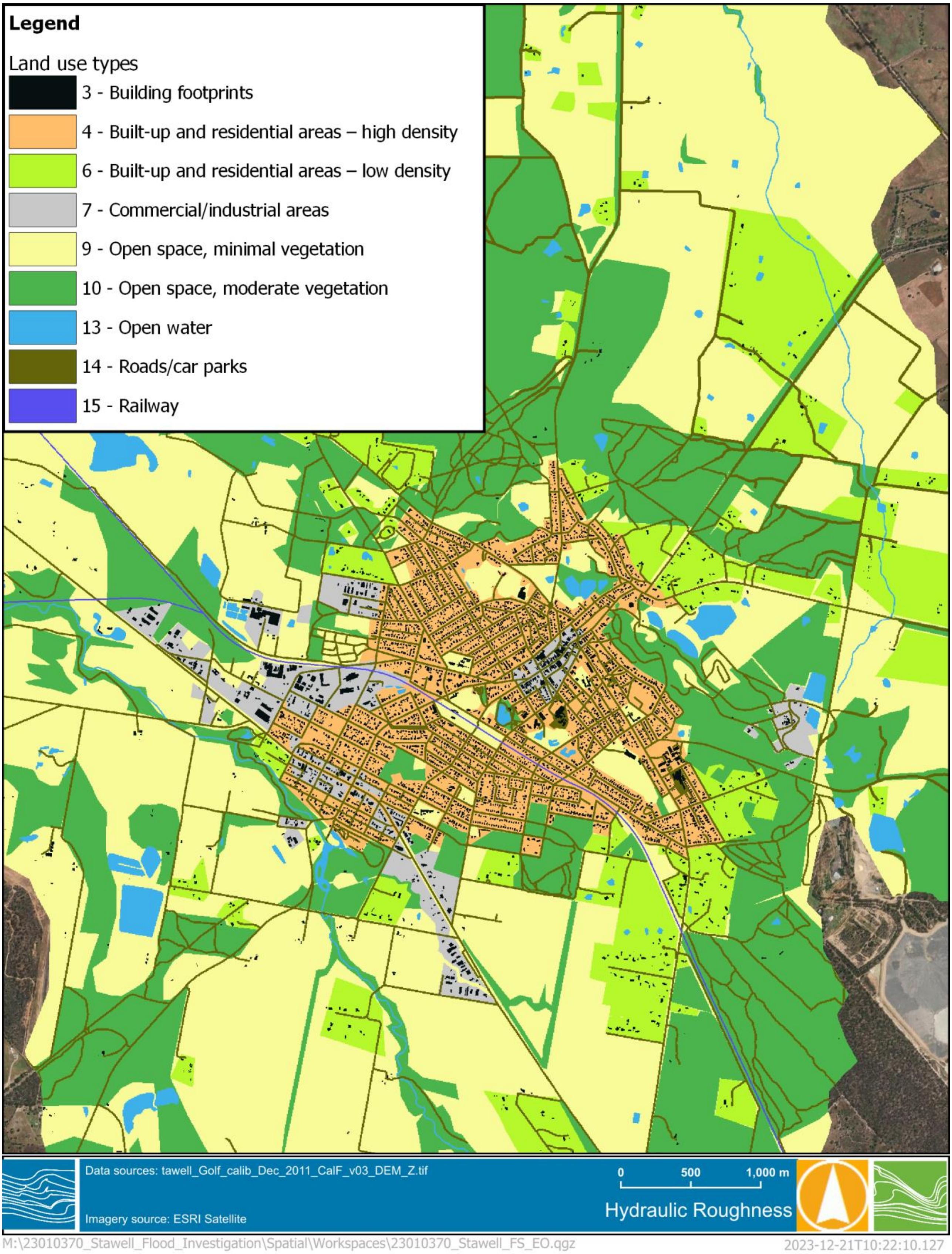

Figure 2-5 Hydraulic roughness

2.7 Model structures

2.7.1 Bridges

12 bridges were incorporated in the hydraulic models as 2D bridge flow constrictions to represent energy losses due to piers and bridge deck. The bridge dimensions were based on existing datasets, survey data and site visit observations. Two bridges were incorporated in the golf course model (labelled BG). Figure 2-6 and Figure 2-7 show the bridge locations.

Table 2-3 Bridges

Map reference	Road	Waterway	Channel bed to bridge soffit (m)
B1	Victoria Street	Main drain	0.9
B2	Frayne Street	Main drain	1.08
B3	Seaby Street	Main drain	1.0
B4	Unnamed	Main drain	1.8
B5	Griffith Street	Main drain	1.3
B6	Smith Street	Main drain	1.25
B7	Darcy Street	Main drain	1.03
B8	Darcy Street	Main drain	1.25
B9	Western Highway	Main drain	0.85
B10	Western Highway	Stinky Creek	1.0
B11	Black Range Road	Pleasant Creek	1.8
B12	Grampians Road	Pleasant Creek	1.0
BG_1	Stawell-Avoca Road	Jerrywell Creek	1.0
BG_2	Donald-Stawell Road	Gambettas Creek	1.2

2.7.2 Culverts

A large number of road culverts were included in the hydraulic models, as shown in Figure 2-6 and Figure 2-7. Culverts were incorporated as 1D structures directly connected to the 2D domain. Culvert dimensions were based on existing datasets, survey data and site visit observations.

2.7.3 Pit and pipe network

The underground pit and pipe network in Stawell was surveyed by Northern Grampians Shire Council in 2023 and the survey data, which included dimensions and invert levels, was incorporated as the 1D pit and pipe structure network. Open pipe ends not connected to a pit were modelled as directly connected to the 2D domain. The pipe network is shown in Figure 2-8.

