HEYFIELD WETLAND FLOOD STUDY

Heyfield Wetlands, Heyfield

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01	10/06/2024	Initial issue
02	30/10/2024	Updated CC modelling and extent change

Climate Change Statement

A wide range of sources, including but not limited to the IPCC, CSIRO and BoM, unanimously agree that the global climate is changing. Unless otherwise stated, the information provided in this report does not take into consideration the varying nature of climate change and its consequences on our current engineering practices. The results presented may be significantly underestimated; flood characteristics shown (e.g. flood depths, extents and hazards) may be different once climate change is taken into account.

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1. Introduction

Afflux Consulting have been engaged by West Gippsland Catchment Management Authority (WGCMA) to prepare a flood study for Heyfield Wetlands, Heyfield (Figure 1). This study will cover the flooding conditions in 0.5%, 1%, 2%, 5%, 10%, 20% and 50% AEP storm events, as well as the 1% and 10% AEP storm events under worst-case climate change scenarios (SSP5-8.5 for year 2100) within the wetland complex, including surrounding areas feeding into the wetland. The intention of this report is to:

- Provide an assessment of flooding associated with area.
- Provide assessment of any flood impacts on potential future developments within the area.
- Inclusion and consideration of guidelines and advice for stormwater management in line with Wellington Shire and WGCMA requirements.

To meet these requirements, a range of hydrological and hydraulic modelling has been undertaken.

Figure 1. Aerial of site

1.1. Information Sources

A number of information sources have been used in the formation of this strategy; these include:

- Site inspection.

- Aerial imagery.
- DEPI planning scheme and cadastral information as accessed online 03/01/24
- Discussions with Wellington Shire.
- Discussions and information as provided by WGCMA.
- Design Guidelines and Guidelines for Development.
- Various Environmental Planning instruments and Planning Frameworks.
- Preliminary plans and Site survey received from client.
- Past models and existing infrastructure information.
- Historic flood and water quality studies.
- Topographic information, including required LiDAR data sourced commercially.

2. Existing Catchment

The existing catchment has been delineated for contributing areas to the Heyfield wetland (Figure 2). The broader catchment drains south towards the wetland and existing floodplain. The wetland is approximately 27.2 hectares, servicing a regional catchment of approximately 543 hectares, which currently consists of farmland to the north and regional township to the east.

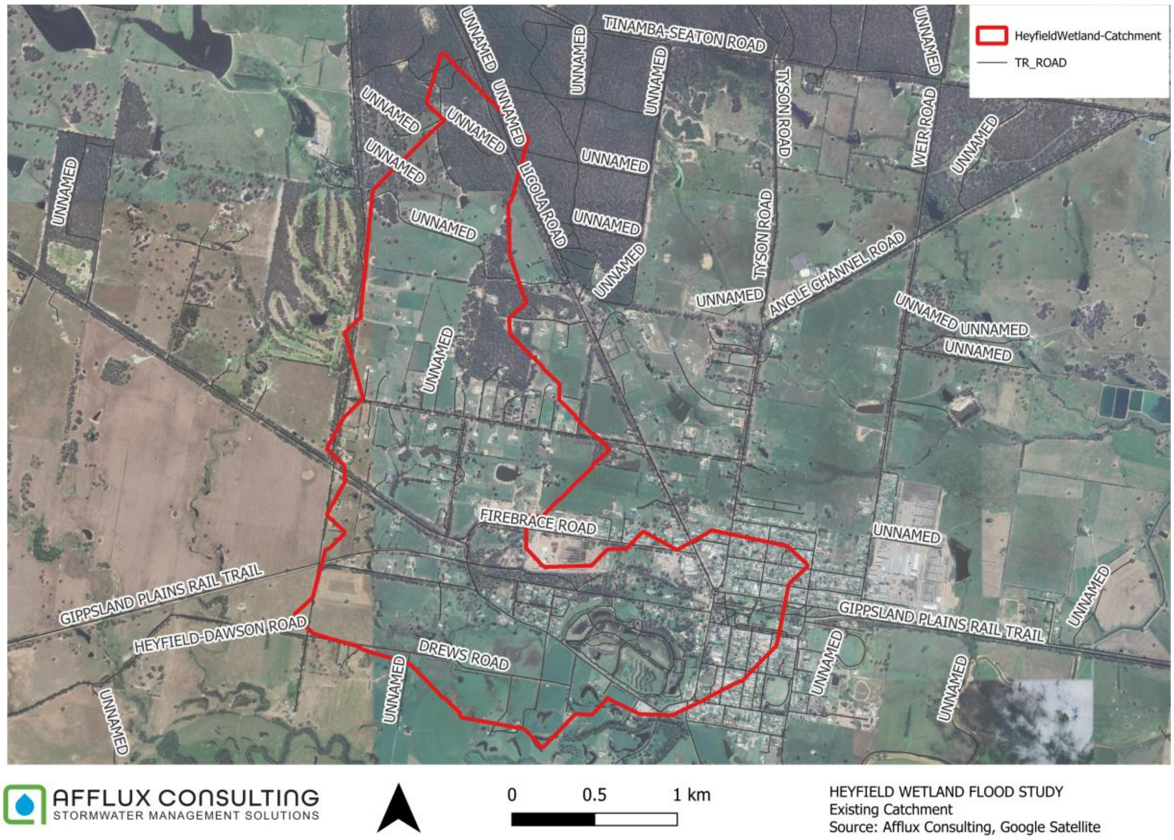


Figure 2. Existing catchment

2.1. Site Visit

A site visit was conducted to ascertain existing hydraulic controls within the area. A number of photos of the existing site can be seen in Figure 3 to Figure 6.

Source: Afflux Consulting

Figure 3. Culvert under Drews Rd

Source: Afflux Consulting

Figure 4. Stagg St, facing north towards Commercial Rd

Source: Afflux Consulting

Figure 5. *Floodplain, looking north from Drews Rd*

Source: Afflux Consulting

Figure 6. *Culverts under Stagg St*

2.2. Historic Flood Information

Information from the Upper Thomson River Flood Study Report, obtained from the WGCMA, provided sound hydrological information for inflows into regional flood models and flood shapes for comparison. The report was undertaken by Water Technology to produce updated information for the Upper Thomson River from Cowwarr Weir to Heyfield. The report provided data with which the hydrological models could be calibrated and acted as a reference point for catchment flows corresponding to the relevant catchment area for this site.

Whilst the report's focus was on the wider river system, there is certain information relevant to the wetland complex. Figure 7 below shows data for the gauge located at Thomson River (Gauge 225200), southeast of the wetland. This was used to inform tailwater conditions for the flood model and assess any impact on the flood extent from the river. This is discussed in subsequent sections of the report.

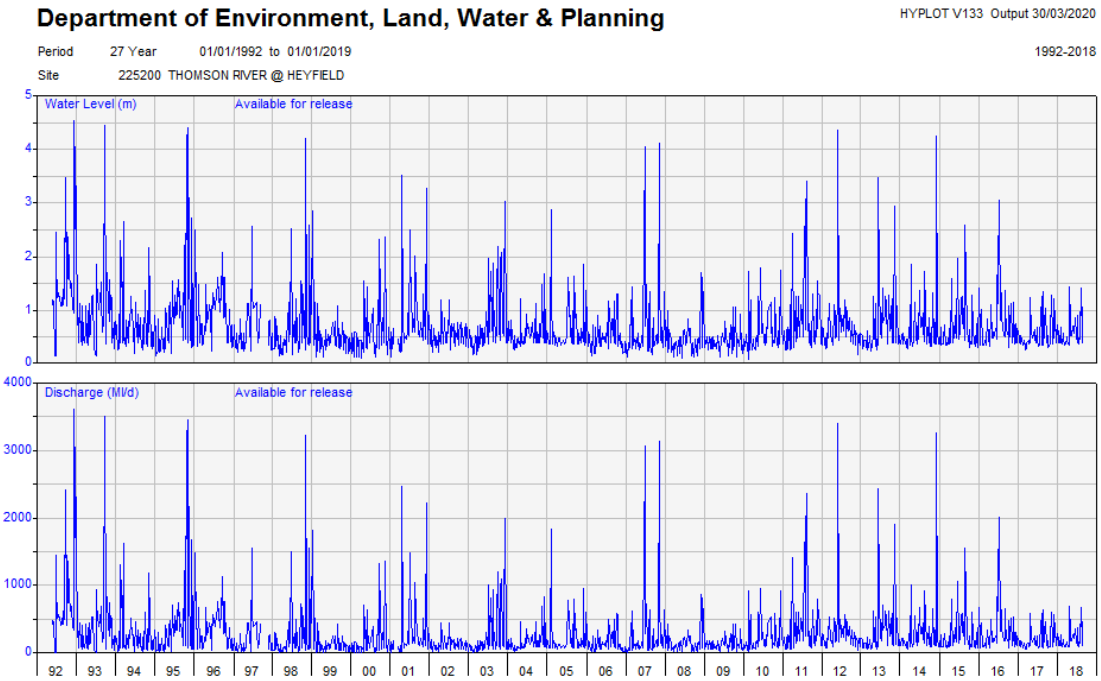


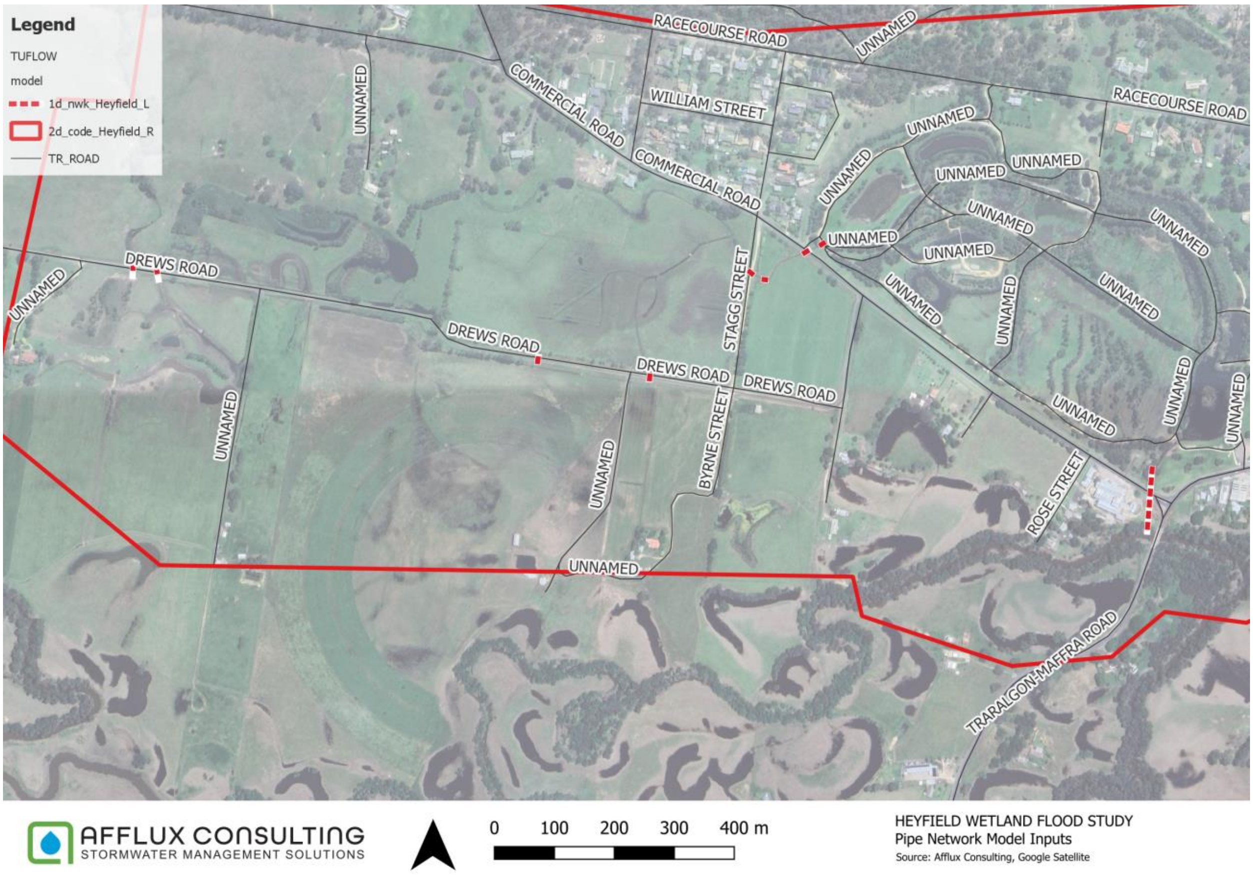
FIGURE 3-4 WATER LEVEL AND FLOW DATA– THOMSON RIVER @ HEYFIELD

Source: Upper Thomson River Flood Study, Water Technology, 2021

Figure 7. Water Level and Discharge plots

2.3. Drainage Infrastructure Data (Pipes, Culverts and Channels)

Pipes, pits, culverts, constructed channels and attenuation structures (etc.) represent hydraulic controls. These structures have the potential to alter flow conveyance through the floodplain and will need to be accurately represented within modelling. Alongside the aforementioned flood study, the conducted site visit provided locations of existing hydraulic controls. This information was then transferred into the hydraulic model and assessed for accuracy and inconsistencies. A schematic representation of these structures in the model is shown in Figure 8.



Source: Heyfield.ecf

Figure 8. Pipe network model inputs

3. Hydrology

To evaluate the hydrology of the proposed development a number of hydrological models have been formed and compared. This method has been chosen to best represent hydraulic influences and hydrologic challenges in the area.

3.1. Sub-Catchment Delineation

Sub-catchments are grouped by examining the drainage asset locations and expected flow direction. Catchment delineation for undeveloped areas is governed predominantly by topography and consideration of model inputs. Figure 9 depicts this delineation as being used in the resultant RORB model.

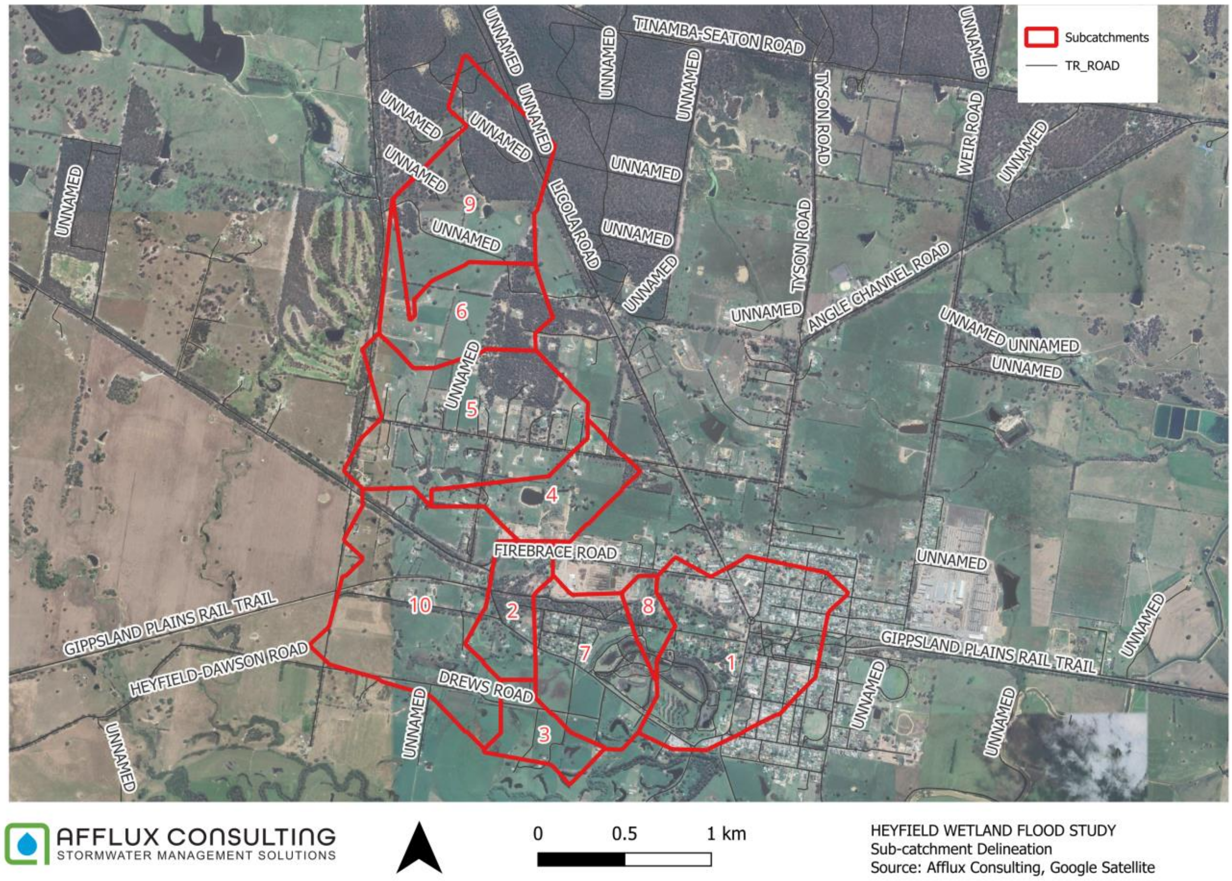


Figure 9. Sub-catchment delineation

3.2. Catchments and Reaches

The sub-catchments and reaches were then translated into a RORB model, as seen below (Figure 10). All sub-catchments within individual reaches are approximately the same area.

