Council Meeting 13 September 2023 Attachments

SOUTHERN GRAMPIANS SHIRE COUNCIL

Council Meeting Minutes
Wednesday 9 August 2023

Held in the Balmoral Mechanics Hall,
26 Glendinning Street, Balmoral at 5:30pm

Southern Grampians
SHIRE COUNCIL

1 Present

Councillors
Cr David Robertson, Mayor
Cr Helen Henry, Deputy Mayor
Cr Mary-Ann Brown
Cr Albert Calvano
Cr Fran Malone
Cr Katrina Rainsford

Officers
Mr Tony Doyle, Chief Executive Officer
Mr Rory Neeson, Director Wellbeing, Planning and Regulation
Ms Marg Scanlon, Director Infrastructure and Sustainability
Mrs Tania Quinn, Council Support Officer

2 Welcome and Acknowledgement of Country

The Mayor, Cr Robertson read the acknowledgement of country:

'Our meeting is being held on the traditional lands of the Gunditjmara, Tjap Wurrung and Buandig people.

I would like to pay my respects to their Elders, past and present, and the Elders from other communities who may be here today.'

Please note: All Council meetings will be audio recorded, and may be livestreamed to Council's social media platform, with the exception of matters identified as confidential items in the Agenda.

By participating in open Council meetings, individuals consent to the use and disclosure of the information they share at the meeting (including any personal and/or sensitive information).

Other than an official Council recording, no video or audio recording of proceedings of Council Meetings will be allowed without the permission of Council.

3 Prayer

Cr Henry led the meeting in a prayer.

"Almighty god, we humbly beseech thee to vouchsafe thy blessing upon this council.

Direct and prosper its deliberations to the advancement of thy glory and the true welfare of the people of the Southern Grampians shire."

4 Apologies

Cr Bruach Colliton
Darren Barber, Director People and Performance

5 Confirmation of Minutes

RECOMMENDATION

That the Minutes of the Council Meeting held on 12 July 2023 be confirmed as a correct record of business transacted.

COUNCIL RESOLUTION

MOVED: **Cr Henry**
SECONDED: **Cr Brown**

That the Minutes of the Council Meeting held on 12 July 2023 be confirmed as a correct record of business transacted.

CARRIED

6 Declaration of Interest

7 Leave of Absence

There were no requests for a leave of absence.

8 Questions on Notice

There were no Questions on Notice.

9 Public Deputations

There were no Public Deputations.

10 Petitions

There were no Petitions.

11 Informal Meetings of Councillors

The Southern Grampians Shire Council Governance Rules require that records of Informal Meetings of Councillors that meet the following criteria:

If there is a meeting of Councillors that:

a. took place for the purpose of discussing the business of Council or briefing Councillors;
b. is attended by at least one member of Council staff; and
c. is not a Council meeting, Delegated Committee meeting or Community Asset Committee meeting;

be tabled at the next convenient Council meeting and recorded in the minutes of that Council meeting.

An Informal Meeting of Councillors record was kept for:

- Briefing Session – 12 July 2023
- Briefing Session – 26 July 2023

This agenda was prepared on 2 August 2023. Any Informal Meeting of Councillors between that date and the date of tonight's Meeting will appear in the agenda for the next Council Meeting.

Informal Meeting of Councillors

ASSEMBLY DETAILS	
Title:	Briefing Session 12 July 2023
Date:	12 July 2023
Location:	MJ Hynes Auditorium
Councillors in Attendance:	Cr Brown Cr Calvano Cr Colliton Cr Henry Cr Rainsford Cr Robertson
Council Staff in Attendance:	Tony Doyle, Chief Executive Officer Darren Barber, Director People and Performance Marg Scanlon, Director Infrastructure and Sustainability Susannah Milne, Acting Director Wellbeing, Planning and Regulation Andrew Nield, Acting Manager Shire Strategy and Regulation

The Informal Meeting commenced at 2:20pm.

MATTERS CONSIDERED		CONFLICTS OF INTEREST DECLARED
1	Councillor and CEO Meeting	Nil
2	Matters Raised by Councillors	Nil
3	Melville Oval Redevelopment Planning Permit	Nil

The Informal Meeting concluded at 5:00PM

Informal Meeting of Councillors

ASSEMBLY DETAILS	
Title:	Briefing Session 26 July 2023
Date:	26 July 2023
Location:	MJ Hynes Auditorium
Councillors in Attendance:	Cr Brown Cr Calvano Cr Colliton Cr Henry Cr Malone Cr Rainsford Cr Robertson
Council Staff in Attendance:	Tony Doyle, Chief Executive Officer Darren Barber, Director People and Performance Marg Scanlon, Director Infrastructure and Sustainability Rory Neeson, Director Wellbeing, Planning and Regulation Daniel Shaw, Economic Development Support Officer Anita Collingwood, Senior Strategic Planner
External Presenters	Angie Doulden, Coordinator Great South Coast DAMA Coordinator Stephen Hoy, Warrnambool City Council - Manager Economic Development and Tourism Nicola Booth, SpendMapp Jane Wong, SpendMapp

The Informal Meeting commenced at 2:00pm.

MATTERS CONSIDERED		CONFLICTS OF INTEREST DECLARED
1	Matters Raised by Councillors	Nil
2	Domestic Area Migration Agreement	Nil

3	Spendmapp	Nil
4	Glenthompson Swimming Pool Options	Nil
5	Planning Application – Function Centre – 11 Collins Street Hamilton	Niil

The Informal Meeting concluded at 4:50pm.

12 Management Reports

12.1 Planning Application TP/104/2022 11 Collins Street, Hamilton

Directorate: Wellbeing, Planning and Regulation
Report Approver: Andrew Nield (Planning Coordinator), Daryl Adamson (Manager Strategy and Regulation), Rory Neeson (Director Wellbeing, Planning and Regulation)
Report Author: Anita Collingwood, Statutory Planner - Contractor

Attachment(s):
1. T P-104-2022 - Attachment 1 - Application Documents [**12.1.1** - 113 pages]
2. T P-104-2022 - Attachment 2 - Redacted Submissions [**12.1.2** - 48 pages]
3. T P-104-2022 - Attachment 3 - Original Submissions [**12.1.3** - 43 pages]

Executive Summary

This report presents the town planning application for a proposed function centre at 11 Collins Street, Hamilton. The application aims to establish a function centre catering to formal events such as luncheons, high tea, weddings, and private gatherings. The proposed operating hours are from 11:00 am to 10:00 pm on Sundays to Thursdays and from 11:00 am to 12:00 am on Fridays and Saturdays. The function centre is proposed to accommodate up to 150 patrons and seeks an on-premises liquor licence. Live music is proposed to be allowed during functions such as weddings.

The proposed development involves the removal of six mature trees, minor internal changes to the building, the addition of a new pergola for outdoor dining, a brick pier front fence, and a redesigned parking and landscaping layout with formalised garden areas for guests.

The application received 15 objections during the consultation process with the key concern being noise impacts. A consultation meeting was held with the applicant, landowner and objectors and the key concerns were discussed. No resolution was reached within this consultation process, however, the applicant has since amended the application by reducing the number of patrons and modifying the hours of operation.

After careful evaluation, it is concluded that using the heritage building as a function centre would have minimal impact on its character. Furthermore, repurposing the old building is viewed as beneficial to Hamilton's economy and society. The objections raised during the planning process were primarily related to noise and it is determined that the proposal could be properly managed to minimise any negative effects on the community.

It is recommended to approve the proposal subject to permit conditions.

Discussion

Proposal summary
The proposal is to convert the former historic Catholic Convent known as the “Academy” building for a Function Centre.

For the purposes of the planning scheme, the proposal is as follows:

Use of the land for a Function Centre, associated building and works, removal of vegetation, the display of business identification signage and an on-premises liquor license.

Key elements included as part of the application received by Council were:

- The Function centre is to cater for formal functions such luncheons, high tea, weddings, and other private gatherings.
- Hours proposed:
  - Sunday to Thursday 11.00am – 10.00pm.
  - Friday and Saturday 11.00am to 12.00am the following day.
- 150 patrons.
- Proposed on-premises liquor license.
- Live music is proposed to be allowed in association with functions such as weddings.
- Removal of six (6) mature trees.
- Minor internal changes to building.
- New pergola structure for outdoor dining.
- New brick pier front fence.
- New parking and landscaping layout with formalised garden areas for guests.
- 45 car parking spaces are proposed on site.
- New signage to identify the centre.
- It is intended that the commercial kitchen is to provide on-site and off-site catering.

Context of the site and surrounds
Eleven (11) Collins Street, Hamilton is approximately 3,341-square metres in size and is located on the corner of Collins Street and Pope Street. It is relatively rectangular in shape, with the exception of a splay to the corner of Collins and Pope Street as well as a small ‘cut out’ in the eastern corner which forms a separately owned lot. The property has a frontage of approximately 58.14 metres to Collins Street and 47.56 metres to Pope Street.

Collins Street itself is a well-established residential street within Hamilton. It is a tree-lined street, exhibiting a mix of architectural styles ranging from charming heritage buildings to modern structures. The street is typically characterised by low to medium-density development, with a mix of single-family homes, small businesses, and community facilities.

Pope Street is a portion of the highway and is managed by the Department of Transport and Planning, providing key vehicular access through Hamilton on the north-western side of the central business district (CBD).

The site is approximately 400 metres to the northwest of the Hamilton CBD.

The site is very much within a residential context as it is surrounded by residential development, with Pope Street acting as a buffer to the south and west.

Permit history
The subject site was part of a residential subdivision that created Chloe Mews (extending from Stephens Street). There are now sixteen (16) residential allotments situated on the former convent site, with the balance of the site being left to the 'Academy' building.

Restrictions
The land contains a Section 173 Agreement (AR519700J) on the certificate of title; however, this only relates to the provision of fencing and states that any front boundary fencing for this property must be complimentary to the heritage building.

Planning policy
The following policies within the Municipal Planning Strategy and the Planning Policy Framework are the most relevant to the planning application:

- Clause 02.02 Vision
- Clause 02.03 Strategic directions
    - Clause -2.03-1 Settlement
    - Clause 02.03-5 Built environment and heritage
    - Clause 02.03-6 Economic development
- Clause 11.03-1S Activity centres
- Clause 11.03-6L Hamilton
- Clause 13.05-1S Noise management
- Clause 15.01-1S Urban design
- Clause 15.03-1L Heritage conservation
- Clause 17.02-1S Business
- Clause 17.02-2S Out-of-centre development

Planning controls and permit requirements
The subject site is within the following zones and overlays:

- Clause 32.08 (General Residential Zone).
- Clause 43.01 (Heritage Overlay).

The proposal requires a planning permit under the following provisions of the Southern Grampians Planning Scheme:

- Clause 32.08-2 (Use).
- Clause 32.08-9 and Clause 43.01-1 (Buildings and works).
- Clause 43.01-1 (Vegetation removal).
- Clause 52.05 (Signs).
- Clause 52.27 (Liquor licence).

The proposal also requires assessment against the following provisions:

- Clause 52.06 Car Parking
- Clause 53.06 Live Music Entertainment Venues
- Clause 65.01 Approval of an Application or Plan

Advertising and objections

The proposal was publicly advertised during the planning process under Section 52 of the *Planning and Environment Act 1987*, by:

- Sending notices to the owners and occupiers of adjoining land.
- Placing two (2) signs on site.
- Publishing the application on the SGSC website.

The amended application was advertised by:

- Sending notices to the same group of owners and occupiers of adjoining land.
- Publishing the application on the SGSC website.

A total of 15 submissions were received from 18 objectors which relate to the following key issues:

- Inappropriate use within a residential area
- Noise
- Traffic/car parking
- Loss of privacy
- Patrons leaving the venue inebriated
- Vandalism/Crime/Safety
- Rubbish/litter within the site and surrounding area
- Devaluation of surrounding properties

A consultation meeting was held with the applicant and the objectors on 28 March 2023, and whilst no objections were resolved, the applicant subsequently opted to amend the application pursuant to section 57A of the *Act* to address some of the concerns. The amended application proposes a reduced number of patrons and hours of operation for the use. As a result of the reduced number of patrons, the car parking rate for the use is reduced and can now be accommodated within the site without a reduction under Clause 52.06.

The amended application was publicly advertised to ensure residents were aware of the changes and had the opportunity to provide further comments or withdraw their objections. Two further submissions were received, and no objections were withdrawn.

Assessment

The key considerations of this application include:

- Is the proposal appropriate within the General Residential Zone?
- Does the proposal appropriately address the Heritage Overlay?
- Is the proposal able to respond to objections?

Function centre, liquor license and live music

The General Residential Zone enables the consideration of non-residential uses in appropriate locations or to serve a community need.

Whilst the re-use of the heritage building is supported for this type of function centre, the property is still within a residential area and must demonstrate that it can reduce its impact via various noise attenuation or operational measures.

In order to appropriately respond to Clause 13.05-1S, Clause 52.27 and Clause 53.06, it is considered reasonable to require an acoustic report and appropriate protections for residents nearby through reporting and planning permit conditions. It is considered crucial to the wellbeing and amenity of residents that nighttime noise be managed through the implementation of noise-reduction measures which will be identified with the appointment of a suitably qualified noise technician. An acoustic report will be required to show measures to be implemented on-site for reducing sound emanating from the building. Ensuring live music is not played outdoors at nighttime, too, is considered essential to minimise noise nuisance to the surrounding residents. The enforcement and monitoring of these noise reduction measures will provide assurance for nearby residents and the operator that the site is managed appropriately and noise is maintained at a reasonable level.

Hours of operation and the number of patrons will also be controlled via planning permit conditions. The proposed hours of 11am to 10pm Sunday to Thursday will allow for evening events such as dinners and ensure the sensitive hours of the day and residential amenity are protected. A closing time of 11pm Friday and Saturday nights allows for evening events to occur and ensure the site is vacated for the duration of the night.

It is noted that despite any given planning permission, the proposed use must be controlled in accordance with the relevant *Environment Protection Regulations* 2021 under the *Environment Protection Act 2017* and must obtain a liquor licence through the Victorian Commission for Gambling and Liquor Regulation (VCGLR).

The proposed car parking onsite is considered acceptable based on the planning scheme requirement of 0.3 spaces per patron and the layout of the carpark, despite being located in front of a heritage place, is considered practical. The landscaping and front fence will help soften the appearance of the car parking and provide a suitable entry to the function centre.

<u>Pergola, fence, removal of vegetation and signage</u>
Other matters such as the proposed pergola, fence and signage are considered acceptable within the heritage context of the street and the former ‘Acadamy’ building. The pergola structure follows the design cues of the existing building and will not adversely impact the integrity of the existing building. The proposal is therefore not considered to prejudice the purposes of the Heritage Overlay.

It is an improvement to see the site re-developed and re-landscaped. Several trees will be removed across the site, but this is deemed satisfactory for an overall design response. The larger gum tree has caused infrastructure damage in the past (footpath) and may continue to do so given its location on the boundary. The planning permit will ensure that the landscaping shown within the application will be carried out and maintained to the satisfaction of the responsible authority.

<u>Response to objections</u>
Due to the number of objections received, the social impact of the application has been considered under Section 60(1B) of the *Planning and Environment Act 1987*.

In order to address the majority of submissions, planning permit conditions have been recommended, particularly to deal with matters relating to noise. An Amenity Management Plan is also recommended so that the operator is required to outline how they are to adequately protect the amenity of the neighbourhood, ensuring the orderly arrival and departure of patrons. This document can and should include details of how staff are to be trained, how records of training – including Responsible Service of Alcohol (RSA) training – are to be kept, and a plan for managing patrons.

The site is located close to the CBD and therefore has access to taxi services and accommodation. Whilst the site is within a residential zone, it is located close to the CBD and is developed with a building that would unlikely be used for residential purposes given its size. A carefully managed commercial use, therefore, is considered acceptable and the overall impact on neighbours will be minimised.

<u>Conclusion</u>
It is considered that the proposal could be appropriately managed, particularly with respect to noise, so that it does not have an unreasonable impact upon the community. It is recommended that the proposal is approved subject to conditions.

Financial and Resource Implications

If an application for review is lodged at the Victorian Civil and Administrative Tribunal (VCAT), Council may be required to enlist the services of a lawyer to represent Council.

Council Planning officers will also have to provide further time away from their normal duties to assist the VCAT process.

Council Plan, Community Vision, Strategies and Policies

Support Our Community
1.1 An empowered and connected community
1.1.3 Provide opportunities for increased community engagement and participation in Council decision making and activities.
1.1.4 Ensure communication and engagement methods use inclusive practices and processes.

Grow Our Regional Economy
2.4 Support local business and industry
2.4.2 Support and facilitate business development and growth initiatives.

Legislation

Section 61 of the *Local Government Act 2020* sets out the requirements for Council meetings.

The *Planning and Environment Act 1987* provides that certain local government, responsibilities and functions can be delegated to Committees of Council or Council officers. This recommendation is consistent with those provisions.

Gender Equality Act 2020

The application does not have any direction implications.

Risk Management

It is recommended that a Notice of Decision to Grant a Permit be issued subject to conditions.

If Council determines to issue a Refusal to Grant a Permit the following process also applies. If a Notice of Decision or Refusal to Grant a Permit is issued, an application to the Victorian Civil and Administrative Tribunal for review of the decision of the responsible authority may be made by either the permit applicant or the objectors.

Climate Change, Environmental and Sustainability Considerations

The development has been designed to have minimal impact on the surrounding environment.

Community Engagement, Communication and Consultation

Council undertook public notification and received eighteen (18) objections to the proposal which have been detailed earlier in this report.

There was a consultation session with the permit applicant and the objectors. The amended application documents were circulated to the original recipients of the public notice, plus two other interested parties, and an opportunity provided for these parties to provide further comments to Council.

Disclosure of Interests

All Council Officers involved in the development and advice provided in this Report affirm that no general or material interests need to be declared in relation to any matters in this Report.

Anita Collingwood, Senior Statutory Planner
Andrew Nield, Planning Coordinator

RECOMMENDATION

That Council having caused notice of Planning Application No. TP/104/2022 to be given under Section 52 of the *Planning and Environment Act 1987* and having considered all the matters required under Section 60 of the *Planning and Environment Act 1987* decides to issue a Notice of Decision to Grant a Permit under the provisions of Clause 32.08-2, Clause 32.08-9, Clause 43.01-1 and Clause 52.05 of the Southern Grampians Planning Scheme in respect of the land known and described as 11 Collins Street, Hamilton, Lot 17 on PS743573F, for the Use of the land for a Function Centre, associated building and works, removal of vegetation, the display of business identification signage and an on-premises liquor license in accordance with the endorsed plans, with the application dated, 16 May 2023, subject to the following conditions:

Amended plans

1. Before the commencement of the use and development, amended plans must be submitted to and approved by the Responsible Authority. When approved the plans will be endorsed and will then form part of the permit. The plans must be drawn to scale and dimensioned and must be generally in accordance with the plans submitted with the application, but modified to show:
    a. A north arrow to be included within the entire plan set as appropriate.
    b. Elevation plans which show the details of the proposed pergola, including dimensions showing maximum height.
    c. Elevation plans which show a typical section of the proposed front boundary fence, including dimensions showing maximum height.
    d. Revised plans which account for the 3.36 x 3.36 metre area of land on Lot 17 of PS743573F. The permitted use/development must be located wholly within the boundaries of the subject site. This may result in the revision of landscaping and car parking within this area. The total number of car parking spaces within the site must be no less than 45.
    e. A revised car parking layout which has regard to Conditions 22 and 23 includes the following:
    f. Internal spaces and civil design to comply with AS2890.
    g. The proposed driveway to have a minimum width of 6 metres.
    h. The nomination of bin and recycling areas in accordance with Condition 18.
    i. Any changes required to maintain consistency with the Car Parking Plan required by Condition 22.
    j. Any changes that are required from the acoustic report in accordance with Condition 10.

Amenity management plan

2. Before the commencement of the use hereby permitted, an Amenity Management Plan prepared to the satisfaction of the Responsible Authority must be submitted to and approved by the Responsible Authority. When approved, the plan will be endorsed and will then form part of the permit. All activities forming part of the use

must comply with the endorsed Amenity Management Plan. The plan must include but is not limited to:

a. Staffing and other measures which are designed to ensure the orderly arrival and departure of patrons;
b. Signage to be used to encourage responsible off-site patron behaviour;
c. The training of staff in the management of patron behaviour;
d. Records of training, including Responsible Service of Alcohol (RSA) training
e. Staff communication arrangements;
f. Measures to control noise emissions from the premises;
g. Litter management;
h. Contact details for taxi services and other transport options for patrons.

Use and development not altered

3. The use and development as shown on the endorsed plans must not be altered without the written consent of the Responsible Authority.

4. The licensed area as shown on the endorsed plans as approved by this permit shall not be altered except with the written consent of the Responsible Authority.

5. All buildings and works must be maintained in good order and appearance to the satisfaction of the Responsible Authority.

Hours of operation

6. The use hereby permitted must operate only between the hours of:
    a. 11am to 10pm from Sunday to Thursday
    b. 11am to 11pm Friday and Saturday.

    Operation of Commercial Kitchen
    c. The use as it relates to the commercial kitchen must only operate between the hours of 6am to 10pm on any given day

    The commercial kitchen operating outside of the normal hours of operation must be for offsite catering purposes only.

Hours of liquor license

7. The licensed trading hours authorised for the premises are:
    a. 11am to 5pm from Sunday to Thursday
    b. 11am to 11pm Friday and Saturday

Hours of deliveries

8. Deliveries to and from the site (including private waste collection) must only take place between:
    a. 7am to 10pm, from Monday to Friday inclusive
    b. 9am to 10pm Saturday, Sundays or public holidays

Maximum number of patrons

9. No more than 150 patrons may be present on the premises at any one time (including any external seating) unless otherwise approved in writing by the Responsible Authority.

Acoustic report

10. Concurrent with the endorsement of plans, an acoustic report prepared by a suitably qualified person must be submitted to and approved by the Responsible Authority, providing recommendations as to how the use may be controlled in accordance with the relevant Environment Protection Regulations under the *Environment Protection Act 2017*. This assessment should comply with Environmental Protection Authority Publication 1826.4:, *Noise Limit and Assessment Protocol for the Control of Noise from Commercial, Industrial and Trade Premises and Entertainment Venues*, particularly, how the noise levels from inside and outside of the Function centre can be reduced to limit the impact on the surrounding residential area.

11. Noise attenuation measures for the development must be in accordance with the acoustic report and associated endorsed plans. Any noise attenuation measures must be completed prior to the occupation of the building and maintained thereafter, all to the satisfaction of the Responsible Authority.

12. No amplified music is permitted outside the building (including open lawn and arbour areas) after 9pm on any day.

13. Noise levels emanating from the premises must comply with the requirements of the *Environmental Protection Authority Publication 1826.4: Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venues.*

14. Six (6) months after the commencement of the use, a suitable qualified acoustic consultant must provide Council with a report confirming that the venue (during a typical event) complies with the requirements of the *Environmental Protection Authority Publication 1826.4: Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venues.*

Amenity

15. All plant and equipment used on site, or to monitor the performance of the development must be:
    a. Maintained in a proper and efficient condition; and
    b. Operated in a proper and efficient manner.

16. External lighting must be designed, baffled and located so as to ensure no loss of amenity to residents of adjoining properties to the satisfaction of the Responsible Authority

Waste

17. Waste and recycling storage areas must be provided on the site, to the satisfaction of the Responsible Authority. In this regard, a sufficient number of watertight receptacles with close fitting lids for the reception of garbage and reuse arising from the premises must be provided. This area must be screened from public view. The contents of such garbage receptacles are to be disposed of at least once in every seven consecutive days. The proprietor must not allow the garbage or refuse to become a nuisance at any time.

18. All waste material not required for further on-site processing must be regularly removed from the site. All vehicles removing waste must have fully secured and contained loads so that no waste is spilled or dust or odour is created, to the satisfaction of the Responsible Authority.

Landscaping

19. Within 3 months of the commencement of the use, or within the next applicable planting season, whichever is the earlier; the landscaping works shown on the endorsed plans must be carried out and completed to the satisfaction of the Responsible Authority. The landscaping must thereafter be maintained to the satisfaction of the Responsible Authority, including that any dead, diseased or damaged plants are to be replaced.

Stormwater

20. Before commencement of the development hereby permitted, a detailed Stormwater Management Plan is to be submitted to, and endorsed by, the Responsible Authority. The works must be designed in accordance with the current Infrastructure Design Manual (IDM) and the Stormwater Management Plan must include:
    a. Identification of any existing drainage infrastructure on the site;
    b. Details of how the works on the land are to be drained and/or retarded;
    c. Computations of the existing and proposed drainage volumes;
    d. A layout plan showing the proposed underground stormwater network to the legal point of discharge;
    e. Details which demonstrate stormwater runoff resulting from a 1 in 100 year storm event is able to pass through the development via reserves and/or easements, or be retained within development.

21. The endorsed Stormwater Management Plan is to be implemented prior to use or occupation of the development and must be maintained in good working order thereafter.

Car parking

22. Before any works commencing on the development hereby permitted, a Car Parking Plan shall be prepared and submitted to the Responsible Authority for approval, clearly showing the layout, proposed method of surfacing and delineation of spaces, and how the car parking area will be landscaped.

This plan, when approved, shall be endorsed as forming part of the Permit and the parking area shall be constructed, maintained, drained and delineated in accordance with the endorsed plans to the satisfaction of the Responsible Authority.

23. Before the commencement of the use, the areas set aside for the parking of vehicles and access lanes as shown on the endorsed plans must be: -
    a. Constructed and drained to the satisfaction of the Responsible Authority;
    b. Properly formed to such levels that they can be used in accordance with the plans;
    c. Line-marked to indicate each car space and all access lanes;
    d. Accessways clearly marked to show the direction of traffic;
    e. Properly illuminated with lighting designed, baffled and located to prevent any adverse effect on adjoining land; to the satisfaction of the Responsible Authority.

24. Car spaces and access lanes must be maintained and kept available for use at all times.

25. Hard surface areas must be constructed and drained to prevent diversion of flood or drainage waters and maintained in a continuously useable condition to the satisfaction of the Responsible Authority.

Signage

26. The location, size, material of construction and details of the signage and any supporting structures, as shown on the endorsed plans, must not be altered without the prior written consent of the Responsible Authority, except where exempt under the Planning Scheme.

27. The sign(s) hereby permitted must not be animated or contain any flashing or intermittent lighting.

28. The signage must not be illuminated by external or internal light except with the prior written consent of the Responsible Authority.

Permit expiry

29. This permit will expire if one of the following circumstances applies:
    a. The approved development does not start within two (2) years of the issue of the permit; or
    b. The approved development is not completed within four (4) years of the issue of the permit; or

c. The approved use does not start within four (4) years of the issue of this permit, or
d. The approved use of the land is discontinued for a period of two (2) years.
e. The erection or display of the signage is not started within two (2) years of the date of this permit.
f. The erection or display of the signage is not completed within four (4) years of the date of this permit.

In accordance with section 69 of the *Planning and Environment Act 1987*, the Responsible Authority may extend the periods referred to if a request is made in writing before the permit expires, or within six months of the permit expiry date, where the development allowed by the permit has not yet started; or within 12 months of the permit expiry date, where the development has lawfully started before the permit expires.

Notes:

- The permitted use/development must be located wholly within the boundaries of the subject site.
- This permit does not authorise the commencement of any building works. Building approval must be obtained prior to the commencement of any approved works.
- Unless a permit is not required under the provisions of the Southern Grampians Planning Scheme, no other signs are permitted to be constructed or displayed without the written consent of the Responsible Authority.
- A liquor license must still be obtained via the Victorian Liquor Commission.
- Food Premises that sells food must comply with the following Victorian legislative requirements:
  - Food Act 1984;
  - Food Standards Australia and New Zealand Food Standards Code:
    - Food Safety Standards Chapter 3.2.2 Food Safety Practices and General Requirements; and
    - Food Safety Standards 3.2.3 Food Premises and Equipment

COUNCIL RESOLUTION

MOVED: **Cr Brown**
SECONDED: **Cr Henry**

That Council having caused notice of Planning Application No. TP/104/2022 to be given under Section 52 of the *Planning and Environment Act 1987* and having considered all the matters required under Section 60 of the *Planning and Environment Act 1987* decides to issue a Notice of Decision to Grant a Permit under the provisions of Clause 32.08-2, Clause 32.08-9, Clause 43.01-1 and Clause 52.05 of the Southern Grampians Planning Scheme in respect of the land known and described as 11 Collins Street, Hamilton, Lot 17 on PS743573F, for the Use of the land for a Function Centre, associated building and works, removal of vegetation, the display of business identification signage and an on-premises liquor license in accordance with the

endorsed plans, with the application dated, 16 May 2023, subject to the conditions listed in the recommendation, with a correction to Condition 7 which reads:

7. The licenced trading hours authorised for the premises are:
   a. 11am to 10pm from Sunday to Thursday
   b. 11am to 11pm Friday and Saturday.

Amended plans

1. **Before the commencement of the use and development, amended plans must be submitted to and approved by the Responsible Authority. When approved the plans will be endorsed and will then form part of the permit. The plans must be drawn to scale and dimensioned and must be generally in accordance with the plans submitted with the application, but modified to show:**
   a. **A north arrow to be included within the entire plan set as appropriate.**
   b. **Elevation plans which show the details of the proposed pergola, including dimensions showing maximum height.**
   c. **Elevation plans which show a typical section of the proposed front boundary fence, including dimensions showing maximum height.**
   d. **Revised plans which account for the 3.36 x 3.36 metre area of land on Lot 17 of PS743573F. The permitted use/development must be located wholly within the boundaries of the subject site. This may result in the revision of landscaping and car parking within this area. The total number of car parking spaces within the site must be no less than 45.**
   e. **A revised car parking layout which has regard to Conditions 22 and 23 includes the following:**
   f. **Internal spaces and civil design to comply with AS2890.**
   g. **The proposed driveway to have a minimum width of 6 metres.**
   h. **The nomination of bin and recycling areas in accordance with Condition 18.**
   i. **Any changes required to maintain consistency with the Car Parking Plan required by Condition 22.**
   j. **Any changes that are required from the acoustic report in accordance with Condition 10.**

Amenity management plan

2. **Before the commencement of the use hereby permitted, an Amenity Management Plan prepared to the satisfaction of the Responsible Authority must be submitted to and approved by the Responsible Authority. When approved, the plan will be endorsed and will then form part of the permit. All activities forming part of the use must comply with the endorsed Amenity Management Plan. The plan must include but is not limited to:**
   a. **Staffing and other measures which are designed to ensure the orderly arrival and departure of patrons;**
   b. **Signage to be used to encourage responsible off-site patron behaviour;**
   c. **The training of staff in the management of patron behaviour;**

d. **Records of training, including Responsible Service of Alcohol (RSA) training**
e. **Staff communication arrangements;**
f. **Measures to control noise emissions from the premises;**
g. **Litter management;**
h. **Contact details for taxi services and other transport options for patrons.**

Use and development not altered

3. **The use and development as shown on the endorsed plans must not be altered without the written consent of the Responsible Authority.**

4. **The licensed area as shown on the endorsed plans as approved by this permit shall not be altered except with the written consent of the Responsible Authority.**

5. **All buildings and works must be maintained in good order and appearance to the satisfaction of the Responsible Authority.**

Hours of operation

6. **The use hereby permitted must operate only between the hours of:**
   a. **11am to 10pm from Sunday to Thursday**
   b. **11am to 11pm Friday and Saturday.**

   Operation of Commercial Kitchen
   c. **The use as it relates to the commercial kitchen must only operate between the hours of 6am to 10pm on any given day**

   The commercial kitchen operating outside of the normal hours of operation must be for offsite catering purposes only.

Hours of liquor license

7. **The licenced trading hours authorised for the premises are:**
   a. **11am to 10pm from Sunday to Thursday**
   b. **11am to 11pm Friday and Saturday.**

Hours of deliveries

8. **Deliveries to and from the site (including private waste collection) must only take place between:**
   a. **7am to 10pm, from Monday to Friday inclusive**
   b. **9am to 10pm Saturday, Sundays or public holidays**

Maximum number of patrons

9. **No more than 150 patrons may be present on the premises at any one time (including any external seating) unless otherwise approved in writing by the Responsible Authority.**

Acoustic report

10. **Concurrent with the endorsement of plans, an acoustic report prepared by a suitably qualified person must be submitted to and approved by the Responsible Authority, providing recommendations as to how the use may be controlled in accordance with the relevant Environment Protection Regulations under the *Environment Protection Act 2017*. This assessment should comply with Environmental Protection Authority Publication 1826.4:, *Noise Limit and Assessment Protocol for the Control of Noise from Commercial, Industrial and Trade Premises and Entertainment Venues*, particularly, how the noise levels from inside and outside of the Function centre can be reduced to limit the impact on the surrounding residential area.**

11. **Noise attenuation measures for the development must be in accordance with the acoustic report and associated endorsed plans. Any noise attenuation measures must be completed prior to the occupation of the building and maintained thereafter, all to the satisfaction of the Responsible Authority.**

12. **No amplified music is permitted outside the building (including open lawn and arbour areas) after 9pm on any day.**

13. **Noise levels emanating from the premises must comply with the requirements of the *Environmental Protection Authority Publication 1826.4: Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venues.***

14. **Six (6) months after the commencement of the use, a suitable qualified acoustic consultant must provide Council with a report confirming that the venue (during a typical event) complies with the requirements of the *Environmental Protection Authority Publication 1826.4: Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venues.***

Amenity

15. **All plant and equipment used on site, or to monitor the performance of the development must be:**
    a. **Maintained in a proper and efficient condition; and**
    b. **Operated in a proper and efficient manner.**

16. **External lighting must be designed, baffled and located so as to ensure no loss of amenity to residents of adjoining properties to the satisfaction of the Responsible Authority**

Waste

17. **Waste and recycling storage areas must be provided on the site, to the satisfaction of the Responsible Authority. In this regard, a sufficient number of watertight receptacles with close fitting lids for the reception of garbage and reuse arising from the premises must be provided. This area must be screened from public view. The contents of such garbage receptacles are to be disposed of at least once in every seven consecutive days. The proprietor must not allow the garbage or refuse to become a nuisance at any time.**

18. **All waste material not required for further on-site processing must be regularly removed from the site. All vehicles removing waste must have fully secured and contained loads so that no waste is spilled or dust or odour is created, to the satisfaction of the Responsible Authority.**

Landscaping

19. **Within 3 months of the commencement of the use, or within the next applicable planting season, whichever is the earlier; the landscaping works shown on the endorsed plans must be carried out and completed to the satisfaction of the Responsible Authority. The landscaping must thereafter be maintained to the satisfaction of the Responsible Authority, including that any dead, diseased or damaged plants are to be replaced.**

Stormwater

20. **Before commencement of the development hereby permitted, a detailed Stormwater Management Plan is to be submitted to, and endorsed by, the Responsible Authority. The works must be designed in accordance with the current Infrastructure Design Manual (IDM) and the Stormwater Management Plan must include:**
    a. **Identification of any existing drainage infrastructure on the site;**
    b. **Details of how the works on the land are to be drained and/or retarded;**
    c. **Computations of the existing and proposed drainage volumes;**
    d. **A layout plan showing the proposed underground stormwater network to the legal point of discharge;**
    e. **Details which demonstrate stormwater runoff resulting from a 1 in 100 year storm event is able to pass through the development via reserves and/or easements, or be retained within development.**

21. **The endorsed Stormwater Management Plan is to be implemented prior to use or occupation of the development and must be maintained in good working order thereafter.**

Car parking

22. Before any works commencing on the development hereby permitted, a Car Parking Plan shall be prepared and submitted to the Responsible Authority for approval, clearly showing the layout, proposed method of surfacing and delineation of spaces, and how the car parking area will be landscaped.

This plan, when approved, shall be endorsed as forming part of the Permit and the parking area shall be constructed, maintained, drained and delineated in accordance with the endorsed plans to the satisfaction of the Responsible Authority.

23. Before the commencement of the use, the areas set aside for the parking of vehicles and access lanes as shown on the endorsed plans must be: -
   a. Constructed and drained to the satisfaction of the Responsible Authority;
   b. Properly formed to such levels that they can be used in accordance with the plans;
   c. Line-marked to indicate each car space and all access lanes;
   d. Accessways clearly marked to show the direction of traffic;
   e. Properly illuminated with lighting designed, baffled and located to prevent any adverse effect on adjoining land; to the satisfaction of the Responsible Authority.

24. Car spaces and access lanes must be maintained and kept available for use at all times.

25. Hard surface areas must be constructed and drained to prevent diversion of flood or drainage waters and maintained in a continuously useable condition to the satisfaction of the Responsible Authority.

Signage

26. The location, size, material of construction and details of the signage and any supporting structures, as shown on the endorsed plans, must not be altered without the prior written consent of the Responsible Authority, except where exempt under the Planning Scheme.

27. The sign(s) hereby permitted must not be animated or contain any flashing or intermittent lighting.

28. The signage must not be illuminated by external or internal light except with the prior written consent of the Responsible Authority.

Permit expiry

29. This permit will expire if one of the following circumstances applies:
   a. The approved development does not start within two (2) years of the issue of the permit; or

b. The approved development is not completed within four (4) years of the issue of the permit; or
c. The approved use does not start within four (4) years of the issue of this permit, or
d. The approved use of the land is discontinued for a period of two (2) years.
e. The erection or display of the signage is not started within two (2) years of the date of this permit.
f. The erection or display of the signage is not completed within four (4) years of the date of this permit.

In accordance with section 69 of the *Planning and Environment Act 1987*, the Responsible Authority may extend the periods referred to if a request is made in writing before the permit expires, or within six months of the permit expiry date, where the development allowed by the permit has not yet started; or within 12 months of the permit expiry date, where the development has lawfully started before the permit expires.

Notes:

- **The permitted use/development must be located wholly within the boundaries of the subject site.**
- **This permit does not authorise the commencement of any building works. Building approval must be obtained prior to the commencement of any approved works.**
- **Unless a permit is not required under the provisions of the Southern Grampians Planning Scheme, no other signs are permitted to be constructed or displayed without the written consent of the Responsible Authority.**
- **A liquor license must still be obtained via the Victorian Liquor Commission.**
- **Food Premises that sells food must comply with the following Victorian legislative requirements:**
    - **Food Act 1984;**
    - **Food Standards Australia and New Zealand Food Standards Code:**
        - **Food Safety Standards Chapter 3.2.2 Food Safety Practices and General Requirements; and**
        - **Food Safety Standards 3.2.3 Food Premises and Equipment**

CARRIED

12.2 Annual Plan Report for the Council Plan - 1 July 2022 - 30 June 2023

Directorate: Chief Executive Office
Report Approver: Tony Doyle (Chief Executive Officer)
Report Author: Karly Saunders, Governance Coordinator
Attachment(s): 1. Council Plan Report - 1 July 2022 - 30 June 2023 [**12.2.1** - 31 pages]

Executive Summary

The Action and Task Progress Report for the period 1 July 2022 to 30 June 2023 has been prepared to provide information regarding the performance of the organisation against the Annual Plan.

Discussion

The Annual Plan is developed each year to assist in the delivery of the Council Plan objectives and to demonstrate to the community the key projects to be delivered that year.

The Annual Plan sets out the specific actions and includes a detailed list of Council's activities and initiatives for the upcoming financial year. These initiatives are projects that are undertaken over and above normal service delivery and are intended to attain important outcomes for Council and the community.

Reports on the progress of the Annual Plan are reported to Council quarterly. This allows Council to receive timely, relevant and measurable information about how the organisation is performing. This in turn allows Council an opportunity to raise concerns about performance in a timely manner. The Annual Plan reporting will also help formulate the Annual Report and support the reporting against the Council Plan each year.

This is the final report on the Annual Plan for the 2022/2023 financial year.

There are 52 actions in the Annual Plan. Of these 52 actions:

- 34 of the 52 actions (65%) have been completed;
- 43 actions (83%) are on track - at least 90% of the target achieved;
- 7 actions (13%) require monitoring –between 70% and 90% of the target achieved;
- 2 actions (4%) are off track – less than 70% of target achieved; and
- 0 actions (0%) have no target set.

	Complete	On Track (includes completed)	Require Monitoring	Off Track	Total Actions
30 September 2022	11% (6)	81% (42)	2% (1)	17% (9)	52
31 December 2022	12% (6)	88% (44)	2% (1)	10% (5)	50
31 March 2023	22% (11)	86% (44)	8% (4)	6% (3)	51
30 June 2023	65% (34)	83% (43)	13% (7)	4% (2)	52

Although not all Actions in the Annual Plan have been completed, excellent progress has been made throughout the year.

The Actions that weren't completed in the 2022-2023 year of the Council Plan have been reviewed and 17 items will roll over into the 2023-2024 financial year, with reporting to commence at the end of the July – September quarter.

Details about the specific performance of the Annual Plan actions are detailed in the attached Action and Task Progress Report.

Financial and Resource Implications

There are no financial or resource implications.

Council Plan, Community Vision, Strategies and Policies

Provide Strong Governance and Leadership
5.1 Transparent and accountable governance
5.1.1 Strengthen the governance role of Councillors by informing, resourcing, skilling and supporting the role.
5.1.2 Ensure flexible and transparent decision making through open and accountable governance.

Provide Strong Governance and Leadership
5.2 Effective advocacy
5.2.2 Advocate on behalf of the community in line with identified and agreed priorities.

Legislation

Council is required to adopt a Council Plan in accordance with Section 90 of the *Local Government Act 2020*. The Council Plan is supported by the development of an Annual Plan which details the actions that will be undertaken to achieve the strategic objectives in the Council Plan.

Gender Equality Act 2020

There are no gender equality implications.

Risk Management

Reporting on the Annual Plan is presented to Council quarterly so that Council can regularly monitor the performance of the organisation.

Climate Change, Environmental and Sustainability Considerations

Not Applicable.

Community Engagement, Communication and Consultation

Under Section 18 of the Local Government Act, it is a requirement for the Mayor to report to the municipal community, at least once each year, on the implementation of the Council Plan.

The Annual Plan is publicly available on the Council website.

Disclosure of Interests

All Council Officers involved in the development and advice provided in this Report affirm that no general or material interests need to be declared in relation to any matters in this Report.

Karly Saunders, Governance Coordinator
Tania Quinn, Council Support Officer

RECOMMENDATION

The Action and Task Progress Report for 1 July 2022 to 30 June 2023 be received.

COUNCIL RESOLUTION

MOVED: **Cr Malone**
SECONDED: **Cr Rainsford**

The Action and Task Progress Report for 1 July 2022 to 30 June 2023 be received.

CARRIED

12.3 Community Satisfaction Survey

Directorate:	Chief Executive Office
Report Approver:	Tony Doyle, Chief Executive Officer Tony Doyle, CEO
Report Author:	Karly Saunders, Governance Coordinator
Attachment(s):	2023 Community Satisfaction Survey

Executive Summary

Results of the 2023 Community Satisfaction Survey carried out by independent market research consultancy, JWS Research, have been provided to Council.

Each year Local Government Victoria coordinates this Community Satisfaction Survey throughout Victoria. This coordinated approach allows for far more cost-effective surveying than would be possible if Councils commissioned surveys individually.

Participation in the Community Satisfaction Survey is optional and participating Councils have a range of choices as to the content of the questionnaire. However, some of the data required for the Local Government Performance Reporting Framework is only available through this survey.

The survey's main objectives are to assess the performance of Southern Grampians Shire Council across a range of measures and to seek insight into ways to provide improved or more effective service delivery.

The survey methodology includes:

- completing 400 interviews (as determined by the most recent ABS population estimates 16,488 with equates to 2.43% of the municipal population)
- Meeting minimum quotas of gender within age groups to ensure an accurate representation of age and gender profile within Southern Grampians Shire Council area
- Each interview takes about 9 minutes to complete
- Publicly available phone records, including up to 60% of mobile phone numbers to cater to the diversity of residents within Southern Grampians, particularly younger people.

This report outlines the relevant and significant survey results and recommends they be noted by Council.

Discussion

Overall, Council's results were disappointing and consistent with a statewide trend that saw the sector significantly back track on 2022 results. In fact, the 2023 results confirm a three-year downward trend in survey results for Southern Grampians Shire Council, the Large Shire Group and the Statewide results.

JWS advised generally, government sentiment and its downward trend can be attributed to cost of living, floods damage including potholes, waste management and the number of councils entering into administration.

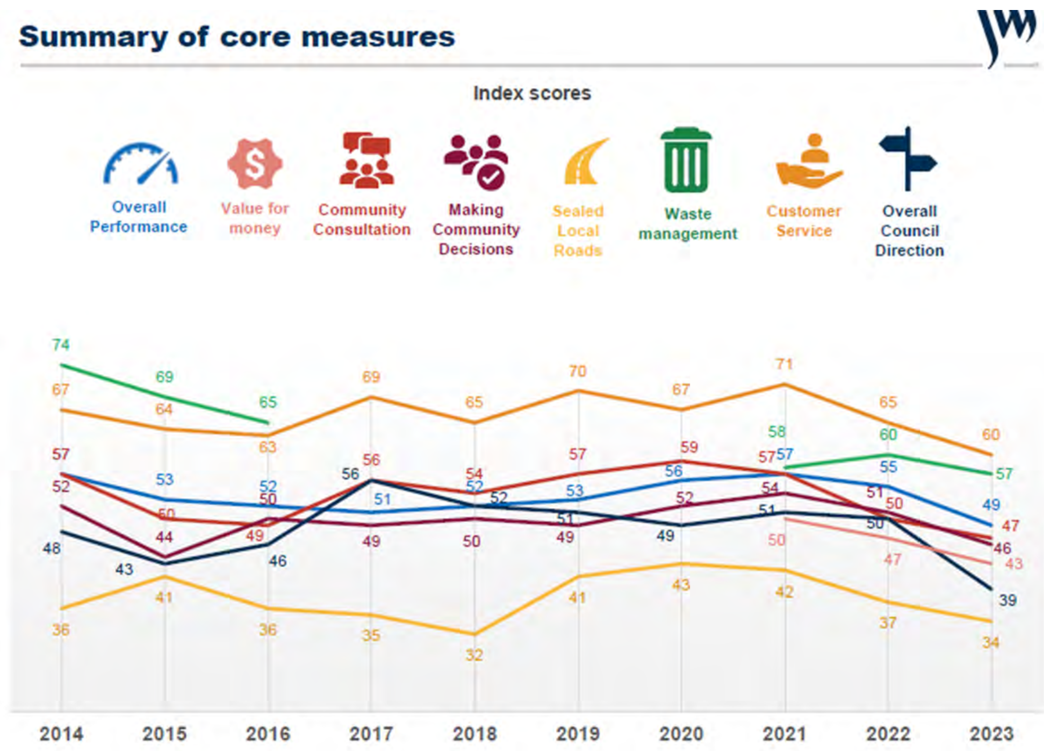
Council's Overall Performance has decreased by six points in 2023 from 55 to 49. The Overall Performance score of 49 is three points lower than the Large Rural average (52) which declined by 3 points.

Whilst Council's performance had been improving steadily from 2017 to 2021, last year's decrease is also reflected in the Large Rural and State-wide average which have both decreased over the past 2 years.

Summary of Southern Grampians Shire Council performance

Services	Southern Grampians 2023	Southern Grampians 2022	Large Rural 2023	State-wide 2023	Highest score	Lowest score
Overall performance	49	55	52	56	Aged 65+ years	Aged 35-49 years
Value for money	43	47	45	49	Aged 65+ years	Aged 35-49 years
Overall council direction	39	50	44	46	Aged 65+ years	Aged 35-49 years, Aged 18-34 years
Customer service	60	65	65	67	Aged 65+ years, Aged 35-49 years, Women	Aged 50-64 years
COVID-19 response	67	70	67	67	Women, Aged 65+ years	Aged 35-49 years
Waste management	57	60	65	66	Aged 65+ years	Aged 35-49 years
Appearance of public areas	51	61	65	67	Men	Aged 35-49 years
Consultation & engagement	47	50	49	52	Aged 65+ years	Aged 35-49 years
Community decisions	46	51	48	51	Aged 65+ years	Aged 35-49 years
Sealed local roads	34	37	40	48	Aged 65+ years	Aged 35-49 years, Aged 18-34 years

Council's Performance Measures in Overall Council Direction (39), Customer Service (60) and Community Decisions (46) Consultation and Engagement (47) and Sealed Local Roads (34) have all decreased from the 2022 scores.



About three in five Council residents (58%) have had contact with Council in the last 12 months, the second highest rate of contact after the 2020 rate of 59%.

Telephone remained the dominant method of contact with Council over the last 12 months (30%, up one point). In person contact increased slightly (26%, up 2 points), whilst contact in writing decreased 8% (down five points). Contact via email is the third highest method of contact (21%, up two points).

The area that stands out as being most in need of Council attention is Sealed Local Roads. With a score of 34, this is the area where Council is performing least well and is lower than the Large Rural and State-wide group averages (being 40 and 48 respectively).

Feedback from residents on what they consider Council most needs to do to improve its performance in the next 12 months supports this finding, with Sealed Road Maintenance mentioned by 22% of residents. This area of improvement has not changed since 2021, however the percentage of residents citing this as the area most in need of improvement has increased by 2 points.

The top five mentions from respondents for the ‘Best Things about Council’ and the ‘Areas for Improvement’ are as follows:

What is the best thing about Council?

1. Customer Service 8%
2. Parks and Gardens 6%

3. Community Engagement/Involvement/ Consultation/Approachable 6%
4. Recreation/Sporting Facilities 5%
5. Location 4%

What does Council most need to do to improve its performance?

1. Sealed Road Maintenance 24%
2. Community Consultation 12%
3. Financial Management 11%
4. Waste Management 9%
5. Communication 8%

Staff will continue to review and analyse the report with a view to developing actions to work towards improving customer perceptions of council services.

Officers are investigating several options that may involve a mix of chatbots and direct personal surveys immediately after service provision.

Nevertheless, the current survey results are being responded to, examples of which are as follows:

- A new website which will improve the accessibility of information for the community.
- A new CRM system will support better reporting and mining of data.
- Community accessibility to roads programs.
- New customer service standards which are currently under development.
- The Better Planning Approvals project implementation.
- Better project communication
- Commencement of Community Podcasts on Council services, events and engagement.
- New business concierge position.
- Review of regulatory services processes (e.g. septic tank permits).

Financial and Resource Implications

The cost to carry out the survey by JWS Research was $18,205.00 (GST inclusive)

There may be some resource implications based on the issues identified in this report. Resources in relation to communication, engagement and service planning may be focused differently to ensure that the issues identified in this Report are a focus of the organisation for the next 12 months.

Council Plan, Community Vision, Strategies and Policies

Support Our Community
1.1 An empowered and connected community
1.1.3 Provide opportunities for increased community engagement and participation in Council decision making and activities.

Legislation

Some of the results from this survey are used as part of the reporting under the Local Government (Planning and Reporting) Regulations 2020.

The information is essential to future policy and strategy development and particularly service planning. It gives comparable data for several years over which Council can identify trends and areas which need attention.

Gender Equality Act 2020

There are no implications.

Risk Management

There is a risk to Council's reputation if attention is not paid to matters of community concern. Beyond the matters of specific services, the approach to the condition of local sealed roads is of clear concern. Whilst Council takes this feedback seriously regarding the local roads, we also have a strong advocacy role with the State and Federal road network which is arguably in a far worse condition than Council Local Roads and our residents cannot differentiate (nor should not) between local and other roads.

Climate Change, Environmental and Sustainability Considerations

The adoption of the recommendations in this report do not have any environmental or sustainability impacts.

Community Engagement, Communication and Consultation

A total of 400 completed interviews of residents were made in the Shire during the period 27 January 2023 – 19 March 2023.

The Community Satisfaction Survey results for 2023 will be released to the community together with an explanatory media release.

Disclosure of Interests

All Council Officers involved in the development and advice provided in this Report affirm that no general or material interests need to be declared in relation to any matters in this Report.

Karly Saunders, Governance Coordinator
Tania Quinn, Council Support Officer

RECOMMENDATION

That Council receive the 2023 Local Government Community Satisfaction Survey Southern Grampians Shire Council Research Report.

COUNCIL RESOLUTION

MOVED: **Cr Henry**
SECONDED: **Cr Malone**

That Council receive the 2023 Local Government Community Satisfaction Survey Southern Grampians Shire Council Research Report.

CARRIED

12.4 Art Gallery Climate Control Upgrade Contract Variation 07/23

Directorate: Infrastructure and Sustainability
Report Approver: Marg Scanlon, Director Infrastructure and Sustainability
Report Author: Vaibhav Gavande, Project Manager
Attachment(s): Nil

Executive Summary

The Hamilton Gallery Climate Control Project has incurred additional costs due to the identified insufficient power supply available to support the new system. This power supply issue was identified post tender award following the contractor's assessment.

It is recommended that Council approve the variation for Contract 07-23 Art Gallery Climate Control Upgrade to the value of $60,928.00 ex GST.

Discussion

During the tender phase, the contractor initially assessed the power availability based on the information provided in the Mechanical Service Switch Board (MSSB) legend, which indicated a power capacity of 160 amps. As construction progressed on site, it was discovered that the existing Level 1 mechanical board only had a 63-amp power supply, which was sourced from the distribution board which serves the Hamilton Library. The legend available in the MSSB was inaccurate. The supply and installation of new mechanical sub-mains from the main switch board is required to increase the power capacity for the additional load required to support the climate control upgrade works.

Works included in this variation specifically includes new mechanical 155A sub mains from the main switchboard, including switchboard connection, new mechanical services, sub-main circuit protection and enclosure as per regulatory standards.

Financial and Resource Implications

It is proposed that the variation cost of $60,928 will be funded through the reallocation of unspent funds listed in the 2022/2023 Capital Program. Specifically, the Hamilton Showgrounds Car Park and Pedestrian Crossing which is noted as a carry-forward item, had a budget allocation of $85,000. With the Hamilton Showgrounds Master Plan progressing a detailed, costed implementation plan will form a part of the final Master Plan. This costed plan will inform future capital programs priority needs.

Council Plan, Community Vision, Strategies and Policies

Grow Our Regional Economy
2.4 Support local business and industry
2.4.1 Support and promote a collaborative approach to marketing and investment.

Legislation

This report assists Council in meeting its obligations under the Local Government Act 2020. This report also relates to the:

- Southern Grampians Shire Procurement Policy 2021-25
- Southern Grampians Shire Procurement Guidelines 2019 V13

Risk Management

The project must be completed by the end of August 2023 to ensure temperature records of 3 months can be provided to NGV to secure future artwork and proceed with the committed exhibitions in December 2023.

Disclosure of Interests

All Council Officers involved in the development and advice provided in this Report affirm that no general or material interests need to be declared in relation to any matters in this Report.

Vaib Gavande, Project Manager
Marg Scanlon, Director Infrastructure and Sustainability

RECOMMENDATION

That Council approve the reallocation of unspent funds from the Hamilton Showgrounds Car Parking and Pedestrian Crossing to fund the variation for Contract 07-23 Art Gallery Climate Control Upgrade to the value of $60,928.00 ex GST.

AMENDED RECOMMENDATION

That Council note the variation for Contract 07-23 Art Gallery Climate Control Upgrade to the value of $60,928.00 exclusive GST.

1. To be funded from savings sourced within this financial year

2. The Director of Infrastructure and Sustainability to provide monthly reports to Council on the status of the Capital Works Program including identifying savings.

COUNCIL RESOLUTION

MOVED: Cr Rainsford
SECONDED: Cr Malone

That Council note the variation for Contract 07-23 Art Gallery Climate Control Upgrade to the value of $60,928.00 exclusive GST.

1. **To be funded from savings sourced within this financial year**

2. **The Director of Infrastructure and Sustainability to provide monthly reports to Council on the status of the Capital Works Program including identifying savings.**

CARRIED

13 Notices of Motion

There were no Notices of Motion.

14 Urgent Business

There was no Urgent Business.

15 Mayor, Councillors and Delegate Reports

Address from the Mayor and Councillors in relation to matters of civic leadership and community representation, including acknowledgement of community groups and individuals, information arising from internal Committees and delegates committees, advocacy on behalf of constituents and other topics of significance.