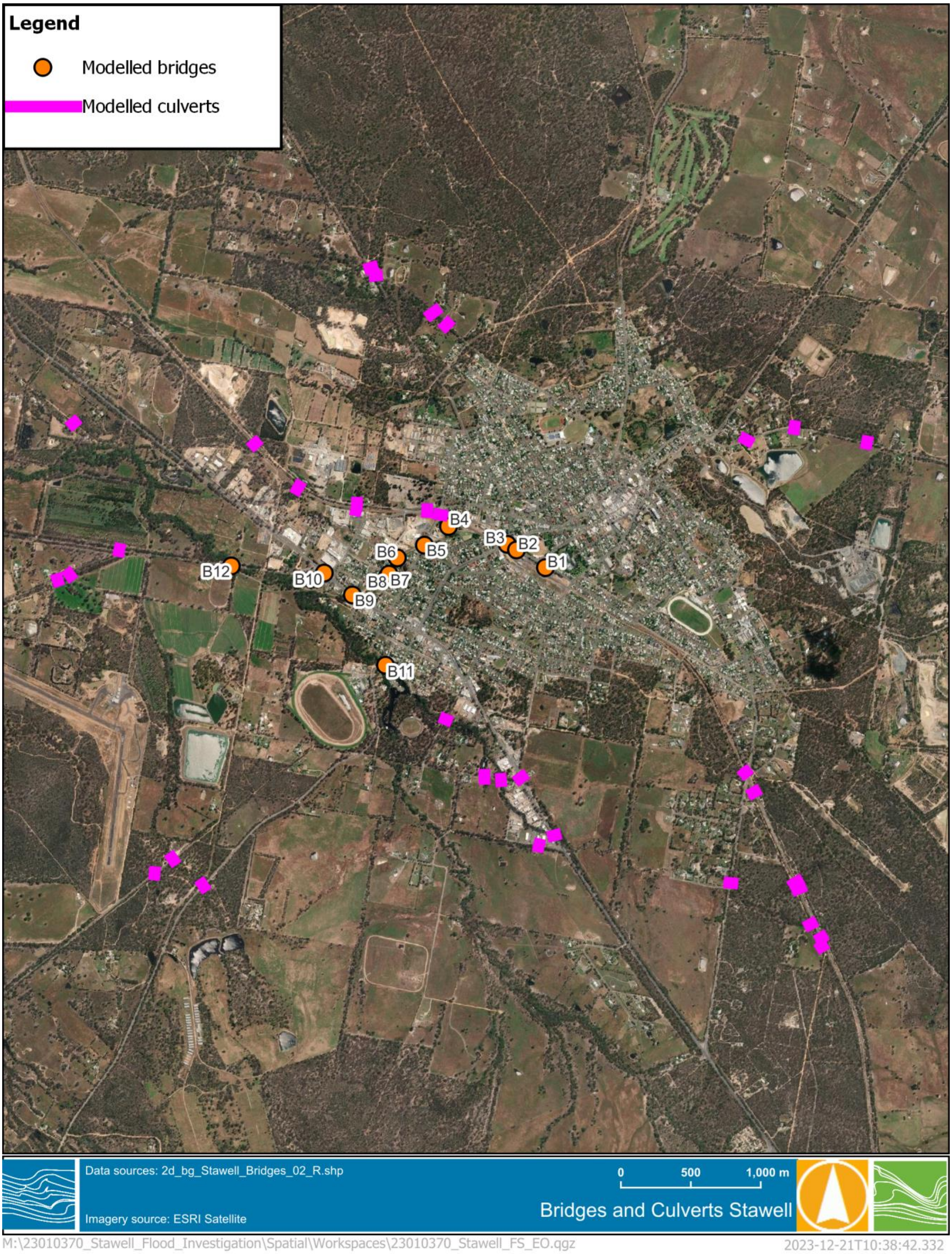

Figure 2-6 Stawell - modelled structures

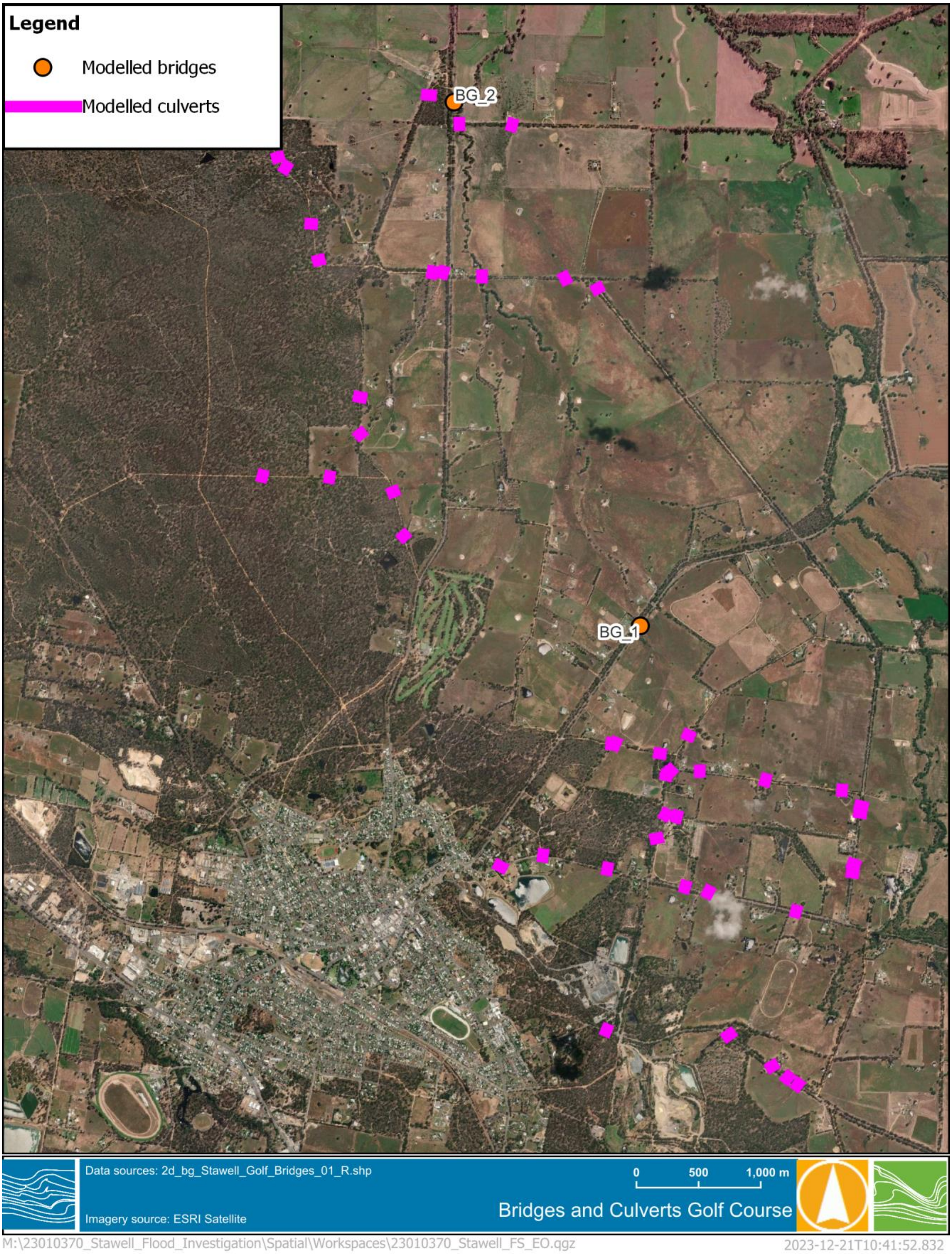

Figure 2-7 Stawell Golf Course - modelled structures

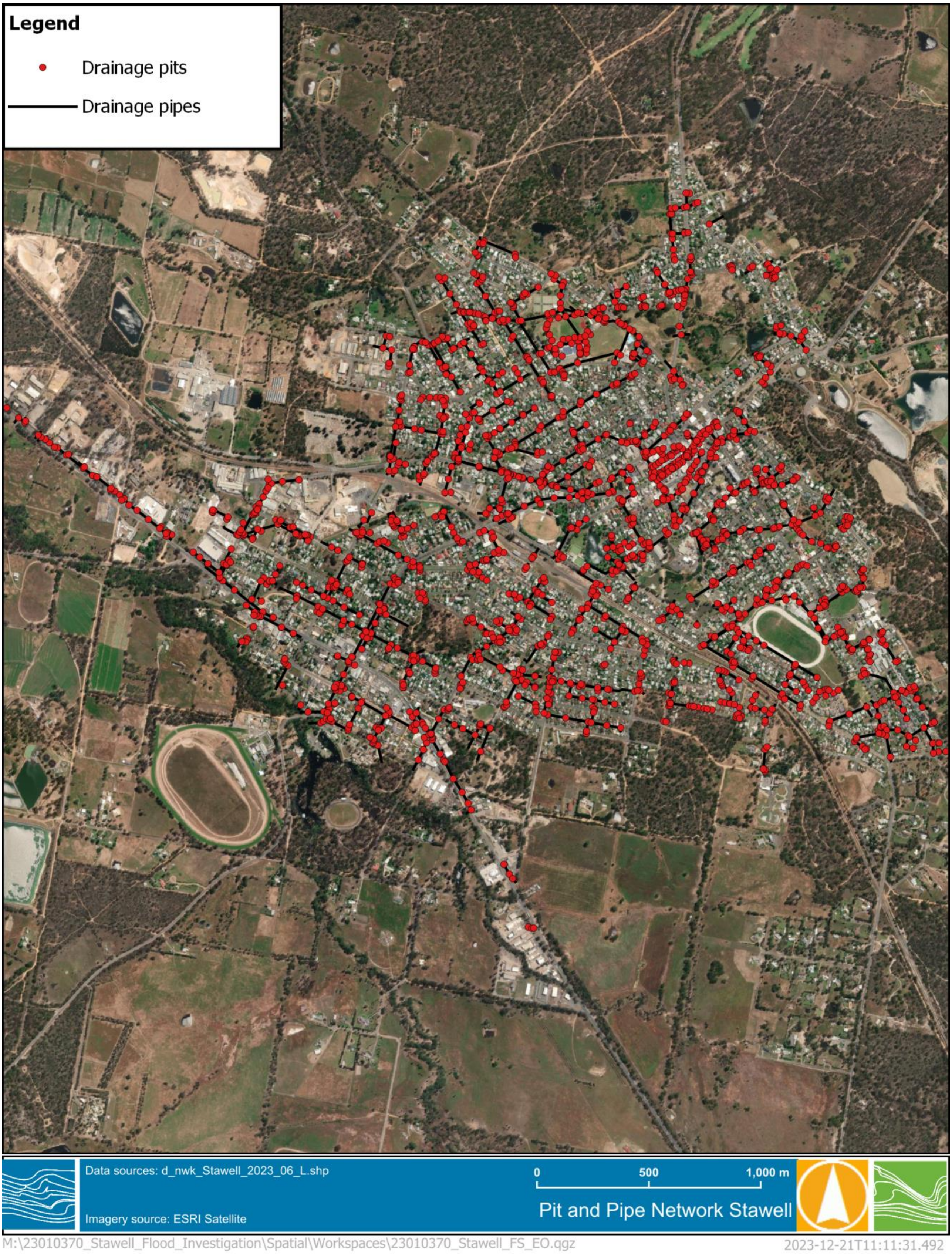

Figure 2-8 Underground drainage infrastructure

3 MODEL CALIBRATION

3.1 Approach

The model calibration and validation focused on the December 2011 event, the largest flood on record in Stawell. The January 2011 event was also modelled as it represents a longer duration storm event and was brought up during community consultation. Due to the lack of river level gauges along Pleasant Creek, and minimal historic survey or flood marks to calibrate to, the calibration process consisted of systematic comparison of observed and modelled flood levels, flows and flood extents based on information gathered at a community consultation meeting held in Stawell in October 2023. The available information included photographs of the inundation extent and anecdotal recollections of water levels at different locations inside Stawell.

The December 2011 event was modelled iteratively in TUFLOW, adjusting rainfall losses, refining the material layer, and adjusting the roughness values until the best overall match to the current historic dataset was achieved. The full details of each run are not documented here due to the number of iterations. However, the results will be discussed in design modelling sensitivity discussion in later reporting. The January event was modelled using the same parameters as adopted for the December event.

It should be noted that the calibration is not considered final, and adjustments are still able to be made once further discussion with the community is complete.