Each sub-catchment was then given a Fraction Impervious (FI) Value. The existing conditions FI's were based on topography and industry recommended FI values. Reach lengths and slopes were calculated based on the existing terrain. All existing channels were modelled as unlined channels, with the urban areas modelled as type 3 and a drowned type 4 for the wetland. The RORB model is shown in Figure 10.

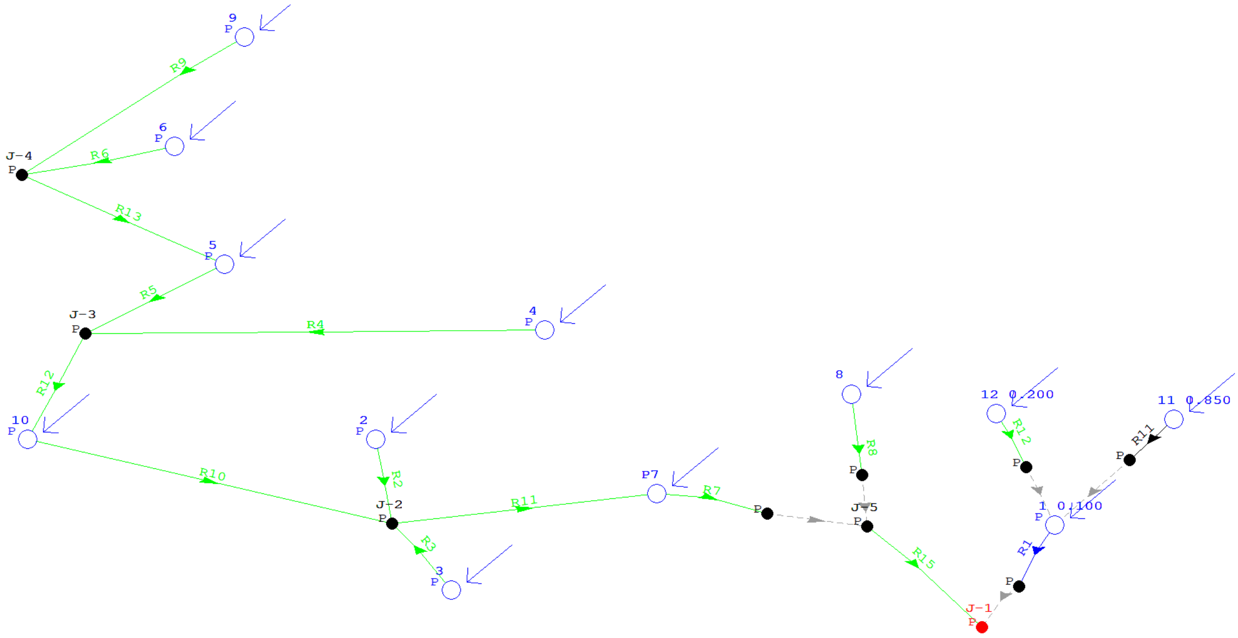


Figure 10. RORB model sub-catchment area and Fraction Impervious

In order to simplify the modelling approach, we have not split surface areas by effective impervious area (EIA) and indirectly connected area (ICA). This methodology contains various uncertainties in estimation when splitting EIA and ICA and may not produce more accurate results. Rather, it adds additional and unnecessary complexity to the model, particularly in a largely rural catchment area. Therefore, leaving the model with general loss assumptions will produce appropriate conservative results in this instance. This is consistent with the approach to consider and use better available information, as recommended by ARR19.

3.3. Rainfall Information

Rainfall depths were extracted from the BoM IFD database. The temporal rainfall patterns were taken from the ARR Data Hub as per guidelines and as shown below in Figure 11, the Southern Slopes VIC/NSW data set was applicable to this site.

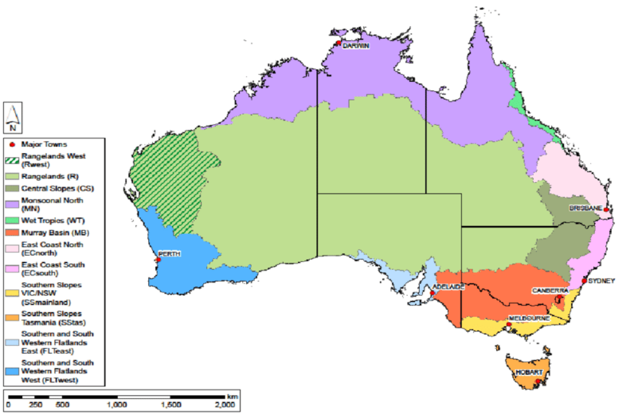


Figure 11. Map of temporal pattern regions

3.4. Rainfall Losses

In addition, the ARR Data Hub provides recommendations for losses, as shown below in Figure 12 and Figure 13. The ARR19 tool estimates losses and reductions using the information from Data Hub. The supplied loss file was found to be suitable with loss factors appropriate to the catchment. Once the estimated rainfall magnitudes are decided upon, the hydraulic model is used to distribute the flows.

Table 1. ARR Data Hub Design Losses

Loss	Initial Loss	Continuing Loss
Value	18.0	3.1

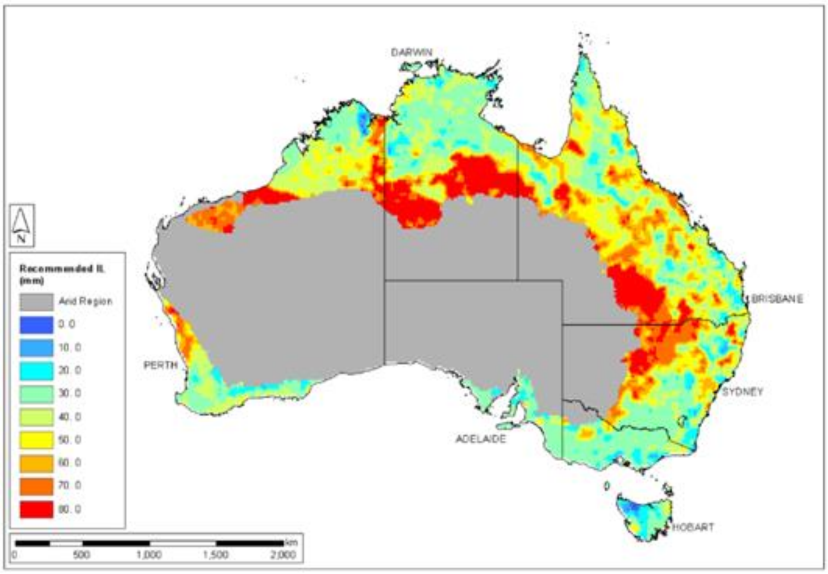


Figure 12. ARR 2016 recommended Initial Loss

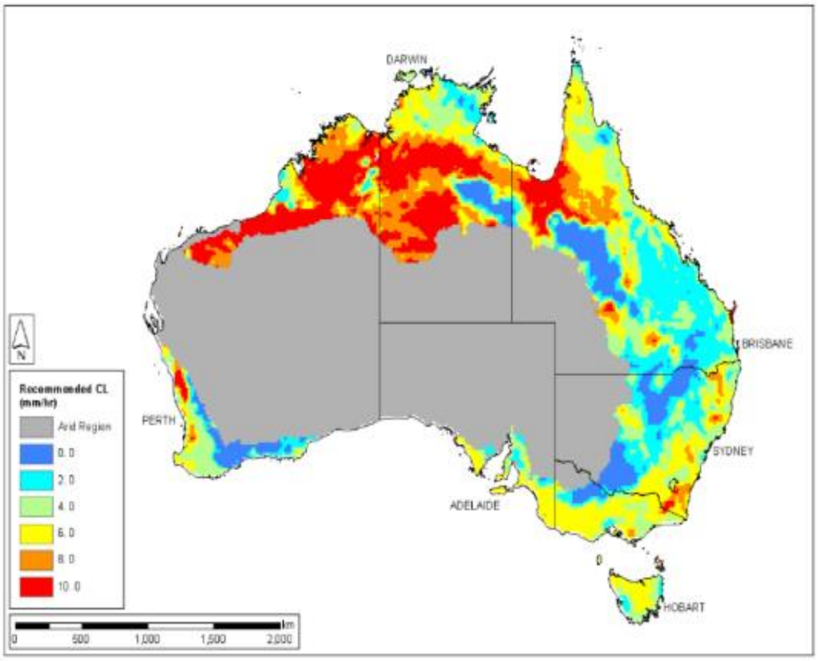


Figure 13. ARR 2016 recommended Continuing Loss

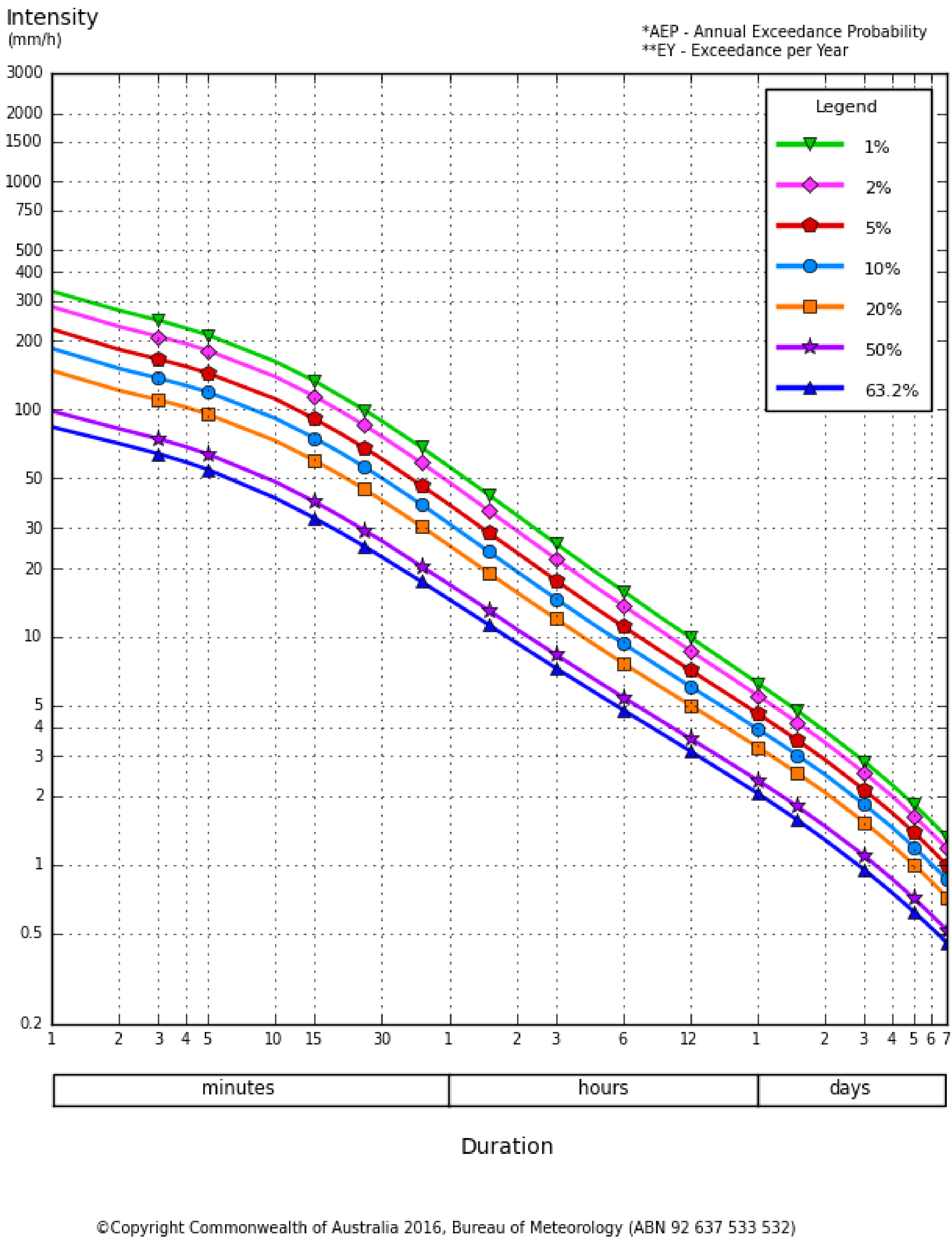


Figure 14. Rainfall Intensity data (mm/hr)

3.5. Catchment Flows Verification

To ensure results are within the expected range, the catchment flows we reconciled to a number of regional equations, as shown below in Figure 15. Based on the range of flows and larger data set, the RFFE flow estimation was adopted for the 1% AEP.

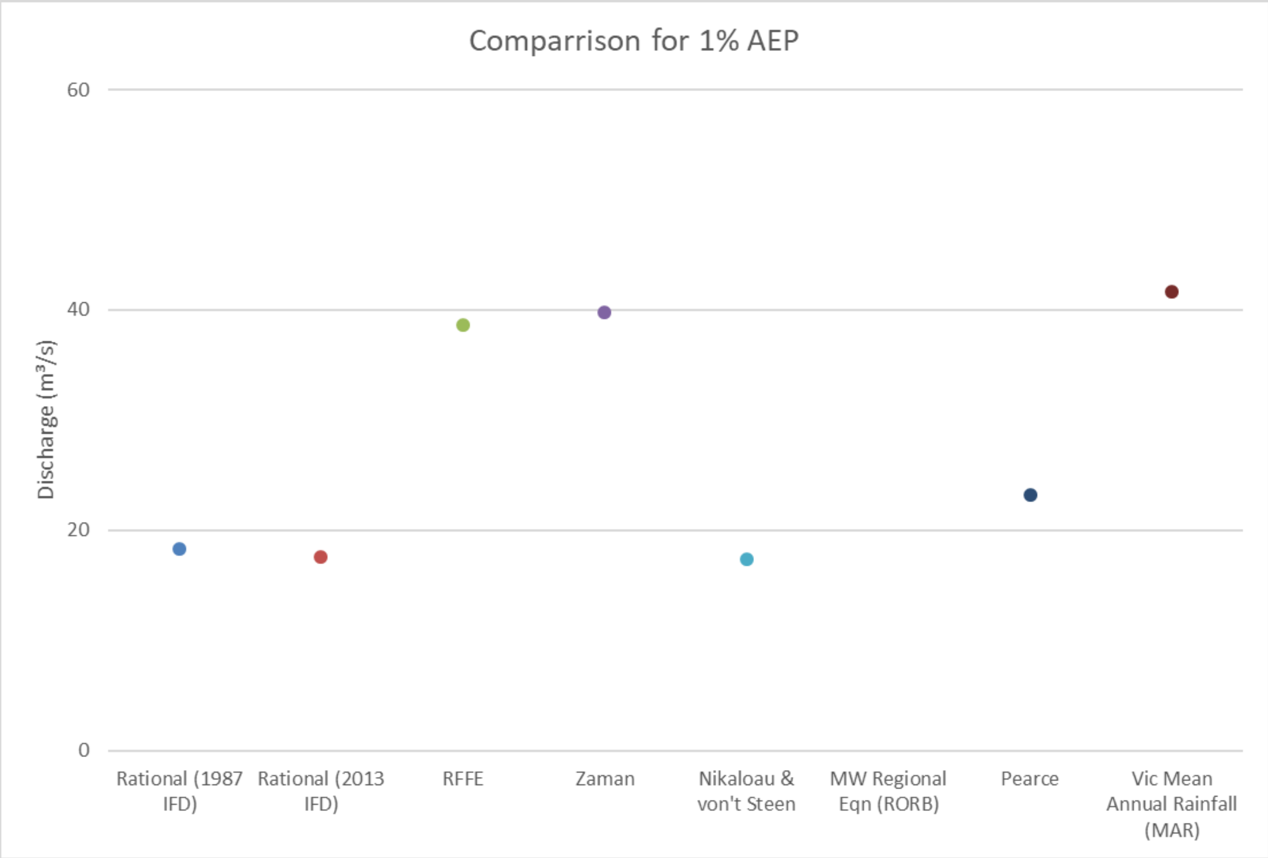


Figure 15. Catchment Flows – Regional Estimates

Adopted Flow Model Results

The model was run to reconcile the regional flood estimations. The Modelled flow comparisons for the 1% AEP storm can be seen in Figure 16 for the ARR19, ARR87 and Climate Change peaks. The full suite of duration flows can be seen in Figure 17.