15.1 Cr Malone

The Coleraine Art Show is on this weekend, starting with the judging on Friday followed by the Gala Evening, with tickets at the door for $2 per person. I encourage everyone in the Shire to come along and view all the beautiful art in different genres. The work that goes into organising the event behind the scenes in phenomenal and everyone involved should congratulated in putting together such an even in the small community of Coleraine.

15.2 Cr Rainsford

July 13/14 - Attended the Annual Rural Councils Forum @ Echuca.

July 14 - Joined in the celebration of 50 years of The Friends of Hamilton Gallery

July 15 - Rejoiced in the opportunity to join 100.s of locals onboard the Spirit of Progress diesel Heritage train form the Seymour Rail Heritage Centre along with family members took the train south towards Portland and return journey. There were long waits and the trip was slow considering the lack of maintenance of our local rail line, but no one seemed to care. It was a really picnic day atmosphere. Providing memories for those locals who recalled the days when passenger rail was a local service not over and hours drive away. And giving hope, proof that passenger rail is popular and would be used.

July 20 - Attended the Hamilton Regional Business Association on DAMA Designated

July 20 - Attended Hamilton Rural Industry Learning campus for their AGM July 22nd we headed north with our caravan to attend

July 26/27 - the Sustainable Regional Growth Australia Foundation Forum in Toowoomba
July 25th - Attended the Hamilton Regional Livestock Exchange Advisory Committee meeting virtually from Goondamindi I visited one of the 8 Pallisade stable of Regional Livestock Exchange facilities Central RLX near SELX on 16 June on Hume Highway near Yass NSW & CWLX Central West Livestock Exchange operated by Forbes Council

July 28/29 - some Continuing Education at the Australia and New Zealander Veterinary Scientist College conference with included attending updates on Biosecurity , risk and impact of Lumpy Skin Disease,

30th July - Tried camping overnight in the Narrabri Showgrounds for $15 unpowered site , good showers, homes try box and record your number plate.

31st July - West Wyalong overnight and visited the new mining workers camp within the township boundary to house the underground mining teams where the gold mine at Lake Cowell has been transitioned to underground

2nd Aug - spent the day helping set up for Sheepvention at our Showgrounds

Aug 3 - TAFE Connecting Universities workshop concerning study hub

August 3 - Meeting with SGSC CEO & Mayor and Councill delegates with P & A stakeholders re need for more permanent shed space urgently

3rd August - Hamilton Showgrounds Advisory Committee meetings- reviewing the consultants summary to date and ground proofing summaries this far.

4th Aug - day trip via car train bus via Ararat railway station to attend the Rail Frieght Alliance Meeting where a comprehensive report was delivered on the Triple Bottom Line value of Rail Freight and progress on improving freight lines within Victoria - nothing happening to date on our Maroona Portland Line with now increase in axle low eights or speed limits with the latest costing and value report on the desk of Victorian Transport Minister. I think it should be on the desk of the Climate Change Response Minister due to efficiencies have huge reduction in use of fossil fuels potential and reduces energy in road repairs.

INLAND RAIL PROJECT
9.9 Billion Inadequate Skills of Board and not knowing the start or finish (or detailed route)
31.4 BILLION NOW

Aug 6/7 - attended Sheepvention Rural Expo both days. Great set up by the P & A , amazing atmosphere of the two Big Top Circus tents which were packed full of exhibitors. The Opening main speaker by meat processing icon Roger Fletcher from meat processing Fletcher International was informative following a detailed address from our Victorian Minister for Agriculture Gale Tierney.

15.3 Cr Calvano

14th of July I attended The Celebrate Youth Event at the PAC.

20th of July I attended, The Field Naturalists meeting at HIRL

6th of August I Attended the Opening of Sheepvention at the Hamilton Showgrounds.

15.4 Cr Henry

Attended the Ansett AGM
Baimbridge Scholarship AGM
Celebrate Youth Event at the PAC
Gallery Opening and commended the work of the friends over the past 50 years
Attended HIRL market
Hamilton Alexandra College Adam's Family, Baimbridge College Production of Alice in Wonderland – provided a good lukc message for these two productions

15.5 Cr Brown

Congratulated Sheepvention
Provided an update on HRLX as the Chair
Three events at Dunkeld, Australian Chamber Choir, Peaks and Trails and Writers Festival – thank you to the volunteers involved.

15.6 Cr Robertson

14/7 – Art Gallery
17/7 – New Citizenship
20/7 – Youth Parliament
25/7 – Rotary Meeting
27/7 – Book Launch Hamilton Academy
6/8 – Sheepvention Opening, Minister Gayle Tierney and Peter Schroder Lecture

16 Confidential Reports

RECOMMENDATION

That the following items be considered in Closed Council as specified in section 66(2)(a) and referenced in section 3(1), (f) personal information, being information which if released would result in the unreasonable disclosure of information about any person or their personal affairs.

COUNCIL RESOLUTION

MOVED: **Cr Brown**
SECONDED: **Cr Rainsford**

That the following items be considered in Closed Council as specified in section 66(2)(a) and referenced in section 3(1), (f) personal information, being information which if released would result in the unreasonable disclosure of information about any person or their personal affairs.

CARRIED

17 Close of Meeting

This concludes the business of the meeting.

Meeting closed at 6:33 pm.

Confirmed by resolution 13 September 2023.

....
Chairperson

DEVELOPMENT PLAN

Recreation Road, Dunkeld (DPO12)

Table of Contents

Southern Grampians SHIRE COUNCIL

INSIGHT Planning Consultants

1 Introduction

The Development Plan has been prepared by Insight Planning Consultants on behalf of Southern Grampians Shire Council for the area identified in Development Plan Overlay, Schedule 12 (DPO12 – Residential Development: Recreation Road, Dunkeld) in accordance with the requirements of the Southern Grampians Planning Scheme.

The Development Plan relates to the future development of residential land and contains information regarding the precinct context, site assessment, general layout and staging of the Recreation Road Precinct.

The approved Development Plan will be the foundational guide for future planning permit applications within the Precinct.

2 Site and Surrounds

The Recreation Road Precinct (Precinct) consists of land in the Township Zone, bound by Recreation Road to the west and north, Bellicourt Road to the east and the Rural Living Zone to the south, in Dunkeld. The Precinct consists of nineteen (19) lots of varying sizes. Some historic subdivision has already occurred within the Precinct at 95 Recreation Road, including the provision for a future road reserve to service the balance of the land parcel.

The Precinct is on the southern edge of the township of Dunkeld, south of the railway line.

FIGURE 1: AERIAL MAP (GOOGLE EARTH 2023)

Land to the north of the Precinct is land within the Township Zone, consisting of existing residential properties and vacant lots, and the Dunkeld Recreation Reserve, which is in the Public Park and Recreation Zone. Land further north includes the railway line, which is in the Transport Zone 1. Land to the west of the Precinct is in the Farming Zone. Land to the east and south of the Precinct is in the Rural Living Zone and consists of rural dwellings on larger land parcels, with a small pocket of Low Density Residential Zone and Public Park and Recreation Zone land to the north-east of the Precinct, and Industrial 3 Zone further north-east. There do not appear to be any land use buffers that encroach into the Precinct from surrounding areas.

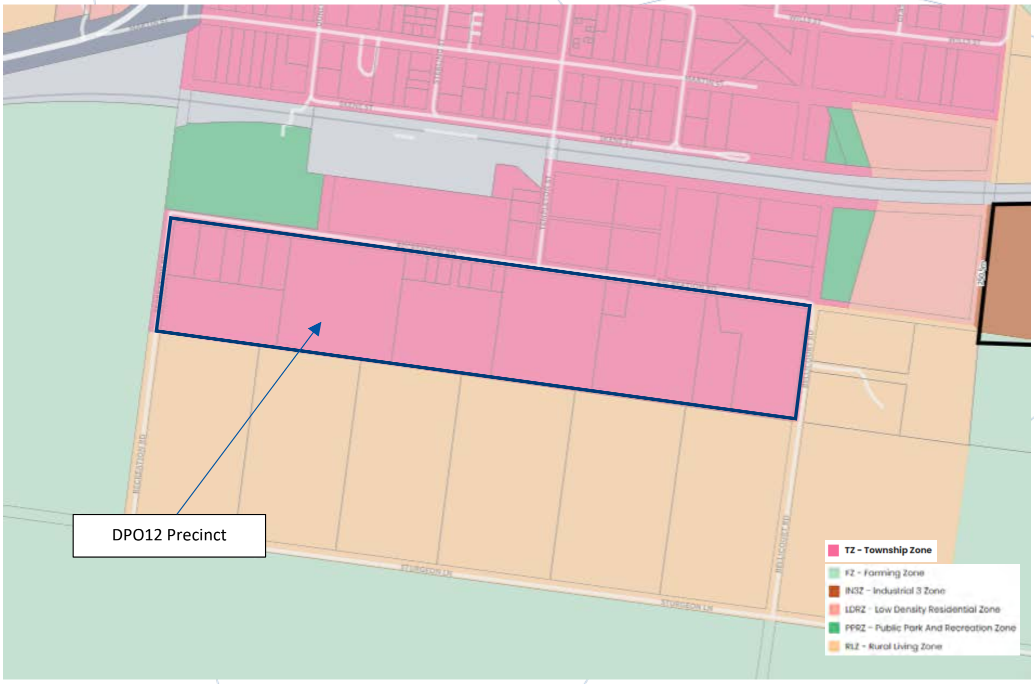


FIGURE 2: PRECINCT CONTEXT (LANDCHECKER 2023)

2.1 Regional Context

Dunkeld is located approximately 230 kilometres west of Melbourne, situated on the Glenelg Hwy and located 29 kilometres north-east of the Hamilton CBD via the Glenelg Hwy.

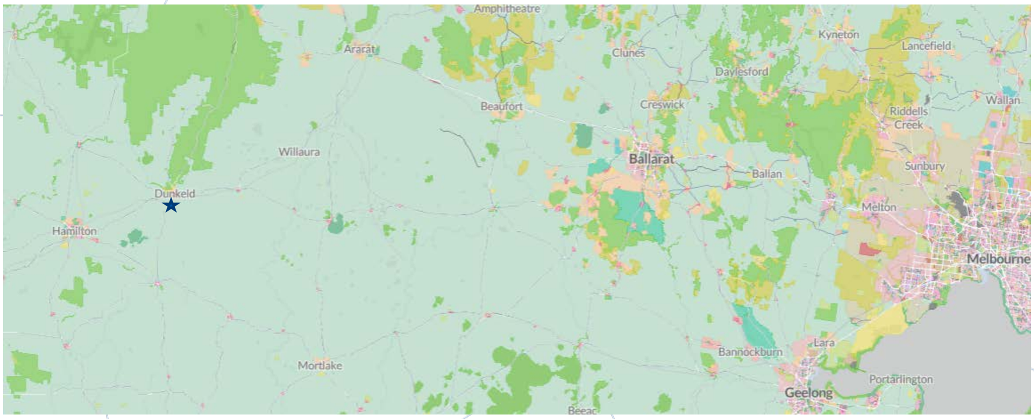


FIGURE 3: REGIONAL CONTEXT MAP (LANDCHECKER 2023)

3 Overview

3.1 Purpose of the Development Plan

The Recreation Road Development Plan will become the key strategic planning document that will provide the short and long term vision for the future planning and development of this residential area.

3.2 Structure of the Development Plan

The structure and content of this Development Plan has been prepared based on the general requirements of Clause 43.04-4 *Preparation of the Development Plan.*

The purpose of a Development Plan is:

- *To implement the Municipal Planning Strategy and the Planning Policy Framework.*
- *To identify areas which require the form and conditions of future use and development to be shown on a development plan before a permit can be granted to use or develop the land.*
- *To exempt an application from notice and review if a development plan has been prepared to the satisfaction of the responsible authority.*

The outcomes of the Development Plan align with the Southern Grampians Planning Scheme, including the Planning Policy Framework, to ensure that any future development of land within the Precinct is undertaken generally in accordance with the approved Development Plan.

4 Objective

Given the vision for Dunkeld as laid out by the Structure Plan for Dunkeld, the following key ambitions will underpin the Recreation Road Development Plan (DPO12).

- Maintain the compact form and rural image of the township;
- Ensure the precinct develops in coordinated manner;
- Sustain the town's rural threshold and views and vistas to the Grampians National Park;

- Improve green linkages through the town;
- Ensure that infrastructure services in the public realm are unobtrusive;
- Require development to respond to the existing topography and natural assets of the site;
- Protect long-term subdivision and development opportunities;
- Allow development to occur incrementally and independently.

This Development Plan seeks to determine the 'pattern' of development within the Precinct. It seeks to spell out the way future residential land on the site should evolve over the next 20 years, ensuring appropriate relationships and connectivity.

DPO12 aims to provide certainty for landowners and developers regarding development expectations, ensure a cohesive and coordinated approach to any future subdivision, and protect long-term opportunities.

The plan seeks to strengthen the valued features of Dunkeld and create the opportunity for a legible, attractive, and connected urban network in this part of Dunkeld. Its focus is to ensure the celebration of the town's natural setting and rural character, while allowing for growth through urban densification.

5 Strategic Context

5.1 Dunkeld Structure Plan

The Dunkeld Structure Plan was approved in 2014 and assists the management and monitoring of future growth and development in the Dunkeld township. The Structure Plan seeks to establish an agreed vision for Dunkeld's urban areas and define the ultimate extent and image of the township and its immediate surrounds over a period of more than 20 years.

The Structure Plan sets out the following key directions for Dunkeld:

1. *Protect key views and vistas to the Grampians National Park and the rural surrounds.*
2. *Grow and diversify employment opportunities to support long term economic sustainability.*
3. *Develop and improve the image of Dunkeld's 'main street'.*
4. *Establish an accessible network of public spaces and community places.*
5. *Improve movement networks and protect the pedestrian experience.*
6. *Preserve and enhance the Salt Creek corridor and connected waterways.*
7. *Retain and advance the informal rural and vegetated character of the township.*
8. *Provide for a diversity of accommodation options within the township.*
9. *Support a diversification of the tourist offering in and around Dunkeld.*
10. *Acknowledge the potential bushfire and flood risks and ensure land management responds appropriately.*

The Structure Plan is shown below.

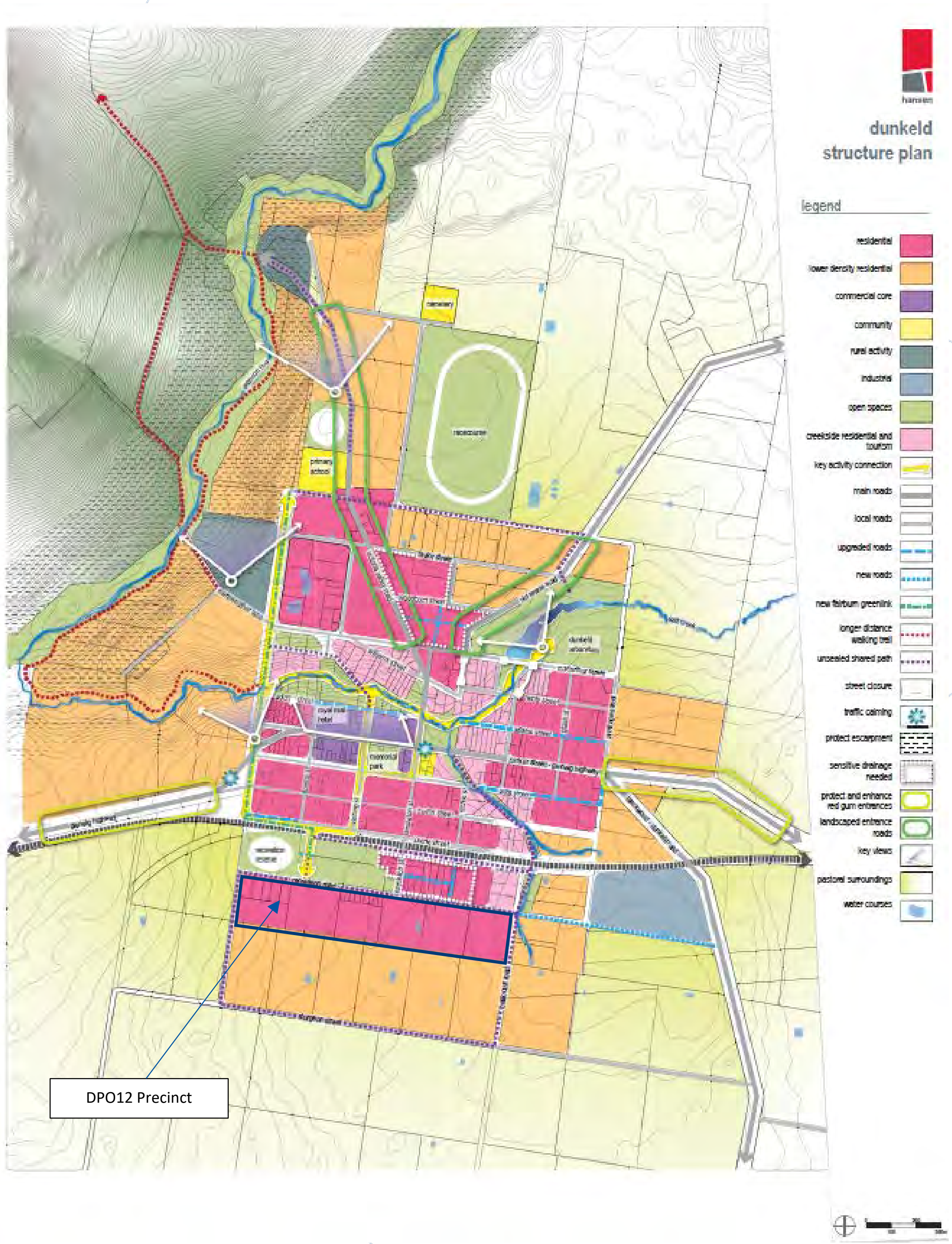


FIGURE 4: DUNKELD STRUCTURE PLAN (HANSEN 2012)

5.2 Dunkeld Structure Plan, Urban Design Guidelines

The Dunkeld Structure Plan – Urban Design Guidelines (2012) set out objectives and guidelines for the different areas subject to the Structure Plan. The DPO12 requires consistency with the 'Town Residential' Urban Design Guidelines.

The town residential design objectives are as follows:

- *To maintain the rural town character of residential areas and reinforce the low profile of buildings within local streetscapes.*
- *To ensure that development in residential areas address local streetscapes and supports the traditional format of detached dwelling on lots with front setbacks.*
- *To ensure that building siting, including side and front setbacks, allow for garden frontages and views through to the broader landscape.*

6 Planning Provisions

The Development Plan needs to ensure that it is consistent with the Planning Policy Framework, including any relevant State or local policies or guidelines.

6.1 Clause 11.03-6L - Dunkeld

The objectives of this policy are:

- *To cohesively plan for the use and development of land in Dunkeld.*
- *To retain Dunkeld's unique character while fostering sustainable growth.*

Strategies to achieve this include (as relevant):

<u>*Settlement*</u>

- *Prioritise infill development that respects neighbourhood character as the preferred form of development*
- *Provide for longer term greenfield growth in the area shown as 'residential' south of Recreation Road around the Templeton Street area, where land is not affected by drainage constraints*

<u>*Built Environment and Heritage*</u>

- *Support buildings that are subservient to the landscape and natural setting of Dunkeld, and protect 'key views', particularly of the Grampians National Park*
- *Encourage development that responds to the rural character of Dunkeld through lower densities and building heights, generous landscaping and traditional building styles*

<u>*Access and Infrastructure*</u>

- *Require unformed roads to be constructed to facilitate subdivision and development*
- *Design new roads in all areas other than the commercial core to reflect the rural character, including informal gravel surfaces with soft verges*
- *Encourage subdivision that adopts a grid layout and avoids dead end streets*
- *Design infrastructure and services to reflect the town's rural character*

6.2 Township Zone

The land within the Precinct is entirely within the Township Zone (TZ), as shown below.

FIGURE 5: ZONING MAP (LANDCHECKER 2023)

The purpose of the TZ is:

- *To provide for residential development and a range of commercial, industrial and other uses in small towns*
- *To encourage development that respects the neighbourhood character of the area*
- *To allow educational, recreational, religious, community and a limited range of other non-residential uses to serve local community needs in appropriate locations*

There is no minimum subdivision area specified in the Township Zone.

A permit is required to subdivide land, and requires consideration of Clause 56.

Additionally, each lot must be provided with reticulated sewerage, if available. If reticulated sewerage is not available, the application must be accompanied by:

- *In the absence of reticulated sewerage, include a Land Capability Assessment on the risks to human health and the environment of an on-site wastewater management system conducted, installed or altered on the lot in accordance with the Environment Protection Regulations under the Environment Protection Act 2017.*
- *A plan which shows a building envelope and effluent disposal area for each lot.*

6.3 Environmental Significance Overlay, Schedule 2

The Environmental Significance Overlay, Schedule 2 (ESO2 – Protection of Waterways) applies to the north-eastern corner of 141 Bellicourt Road on the eastern end of the Precinct, as shown below.

FIGURE 6: EXTENT OF ESO2 (LANDCHECKER 2023)

The ESO2 identifies the following statement of environmental significance for land affected by this overlay:

Salt Creek and the Wannon River play a key role in the landscape character of Dunkeld and in maintaining clean water, soil stability and habitat for flora and fauna. The management of land adjacent to streams and watercourses is necessary to reduce erosion, maintain vegetation and habitat, and improve water quality.

The environmental objectives to be achieved are as follows:

- *To maintain water quality*
- *To maintain the ability of streams and watercourses to carry natural flows*
- *To prevent erosion of banks, streambeds and adjoining land and the siltation of watercourses, drains and other features*
- *To protect and encourage the long term future of flora and fauna habitat in and along watercourses*
- *To ensure development does not occur on land liable to flooding and minimise the potential for damage to human life, buildings and property caused by flood events*
- *To prevent pollution, elevated nutrients and increased turbidity in natural watercourses*
- *To prevent increased surface run-off or concentration of surface water run-off leading to erosion or siltation of watercourses*
- *To conserve existing wildlife habitats close to natural watercourses and, where appropriate, to allow for generation and regeneration of habitats*
- *To restrict the intensity of use and development of land and water to activities which are sensitive to environmental values and which are compatible with potential drainage or flooding hazards*

Under the ESO, a permit is required to:

- Construct a building or construct or carry out works, unless as specified in the schedule to the overlay
- Construct a fence if specified in the schedule
- Construct bicycle pathways and trails
- Subdivide land, unless as specified in the schedule to the overlay
- Remove, destroy or lop any vegetation, including dead vegetation, unless as specified in the table to Clause 42.01-3 or in the schedule to the overlay

Under Schedule 2 of the ESO, a permit is not required to:

- Construct a residential or commercial building provided:
    - The building is connected to reticulated sewerage; and
    - Written advice has been received from the relevant Floodplain Management Authority stating that the proposed building envelope is on land that is higher than the estimated 100 year ARI flood level.

6.4 Vegetation Protection Overlay, Schedule 1

The Vegetation Protection Overlay, Schedule 1 (VPO1 – Dunkeld River Red Gums) applies to the entire Precinct, as shown below.

FIGURE 7: EXTENT OF VPO1 (LANDCHECKER 2023)

The VPO1 identifies the following statement of nature and significance of vegetation to be protected for land affected by this overlay:

The flats to the east and west of the Dunkeld township are open pastoral land scattered (in particular to the west) with notable cover of River Red Gums (Eucalyptus camaldulensis). These have a considerable presence on approach to the town along the Glenelg Highway and have a more limited presence in the town itself. There are also notable examples of large Red Gums in road reserves and on private property within Dunkeld and broad canopies are evident in the front and rear yards of private residences. This existing vegetation while in private ownership is considered important in its contribution to the rural feel of the Township.

The vegetation protection objectives to be achieved are as follows:

- *To conserve the existing pattern of vegetation and landscape quality within Dunkeld*
- *To protect remnant River Red Gums*
- *To ensure that River Red Gums are maintained as a dominant feature of the landscape*
- *To retain dead River Red Gum trees where possible to provide habitat and protect biodiversity*

Pursuant to the VPO1, a permit is required to remove, destroy or lop any River Red Gum tree. This does not apply to pruning to improve tree health, structure or safety, provided normal growth habit is not adversely affected.

6.5 Design and Development Overlay, Schedule 5

The Design and Development Overlay, Schedule 5 (DDO5 – Dunkeld Township and Residential Areas) applies to the entire precinct, as shown below.

FIGURE 8: EXTENT OF DDO5 (LANDCHECKER 2023)

The design objectives to be achieved are as follows:

- *To maintain the rural town character of residential areas and reinforce the low profile of buildings within local streetscapes*
- *To ensure that development in residential areas addresses local streetscapes and support the traditional format of detached dwellings on lots with front setbacks*
- *To ensure that building siting, including side and front setbacks allow for garden frontages, layered landscaping and views through to the broader landscape*
- *To encourage new development to be subservient to the broad landscape character of Southern Grampians and the open pastoral landscape*
- *To ensure site design avoids the removal of native canopy vegetation, including, established River Red Gums, wherever possible*
- *To encourage high quality architectural design and development that adopts a design theme and palette drawn from the town's rural character and landscape setting*
- *To encourage view sharing across the town towards the Grampians and the pastoral surrounds*
- *To ensure that subdivision proposals enable new buildings to be integrated with their site and the surrounding area*

A permit is required to subdivide land, and must meet the following requirements:

- *The configuration of new lots must address existing street patterns and create a sense of street address by fronting onto existing roads*
- *Avoid the use of common property access and battle-axe lots where possible by utilizing existing road reserves for access to new lots*

6.6 Development Plan Overlay, Schedule 12

The Development Plan Overlay, Schedule 12 (DPO12 – Residential Development: Recreation Road, Dunkeld) applies to the entire precinct, as shown below.

Figure 9: Extent of DPO12 (Landchecker 2023)

The Development Plan Overlay (DPO) requires that:

A permit must not be granted to use or subdivide land, construct a building or construct or carry out works until a development plan has been prepared to the satisfaction of the responsible authority.

This does not apply if a schedule to this overlay specifically states that a permit may be granted before a development plan has been prepared to the satisfaction of the responsible authority.

A permit granted must:

- *Be generally in accordance with the development plan.*
- *Include any conditions or requirements specified in a schedule to this overlay.*

The development plan must describe:

- *The land to which the plan applies*
- *The proposed use and development of each part of the land*
- *Any other requirements specified for the plan in a schedule to this overlay*

Schedule 12 of the DPO states that a permit may be granted for the following before the Development Plan has been prepared:

- *One dwelling on an existing lot, including outbuildings, provided it is the only dwelling on a lot.*
- *Agriculture and any buildings or works in association with the use of the land for agricultural purposes.*
- *Extension, alteration or modification to an existing use or development.*

Any other use, subdivision or building and works in the Precinct requires approval of the Development Plan before a permit can be granted.

<u>Conditions</u>

Schedule 12 of the DPO sets out the following conditions for permits within the Precinct:

- *Condition/s ensuring that any requirement or conditions set out in the development plan are implemented as part of the permit or the plans endorsed under the permit*

- *Condition/s requiring that all residential development must be serviced with reticulated water and sewerage and underground reticulated electricity*
- *Condition/s requiring that all lots must be serviced with unsealed roads provided at the developers cost before a statement of compliance is issued*
- *Condition/s requiring that detailed construction plans must be submitted to and approved by the responsible authority. When approved, the plans will be endorsed by the responsible authority and will form part of the planning permit. The plans must be drawn to scale with dimensions and three copies must be provided. The plans must detail:*
    - *All roads shown on the plan of subdivision;*
    - *Roads, footpaths, verges and stormwater infrastructure with dimensions commensurate with the requirements of Clause 56.*

  All works constructed or carried out must be in accordance with these plans.

<u>Requirements</u>

Schedule 12 of the DPO sets out the following requirements for the Development Plan:

- *The relationship of uses proposed on the land to existing and proposed uses on adjoining land, and proposed buffer areas separating land uses and public land.*
- *The location of any sites of conservation, heritage or archaeological significance and the means by which they will be managed.*
- *Provision of a hierarchy of streets to allow for progressive subdivision over time.*
- *Roads located to integrate with the existing land ownership pattern, to respond to the existing topography and to avoid existing dwellings and significant vegetation.*
- *Arrangements for the provision of all physical and community infrastructure services to the land.*
- *The shared pathway network, including opportunities to link paths to formal networks on abutting land. Footpaths should be unsealed and informal, in keeping with the precinct's character.*
- *The layout of major areas of open space and the type of facilities, if any, to be provided for users of the open space.*
- *A landscape plan that includes:*
    - *Any necessary arrangements for the preservation or regeneration of existing vegetation.*
    - *Provision of informal indigenous planting along key roads.*
    - *Provision of Water Sensitive Urban Design (WSUD) treatments along natural drainage lines and along key roads.*
- *Stormwater management methods, including the location of any on-site drainage retention facilities.*
- *The proposed subdivision layout and development of the land including roads, lot boundaries, streetscape treatments and landscaping.*
- *The staging and anticipated timing of development.*
- *General consistency with the Dunkeld Structure Plan, January 2014 and 'Township Residential' Urban Design Guidelines, 2012.*
- *A soil and water report must be provided with all applications to demonstrate the capacity of infrastructure to service the development, treat and retard stormwater and reduce any impacts on soil and water downstream of the development.*

7 Development Plan Requirements

The following section responds to the requirements set out in Schedule 12 of the DPO.

7.1 Strategic Use of the land

While the Township Zone allows for a multitude of uses, the DPO12 titled "Residential Development: Recreation Road" anticipates that the strategic predominant use within the Precinct is to be residential. For the purpose of the Development Plan, it is interpreted that alternative uses can be contemplated however they are to be undertaken within a context of a residential environment set in a sensitive landscape.

7.2 Heritage

A report from ACHRIS suggested that there are no significant areas of Aboriginal Cultural Heritage found within the Precinct. A search of the Victorian Heritage Database was undertaken which identified that no historic heritage places are found within the Precinct. Similarly, no properties are included within the Heritage Overlay within the Planning Scheme.

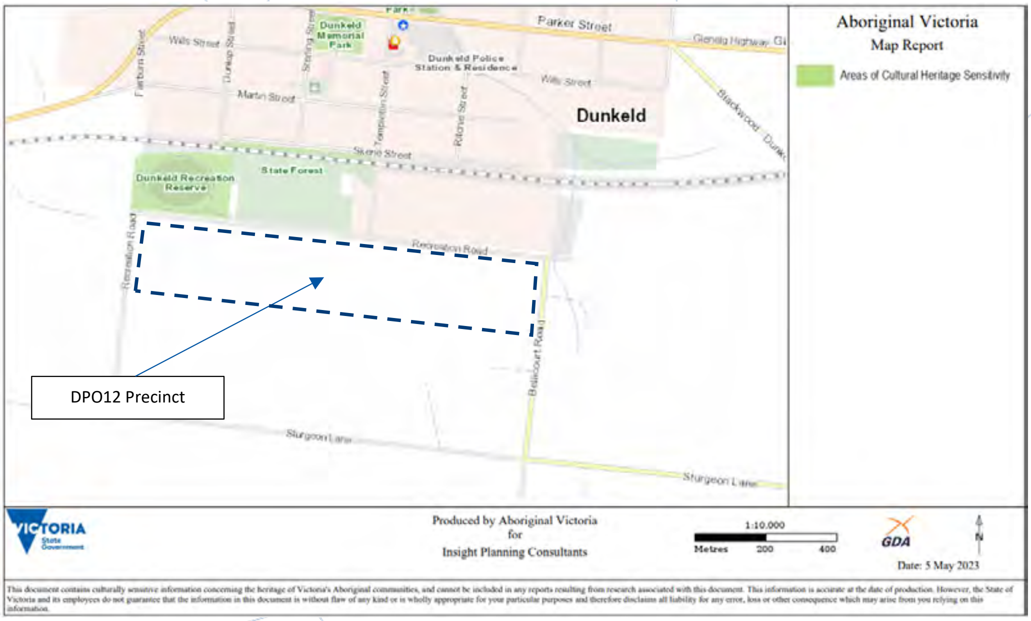


FIGURE 10: AREAS OF CULTURAL HERITAGE SENSITIVITY

7.3 Ecological Report

The Precinct is located within the natural temperate grasslands of the southern volcanic plain of Victoria. As a result, there is a presence of River Red Gums (*Eucalyptus camaldulensis*) and dispersed native grass species. Many flora species are endemic to the extended township and should strongly be considered as ideal plant species for revegetation endeavours including roadside vegetation.

The preservation and enhancement of native grassland species is encouraged to protect the natural habitat of the critically endangered Golden Sun Moth. Furthermore, the replanting of the highly endangered Plump Swamp Wallaby Grass (*Amphibromus pithogastrus)*, which was discovered in 2003 at the Dunkeld water reclamation plant, should be encouraged within the development where appropriate.

It is recommended that any development should avoid the destruction of native plant species. Construction under or near any River Red Gum canopy should be avoided, with a recommended buffer zone of 10 meters to be applied wherever possible. A Tree Retention Management Plan will be required to be prepared for all subdivision applications within the Precinct for land that contains mature River Red Gum trees.

The locations of River Red Gums (circled in red) within the Precinct are shown in Figure 10 below.

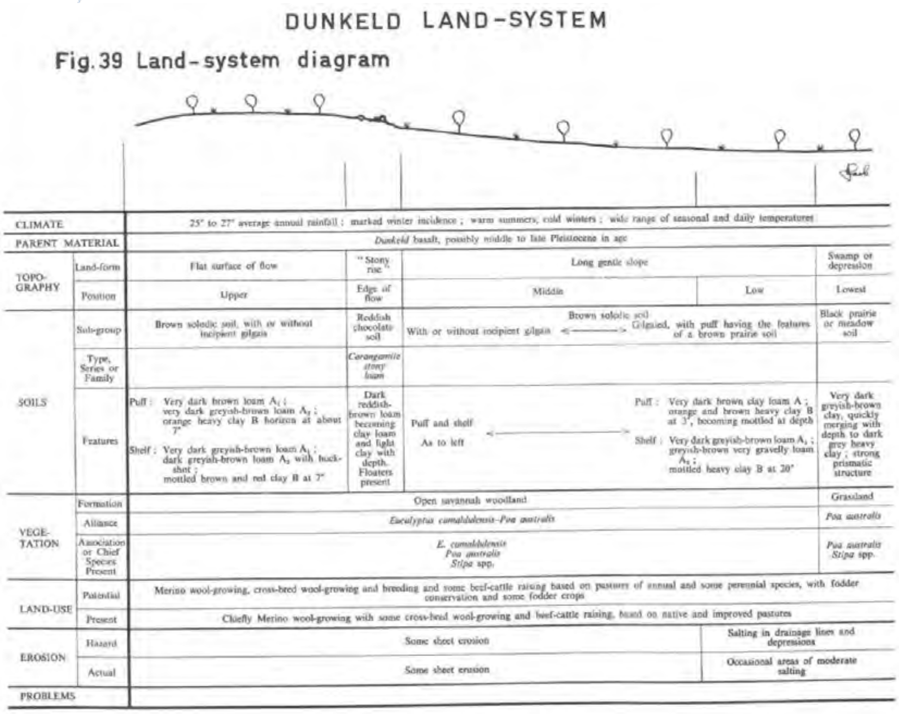
FIGURE 11: MAP OF KEY VEGETATION

7.4 Soil and Water Report

The township of Dunkeld is found on soils that have formed from the presence of basalt that likely originated during the middle to late Pleistocene era. The soils are brown solodic in nature and are made up of various clay loams, as shown in Figure 12 below.

The site is located on a gentle slope appearing almost flat and receives on average around 630 to 690 mm of rainfall annually. There is some sheet erosion resulting in occasional areas of moderate salting, particularly along drainage lines and depressions. Sensitive drainage methods, which essentially includes the vegetation of drainage swales, should be considered to prevent any significant drainage hazard.

Southern Grampians Shire Council
INSIGHT Planning Consultants



DUNKELD LAND-SYSTEM

Fig. 39 Land-system diagram

CLIMATE		25" to 27" average annual rainfall ; marked winter incidence ; warm summers, cold winters ; wide range of seasonal and daily temperatures				
PARENT MATERIAL		*Dunkeld* basalt, possibly middle to late Pleistocene in age				
TOPO-GRAPHY	Land-form	Flat surface of flow	"Stony rise"	Long gentle slope		Swamp or depression
	Position	Upper	Edge of flow	Middle	Low	Lowest
SOILS	Sub-group	Brown solodic soil, with or without incipient gilgais	Reddish chocolate soil	Brown solodic soil: With or without incipient gilgais <——> Gilgaied, with puff having the features of a brown prairie soil		Black prairie or meadow soil
	Type, Series or Family		*Coranganite stony loam*			
	Features	Puff : Very dark brown loam A_1 ; very dark greyish-brown loam A_2 ; orange heavy clay B horizon at about 7" Shelf : Very dark greyish-brown loam A_1 ; dark greyish-brown loam A_2 with buck-shot ; mottled brown and red clay B at 7"	Dark reddish-brown loam becoming clay loam and light clay with depth. Floaters present	Puff and shelf As to left <——>	Puff : Very dark brown clay loam A ; orange and brown heavy clay B at 3", becoming mottled at depth Shelf : Very dark greyish-brown loam A_1 ; greyish-brown very gravelly loam A_2 ; mottled heavy clay B at 20"	Very dark greyish-brown clay, quickly merging with depth to dark grey heavy clay ; strong prismatic structure
VEGE-TATION	Formation	Open savannah woodland				Grassland
	Alliance	*Eucalyptus camaldulensis–Poa australis*				*Poa australis*
	Association or Chief Species Present	*E. camaldulensis* *Poa australis* *Stipa* spp.				*Poa australis* *Stipa* spp.
LAND-USE	Potential	Merino wool-growing, cross-bred wool-growing and breeding and some beef-cattle raising based on pastures of annual and some perennial species, with fodder conservation and some fodder crops				
	Present	Chiefly Merino wool-growing with some cross-bred wool-growing and beef-cattle raising, based on native and improved pastures				
EROSION	Hazard	Some sheet erosion			Salting in drainage lines and depressions	
	Actual	Some sheet erosion			Occasional areas of moderate salting	
PROBLEMS						

FIGURE 12: DUNKELD LAND SYSTEM

There are two dams located on the site which may pose development issues and likely require development envelopes to address any inundation concerns. It is to be noted that the eastern-most dam falls within the 100-year flood boundary extending outwards from the salt-creek corridor and will need a more considered approach. The 100-year flood boundary also generally aligns with the ESO3.

It is recommended that development should not occur within the 100-year flood boundary to avoid any significant hazards in the future.

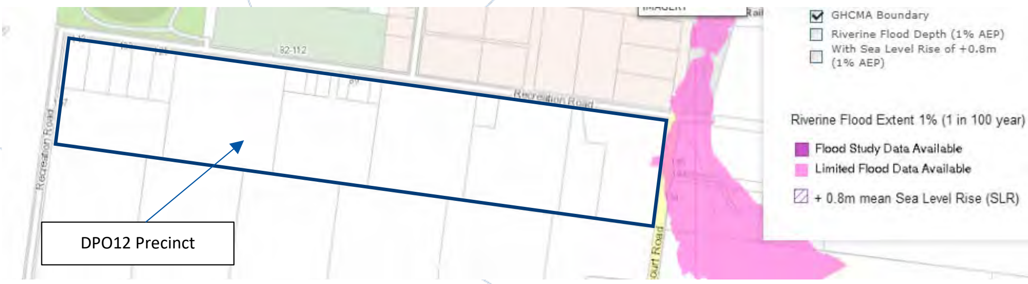


FIGURE 13: EXTENT OF 1%AEP (1 IN 100 YEAR FLOOD) (GHCMA 2023)

7.5 Sewerage

The Dunkeld township has been serviced with both reticulated water and reticulated sewerage provided by Wannon Water. Figure 13 below outlines the extent of Wannon Water services provided to the broader Dunkeld Township and surrounding region.

FIGURE 14: WANNON WATER REGIONAL MAP

In proximity to the Precinct, existing reticulated sewerage can be found along Recreation Rd between Templeton St and the proposed road that aligns with Richie St. New sewerage lines would need to be run along Recreation Rd and extended down through any proposed north-south roads into the Precinct.

FIGURE 15: EXTENT OF EXISTING SEWER

7.6 Opportunities and Constraints

The following table outlines some of the opportunities and constraints to subdivision and development within the Precinct.

Opportunities	Location	Comment
Green-link & Salt Creek walking trail	Dunlop St through Dunkeld Recreation Reserve & Salt Creek corridor	With the existing walking trails along the river system to the east and shared path connection to the Grampians National Park to the west, there is an opportunity to extend the green-link along Recreation Rd in order to better connect existing pedestrian and cycling networks together
100-year flood zone and dam	Centred along the eastern boundary of the easternmost property	This area provides an interesting opportunity for revegetation of the area given the limitations imposed upon development. At the very least the site poses an opportunity for the preservation of native vegetation through the implementation of development envelopes.

Constraints	Location	Comment
Sewage Network	Existing sewage pipeline along Recreation Rd located between Templeton Rd and the proposed extension of Ritchie St	The existence of a nearby sewage pipeline allows for expansion of the sewage network into the proposed development area. Given that the proposed future subdivisions will likely fall within the size requirements for necessary connection to reticulated sewerage, any future development will need connection to the sewerage system.
Road network	Throughout the site	Given the size of the properties and the lack of a local access road along the southern boundary of all properties, the construction of a road network through the site that mimics the town centre is somewhat difficult to create. Existing dwellings and the location of river red gums prevent new roads from forming an exact grid-like pattern, whilst also preventing their direct connection to existing roads leading in the same direction.
River Red Gums	Throughout the site	As per the requirements of VPO1 every effort must be made to avoid the removal of River Red Gums when development occurs. All proposed roads should generally avoid these trees or incorporate them into the grassed swales and roadside buffers. All buildings should be set back at least 10m from the canopy edge of any existing River Red Gum.
Existing Dams	Two of the existing eastern properties	Two dams exist on some of the properties. Unless infilling is proposed, a building envelope on all affected properties could prevent the construction of residential dwellings within or near the dams.

Table 1 Opportunities and Constraints

8 The Development Plan

8.1 Development Staging

The ongoing Wannon Water sewerage scheme process requires the Development Plan to be considered in stages. Specifically, Stage 1 of the Development Plan will include land which is able to connect into the existing sewerage infrastructure, as shown in the below plan. Future stages will be subject to Wannon Water completing their servicing scheme.

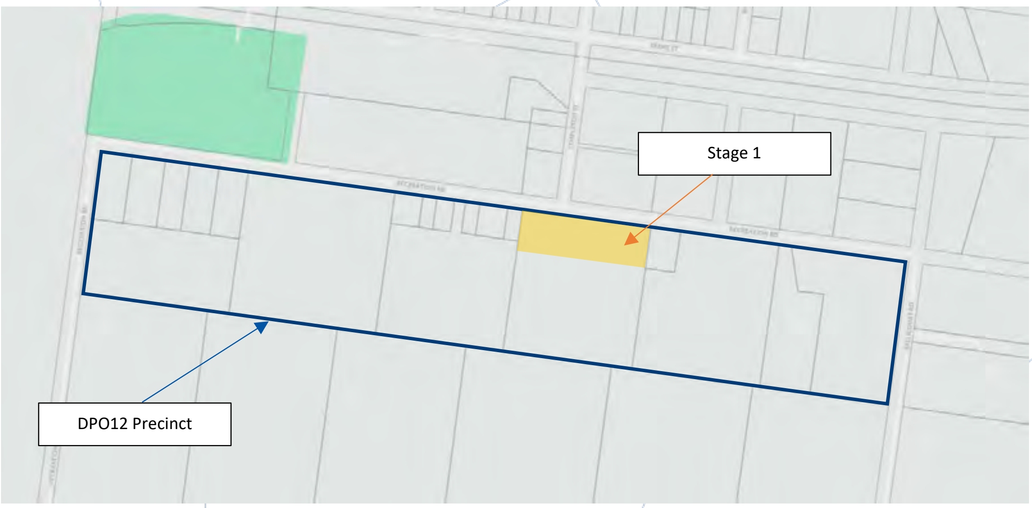


FIGURE 16: STAGE 1 OF THE DEVELOPMENT PLAN

8.2 Lot size

In line with the Development Plan objectives, the subdivision and development of land within the Precinct should protect the long-term subdivision and development opportunities which directly respond to the existing topography and natural assets of the Precinct.

Stage 1 of the Development Plan will feature lots with direct access to Recreation Road. The area of these lots will range between approximately 1,760 – 4,390 square metres. An indicative subdivision layout is shown below. The balance of the property will remain in subsequent stages of the Development Plan.

FIGURE 17: INDICATIVE STAGE 1 SUBDIVISION LAYOUT

8.3 Road Layout

The indicative subdivision layout for Stage 1 of the Development Plan accommodates for a 16m road reserve from Recreation Road between proposed Lots 1 and 2, to service the balance of the property in the future under subsequent stages of the Development Plan.

The cross section for a 16m wide 'Access Street' from the Infrastructure Design Manual (IDM) is shown below, noting that under the requirements for DPO12 all local access roads should be unsealed.

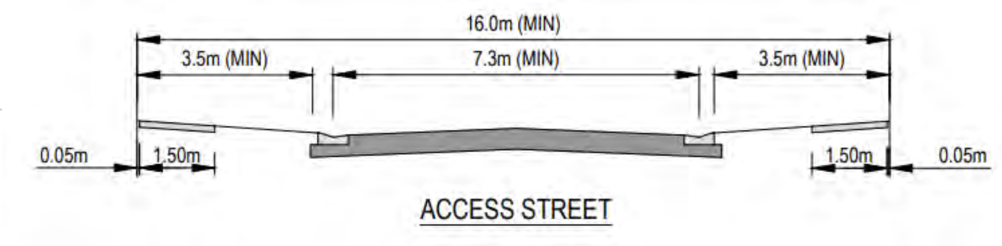


FIGURE 18: ACCESS STREET CROSS SECTION (IDM)

8.4 Concept Masterplan

While future stages of the Development Plan are subject to the completion of the Wannon Water sewerage scheme, the below Indicative Concept Plan provides a potential layout for the future subdivision and development of the overall Precinct. This plan is indicative only and can be amended from time to time. It may also require amendment following the completion of the Wannon Water scheme.

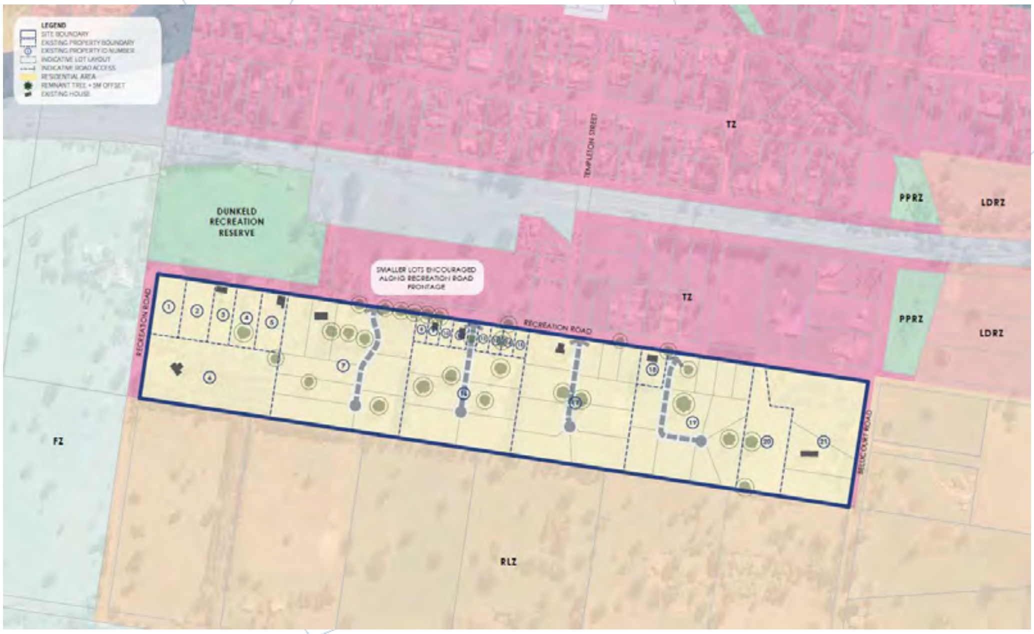


FIGURE 19: INDICATIVE CONCEPT PLAN (PATCH 2023)

8.5 Servicing

Under Standard B4 of Section 55.02-4 of the planning scheme all development should be connected to reticulated services, including reticulated sewerage, drainage, electricity, and gas, if available. Development should not unreasonably exceed the capacity of utility services and infrastructure, including reticulated services and roads.

8.6 Sewerage

Given the proposed residential lot sizes within this area, and to maintain environmental protection, it is critical that reticulated sewerage is provided to any future lots subdivided under this Development Plan. This can be provided through an extension of the existing reticulated sewerage infrastructure.

A section of Recreation Rd is currently serviced by a sewerage pipeline, highlighted in Figure 14, allowing for the connection of new developments within the Precinct to reticulated sewerage services. Stage 1 of the Development Plan will be able to connect into the existing sewerage services. Wannon Water is currently working on a scheme for the remainder of the Precinct.

8.7 Subdivision and Development Design

All buildings and works should be in accordance with the planning controls that apply and the standards of Clause 54 or 55 of the planning scheme.

All subdivision should be in accordance with the planning controls that apply and the standards of Clause 56 of the planning scheme.

Subdivision and development within the precinct should follow the following guidelines:

8.7.1 Building Requirements

Buildings should generally be:

- Single storey and not more than 8 meters above natural ground level;
- Developments with pitched roofs as a preference;
- Set back from the front and side property boundaries in a manner consistent with the prevailing pattern of front setbacks within the streetscape;
- Sufficiently set back to avoid the removal of any River Red Gum tree;
- Sited to respond to existing established vegetation, including canopy forms within the allotment and provide for new landscaping within setback areas;
- Garages must not be the dominant front façade element of the dwelling and / or the streetscape;
- Designed to consider sustainability principles.

The following figures show examples of the preferred building style:

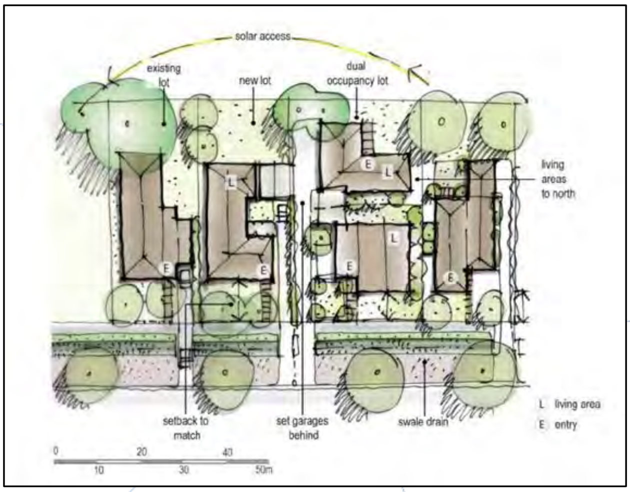


FIGURE 20: PREFERRED BUILDING STYLE

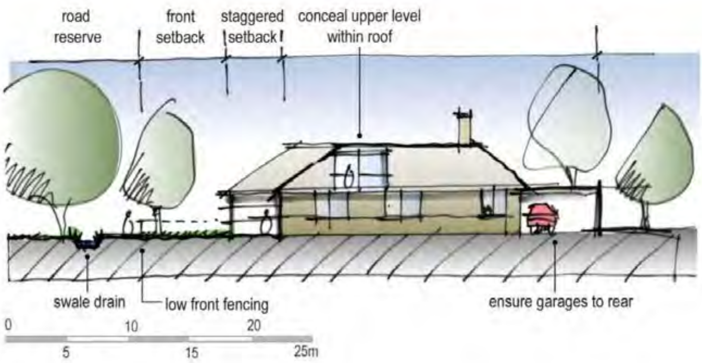


FIGURE 21: CROSS SECTION

8.7.2 Subdivision Requirements

All approved subdivision of land should front onto existing and/ or proposed roads to create a sense of street address. As such, the use of common property access and battle-axe lots should be avoided where possible as their development would likely compromise future subdivision and development opportunities.

8.7.3 Building Envelopes

- For properties adjoining bodies of water, a land inundation report should be required with any planning application along with proposed building envelopes to avoid any future hazards that may result;
- For properties where native vegetation is likely present, a detailed biodiversity report should be included alongside any planning application and sufficient buffers implemented from any building to protect all native flora.

8.8 Stormwater Management

The primary method used for stormwater management will be grassed swales alongside existing and proposed roads, drainage pits will also be considered where required. Grassed swales align with the existing neighbourhood character of Dunkeld and are heavily used throughout the township. Extra width in road reserves can be implemented to allow for greater planting and capacity as specified above. Example images of grassed swales that can be tailored to suit neighbourhood character using native plant species are shown below:

FIGURE 22: EXAMPLES OF GRASSED SWALE DESIGNS

8.9 Open Spaces

8.9.1 Landscape Objectives:

- To reflect and enhance the natural environment and character of Dunkeld
- To preserve and protect indigenous plant and animal species, particularly River Red Gums.
- To utilise native plant species in Water Sensitive Urban Design (WSUD) where possible

8.9.2 Landscape Features

A key landscape feature of the Development Plan is the opportunity to create a 'Greenlink' along Recreation Rd that connects the Grampians National Park trails to the Salt Creek walking trails. Ideally this should be achieved through extensive planting of native vegetation along the roadside.

Native plant species should be used as screening on private developments and generally in drainage swales throughout the Precinct.

Southern Grampians Shire Council INSIGHT Planning Consultants

Water Sensitive Urban Design (WSUD) treatments should be utilised along Recreation Road and any natural drainage lines through the Precinct.

8.9.3 Significant Trees, Landscapes and Vegetation

All native vegetation should be preserved unless removal is unavoidable. Most River Red Gums are to be retained within the Precinct. Native species are encouraged to be used along roadsides and as part of the landscaping of private dwellings.

8.9.4 Parking Provisions

On-street parking provisions are not encouraged as private dwellings should provide for sufficient off-street parking to satisfy capacity.