3.2 January 2011 event

3.2.1 Overview

January 2011 was the wettest January on record across many parts of Victoria, causing flood events affecting over 100 towns. The highest local monthly total was recorded at Halls Gap with 297.0 mm followed by Mount William with 289.6 mm. Rainfall was concentrated over the north-central and western regions and fell between January 9 and January 15. In Stawell, the storm event began on January 9, with rainfall intensifying on January 12. The rainfall eased on January 13 before intensifying again on January 14. This resulted in a long duration event with dual bursts. While the short term intensities (< 24 hrs) were relatively frequent, longer durations were more infrequent with the 72 and 96 hr events corresponding to between 2% and 1% AEP, see Figure 3-1.

3.2.2 Model inflow

A rainfall spatial distribution was generated using 12 rainfall gauges with data recorded during the January event. This included all currently open stations listed in Table 2-1. The temporal pattern for the event was generated using the Stawell Aerodrome gauge. The January 2011 event was modelled from 0230 hours on January 10 to 0618 hours on January 14 to capture the two rainfall bursts occurring during the storm event. The rainfall totals across this period are shown in Table 3-1 and the temporal pattern adopted from the Stawell Aerodrome gauge is shown in Figure 3-2.

3.2.3 Calibration data

The following calibration data sources were available from the January 2011 event:

- Photographs taken by Council staff showing inundation of bowling club grounds on Napier Street.
- Photographs taken by Council staff showing post-flood damage on Sloane Street.
- No anecdotal records specific to the January 2011 event were available.

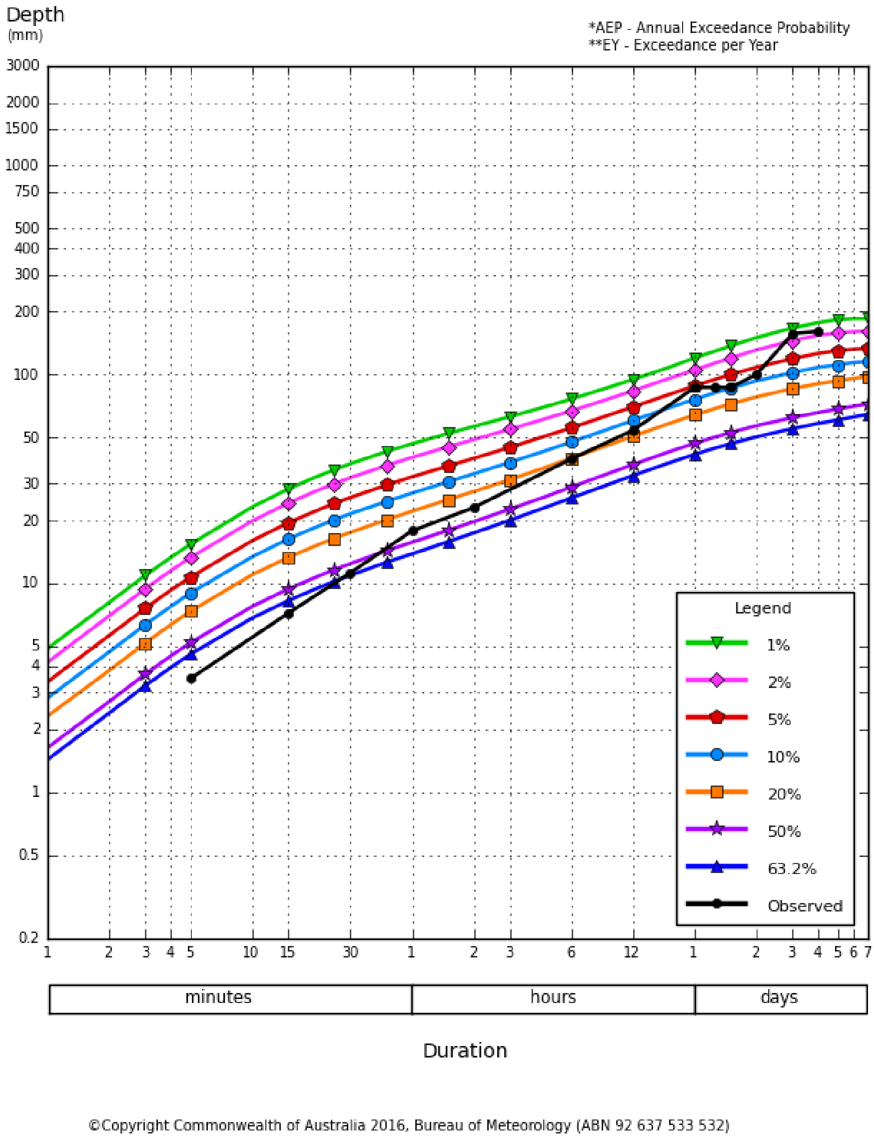

Figure 3-1 IFD curves for Stawell Aerodrome gauge (079105) and observed rainfall intensities – January 2011

Table 3-1 January 2011 event rainfall totals

Station No.	Station Name	January 9 to 14 2011 Rainfall total (mm)
079105	Stawell Aerodrome	166.2
079019	Great Western (Seppelt)	185.4
079015	Glenorchy	229.0
079074	Halls Gap	286.8
079032	Morrl Morrl (Valley View)	147.0
079050	Moyston (Barton Estate)	172.0
089085	Ararat Prison	169.2

Station No.	Station Name	January 9 to 14 2011 Rainfall total (mm)
079046	Wartook Reservoir	204
079103	Grampians (Mount William)	279.0
079077	Dadswells Bridge	156.0
079073	Pomonal	210.6
079027	Landsborough	155.2

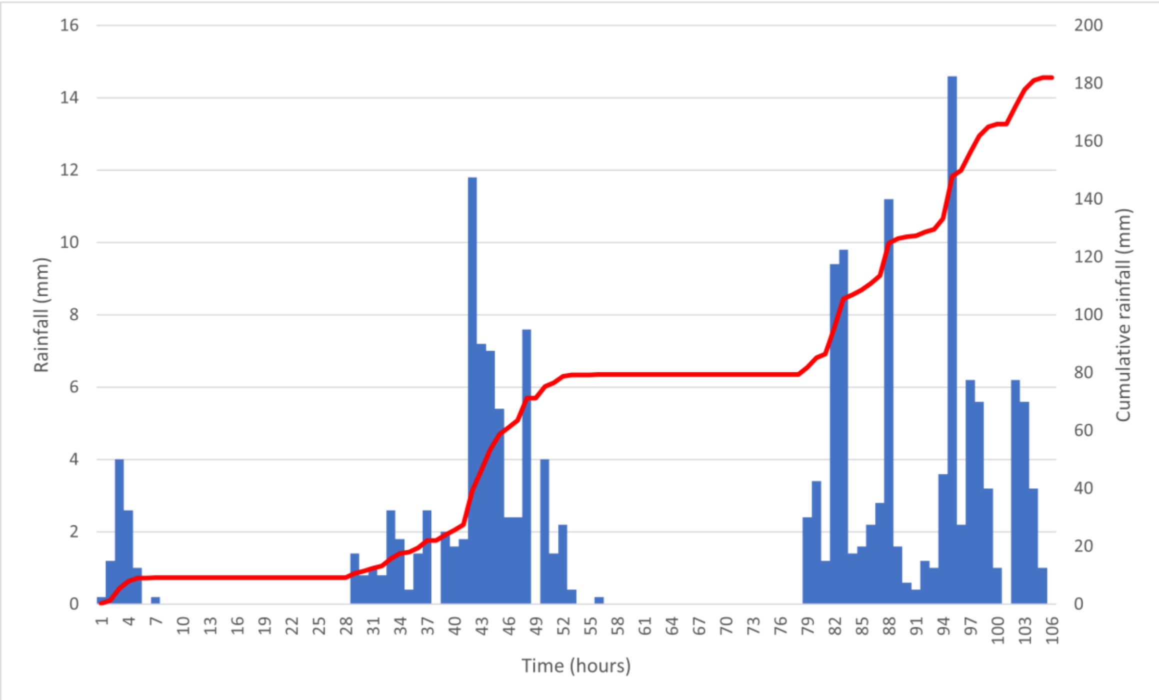

Figure 3-2 January 2011 event temporal pattern - Stawell Aerodrome gauge (079105)

3.2.4 Calibration result

Figure 3-3 and Figure 3-4 show the modelled flood depth for the January 2011 event for the Stawell and golf course study areas respectively.

The Stawell township catchment responds rapidly to incoming rainfall due to the large fraction of surfaces of low permeability. This means that runoff from a long duration event with relatively low intensity for short durations, such as the storm occurring in January 2011, has time to drain in between rainfall bursts. Therefore, the modelled maximum depths across the study area are relatively low and flow is concentrated to a small number of overland flow paths. Some breakouts are observed along Pleasant Creek and the Main drain but only a small number of residential lots are inundated.

In the golf course catchment, the January 2011 event causes overland flow paths from the elevated areas in the western parts of the study area towards Jerrywell Creek, mostly impacting agricultural land.