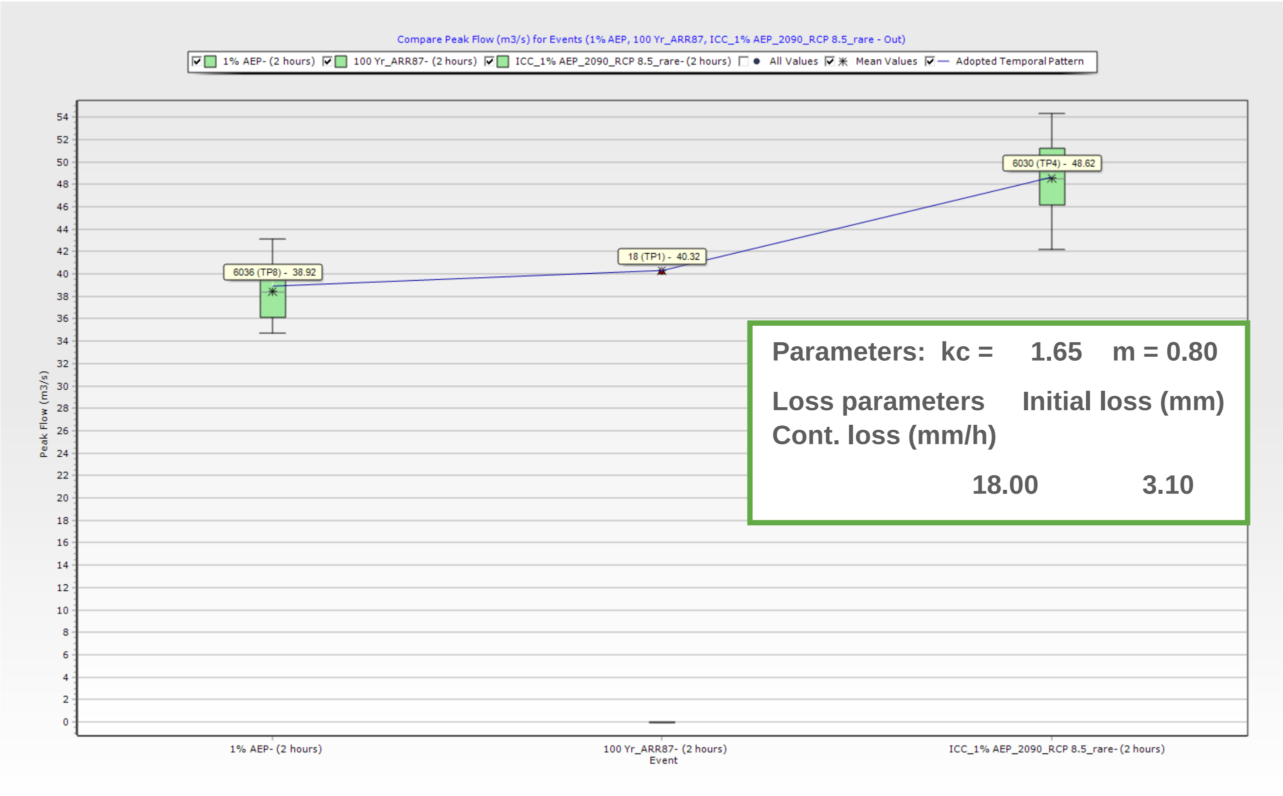


Figure 16. Modelled flow comparison

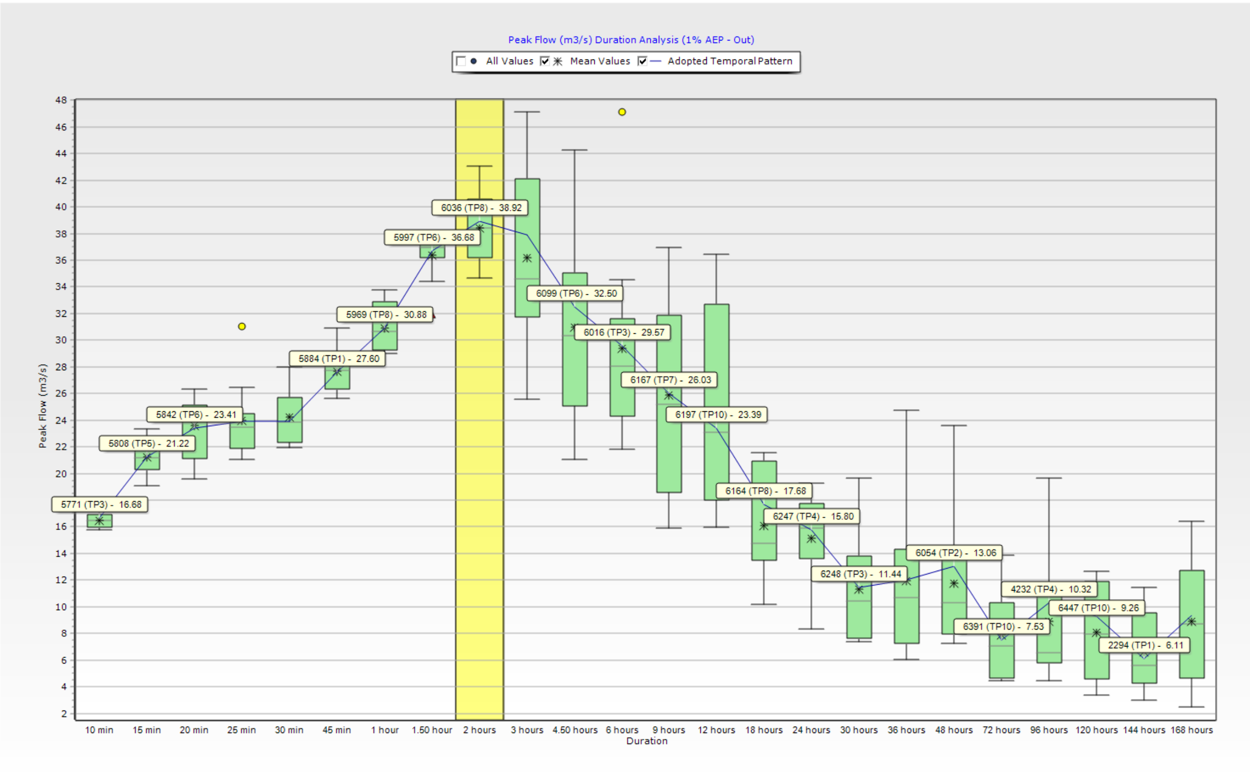


Figure 17. Peak 1% AEP Flow all durations

17.1. RORB Results

Based on the adopted flow results, the full Ensemble Event approach was adopted, as per ARR2019 guidelines, involving the use of a set of 10 temporal rainfall patterns for all durations and AEPs. All temporal patterns were run from the 15-minute storm to the 168-hour storm from gauged local catchments to derive a set of hydrographs for each event AEP. Each hydrograph was run through the hydrologic model; however, only the mean for the critical duration storm results was selected for design as recommended. The results for 1% AEP are shown in Figure 18.

The full set of flows for all AEP's are shown in Figure 19.

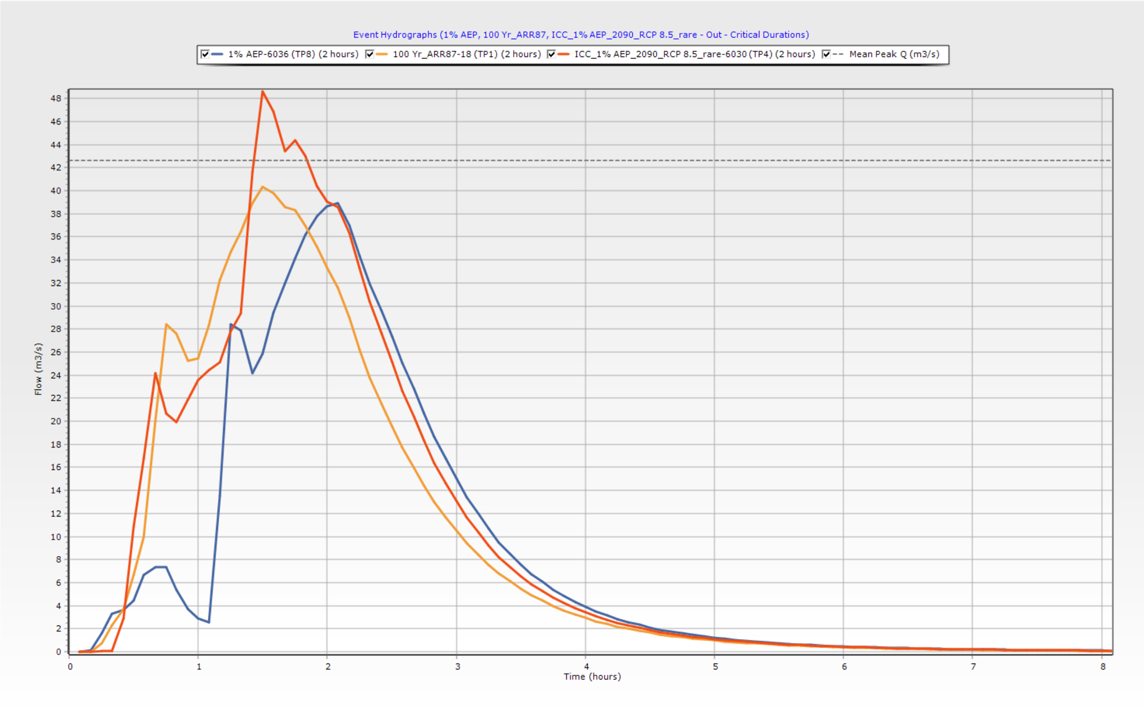


Figure 18. RORB model flow hydrograph to be applied for 1% AEP storm event

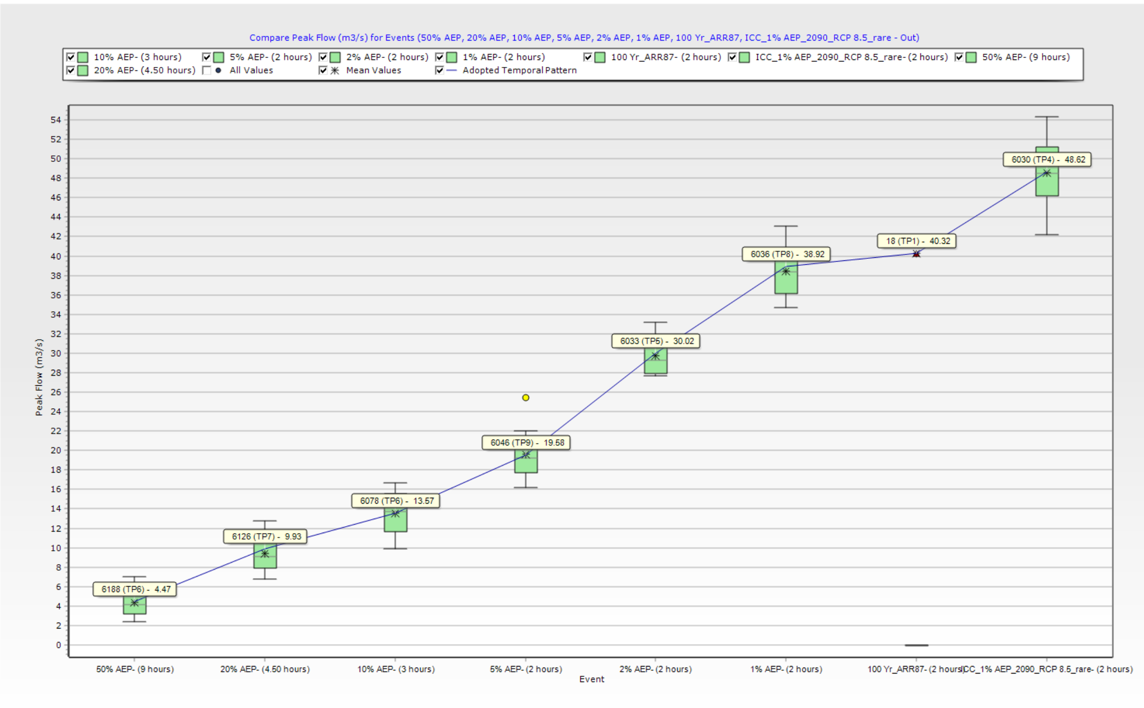


Figure 19. All AEP storm peak flows

4. Flood Modelling

As part of flooding investigations for the site, the regional and local stormwater conditions were considered. The major influencing factors include the impact of flooding from rainfall on the immediate catchment, as well as interactions with greater regional flows and relevant upstream events. The main considerations include the availability of floodplain storage, safe overland flow conveyance, water surface levels in relation to proposed developed floor levels and any changing impacts to neighbouring properties.

Once the estimated rainfall magnitudes were decided upon (discussed within Hydrology section), a high-definition model was constructed to understand flood mechanisms during different AEP storm events. The model was built and run in TUFLOW using a linked 1d/2d approach, parameters, and data sources.

4.1. Topographic Data

Commercially supplied LiDAR data was used as the base information to generate the Digital Elevation Models (DEM), informing surface elevations required for the model. There is some discrepancy in data on the western side of the model, as shown in Figure 20. However, as the modelling will show, this area lies outside the location of interest – namely, the floodplain immediately southwest of the wetland – and, therefore, has a negligible impact on the model results. LiDAR survey information is shown in Table 2.