9 Application Requirements and Conditions

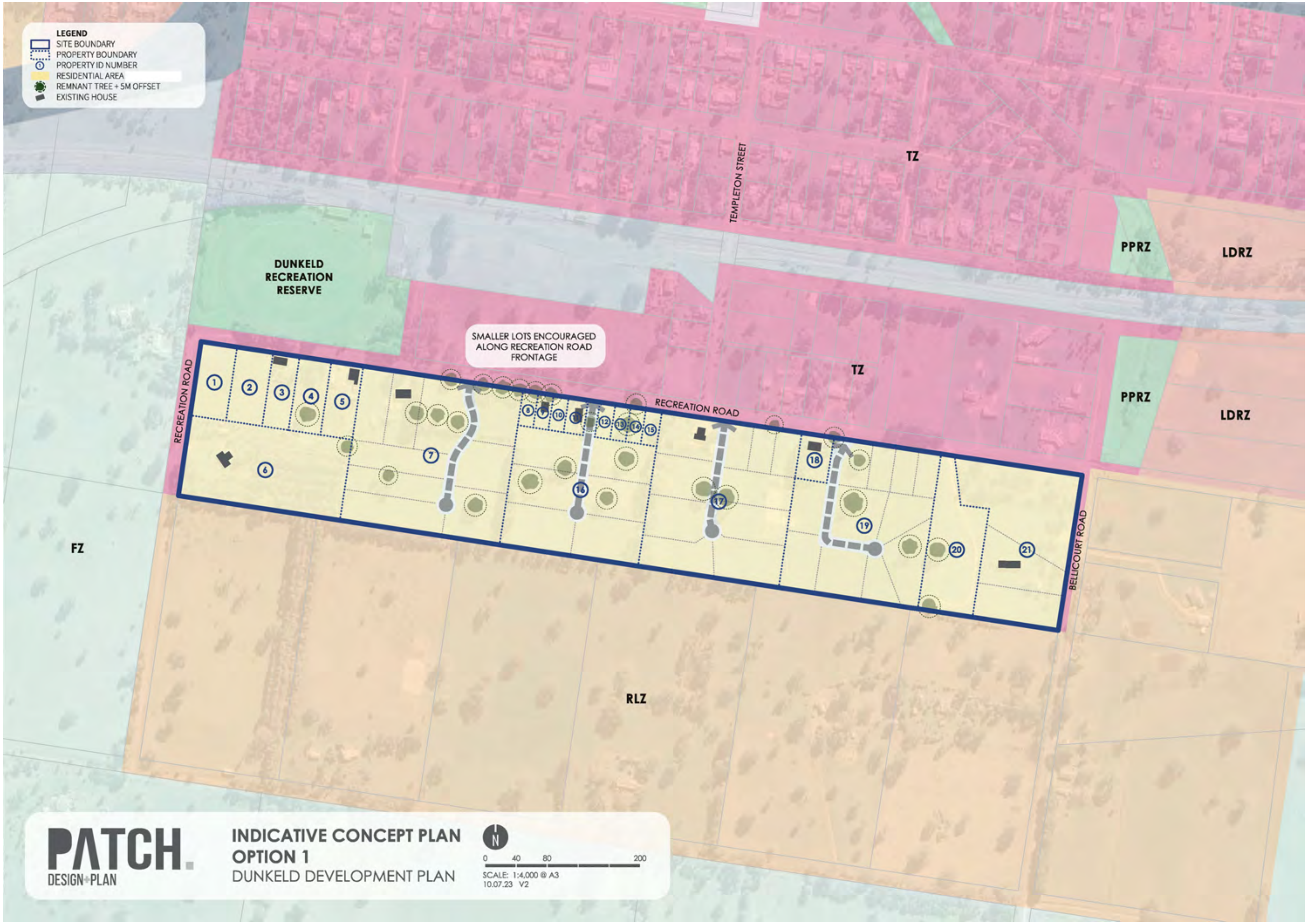
All applications for subdivision and development of land within the Precinct must be accompanied by the following information, as appropriate:

- A landscape plan that includes:
    - Any necessary arrangements for the preservation or regeneration of existing vegetation.
    - Retention of River Red Gums, where possible.
    - Provision of informal indigenous planting along key roads.
    - Provision of Water Sensitive Urban Design (WSUD) treatments along natural drainage lines and along key roads.
- Arboricultural Assessment, that includes the location and assessment of all native vegetation.
- Stormwater Management Plan, that includes any on-site drainage retention.
- Soil and Water report, to demonstrate the capacity of infrastructure to service the development, treat and retard stormwater and reduce any impacts on soil and water downstream of the development.

All applications for subdivision and development of land within the Precinct will be subject to the following conditions.

- Condition/s ensuring that any requirement or conditions set out in the development plan are implemented as part of the permit or the plans endorsed under the permit
- Condition/s requiring that all residential development must be serviced with reticulated water and sewerage and underground reticulated electricity
- Condition/s requiring that all lots must be serviced with unsealed roads provided at the developers cost before a statement of compliance is issued
- Condition/s requiring that detailed construction plans must be submitted to and approved by the responsible authority. The plans must detail:
    - All roads shown on the plan of subdivision;
    - Roads, footpaths, verges and stormwater infrastructure with dimensions commensurate with the requirements of Clause 56.

All works constructed or carried out must be in accordance with these plans.


LEGEND
SITE BOUNDARY
PROPERTY BOUNDARY
PROPERTY ID NUMBER
RESIDENTIAL AREA
REMNANT TREE + 5M OFFSET
EXISTING HOUSE
TZ
TEMPLETON STREET
PPRZ
LDRZ
DUNKELD RECREATION RESERVE
SMALLER LOTS ENCOURAGED ALONG RECREATION ROAD FRONTAGE
RECREATION ROAD
BELLICOURT ROAD
FZ
RLZ
PATCH. DESIGN+PLAN
INDICATIVE CONCEPT PLAN OPTION 1
DUNKELD DEVELOPMENT PLAN
SCALE: 1:4,000 @ A3
10.07.23 V2

Attachment 3: Submissions Review, Development Plan Recreation Road, Dunkeld

Submission	Submission Summary	Response
1 Coast to Country on behalf of Bruce and Kelly McNaughton Lot 1 TP159903	1. Request that the Council do not yet adopt the proposed Development Plan, until further revisions are made to the Development Plan report to include Lot 1 TP159903E into the 'Stage 1' area detailed in the report. 2. Clarify and resolve any terms and all matters highlighted in this submission with revisions to content of the Development Plan report. 3. Have an additional consultation process provided by Council to allow the community to review of any subsequent changes to the Development Plan report resulting from additional submissions. 4. Please confirm what the communication, document revision and decision-making process will be following receipt of additional submissions.	It is recommended that the Recreation Road Development Plan (July 2023 Draft) be amended to include Lot 1 TP159903E into Stage 2. An additional consultation process is not required as the DP has been prepared and amended in response to the community consultation with the landowners and the submissions received as part of the Development Plan process.
2 Jarrod and Jackie 133 Recreation Road	Thanks for your work on this and not restricting the subdivision to only larger blocks. That allows for greater flexibility long term.	Noted.
3 Jane & Peter Besgrove 67-83 Recreation Road, Dunkeld	1. Based on our reading of the documentation and consistent with feedback already provided, we are satisfied that the draft development plan provides a reasonable basis for the future development needs of the Recreation Rd precinct. We also note that the plan seems to be consistent with our own objectives, of which SGSC has been aware since February 2022. 2. Whilst being somewhat frustrated by the process and time taken to get to this point, we do appreciate the efforts of the SGSC staff and consultants in respect of our subdivision application, following meetings late in 2022. They have at all times shown courtesy, patience and some empathy with our circumstances.	Noted. The Development Plan is prepared to allow future development of the precinct and provide with more flexibility in delivering the best outcome for the Wannon Water's sewer scheme for the precinct.
4 Roslyn Greenwood	Protection of red gum and other vegetation within and around the precinct.	The Vegetation Protection Overlay, Schedule 1 (VPO1 – Dunkeld River Red Gums) applies

141 Bellicourt Rd, Dunkeld		to the entire Precinct. The Development Plan provides guidelines to conserve the existing pattern of vegetation and landscape quality, to protect and ensure that River Red Gums are maintained as a dominant feature of the landscape.
5 Agencies Response: Wannon Water	*As outlined in the report*	

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Glenelg River Regional Flood Mapping

November 2014

State Government Victoria
Department of Environment and Primary Industries

DOCUMENT STATUS

Version	Doc type	Reviewed by	Approved by	Distributed to	Date issued
v01	Report	Ben Tate	Ben Tate	Simone Wilkinson	30/05/2014
v02	Report	Ben Tate	Ben Tate	Simone Wilkinson	12/06/2014
v03	Report	Ben Tate	Ben Tate	Simone Wilkinson	18/11/2014
v04	Report	Ben Hughes	Ben Hughes	Simone Wilkinson	28/11/2014

PROJECT DETAILS

Project Name	Glenelg River Regional Flood Mapping
Client	Department of Environment and Primary Industries
Client Project Manager	Simone Wilkinson
Water Technology Project Manager	Ben Hughes
Report Authors	Ben Hughes
Job Number	2801-01
Report Number	R03
Document Name	2801-01R01v04

Cover Photo: Glenelg River near Harrow.

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1. INTRODUCTION

1.1 Project Purpose

The Department of Environment and Primary Industries (DEPI) commissioned Water Technology to investigate a regional flood mapping methodology for the Glenelg River from Rocklands to Casterton. The project developed hydrologic and hydraulic models of the catchment and river floodplain, and produced flood mapping outputs.

This report is the final project report documenting the two previous reporting stages as well as design modelling and modelling methodology comparison. The previous reporting content and additional information included in this report is as follows:

- Data Collation and Hydrology Report, documenting the data collated and verification, Flood Frequency Analysis, RORB model development, calibration and design modelling
- Hydraulics Report, documenting the development of 1D and 2D hydraulic models, calibration
- Final Investigation Report, documenting the design modelling, comparison of 1D and 2D design results, methodology discussion.

Reporting was completed as a progressive addition rather than separate reports allowing the reader to have a full background of the project rather than individual components.

1.2 Catchment overview

The study area covers approximately 213 km of the Glenelg River, with a total catchment area of approximately 4,730 km^2. The catchment extent and reach of the Glenelg River covered in the study area is shown below in Figure 1-1. The Glenelg River catchment to Casterton can be thought of in two separate units; the steep catchment of the south-western Grampians upstream of Rocklands Reservoir, and the low gradient catchment below Rocklands fed by numerous tributaries. Immediately downstream of Casterton the Wannon River meets the Glenelg River, draining a large catchment from the southern Grampians.

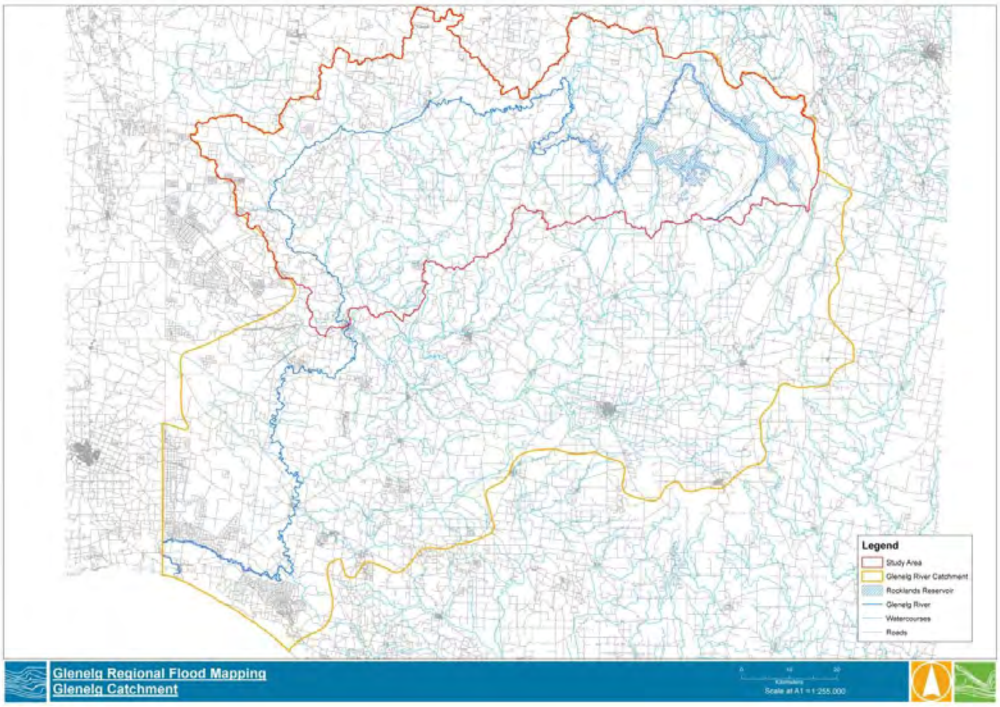


Figure 1-1 Project Study Area in respect to the entire Glenelg River catchment

Rocklands Reservoir and Moora Moora Reservoirs are the only recognised storages impacting on the hydraulic model area, both are managed by GWMWater.

Moora Moora is relatively small with a maximum operational volume of 6,300 ML and an outlet capacity of 65 ML/d. Water is passed from Moora Moora Reservoir via Moora Channel to the Mackenzie River at Distribution Heads. The Reservoir is not on the Glenelg River but an area of contributing catchment. Water can be transferred from Moora Moora to the Glenelg River via the channel network. Moora Moora Reservoir was constructed in 1934.

Construction of Rocklands Reservoir began in 1941 and finished in 1953. A large break in the construction period occurred due to World War 2. The Reservoir has a full supply volume of 348,300 ML with a controlled outlet. This allows the Reservoir to be used for water supply purposes with regulated releases. The Reservoir's combined controlled outlet capacity is 1,250 ML/d, with outlets at two locations. The main outlet connects to Toolondo Channel which can direct water to the Glenelg River via 5 Mile outlet and 12 Mile outlet. The capacity of the Toolondo Channel is 600 ML/d. The secondary outlet from the Reservoir is direct to the Glenelg River. The Reservoir has a spillway capacity of 66,000 ML/d which spills to the Glenelg River.

There are three major townships within the study area; Balmoral, Harrow and Casterton. Balmoral and Harrow are the smallest of the three townships with Casterton containing a much larger population.

2. DATA AVAILABILITY

2.1 Previous Investigations

2.1.1 Overview

Several relevant investigations have been undertaken within the study area. These include:

- Glenelg Flood Investigations (Cardno Lawson and Treloar, 2008)
- Casterton Flood Investigation (Cardno, 2011)
- Review of Storage Operation During Floods Grampians Wimmera Mallee Water (Water Technology, 2011)
- Preparation of Glenelg Hopkins CMA Submission to the Review of 2010-11 Flood Warnings and Response (Water Technology, 2012)
- Casterton Flood Intelligence & Warning Improvements (WBM BMT, 2014)

Information was extracted from the above studies during the progress of the Glenelg River Regional Flood Mapping Project, and is referenced throughout this report.

2.2 Streamflow gauges

There are numerous streamflow gauges on the Glenelg River upstream of Casterton, as well as on its tributaries. Each of these gauges is shown in Table 2-1, detailing their period of record and maximum flow recorded. The gauge locations are also shown in Figure 2-1.

Table 2-1 Study area gauge details

Gauge Name	Gauge Number	Start of daily flow recording	Start of instantaneous flow recording	End Date	Max. Peak Flow (m^3/s)	Year achieved
Glenelg River @ Big Cord	238231	24/04/1968	17/05/1979 15:00	Current	10.2	2011
Glenelg River @ Rocklands	238205	22/03/1941	21/07/1983 4:01	Current	77.9* (47.0^)	1942 and 1946* (1956^)
Glenelg River @ Balmoral	238201	25/05/1889	-	1/10/1956	365.4	1946*
Glenelg River @ Fulham Bridge	238224	-	8/01/1976 13:00	Current	131.3	2010
Glenelg River @ Harrow	238210	-	30/11/2001 14:58	Current	116.7	2010
Glenelg River D/S Burkes Bridge	238249	-	18/05/2001 13:29	Current	26.4	2004, 2009, 2010, 2011, 2013#
Glenelg River @ Dergholm	238211	-	13/09/2004 2:45:00 PM	Current	118.0	2011
Glenelg River @ Casterton	238212	1/08/1960	21/06/1965 11:40	25/03/2002	270.4	1960
Chetwynd River @ Chetwynd	238229	-	30/03/1967 14:25	Current	69.6	1978
Wando River @ Wando Vale	238228	16/04/1964	19/12/1974 8:50	Current	108.5	1978
Pigeon Ponds Creek @ Koolomert	238234	-	22/10/1969 13:45	20/01/1989	101.1	1974

* Events have occurred prior to the construction of Rocklands Reservoir in 1953

^ Peak flow post the construction of Rocklands Reservoir

Peak flow is listed in the Thiess data quality codes as occurring in the extrapolated section of the rating curve, however all years display the same peak flow, the highest on record.

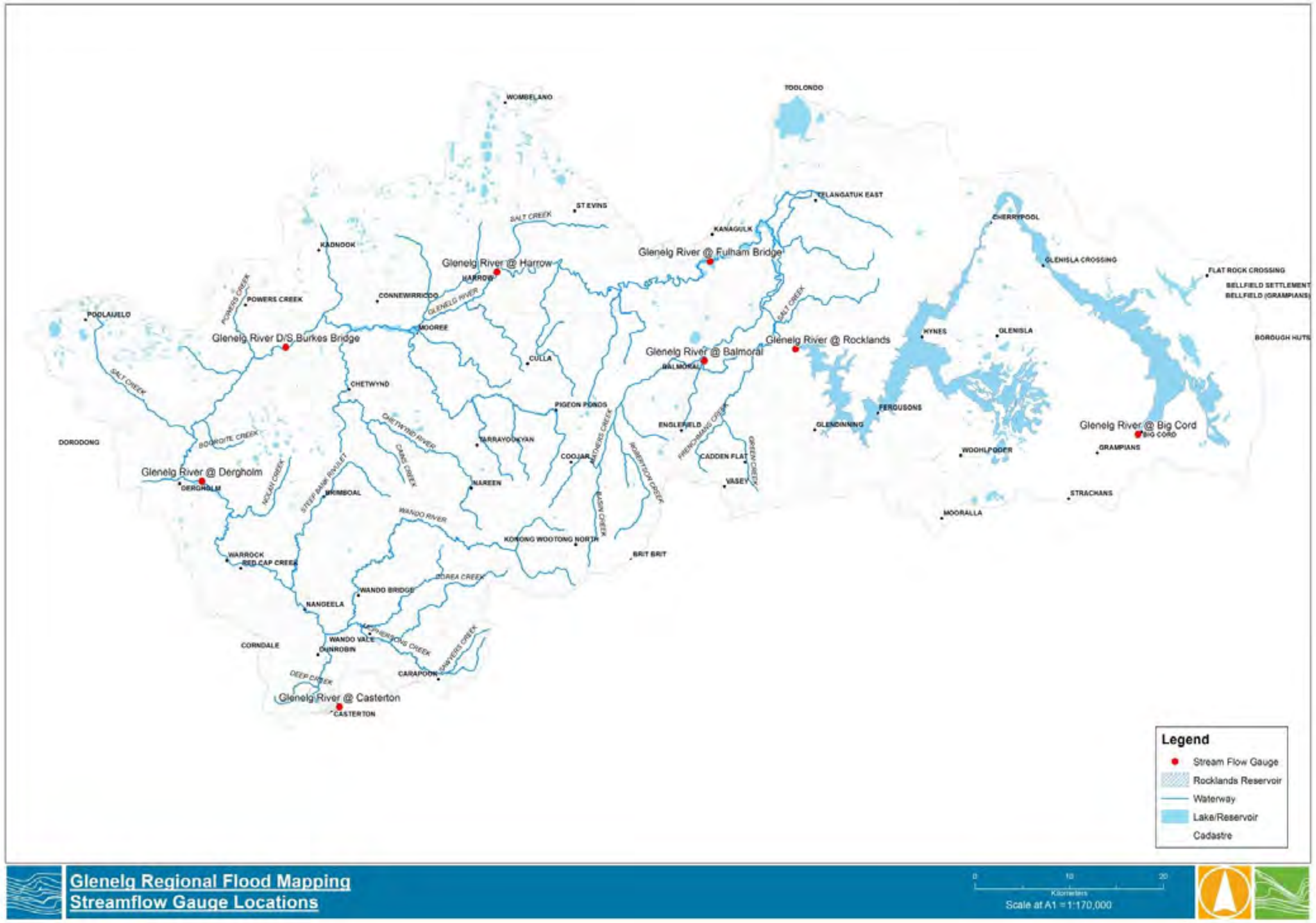


Figure 2-1 Streamflow gauge locations

2.2.1 Gauge Reliability

Gauged water levels in a waterway can be used to estimate a flow rate by the development of a rating curve. Rating curves are based on a generalised relationship between flowrate and height developed across numerous observed events. In general, the greater number of events where the gauge height and flowrate are measured, the better the derived relationship between flow rate and height. A stream water level may not necessarily correlate to the same flowrate each time it is measured due to varying velocity at the gauging station. This can be influenced by many factors including the rate of water level rise and fall. This results in varying rating curve accuracy at each gauging station.

A comparison of the measured flow rate and height values and the rating curve for each gauge is discussed in this section.

Glenelg River at Fulham Bridge

A comparison of the measured water level and flowrate for the Glenelg River at Fulham Bridge and the Fulham Bridge rating curve is shown in Figure 2-2.

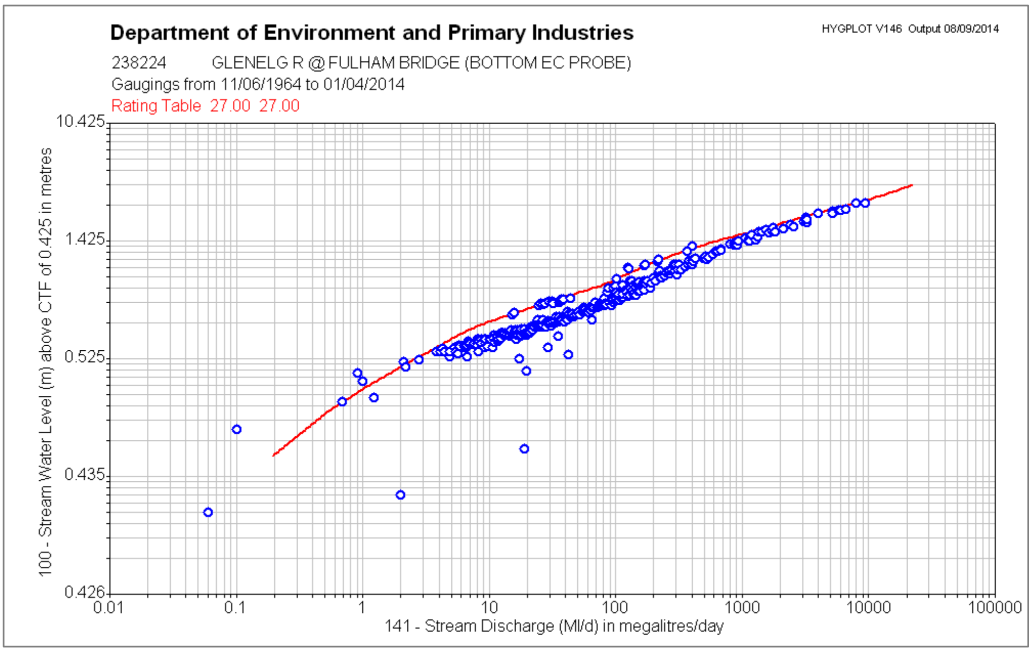


Figure 2-2 Comparison of the measured water levels and flows at Fulham Bridge[1]

The measured data matches the adopted rating curve relatively well with the rating slightly overestimating the majority of measured flows between 5 ML/d to 1000 ML/d, but are within 0.1-0.2 m.

Glenelg River at Harrow

A comparison of the measured water level and flowrate for the Glenelg River at Harrow and the Harrow rating curve is shown in Figure 2-3.

[1] DEPI Water Measurement Information System - http://data.water.vic.gov.au/monitoring.htm Accessed: 15/10/2014

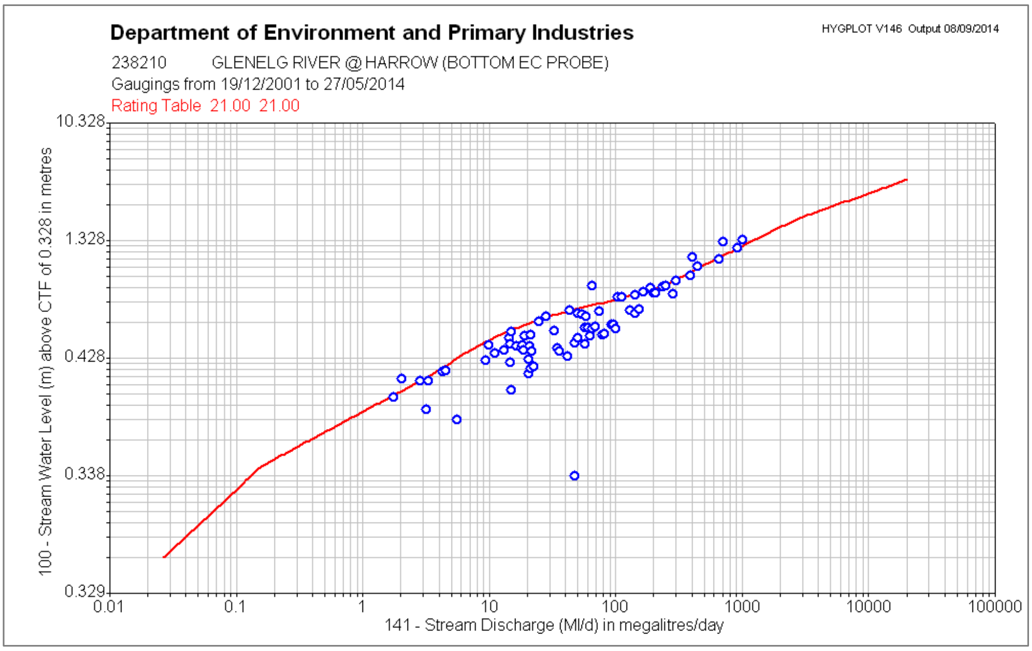


Figure 2-3 Comparison of the measured water levels and flows at Harrow[1]

The Harrow measured data and rating curve does not have the same number of points as that determined at Fulham Bridge. The spread of measured points indicates variability in water level with flow of up to 0.3 m in the full range of measured flows.

Glenelg River at Dergholm

A comparison of the measured water level and flowrate for the Glenelg River at Dergholm and the Dergholm rating curve is shown in Figure 2-4.

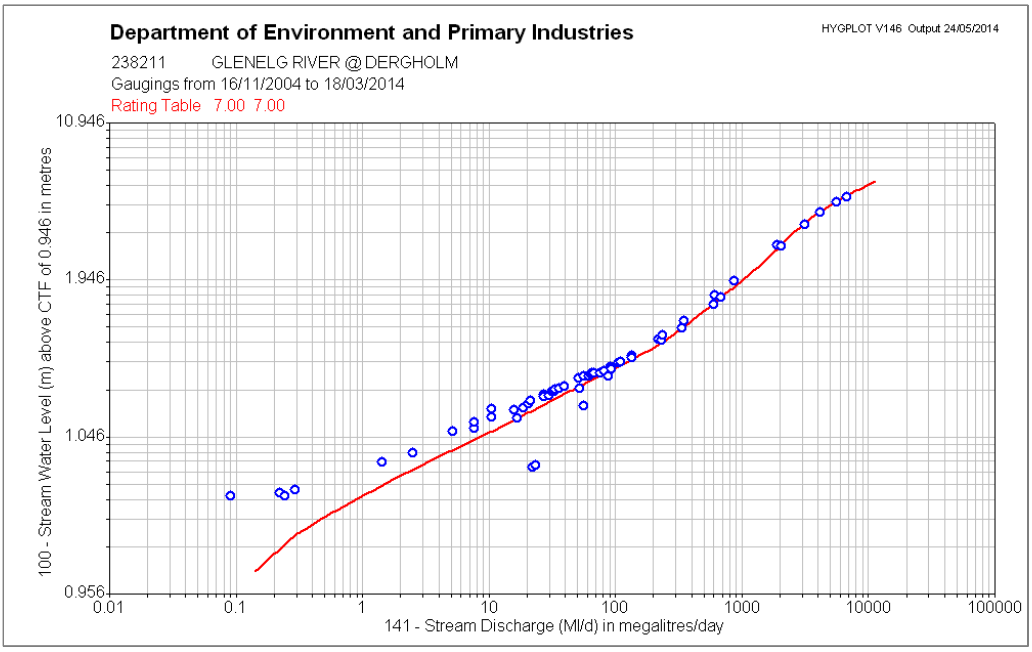


Figure 2-4 Comparison of the measured water levels and flows at Dergholm[1]

The Dergholm measured data and rating curve does not have the same number of points as that determined at Fulham Bridge but the there is much less spread than that observed at Harrow. The measured points follow a relatively straight line with two major outliers. At flows less than 1 ML/d the measured data and the rating curve separate somewhat, with the measured data flattening, this may indicate a hydraulic control downstream of the gauging station. However, at high flows the measured height and flow are fairly consistent.

Glenelg River at Casterton

A comparison of the measured water level and flowrate for the Glenelg River at Casterton and the Dergholm rating curve is shown in Figure 2-5.

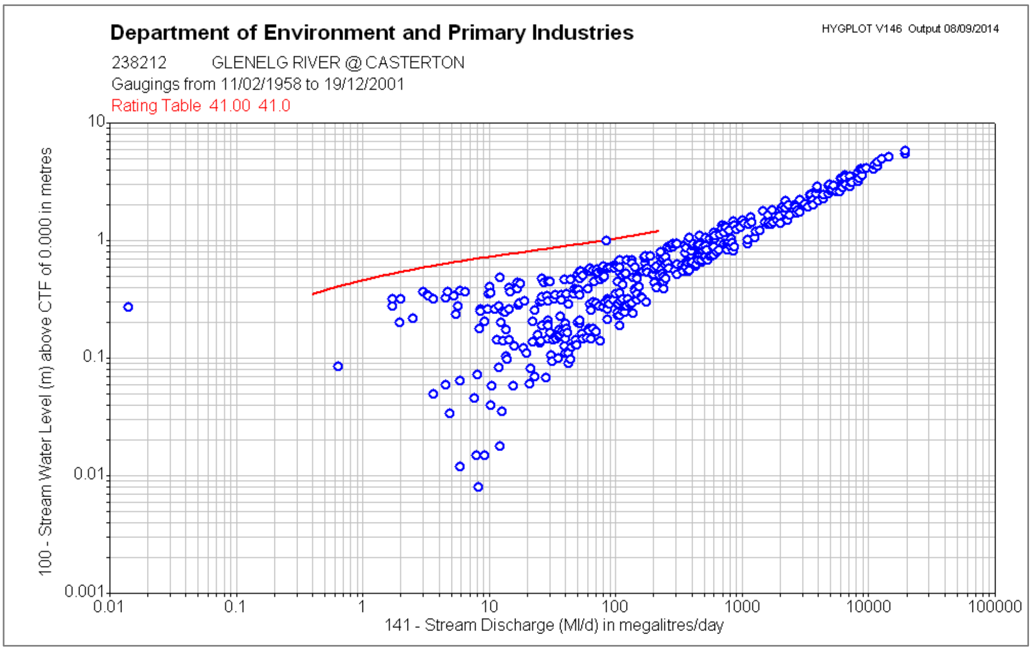


Figure 2-5 Comparison of the measured water levels and flows at Casterton[1]

The Casterton measured data contains a significant number of points. The data has a large spread at lower flows but narrows at higher flows. This is likely to be due to the presence of a weir with drop boards downstream of the gauging station; the weir level influences the gauge height at low flows and does not show a representation of the flow[2].

Instantaneous flow recordings at the gauge ceased in 1988, but ran again for four months in late 2001/early 2002. Instantaneous gauging was stopped due to the influence of the weir at low flows and close proximity to the Sandford gauge.

The rating curve shown in Figure 2-5 does not appear to match the measured water levels and flows. This rating table is shown as completed in December 2001. The recorded water levels and flows were plotted to gain an understanding of the rating curve application over the gauge record as shown in Figure 2-6.

[2] Pers. Com. Thiess - Paul Cleaver (15/10/2014)

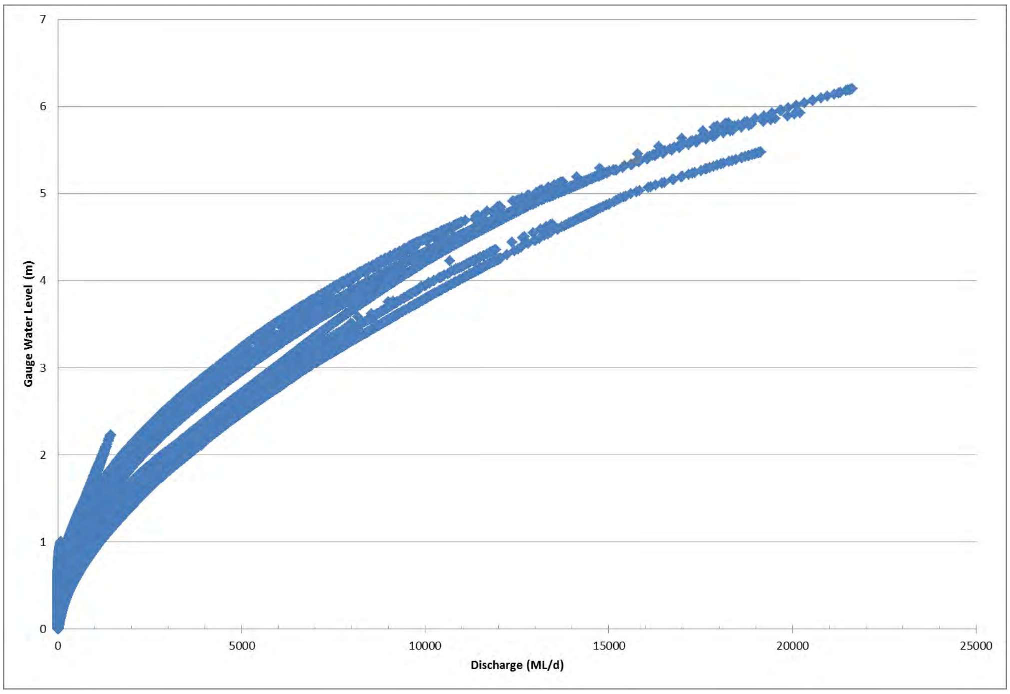


Figure 2-6 Water levels vs. flow at Casterton over the gauge record

The water level and flow relationship indicates several rating curves have been utilised throughout the gauge record. It is unknown what physical changes occurred at the Casterton gauge to warrant a rating curve that is so vastly different to the measured data. The current rating curve was not adopted during the majority of the gauge record and the gauge is no longer in service.

Glenelg River at Sandford

A comparison of the measured water level and flowrate for the Glenelg River at Sandford and the Sandford rating curve is shown in Figure 2-7.

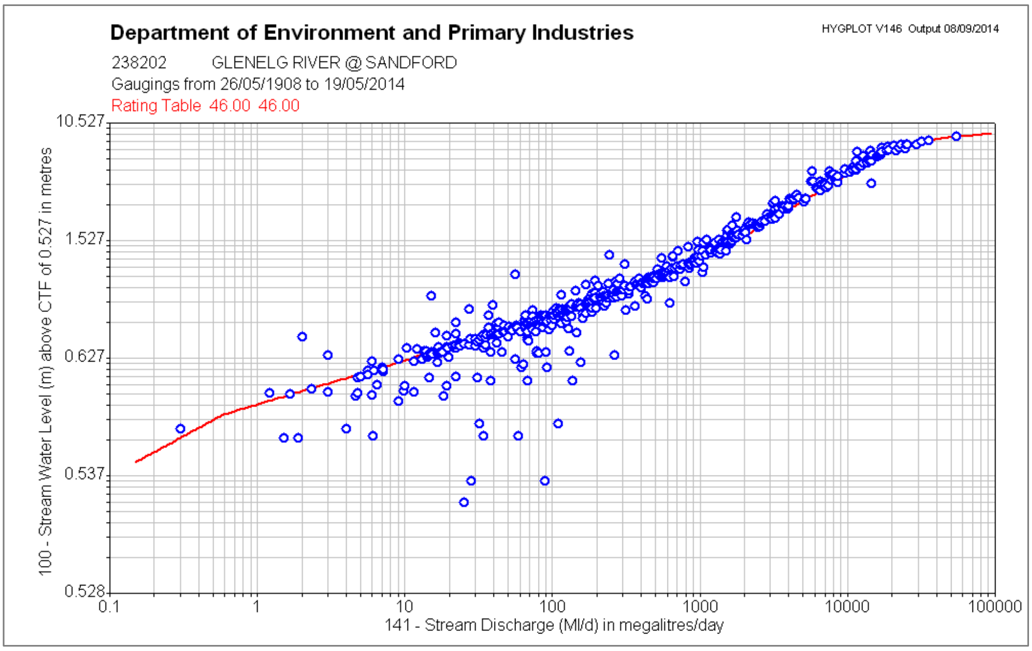


Figure 2-7 Comparison of the measured water levels and flows at Sandford[1]

The Sandford measured data has a large number of points on which to base a rating curve. There is some spread of points at less than 200 ML/d; however this is reduced for higher flow where a good rating curve match can be achieved.

2.2.2 Discussion

Assessing the reliability of streamflow gauges within a study area is a relatively fast and easily completed task. This is due to the availability of the gauge rating curves and base data on the DEPI online Water Measurement Information System[1]. While even a poorly defined rating curve is likely to provide the best estimate of historical event available it is still valuable to understand a gauge rating curve, its limits and sections of the curve that are most likely to contain a higher degree of uncertainty. It is also valuable to speak to the local gauge operator about the gauges within the study area in general; this can provide insight that may not have otherwise been understood.

Maximising the understanding of each gauges rating curve ensures the correct amount of emphasis is put on matching the historical flowrates.

In this project it was found the Glenelg River at Harrow had a fairly inconsistent rating curve, surveyed peak flood height was available for Harrow and this data was used to improve the confidence in model calibration.

Discussion with Thiess Environmental[3] revealed the issues with the Casterton gauge during periods of low flow prior to decommissioning. It was also highlighted that the Glenelg River at Harrow streamflow gauge location was incorrect on the DEPI online Water Measurement Information System[1] with the gauge moved downstream of the reported location.

[3] Pers. Comm. – Brent Deckert, Thiess Environmental.

2.3 Rainfall gauges

Numerous daily rainfall gauges are located across the Glenelg River catchment upstream of Casterton. There are also two relevant sub-daily rainfall gauges located at Casterton Showgrounds and Rocklands.

The list of daily and sub daily gauges considered relevant to this study is shown below in Table 2-2, detailing each gauge's period of record and maximum daily recording. Gauge locations are shown in Figure 2-8.

Table 2-2 Relevant rainfall gauges and their respective gauge record

Gauge Name	Gauge Number	Start of daily record	End of record	Max. Daily Recording (mm)	Year achieved
Charam	79007	1903	1983	110	1980
Clear Lake (Marlbro)	79008	1903	-	117.1	1957
Edenhope (Post Office)	79011	1890	-	88	1980
Harrow (Post Office)	79021	1908	-	108	1946
Harrow (Pine Hills)	79022	1884	2011	88.9	1952
Wartook Reservoir	79046	1890	-	118.4	1941
Rocklands Reservoir*	79052	1948	2010	118.1	1957
Halls Gap (Post Office)	79074	1958	-	146.6	2011
Telangatuk East (Milingimbi)	79078	1968	-	95	2011
Balmoral (Post Office)	89003	1884	-	104.1	1952
Cavendish (Post Office)	89009	1884	-	106.8	2010
Mirranatwa (Bowacka)	89019	1901	-	124	1957
Willaura (Yarram Park	89037	1902	-	98	2010
Gatum (Orana)	89043	1953	-	88.4	1957
Casterton (Roseneath)	90019	1891	-	119	2007
Casterton (Warrock)	90020	1880	-	115	1986
Coleraine Hospital	90024	1898	-	134.6	1946
Coojar (Killara)	90026	1939	-	90.4	1946
Dergholm (Hillgrove)	90033	1899	-	138.2	2007
Dergholm (Dorodong)	90034	1943	-	109	2007
Chetwynd	90091	1889	1912	88.6	1910
		1947	1980		
Coleraine (Melville Forest)	90095	1954	-	72.8	1983
Casterton Showgrounds*	90135	1956	-	114	2007
Nareen	90140	1968	2005	68	1987
Dartmoor CFA	90182	2009	-	73.6	2011
Poolaijelo (Karinya)	90164	1974	1986	133	2007
		2006	-		

* sub daily rainfall gauge

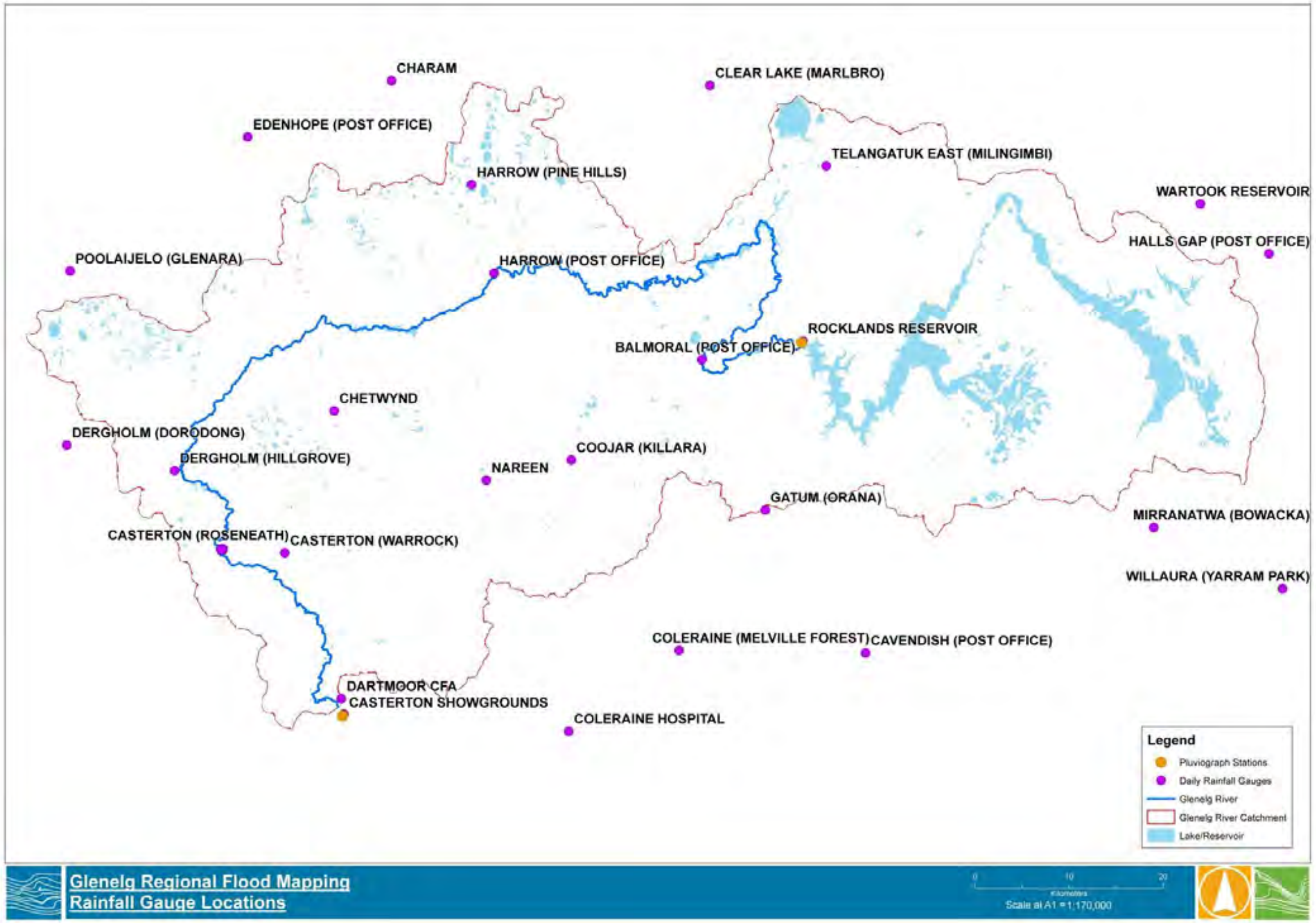


Figure 2-8 Rainfall gauge locations

2.4 Topographic and structure details

2.4.1 LiDAR Data

Several gridded topographic datasets are available covering the Glenelg River downstream of Rocklands Reservoir. These include –

- VicMap 20 m DTM – 20 m gridded raster topography owned and produced by DEPI for all of Victoria at 10 and 20 m resolutions. The Glenelg River is covered by the 20 m resolution data.
- Floodplains LiDAR – 1 m gridded raster topography owned and produced by DEPI for the purposes of floodplain mapping.
- ISC LiDAR – 1 m gridded raster topography owned and produced by DEPI for the purposes of completing Index of Stream Conditions for Victoria.

The topographic datasets cover varying extents. The VicMap 20 m DTM covers all of the Glenelg River Catchment area reaching from the western side of the Mt Difficult Range to west of Poolaijelo. The Floodplains and ISC LiDAR cover a smaller portion of the Glenelg River catchment, with the Floodplains data limited to the Glenelg River from approximately Ferres Creek to Casterton. The ISC data is limited to the Glenelg River downstream of Rocklands Reservoir. The majority of the river floodplain was captured in the LiDAR datasets, however some of the extremities may have been missed. Modelling of the 1% AEP event was used to confirm any data gaps in the topography.

The extent of each LiDAR dataset is shown in Figure 2-9 with the 20 m VicMap DEM available for the entire study area.

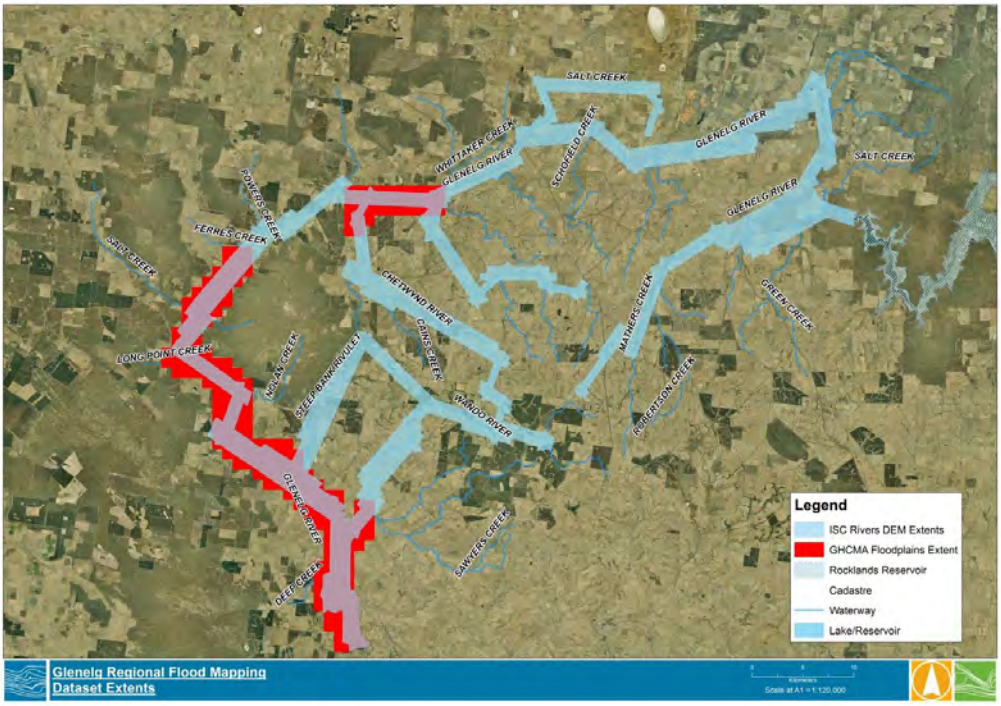


Figure 2-9 LiDAR data available of the Glenelg River

2.4.2 Structure details

Several major road structures are located on the Glenelg River between Rocklands Reservoir and Casterton. These structures are owned and maintained by varying Local Councils. Structures were included in the hydraulic models developed as part of this project. Structures located on the Glenelg River between Rocklands Reservoir and Casterton are as follows:

- Stirling Street Disused Bridge, Balmoral
- Rocklands Road, Balmoral
- Private Access Bridge, Channel Road, Rocklands
- Natimuk-Hamilton Road, Kanangulk
- Disused Railway Bridge, Kanangulk
- Coleraine-Edenhope Road, Harrow
- Coleraine-Nareen-Moo Road (Moree Bridge), Culla
- Casterton – Edenhope Road (Burkes Bridge), Chetwynd
- Dergholm-Chetwynd Road at Dergholm
- Warrock Road, Roseneath
- Section Road, Dunrobin
- Glenelg Highway, Casterton
- Anderson Road, Casterton

Data requests were sent to each of the local councils requesting information on the structures, however they were relatively unresponsive. In the absence of design or as constructed plans a road level survey was undertaken with the waterway cross sections extracted from the LiDAR. It was considered good value for money to survey the road structures as part of the data verification and also use that detail in the hydraulic model schematisation. No low level crossings or minor tracks were included because of their low impact on flood levels and they are unlikely to be used during a flood event. The inundation potential of the more major roads is of more interest for flood response and they more likely to have an impact on flood levels in high flow events.

The location of structures included in the hydraulic modelling is shown in Figure 2-10.

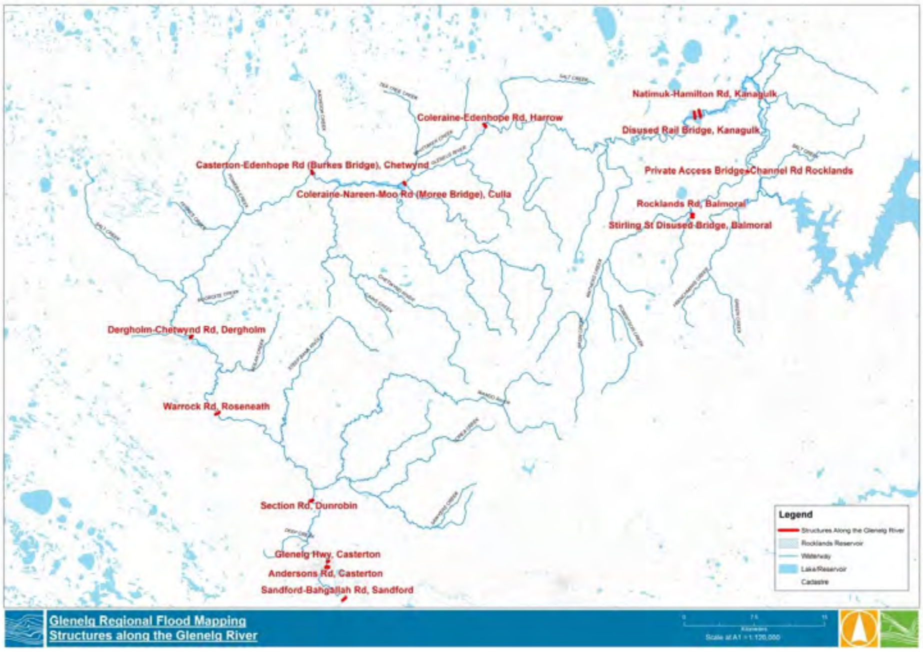


Figure 2-10 Structures along the Glenelg River downstream of Rocklands Reservoir

2.4.3 Cross section feature survey

Numerous waterway surveys have been completed along the Glenelg River. These surveys were completed as part of planned sand extraction and/or environmental works. Glenelg Hopkins CMA has provided the following waterway survey data for the Glenelg River:

- 1996, Sand extraction survey (Rutherfurd)
- 1999, Glenelg River Channel Survey (Thiess)
- 2001, Stressed Rivers (SKM)
- 2003, Harrow Rehabilitation Survey

This survey information provides a basis for comparison against the captured LiDAR data and gives an indication of the variance in stream invert along the Glenelg River.

The survey data locations are shown in Figure 2-11.

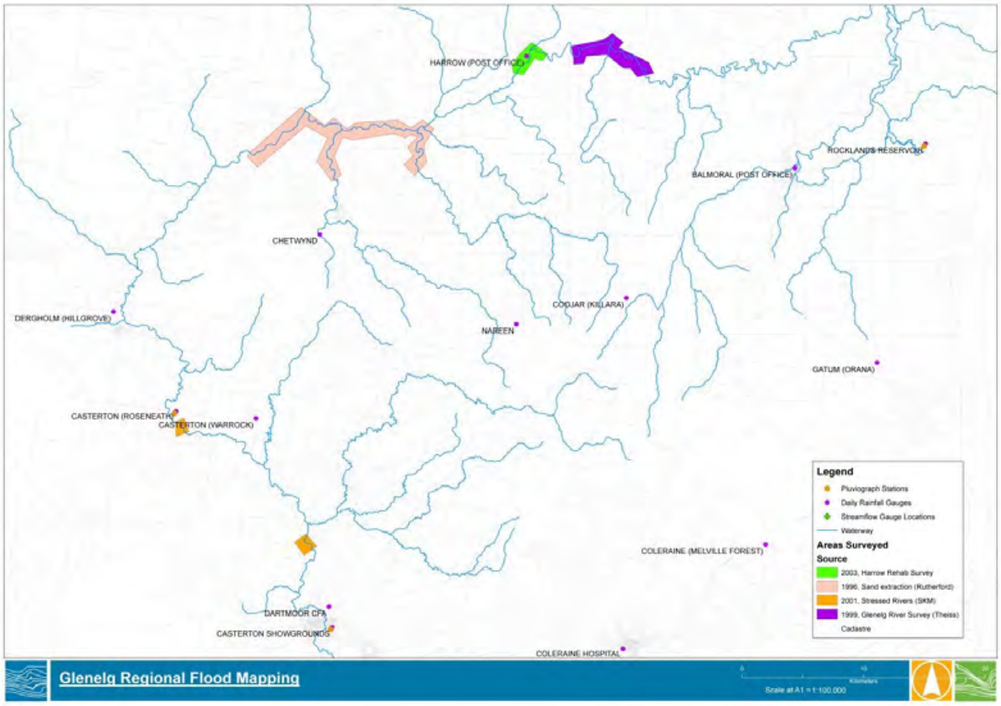


Figure 2-11 Survey data locations

The majority of the cross section data provided to Water Technology contained spatial information; this allowed the cross sections to be placed in their correct location on the Glenelg River. However, spatial data captured in the 1996 Sand Extraction Survey was found to be located in the incorrect position. This data was left out of the analysis as incorrect cross section placement would result in a false comparison.

2.4.4 LiDAR Verification

The ISC LiDAR dataset had the most comprehensive coverage of the Glenelg River and was used as the primary topography dataset for hydraulic modelling. The ISC LiDAR data was verified to ensure the data's representation of the ground surface was accurate. During this verification three comparisons were made against:

- Stream cross section surveys undertaken over several projects
- Floodplains LiDAR dataset
- Road transects surveyed as part of this project.

Stream cross section survey

A comparison of the available stream cross sections and ISC LiDAR was made for all the spatially correct survey data. A sample of this comparison is shown in Figure 2-12 and Figure 2-13. Cross sections from the VicMAP 20m DEM are also included in the figures.

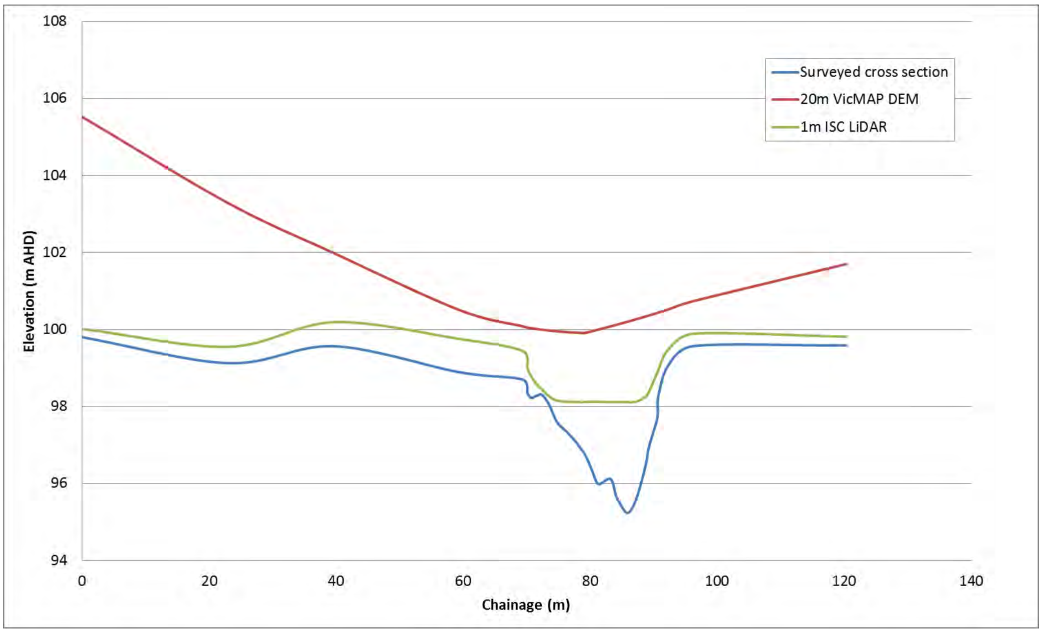


Figure 2-12 Survey vs. ISC LiDAR data cross section comparison at Harrow, Harrow Rehabilitation Survey – Chainage 1400m

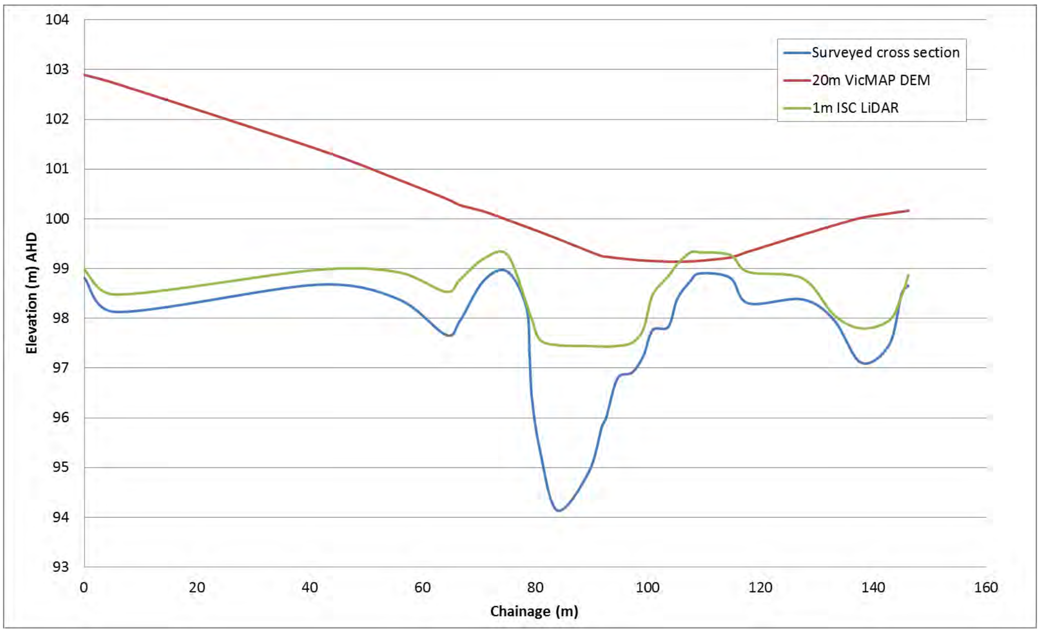


Figure 2-13 Survey vs. ISC LiDAR data cross section comparison at Harrow, Harrow Rehabilitation Survey – Chainage 2800m

Comparison of surveyed and LiDAR extracted cross sections are expected to contain some discrepancy due to the highly variable topography, the point by point comparison and the potential for horizontal inaccuracy; however they did indicate the ISC LiDAR was consistently higher than the surveyed levels.