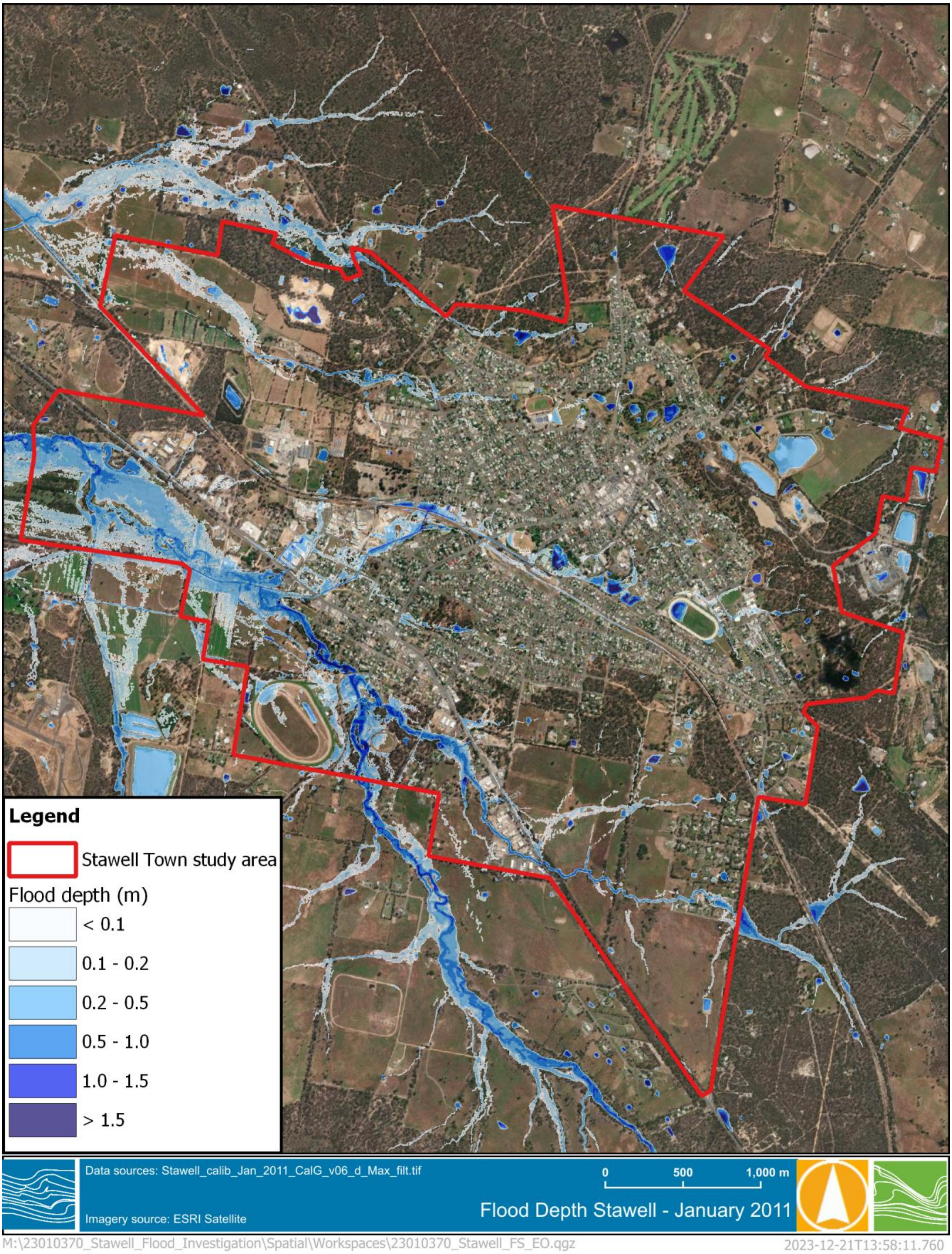

Figure 3-3 Calibration modelling flood depth Stawell – January 2011

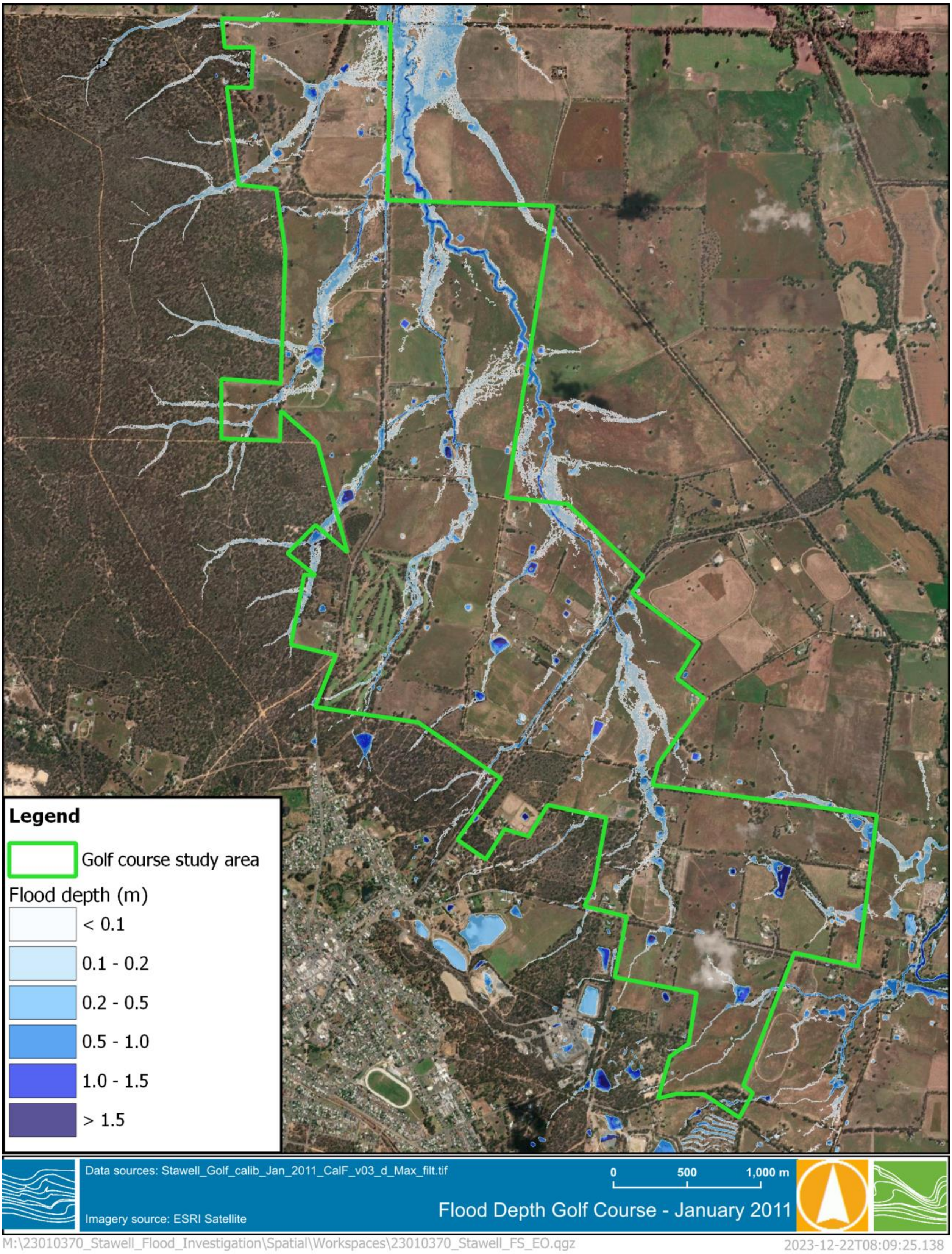

Figure 3-4 Calibration modelling flood depth Stawell Golf Course – January 2011

3.3 December 2011 event

3.3.1 Overview

The December 2011 event was shorter in duration when compared to January 2011, but the rainfall intensities were significantly higher. The Stawell Aerodrome gauge recorded almost 100 mm of rainfall in 24 hours from 0000 hours on December 18. The event consisted of smaller rainfall amounts early on December 18 with a main burst around 1800 hours. Rainfall intensities during the main burst were less frequent than a 1% AEP event, see Figure 3-5. Anecdotal rainfall records indicated rural areas outside of Stawell recorded intensities up to a 1 in 1000 year ARI event.