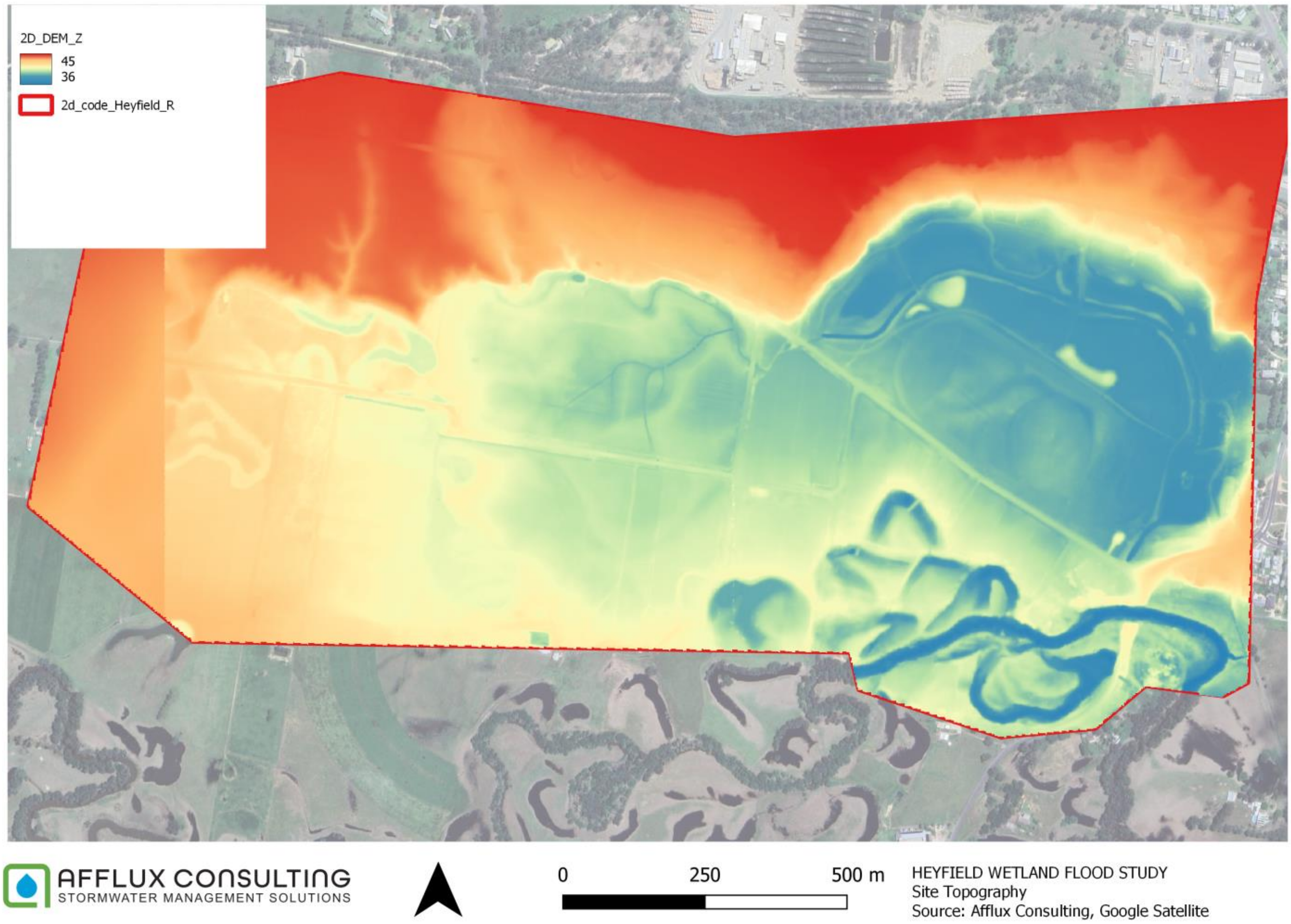


Figure 20. Site topography

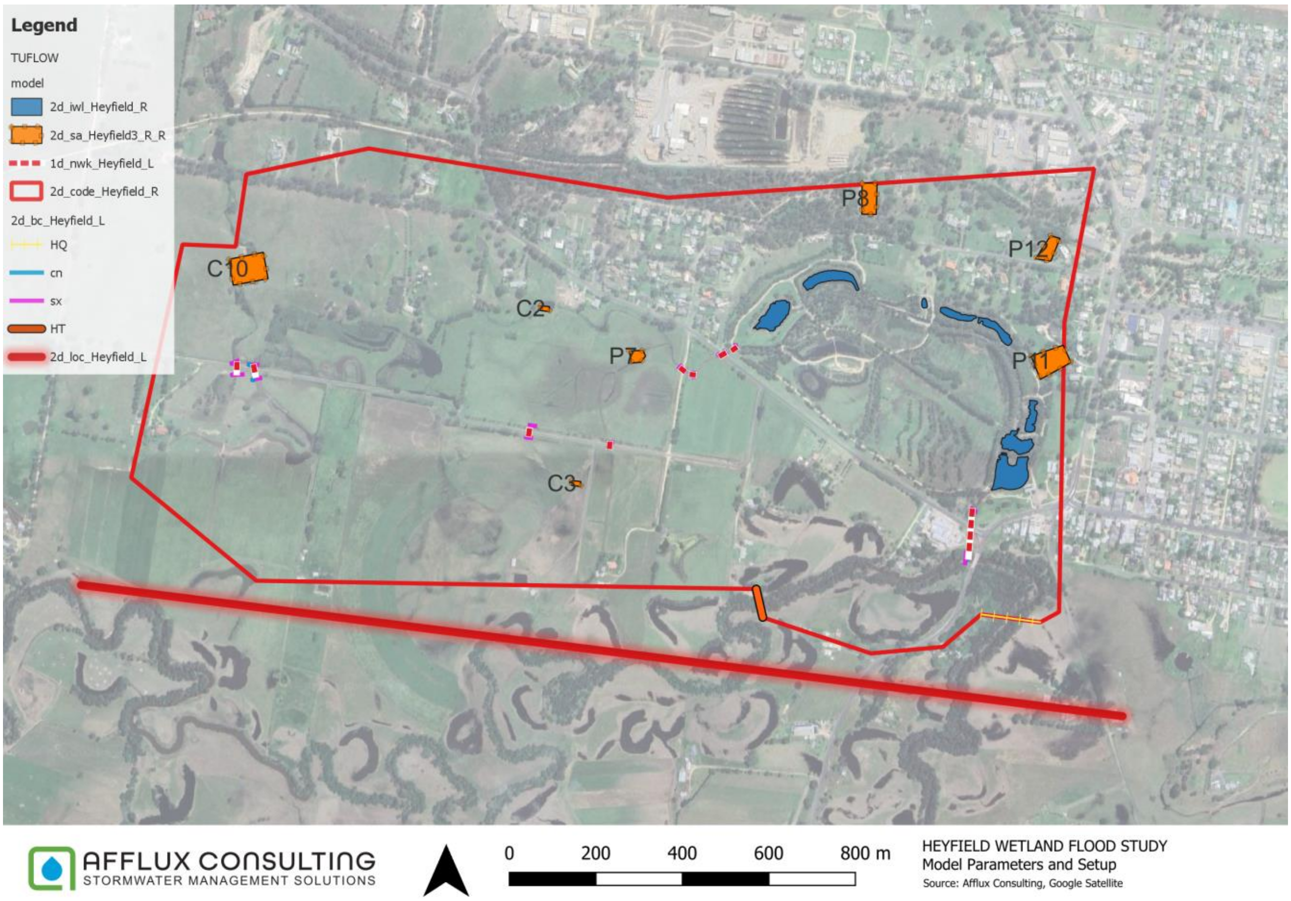
Table 2. LiDAR survey metadata

LiDAR survey metadata	CEP09	CEP06
Acquisition Start Date	29/12/10	11/4/18
Acquisition End Date	10/2/11	23/4/18
Horizontal datum	GDA 1994	GDA 2020
Vertical datum	AHD	AHD
Map projection	MGA zone 55	MGA zone 55
Horizontal accuracy	+/- 20 cm	+/- 30 cm
Vertical Accuracy	+/- 10 cm	+/- 20 cm

4.2. Model Parameters

The initial model setup for the catchment model involved accessing survey surface levels and a setup of existing drainage networks for the model area. The model extent is based on topographical catchment boundaries. Land use in the model has been determined based on inspection of aerial imagery and visual inspection and has been used to inform Manning's roughness factors in the model. Downstream boundary conditions have been established based on an examination of topography. This has been set a considerable distance downstream of the proposed assets to ensure no undue model boundary influence.

A schematic representation of the model can be seen in Figure 21 below.



Source: Heyfield.tcf

Figure 21. Model parameters and setup

4.3. Model Reporting and Analysis

The model has been set up to report the following key indicators:

- Water Surface Elevation (WSE) showing the water level relative to a datum (m AHD) at each model grid cell.
- Maximum water depths for each model grid cell.
- Maximum water depths at defined reporting cross sections immediately onto and off the site.
- 2D Time-Series Plot Output (PO) and Map Output data at various locations across 1D and 2D networks.

Analysis of results will show WSE and water depth based on flood conditions and will be used to establish flood extents on the property. The 2D Time-Series Plot Output (PO) data provide Flow-Time hydrographs at user-defined locations. Additionally, the 1d connections report Flow-Time hydrographs for assessment and validation of underground drainage network systems.

Based on the assessment of these results, recommendations for flood extents and floor levels for potential future development will be made.

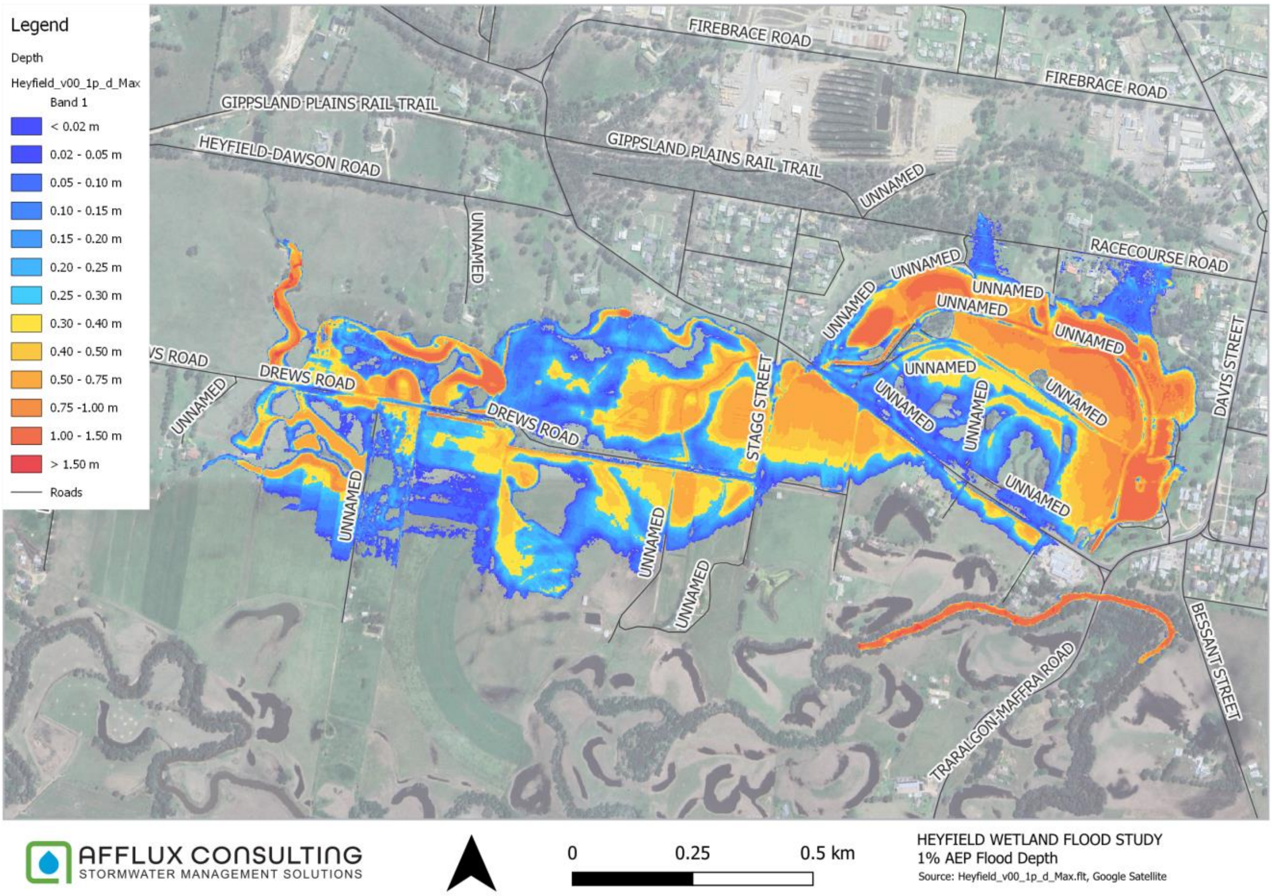
4.4. Existing Conditions

Flows for critical storms were run through the area defined by the local model extent in Figure 21 (as defined in the Hydrology section). This enables the identification of the flood extent and its impact on the wetland and surrounding sites.

The assumptions made for this model include:

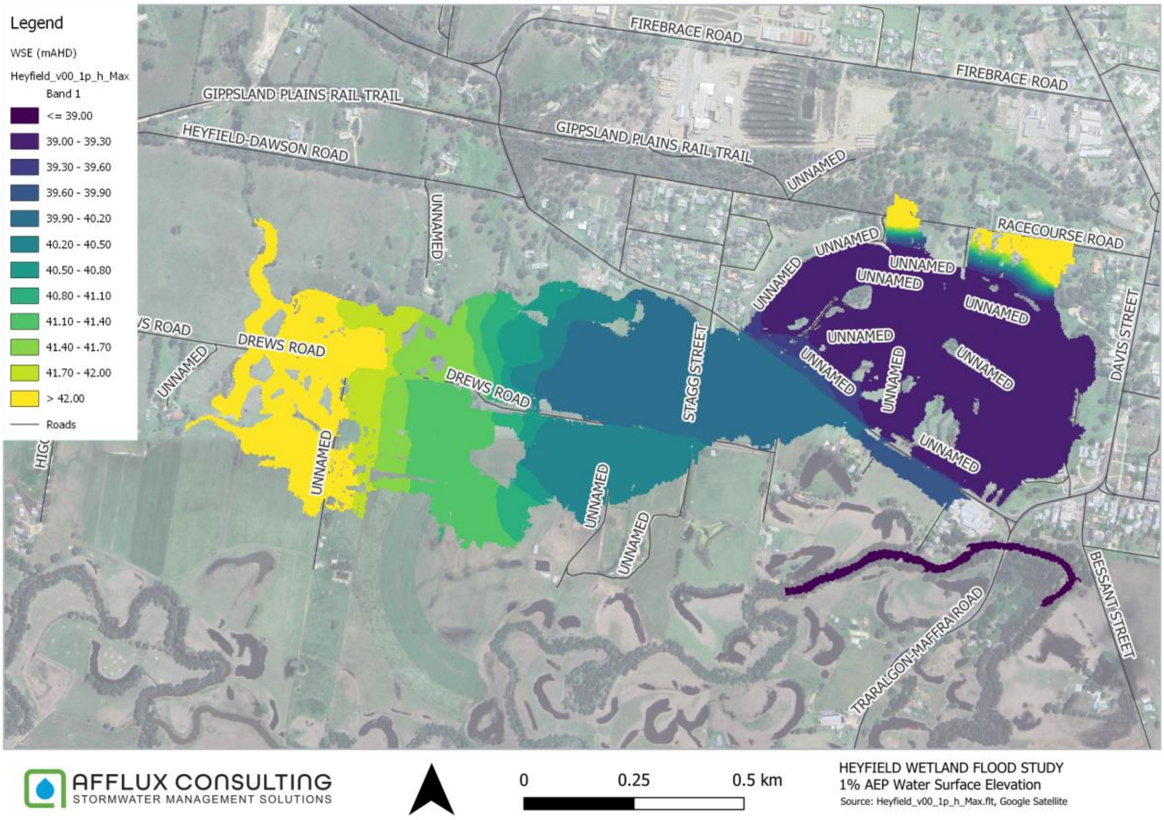
- The 0.5%, 1%, 2%, 5%, 10%, 20%, and 50% Annual Exceedance Probability (AEP) storms presented
- Inflows from key locations were defined by the larger hydrology model
- 3 m grid resolution and a time step of 1.5 seconds were used

The flood model results for the 1% and 10% AEP storms are shown below. Results for other AEP events can be found in Appendix A.