Comparison of the LiDAR extracted and surveyed cross sections has indicated the ISC LiDAR is generally matching the Glenelg River cross section shape, aside from instances where water has given a LiDAR return, missing the cross section invert. However, in all comparisons the LiDAR data has given a consistently higher elevation than that surveyed. The difference between the ISC LiDAR and surveyed levels vary from 0.1 m to up to 1.0 m.

The comparison showed the water level at the time the LiDAR was flown, indicating that when the LiDAR cross sections were incorporated into the hydraulic modelling the cross section invert would need to be lowered.

Floodplains LiDAR

The ISC LiDAR was compared to the floodplains LiDAR dataset to determine spatial variations between the two datasets.

Comparison between the LiDAR datasets was calculated by subtracting the Floodplains LiDAR data from the ISC LiDAR. This results in positive values when the ISC data is higher and negative values when it is lower. Comparison at the two locations where the LiDAR datasets overlap, at the Chetwynd River and Glenelg River confluence and along the lower Glenelg River are shown below in Figure 2-14 and Figure 2-15 respectively.

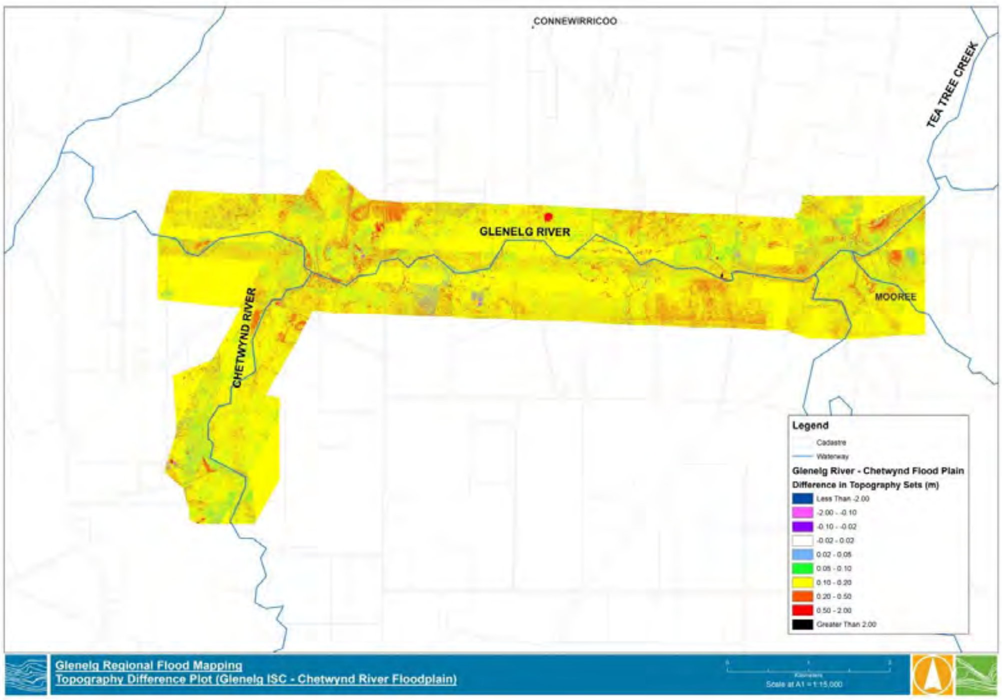


Figure 2-14 Comparison of the available LiDAR datasets at the Chetwynd and Glenelg River confluence

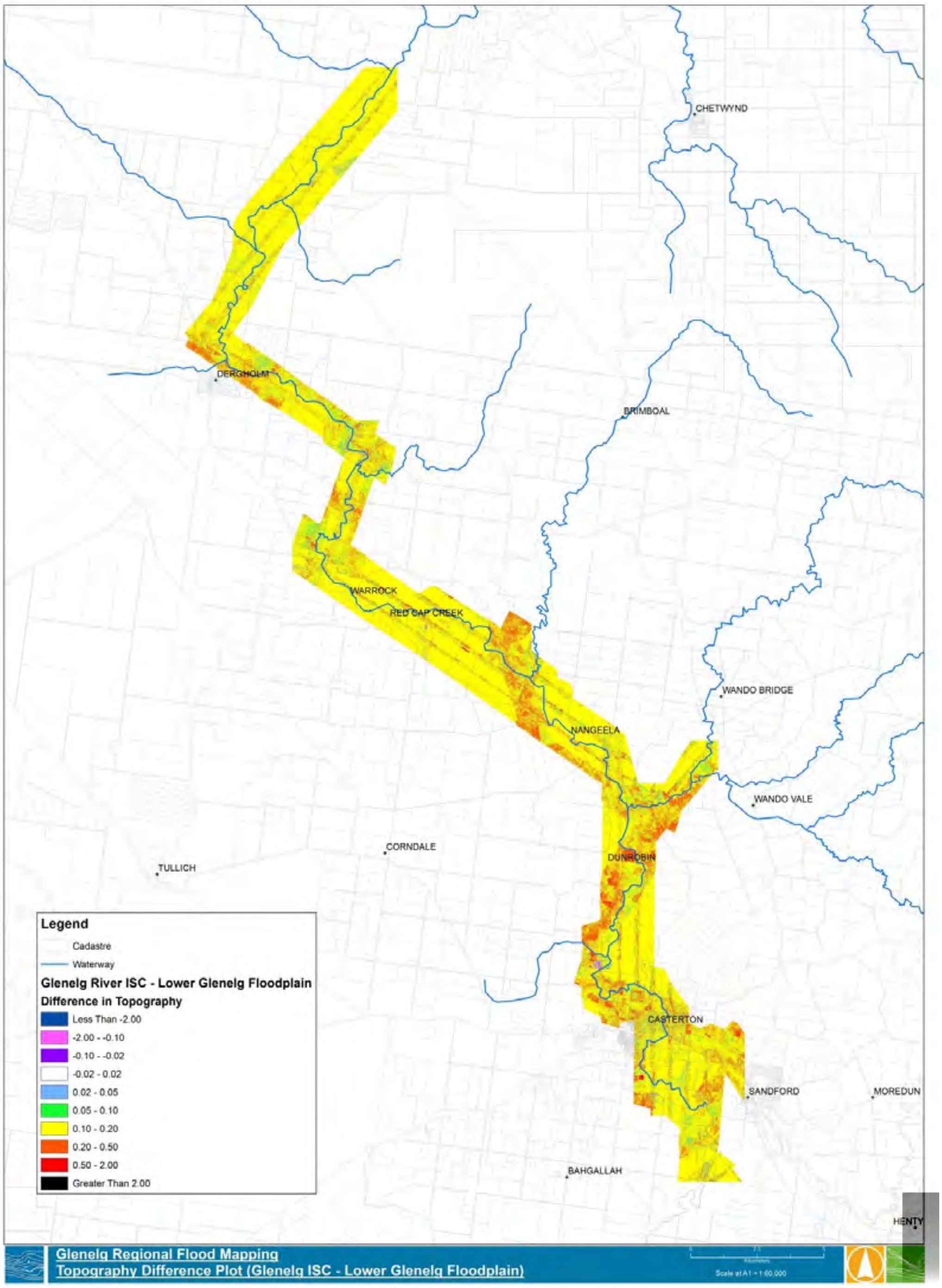


Figure 2-15 **Comparison of the available LiDAR datasets along upstream and around Casterton**

No spatial variation was observed along each of the reaches compared. However, there were some bands where the ISC LiDAR was higher (shown in orange). These areas appear to be on the edge of the LiDAR swathes or areas of overlap.

Comparison of the two LiDAR datasets showed the ISC LiDAR data to be consistently higher than the Floodplains data, in the range of 0.1-0.2 m. Statistics drawn from the comparison on the two overlapping locations is shown in Table 2-3.

Table 2-3 Statistics from a comparison of the Floodplains and ISC LiDAR datasets

Statistic	Chetwynd Glenelg Confluence	Lower Glenelg River
Mean difference (m)	0.16	0.12
Max. difference (m)	7.96	10.83
Min. difference (m)	-17.59	-14.67
Standard Deviation (m)	0.07	0.06

Road crossing survey transects

Road centreline survey was commissioned in Figure 2-16.

250 m transects along several of the major bridge structures along the Glenelg River from Casterton to Rocklands. The eight locations surveyed are shown in Figure 2-16.

Figure 2-16 Surveyed road crossing transects

The eight surveyed transects were compared to the ISC LiDAR showing the LiDAR to be consistently higher than the survey data.

An example of the transect comparison at Rocklands Road, Balmoral is shown in Figure 2-17. All comparisons are shown in Appendix C.

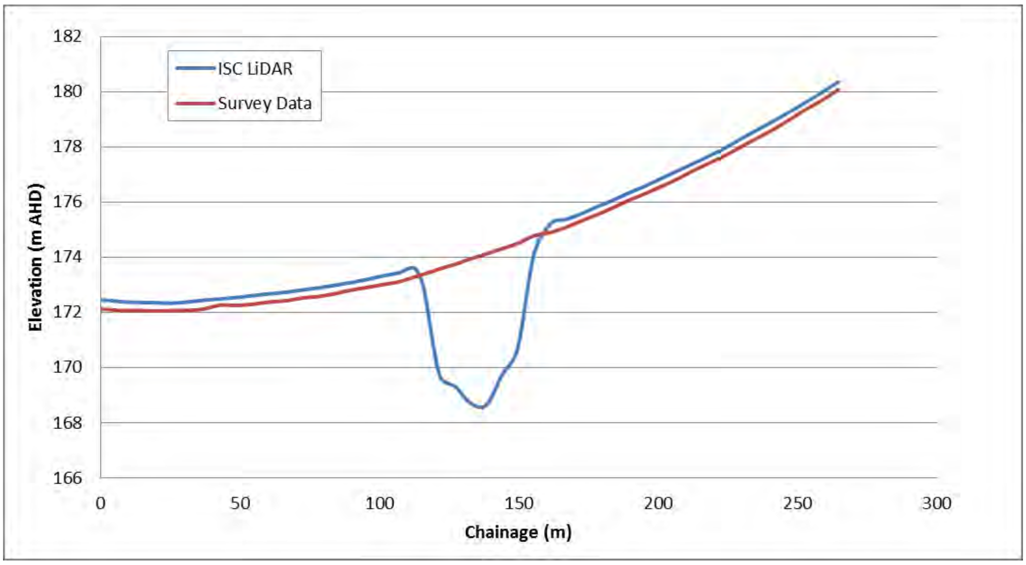


Figure 2-17 LiDAR and Survey data comparison at Rocklands Road, Balmoral

Figure 2-17 shows the LiDAR to be consistently higher than the surveyed Road level, with the exception of the waterway itself.

By comparing the ISC and surveyed elevations either side of the bridge (removing the Glenelg River channel) the maximum and average difference between the two datasets were determined for each cross section.

The maximum and mean difference between the datasets is shown for each cross section in Table 2-4. The mean, median and standard deviation of the mean values is also shown.

Table 2-4 Max and mean difference between the surveyed and ISC LiDAR levels

Transect	Max. Difference	Mean Difference
1	0.34	0.29
2	0.31	0.28
3	0.42	0.31
4	0.42	0.33
5	0.40	0.36
6	0.38	0.32
7	0.39	0.32
8	0.38	0.32
Mean difference = 0.32		
Median difference = 0.319		

Standard Deviation = 0.043

Discussion

All analysis undertaken has indicated the ISC LiDAR data is higher than the actual ground levels. The road centreline survey is considered the most accurate method for level comparison. Road centrelines give a consistent ground surface for LiDAR returns with levels not expected to vary significantly in the horizontal direction.

A 0.32 m mean difference between the ISC LiDAR and surveyed transects was calculated, with a median difference of 0.319 m.

This value is the same as determined in Casterton Flood Investigation[4], which also utilised a 0.32 m lowering. It was determined that a 0.32 m lowering of the topography would be used in the hydraulic modelling completed in this project.

2.4.5 Discussion

Verification of the ISC LiDAR to feature survey data is considered highly valuable and confirmed a uniform inconsistency between the LiDAR and surveyed levels in this project. Verification of LiDAR ground surface data should always be completed at the beginning of a project ensuring the base data is correct. It is also important to ensure the feature survey is captured over the extent of the study area. If there is a discrepancy between the LiDAR and surveyed levels it may not be geographically consistent. Water Technology has worked on projects where there the discrepancy between LiDAR and feature surveyed levels has varied across the LiDAR data extent. If these issues are highlighted at an early stage long delays and repeating parts of the project can be avoided.

Survey of the numerous bridge decks across the study area was completed for dual purpose; to be used in the LiDAR verification and for input to the hydraulic model. The bridges surveyed had good spatial coverage of the model extent and provided a flat surface for the comparison; however they didn't provide any real additional detail to the hydraulic model that could not be extracted from the LiDAR data. The cross sections at the majority of locations were deep with extremely steep banks making cross section survey difficult to obtain and the additional cost of these cross sections exceeded a reasonable amount. These bridges are very high and well above flood level.

[4] Cardno, 2011 – Casterton Flood Investigation

3. HYDROLOGIC ANALYSIS

3.1 Overview

A combined approach to the hydrology was adopted for this study. Numerous streamflow gauges were available along the modelled reach; these were used to undertake Flood Frequency Analysis for design peak flows.

As there are a number of tributaries and this study is interested in flood mapping the entire reach, accurate streamflow estimates of the entire system are required. For this reason a hydrologic RORB model was developed and calibrated and used to provide information on design volume and hydrograph shape for design hydrology.

The RORB design flow hydrographs were then scaled to match the peak flows from the flood frequency analysis using varied loss values. The RORB models primary purpose was to develop the hydrographs shape and volume with the peak flows dictated by the FFA. However, every effort was made to ensure the RORB calibration was as accurate as possible for input of flows into the hydraulic model.

3.2 Flood Frequency Analysis

3.2.1 Overview

As discussed in Section 2.2 there are numerous streamflow gauges in the Glenelg River catchment. To complete a relevant Flood Frequency Analysis (FFA) data recorded prior to the construction of Rocklands Reservoir in 1953 must be excluded because of the change in flow regime its construction has caused. This means a maximum of 59 years of gauge record is possible for the FFA analysis on Glenelg River gauges downstream of Rocklands Reservoir.

This study is focused on large flow events ranging from 20% to 0.5% AEP. For this reason an annual series FFA was determined as the most appropriate methodology. Gauges located at Balmoral, Harrow, Downstream Burkes Bridge and Dergholm have insufficient gauge records to complete an annual series FFA.

The list of gauges available, their complete annual record post 1953, and years of record is shown in Table 3-1, with the gauges with an insufficient gauge record for the completion of an Annual Series FFA highlighted in grey.

For gauges located at Big Cord, Rocklands, Fulham Bridge, Casterton and Wando Vale the gauge record includes both mean daily flow (MDF) and instantaneous gauge records. In most instances the MDF series is longer than the instantaneous series. The recorded MDF values are generally less than the instantaneous peak flow due to the flow rate being averaged over 24 hours. To translate each recorded peak annual MDF into an instantaneous peak flow, a ratio of MDF to instantaneous peak flow was determined for the period of instantaneous record for each gauge. The annual maximum MDF was then scaled up as an estimate for the instantaneous peak flow and the instantaneous peak flow series was extended. A measure of the correlation was determined by an R^2 value. Table 3-2 shows the gauges with an extended instantaneous gauge record, the length of extension and the R^2 value representing the fit. A visual representation of correlation is shown in Appendix B.

In all cases flood frequency analysis was undertaken using a range of typical flood frequency distributions including Generalised Extreme Value (GEV), Log Normal and Log Pearson Type 3 (LP3). A LP3 distribution was found to be the best match for all datasets.

A FFA distribution can be influenced by a number of small annual peaks at the lower end of the series. To combat this censoring of low flows was completed in the majority of the FFAs completed.

Censoring was either undertaken using the Multiple Grubbs Beck Test or if this approach did not yield sufficient results an iterative approach was taken to determine the most appropriate low flow threshold. Censoring of low flows is especially significant for gauges in the Glenelg River catchment due to the number of low flow years that are present in each gauge annual series. These peaks could not be classified as “floods” and skew the analysis.

An example of the low flow censoring for the Glenelg River gauge at Big Cord is shown below in Table 3-3 and Figure 3-1.

Table 3-1 Stream flow gauges and years of record

Gauge Name	Gauge Number	Complete annual record post 1953	Years of record
Glenelg River @ Big Cord	238231	1968 – 2013	45
Glenelg River @ Rocklands	238205	1954 – 2013	59
Glenelg River @ Balmoral	238201	1954 – 1956	2
Glenelg River @ Fulham Bridge	238224	1977 - 2013	36
Glenelg River @ Harrow	238210	2002 – 2013	11
Glenelg River D/S Burkes Bridge	238249	2002 – 2013	11
Glenelg River @ Dergholm	238211	2005 - 2013	8
Glenelg River @ Casterton	238212	1966 – 2001	35
Chetwynd River @ Chetwynd	238229	1968 – 2013	45
Wando River @ Wando Vale	238228	1965 - 2013	48
Pigeon Ponds Creek @ Koolomert	238234	1970 - 2013	43

Table 3-2 Regression relationship between each gauges MDF and peak instantaneous flow

Gauge Name	Complete annual record post 1953	Years of extended instantaneous record	R^2 value
Glenelg River @ Big Cord	1968 – 2013	10 of 45	0.959
Glenelg River @ Rocklands	1954 – 2013	28 of 59	0.991
Glenelg River @ Casterton	1966 – 2001	14 of 35	0.906
Wando River @ Wando Vale	1965 - 2013	11 of 48	0.880

Table 3-3 FFA results for Big Cord with and without low flow censoring

AEP	Big Cord Peak Flow (m^3/s)	
	Raw annual series	Censored annual series
20%	7.1	7.0
10%	8.6	8.5
5%	9.7	9.7
2%	10.8	10.9
1%	11.3	11.7
0.5%	11.8	12.3

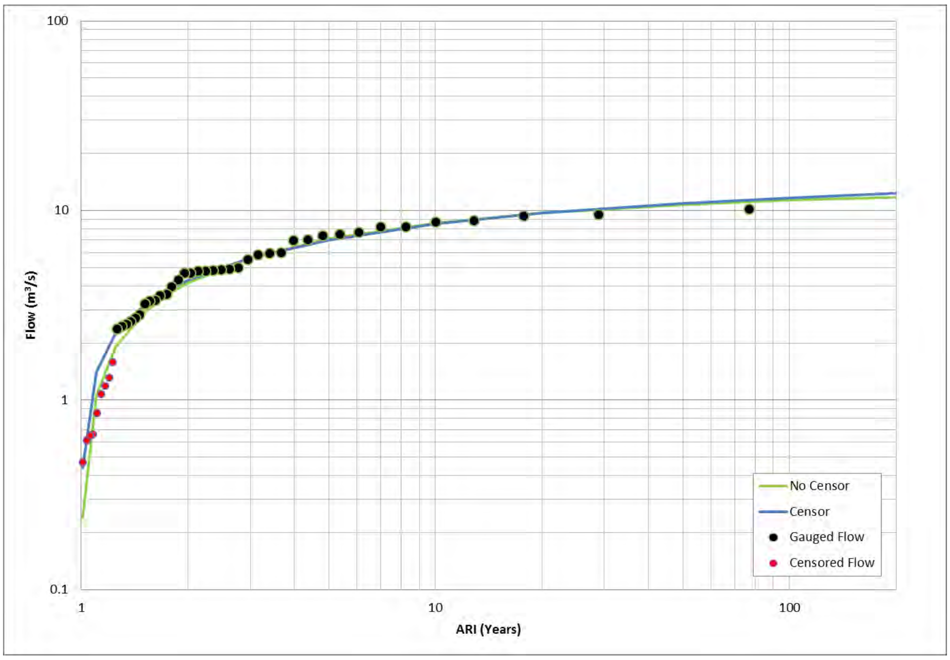


Figure 3-1 Glenelg River at Big Cord - FFA distributions with and without low flow censoring

The change in FFA results is more significant at the lower end in this case, however the gauged flow distribution shows a clear disconnect between censored and uncensored flows. The censored flows are in years where no 'flood' flows occurred.

3.2.2 Glenelg River at Big Cord

The extended Big Cord instantaneous flow gauge record included 45 years of data, of these annual peak flows one year was extracted from an extrapolated rating curve, recorded in 2011. This recording was considered to be of sufficient certainty for inclusion into the flood frequency analysis.

Censoring of low flows was undertaken using the Multiple Grubbs Beck Test. A 2.5 m^3/s threshold was determined removing 9 years from the annual series.

Results for the Big Cord gauge are shown in Table 3-10 with the annual series, censored flows and FFA graph shown in Appendix A.

3.2.3 Glenelg River at Rocklands

The extended Rocklands gauge record included 56 years of data, with only one manually estimated peak flow in the record. The annual series shows very low peak flows for a number of the years; which is primarily due to the heavily modified flow regime at the Rocklands gauge immediately downstream of Rocklands Reservoir. All of these years were considered of sufficient certainty for inclusion into the flood frequency analysis with censoring of low flow values.

Censoring of low flows was undertaken using the Multiple Grubbs Beck test. A 2.0 m^3/s threshold was determined, removing 31 years from the annual series, leaving 25. The flow recorded at the Rocklands Gauge is so heavily modified and given the maximum outflow recorded since construction of the reservoir is only 5,300 ML/d FFA is considered indicative only.

Results for the Rocklands gauge are shown in Table 3-10 with the annual series, censored flows and FFA graph shown in Appendix A.

3.2.4 Glenelg River at Fulham Bridge

The Fulham Bridge gauge record was comprised of instantaneous flow data for all years of the record. The annual peak series contained one year with the flow extracted from an extrapolated rating curve recorded in 2010. All annual peaks were considered of sufficient certainty for inclusion into the flood frequency analysis with censoring of low flow values.

No low flow censoring was undertaken.

Results for the Fulham Bridge gauge are shown in Table 3-10 with the annual series, censored flows and FFA graph shown in Appendix A.

3.2.5 Glenelg River at Casterton

The Casterton gauge record was extended by 14 years to bring the total number of years available for a FFA to 35. The gauge record finished in 2002. It was considered a further extension could be made to 2013 by correlating the Casterton gauge to the gauge at Sandford, which is approximately 7 km downstream. There is a tributary of the Glenelg River, the Wannon River, entering between the two sites. A gauge is located on the Wannon River immediately upstream of the confluence at Henty.

To determine the correlation between the Casterton and Sandford gauges a regression relationship was developed between the two gauges. This was undertaken by comparing the peak daily flows at Casterton and Sandford for their concurrent period of record, as well as comparing the Sandford – Henty peak daily flow records to those recorded at Casterton. The regression relationships for the Sandford vs. Casterton and Sandford minus Henty vs. Casterton are shown in Figure 3-2 and Figure 3-3 respectively. Daily peak flows were used rather than annual peak flows to give a larger data sample size containing more events. As it is likely more than one event could occur in a calendar year, this was appropriate given the very small distance between the Casterton and Sandford gauges.

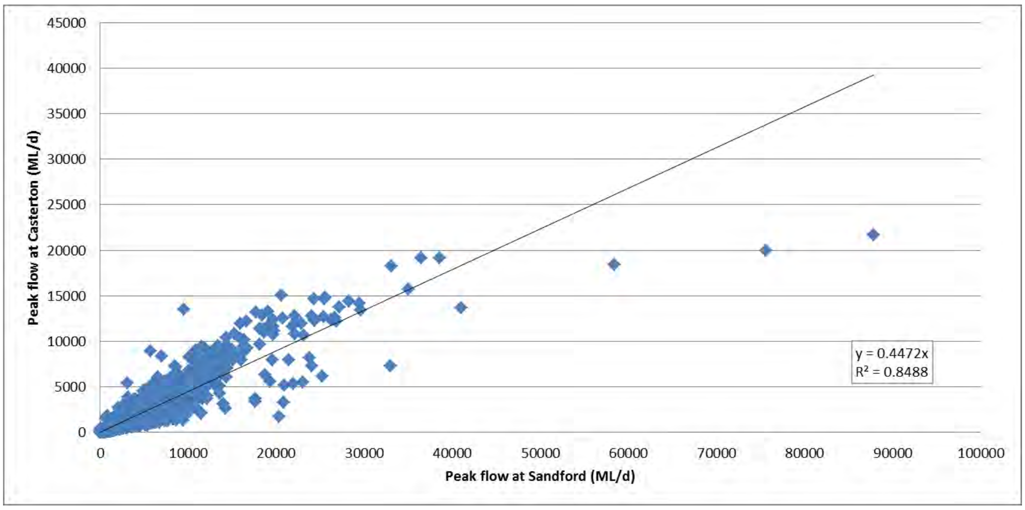


Figure 3-2 **Peak daily flow regression relationship for Sandford and Casterton**

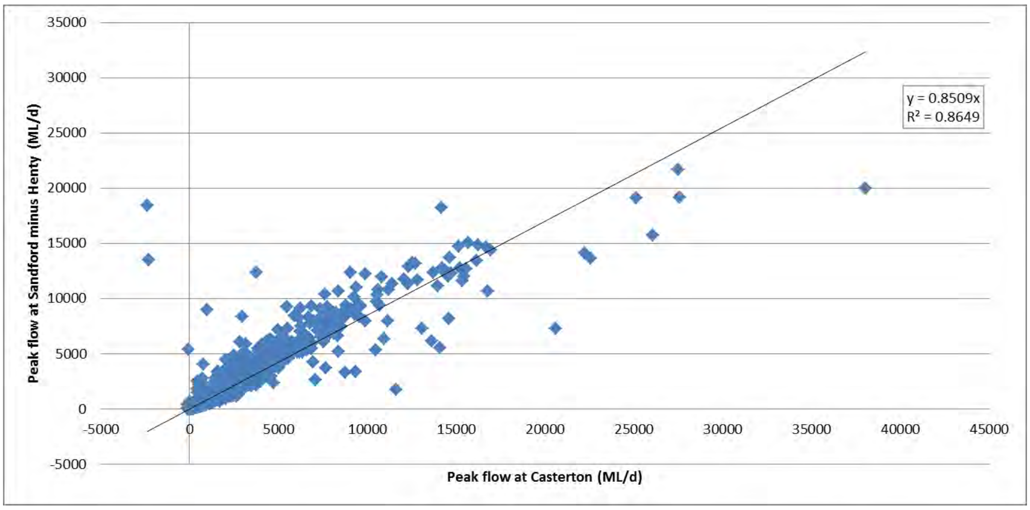


Figure 3-3 **Peak daily flow regression relationship for Sandford minus Henty and Casterton**

The relationship between Sandford and Casterton is impacted by three maximum daily flows which are much higher at the Sandford gauge than at Casterton. These flows all occurred during an event in 1983 which was heavily influenced by the Wannon River. The Wannon River/Glenelg River confluence is located approximately 600 m upstream of the Sandford gauge. For this reason the regression relationship was repeated with the exclusion of this event.

The resulting relationship is shown below in Figure 3-4.

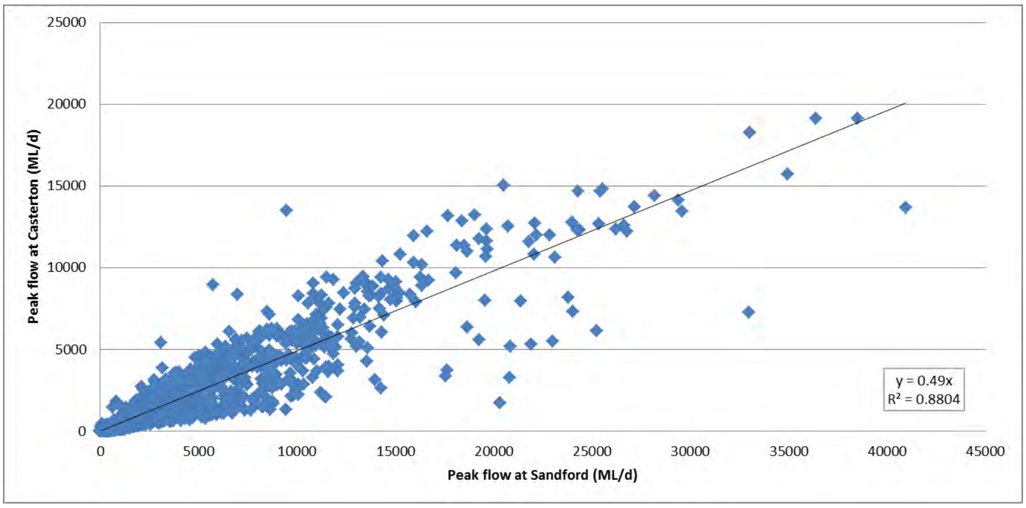


Figure 3-4 **Peak daily flow regression relationship between Sandford and Casterton minus the 1983 event**

A regression assessment was also undertaken between the Sandford and Casterton gauges on an annual basis for the overlapping period of instantaneous gauging. This yielded a regression equation of y=0.555x and an R^2 value of 0.951. The relationship is shown in Figure 3-5.

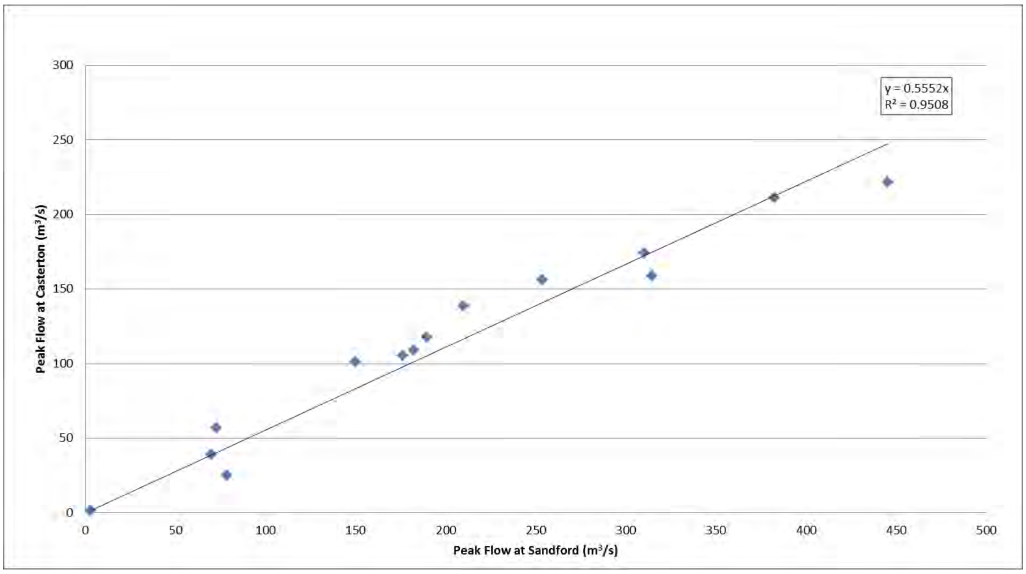


Figure 3-5 **Peak daily flow regression relationship between Sandford and Casterton minus the 1983 event on an annual basis**

The regression relationships and R^2 values for all scenarios are shown in Table 3-4.

Table 3-4 Regression relationship between Casterton and Sandford

Gauge comparison	Regression equation	R^2 value
Casterton vs. Sandford	y=0.447x	0.859
Casterton vs. Sandford minus Henty	y=0.851x	0.865
Casterton vs. Sandford minus 1983	y=0.490x	0.880
Casterton vs. Sandford minus 1983 (annual basis)	y=0.555x	0.951

Given the improvement in the regression relationship with the removal of the 1983 event it was determined the regression between the Casterton vs. Sandford minus 1983 would be used to extend the Casterton gauge record from 1988 to 2013. This was further justified as the regression relationship was very similar to that of the annual regression relationship developed between Casterton and Sandford.

The extended annual peak series contains one year with the flow manually estimated in 1982[5] in the Casterton annual peaks series and eight from the period of record extended with the Sandford annual peaks. All annual peaks were considered sufficient for inclusion into the flood frequency analysis with censoring of low flow values.

As an alternative method, the correlation between the two gauges was also determined using a Maintenance of Variance Extension (MOVE)[6] to derive a relationship between the flows at Sandford and Casterton. The relationship was derived by the following equation.

$$q_1 = E(q_1) + sign(r)\sqrt{\frac{Var(q_1)}{Var(q_2)}}[q_1 - E(q_2)]$$

Where,

$E(\quad) = mean\ values$

$sign(r) = the\ correlation\ between\ q_1\ and\ q_2$

$Var(\quad) = Variance$

The annual peak flows estimated using the raw regression equation and the Maintenance of Variance Extension on the concurrent annual series (1974-1988) were tested based on both mean daily flows and annual maximum flows. These results are shown in Table 3-6. Results highlighted in green represent flows at Casterton greater than 100 m^3/s and are representative of large flows. This value was selected arbitrarily.

[5] Flow listed as manually estimated in the data quality codes, method of estimation is unknown

[6] Kuczera, G. and Franks, S. (2006) Book 3, Chapter 2. Draft chapter for Australian Rainfall and Runoff http://www.arr.org.au/downloads-and-software/chapters/

Table 3-5 Casterton gauge extension

Year	Sandford peak flow (m^3/s)	Casterton peak flow (m^3/s)	Analysis undertaken with daily maximum flow data as the basis for the regression and MOVE analysis				Analysis undertaken with annual maximum flow data as the basis for the regression and MOVE analysis			
			Casterton peak flow (Regression) (m^3/s)	Difference	Casterton peak flow (MOVE) (m^3/s)	Difference	Casterton peak flow (Regression) (m^3/s)	Difference	Casterton peak flow (MOVE) (m^3/s)	Difference
1974	189	118	93	-25 (-21%)	54	-64 (-54%)	105	-12 (-11%)	112	-6 (-5%)
1975	446	222	218	-4 (-2%)	122	-100 (-45%)	247	26 (12%)	186	-35 (-16%)
1976	254	156	124	-32 (-21%)	71	-85 (-54%)	141	-15 (-10%)	130	-26 (-17%)
1977	79	25	39	14 (56%)	25	0 (0%)	44	19 (76%)	79	54 (219%)
1978	382	211	187	-24 (-11%)	105	-106 (-50%)	212	1 (0%)	168	-43 (-21%)
1979	314	159	154	-5 (-3%)	87	-72 (-45%)	175	16 (10%)	148	-11 (-7%)
1980	73	57	36	-21 (-37%)	23	-34 (-60%)	40	-17 (-29%)	78	20 (36%)
1981	310	174	152	-22 (-13%)	86	-88 (-51%)	172	-2 (-1%)	147	-27 (-16%)
1982	3	2	1	-1 (-50%)	5	3 (150%)	2	0 (-5%)	57	55 (3313%)
1983[7]	-	-	-	-	-	-	-	-	-	-
1984	210	139	103	-36 (-26%)	59	-80 (-58%)	116	-22 (-16%)	118	-21 (-15%)
1985	70	39	34	-5 (-13%	22	-17 (-44%)	39	0 (-1%)	77	38 (96%)
1986	176	106	86	-20 (-19%	50	-56 (-53%)	98	-8 (-7%)	108	2 (2%)
1987	150	101	73	-28 (-28%)	43	-58 (-57%)	83	-18 (-18%)	100	-1 (-1%)
1988	182	109	89	-20 (-18%)	52	-57 (-52%)	101	-8 (-7%)	110	0 (0%)

[7] Excluded from the analysis due to very high flows in the Wannon River between the two gauges

Using maximum daily flows the raw regression equation produced flows lower than observed for all years except 1977. For flows larger than 100m^3/s the maximum error was negative 28%. The majority of the annual comparisons showed a value approximately 20% low than observed.

Using daily maximum flows the MOVE method produced results less than those observed except for 1982 (2 m^3/s) and 1977 (25 m^3/s), which had very low flows. The MOVE method showed significantly lower estimated peak flows with the minimum error negative 44%.

Using the maximum annual flows the raw regression equation produced peak flows with values both above and below that observed. The maximum difference between observed and predicted flows was 76% in 1977 a year of low flow. For years with a peak flow rate larger than 100 m^3/s the maximum difference was negative 18%.

The MOVE method and maximum annual flows produced large over estimations at the lower flows (less than 50 m^3/s), with the difference between observed and predicted flows exceeding 100%. At flows greater than 100m^3/s the maximum difference was -21%. In all instances the MOVE method produced flows lower than observed, except for 1986 and 1987. These years had peak flows of 101 and 109 m^3/s.

In general the annual series raw regression produced the most accurate predictions of annual peak flow with no trend for over or underestimation. This method was chosen to extend the Casterton annual series.

Censoring of low flows was undertaken using the Multiple Grubs Beck test. A 65 m^3/s threshold was determined, removing 27 years from the annual series with 27 years remaining. The low flow censoring did not heavily influence the FFA results for the more significant events of interest to this study, with a comparison shown in Table 3-6.

Table 3-6 Casterton FFA results with and without low flow censoring

AEP	Casterton FFA Results Peak Flow (m^3/s)	
	Raw annual series	Censored annual series
20%	158	155
10%	207	207
5%	245	246
2%	280	283
1%	298	302
0.5%	311	316

The Casterton FFA including censored low flows is shown in Figure 3-6

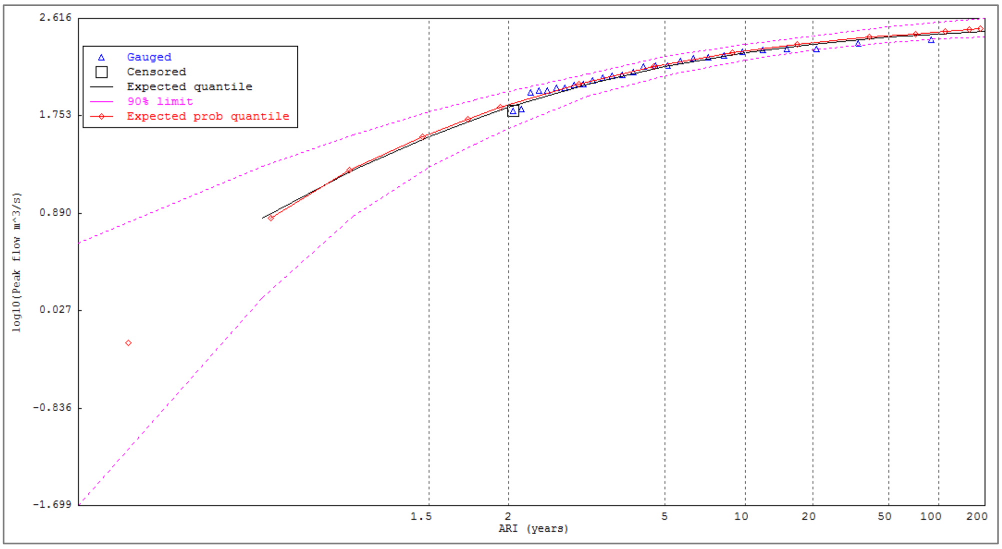


Figure 3-6 Casterton FFA – Including low flow censoring

These values differ from FFA results predicted during previous studies. The results of previously completed studies are shown in Table 3-7.

A comparison to FFA results completed as part of the Casterton Flood Investigation[4] show similar results at the Casterton Gauge for the 20%, 10% and 5% AEPs but there is a large difference at the 2% and 1% AEPs. The reason for this difference can be attributed to the FFA methods and method of low flow censoring. The Casterton Flood Investigation utilised the method outlined in AR&R Vol. 2, Book 4 (1987) but no description of the calculations made has been shown. Testing of the Casterton FFA was undertaken using the FFA Spreadsheet developed by the CRC for Catchment Hydrology[8], this testing showed the omission of low flows caused large changes to the predicted 1% AEP design flow. This difference was not as pronounced in the Flike[10] assessment.

The FFA completed in this study more closely matches that completed in the Glenelg Flood Investigation[9], however these were not the final adopted values. Both this study and the Glenelg Flood Investigation used Flike[10] for completion of the FFA. The FFA completed in the Glenelg Flood Investigation[9] only used the instantaneous data set available without extension, 1975-1988, 15 years of data. The Glenelg Flood Investigation states the ratio between the 20% AEP and 1% AEP is lower than is expected by experience but the 20% AEP FFA result is likely to be accurate given the short period of record available. However, the annual series was used rather than a partial series, therefore a small sample size of events was used. A revised set of flows were determined by scaling the Casterton 20% AEP flow by the ratio between the 20% AEP and all other AEPs from two other Glenelg River gauges, Dartmoor and Fulham Bridge. The method for the FFA results at Dartmoor and Fulham Bridge is unknown and the results were not discussed. It is a big assumption that the ratio in AEP at two gauges a significant distance upstream and downstream on the Glenelg River is the same as that at Casterton. Further it is not discussed in the Cardno report why the Sandford gauge only a

[8] Cooperative Research Centre for Catchment Hydrology, 2000 – Flood Frequency Analysis Spreadsheet, Log Pearson Type 3 analysis.

[9] Cardno Lawson Treloar (2008) - Glenelg Flood Investigation

[10] University of Newcastle - Flike – Flood Frequency Analysis Package

short distance downstream was not used to develop this ratio - the Sandford gauge has a long period of record.

The flows adopted in the Casterton Flood Investigation using the ratio scaling method are considerably higher than those predicted by the FFA of the same study.

Table 3-7 Casterton FFA results by comparison to previous studies

AEP	This study FFA	Glenelg Flood Investigation[9] FFA Flike	Glenelg Flood Investigation adopted flows[9] scaling method	Casterton Flood Investigation FFA[4] ARR87
20%	155	200	200	164
10%	207	244	272	220
5%	246	273	344	277
2%	283	297	442	355
1%	302	307	520	415
0.5%	316	-	-	-

Given the range of adopted design flows at Casterton across the three studies FFA was undertaken at the Glenelg River at Sandford and the Wannon River at Henty.

The Sandford gauge has 50 years of instantaneous record from 1967 to present. As discussed previously in this section the Sandford gauging station is approximately 7 km downstream of Casterton and there is a significant flow contribution made between the two gauges via the Wannon River.

The Sandford FFA was completed with censoring of low flows undertaken using the Multiple Grubbs Beck test. A 48.5 m^3/s threshold was determined, removing 12 years from the annual series, leaving 38 years. The FFA was completed for two scenarios, with and without high flow censoring of the 1983 event. As discussed earlier in this section the 1983 event was heavily influenced by the Wannon River, it also heavily influences the FFA results. FFA results with no high flow censoring of the 1983 event are shown in Figure 3-7. Results with a high flow censoring are shown in Figure 3-8. A comparison of the results is shown in Table 3-8.

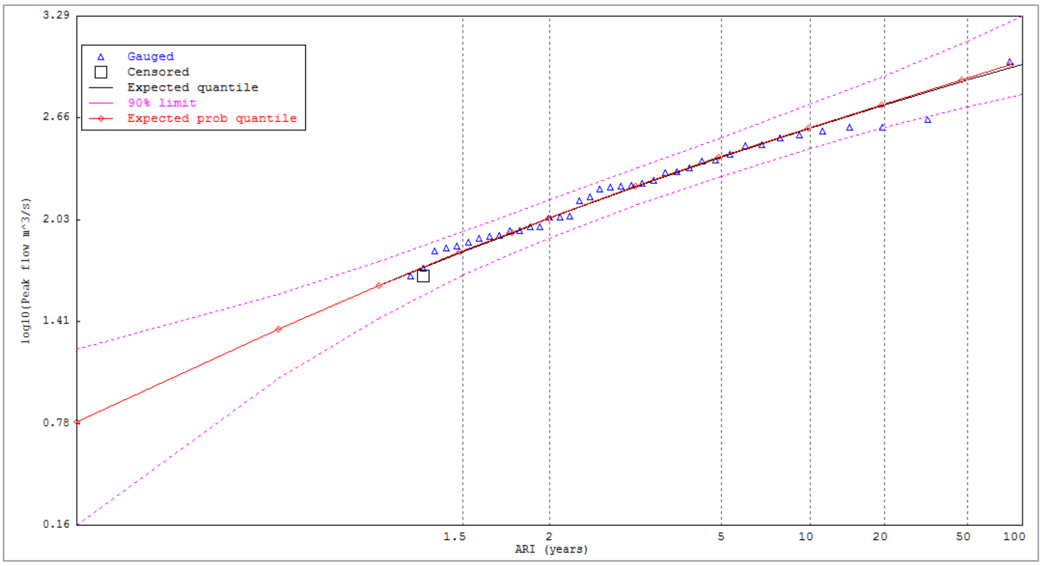


Figure 3-7 **Sandford FFA – No high flow censoring**

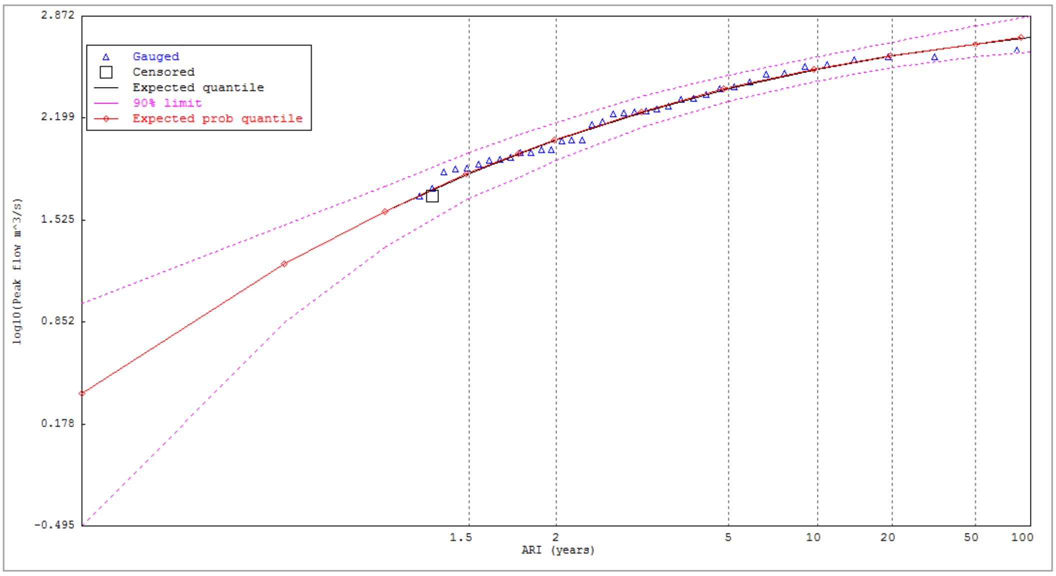


Figure 3-8 **Sandford FFA – High flow censoring of 1983**

Table 3-8 Sandford FFA results – Censored and uncensored

AEP	No high flow censoring	High flow censoring of 1983
20%	262	247
10%	398	334
5%	552	408
2%	783	488
1%	978	536
0.5%	1190	576

Censoring of the 1983 event significantly alters the FFA results, especially at the higher end of flows estimated. Censoring the 1983 event has provided a better match to the overall 50 year annual series between the Casterton and Sandford locations.

The Wannon River gauge at Henty has 40 years of complete annual record, 1974 to present. The Wannon River gauge at Henty is very close to the confluence of the Glenelg River and is representative of the flow from the entire Wannon River catchment flowing to the Glenelg River. The Henty FFA was completed for three scenarios:

- No censoring
- Censoring of low flows using the Multiple Grubbs Beck test with a threshold of 22 m^3/s
- Low flow censoring and censoring of the 1983 event, which was more than triple that of any other recorded flow.

FFA plots for these events are shown in Figure 3-9, Figure 3-10 and Figure 3-11 respectively, with a comparison of the results shown in Table 3-9.

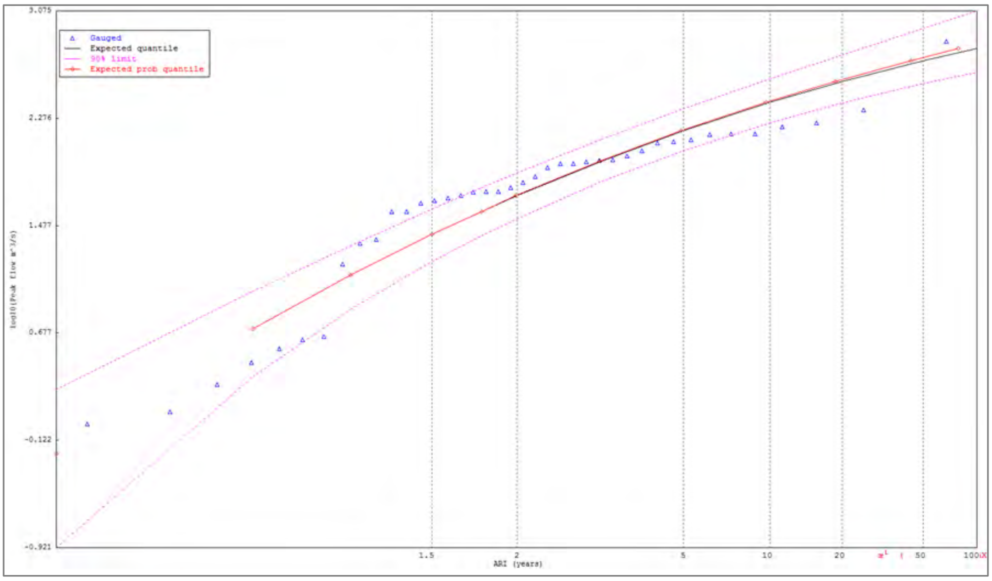


Figure 3-9 Wannon River at Henty - FFA distribution with no censoring

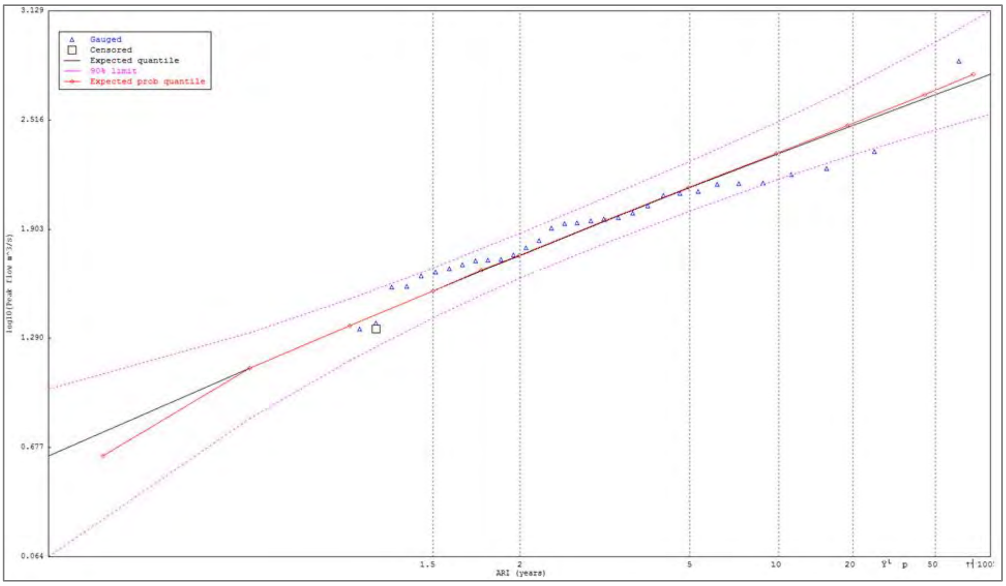


Figure 3-10 Wannon River at Henty - FFA distribution with low flow censoring

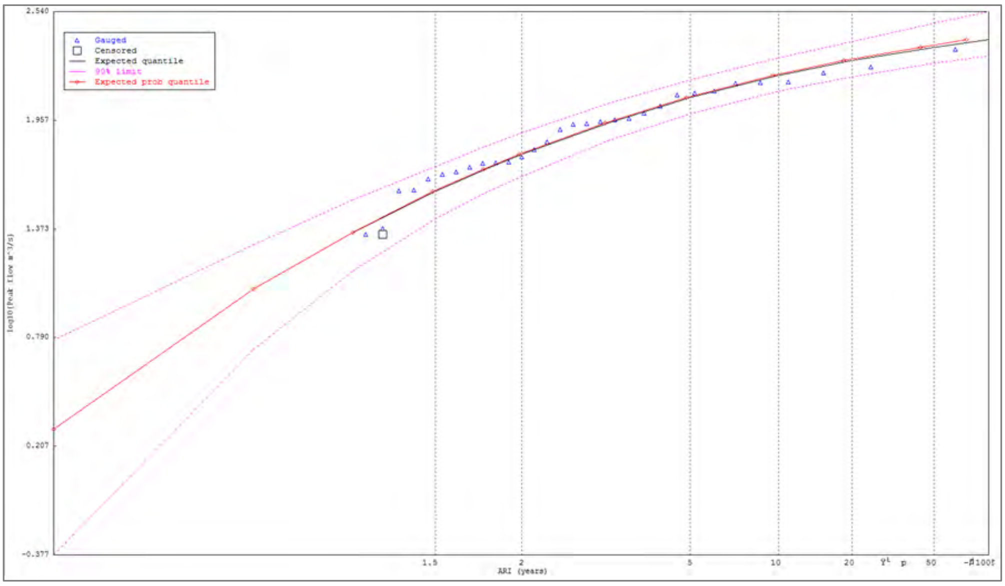


Figure 3-11 Wannon River at Henty - FFA distribution with low flow and censoring of 1983

Table 3-9 Wannon River at Henty FFA comparison

AEP	No high flow censoring	Low flow censoring	Low flow censoring and high flow censoring of 1983
20%	152	137	120
10%	247	213	158
5%	354	306	189
2%	506	455	224
1%	626	592	244
0.5%	747	750	262

The Henty FFA results show the 1983 event has a large impact on the FFA results. The event has a recorded peak flow of 702 m^3/s, with the next highest recorded instantaneous peak recorded in 1978 at 218 m^3/s, followed by 175 m^3/s in 1992. The 1983 flow is well beyond the limit of the rating curve, with the extrapolated section of the curve beginning at 190 m^3/s.

All FFA completed at Henty indicate the 1983 event was greater than a 1 % AEP event, it is likely censoring it from the FFA has caused an under prediction of the design flows and its inclusion has caused an over prediction.