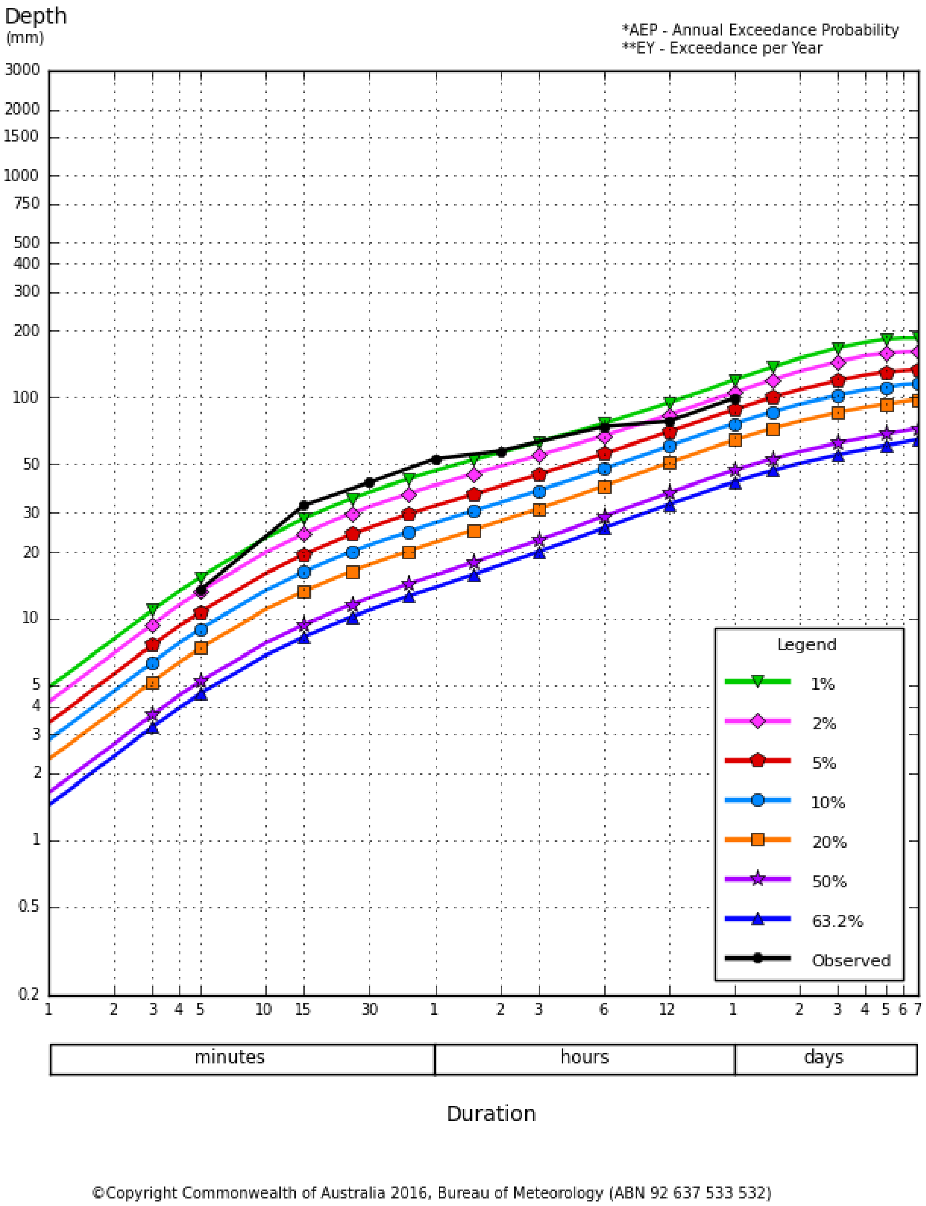

Figure 3-5 IFD curves for Stawell Aerodrome gauge (079105) and observed rainfall intensities – December 2011

3.3.2 Model inflow

The rainfall spatial and temporal patterns were developed in the same manner as for the January event. The December 2011 event was modelled from 1200 hours to 2359 hours on December 18 to capture the main event rainfall burst. The rainfall totals across this period are shown in Table 3-2 and the temporal pattern adopted from the Stawell Aerodrome gauge is shown in Figure 3-6.

Table 3-2 December 2011 event rainfall totals

Station No.	Station Name	December 17 to 19 2011 Rainfall total (mm)
079105	Stawell Aerodrome	99.2
079019	Great Western (Seppelt)	92.0
079015	Glenorchy	52.5
079074	Halls Gap	108.0
079032	Morrl Morrl (Valley View)	39.6
079050	Moyston (Barton Estate)	54.0
089085	Ararat Prison	47.6
079046	Wartook Reservoir	63.4
079103	Grampians (Mount William)	95.2
079077	Dadswells Bridge	43.0
079073	Pomonal	75.0
079027	Landsborough	91.6

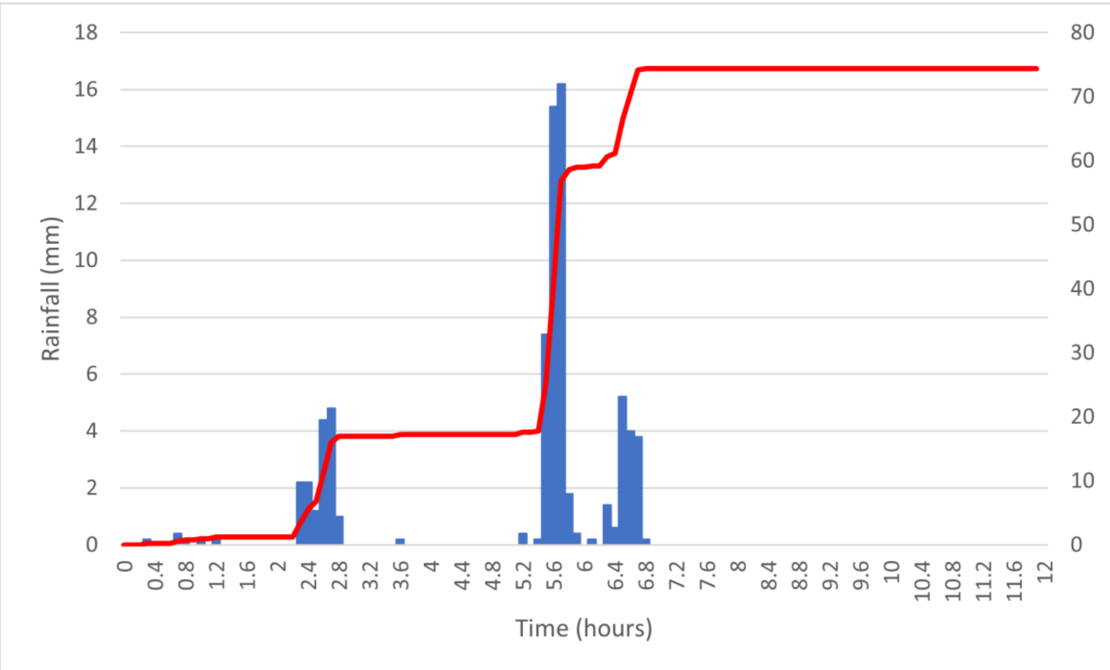

Figure 3-6 December 2011 event temporal pattern - Stawell Aerodrome gauge (079105)

3.3.3 Calibration data

The following calibration data sources were available from the December 2011 event:

- Video footage taken by Council staff showing inundation at various locations in Stawell during the event.
- Photographs taken by Council staff showing post-flood damage at Federation Park.
- Photographs taken by a resident showing inundation at the intersection of Ligar Street and Franklin Street.
- Articles in the Stawell Times newspaper with photographs showing inundation at Pomonal Road, Stawell Racecourse, Sloane Street and Cooper Street.
- Several anecdotal records specific to the December 2011 event are available, relating to inundation at specific properties:
  - The undeveloped road easement east of 73 White Street was not flooded in December 2011.
  - Flooding north of 6 Ormston Road reached halfway up the paddock located behind the property.
  - Properties near 9 Franklin Street were inundated.
  - Overland flow on Freeland Avenue moved through the backyard of 2 Freeland Avenue and reached shed on 5 Lindsay Court.
  - Water reached front fence on 5 Mareli Street.
  - Flooding did not reach the shed on 35 Holloway Road.
  - There was inundation in the backyard of 43 Burgh Street.
  - 22 Oregan Street is inundated in large events.
  - Flooding from Dawson Street and King Street entered Lindsay Court, but no above floor flooding was experienced.

3.3.4 Calibration result

Figure 3-7 and Figure 3-8 show the modelled flood depth for the December 2011 event for both study areas.

As mentioned in Section 3.2.4, the Stawell township catchment responds rapidly to incoming rainfall. The December 2011 storm event consisted of a short main burst (less than 30 minute) with very high intensity. The resulting runoff overwhelmed the drainage infrastructure and several wide overland flow paths were observed throughout the town. Pleasant Creek broke its banks and inundated a floodplain up to 700 m wide. Comparison between the modelled depth and calibration data at specific locations is presented below.

Wide overland flow paths were observed in the golf course catchment, flowing from the elevated areas in the western parts of the study area towards Jerrywell Creek. The creek escaped its banks along the entire reach.