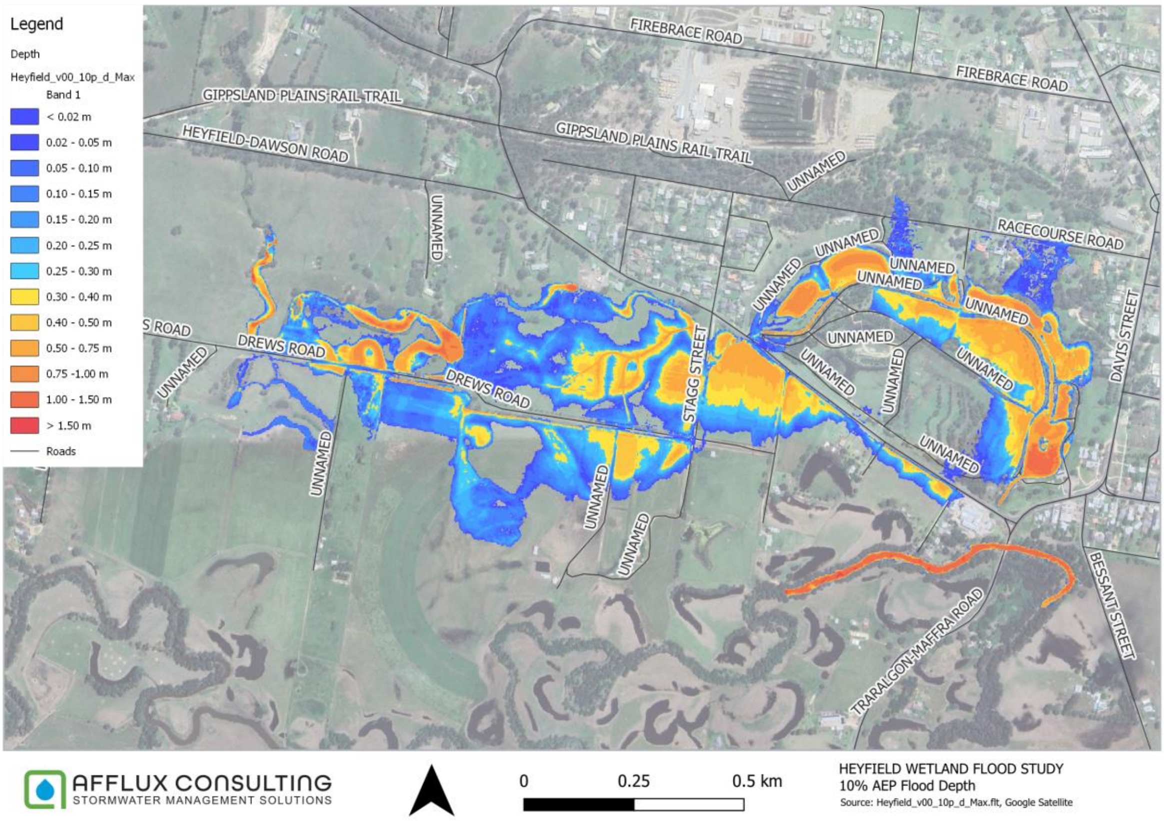
Source: Heyfield_v00_1p_d_Max.flt

Figure 22. 1% AEP Flood Depth Estimate



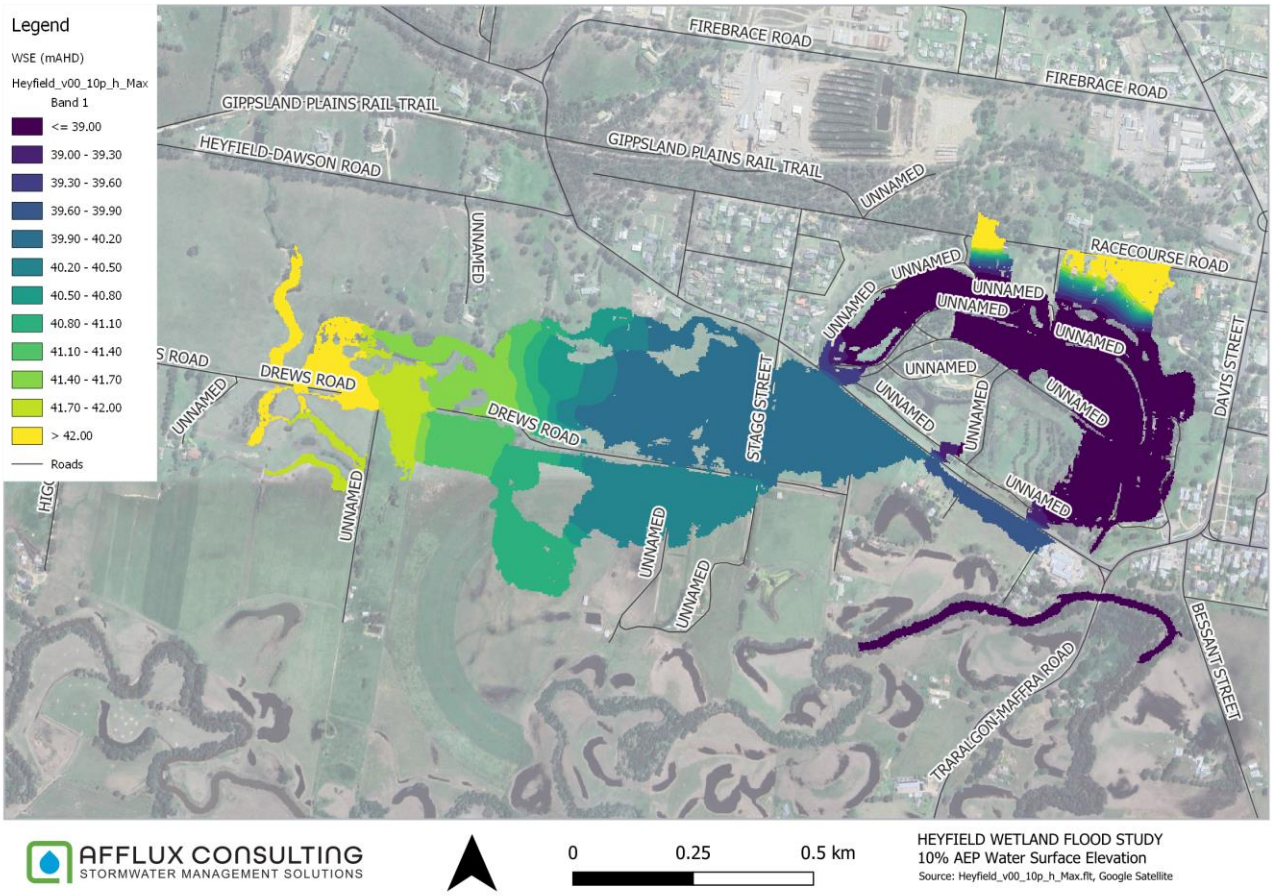
Source: Heyfield_v00_1p_h_Max.flt

Figure 23. 1% AEP WSE Estimate



Source: Heyfield_v00_10p_d_Max.flt

Figure 24. 10% AEP Flood Depth Estimate



Source: Heyfield_v00_10p_h_Max.flt

Figure 25. 10% AEP WSE Estimate

5. Sensitivity

For a more conservative analysis, sensitivity testing was conducted. In this project, flows from a rare event (0.5% AEP) and climate change scenarios were simulated. These simulations are expected to produce higher flood levels and larger flood extents.

0.5%AEP (1 in 200 year) Storms

Critical flows for 0.5% AEP were extracted and ran through the flood model. The corresponding flood results are shown in Figure 26 and Figure 27.

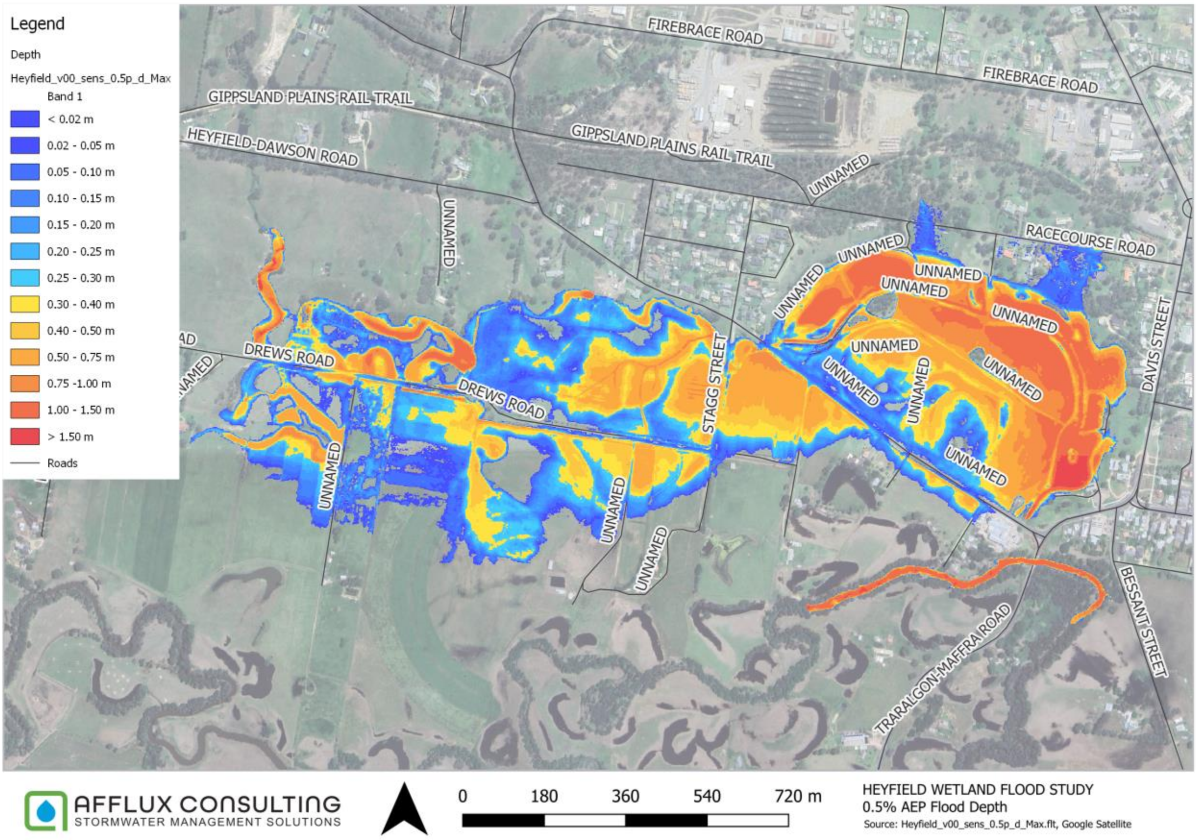


Figure 26. 0.5% AEP Flood Depth Map

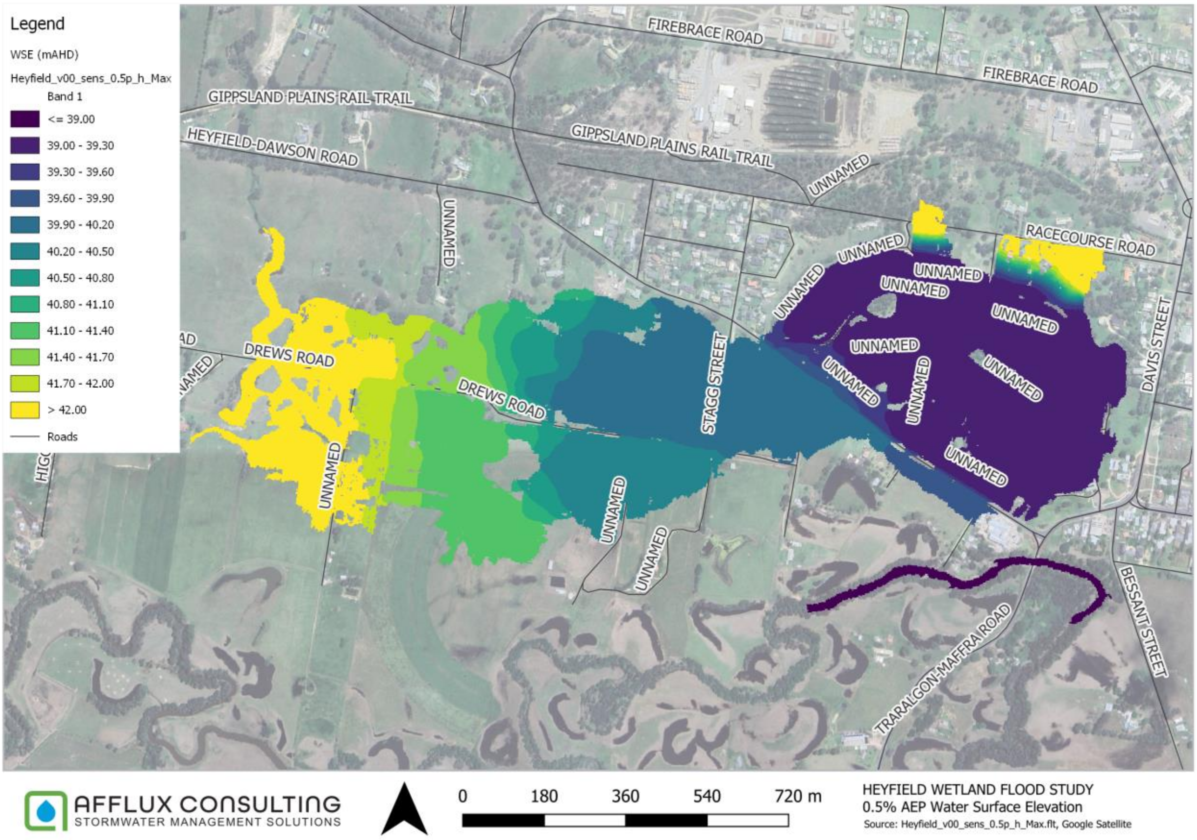


Figure 27. 0.5% AEP Water Surface Elevation Map

Climate Change

Sensitivity checks through climate change have been performed in subsequent analyses to assess the effects of climate change on the flood extent. The Shared Socioeconomic Pathways (SSPs) project the temperature changes from the current year to 2100. It covers different emissions pathways described as follows: very low (SSP1-1.9), low (SSP1-2.6), medium (SSP2-4.5), high (SSP3-7.0) and very high (SSP5-8.5). As of the time of writing, the Australian Rainfall and Runoff guidelines has moved away from the Representative Concentration Pathways (RCP) approach and has been superseded by the SSPs. Current worst-case scenario is described by SSP5-8.5 for the year 2100 as shown in Figure 28.