The Wannon River upstream of the Henty stream flow gauge has a catchment area of 4,159 km^2 [1]. This compares to 4,730 km^2 of catchment area upstream of Casterton and a combined 9,420 km^2 upstream of Sandford. Of the 4,730 km^2 upstream of Casterton, 29%, 1,370 km^2, is upstream of Rocklands Reservoir. By removing the 1983 event from the Wannon River at Henty and the Glenelg River at Sandford it is considered that the annual series at the three gauge locations can be compared with confidence, comparing like datasets. The ratio between the adopted 20% and 1% AEP flows using the Cardno scaling method was 2.6. Using the FFA results from this study at Casterton, Sandford and Henty with the 1983 event removed, a ratio of 1.9, 2.2 and 2.0, was calculated respectively. These ratios are all much lower than the previously adopted ratio from the Cardno work.

Given the balance of evidence it is Water Technology's opinion that the previously adopted 1% AEP flow at Casterton was too high, and that the FFA results developed in this study should be used for design flood modelling in this study.

3.2.6 Chetwynd River at Chetwynd

Similar to the Fulham Bridge gauge, the Chetwynd peak annual series comprised a full record of instantaneous peak flows. The peak annual series contains one year where the peak flow was extracted from an extrapolated rating curve, recorded in 1978. All annual peaks were considered of sufficient certainty for inclusion into the flood frequency analysis with censoring of low flow values.

Censoring of low flows was undertaken using Multiple Grubbs Beck test. A 3.0 m^3/s threshold was determined, removing 10 years from the annual series.

Results for the Chetwynd gauge are shown in Table 3-10 with the annual series, censored flows and FFA graph shown in Appendix A.

3.2.7 Wando River at Wando Vale

The extended Wando Vale gauge record included 50 years of data. Of the annual peak flows there were three instances where an extrapolated rating curve was used to determine the peak flow;

1991, 1992 and 1998. All annual peaks were considered of sufficient certainty for inclusion into the flood frequency analysis with censoring of low flow values.

Censoring of low flows was undertaken using Multiple Grubbs Beck test. A 10.0 m^3/s threshold was determined, removing 16 years from the annual series.

Results for the Wando Vale gauge are shown in Table 3-10 with the annual series, censored flows and FFA graph shown in Appendix A.

3.2.8 Pigeon Ponds Creek at Koolomert

Similar to the Fulham Bridge and Chetwynd gauges the Koolomert peak annual series comprises instantaneous peak flows only. The peak annual series contained no recorded data anomalies.

No censoring of low flows was undertaken at Koolomert. Censoring of the data using the Multiple Grubbs Beck test determined a low flow threshold of 19 m^3/s. However, the results of the FFA indicated this value was detrimental to the distribution.

Figure 3-12 shows a comparison of the censored and uncensored FFA results.

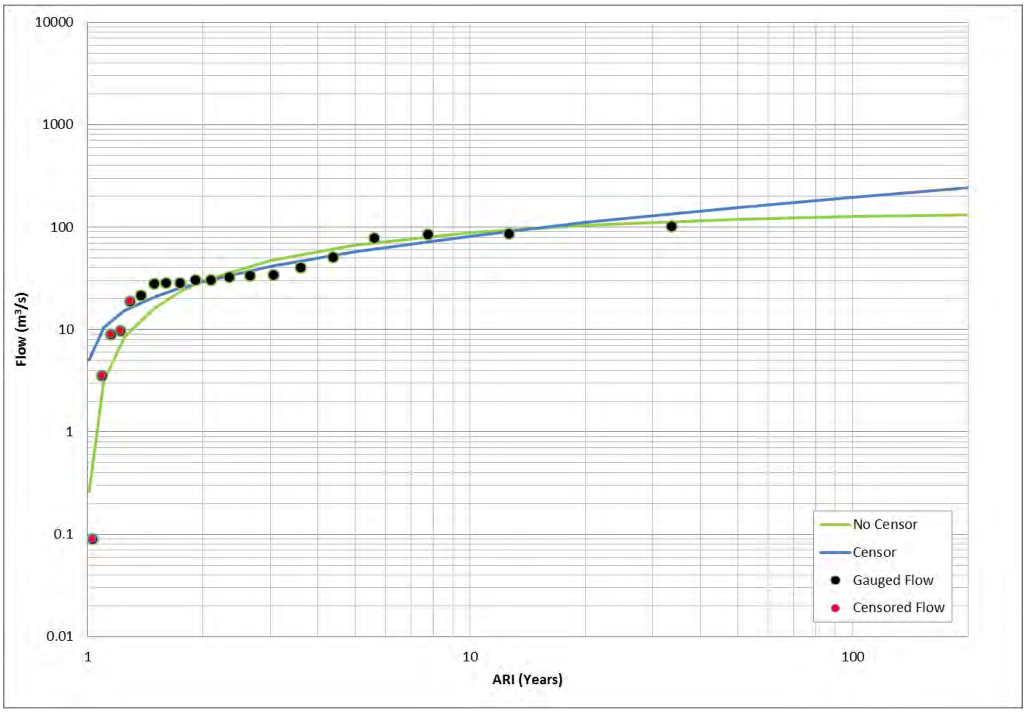


Figure 3-12 Pigeon Ponds at Koolomert - FFA distributions with and without low flow censoring

Results for the Rocklands gauge are shown in Table 3-10 with the annual series, censored flows and FFA graph shown in Appendix A.

3.2.9 Flood Frequency Analysis Results

The FFA results indicate a progressive increase in estimated peak flow downstream as would be expected in the Glenelg River catchment. Gauges at Balmoral, Harrow, Burkes Bridge and Dergholm did not have sufficient data for a FFA to be undertaken.

Table 3-10 All FFA Results

AEP	Glenelg River Flow (m^3/s)					Tributary Flow (m^3/s)			
	Big Cord	Rocklands	Fulham Bridge	Casterton	Sandford	Pigeon Ponds Creek	Wando River at Wando Vale	Chetwynd River at Chetwynd	Wannon River at Henty
20%	7.0	30	73	155	247	66	40	33	120
10%	8.5	51	101	207	334	87	59	47	158
5%	9.7	75	121	246	408	103	78	60	189
2%	10.9	110	137	283	488	118	103	75	224
1%	11.7	138	145	302	536	126	121	85	244
0.5%	12.3	167	150	316	576	132	139	93	262

3.3 RORB model construction

A hydrologic model of the Glenelg River catchment was developed for the purpose of extracting flows to be used as boundary conditions in the hydraulic models. The rainfall-runoff program, RORB, was utilised for this study.

RORB is a non-linear rainfall runoff and streamflow routing model for calculation of flow hydrographs in drainage and stream networks. The model requires catchments to be divided into subareas, connected by a series of conceptual reach storages. Observed or design storm rainfall is input to the centroid of each subarea. Specific losses are then deducted, and the excess routed through the reach network.

The following methodology was applied for the RORB modelling:

- Glenelg River catchment upstream of Casterton was delineated
- Catchment divided into subareas based on the site's topography and required hydrograph print (result) locations
- RORB model constructed using appropriately selected parameters including reach types, slopes and subarea fraction impervious values
- Storm files for the chosen calibration events were constructed
- RORB model was calibrated varying Kc and losses for each design event. As well as comparison to other models developed for the same area.
- Design loss parameters were adopted
- Design flood events for the 20, 10, 5, 2, 1 and 0.5 % AEP were run for multiple durations
- Hydrographs were extracted from RORB for use as inflow boundaries to the hydraulic model.

Hydrographs were extracted at each tributaries inflow point into the Glenelg River for insertion into the hydraulic models.

Historical flows were calibrated using observed gauge flows along the Glenelg River.

3.3.1 Subarea and Reach Delineation

The downstream outlet of the RORB model is downstream of Casterton, and covers the entire upstream catchment. The study area's catchment boundary covers an area of approximately 4730 km^2. Upstream of Casterton there are numerous tributaries contributing significant flows during times of high rainfall.

The RORB model was constructed using MiRORB (MapInfo RORB tools), RORB GUI and RORBWIN V6.15. A catchment boundary was delineated from the 20m Vicmap Elevation Digital Terrain Model (DTM) of the area. Sub-area boundaries were delineated using ArcHydro and revised as necessary to allow flows to be extracted at the points of interest. The RORB model was delineated into 72 sub-areas. Figure 3-13 shows the RORB sub area delineation for the study area. There are roads, drains and other man made features which have changed the topography and therefore the areas contributing to each tributary of the Glenelg River. The sub-area delineation represents the current Glenelg River Catchment.

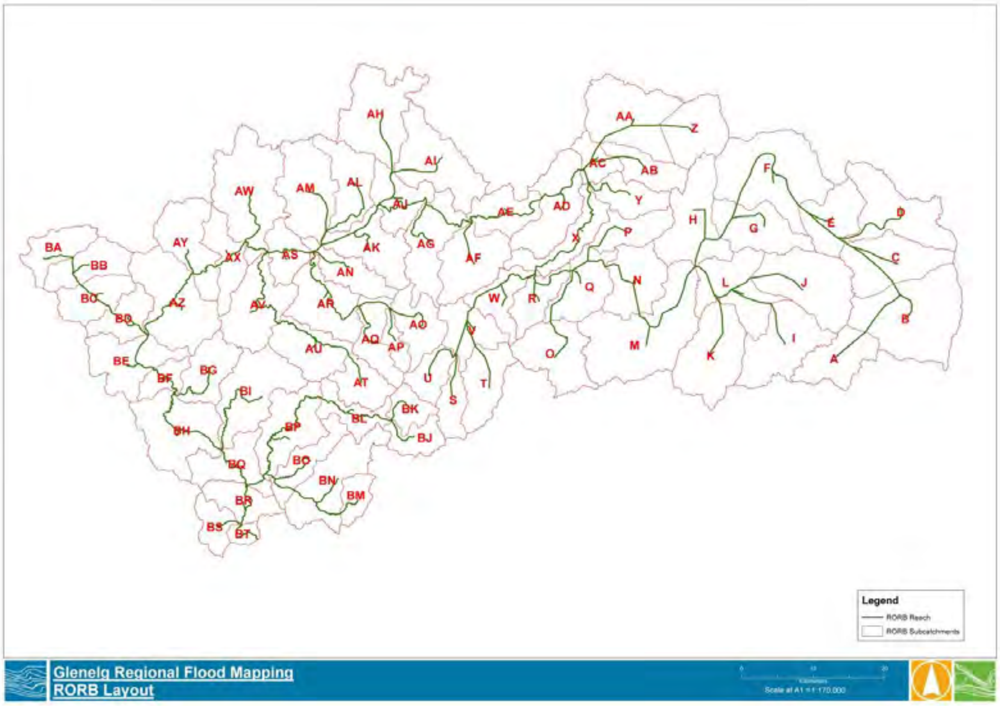


Figure 3-13 Glenelg RORB model structure

Nodes were placed at areas of interest, the centroid of each sub-area and the junction of any two reaches. Nodes were then connected by RORB reaches, each representing the length, slope and reach type. Reach slopes were calculated using a digital elevation model (DEM) created from the 20m Vicmap Elevation DTM.

Reach types in the model were set to be consistent with the land use across the catchment. Five different reach types are available in RORB (1 = natural, 2= excavated & unlined, 3= lined channel or pipe, 4= drowned reach, 5= dummy reach). Drowned reaches were used within Rocklands Reservoir. All other reaches were set to natural, representative of the open grassed areas and natural waterways in the catchment.

3.3.2 Fraction Impervious Data

The RORB model required Fraction Impervious (FI) values for the subareas. FI values were calculated using MiRORB. Default sub-area FI values were calculated based on the current Planning Scheme Zones (current July 2013). The area weighted average FI of the Glenelg River catchment was calculated to be 0.07, reflecting the predominantly rural/natural nature of the catchment. The spatial distribution of the fraction impervious data is shown in Figure 3-14 on a land zoning basis, the weighted average for each sub-area has been calculated and used in the RORB model. A graphical representation of the sub-area delineation and the applied FI is shown in Figure 3-15. These figures show the areas upstream of Rocklands Reservoir have a very low fraction impervious state due to the catchment remaining forested. The mid catchment is predominantly agricultural with the residential areas of Harrow and Balmoral slightly influencing the fraction impervious. There is also an increase in fraction impervious around Casterton and Dergholm.

The different zones and their corresponding fraction impervious values used in the construction of the RORB model are shown below in Table 3-11.

Table 3-11 RORB Model fraction impervious values and zones[11]

Zone	Description	Typical Fraction Impervious
FZ	Farming Zone	0.1
PCRZ	Protection of natural environment or resources.	0
PPRZ	Main zone for public open space, incl golf courses.	0.1
PUZ1	Power lines, Pipe tracks and retarding basins	0.05
PUZ2	Schools and Universities	0.7
PUZ3	Hospitals	0.7
PUZ7	Museums	0.6
RDZ1	Major roads and freeways.	0.7
RLZ	Predominantly residential use in rural environment.	0.2
TZ	Small township with little zoning structure	0.55

The sensitivity of the Farming Zone fraction impervious was tested using the 1975 event as a basis. The event was modelled with a fraction impervious of 0.1 and 0.0.

The results of this reduction are shown in Table 3-12.

Table 3-12 Fraction impervious Farm Zone sensitivity

FI	Peak Flow Rate (m^3/s)
0.1	221
0.0	208
Change in peak flow (m^3/s)	14 (6%)

[11] Melbourne Water, 2010 – Music Guidelines, Recommended input parameters and modelling approaches for MUSIC users

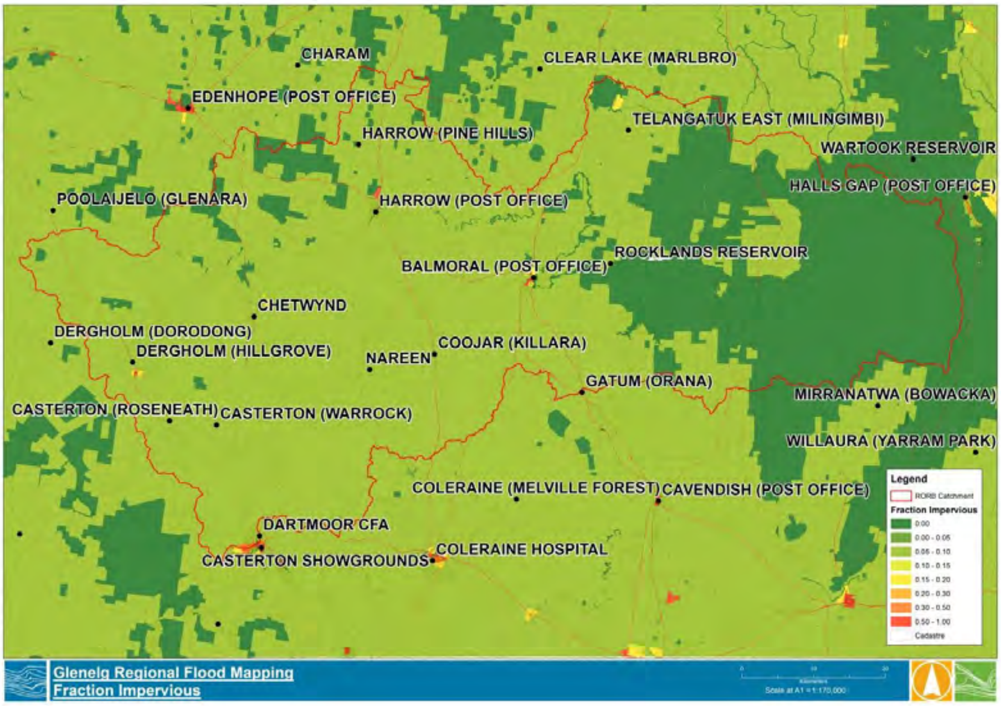


Figure 3-14　Glenelg catchment fraction impervious

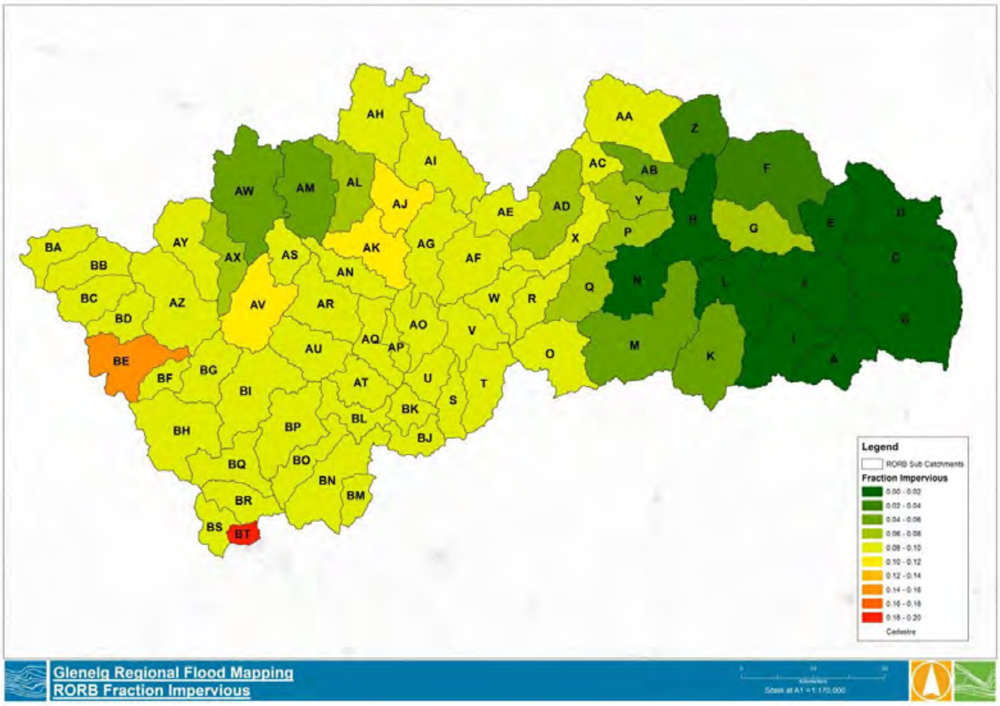


Figure 3-15　RORB sub-area fraction impervious values

3.3.3 Catchment Storages

There are two major water storages within the Glenelg River catchment, Rocklands Reservoir and Moora Moora Reservoir.

Moora Moora Reservoir is a relatively small reservoir upstream of Rocklands Reservoir, constructed in 1934. The reservoir has a Full Supply Volume of 6,300 ML and captures flows from Moora Moora Creek. The Reservoir is off line from the Glenelg River. Moora Moora Reservoir Outlets to the Moora Channel which passes on to Distribution Heads.

Rocklands was finished construction in 1953, with a capacity of 348,000 ML. It is managed and maintained by GWMWater, the largest storage their system. It was originally designed as a carry-over storage to be managed along with Toolondo Reservoir[12]. Due to its shape, Rocklands has much higher evaporation than Toolondo and therefore, water was transferred to and stored in Toolondo in preference to Rocklands. Inflow to Rocklands Reservoir averages 101,000 ML/year with much of the flow occurring during the period July to October[13].

In light of the Northern Mallee and Wimmera Mallee Pipeline Projects, Rocklands is used primarily to supply environmental flows and as a supplementary water source for Hamilton, suppling some irrigation and Supply by Agreement demands.

Approximately 40% of the water released by GWMWater for the environmental allocation each year is made as releases from Rocklands Reservoir into the Glenelg River to meet the Environmental Demands on the Glenelg River at Harrow[14]. The Reservoir is currently run with a maximum operating volume of 261,000 ML (or 75% capacity) at 194.1 m AHD, providing a de facto 87,000 ML of flood reserve. This reduced operating volume is in light of the storage being operated primarily for environmental flows but will also minimise flood overflows to the Glenelg River. The reduced operational level public consultation occurred during 2010 with the implementation occurring in early 2011. There was intention to change the operational capacity of Rocklands Reservoir to 85% in late 2014. The change had not occurred at the time of this reports production but was considered imminent[15]. The Rocklands Reservoir spillway is at 195.47m AHD with a length of 154.5 m. The chance in operational rules is unlikely to change the attenuation of flood flows.

The outlet capacity of Rocklands Reservoir is 1,250 ML/d and releases from Rocklands Reservoir occur via the main outlet which connects to the Toolondo Channel and Glenelg River. Flows can be discharged to the Glenelg River at three locations: 5 Mile outlet, 12 Mile outlet and the wall. Transfers to Toolondo Reservoir are limited when the capacity of Rocklands exceeds 75% due to outlet constraints[13].

The GWMWater O&M Manual for Rocklands Reservoir states the dam has never passed a major flood, with the maximum outflow stated at 5,300 ML/d in 1975[16]. Unfortunately, the data available via the DEPI Water Measurement Information System only shows the rising and falling limbs of the measured hydrograph on the Glenelg River at Rocklands. At what is assumed to be the peak flow the data quality code is listed as 254, Rating Table Exceeded.

[12] Barlow (1987) - Wimmera / Mallee Headworks System Reference Manual

[13] Water Technology (2011) - Review of Storage Operation During Floods Grampians Wimmera Mallee Water

[14] GHD (February 2011) - Report for the Wimmera-Glenelg REALM Model Update, produced for the Department of Sustainability and Environment

[15] GWMWater (March 2014) – Bulk and Environmental Entitlements Operations Review

[16] GWMWater (March 2010) - Rocklands Reservoir Operation, Inspection and Maintenance Manual (O&M Manual)

The partial hydrograph recorded at the Rocklands streamflow gauge is shown in Figure 3-17.

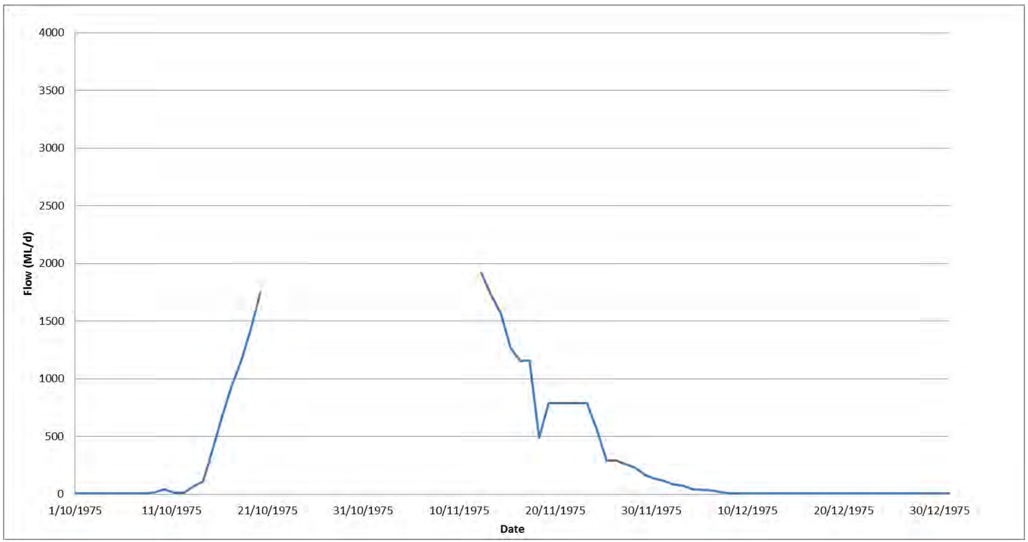


Figure 3-16 October 1975 flow on the Glenelg River at Rocklands

A review of the Rocklands Reservoir Head Gauge levels and discussion with former GWMWater staff[17] indicted reservoir spills have occurred in:

- 1953
- 1955
- 1956
- 1958
- 1960
- 1974
- 1975
- 1988
- 1989
- 1990
- 1992
- 1993
- 1996

A number of these spills are not identified in the GWMWater reservoir level online record due to a re-rating of the reservoir volume which changed from 335,500 ML to 348,300 ML. In the years prior to 1988 the surcharge volume was also not recorded with the reservoir height only recorded as the spill way height. Of the spills that have occurred at Rocklands, only five have recorded flows greater than 2000 ML/d (23m^3/s). The data and peak flow measured at the Glenelg River at Rocklands gauge for these spills is shown below in Table 3-13.

Table 3-13 Rocklands Reservoir spill details

Spill Date	Maximum discharge recorded on the Glenelg River at Rocklands	
	ML/d	m^3/s
August 1956	4060	47.0
September 1974	2250	26.0
October 1975	5300	61.3
July 1983	2605	30.2
August 1988	3280	38.0
August 1992	3540	41.0

[17] Pers. Comm – John Martin (Former Executive Manager, Sustainable Water and Infrastructure)

No flood release procedures exist for Rocklands Reservoir[13].

3.4 RORB Model Calibration

3.4.1 Overview

The RORB model was calibrated by applying recorded daily rainfall depths across the Glenelg River catchment at the temporal pattern recorded at the sub daily rainfall gauges. Rainfall records for each of the selected events were extracted and applied to the RORB model.

The RORB model flows were then compared to the gauged flows at each of the available Glenelg River gauge locations and alterations made to the RORB model parameters to align the results. The RORB model was calibrated for all available gauges within the study area, from Rocklands Reservoir to Casterton.

3.4.2 Calibration Parameters

Overview

There are several model parameters used in RORB that control the resulting peak flow rate and volume of runoff – kc, m and initial and continuing losses. These parameters can be adjusted to fit calculated to observed information.

Losses

The loss model chosen for the Glenelg River catchment was an initial and continuing loss model. This model was chosen because it is a predominantly rural/forested catchment. The catchment is likely to have high rainfall infiltration at the beginning of an event when the ground is dry, which will then reduce to a constant loss rate over the remainder of the event.

As part of the calibration process several initial and continuing loss values were trailed for each calibration event with the RORB model results used for comparison against gauge records. These loss values are discussed in respect to each event.

m

The RORB m value is typically set at 0.8. This value remains unchanged and is an acceptable value for the degree of non-linearity of catchment response (Australian Rainfall and Runoff, 1987)[18]. There are alternate methods for determining m, such as Weeks (1980),[19] which uses multiple calibration events to select kc and m. However, retaining a value of 0.8 is the best option unless there is significant evidence a change is necessary.

kc

The RORB model kc value was estimated using a range of prediction equations as shown below in Table 3-14. These equations use either catchment area or D_{av} (the average flow distance in the channel network of sub area inflows) and have been developed using different data sets (or subsets of the same data set). The parameter selected for design is based on consistency of prediction and resulting flows.

[18] AR&R, 1987 – Australian Rainfall and Runoff

[19] Weeks, W. D. (1980). Using the Laurenson model: traps for young players. Hydrology and Water Resources Symposium, Adelaide, Institution of Engineers Australia

Based on the regional prediction equations, several kc values were initially trialled, with calibration to the gauge records used to refine the kc value for each of the selected calibration events.

Table 3-14 Various kc calculated values

Method	Equation	Predicted kc
Default RORB	$kc = 2.2*A^{0.5}$	151
Vic MAR<800 mm - Eq 3.22 ARR (BkV)[18]	$kc=0.49*A^{0.65}$	120
Victoria data (Pearse et al, 2002)[20]	$kc=1.25*D_{av}$	164
Aust wide Dyer (1994) (Pearse et al 2002)[20]	$kc=1.14*D_{av}$	150
Aust wide Yu (1989) (Pearse et al 2002) [18]	$kc=0.96*D_{av}$	126

3.4.3 Event Selection

The RORB model was calibrated using observed events in the Glenelg River focusing on the available Glenelg River gauges. During the initial stages of the streamflow data review several large events were highlighted as potential calibration events. As discussed in Section 0, these events occurred after the construction of Rocklands Reservoir in 1953. The events used in the calibration of the RORB model were 1975, 1983 and December 2010. The September 2010 event was also considered but three calibration events was determined as appropriate for this study. The 1975 and 1983 events were also used in the calibration of the RORB model developed as part of the Casterton Flood Investigation. The choice of events was discussed with GHCMA[21].

As discussed in Section 2.2.1 there are currently two sub daily rainfall gauges in proximity to the Glenelg River catchment area; Casterton and Rocklands Reservoir. During the three chosen events these gauges were active.

3.4.4 Event Calibration

Overview

For input into RORB each calibration event is required to have a temporal and spatial pattern. The spatial pattern represents how total rainfall has varied across the catchment. The daily rainfall totals over the event are used to develop a spatial rainfall pattern covering a catchment area. The temporal pattern represents how rainfall falls over a catchment or subarea over time. The temporal pattern is determined by a sub-daily rainfall gauge recording rainfall, usually in mm/hr. The temporal pattern is used to apply each subarea's total depth determined by the spatial pattern over the length of the event.

October 1975

Temporal Pattern

The 1975 temporal pattern at Casterton was characterised by a single peak approximate 48-72 hour rainfall event with 15.2 mm recorded on 24th October followed by 37.2 mm on the 25th and 10.8 mm on the 26th. There was also significant rainfall early in the month with 73.2 mm recorded prior to the 20th. Rainfall occurred relatively consistently at a low intensity of less than 10 mm/hour in two bursts

[20] Pearse et al, 2002 – A Simple Method for Estimating RORB Model Parameters for Ungauged Rural Catchments, Water Challenge: Balancing the Risks: Hydrology and Water Resources Symposium, 2002

[21] Pers. Comm. Jacinta Baily (GHCMA)

separated by approximately 20 hours. One high intensity burst of rainfall was recorded at 9.30am, 20 October 1975 reaching 43mm/hr.

The Rocklands Reservoir gauge indicated a slightly different temporal pattern with a more even spread of rainfall on the 24th and 25th October with 26.8 and 30.0 mm respectively, and only 9.6 mm on the 26th. This rainfall was recorded in one six minute interval and is considered to be erroneous.

The temporal pattern of the September 1975 event recorded at Casterton and Rocklands Reservoir is shown in Figure 3-17 and Figure 3-18 respectively.

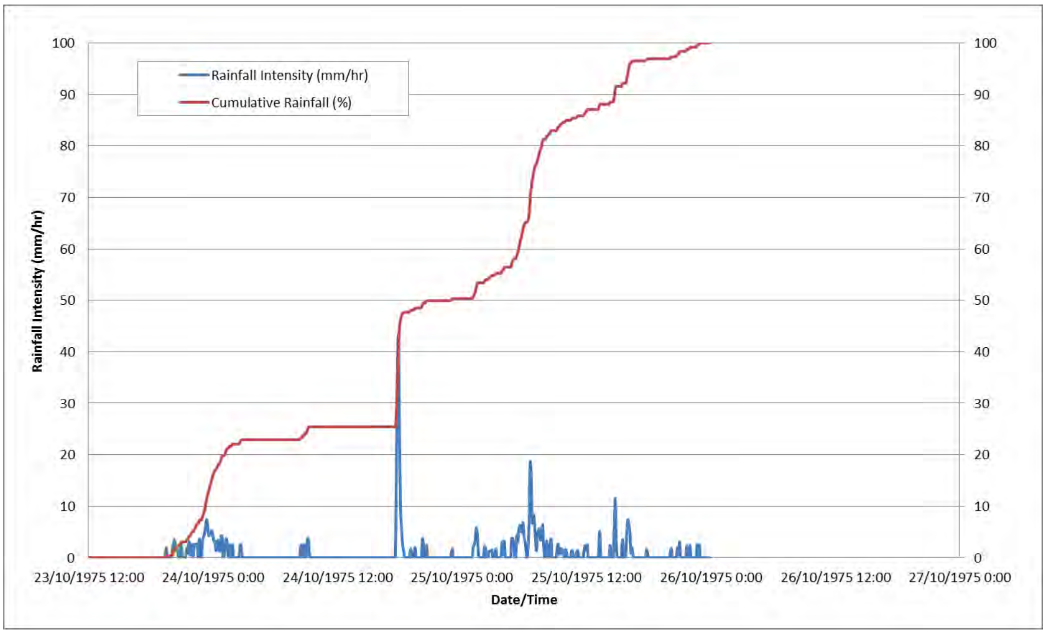


Figure 3-17 Temporal rainfall pattern recorded at Casterton during September 1975

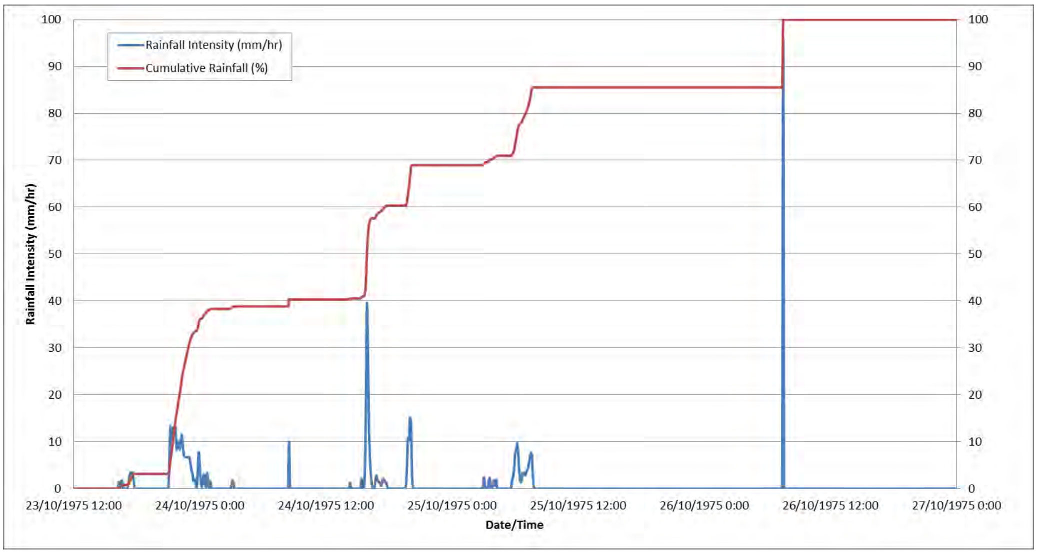


Figure 3-18 Temporal rainfall pattern recorded at Rocklands Reservoir during 1975

Spatial Pattern

The spatial pattern developed for the October 1975 event covering the Glenelg River catchment is shown in Figure 3-19.

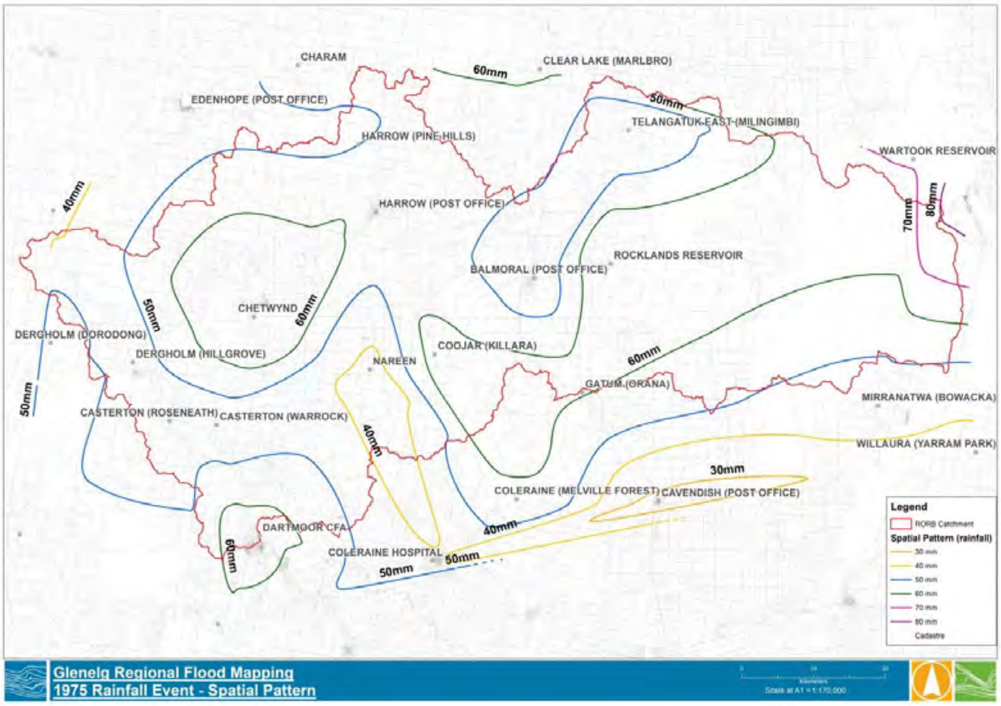


Figure 3-19 Spatial rainfall pattern occurring across the Glenelg River catchment for 19-27 October 1975

Rainfall is shown to be relatively well spread with larger totals around Chetwynd and Wartook Reservoir.

Calibration Parameters

Gauged streamflow data for calibration of the 1975 event for the Glenelg River was available only for the Casterton gauge. The Casterton streamflow gauge recorded a peak flow of 221.6 m^3/s at 10pm on the 26th of October.

The calibration parameters shown in Table 3-15 provided the best match to the observed gauge data.

Table 3-15 Adopted model parameters for the October 1975 event

Calibration Parameter	Value
Kc	260
m	0.8
Initial Loss (mm)	15
Continuing Loss (mm)	1.25

A comparison of the RORB modelled and gauge hydrographs at Casterton is shown in Figure 3-20, with calibration summary statistics shown in Table 3-16.

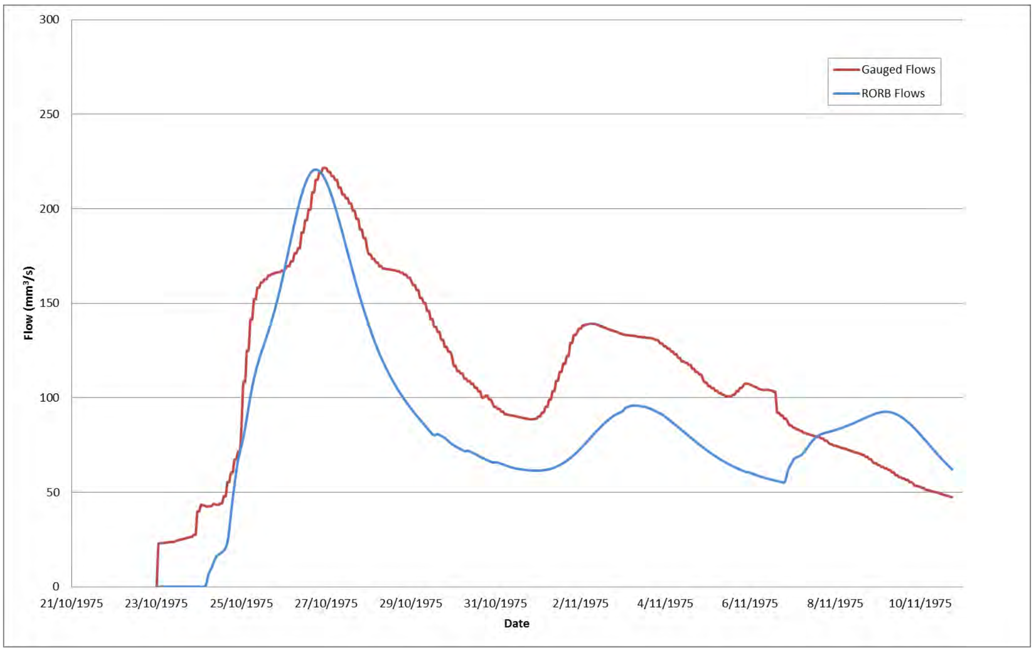


Figure 3-20 Gauged and modelled hydrographs for the October 1975 event at Casterton

Table 3-16 1975 calibration summary at Casterton

Streamflow	Peak discharge (m^3/s)	Peak timing	Event volume (ML)
Gauged flow	222	26/10/1975 22:00	179,575
RORB Flow	221	26/10/1975 18:00	139,540
Difference (%)	-1 (-0.5%)	-4 hours	-40,035 (-21%)

The modelled peak flow and timing at Casterton match the gauge recording closely. However, there is a 21% difference in the event volume. The majority of this difference is after the peak of the event in the falling limb of the hydrograph and in a second flow peak. The lack of volume in the hydrograph could be a result of the continuing loss being too high or the spatial pattern of rainfall depth not identifying more intense storms within the catchment due to the ungauged areas between rainfall gauges.

September 1983

Temporal Pattern

The 1983 temporal pattern at Casterton had two separate bursts with the peaks of the two bursts occurring on the 5th and 8th September. There was a period of 28 hours with no rainfall recorded between the bursts. The initial burst totalled 16.0mm over 26 hours with a low maximum rainfall intensity of 5mm/hr. The second burst totalled 21.0 mm over 34 hours recording higher intensity periods of rain reaching 20 mm/hour.

The Rocklands Reservoir gauge indicated a very similar temporal pattern with two bursts. The highest rainfall totals occurred in the 24 hours prior to 9am the on the 6th and 8th September. The initial burst of rainfall recorded 19.4 mm over 35 hours at a low maximum rainfall intensity of 6.7 mm/hour. The second burst totalled 27.8mm, with periods of much higher rainfall intensity, reaching up to 29 mm/hr. The second burst occurred over 41 hours.

Similar to 1975 the event occurred over an approximate 48-72 hour period. The temporal pattern of the September 1983 event recorded at Casterton and Rocklands Reservoir is shown in Figure 3-21 and Figure 3-22 respectively.

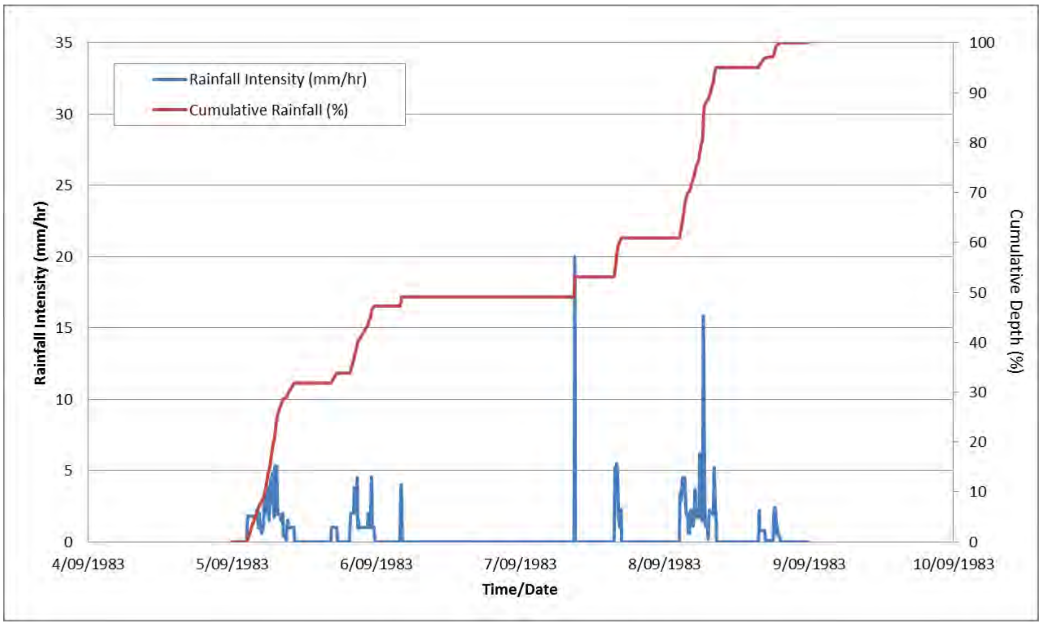


Figure 3-21 Temporal rainfall pattern recorded at Casterton during September 1983

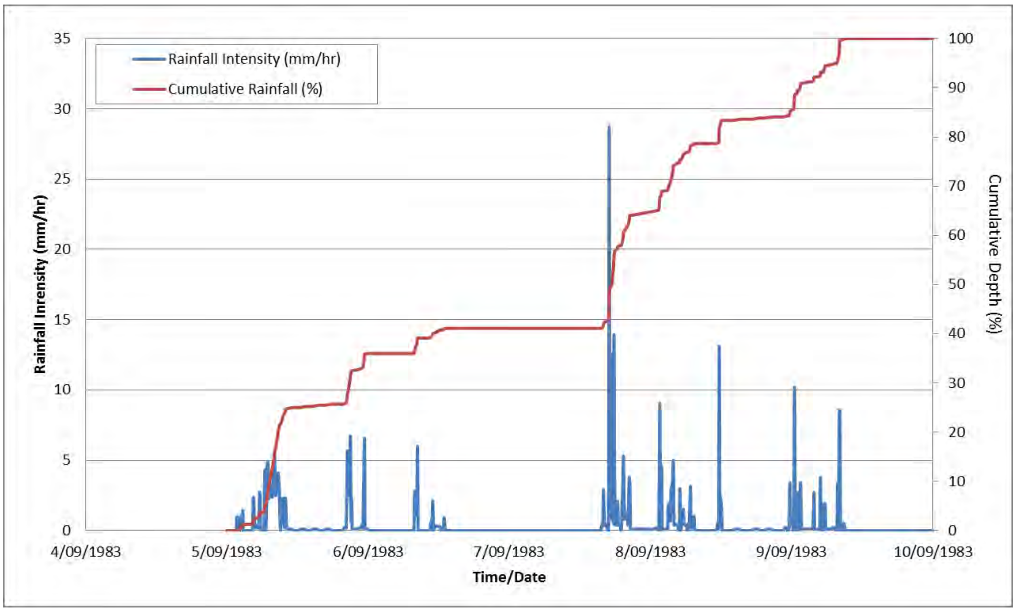


Figure 3-22 **Temporal rainfall pattern recorded at Rocklands Reservoir during 1983**

Spatial Pattern

The spatial pattern developed for the September 1983 event over the Glenelg River catchment is shown in Figure 3-23.

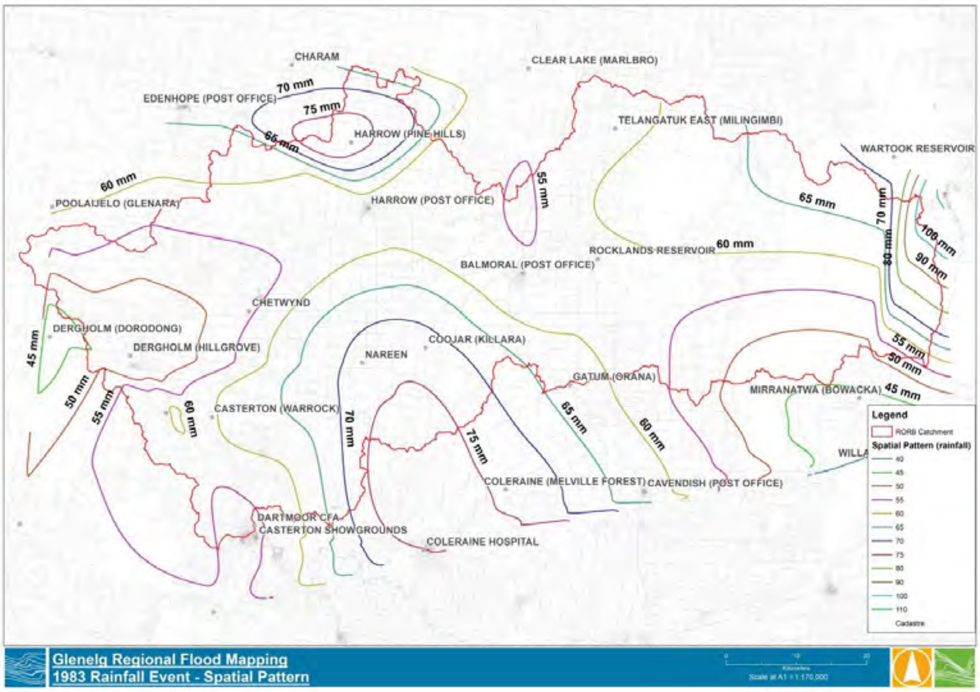


Figure 3-23 **Spatial rainfall pattern occurring across the Glenelg River catchment for 5-10 September 1983**

Similar to the 1975 event the largest rainfall totals were recorded at the eastern end of the Glenelg River catchment towards the Grampians. Large totals were also recorded at Charm and Nareen, approximately mid catchment.

Calibration Parameters

Three Glenelg River gauges had data available for calibration of the 1983 event upstream of Casterton; Rocklands, Fulham Bridge and Casterton. The Rocklands gauge recorded very little flow with all releases stopped and no spilling of the reservoir.

The calibration parameters shown in Table 3-17 were shown to provide the best match to the observed gauge data.

Table 3-17 Adopted model parameters for the September 1983 event

Calibration Parameter	Value
Kc	260
m	0.8
Initial Loss	10
Continuing Loss	0.9

The modelled and observed peak discharge, timing and event volume for Fulham Bridge and Casterton are shown in Table 3-18, and Table 3-19 respectively. These statistics are not presented for the Rocklands Reservoir gauge because no releases or spills occurred.

Table 3-18 1983 calibration summary at Fulham Bridge

Streamflow Gauge	Peak discharge (m^3/s)	Peak timing	Event volume (ML)
Gauged flow	72	6/09/1983 20:00	37,980
RORB Flow	51	6/09/1983 14:00	28,951
Difference	-21 (-29%)	-6 hours	-9,029 (-24%)

Table 3-19 1983 calibration summary at Casterton

Streamflow Gauge	Peak discharge (m^3/s)	Peak timing	Event volume (m^3)
Gauged flow	251	10/09/1983 0:00	131,664
RORB Flow	260	10/09/1983 6:00	108,699
Difference	9 (4%)	6 hours	-22,965 (-17%)

A comparison of the RORB modelled and gauge hydrographs at Fulham Bridge and Casterton are shown Figure 3-24 and Figure 3-25 respectively.

The calibration is reasonable at Casterton although there is still a lack of volume in the modelled hydrograph on the falling limb. The general shape, volume, timing and peak flow are all reasonable.

The calibration at Fulham Bridge shows a less peaky hydrograph than that observed at the gauge. The general shape of the modelled hydrograph is reasonable but the two peaks are not matched well, with the model flattening the peaks.

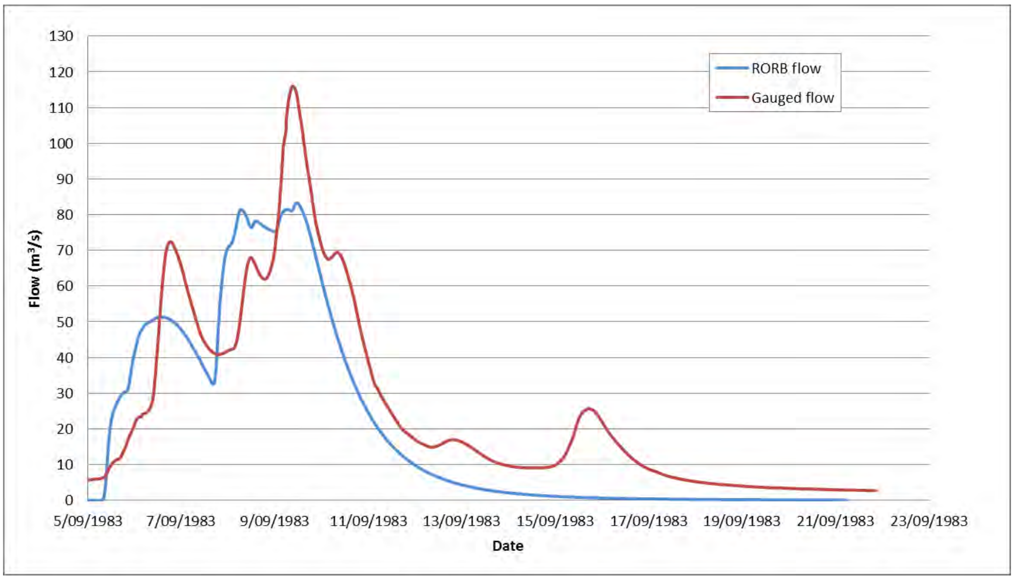


Figure 3-24 Gauged and modelled hydrographs for the September 1983 event at Fulham Bridge

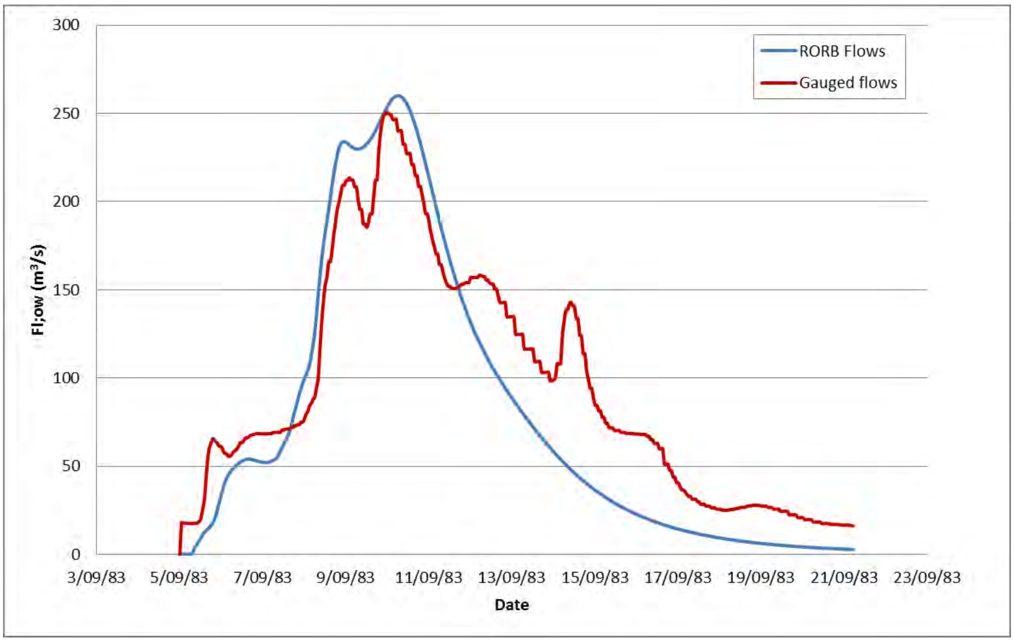


Figure 3-25 Gauged and modelled hydrographs for the September 1983 event at Casterton

December 2010

Temporal Pattern

Similar to the September 1983 event, the December 2010 event also had two peak periods of rainfall. The event was also a similar length with rainfall occurring over a 48-72 hour period.

The Casterton rainfall gauge recorded a large initial burst with 24 mm falling in an hour at around 3-4pm, 5 December 2010. An extended period of 36hrs with little to no rainfall between 4 pm, 5 December 2010 and 4 am, 7 December 2010. The second peak occurring across the 7th and 8th of December recorded a higher total with 48.2 mm recorded over around 30 hours.

The Rocklands gauge recorded a more even hyetograph three discrete bursts of rainfall separated by periods of little to no rain. The first burst totalled 40.0 mm over 90 hours reaching a maximum intensity of under 40 mm/hr, the second burst totalled 23.8 mm over 3.5 hours with a maximum intensity of 48 mm/hour, the third burst totalled 31.6 mm over a longer 19 hours with the highest intensity of 54 mm/hr.

The temporal pattern of the December 2010 event recorded at Casterton and Rocklands Reservoir is shown in Figure 3-26 and Figure 3-27 respectively.