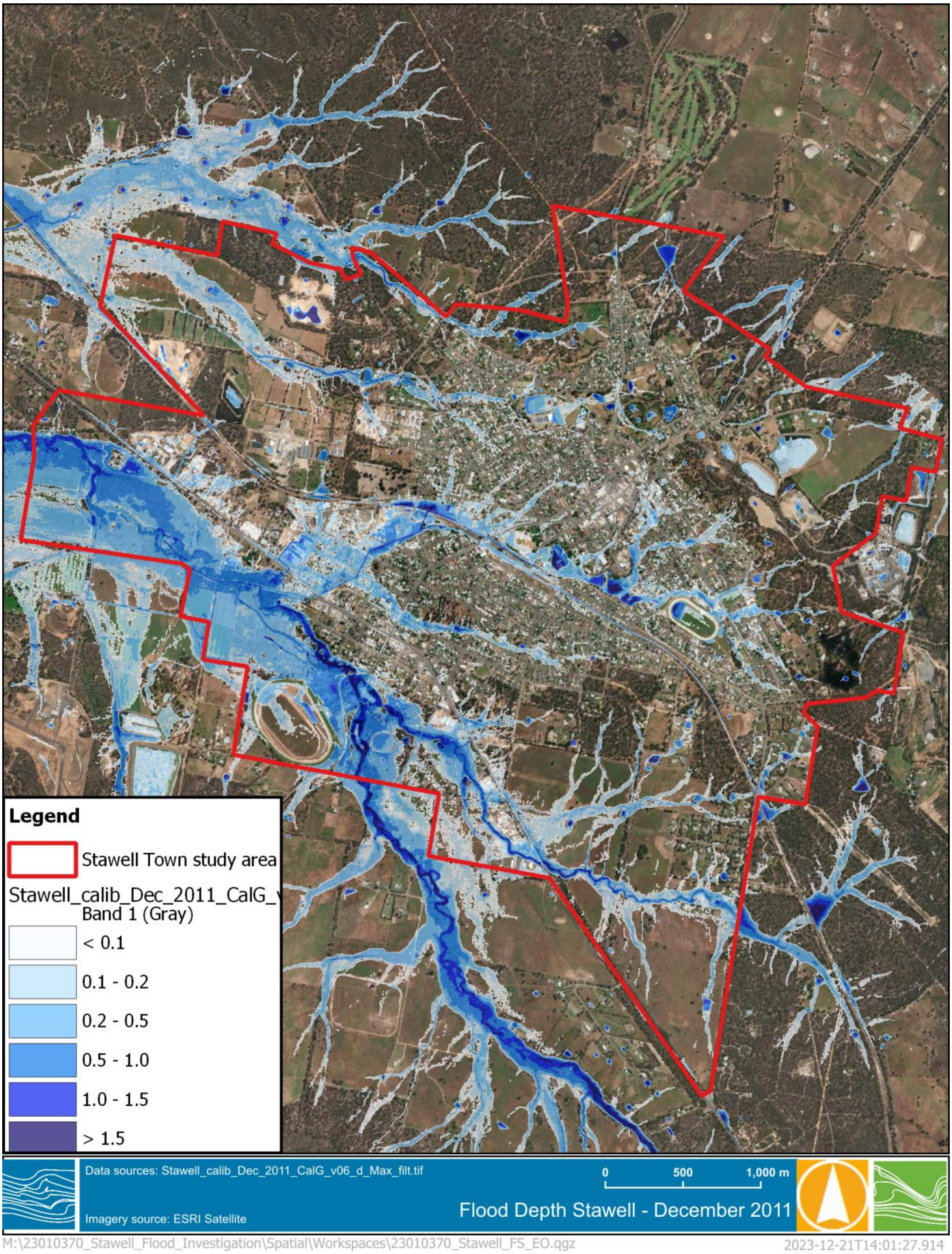

Figure 3-7 Calibration modelling flood depth Stawell – December 2011

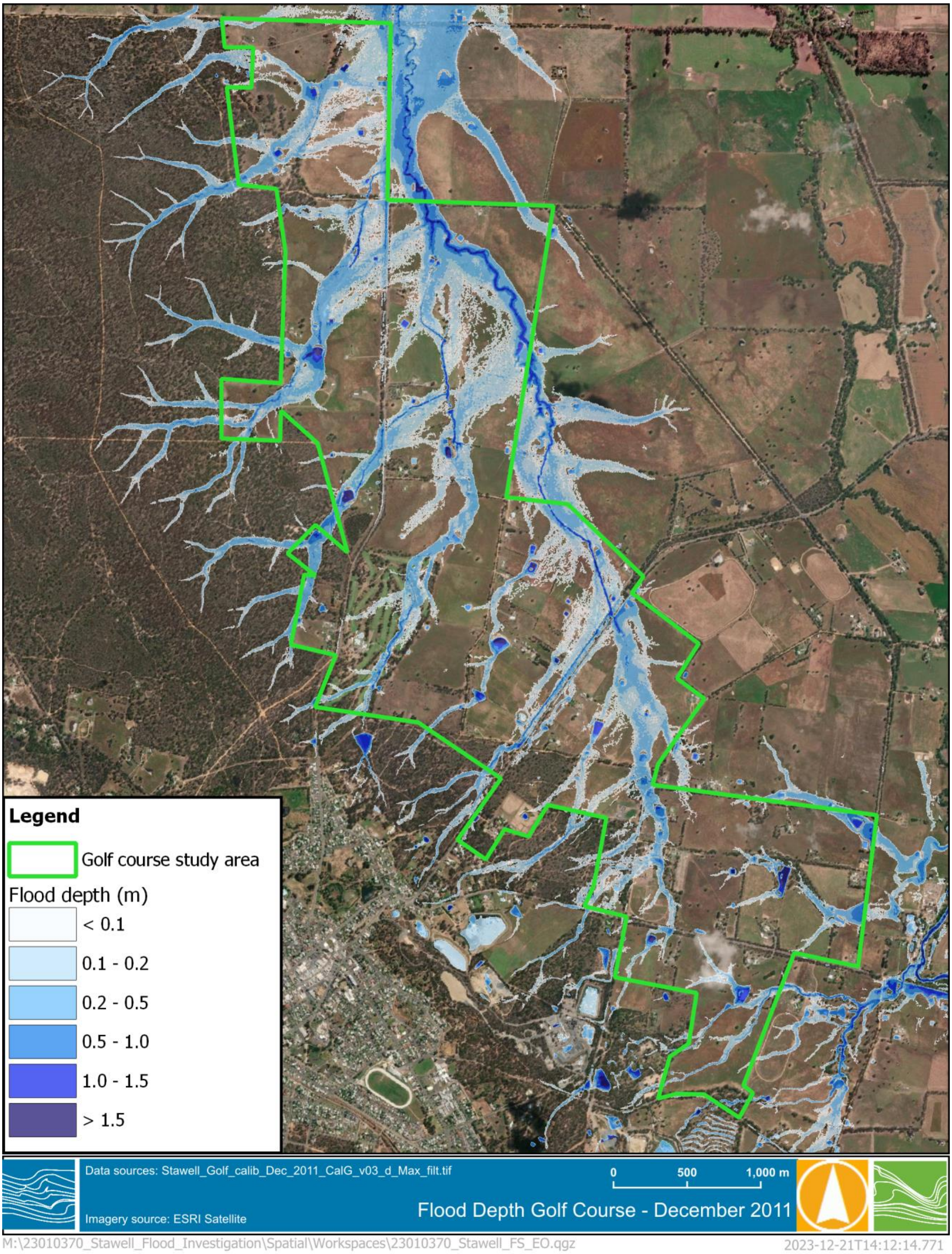

Figure 3-8 Calibration modelling flood depth golf course – December 2011

3.3.4.1 Northwest Stawell

Calibration information for northwest Stawell includes:

- No inundation of road easement near 73 White Street.
- Flooding in the paddock located behind 6 Ormston Road reached halfway up the paddock.
- Properties near 9 Franklin Street were inundated.
- Figure 3-9 shows flooding at the Ligar/Franklin Street intersection:

Figure 3-9 December 2011 inundation near Ligar Street / Franklin Street intersection

Figure 3-10 shows the modelled flood depth in this area. The flood extent and depth agrees with the anecdotal evidence and photographs.

Figure 3-10 December 2011 calibration modelling flood depth – northwest Stawell

3.3.4.2 Central Stawell

Calibration information for central Stawell includes:

- Water reached front fence on 5 Mareli Street.
- Figure 3-11 shows a photo from the Stawell Times showing inundation at Cato Park:

Figure 3-11 December 2011 inundation on Sloane Street at Cato Park

Figure 3-12 shows the modelled flood depth in this area. The flood extent at Cato Park agrees with the photograph, but the modelled depth (up to 0.5m) appears high. It is noted that the photograph may have been taken after the peak depth had occurred. The flooding would have reached peak depth and receded again rapidly after the peak storm burst. The modelling shows inundation of the 5 Mareli Street backyard, which was not mentioned in relation the record that water reaches the front fence. Further investigation into local topography and flood extent may be required.