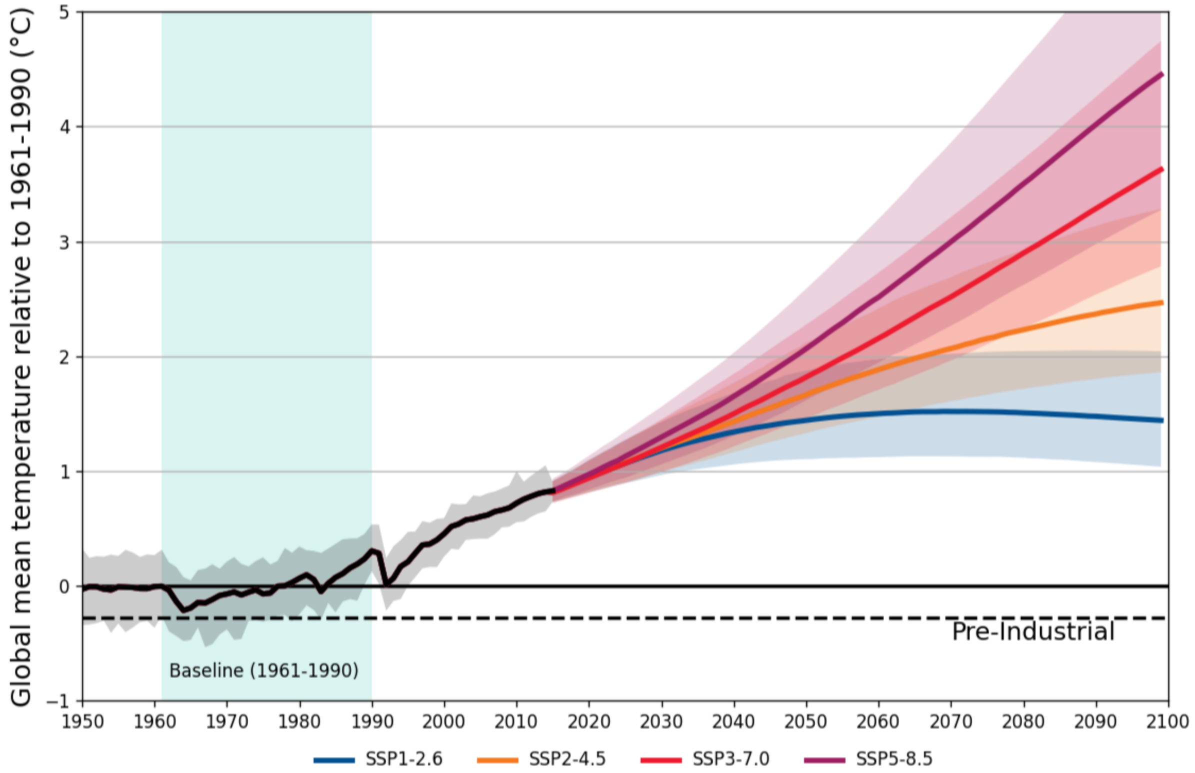


Figure 28. Projected temperature increases associated with AR6 socioeconomic pathways relative to 1961-1990 and their associated uncertainty

The critical flow hydrograph for a 1% AEP and 10% AEP storm events under SSP5-8.5 conditions is shown through Figure 29 and Figure 32. The depth output plots for these flows are shown in Figure 33 and Figure 34. Other flood outputs can be found in Appendix A.

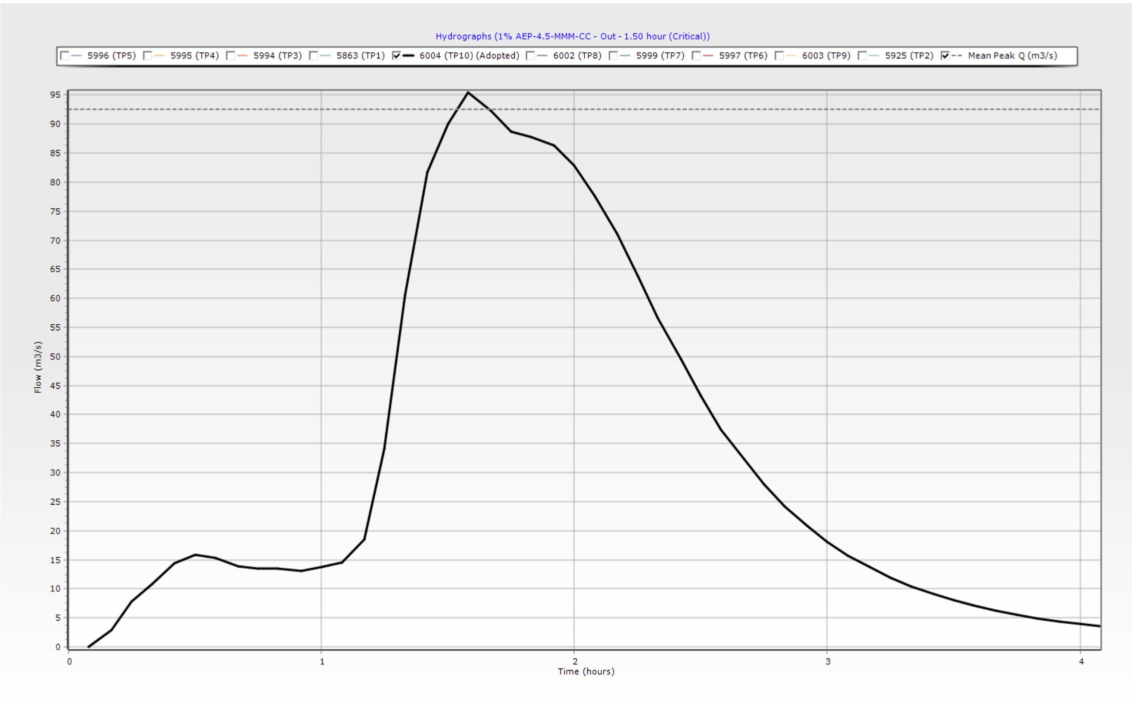


Figure 29. Flow hydrograph for 1% AEP Worst-Case Climate Change Scenario

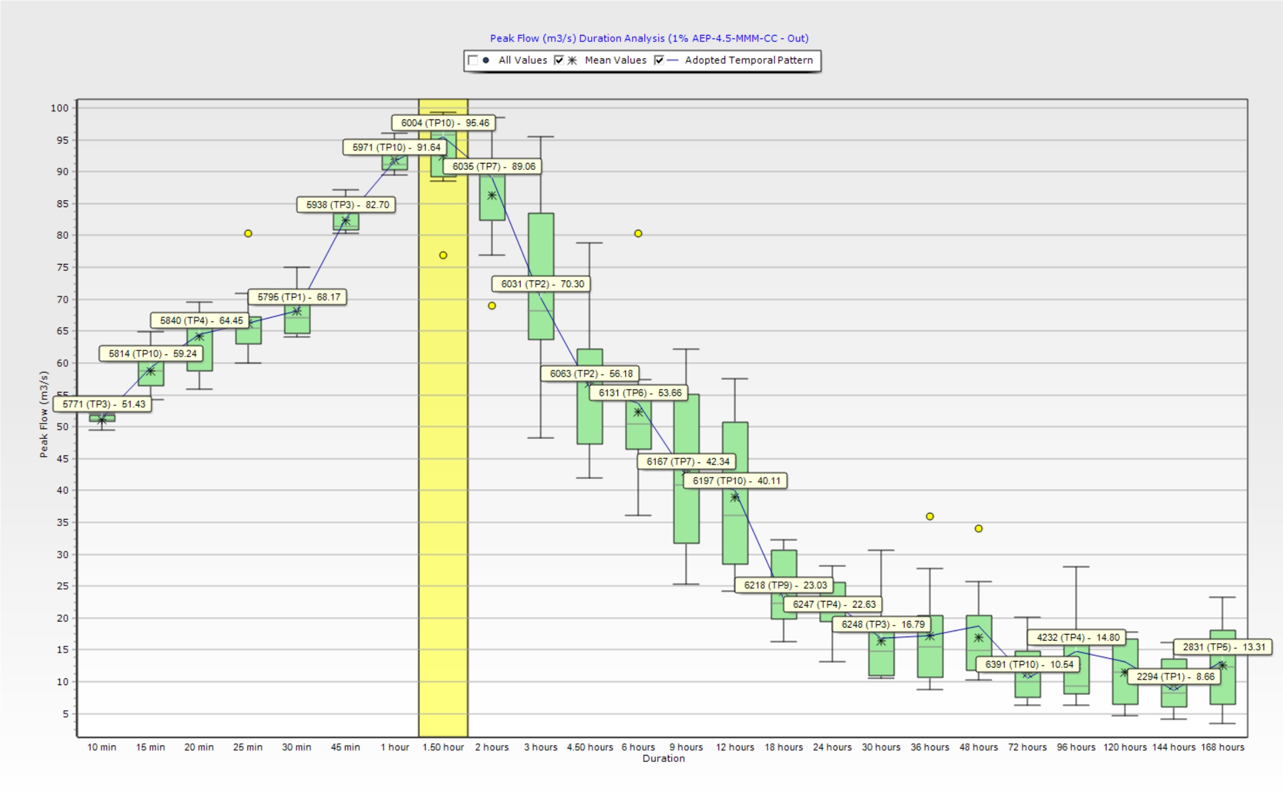


Figure 30. Box Chart for 1% AEP Worst-Case Climate Change Scenario

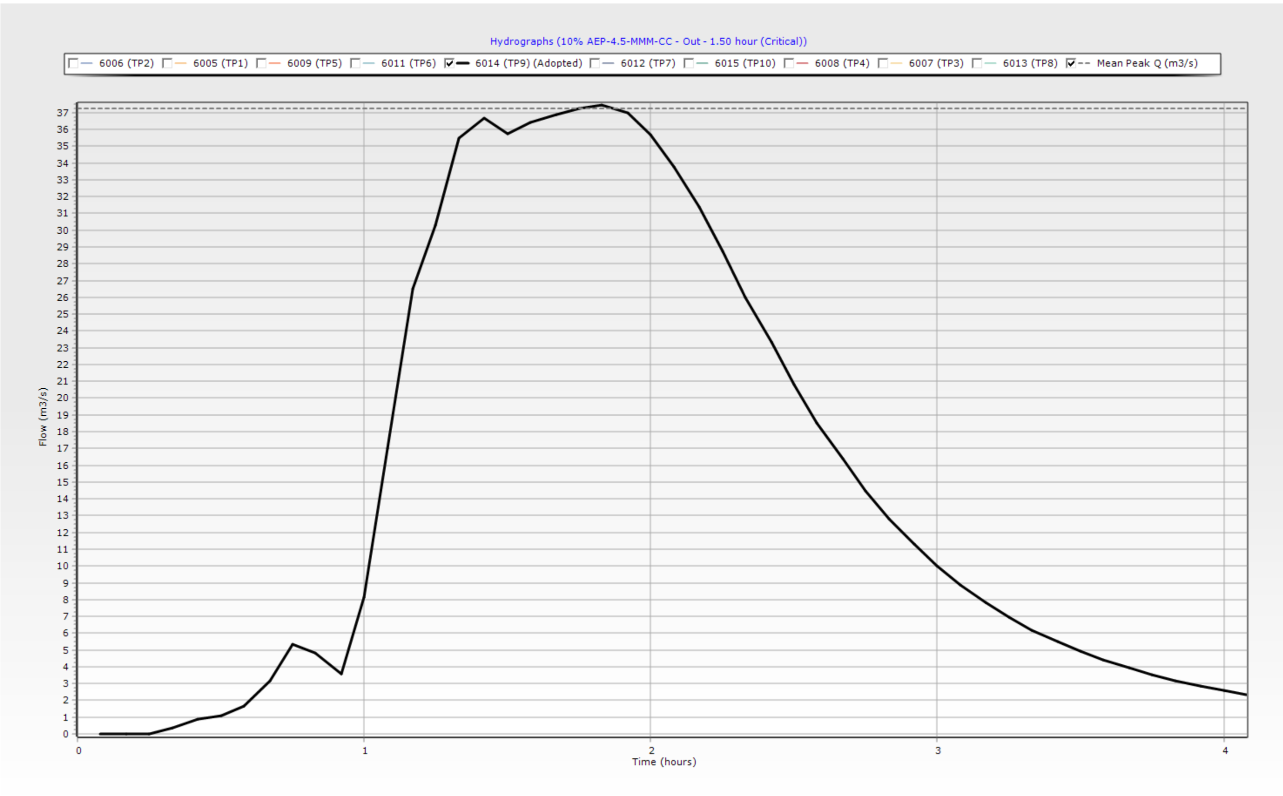


Figure 31. Flow hydrograph for 10% AEP Worst-Case Climate Change Scenario

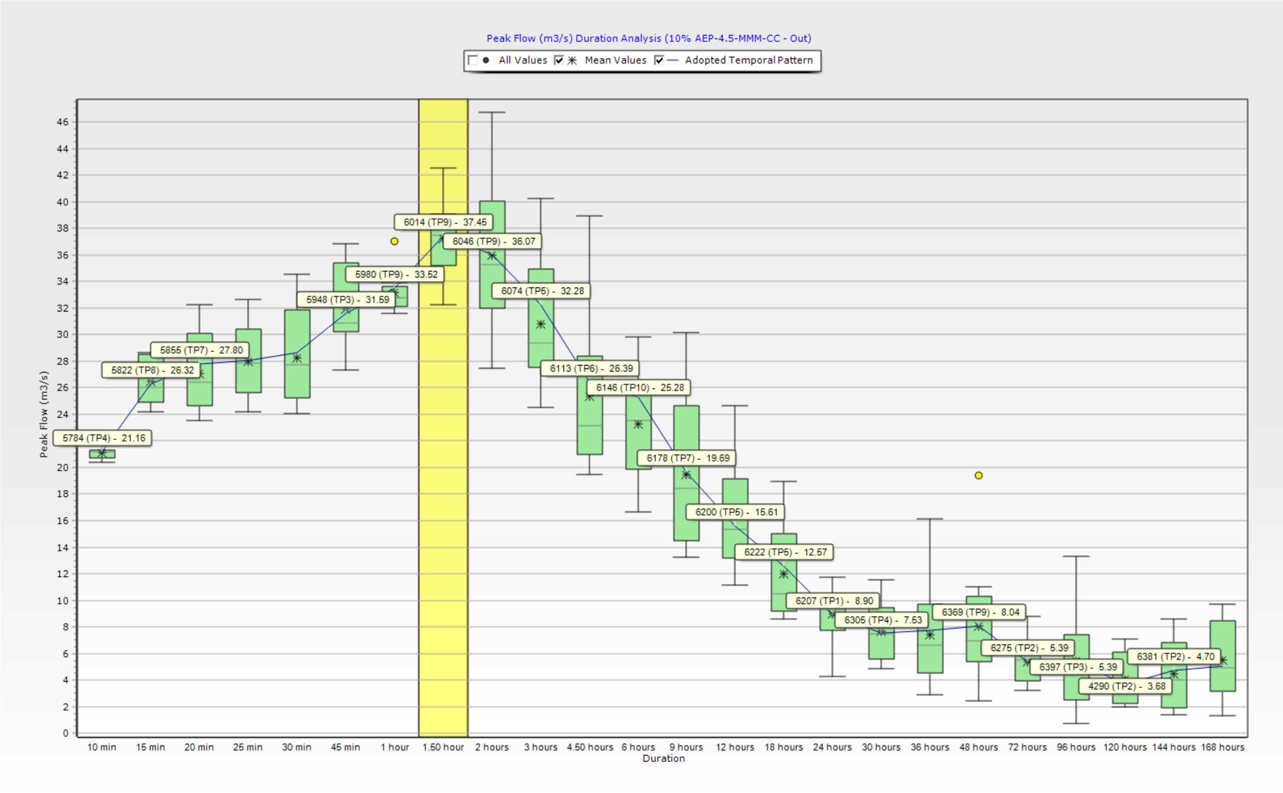


Figure 32. Box Chart for 10% AEP Worst-Case Climate Change Scenario

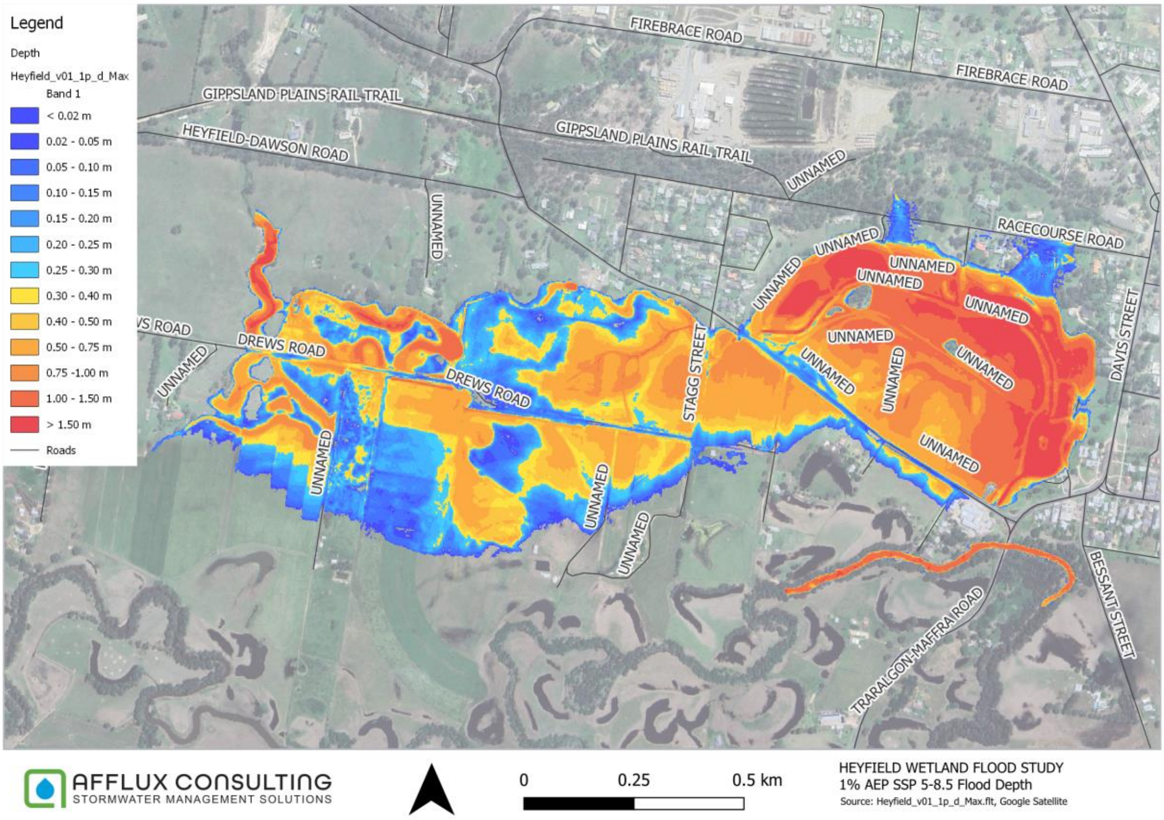


Figure 33. Sensitivity test depth plot for 1%AEP worst-case climate change scenario