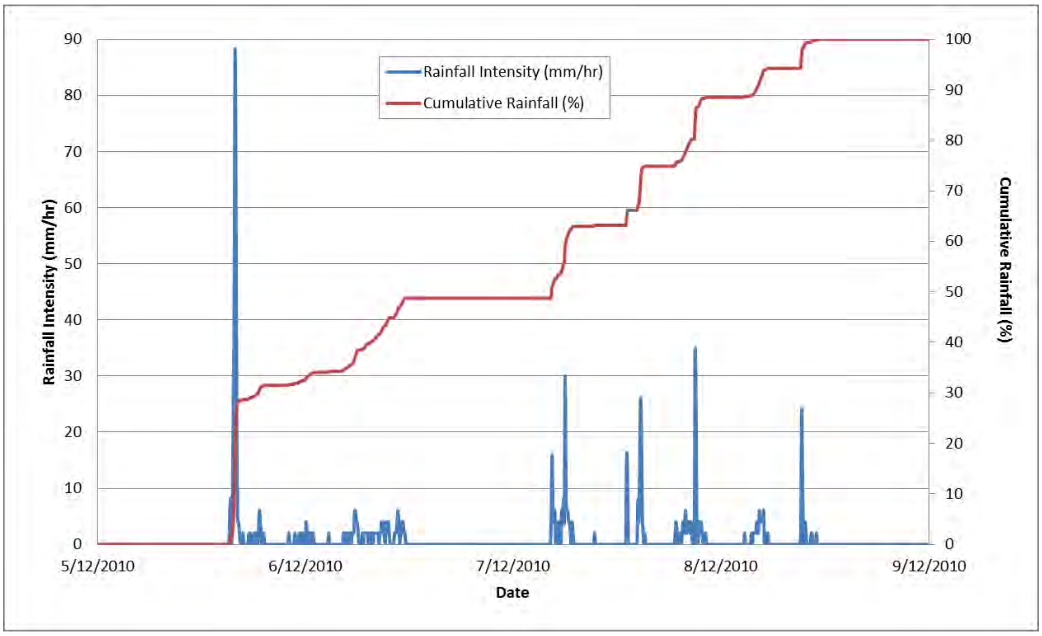


Figure 3-26 Temporal rainfall pattern recorded at Casterton during December 2010

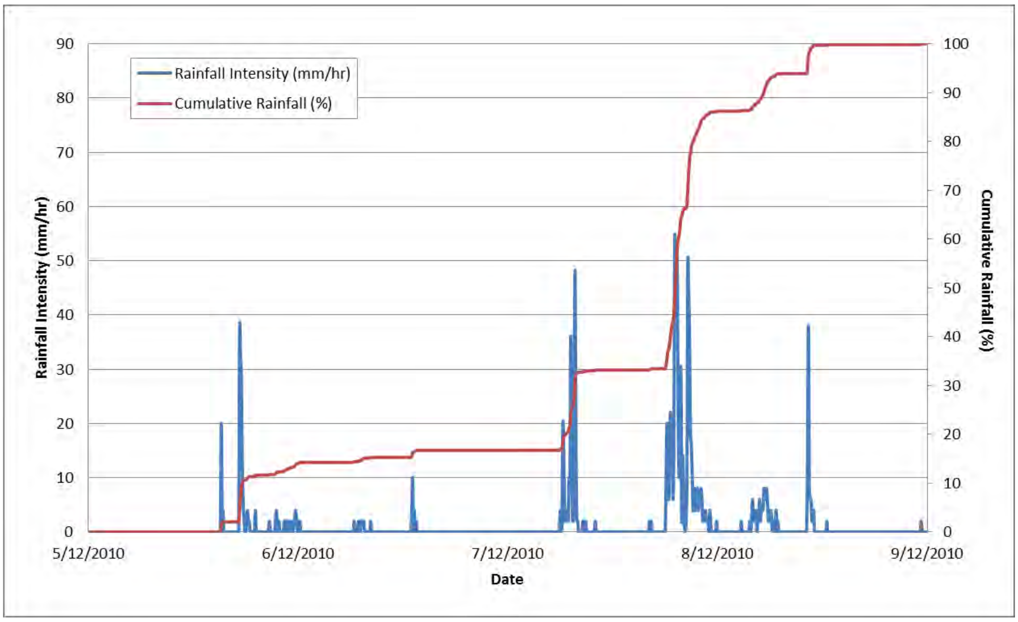


Figure 3-27 **Temporal rainfall pattern recorded at Rocklands Reservoir during 2010**

Spatial Pattern

The spatial pattern developed for the December 2010 event over the Glenelg River catchment is shown in Figure 3-28.

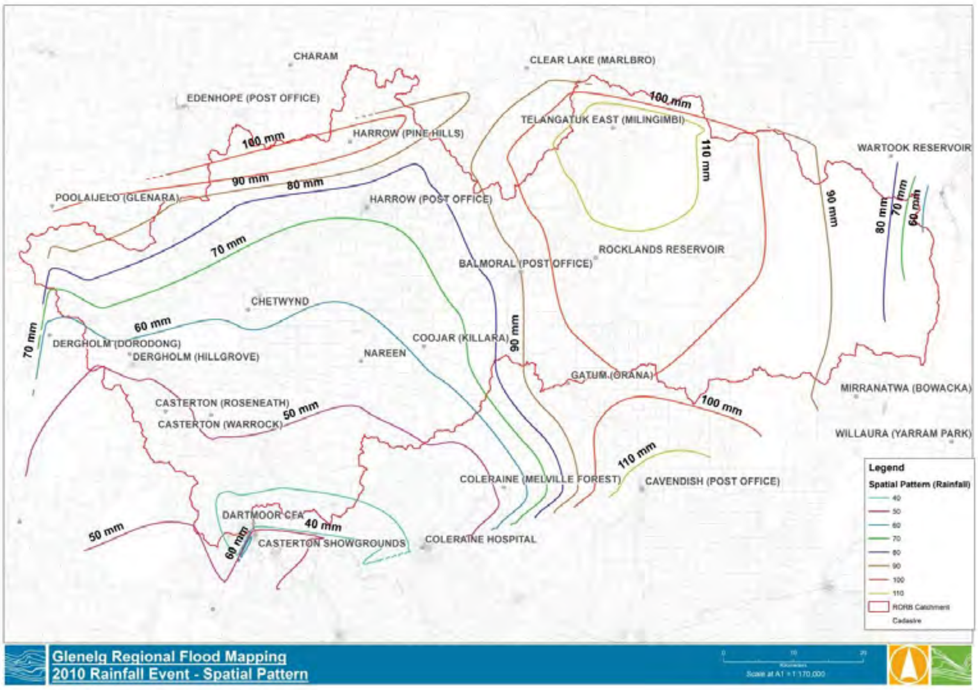


Figure 3-28 **Spatial rainfall pattern occurring across the Glenelg River catchment for 5-9 December 2010**

The spatial pattern observed during December 2010 showed the largest rainfall totals occurring on the northern fringe of the Glenelg River catchment around Telangatuk East (100-110 mm). Much lower totals were recorded around Dartmoor (40-50 mm). The event rainfall had a much higher rainfall gradient across the catchment compared to that of the 1975 and 1983 events.

Calibration Parameters

Three Glenelg River gauges with data were available for calibration of the 2010 event upstream of Casterton; Fulham Bridge, Harrow and Dergholm. Similar to the 1983 event the Rocklands gauge recorded very little flow with all releases stopped and no spilling of the reservoir. No gauge data was available for Casterton or Burkes Bridge.

Table 3-20 shows the calibration parameters that provided the best match to the observed gauge data.

Table 3-20 Method of kc value calculation

Calibration Parameter	Value
Kc	260
m	0.8
Initial Loss	20
Continuing Loss	3.5

The modelled and observed peak discharge, timing and event volume for Fulham Bridge, Harrow and Casterton are shown in Table 3-21, Table 3-22 and Table 3-23 respectively. These statistics are not presented for the Rocklands Reservoir gauge because no releases or spills occurred during the event.

Table 3-21 December 2010 calibration summary at Fulham Bridge

Streamflow Gauge	Peak discharge (m^3/s)	Peak timing	Event volume (ML)
Gauged flow	131	8/12/2010 18:00	24,755
RORB Flow	127	9/12/2010 0:45	30,358
Difference	-4 (-3%)	6:45	5,603 (23%)

Table 3-22 December 2010 calibration summary at Harrow

Streamflow Gauge	Peak discharge (m^3/s)	Peak timing	Event volume (ML)
Gauged flow	117	9/12/2010 22:00	28,077
RORB Flow	124	9/12/2010 9:00	38,726
Difference (%)	7 (6%)	-13	10,649 (38%)

Table 3-23 December 2010 calibration summary at Dergholm

Streamflow Gauge	Peak discharge (m^3/s)	Peak timing	Event volume (m^3)
Gauged flow	105	11/12/2010 13:00	29,559
RORB Flow	138	10/12/2010 5:00	50,196
Difference	33 (31%)	-16	20,637 (70%)

A comparison of the RORB modelled and gauge hydrographs at Fulham Bridge, Harrow and Dergholm are shown in Figure 3-29, Figure 3-30 and Figure 3-31 respectively.

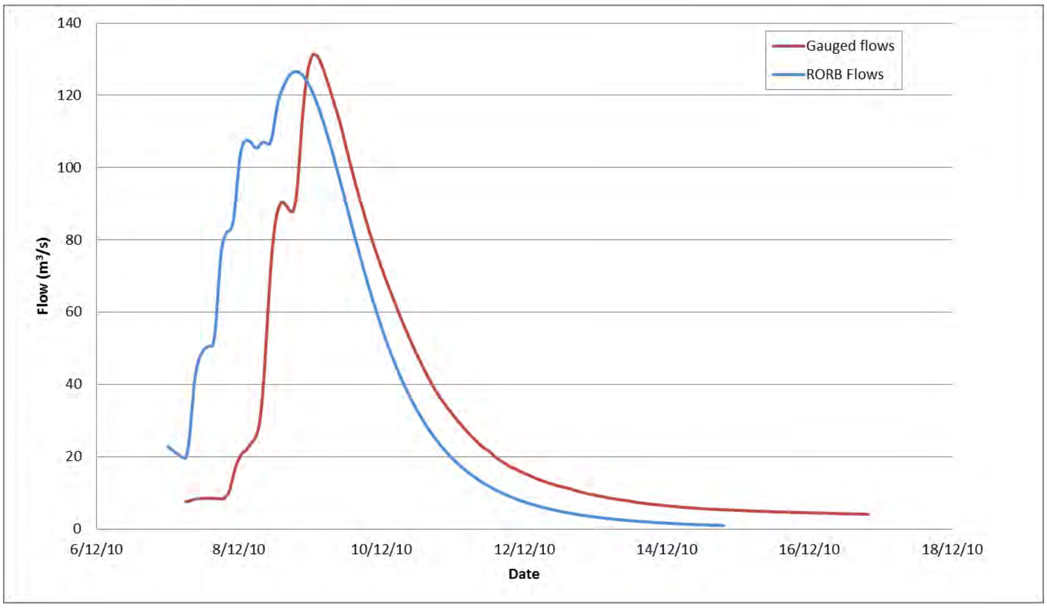


Figure 3-29 Gauged and modelled hydrographs for the December 2010 event at Fulham Bridge

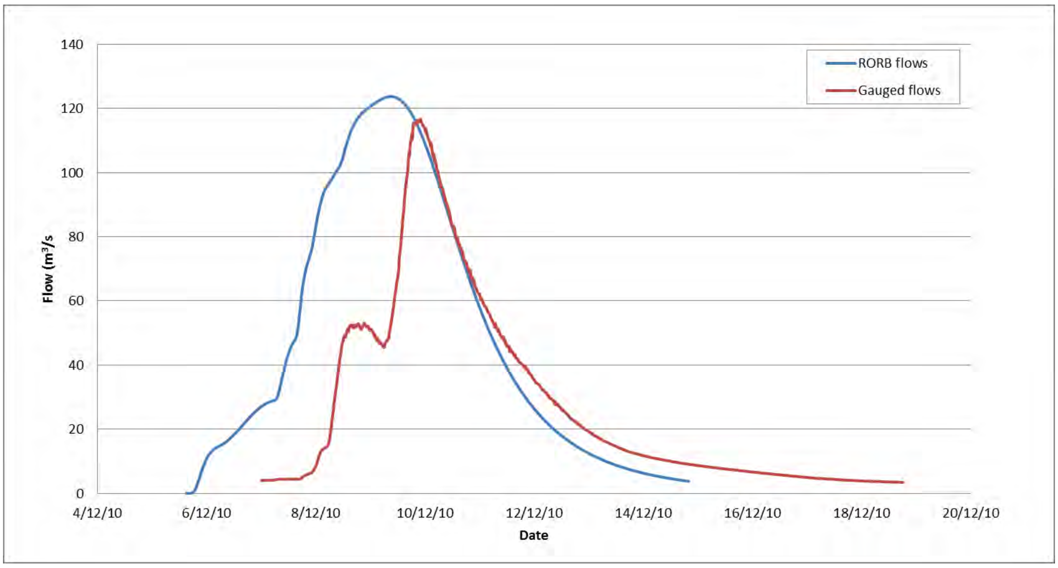


Figure 3-30 Gauged and modelled hydrographs for the December 2010 event at Harrow

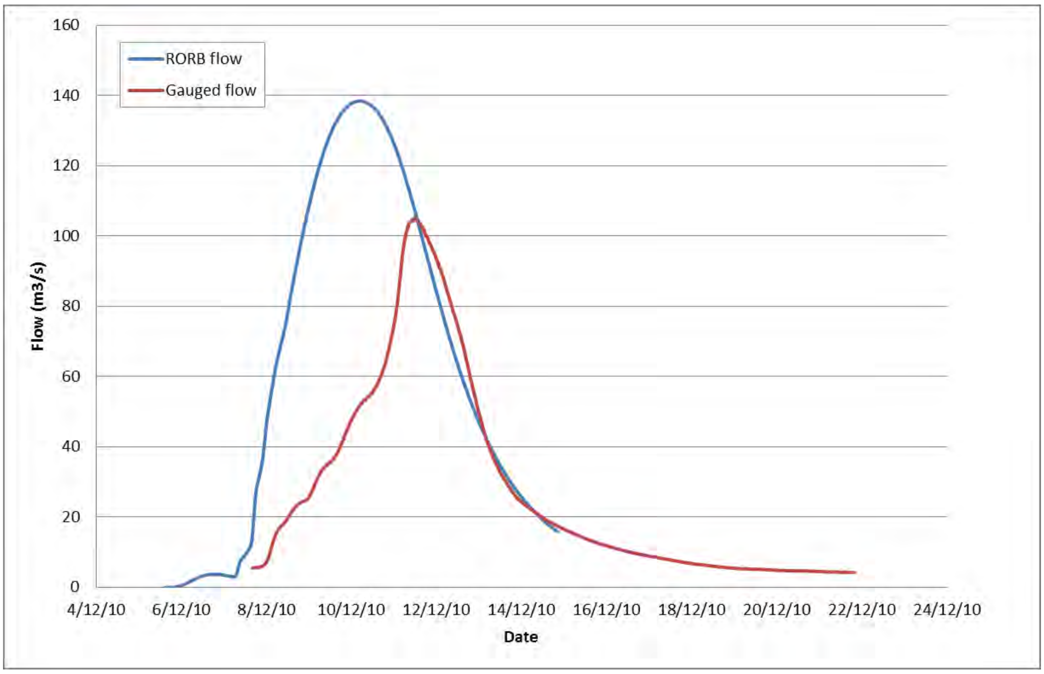


Figure 3-31 Gauged and modelled hydrographs for the December 2010 event at Dergholm

Modelled peak flows at Fulham Bridge and Harrow more closely matched the observed peak flows (within 3 and 6% respectively) but overestimated the event volume on the rising limb of the hydrograph.

The observed peak flow during December 2010 decreased from Fulham Bridge downstream, indicating the majority of the rainfall fell upstream of this gauge and was attenuated as it progressed down through the catchment. In addition there appears to be an obvious difference in the timing of the rainfall bursts across the catchment, which may have led to rainfall falling in the lower catchment early in the event before the most intense rainfall which fell in the Grampians region in the upper catchment. The RORB model results show the peak flows decreasing between Fulham Bridge and Harrow; however, peak flow increases again at Dergholm. This has caused the difference in observed and modelled peak flow to jump from 6% to 30%.

Calibration Summary and Discussion

Model calibration results have shown the RORB model is able to predict peak timing and flow rate downstream of Rocklands Reservoir. Across the 1975 and 1983 events the RORB model matched the observed peak flows and timing at Casterton reasonably well. However, flows and timing through the system for the December 2010 event were not calibrated to the same degree of accuracy.

The December 2010 event was predicted to be much larger than eventuated[22] with the flow at Casterton not reaching anticipated levels. This is thought to be a result of the relatively isolated nature of the event, with an initial large burst of rainfall as recorded at Casterton. The closest RADAR site to the Glenelg River catchment upstream of Casterton is Mt Gambier, SA. The RADAR recorded a relatively narrow front of rainfall across the Glenelg River catchment with variable spatial intensity.

[22] GHCMA – Pers. Comm.

It is likely the spatial distribution of rainfall in the RORB model is not well defined enough to represent the event accurately with an over estimate of the volume of rainfall falling over the catchment area.

The level of calibration achieved with the RORB model was varied across the three events. The model upstream of Rocklands was not calibrated at all as this was of no consequence to this study. Rocklands has the capacity to capture almost all of the volume of a large flood and the catchment could have been modelled from just downstream of the dam for the purpose of this study.

The RORB model calibration parameters used for each of the calibration events is shown in Table 3-24.

Table 3-24 Calibration parameters used for each of the calibration events.

Calibration Parameter	1975	1983	2010
Kc	260	260	260
M	0.8	0.8	0.8
Initial Loss	15	10	20
Continuing Loss	1.25	0.9	3.5

3.5 Design Event Modelling

3.5.1 Overview

RORB model design runs provided design flow hydrographs over a range of AEPs for input into the calibrated hydraulic model. For this study the 20, 10, 5, 2, 1 and 0.5% AEP events were required. The inputs for design flood estimation are described throughout the following sections.

3.5.2 Rainfall Depths

Design rainfall depths were determined using the BoM Online IFD Tool[23]. The IFD parameters were generated for the central location of Balmoral (141.84E, 37.25S) and are shown in Table 3-25 below.

Table 3-25 Catchment IFD Parameters

$2I_1$ (mm/hr)	$2I_{12}$ (mm/hr)	$2I_{72}$ (mm/hr)	$50I_1$ (mm/hr)	$50I_{12}$ (mm/hr)	$50I_{72}$ (mm/hr)	G	F2	F50
17.92	3.38	0.88	34.71	6.54	1.67	0.47	4.38	14.76

3.5.3 Temporal Pattern

Design temporal patterns were taken from AR&R 1987; the Glenelg River catchment is located within Zone 6 of the temporal pattern map as defined in AR&R 1987; however it is located close to the boundary between Zone 2 and Zone 6.

[23] BoM Online IFD Tool - http://www.bom.gov.au/hydro/has/cdirswebx/cdirswebx.shtml *Accessed: December 2011*

To understand the similarities between the AR&R defined temporal patterns for Zone 2 and Zone 6 and those observed in the Glenelg River catchment a comparison was made against the 1975 and 2010 temporal patterns.

A 48 hour duration was selected as approximately representative of the length of the observed events. Figure 3-33 shows a comparison of the temporal patterns using percentage of storm duration and total rainfall.

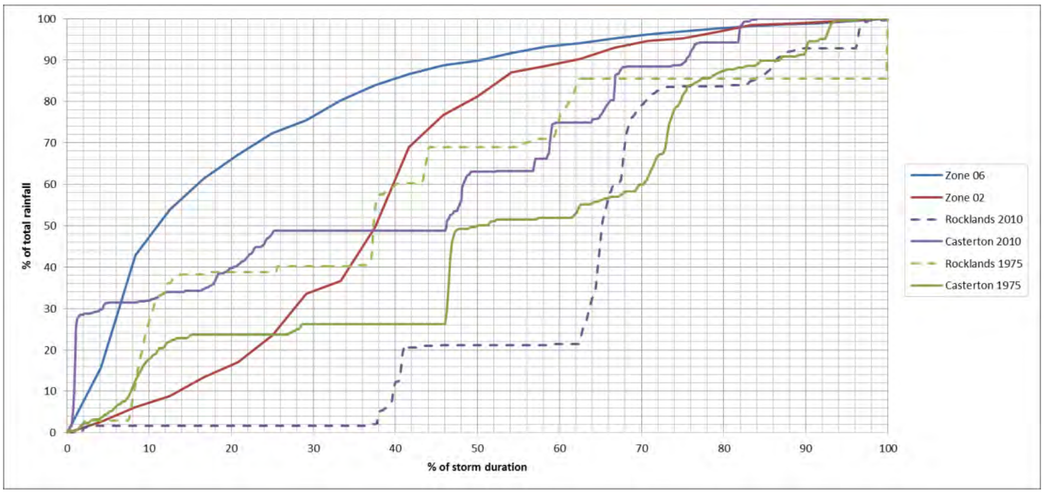


Figure 3-32 Zone 02, Zone 06 and historic temporal patterns over a 48 hour duration

The observed temporal patterns for both 1975 and 2010 for Rocklands and Casterton follow the Zone 2 temporal pattern more closely than Zone 6. For this reason the Zone 2 temporal pattern was chosen for design event modelling.

3.5.4 Spatial Pattern

A uniform spatial rainfall pattern (i.e. same rainfall depths applied to the entire catchment) is considered too conservative for the size of the Glenelg River catchment upstream of Casterton. Given the similarities between the spatial pattern observed in October 1975 and September 1983 it was determined an average of the two patterns would be used to apply the design rainfall depths. This results in a more reasonable design rainfall spatial pattern than the alternative of applying a uniform spatial pattern and is considered appropriate given the catchment characteristics, with the Grampians located in the north-east corner of the catchment heavily influencing the distribution of rainfall across the catchment.

Other methods of determining the design event spatial pattern could have been adopted, using IFD[18] maps however this was not considered to add additional certainty to the spatial patterns.

3.5.5 Aerial Reduction Factors

Areal reduction factors are used to convert point rainfall to areal estimates and are used to account for the variation of rainfall intensities over a large catchment. Siriwardena and Weinmann (1996)[24]

[24] Siriwardena and Weinmann, 1996 - Derivation of Areal Reduction Factors For Design Rainfalls (18 - 120 hours) in Victoria

areal reduction factors were applied to the Glenelg River catchment area upstream of Casterton as recommended in AR&R 1987[18].

3.5.6 Routing Parameters

Various kc values were determined during the RORB model calibration. A kc value of 260 was determined as the best fit for design modelling. This value was proven successful in the 1975, 1983 and 2010 calibration events. An m value of 0.8 was adopted as routing parameters for the calibration and design flood estimation.

Table 3-26 shows a comparison between this study's adopted kc value and m value opposed to regional and other study kc and m values.

Table 3-26 Design model parameters

Source	m	kc
This study	0.8	260
Casterton Flood Investigation	0.96	115
Default RORB	-	151
Vic MAR<800 mm - Eq 3.22 ARR (BkV)	-	120
Victoria data (Pearse et al, 2002)	-	164
Aust. wide Dyer (1994) (Pearse et al 2002)	-	150
Aust. wide Yu (1989) (Pearse et al 2002)	-	126

This study determined a kc value much higher than previous studies or regional calculations. If this was in an ungauged catchment then the adoption of this kc may not be warranted, however as shown in the calibration hydrographs the timing and shape of the modelled hydrographs is generally good, justifying the selection.

The RORB manual offers a method for adjusting a kc value should the m coefficient be changed. In the previous Cardno study a m of 0.96 was used. The adjustment equation is provided below:

$$kc_{(new)} = kc_{(old)} \times (Qp/2)^{m-m'} \text{ (where m equals old m and m' equals new m)}$$

Using the adjustment equation and a peak flow of 302 m^3/s for the 1% AEP flow from flood frequency we get an adjusted kc of 257. This is very close to that adopted by Water Technology in this study.

Water Technology has noticed on a number of recent studies that the use of ArcHydro to delineate sub areas and reaches at a much finer resolution than has been done in the past has resulted in some RORB models having very high kc values in order to calibrate to observed streamflow.

The Water Technology Glenelg River RORB model included 8,600 km of reach length and 72 sub areas as compared to only 2,790 km of reach length and 25 sub areas in the Cardno RORB model. The Water Technology dav was 131 compared to 118 in the Cardno RORB model.

Sensitivity testing of the kc value was undertaken by comparing varying kc values to the 1975 and 1983 gauge hydrographs at Casterton. Comparisons are shown in Figure 3-33 and Figure 3-34.

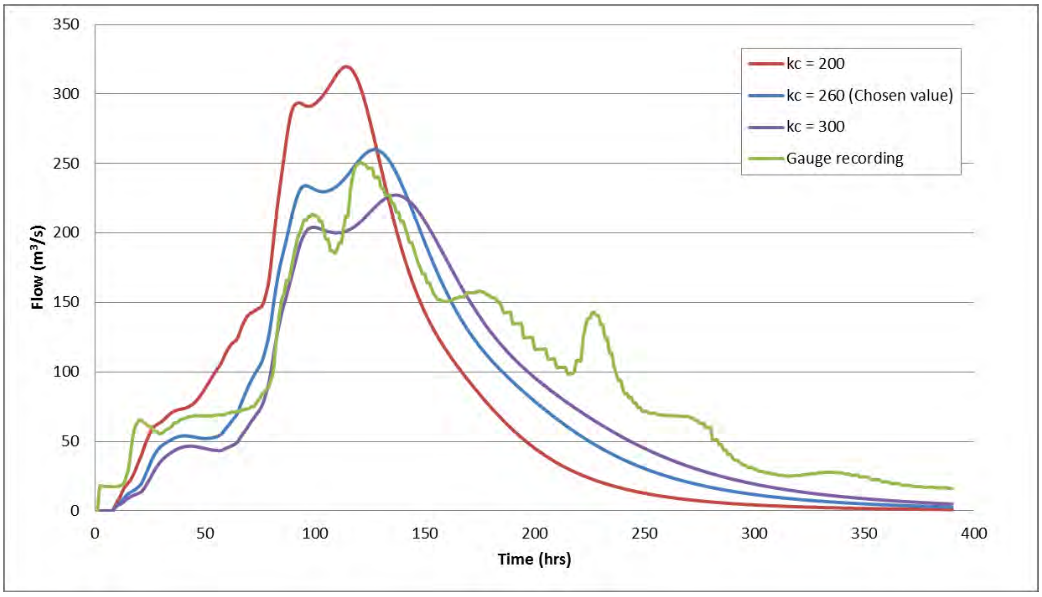


Figure 3-33 **Gauged and modelled hydrographs for kc values of 200, 260 and 300 for the 1983 event at Casterton**

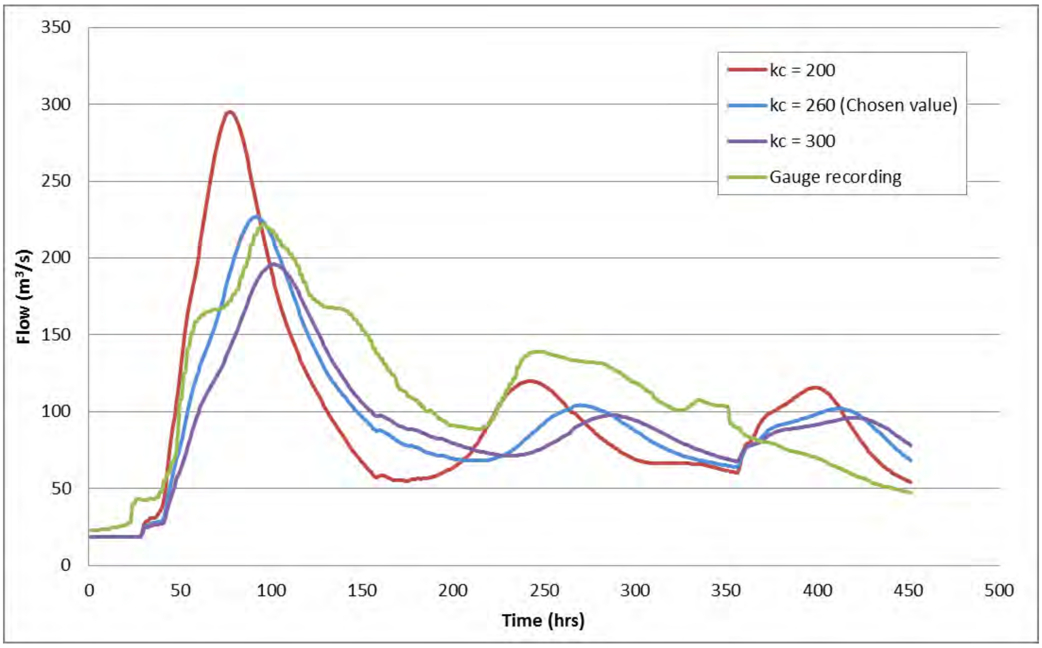


Figure 3-34 **Gauged and modelled hydrographs for kc values of 200, 260 and 300 for the 1983 event at Casterton**

By modifying the kc value to 200 the peak flow was considerably higher than the gauged flow in both the 1983 and 1975 events. The peak also occurred early, with hydrograph becoming peakier. This shows lowering the kc value to a value more similar to calculated in the regional equations would not match either the peak flow rate or timing at Casterton. By modifying the kc value to 300 the RORB model predicted peak flows lower and later than the gauge records.

3.5.7 Design Losses

In modelling the three calibration events, losses were varied to adjust peak flow in line with the flood frequency analysis. Losses selected for the calibration events take into account antecedent conditions and are not considered applicable for design event modelling.

Recommended design losses from a range of sources including other studies in south west Victoria are shown in Table 3-27.

Table 3-27 Recommended and previously adopted design Losses

<table>
<tr><th colspan="2">Source</th><th>Initial loss (mm)</th><th>Continuing loss (mm)</th></tr>
<tr><td colspan="2">Casterton Flood Investigation (2011)[4]</td><td>20</td><td>2</td></tr>
<tr><td colspan="2">Skipton Flood Investigation (2011)[25]</td><td>15.2</td><td>2.8</td></tr>
<tr><td colspan="2">Halls Gap Flood Study (2008)[26]</td><td>20</td><td>2</td></tr>
<tr><td colspan="2">Port Fairy Regional Flood Study (2008)</td><td>15</td><td>1.3-1.85 (varying with duration)</td></tr>
<tr><td colspan="2">South Warrnambool Flood Study (2007)</td><td>20</td><td>1.7-3.9 (varying with AEP)</td></tr>
<tr><td rowspan="3">AR&R (1987)[18]</td><td>Cordery & Pilgrim (1983)[27]</td><td></td><td>2.5</td></tr>
<tr><td>Melbourne and Metropolitan Board of Works[28]</td><td>15-20</td><td></td></tr>
<tr><td>Rural Water Commission[28]</td><td>25-35</td><td></td></tr>
</table>

The adopted design losses were modified to meet the FFA peak flows determined in Section 3.2. Initial and continuing losses were varied according to AEP, to match FFA peak flows. The continuing loss was also varied marginally up and downstream of Fulham Bridge to best match the FFA results. The values used in the design modelling are shown in Table 3-28.

[25] Skipton Flood Investigation – Water Technology, 2011

[26] Halls Gap Flood Investigation – Water Technology, 2008

[27] Cordery, I., & Pilgrim, D.H. (1983) On the lack of dependence of losses from flood runoff on soil and cover characteristics

[28] Government organisations listed as data sources in Australian Rainfall and Runoff - Volume 1, Book II Section 3

Table 3-28 Adopted design losses

Event AEP	Initial loss (mm)	Continuing loss (mm)	
		US Fulham Bridge	DS Fulham Bridge
20%	20	1	
10%	20	1.3	
5%	20	1.7	
2%	20	2.5	2.5
1%	25	3.0	2.9
0.5%	25	4.2	4

These values are within the range of the design loss parameters as set out within AR&R 1987[18] and are most similar to that adopted in the South Warrnambool Flood Study.

3.5.8 Rocklands Reservoir

Rocklands Reservoir has a large storage capacity and a significant catchment area. The reservoir's operational capacity is likely to be 85% of its total capacity, leaving 15% for flood storage. Design modelling for Rocklands Reservoir was not completed in RORB. Inflows to the hydraulic model were determined by a FFA at Fulham Bridge as discussed in Section 4.2 and 4.3 for the 1D and 2D models respectively.

3.5.9 Design Flood Hydrographs

Design flood hydrographs were determined at input locations into the hydraulic model. A range of storm durations were run (12 to 72 hours) to ensure that the critical storm durations of the large branches and smaller tributaries were determined. The peak flows determined by the RORB model were compared to the results of the FFA at each of the gauge locations where a FFA was able to be completed. These comparisons are shown below in Table 3-29.

Table 3-29 FFA and RORB model peak flows

AEP	Fulham Bridge		Duration (hours)	Casterton		Duration (hours)
	FFA (m^3/s)	RORB (m^3/s)		FFA (m^3/s)	RORB (m^3/s)	
20%	73	77	30	155	152	30
10%	101	103	36	207	207	36
5%	121	124	30	246	251	30
2%	137	139	30	283	282	30
1%	145	146	30	302	302	30
0.5%	150	150	30	316	318	30

3.5.10 Design Summary

Based on the hydrological analysis undertaken the following parameters were adopted for design purposes:

- IFD design rainfall depths for Balmoral, central to the Glenelg River Catchment
- Zone 2 design temporal patterns
- Siriwardena and Weinmann Areal Reduction Factors for the Glenelg River upstream of Casterton
- A spatial rainfall pattern representing a similar pattern to that observed in October 1975 and September 1983
- Varying design losses with AEP, as show in Table 3-28.

3.6 Discussion

3.6.1 General

The hydrology component of a flood investigation contains the highest degree of uncertainty, and as such, time spent ensuring the final design estimates are as robust as possible is of the utmost importance to a study. The large spatial coverage of this study poses challenges in ensuring the hydrology is accurate along several tributary reaches as well as the main waterway and several specific populous areas. This study reviewed previous hydrology estimates and used both runoff routing and FFA to achieve accurate design flow estimations at varying locations.

3.6.2 FFA

The FFA undertaken in this project showed design estimates that varied significantly from that of previous studies. This was due to utilising different software (Flike vs. CRC for Catchment Hydrology Spreadsheet), and the ratio comparison used to increase the design estimates at Casterton in the previous studies. Given the Casterton Flood Investigation[4] and Casterton Flood Warning and Intelligence Report[29] were focused on the Casterton township and used a more detailed and location specific hydraulic model schematisation and calibration process, the outputs from this study are not going to supersede those already completed. However, Water Technology does consider further consideration of the design flows at Casterton should be undertaken.

3.6.3 RORB Modelling

RORB was built to estimate streamflows at a single outflow location. Because of the regional nature of this project, RORB modelling was used to estimate flows at a range of locations within the study area including along the main Glenelg River reach and several tributaries. The Kc was applied to the RORB model over its entire extent and was shown to be appropriate for the gauge locations, however, given inflows to the hydraulic model are extracted at a range of locations with a varying number of subareas, the calibrated kc value might not be appropriate for each individual hydraulic model inflow location. Further work to validate this could include using regional estimation equations at all model inflow locations, however given the number of inflow locations and the time it would take to determine the best regional estimations for each location it was considered unwarranted for this study.

4. HYDRAULICS

4.1 Overview

The hydraulic modelling area included the Glenelg River from immediately downstream of Rocklands Reservoir to Casterton, as well as several tributaries including Salt Creek, Chetwynd River, Pigeon Ponds Creek, Mathers Creek, Wando River and Steep Banks Creek. This is approximately 220 km of the Glenelg River and an approximate combined tributary length of 180 km.

Given the length of waterway to be modelled a single standard 2D model at a reasonable resolution was not possible. Emerging technologies like Graphical Processing Units (GPU) and High Performance Computing (HPC), may change this in the future but at the time of the study commencing they were not available to the Study Team. Although the GPU technology is now available initial testing by Water Technology is showing some promise, but caution must be used, particularly around constrictions, where significant differences are observed in traditional CPU and the new GPU technologies. Initial testing has shown differences of half a metre or more around constrictions at bridge crossings.

During this project a one dimensional (1D) model of the entire model extent was developed in DHI's MIKE11 along with a two dimensional model (2D) covering the Glenelg River from Rocklands Reservoir to downstream of Harrow. These models and their results are discussed individually within this report and compared in Section 4.6. Two model varying model schematisations were included in the scope to allow some comparison of the types of outputs, the accuracy of results and to compare the relative merits of the two hydraulic modelling approaches.

LiDAR data was used as the basis for all hydraulic modelling. The data was available in two data sets; data captured as part of the Floodplains and ISC projects. The ISC data has a better coverage and was used in the development of the hydraulic model topography. The benchmarking of the ISC LiDAR is discussed in Section 2.4, with a universal lowering of 0.32 m made to correct the LiDAR.

Balmoral and Harrow are the two most significant townships in the study area, with the highest populations. These townships are in close proximity to the Glenelg River and are covered by both the 1D and 1D-2D hydraulic models. Casterton is also within the study area and is covered by the 1D model. Casterton has been modelled and mapped in detail by the Casterton Flood Investigation[4] and Casterton Flood Warning and Intelligence Report[29].

The 2D and 1D model domain limits are shown in Figure 4-1 and Figure 4-2 respectively.

[29] WBM, 2013 – Casterton Flood Warning and Intelligence Report

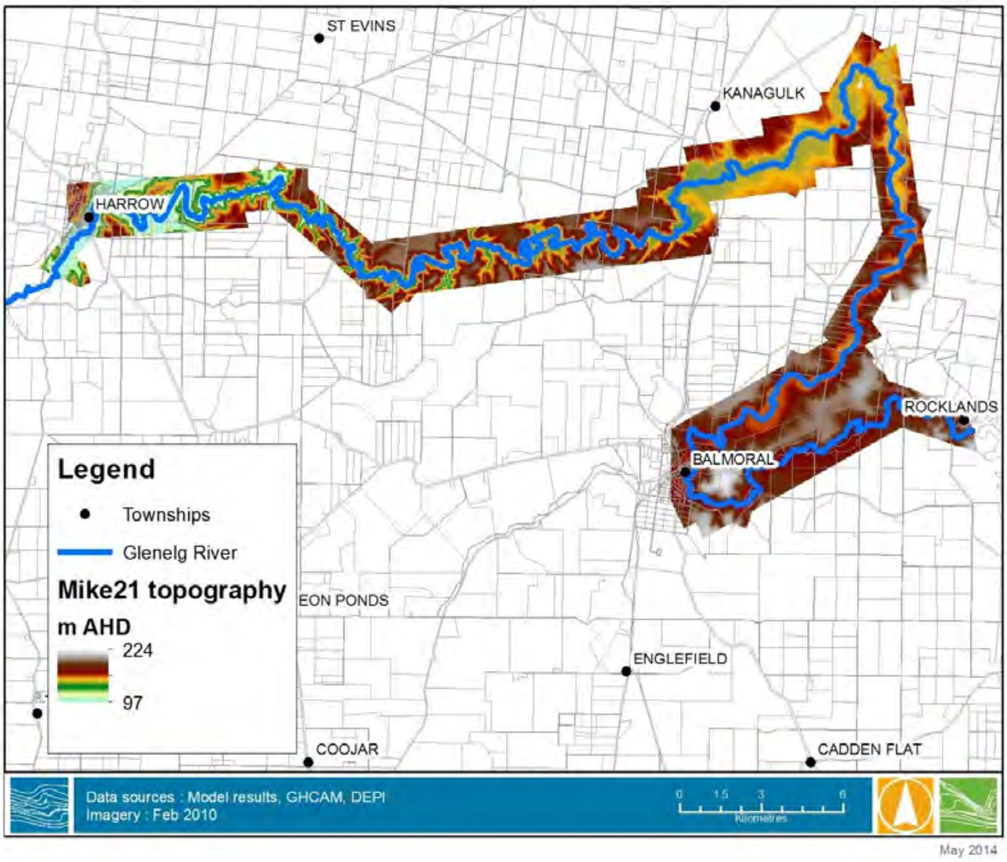


Figure 4-1 2D model domain limits

The 1D hydraulic model was separated into three reaches for the calibration phase to allow each reach to be modelled separately utilising the available gauge information. The three reaches were:

- Reach A – Rocklands Reservoir Outlet to Fulham Bridge
- Reach B – Fulham Bridge to Harrow
- Reach C – Harrow to Dergholm
- Reach D– Dergholm to Sandford

The three reaches and their respective tributaries are shown in Figure 4-2.

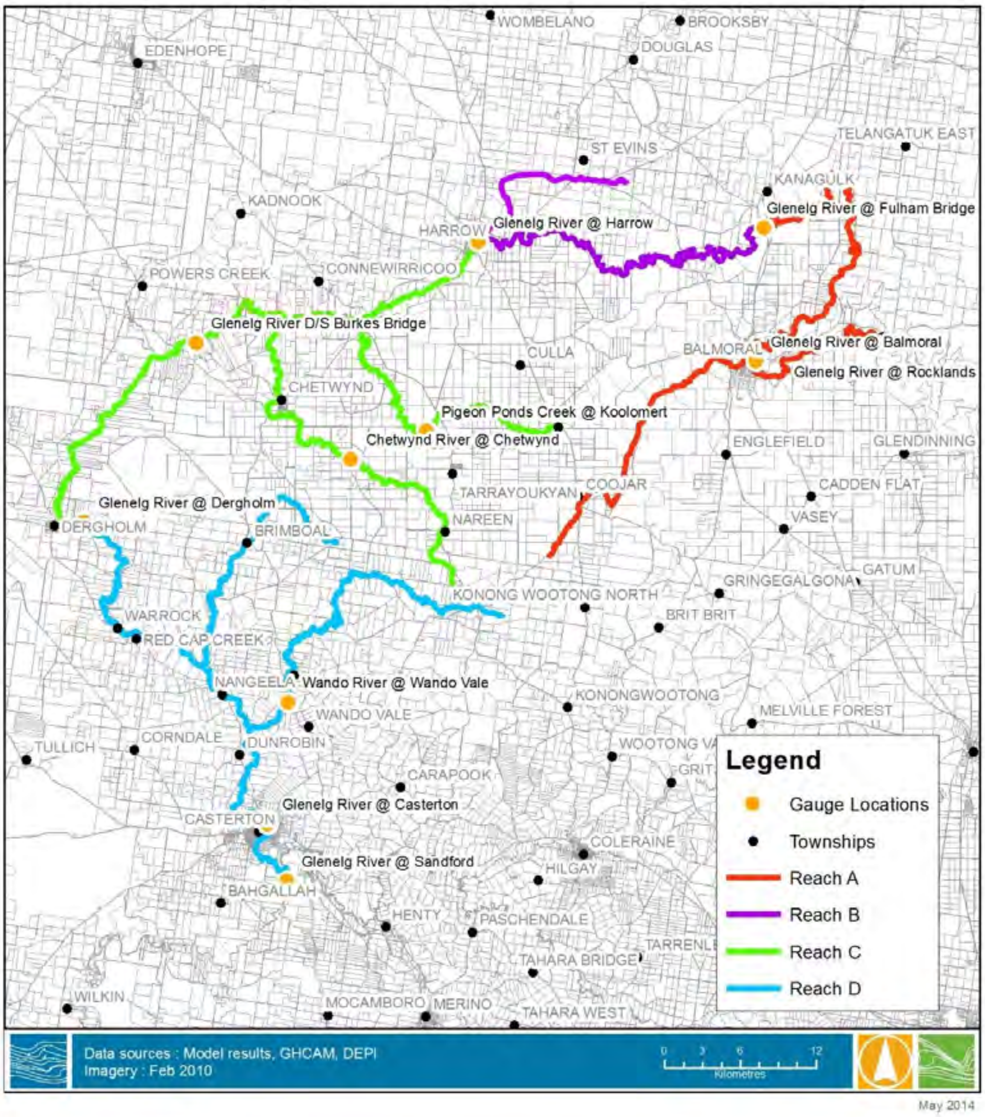


Figure 4-2 **1D reaches A, B, C and D with their respective tributaries and streamflow gauge locations**

The hydraulic models were calibrated using surveyed flood levels and gauged flows and heights depending on the data availability for each event. Calibration was completed for events occurring in September 1983, September 2010 and December 2010.

The 1D model was calibrated using the September 1983 and December 2010 events; the calibration was based primarily on the gauge flows, heights and timing. The 1983 event also had 44 surveyed peak flood heights in Casterton that were utilised. The calibration proved to match the observed historic data well with a varying uniform roughness between 0.06-0.1 along each of the four reaches.

The 2D model was calibrated to the September 2010 event as there were seven surveyed extent and flood height locations in Harrow. The event was not as large as other events in the Glenelg River; however it was significant in the upper reaches. The 1983 event was also used in the calibration process for comparison against the 1D model. Comparisons of the 1983 event between the 1D and 2D models was undertaken for flow and varying water levels at the Glenelg River gauge at Harrow and over the model extent using the maximum water levels observed.

4.2 One Dimensional Modelling

4.2.1 Model development

Overview

The 1D model has the following major components:

- Waterway centrelines of the Glenelg river and its tributaries;
- Riverine and floodplain cross sections;
- Inflow and tailwater boundaries;
- Riverine and floodplain roughness characteristics; and
- Hydraulic structures such as bridges.

Each of these components were used to develop a representation of the waterways and floodplain covered by the 1D hydraulic model.

Riverine and Floodplain cross sections

Cross sections of the Glenelg River and the major tributaries were extracted from the adjusted ISC LiDAR.

Figure 4-3 shows the comparison between a surveyed cross section and a cross section extracted from the ISC LiDAR data in the same location. The figure also shows the change in cross section level as a result of the 0.32 m lowering.

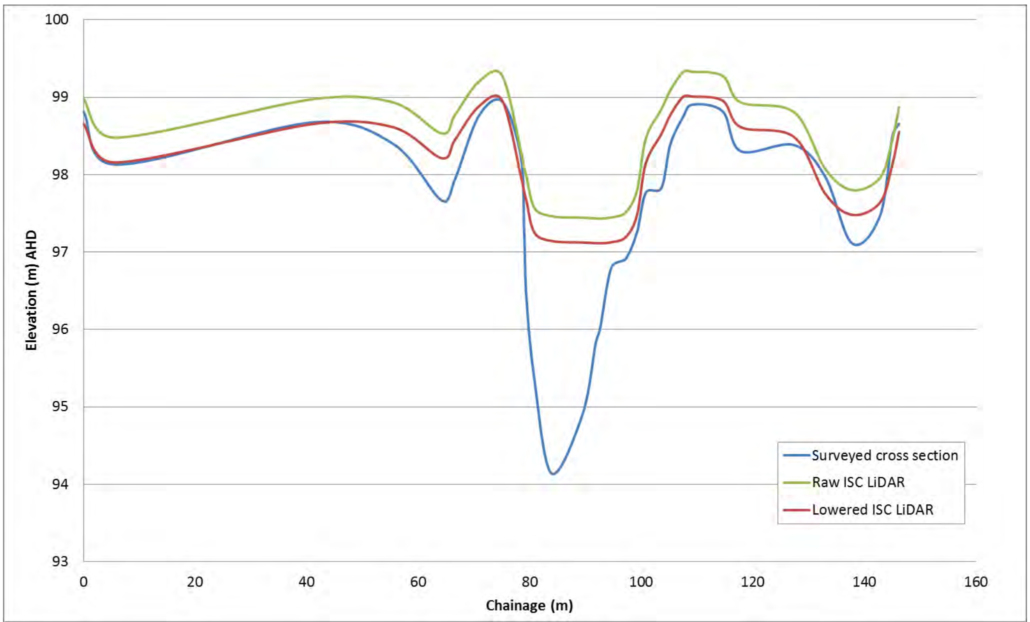


Figure 4-3 Surveyed, ISC and lowered ISC cross sections

The cross sections extracted from the ISC LiDAR also showed a flat section at the bottom of each cross section where the LiDAR point data was unable to penetrate the water surface. The flat section represents the water level at the time the survey data was flown.

A comparison of cross section feature survey completed of the Glenelg River and cross sections extracted from the LiDAR was made to determine what proportion of the cross section was not captured by the LiDAR data.

A comparison of all spatially correct riverine cross sections and the ISC data showed the average difference between the Glenelg channel invert was 1.5 m. It was determined an invert lowering of 1.5 m would be applied to each Glenelg River cross section. Lowering was undertaken at the center of the channel creating a V channel shape.

Figure 4-4 below shows a raw cross section extracted from the LiDAR, a surveyed cross section completed as part of the Glenelg River Channel Survey and an invert modified channel cross section.

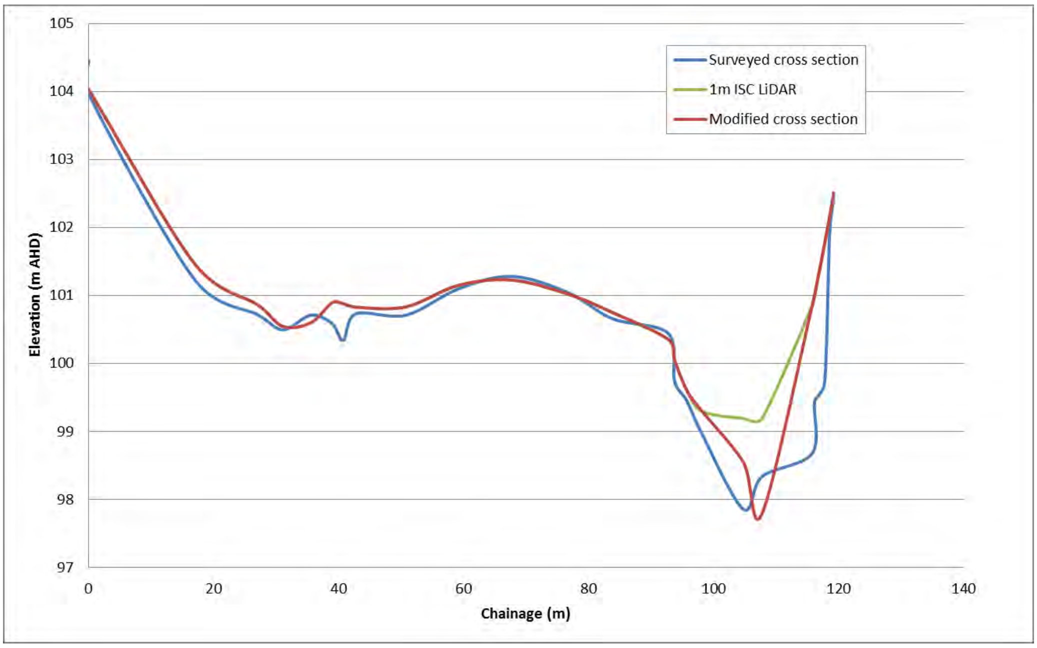


Figure 4-4 Surveyed, ISC and invert modified ISC cross sections

Cross sections were generally extracted every 1 km along the Glenelg River with additional cross sections located at potential hydraulic controls, bridges, through townships etc. Cross sections along the modelled tributaries were extracted every 200 m, this allowed for better definition of the smaller waterways. A 1 km cross section spacing allowed for a reasonable definition of the waterway, 1D models do not take stream sinuosity into account unless it is accounted for in a stream roughness value. 1D models use a simple flowrate, height and slope relationship with an average velocity calculated within each cross section rather than velocity variable depending on location within the cross section e.g. inside/outside of bends. In terms of the model water level predictions the cross section spacing's only become relevant with changing channel/floodplain shape. A consistent channel shape along a channel can be modelled a lower density of cross sections while a complex channel with numerous chokes requires those represented, and therefore denser cross section spacing. The regular cross section spacing is not as relevant as the cross section locations themselves. The cross section locations ensure a channel and floodplain are accurately represented. In the Glenelg River hydraulic model the regular cross section spacing was modified to ensure the waterway hydraulic features were accurately represented. However, the cross section spacing does become relevant when results are processed as discussed in Section 5.2.

The Glenelg River is relatively consistent in channel width, especially downstream of Fulham Bridge. As discussed in Section 4.1 the 1D model was separated into three reaches focusing on the location of streamflow gauges.

Model reaches A, B, C D and their respective tributary cross sections are shown in Figure 4-5, Figure 4-6, Figure 4-7 and Figure 4-8.