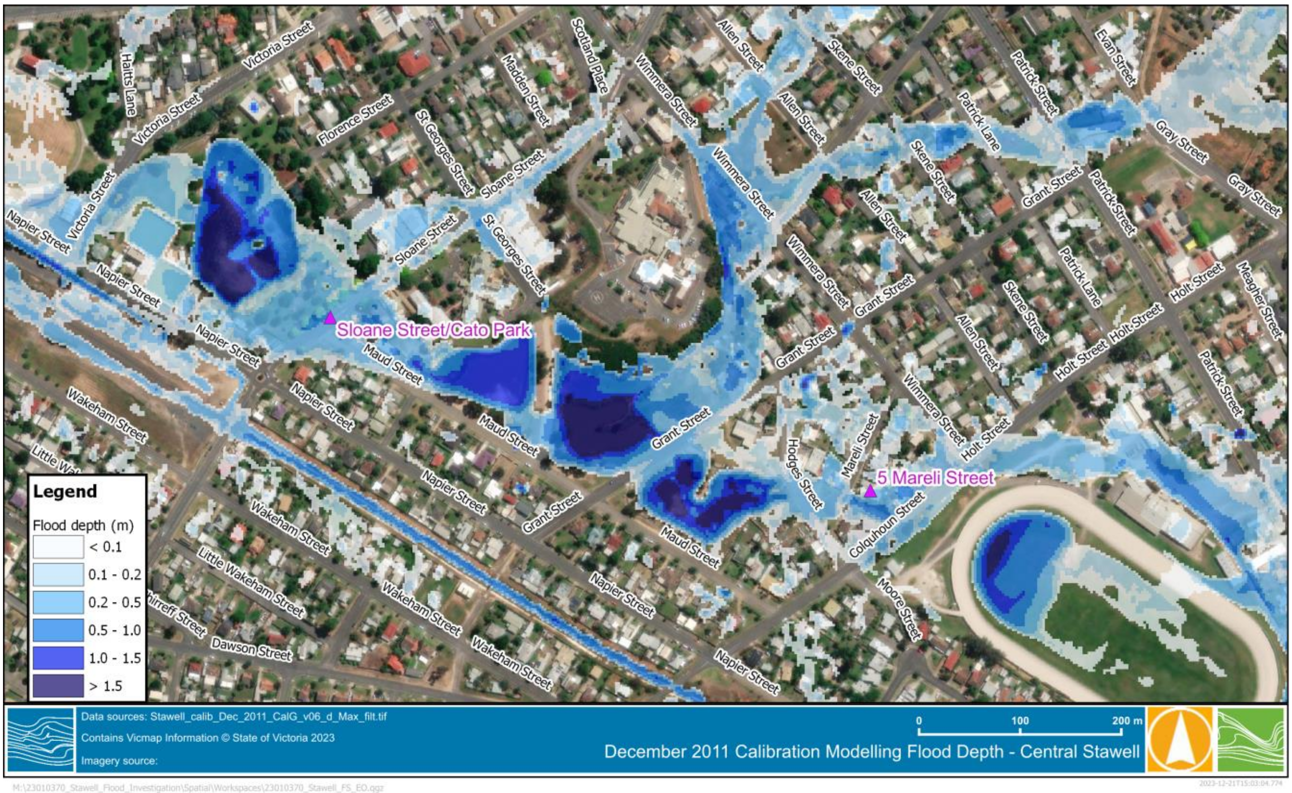

Figure 3-12 December 2011 calibration modelling flood depth – central Stawell

3.3.4.3 South Stawell

Calibration information for south Stawell includes:

- Overland flow on Freeland Avenue moved through the backyard of 2 Freeland Avenue and reached shed on 5 Lindsay Court
- There was inundation in the backyard of 43 Burgh Street
- Figure 3-13 from Stawell Times showing inundation at 51 Cooper Street:

Figure 3-13 December 2011 inundation at 51 Cooper Street

Figure 3-14 shows the modelled flood depth in this area. Flood depth and extent of the northern overland flow path in the map agrees with records provided, taking into account that the photograph may have been taken after the peak depth has occurred. No inundation is shown in 43 Burgh Street and there is a lack of flooding in the vicinity of this location, indicating that the model wouldn't show inundation here even if parameters are adjusted.

Figure 3-14 December 2011 calibration modelling flood depth – south Stawell

3.3.4.4 East Stawell

Calibration information for east Stawell includes:

- Flooding did not reach the shed on 35 Holloway Road.
- 22 Oregan Street is inundated in large events.

Figure 3-15 shows the modelled flood depth in this area. The modelled extent agrees with the provided information.

Figure 3-15 December 2011 calibration modelling flood depth – east Stawell

3.3.4.5 Federation Park

Calibration information for Federation Park consisted of photographs provided by Council showing widespread damage to walkways and bridges in Federation Park, taken after the end of the event.

Figure 3-16 shows the modelled flood depth in this area. The calibration modelling shows flood depths up to 1 m (outside of existing ponds) in this area, which could have caused the observed damage.

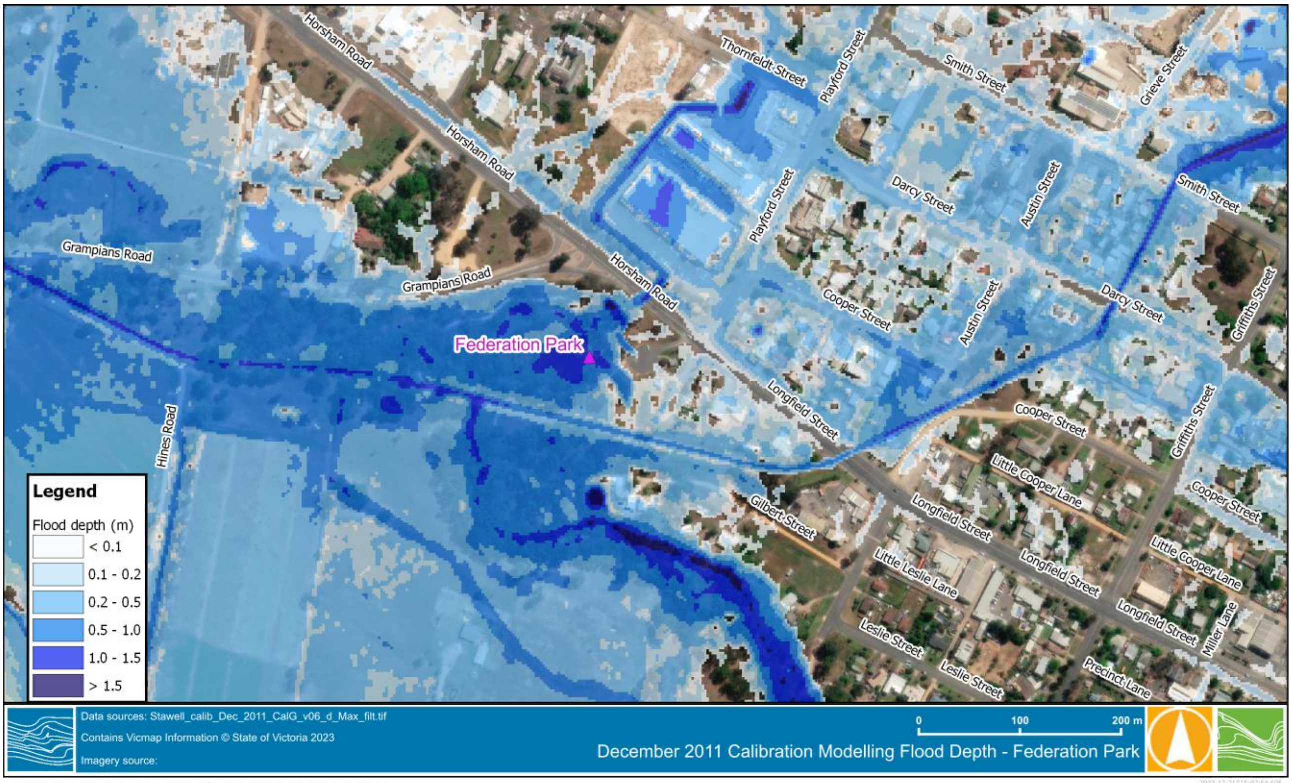

Figure 3-16 December 2011 calibration modelling flood depth – Federation Park

3.3.4.6 Stawell racecourse

Calibration information from the racecourse included two photographs from Stawell Times showing the inundation at the racecourse as seen from Pomonal Road, as shown in Figure 3-17 and Figure 3-18.


The rear of the Stawell Racecourse and the adjoining stables of Terry and Karina O'Sullivan were under water as nearby creeks failed to handle the sudden influx of water as a result of the storm.

Figure 3-17 December 2011 inundation at the racecourse (east side of Pomonal/Black Range Road)

Figure 3-18 December 2011 inundation at the racecourse (west side of Pomonal/Black Range Road)

Figure 3-19 shows the modelled flood depth in this area. Flood depth and extent matches with records provided, showing widespread inundation of both sides of Pomonal/Black Range Road.

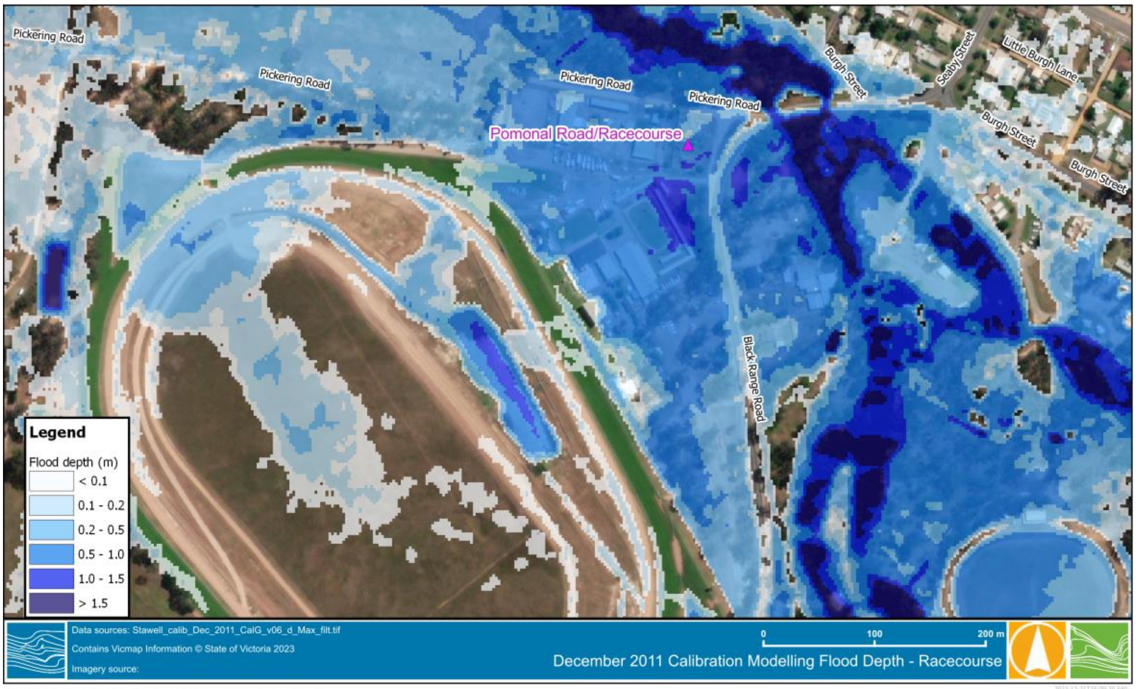

Figure 3-19 December 2011 calibration modelling flood depth – Stawell racecourse

3.4 Discussion

Modelling of the December 2011 event shows an acceptable match to the available calibration data sources, which are all qualitative. The lack of surveyed flood levels limits the ability to calibrate the model, and it is recommended that the results provided in this report are presented to the community for further review. Specific calibration data relating to the January 2011 event should also be sought.