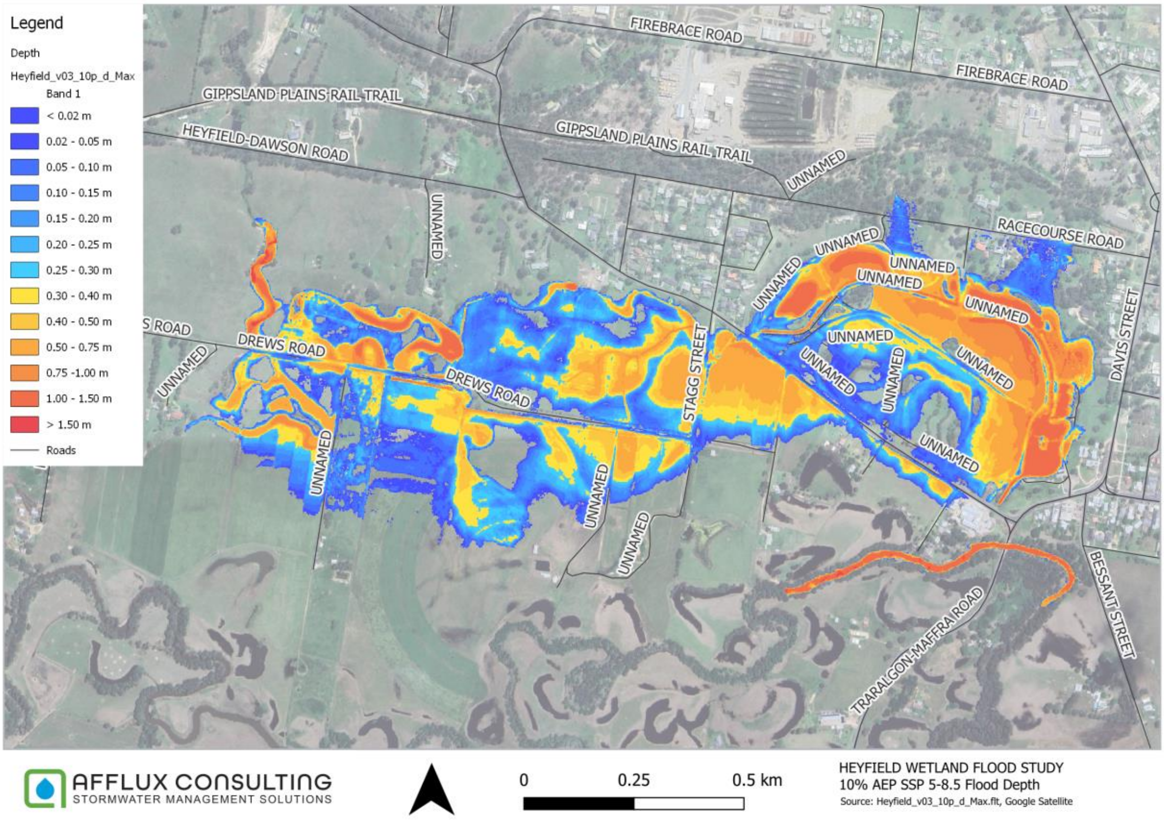


Figure 34. Sensitivity test depth plot for 10%AEP worst-case climate change scenario

6. Comparison with Planning Overlays

Figure 35 shows the relevant planning overlays relevant to the wetland complex, namely the Flood Overlay (FO) and Land Subject to Inundation Overlay (LSIO).

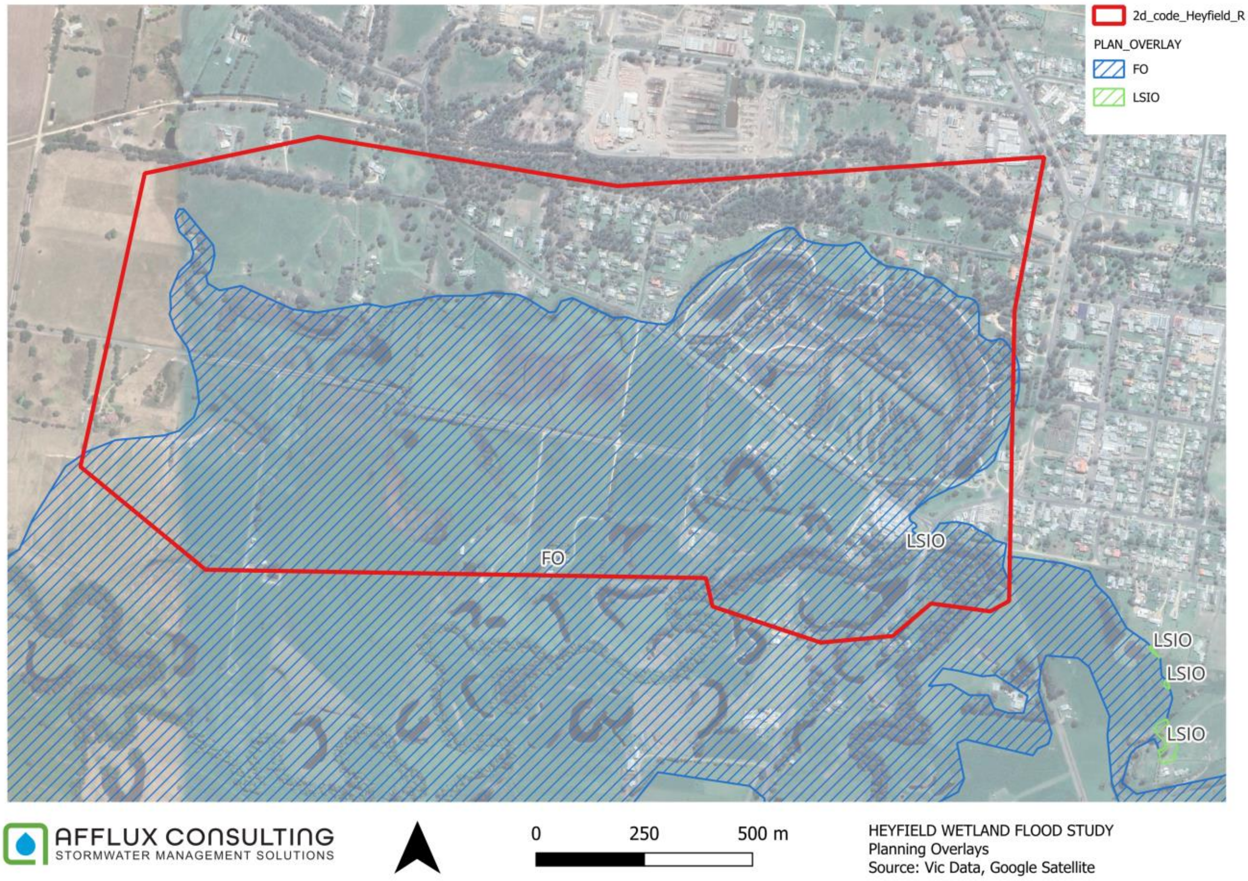


Figure 35. Planning Overlays

To aid in the interpretation of these results, a Hydraulic Categorisation has been used for the results (refer to Figure 36 below). The categorisation is obviously a subjective classification and, as such, could be varied from study to study. Currently, there is no definitive set of values to use. For this study, we have used an interpretation that was used in similar local government studies in NSW. That is:

Table 3. Hydraulic Categorisation Used in this study

Classification	Value	Comment
Floodway	V x D =>0.25m²/s and velocity >0.25 or Velocity >1m/s	The remainder of the floodplain outside the Floodway becomes either Flood Storage or Flood Fringe
Flood Storage	D>0.5m	Is defined where depth is >0.5m outside of the Floodway
Flood Fringe	D <0.5	Where depth is less than 0.5m outside of Floodway

As can be seen from the Hydraulic Categorisation, the current 1% AEP modelling is similar in extent to the Flood Overlay. Still, it has significant areas that may be classified as Flood Fringe.

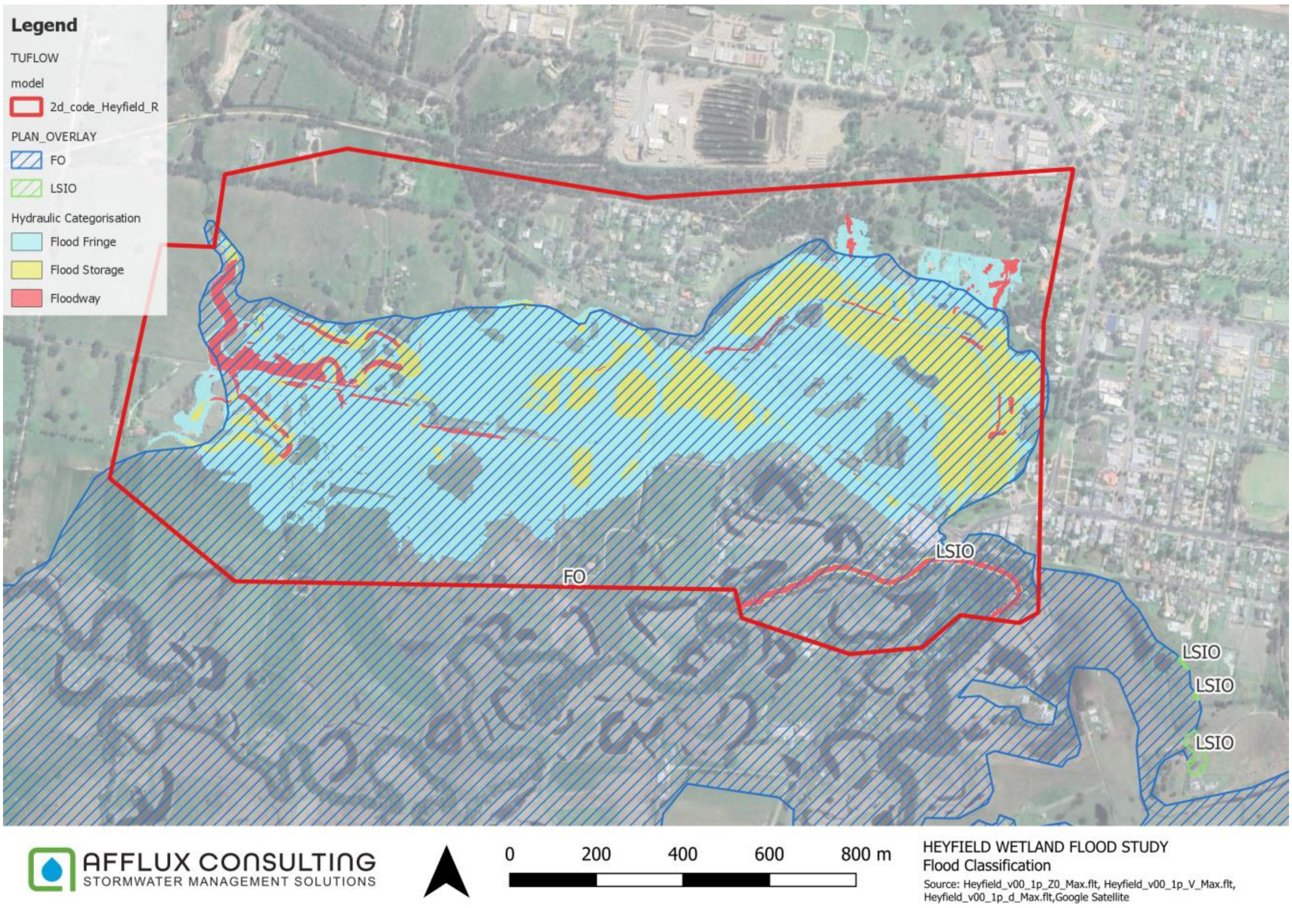
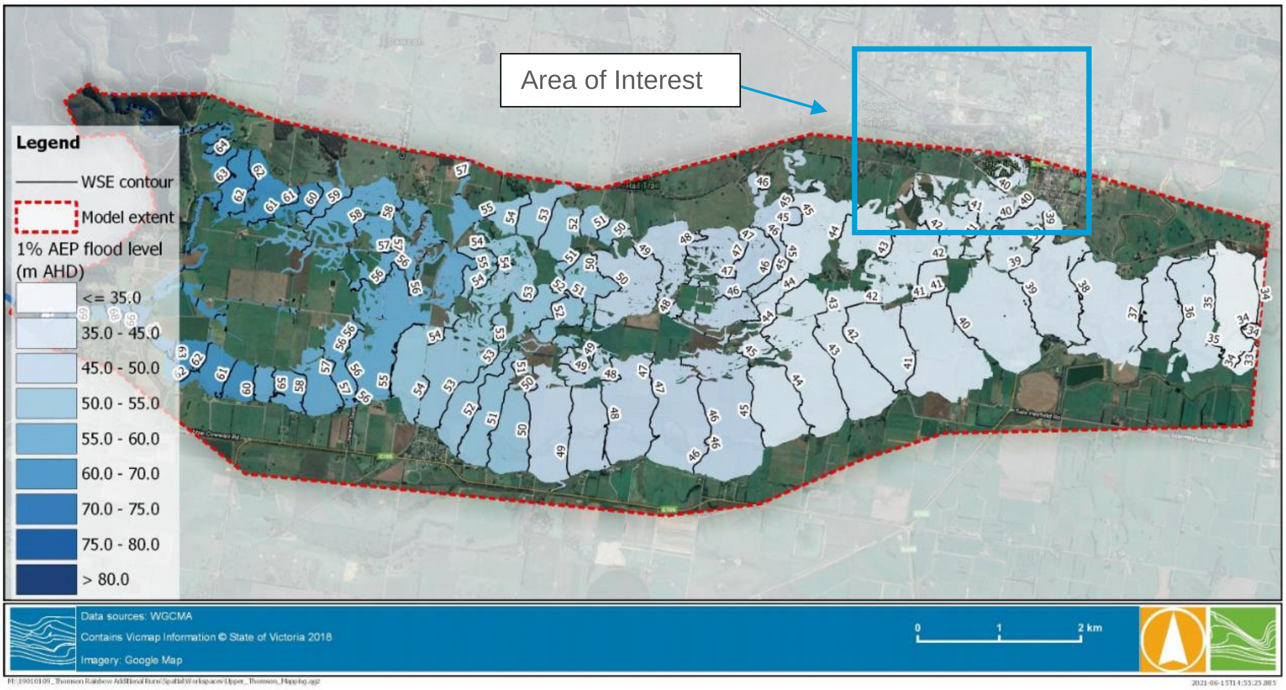


Figure 36. Hydraulic Categorisation of 1% AEP Results

7. Comparison with Historic Flood Information

The Thompson River Flood study was used to inform tailwater conditions as well as to validate model results.