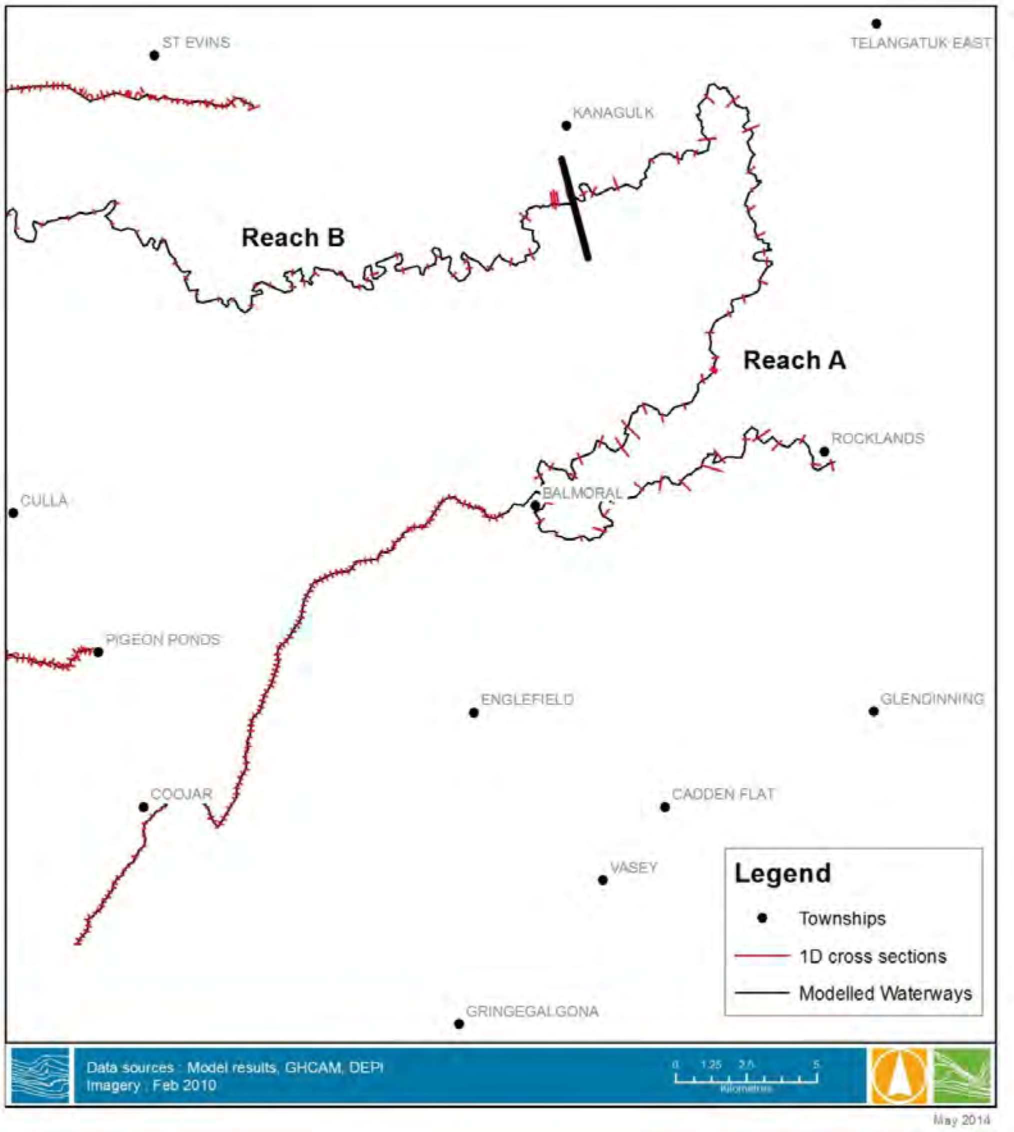


Figure 4-5 **Glenelg River Reach A and Mathers Creek cross sections**

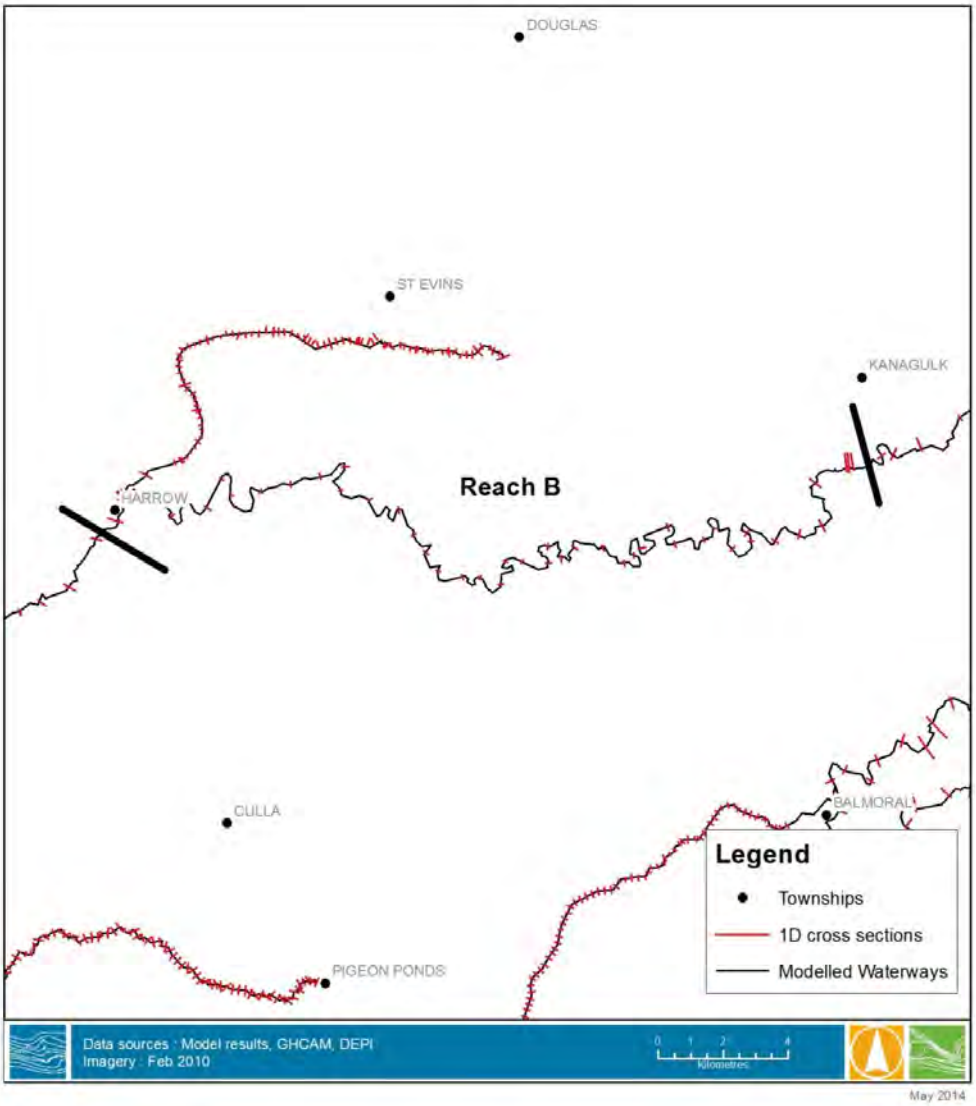


Figure 4-6 Glenelg River Reach B and Salt Creek cross sections

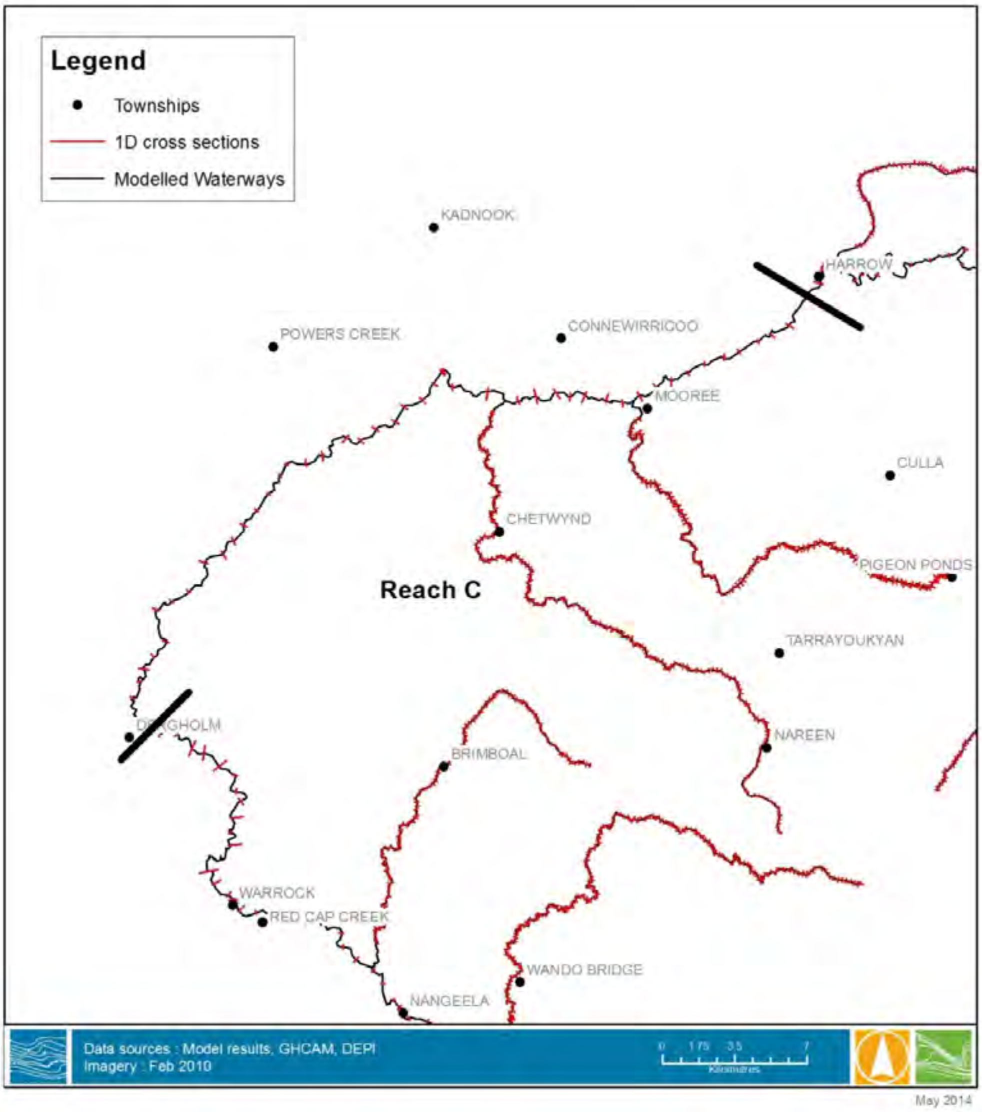


Figure 4-7 Glenelg River Reach C, Pigeon Ponds Creek and Chetwynd River cross sections

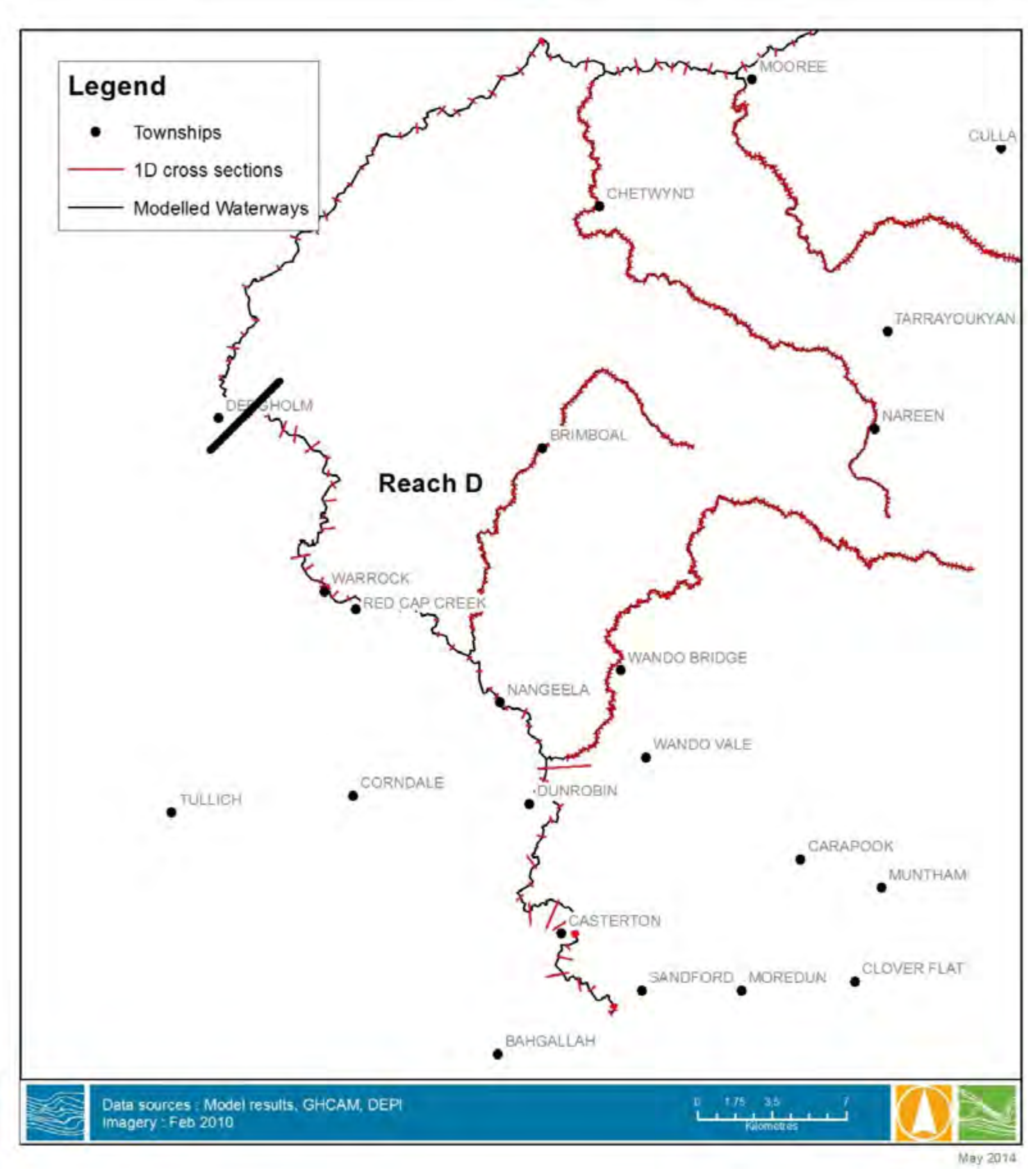


Figure 4-8 Glenelg River Reach D, Steep Creek and Wando River cross sections

Waterway alignment and inflows

The alignment of the waterways covered by the 1D model was initially determined using ArcHydro, then refined using the available aerial photography.

Inflows to the 1D model were either extracted from stream flow gauges, or the calibrated RORB model. Tributary inflows to the waterways covered by the 1D model were modelled using point source inflows. Localised inflows from RORB sub-areas that contributed directly to the Glenelg River were not added as boundaries in the hydraulic model due to the lack of attenuation and the unrealistic hydrograph shape. This is discussed further in Section 4.2.3.

Waterway characteristics and structures

The characteristics of each waterway are primarily defined through waterway roughness and have been characterised using Manning's 'n'. In the 1D model the roughness is a combination of stream/floodplain vegetation, waterway sinuosity, geomorphic characteristics and waterway bed roughness.

The waterway roughness has been used as the primary form of calibration for the 1D model and varying roughness values are discussed with the calibration of each event.

Structures along the Glenelg River were built into the 1D model by extracting cross sections of the bridges from the ISC LiDAR and the bridge deck survey completed during the data verification stage of the project.

4.2.2 Model Calibration

Overview and Data Availability

The models were calibrated to both flow and water level records for the December 2010 and September 1983 events. Additional to the gauged streamflows and heights the following surveyed levels were available:

- December 2010 – 7 surveyed flood marks at Harrow, 2 at Casterton
- September 1983 – 44 surveyed flood marks at Casterton

The calibration was undertaken using the gauged flows available rather than predictions made by the RORB model. This removes the uncertainty around the RORB model predictions.

As discussed the hydraulic model was calibrated in sections based on the available gauge locations and survey data. Each section of the 1D model was calibrated using varying events with calibration of Reach B occurring first, followed by Reach C, Reach D and Reach A. The data and events used for each reach are as follows:

- Reach B - Fulham Bridge to DS Harrow – Calibrated using streamflow/height records at Harrow and Fulham Bridge as well as surveyed flood heights within Harrow. The Fulham Bridge gauge recording was used as the model inflow, to ensure inflow was as accurate as possible. Reach B begins at the Fulham Bridge gauging station on the Natimuk - Hamilton Road and ends at the Harrow gauging station at the Harrow-Casterton Road. The reach begins at Glenelg River chainage 55 km and ends at chainage 102 km, 47 km in length. Reach B includes one major tributary, Salt Creek (17 km in length).
- Reach C – Harrow to Dergholm – Calibrated using streamflow/height records at Dergholm. Gauged flows at Harrow were used where available; if unavailable flows were routed down Reach B. Reach C begins at the Harrow gauging station and ends at Dergholm at the Dergholm-Chetwynd Road. The reach begins at Glenelg River chainage 102 km and ends at 159 km, totalling 57 km. Reach C contains two major tributaries Pigeon Ponds Creek (30 km in length) and Chetwynd River (39 km in length). Both tributaries have streamflow/height gauges.
- Reach D – Dergholm to Sandford – Calibrated using streamflow/height records at Casterton and Sandford. As well as flood heights surveyed in Casterton during September 1983. Gauged inflows at Dergholm were used where available; if unavailable flows were routed down Reach C. The reach begins at Glenelg River chainage 159 km and ends at 212 km, totalling 53 km. Reach D contains two major tributaries, Steep Banks Creek and Wando River. The Wando River has a streamflow/level gauging station.
- Reach A – Rocklands to Fulham Bridge – No calibration was undertaken for Reach A, as no accurate calibration data was available. The calibration parameters determined for Reach B were applied for this reach.

December 2010

Reach B

The December 2010 event was modelled in Reach B using the Fulham Bridge inflow, the storm event was reported to be isolated with the majority of the rainfall occurring in the Glenelg River catchment upstream of Fulham Bridge.

The Fulham Bridge inflow is shown below in Figure 4-9, peaking at 12am, 9 December 2010 at 131 m^3/s.

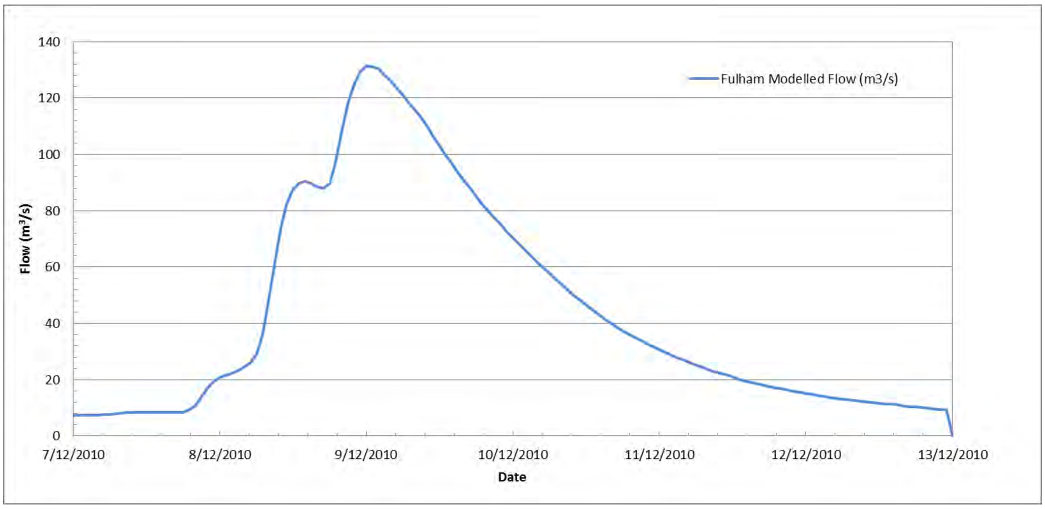


Figure 4-9 Reach B – Fulham Bridge inflow

Harrow is the only streamflow/level gauge within Reach B. A comparison of the modelled and observed hydrographs and stage hydrographs were available for the Harrow gauging station as shown in Figure 4-10 and Figure 4-11 respectively.

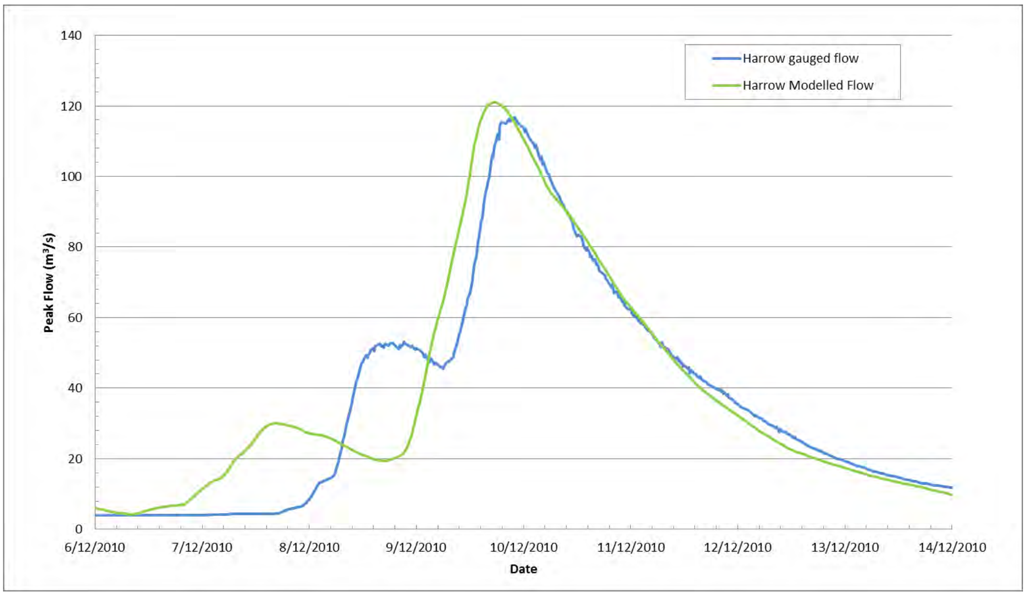


Figure 4-10 **Modelled and gauged flows at the Harrow gauging station during the December 2010 event**

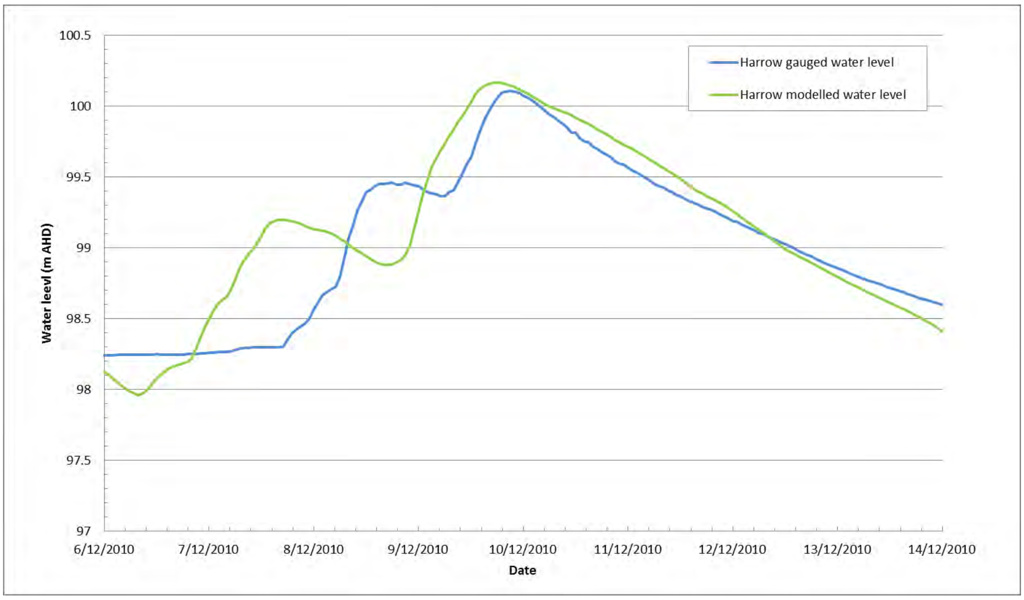


Figure 4-11 **Modelled and gauged water levels at the Harrow gauging station for the December 2010 event**

A comparison of the maximum modelled and observed flow, level and timing is shown below in Table 4-1, along with the total volume of the event.

Table 4-1 Harrow modelled and observed peak flow, level timing and total volume

	Modelled	Observed	Difference
Peak flow (m^3/s)	121	117	+ 4 (3%)
Peak level (m AHD)	100.17	101.12	+ 0.05 m
Timing	6pm 9/12/10	9pm 9/12/10	+ 3 hours
Volume (ML)	26,900	25,200	+ 1,700 (6.7%)

The modelled and observed hydrographs at Harrow match closely to shape, peak height and peak flow. The timing of the gauged hydrograph is slightly earlier than the observed. The model was calibrated using a uniform Manning's n roughness value of 0.067 upstream of Harrow.

Reach C

The gauged hydrograph at Harrow was utilised as the inflow to Reach C, routing the hydrograph down to the Dergholm gauging station. There are two major tributaries in Reach C, Chetwynd River and Pigeon Ponds Creek. Both of these waterways have streamflow/level gauges located at Chetwynd and Koolomert respectively. The Chetwynd gauge recorded the December 2010 event, whereas gauging at Koolomert ceased operation in 1989. A comparison of the modelled and observed flows at Chetwynd is shown below in Figure 4-12. The gauge zero for Chetwynd is listed as 'Arbitrary' on the DEPI Water Measurement Information System website so there is no water level to calibrate to.

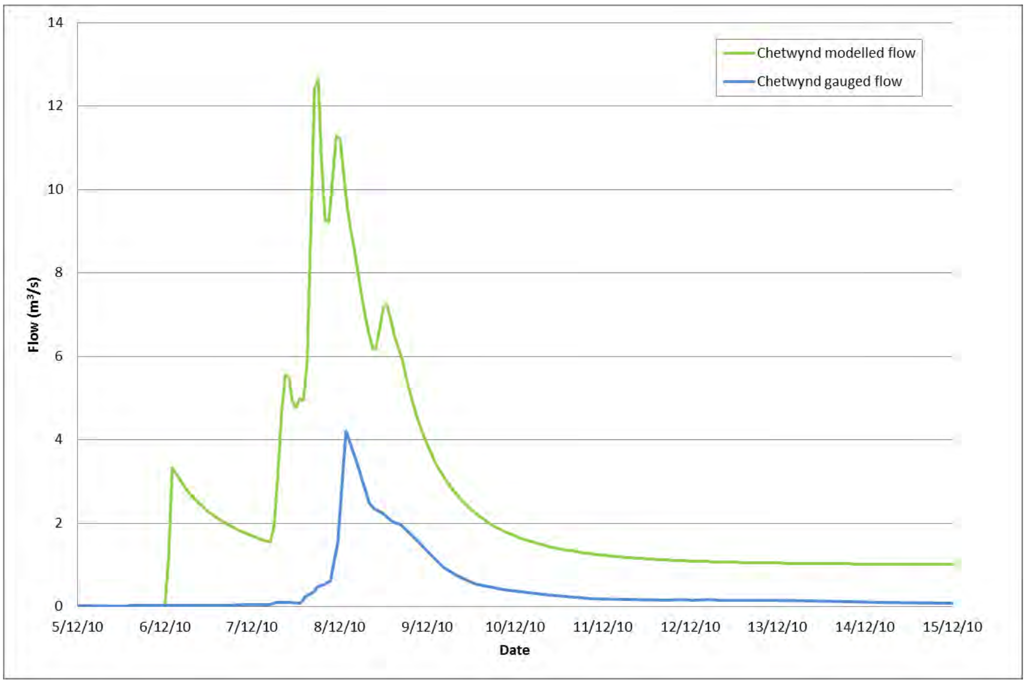


Figure 4-12 Modelled and gauged flows at the Chetwynd gauging station for the December 2010 event

The modelled flows are significantly larger than the observed, as highlighted in Section 3.4. This is likely to be due to the limited spatial extent of the December 2010 event and an insufficient number of rainfall gauges to represent the spatial pattern in RORB.

A comparison of the Dergholm modelled and observed hydrographs is shown in Figure 4-13. The gauge zero of Dergholm is listed as 'Arbitrary' on the DEPI Water Measurement Information System website so there is no water level to calibrate to.

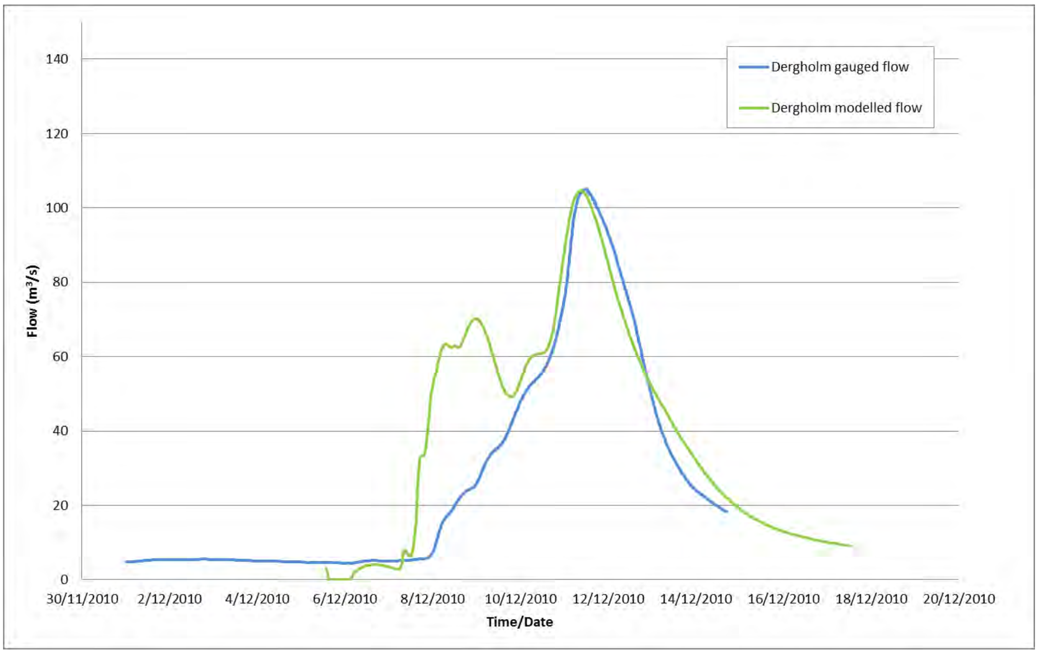


Figure 4-13 Modelled and gauged flows at the Dergholm gauging station for the December 2010 event

A comparison of the modelled and observed peak flow, timing and total volume is shown below in Table 4-2.

Table 4-2 Dergholm modelled and observed peak flow, timing and total volume

	Modelled	Observed	Difference
Peak flow (m^3/s)	105	105	0
Timing	11/12/2010 9:00 am	11/12/2010 10:30 am	- 1.5 hours
Volume (ML)	35,500	27,500	+ 8,000 (29%)

The modelled and observed peak flow and timing were shown to match closely, however the modelled volume was significantly larger than that observed. This can be observed in the hydrograph shape with the modelled hydrograph having an initial peak which was not observed in the gauge record. This modelled peak is due to catchment inflows between Harrow and Dergholm which did not occur during the event. The difference between modelled and observed flows at

Chetwynd indicates the deference between the modelled and observed tributary inflows. This is verified by the marginal increase in observed hydrograph volume between Harrow and Dergholm, where no significant contributions to the event hydrograph were observed. Reach C was calibrated using a uniform Manning's n roughness value of 0.09 between Harrow and Dergholm.

Reach D

The gauged hydrograph a Dergholm was utilised as the inflow for Reach D, routing the hydrograph down to the Sandford gauging station. Unfortunately no gauging was available at Casterton.

There are three major tributaries within Reach D, the Wando River, Steep Banks Creek and the Wannon River. A gauge is located on the Wando River at Wando Vale in the lower reaches and another on the Wannon River at Henty immediately upstream of the Glenelg River confluence. The Wannon River was not covered by the RORB model extent, however due to the proximity to the Glenelg River the Wannon River flow was extracted directly from the streamflow gauge at Henty. During December 2010 the Wando Vale gauge only recorded a peak flow of 10 m^3/s as shown in Figure 4-14.

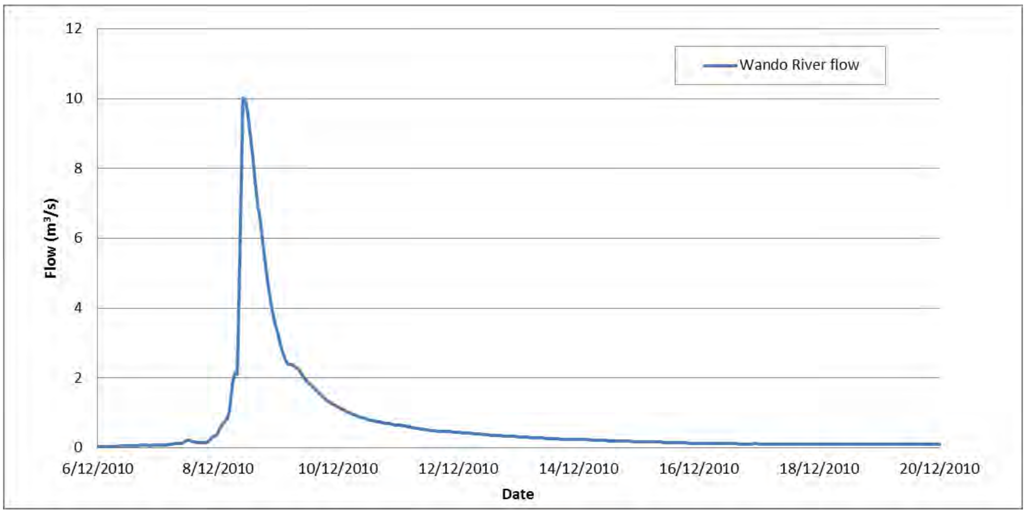


Figure 4-14 Flow recorded on the Wando River at Wando Vale during December 2010.

The FFA completed in Section 3.2.7 showed this flow to be much less than a 20 % AEP (40 m^3/s). This reinforces the observation that the December 2010 event was isolated to the upper Glenelg River catchment. As observed in the RORB modelling the spatial distribution of rainfall gauges was not sufficient to accurately define the storm spatial pattern with an over estimation of the flows that occurred. To negate this in the hydraulic modelling no tributary inflows were modelled in Reach D, except for the Wannon River for which the gauged flow was used. The tributary flows in Reach D were minor with the largest, the Wando River contributing peak flow of 10 m^3/s approximately 3 days before the peak flow on the Glenelg River at Sandford. A comparison of the Sandford modelled and observed hydrographs and stage hydrographs is shown below in Figure 4-15 and Figure 4-16 respectively.

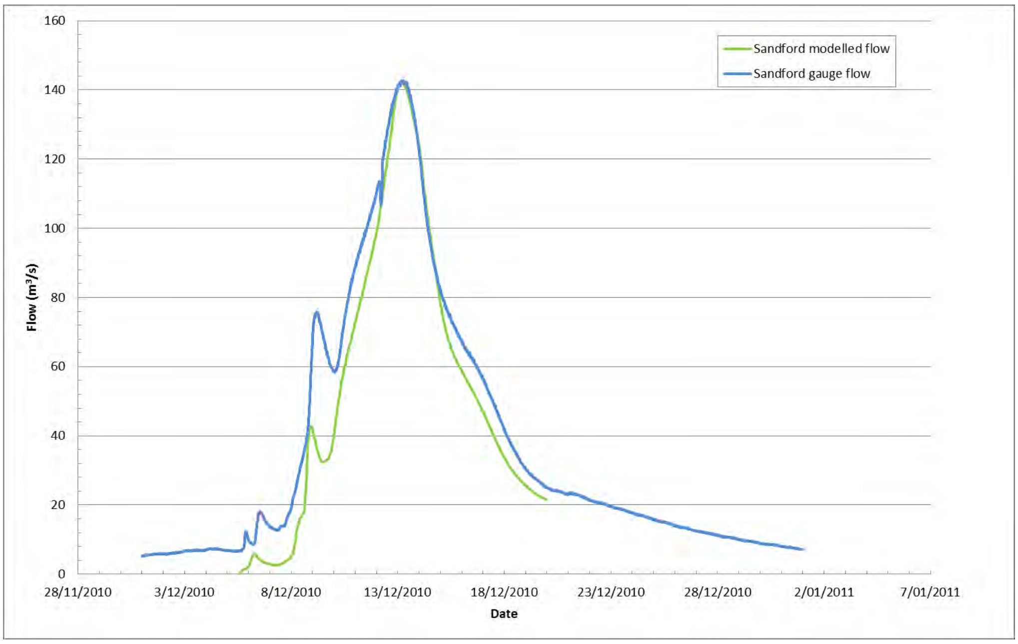


Figure 4-15 Modelled and gauged flows at the Glenelg River at Sandford gauging station for the December 2010 event

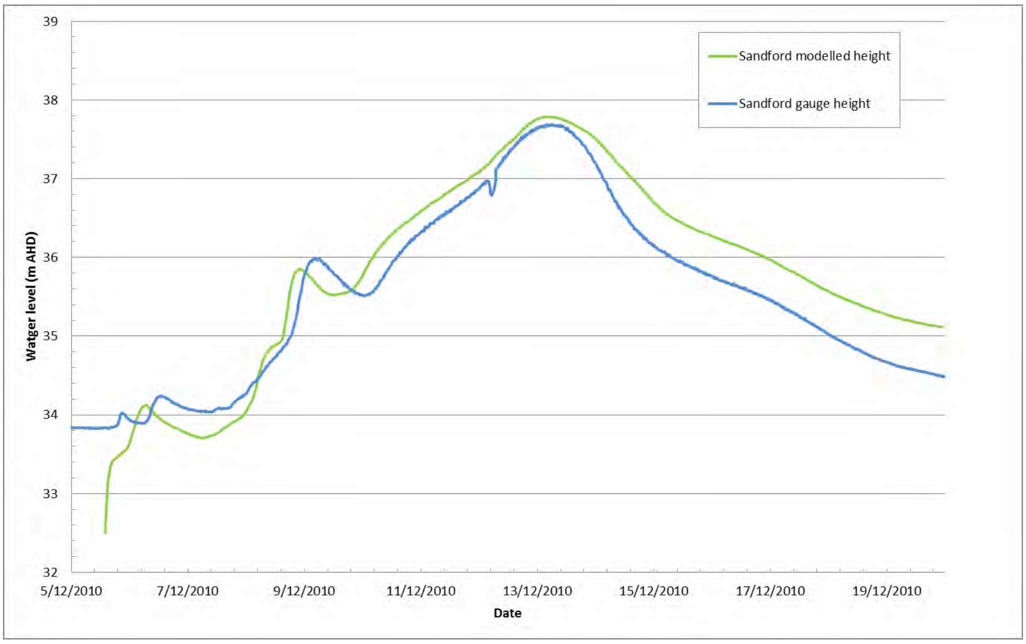


Figure 4-16 Modelled and gauged heights at the Glenelg River at Sandford gauging station for the December 2010 event

A comparison of the maximum modelled and observed flow, level and timing is shown below in Table 4-3, along with the total volume of the event.

Table 4-3 Glenelg River at Sandford modelled and observed peak flow, level timing and total volume

	Modelled	Observed	Difference
Peak flow (m^3/s)	142	143	- 1 (0.7%)
Peak level (m AHD)	37.78	37.69	+ 0.09 m
Timing	13/12/2010 5:00:00 AM	13/12/2010 4:30:00 AM	- 0.5 hours
Volume (ML)	67,000	78,300	- 11,300 (14%)

The modelled peak level, flow and timing at Sandford match closely to that observed, however there was a 14% difference in event volume. This is likely to be due to the localised catchment inflows not being represented in the hydraulic modelling. The majority of the volume discrepancy is in the early and late stages of the hydrograph, as shown in Figure 4-15. The peak of the hydrograph which is driven by upstream Glenelg River flows not the smaller tributaries in this reach is well represented.

Reach D was calibrated using a uniform Manning's n roughness value of 0.1 between Dergholm and Sandford.

September 1983

Reach B

Similar to the December 2010 event, September 1983 in Reach B was modelled using the Fulham Bridge gauge recording. Unfortunately, no gauge records were available at Harrow so no comparisons to gauge flows or heights could be made; flows from Reach B were routed to Reach C.

Reach C

As there was no gauge record at Harrow the model inflow for Reach C was extracted from Reach B. Unfortunately, no records were available at Dergholm so no comparisons to gauge flows or heights could be made; flows from Reach C were routed to Reach D.

Gauge records were available for both Pigeon Ponds Creek at Koolomert and Chetwynd River at Chetwynd.

A comparison of the modelled and observed flows at Koolomert and Chetwynd are shown in Figure 4-17 and Figure 4-18 respectively.

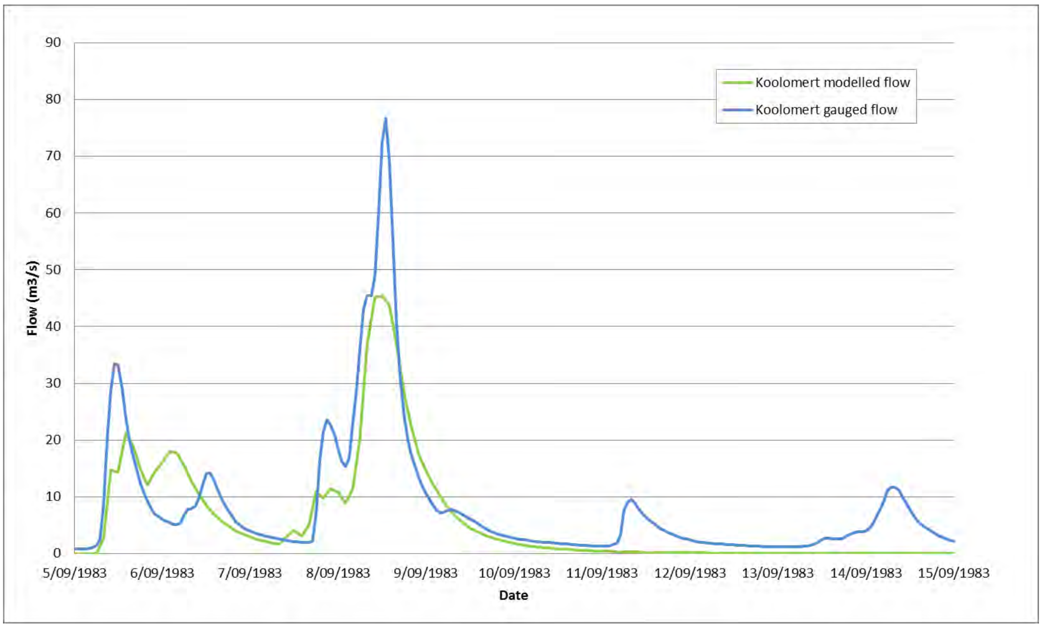


Figure 4-17 Modelled and gauged flows at the Koolomert gauging station for the September 1983 event

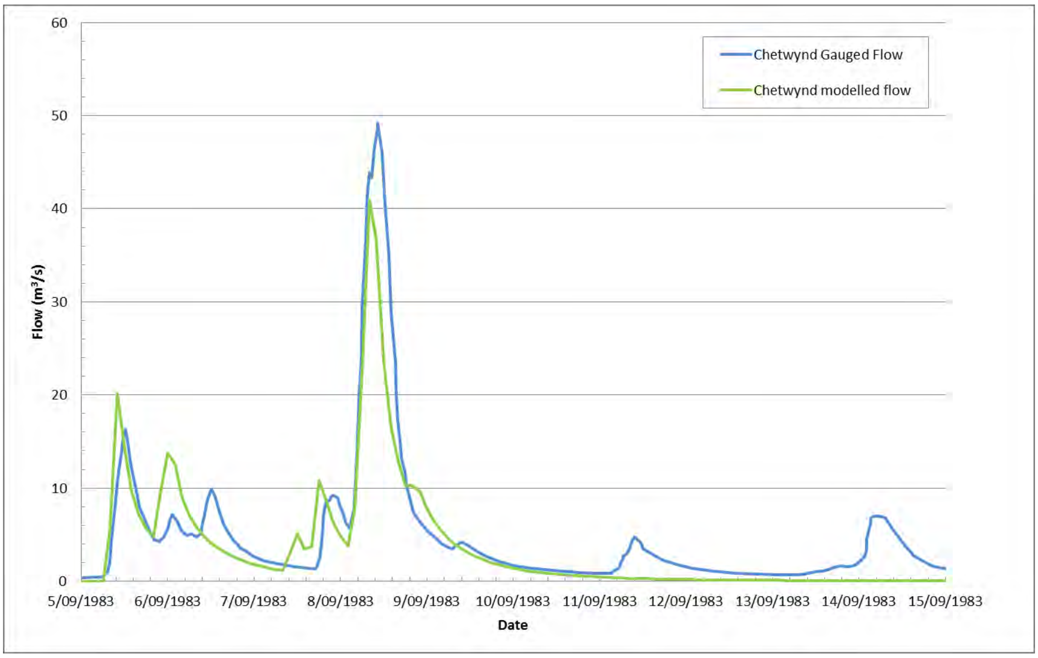


Figure 4-18 Modelled and gauged heights at the Chetwynd gauging station for the September 1983 event

The shape of both the Chetwynd and Koolomert hydrographs is relatively consistent with the gauge recordings, however in both cases the modelled flow is less than the observed. This is the case more so for the Koolomert gauge with a large spike at the peak of the event. This may be a result of rainfall not being fully represented in the temporal or spatial pattern. Comparisons of peak flow, timing and event volume for Koolomert and Chetwynd are shown in Table 4-4 and Table 4-5 respectively.

Table 4-4 Koolomert modelled and observed peak flow, timing and total volume

	Modelled	Observed	Difference
Peak flow (m^3/s)	45	77	- 44 (57%)
Timing	8/09/1983 12:00	8/09/1983 13:00	- 1 hour
Volume (ML)	2166	5391	- 3225 (60%)

Table 4-5 Chetwynd modelled and observed peak flow, timing and total volume

	Modelled	Observed	Difference
Peak flow (m^3/s)	41	49	- 8 (16%)
Timing	8/09/1983 8:00	8/09/1983 10:24	- 2.5 hours
Volume (ML)	3266	3711	- 445 (12%)

The large difference in modelled and observed peak flow and total event volume is due to the very sharp peak in the observed flow dataset. This is considered to be a result of a localised burst of rainfall not represented in the RORB temporal or spatial patterns. There was a smaller difference observed in the observed and modelled comparison at Chetwynd but with a similar event volume.

Reach D

As there was no gauged flow for Dergholm the modelled flow was used from Reach C, this flow was also routed through Reach B as no flow at Harrow was available.

The gauging stations within Reach D that did have gauging information were Wando Vale and Casterton. There were also surveyed flood heights throughout Casterton.

The Wando River modelled and gauged flow at Wando Vale is shown below in Figure 4-19, with modelled and observed peak flows, timing and event volumes shown in Table 4-6.

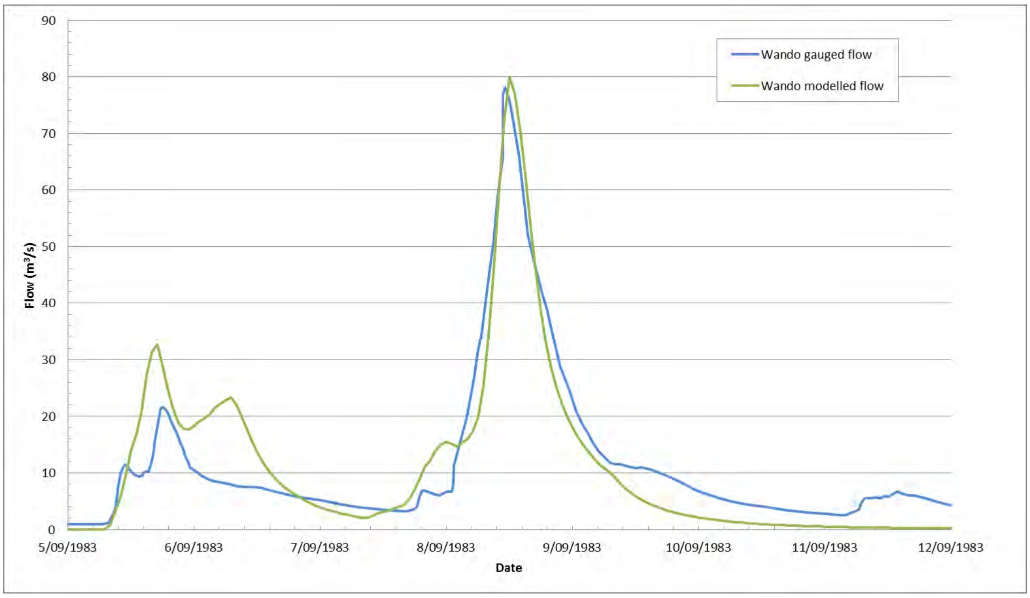


Figure 4-19 Modelled and gauged flows at the Wando River at Wando Vale gauging station for the September 1983 event

Table 4-6 Wando River at Wando Vale modelled and observed peak flow, timing and total event volume

	Modelled	Observed	Difference
Peak flow (m^3/s)	80	78	+ 2 (2.5%)
Timing	8/09/1983 12:00	8/09/1983 11:06	+ 1 hour
Volume (ML)	6760	7031	- 271 (4%)

The modelled shape, timing and peak flows match closely to that observed at Wando Vale. Both hydrographs show a smaller peak followed by a larger one. The initial peak is over represented in the model results but the timing is matched closely. The peak flow and total event volume are also matched closely.

Glenelg River observed and gauged flows and water levels at the Casterton gauge are shown in Figure 4-20 and Figure 4-21, with a comparison of the peak flow, level, timing and event volume shown in Table 4-7.

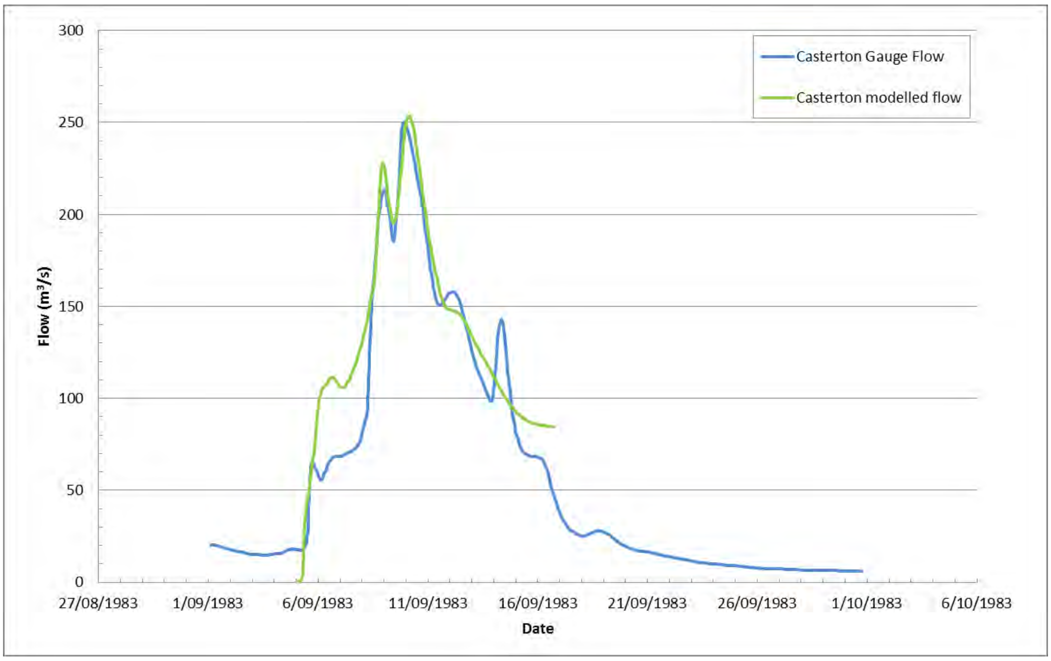


Figure 4-20 Modelled and gauged flows at the Casterton gauging station for the September 1983 event

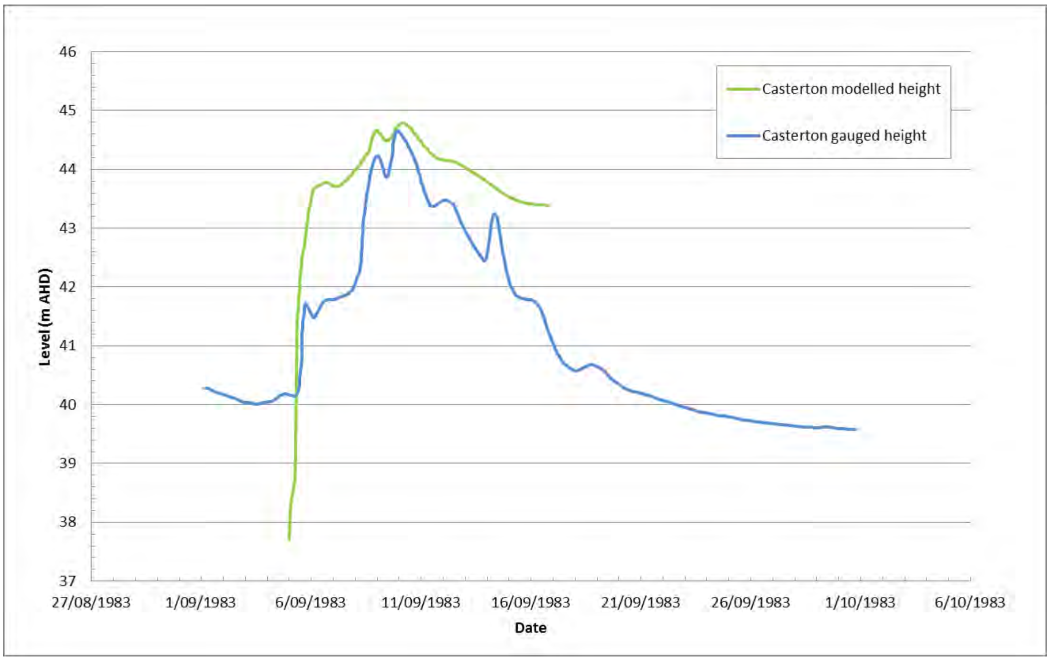


Figure 4-21 Modelled and gauged heights at the Casterton gauging station for the September 1983 event

Table 4-7 Casterton modelled and observed peak flow, level, timing and total event volume

	Modelled	Observed	Difference
Peak flow (m^3/s)	253	250	+ 3 (1%)
Peak Level (m AHD)	44.79	44.66	+ 0.13
Timing	10/09/1983 4:00	9/09/1983 22:39	+ 5.5 hours
Volume (ML)	135,000	120,890	+ 14,110 (11.5%)

The modelled and observed peak flows and levels match closely with the modelled flow occurring 5 hours later than the observed. Considering the Glenelg River flow was modelled from Harrow with no gauging between Harrow and Casterton this is a reasonably good result. The modelled water level hydrograph at Casterton is not as peaky as the observed hydrograph, possibly due to the input of the tributary inflows.

Forty four surveyed flood heights at Casterton were compared to the peak modelled levels by linearly interpolating the water surface elevation between the model cross sections. A comparison of the modelled and observed peak levels is shown below in Figure 4-22. Grey scale aerial photography has been used to allow the coloured survey points to be more visible.

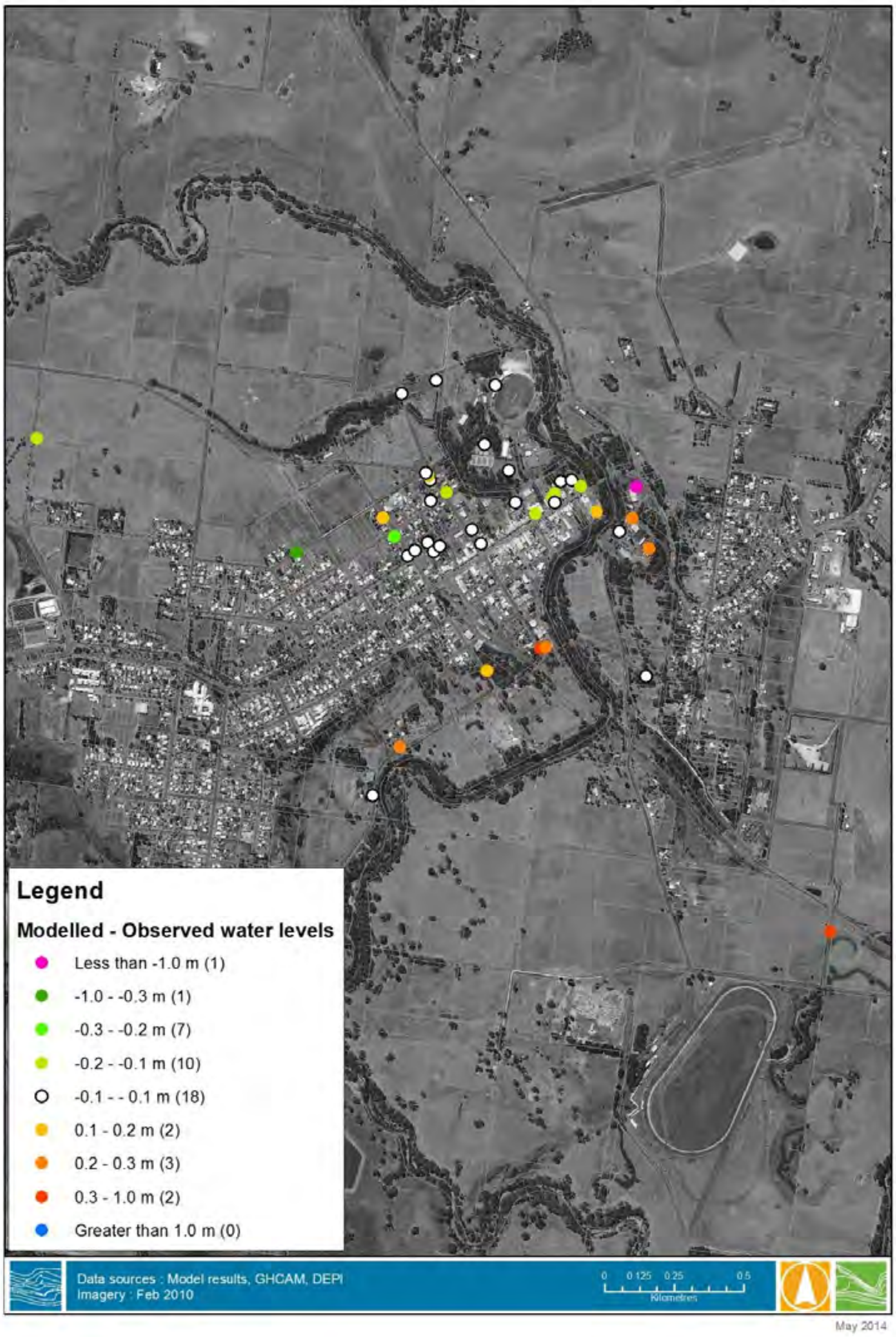


Figure 4-22 September 1983 modelled and surveyed peak water levels

Given Casterton is modelled in 1D with a relatively sparse set of cross sections it is expected some of the more isolated hydraulic controls may not be as well represented as if modelling was completed in 2D. However, the 1D model results match the surveyed levels relatively well with the model predicting 18 of the surveyed points to be within 100 mm of the surveyed level (41%), 30 within 200 mm (68%) and 40 within 300mm (90%).

4.2.3 Discussion

The 1D hydraulic models for reaches A through to D were shown to accurately match the observed gauge flows and levels with a uniform roughness for each reach. The required roughness chosen for each reach was varied to allow this calibration result to be achieved.

The roughness values used in each reach for both the December 2010 and September 1983 events are summarized in Table 4-8. The roughness values determined in the hydraulic model calibration were surprisingly high, however it must be noted they are representative of an average channel and floodplain value. Manning's n values of 0.07 and 0.2 are expected of "sluggish reaches, weedy, deep pools" and "very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush" respectively. A floodplain Mannings n of 0.07-0.1 would be expected of medium to dense brush or timber[30]. The values are within the higher end of the expected range, however they were found to be the best match to observed water levels and flows.

Table 4-8 Calibrated roughness values used in each reach and calibration event

Reach	Calibrated Mannings 'n' roughness value	
	December 2010	September 1983
B	0.067	0.067[31]
C	0.09	
D	0.1	0.1

During the hydraulic model calibration phase the RORB model inflows from sub-areas immediately contributing runoff to the Glenelg River were omitted. These inflows were found to cause significant overestimation of peak flows and levels in the Glenelg River. These sub-areas did not contain sufficient routing within the RORB model to reduce the peak flow appropriately. For example, subarea AZ with a catchment area of approximately 100 km^2 was immediately entering the Glenelg River contributing a peak flow of 77 m^3/s during the 1983 event, while a combination of subareas upstream of sub-area BD, with a combined area of 184 km^2, contributed a peak flow of 40 m^3/s. This was similar for other subareas immediately entering the Glenelg River. A hydrograph of the AZ and upstream of BD sub-area inflows to the Glenelg River are shown in Figure 4-23, with a RORB sub-area and reach map shown in Figure 4-24.