4 DRAFT DESIGN MODELLING

The calibrated hydraulic model was utilised to produce a draft design flood depth map for the 1% AEP event. The draft 1% AEP flood depth for the two study areas is shown in Figure 4-1 and Figure 4-2.

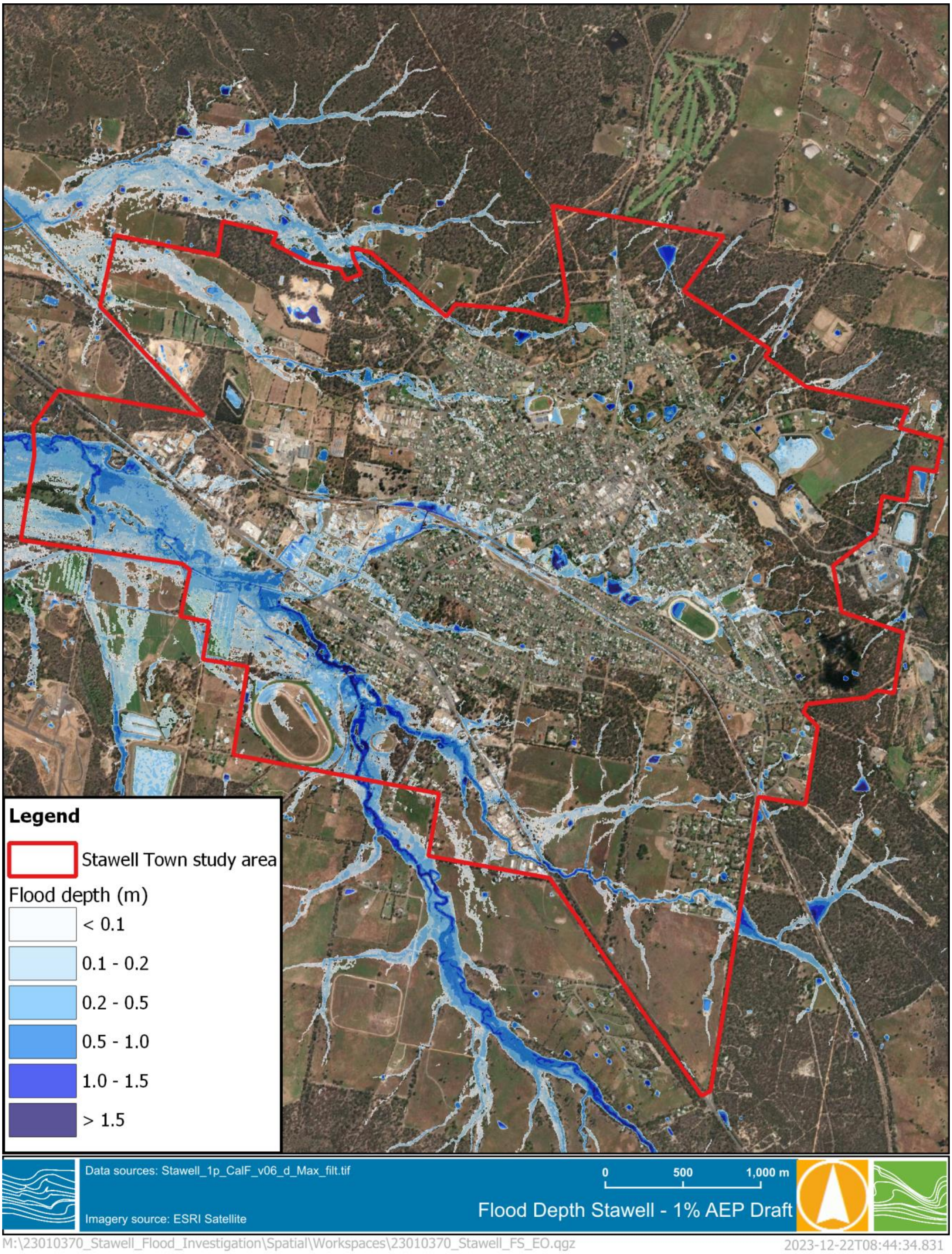

Figure 4-1 1% AEP flood depth Stawell study area

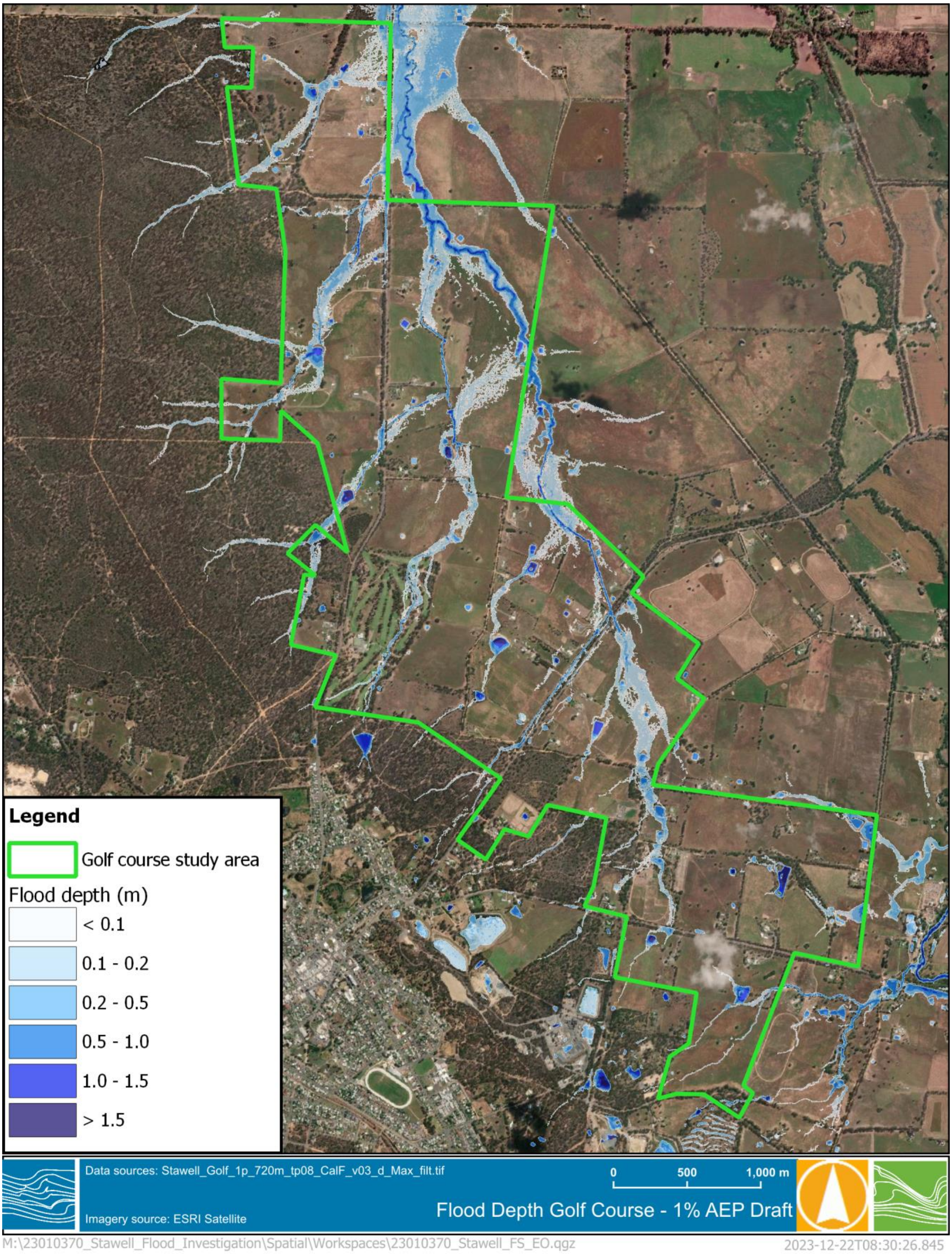

Figure 4-2 1% AEP flood depth Stawell Golf Course study area

5 SUMMARY AND NEXT STEPS

Modelling shows a generally acceptable match to the available calibration data sources. However, a lack of surveyed flood levels limits the ability to calibrate the model . The results provided in this report were presented to the community and Council staff who were able to provide additional confidence in the model results.

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