Figure 37 and Figure 38 show the 1% AEP WSE and flood extent for the regional catchment provided by Water Technology. This was used to calibrate the flood modelling performed by Afflux. As can be seen, the results are comparable – WSE immediately southwest of the wetland ranges approximately between 40 to 41 m AHD. This aligns with the results in Figure 23. The flood extent is shown in Figure 38 is limited by Drews Road to the south of the study area. These extents would increase the area of flooding, though not necessarily the planning Flood Overlay as shown previously. As can be seen in further detail in Figure 38, this area is covered by the Thompson PMF extent.



Source: Upper Thomson River Flood Study, Water Technology, 2021

Figure 37. 1% AEP WSE in Upper Thomson River Catchment

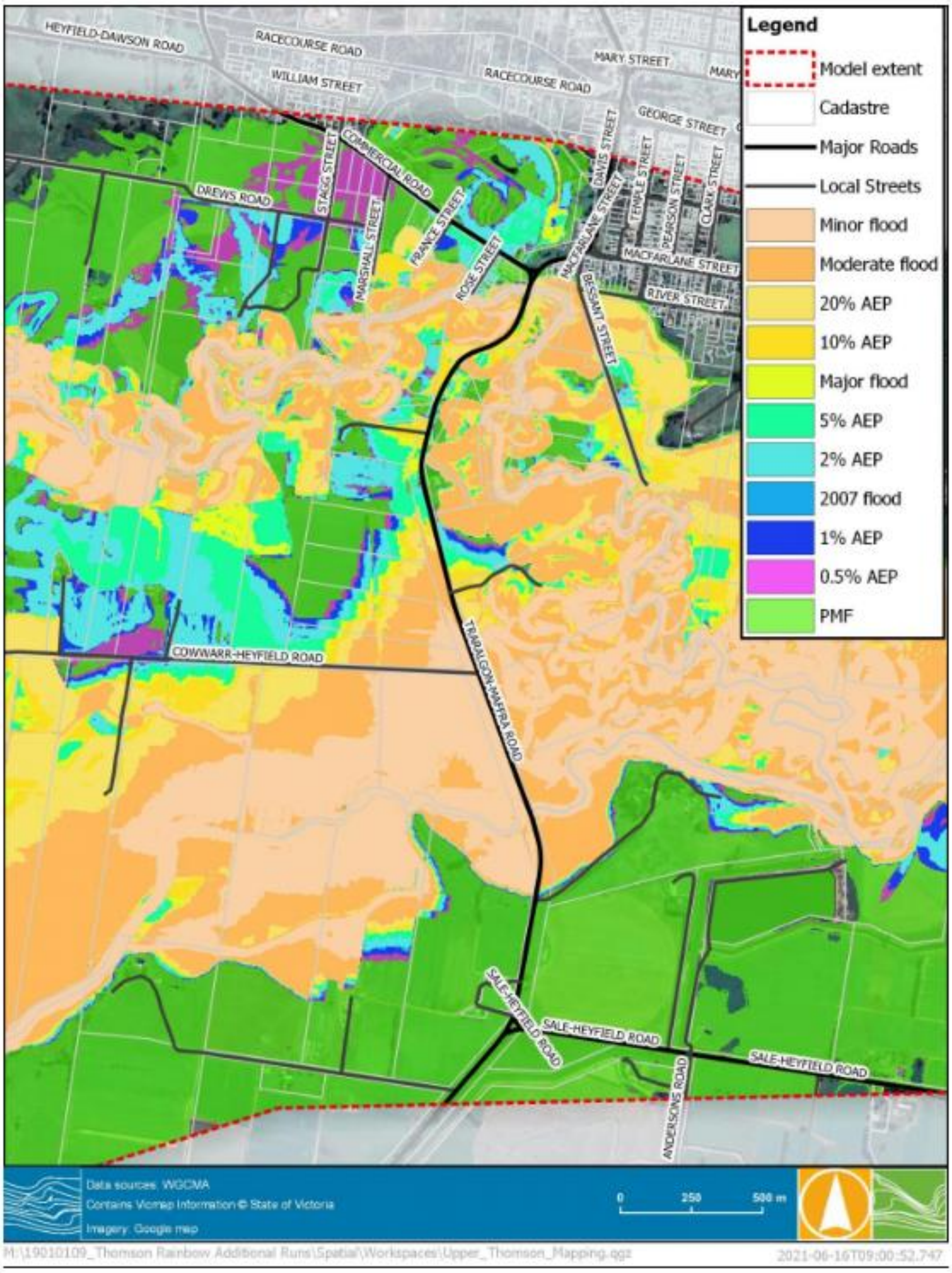


FIGURE 6-5 ROADS IMAPCTED IN DESIGN MODELLING EXTENTS – LOWER REGION

Source: Upper Thomson River Flood Study, Water Technology, 2021

Figure 38. Flood extent under different AEP storm events

The flood study considered when determining the flow through the Thomson River influenced the Heyfield wetland in order to determine if tailwater would impact the flood extent. From the area's topography, there is a high point between the wetland and the river of approximately 42 m AHD, in addition to the road being used as a hydraulic control, meaning excess flow in the river will not flow back towards the flood extent of the study area. Figure 39 shows this topography. This is supported by the WSE from the Thomson River Flood Study, shown in Figure 37. A single 525mm pipe has been connected through this high point as per the site visit measurements (Figure 40). It is noted that the one-way valve on this system is currently wedged shut by

The results from climate change conditions, assuming an 8.5 RCP, also indicate that despite the size of the storm, the topography prevents influence from the river. Hence, it is assumed that any smaller storm events will have no impact on the study area.

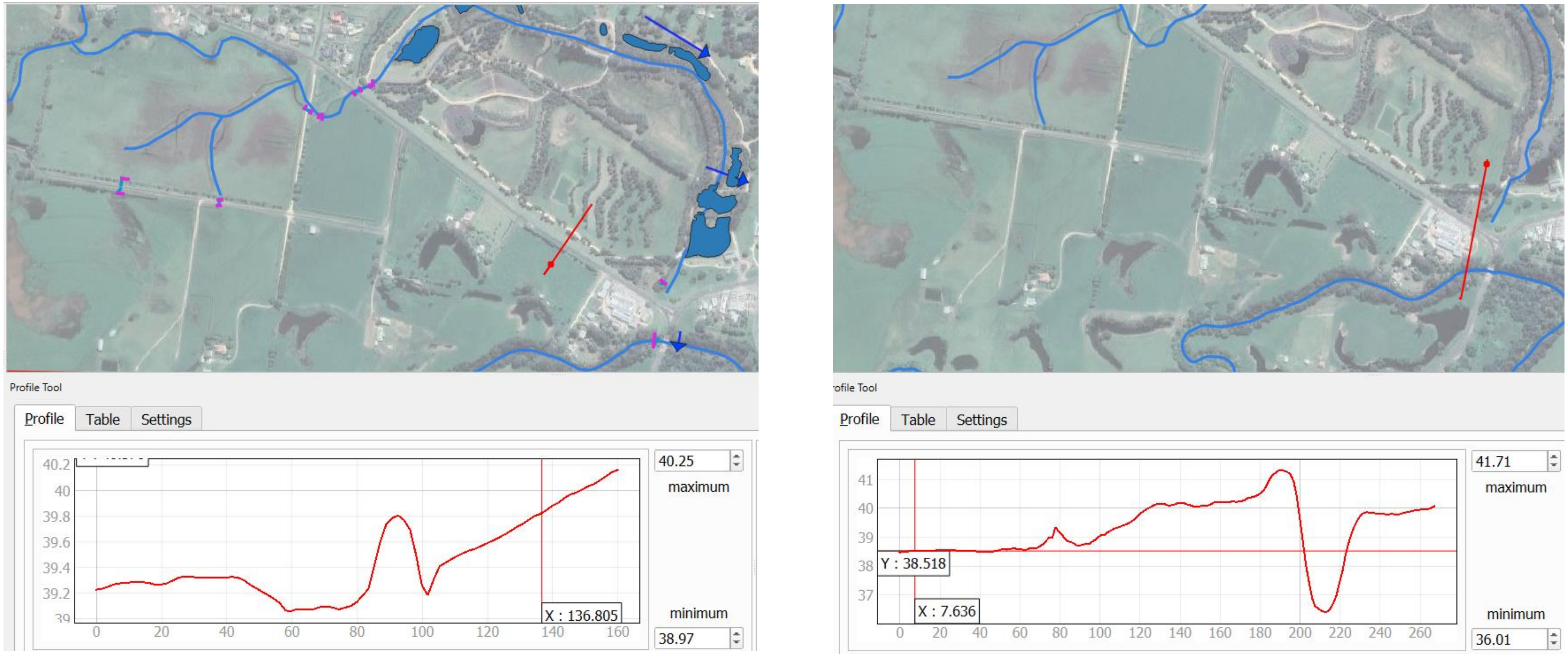


Figure 39. Topography between Thomson River and Wetland

Figure 40. Pipe Connection through high point

8. Conclusions

This report presents a flood study for the Heyfield Wetlands, Heyfield within Wellington Shire. The site has important interactions with its immediate catchment, which have been considered in this report. To maintain the behaviour of the hydraulic systems, including floodplain storage, this report presents the following:

- A hydrological estimate of flows into the wetland from the immediate and local catchments.
- The extent of flooding in current and RCP conditions is captured within the existing council Flood Overlay. However, there may be some ability to change some of the land planning categorisations.
- High flood risk areas include the discharge point at the corner of Commercial Rd and Stagg St and the west end of Drews Rd, where it interacts with One Mile Creek and La Trobe Floodplain.

9. Abbreviations and glossary

For clarification, provided are terms referred to within this report and their definitions as applicable to stormwater and water engineering.

TERM (Abbreviation)	DEFINITION
Afflux	A measure of the increase in water elevation (or flood level difference) at a given location, relative to the water elevation that would have occurred.
Alluvium\alluvial material	Extensive deposits of sand, silt and/or clay formed by a river or flood, typically forming a floodplain. Alluvium is generally unconsolidated.
Annual Exceedance Probability (AEP)	The likelihood of a storm event or flood occurring or being exceeded within any year. Where, $$AEP = 1 - e^{\left(\frac{-1}{ARI}\right)}$$
Attenuation	Reduction in the magnitude of a flood peak
Australian Rainfall and Runoff (ARR)	Australian Rainfall and Runoff guidelines document.
Average Recurrence Interval (ARI)	A statistical estimate of the average length of time (in years) between equivalent (or larger) flood events. Note. Events do not occur at regular intervals. This is an average and not the expected elapsed time until the next exceedance. e.g. a “100 year ARI flood event” has a 1% exceedance probability each year.
Australian Height Datum (AHD)	Vertical height in meters above the mean sea level.
Baseflow	The slow component of catchment runoff, not immediately in response to a storm event. Encompasses interactions with seepage and groundwater discharge into a waterway.
BPEM	Best practice environmental management guidelines used for planning, designing or managing stormwater systems or urban land uses
Catchment	The upstream land and water surface area that drains to a specified location under consideration.
Consequence	Outcome or impact of an event.
Critical Sorm Duration	The length of time of a rainfall event that results in the peak flow or level at a particular location of interest for a given AEP.
Cumec	An abbreviation of cubic meters per second, a unit of discharge (m^3/s)
Drainage Network **or System**	A system of natural or constructed flow paths within a catchment used to convey runoff to its outlet. This may include surface or subsurface systems such as pipes, channels, gutters, overland flow paths, culverts, water storages, etc.

Design Event	A probabilistic or statistical flood or rainfall event used for flood/flow estimation processes for a given AEP.
DELWP	Department of Environment, Land, Water and Planning
EPA	Environmental protection agency
Extended Detention	Distance above normal water level in where stormwater is temporarily stored
Evaporation	The transfer of water, as vapour, from a water surface to the air
Evapotranspiration	The transfer of water, as vapour, from near the earth's surface to the air. Includes open water surfaces, ice, frost, soil and transpiration from plants.
Freeboard	The difference in height between the calculated water surface elevation and the top, obvert, crest of a structure or the floor level of a building, provided for the purpose of ensuring a safety margin above the calculated design water elevation.
Flood	Inundation of normally dry land by water that has exceeded the capacity of the normal confines of waterbodies, water storages or watercourses.
Flood Frequency	Descriptor for the annual exceedance probability or average recurrence interval of a flood
Floodplain	The land area which experiences flooding during high discharge events.
Hazard	Potential for damage or harm. Considered alongside consequence and likelihood of occurrence.
Hydrological Analysis	Developing and understanding a set of relationships to determine how rainfall is converted into runoff or streamflow (includes consideration of climate, losses, soil types, etc).
Hydraulic Design	The process of numerically analysing actual or expected flow conditions (such as water surface elevation and velocity) associated with a given hydraulic structure or overland flow.
Infiltration	The downward movement of water into a catchment surface or infiltration system. Largely governed by soil conditions, vegetation and antecedent moisture content.
Loss rate	Removal (loss) of water from the rate of rainfall that occurs during the process of forming stormwater runoff. Usually measured in units of mm/hr. The assumed loss rate usually varies across the drainage catchment in accordance with known or assumed surface conditions.
Local Authority	Any local or regional external authorities (including local and State Governments or non-government authorities) that have a legal interest in the regulation or management of a given activity, or the land on which the activity is occurring, or is proposed to occur.
Manning's 'n' Roughness Coefficient	The numerical representation of the hydraulic roughness of a conduit, flow path or channel as used in the Manning's formula.
Rainfall Excess	The portion of rainfall that contributes to streamflow
Rainfall Intensity	The rate at which rain falls, typically measured in mm/hour.
Runoff	The part of rainfall (or snow/hail) not lost to infiltration, evaporation, transpiration or depression storage that flows from the catchment

	area past a specified point.
Sedimentation Basin	A basin or tank in which sediment collects primarily through the actions of gravitational settlement. The basin facilitates low-velocity, low-turbulent flows to facilitate the settling of coarse sediment particles from stormwater runoff.
Soil Erosion	The detachment and transportation of soil and its deposition at another site by wind, water or gravitational effects. Although a component of natural erosion, it becomes the dominant component of accelerated erosion as a result of human activities, and includes the removal of chemical materials.
Stage	Elevation of the water surface in a stream measure to some convenient datum
Storm	In hydrology this includes any rainfall event. Unlike common usage implying a period of extreme weather with intense rain and strong wind.
Stormwater Flooding	Inundation by local runoff caused by heavier than usual rainfall. Stormwater inundation is caused by local runoff before it has entered a watercourse or joined watercourse flow. In a rural setting and within large rural allotments, we define stormwater flooding as sheet flow caused by local runoff before it has concentrated into a watercourse, including a drainage channel, stream, gully, creek, river, estuary, lake or dam, or any associated water holding structure.
Surface Water or Inundation	Any water collecting on the ground or in an open drainage system or receiving water body. In this report we use these terms to discuss water before it is categorised into flood, stormwater or other.
Temporal pattern	The time sequence of rainfall intensity. A representation of the variability of rainfall throughout a storm event.
Water Balance	An account of all the water in a specified system. Includes measurement of all inflows, outflows and changes in stored water volumes.
Wetland	A natural or constructed area of land inundated temporarily or permanently with shallow water that is usually slow moving or stationary

10. References

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11. Appendix A – Flood Mapping

For information on this report:

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