[30] Chow, 1959 – Open Channel Hydraulics

[31] Modelled as one reach as no gauge information was available at the Glenelg River at Harrow gauge

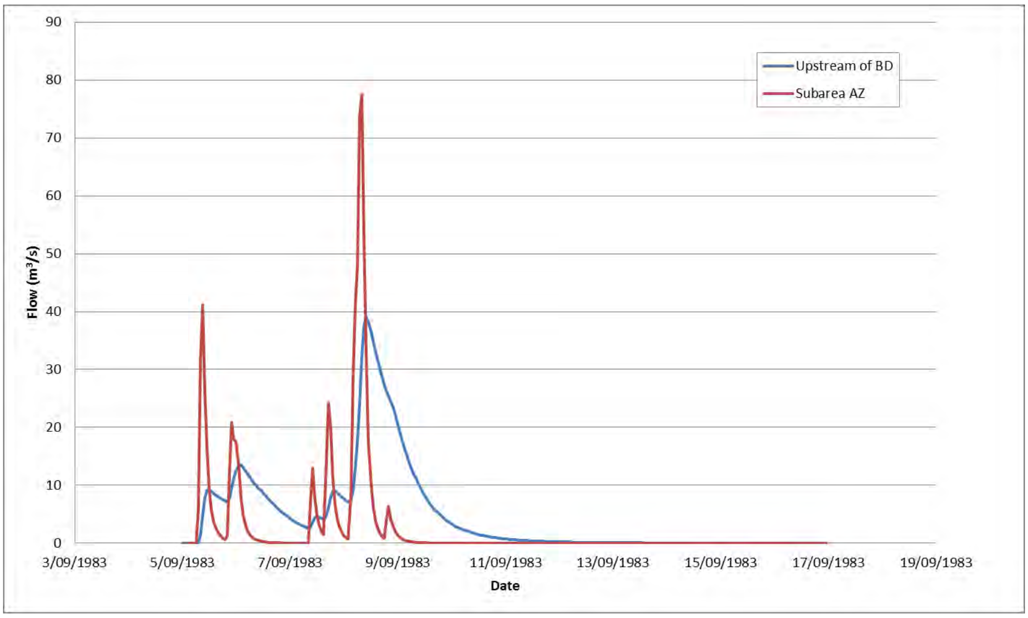


Figure 4-23 Subarea AZ and upstream of BD inflows to the Glenelg River

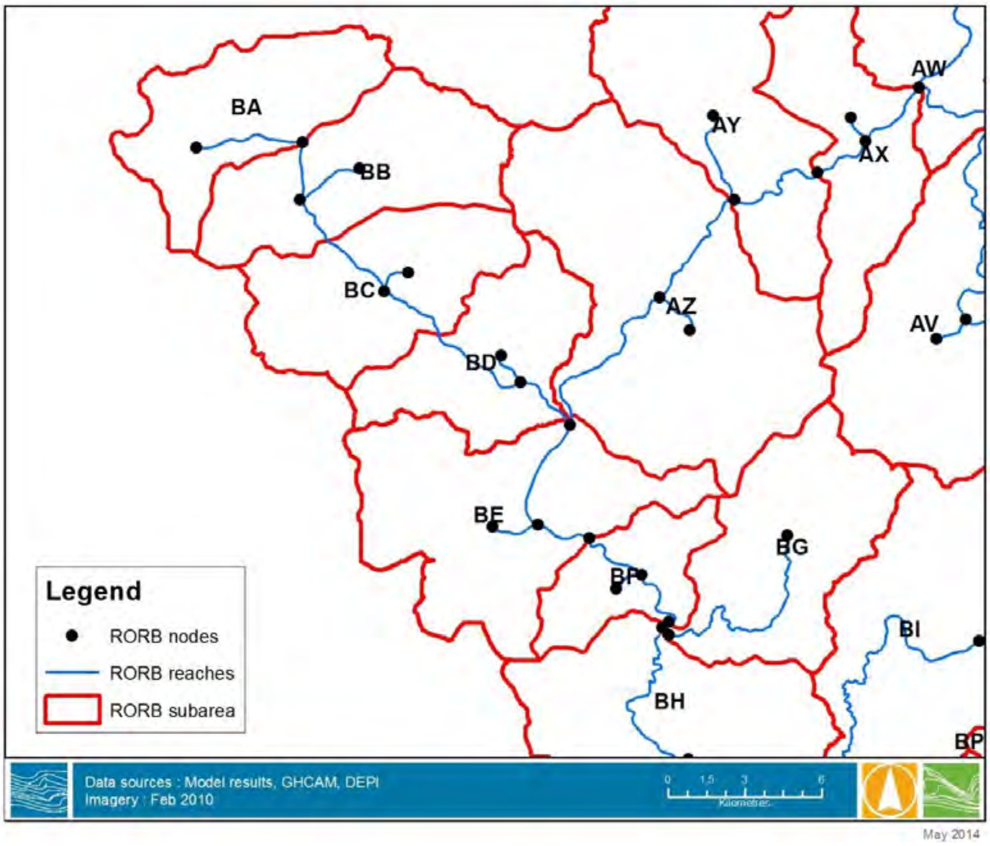


Figure 4-24 Sub-area inflows AZ and upstream of BD

As shown in the model calibration their omission from the 1D model has not caused any significant reduction to the hydrograph peaks or event volumes. In some cases there may be some initial flow lost in the early stages of the modelled events however this has not impacted the peak flows or levels.

4.3 Two Dimensional Modelling

4.3.1 Overview

A 2D model was developed reaching from Rocklands Reservoir to Harrow, giving this reach two sets of model results with varying methodologies. Modelling was completed in MIKE FLOOD.

The 2D hydraulic model limit is shown below in Figure 4-25.

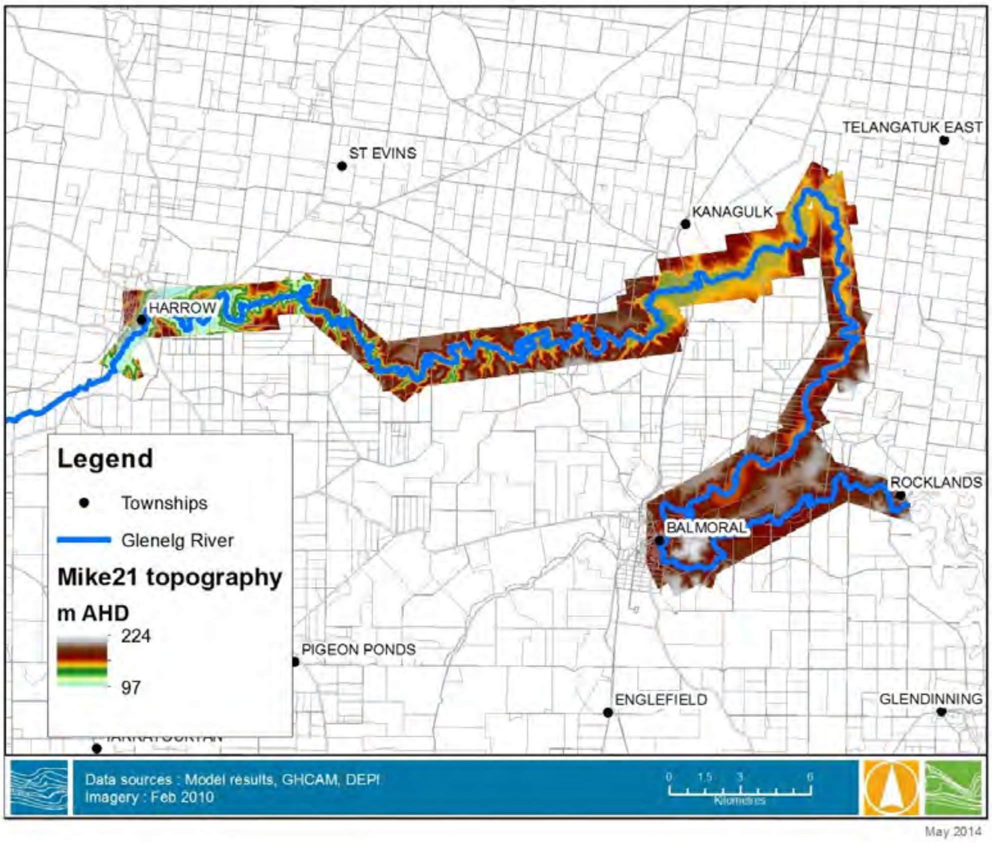


Figure 4-25 2D hydraulic model limits

4.3.2 Model development

Model topography

Similar to the 1D model the 2D model topography was developed from the ISC LiDAR data, the topography was lowered uniformly by 0.32 m, the same as applied to the 1D topography, as discussed in Section 2.4.4.

To assist in the determination of the 2D model grid cell size the LiDAR was resampled to resolutions of 2 m, 5 m, 10 m and 20 m, cross sections were then extracted from the topography and compared to the surveyed cross sections discussed in Section 2.4.3. Cross sections extracted at an example location in Harrow for the range of grid resolutions are shown Figure 4-26.

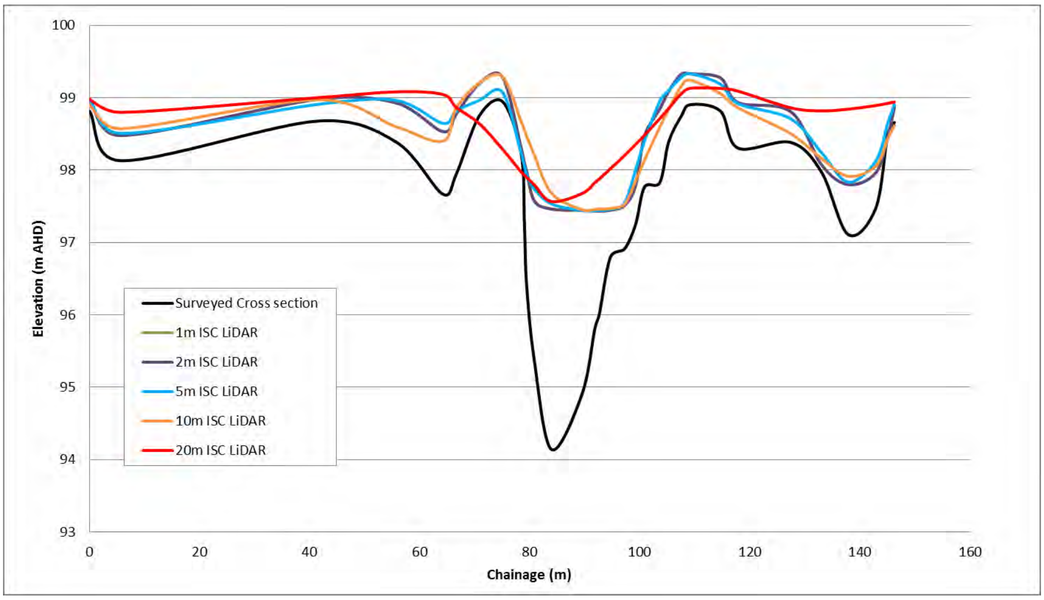


Figure 4-26 Cross sections extracted from various sample grid resolutions at Harrow

The extracted cross sections all lack some of the detail represented in the survey cross section, in particular areas that rise and fall dramatically and the area below the water surface at the time the LiDAR data was flown.

The 1, 2 and 5m resolution grids show the most defined cross sections, this then reduces somewhat at resolutions of 10 and 20 m. The channel form is still represented reasonably well at a grid resolution of 20 m, however the channel shape changes slightly.

The 2D model topography was required to cover the Glenelg River from the Rocklands Reservoir outlet to downstream of Harrow. Table 4-7 below shows the number of cells required in the X and Y direction for the model to cover this area at resolutions of 1, 2, 5, 10 and 20 m.

Table 4-9 The required number of grid cells in the X and Y directions to cover the 2D model area

Resolution	No. of cells required	
	X	Y
1 m	38,260	20,208
2 m	19,130	10,104
5 m	7,652	4,052
10 m	3,826	2,026
20 m	1913	1013

At resolutions finer than 20 m the number of grid cells required becomes too many to run a standard hydraulic model in a reasonable timeframe.

Given a resolution of 20 m results in an acceptable number of model grid cells and the Glenelg River channel remains relatively well represented it was chosen as the resolution for the model topography.

To ensure the Glenelg River channel depth was adequately represented the channel invert was lowered in a similar fashion to that completed in the 1D model with a uniform lowering. The channel centreline was set at the level represented in the 1m LiDAR then lowered by 1.5 m based on the lowest 1m LiDAR value within the channel.

Model Inflows/Outflows

Inflows to the 2D hydraulic model were distributed along the reach and inserted at the extent of the model topography. Inflows were either extracted from the RORB model, or in the case of model calibration gauged flows were input at the Fulham Bridge gauge. The model inflow locations are shown in Figure 4-27.

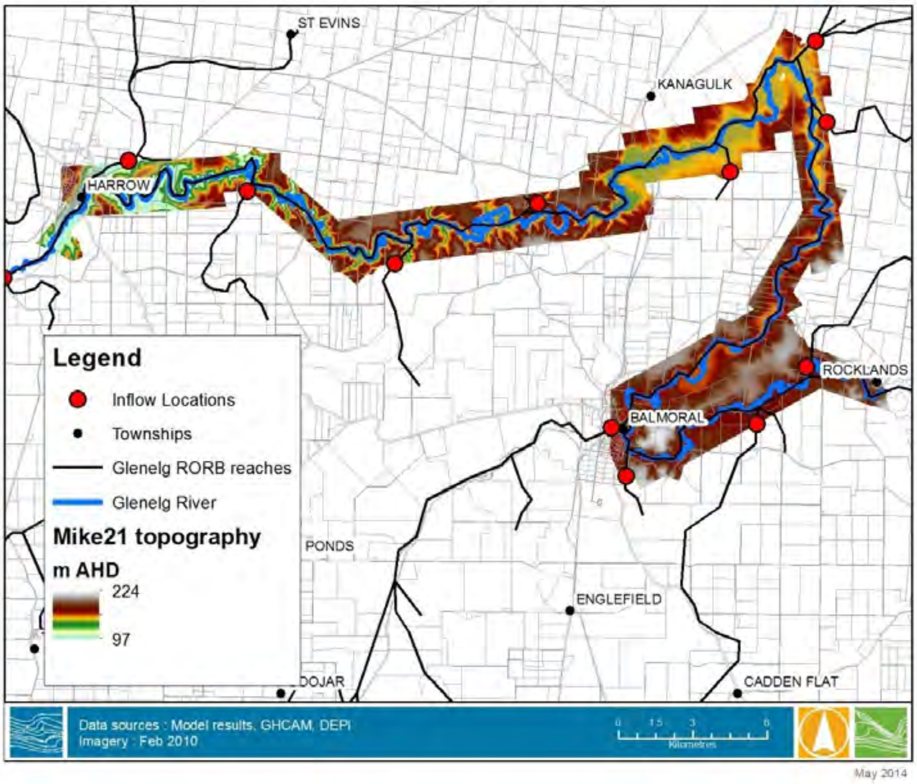


Figure 4-27 2D model inflow locations

The downstream model boundary was modelled as a 1D/2D link to the constructed 1D model, this allowed for a variable water level at the downstream end with a flowrate height relationship controlling the water level.

Model roughness

The 2D hydraulic model was run with a uniform Manning's 'n' roughness value; the uniform roughness value was used to calibrate the model and represented an average of the floodplain and riverine roughness.

The roughness values used in the model calibration and design modelling are discussed in Section 4.3.3 and 4.4.2 respectively.

4.3.3 Model Calibration

The 2D model was calibrated in a similar fashion to the 1D model, focusing on using gauged flows and surveyed peak flood heights. The September and December 2010 events had surveyed flood heights available and gauged flows and water levels were available for the September 1983 event.

The 2D model was run downstream of Fulham Bridge, utilising gauged flows as the model boundary. This removed any potential uncertainty in the RORB model flows. The RORB model was used to generate tributary inflows downstream of Fulham Bridge.

September 2010

There were seven flood marks surveyed of the September 2010 flood peak in Harrow. Unfortunately, only two of these were referenced to AHD and one was referenced to a gauge board on the Glenelg River with an unknown gauge zero.

A comparison of the hydraulic model results, surveyed flood marks and maximum level reached at the Harrow Streamflow gauge are shown in Figure 4-28.

The surveyed flood marks matched the modelled peak levels and extents using a uniform Manning's 'n' roughness of 0.06. All flood marks were on the extent of inundation, aside from the gauge board location. The two marks with a reference to AHD matched the model results within 3 cm and 1 cm.

The maximum level reached at the Harrow streamflow gauge was 99.48 m AHD. This compares to a modelled level of 99.54 m AHD, within 6cm of the recorded level.

A comparison was made between the modelled and observed water levels at the Harrow gauging station as shown in Figure 4-28.

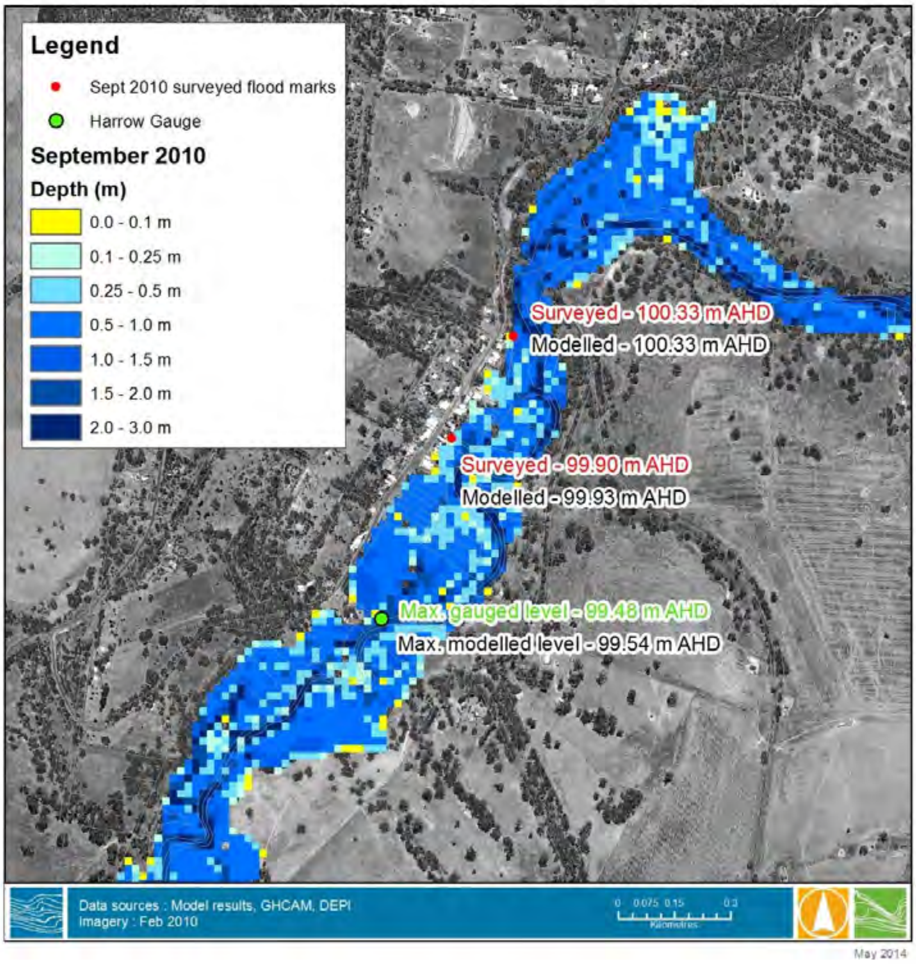


Figure 4-28 September 2010 1D-2D model results and surveyed flood marks

The Harrow streamflow gauge recorded a peak flow of 54.1m^3/s, whereas the hydraulic model calculated a peak flow of 61.1m^3/s at the gauge location.

September 1983

The September 1983 event was modelled in the 2D hydraulic model; however no calibration points or gauge information was available within the model extent. The event was run in the 2D model to form a comparison against the 1D model calibration discussed in Section 4.6.

The depth and extent of inundation during the 1983 event is shown below in Figure 4-29.

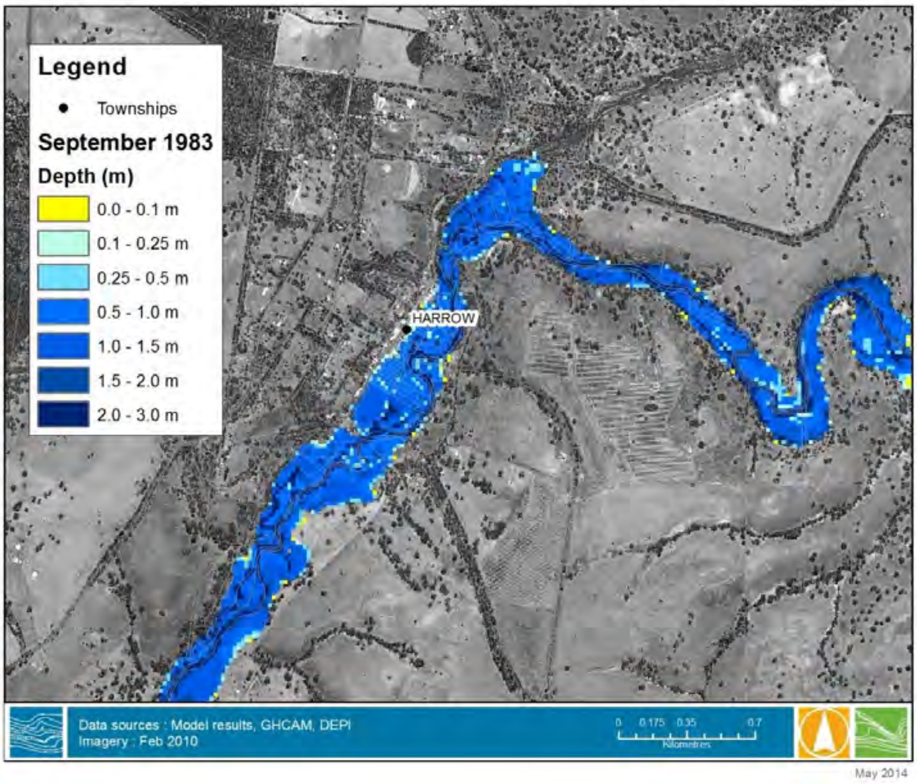


Figure 4-29 **September 2010 1D-2D model results and surveyed flood marks**

4.4 Design Modelling

4.4.1 1D Model

Design modelling was competed using each of the 1D model components individually with the Glenelg River and tributaries modelled separately. The Glenelg River was modelled matching the RORB design flows and FFA (where available) along the waterway at each of the gauge locations, whereas the tributaries were modelled distributing the downstream RORB model peak flow along each reach. Using the RORB model inflows directly in each tributary reach was shown to cause an overestimation of the peak flow due to different routing between the RORB and hydraulic models.

Modelling was completed using the uniform calibrated roughness values for the December 2010 event, as shown in Table 4-10.

Table 4-10 M11 design roughness

Reach	Calibrated Mannings 'n' roughness value
A	0.067
B	0.067
C	0.09
D	0.1
Tributaries	0.067

A comparison of the 1% AEP flows determined using FFA, RORB and 1D model for each comparison location shown in

Table 4-14, hydrographs for each location are also shown in Table 4-11.

Table 4-11 1% AEP FFA, RORB and M11 peak flow comparison

Location	Peak Flow (m³/s)		
	FFA	RORB	M11
Fulham Bridge	145	146	146
Harrow	-	163	169
Dergholm	-	311	330
Casterton	302	302	305

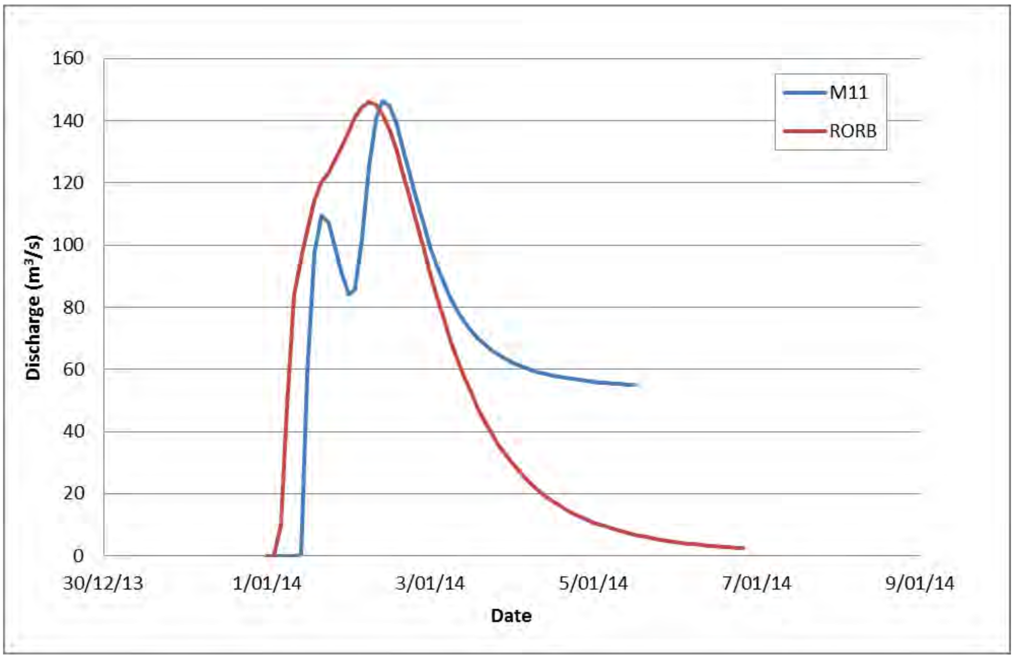


Figure 4-30 1% AEP Fulham Bridge RORB and M11 flow comparison

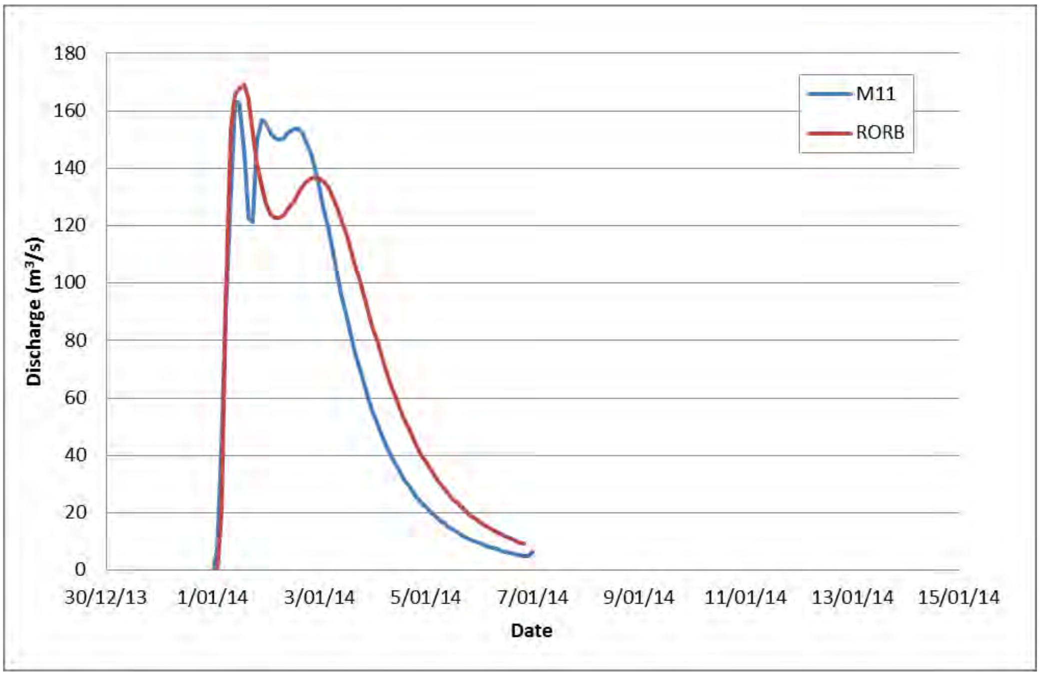


Figure 4-31 **1% AEP Harrow RORB and M11 flow comparison**

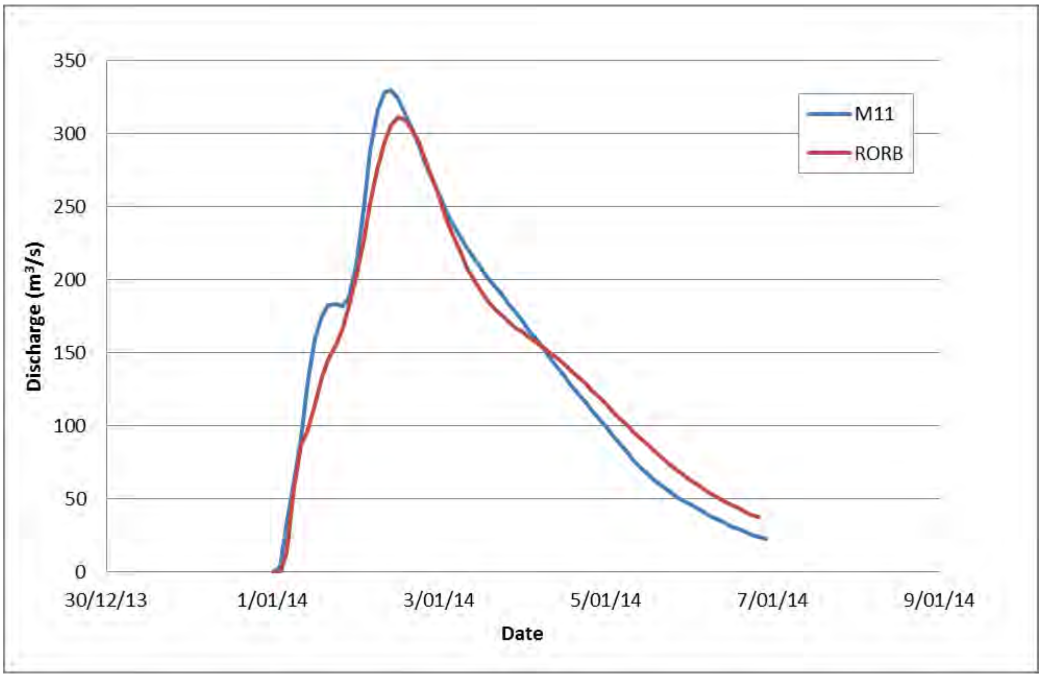


Figure 4-32 **1% AEP Dergholm RORB and M11 flow comparison**

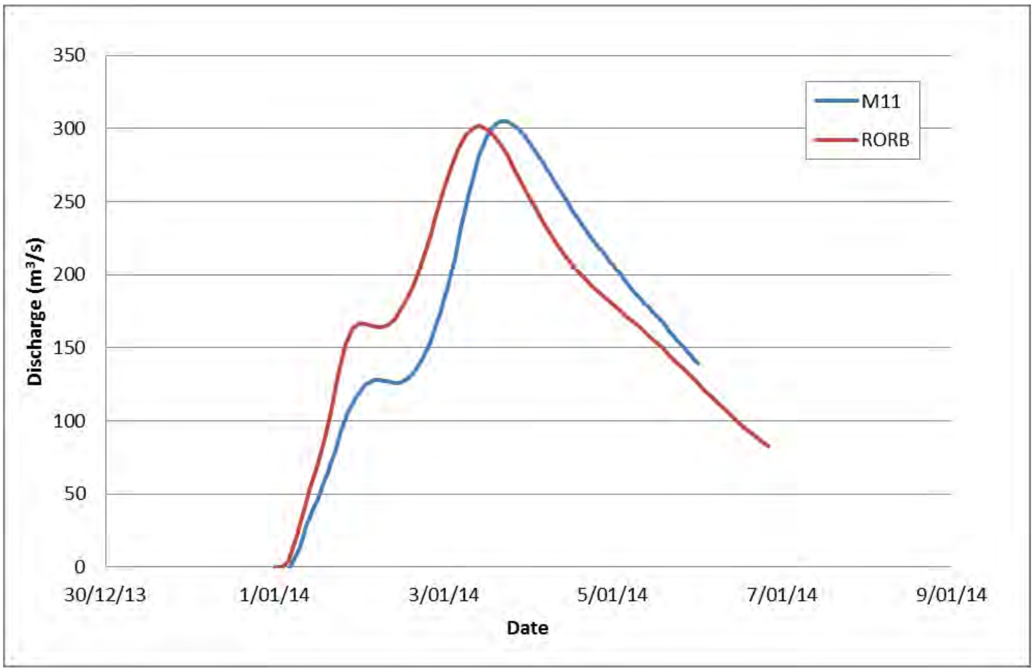


Figure 4-33 1% AEP Casterton RORB and M11 flow comparison

Comparisons of the 20, 10, 5, 2 and 0.5 % AEP event peak flows at each gauge location are shown in Appendix D with hydrographs shown in Appendix E.

4.4.2 2D model

Design modelling completed in the 2D model was completed using the uniform roughness value determined in the September 2010 and December 2010 calibration events, a Mannings 'n' of 0.06. Although a value of 0.06 is considered relatively high for riverine floodplain, it has shown to produce an accurate representation of water levels across two events and is a generalised value of both the Glenelg River floodplain and river.

Similar to the 2D model calibration and the 1D design modelling, RORB model inflows were used which matched the FFA completed at each gauge location.

There are two streamflow gauge locations within the 2D model extent, Dergholm and Harrow, as shown in Figure 4-33.

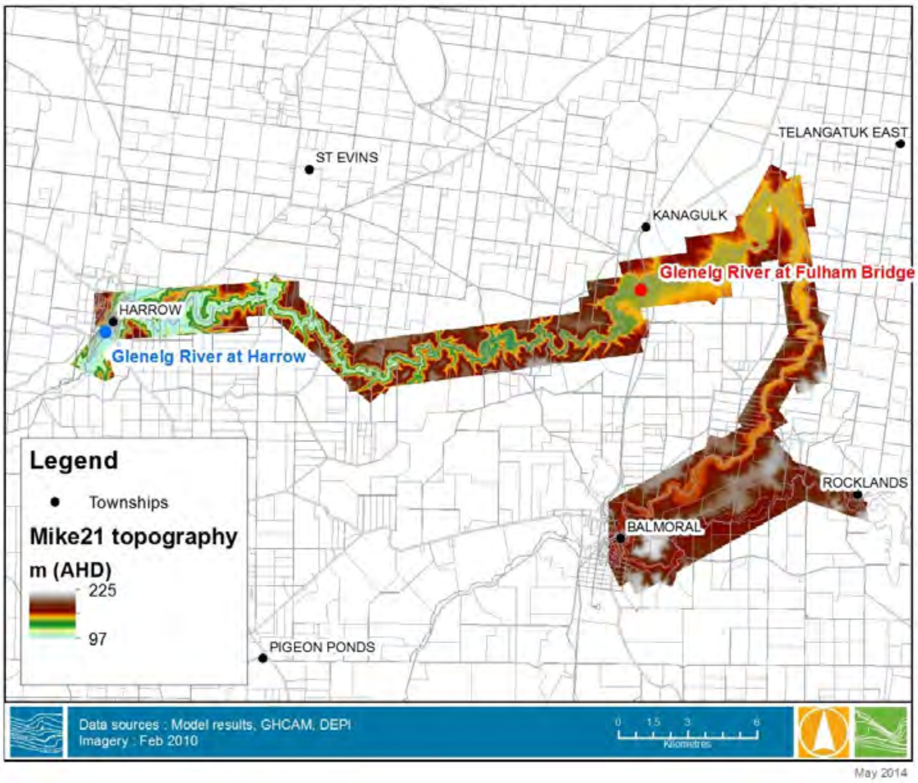


Figure 4-34 2D model extent gauge locations

Peak flows were extracted at each of the gauge locations for comparison to the FFA, RORB and 1D model peak flows.

The comparison of 1% AEP peak flows is shown in

Table 4-12, with hydrograph comparisons for Fulham Bridge and Harrow shown in Figure 4-35 and Figure 4-36 respectively.

Table 4-12 1% AEP FFA, RORB, M11 and M21 peak flow comparison

Location	Peak Flow (m^3/s)			
	FFA	RORB	M11	M21
Fulham Bridge	145	146	146	148
Harrow	-	163	169	160

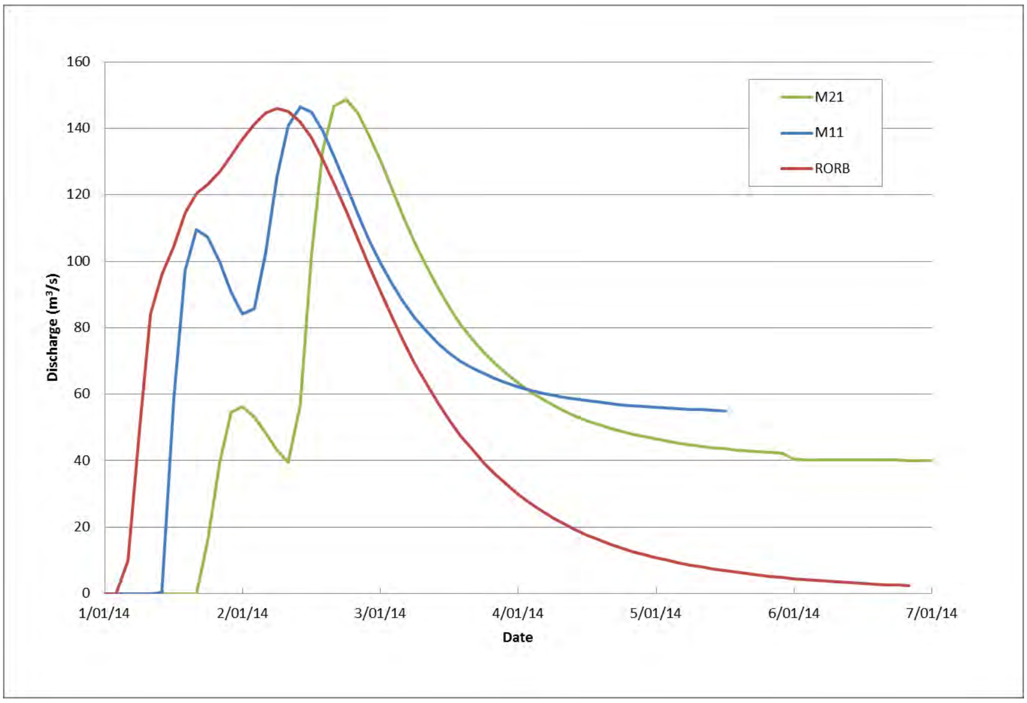


Figure 4-35 1% AEP RORB, M11 and M21 hydrograph comparisons at Fulham Bridge

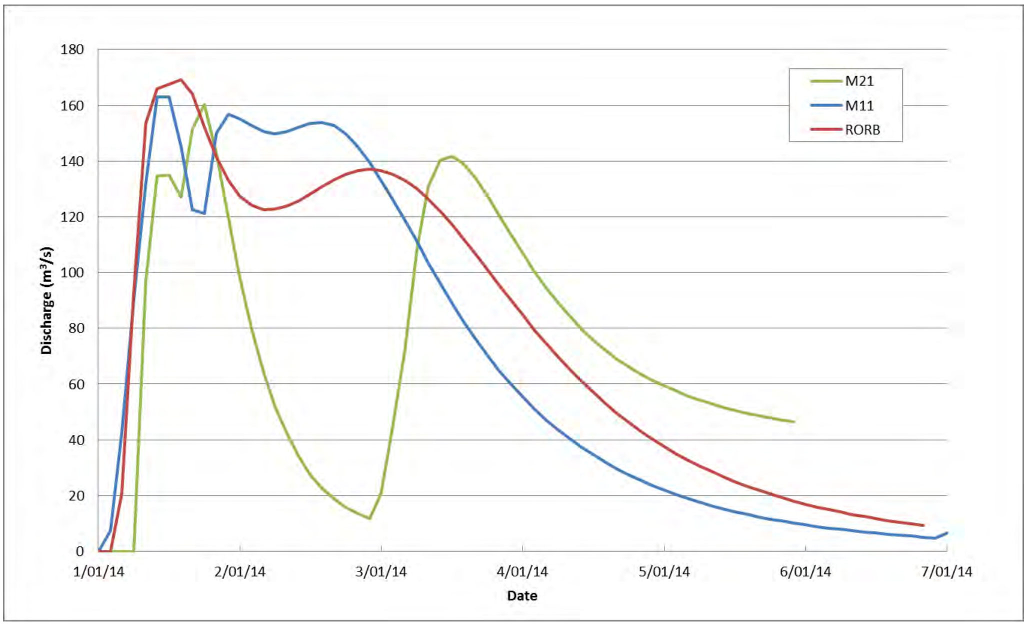


Figure 4-36 1% AEP RORB, M11 and M21 hydrograph comparisons at Harrow

Peak flow and hydrograph comparisons are shown in Appendix F and G respectively.

4.5 Model Comparison

A comparison of the 1D and 2D hydraulic model results was made using the 1983 calibration event and across the modelled design events. Comparisons using a calibration event and a design event provide two perspectives; the hydraulic models have been calibrated to the 1983 event and modelled with observed flows, whereas the design events have generated flows and no calibration has occurred.

4.5.1 1983 Event Comparison

A comparison of flows and water levels was made at the Glenelg River gauging station at Harrow (the 2D model was run from Fulham Bridge to Harrow only). Unfortunately no gauge recordings were made during the event.

Comparisons of flow and level are shown below in Figure 4-37 and Figure 4-38. A comparison of the peak flow, level and timing is also shown in Table 4-13.

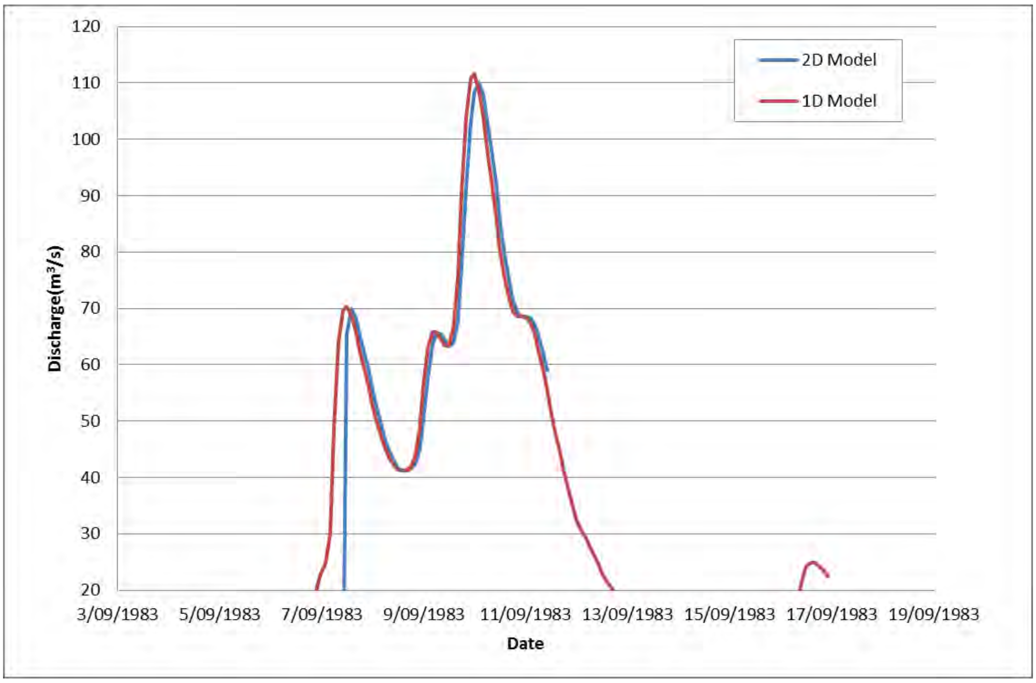


Figure 4-37 **1D and 2D flows extracted at the Glenelg River at Harrow gauging station**

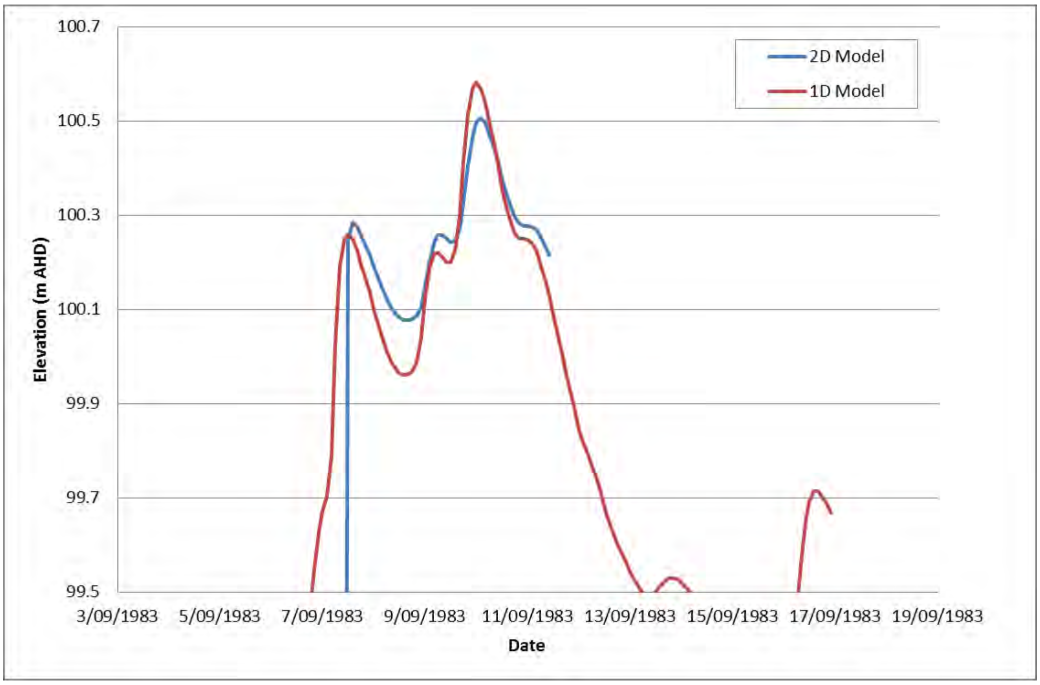


Figure 4-38 **1D and 2D levels extracted at the Glenelg River at Harrow gauging station**

Table 4-13 **Comparison of 1D and 2D peak flow, level and timing**

	2D	1D	Difference

Peak flow (m^3/s)	110	112	2 (2%)
Peak level (m AHD)	100.51	100.58	0.07
Peak timing	10/09/1983 2:00	10/09/1983 0:00	2 hours

A spatial comparison of water levels was also completed to demonstrate how the water levels varied across the floodplain. A long section comparison of water levels extracted at each cross section location is shown in Figure 4-39.

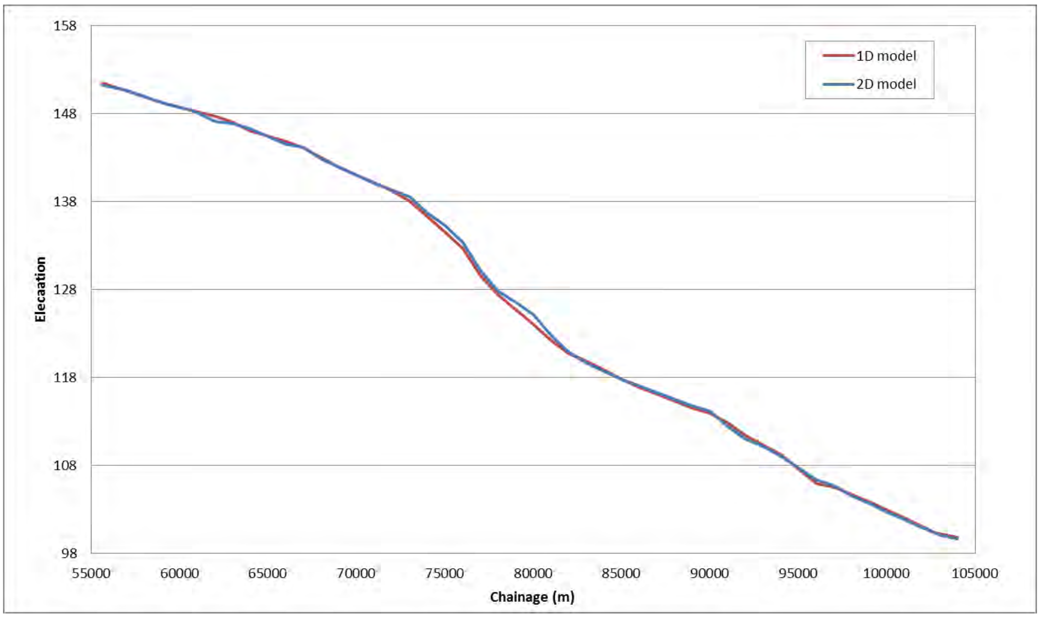


Figure 4-39 Comparison of the 1D and 2D water surface elevations

The comparison of water levels showed a general match along the waterway. There was no consistent difference between the two model results. On average the 2D model was 7cm higher than the 1D results. This may have been influenced by several instances where the 2D model was greater than 0.5 m higher than the 1D between chainage 72,000 m and 82,000 m.

The 1D model results were subtracted from the 2D to provide a summary of the differences in the maximum water levels as shown below in

Table 4-14.

Table 4-14 Comparison of 1D and 2D water levels

	2D – 1D (m)
Mean difference in water level	0.07
Maximum difference in water level	1.04
Minimum difference in water level	-0.591
Standard Deviation	0.36
% of instances the 2D results were higher	50%

The model result comparison shows the split between the instances the 2D model is higher than the 1D is 50%. However, where the 2D model has produced higher elevations than the 1D model, they are likely to be greater. This shows no bias in the comparison of 1D and 2D results.

4.5.2 Design Event Comparison

A comparison of the 1D and 2D model results for the 1% AEP event was shown briefly in Section 4.4.2. This section expands on that comparison across the range of modelled design events and compares water levels and extents additional to flows.

The 1D and 2D model peak flows are shown in Table 4-15 and

Table 4-16 for the Fulham Bridge and Harrow gauge locations. The tables also show the difference in the 1D and 2D peak flows.

Table 4-15 Comparison of 1D and 2D across the modelled peak flows at Fulham Bridge

Event AEP (%)	Peak Flow (m^3/s)		Difference (%)
	1D	2D	
20	78	63	15
10	104	92	12
5	123	94	29
2	139	139	0
1	146	148	-2
0.5	150	152	-2

Table 4-16 Comparison of 1D and 2D across the modelled peak flows at Harrow

Event AEP (%)	Peak Flow (m^3/s)		Difference (m^3/s)
	1D	2D	
20	87	67	20
10	133	100	33
5	137	127	10
2	153	147	6
1	169	160	9
0.5	185	182	3

The model results indicate that at lower flows there is a larger disparity between the peak flows in the 1D and 2D models. This is especially prevalent in the 20 and 10% AEP event. At the 2% AEP event and above the difference in peak flow becomes quite small. This indicates that the 2D model may include additional storage in the model as compared to the 1D model, and this may be leading to additional attenuation in the lower events where volume becomes more critical. It may also be indicative of the lower resolution of the channel form in the 2D, with only a few grid cells representing the lower flow channel. For the small events where flow is constrained to the low flow channel, this becomes more critical.

A comparison of the water levels at Fulham Bridge and Harrow gauge locations is shown in Table 4-17 and

Table 4-18 respectively. When discussing differences in water level throughout this report the calculation was made 2D result minus 1D result (2D-1D). Positive numbers indicate the 2D model results are higher, negative numbers indicate the 1D result is higher. The difference between the model results is also shown in Figure 4-39 and a closer perspective in Figure 4-41.

Table 4-17 Comparison of 1D and 2D across the modelled water levels at Fulham Bridge

Event AEP (%)	Peak Water Level (m AHD)		Difference (m) (2D-1D)
	1D	2D	
20	150.96	151.26	0.3
10	151.14	151.43	0.29
5	151.27	151.55	0.28
2	151.34	151.65	0.31
1	151.37	151.69	0.32
0.5	151.39	151.71	0.32

Table 4-18 Comparison of 1D and 2D across the modelled water levels at Harrow

Event AEP (%)	Peak Water Level (m AHD)		Difference (m) (2D-1D)
	1D	2D	
20	100.00	99.75	-0.25
10	100.36	100.02	-0.34
5	100.53	100.23	-0.3
2	100.67	100.38	-0.29
1	100.78	100.48	-0.3
0.5	100.93	100.60	-0.33

The comparison of the 1D and 2D model peak water levels show the 2D model to be predicting higher water levels at Fulham Bridge, and lower water levels at Harrow. The differences at each location are similar in magnitude, but inverse.

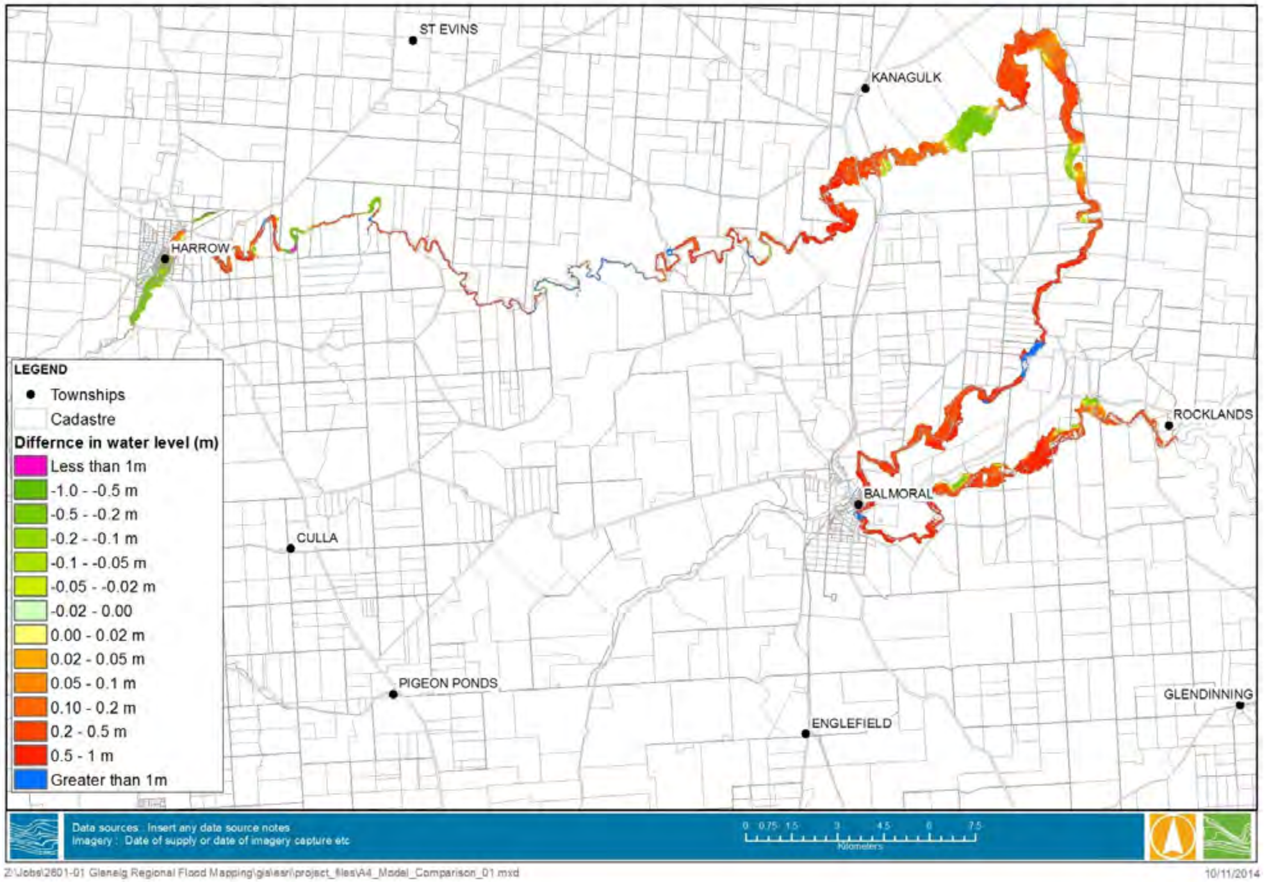


Figure 4-40 Comparison of the 1D and 2D water surface elevations over the model extent

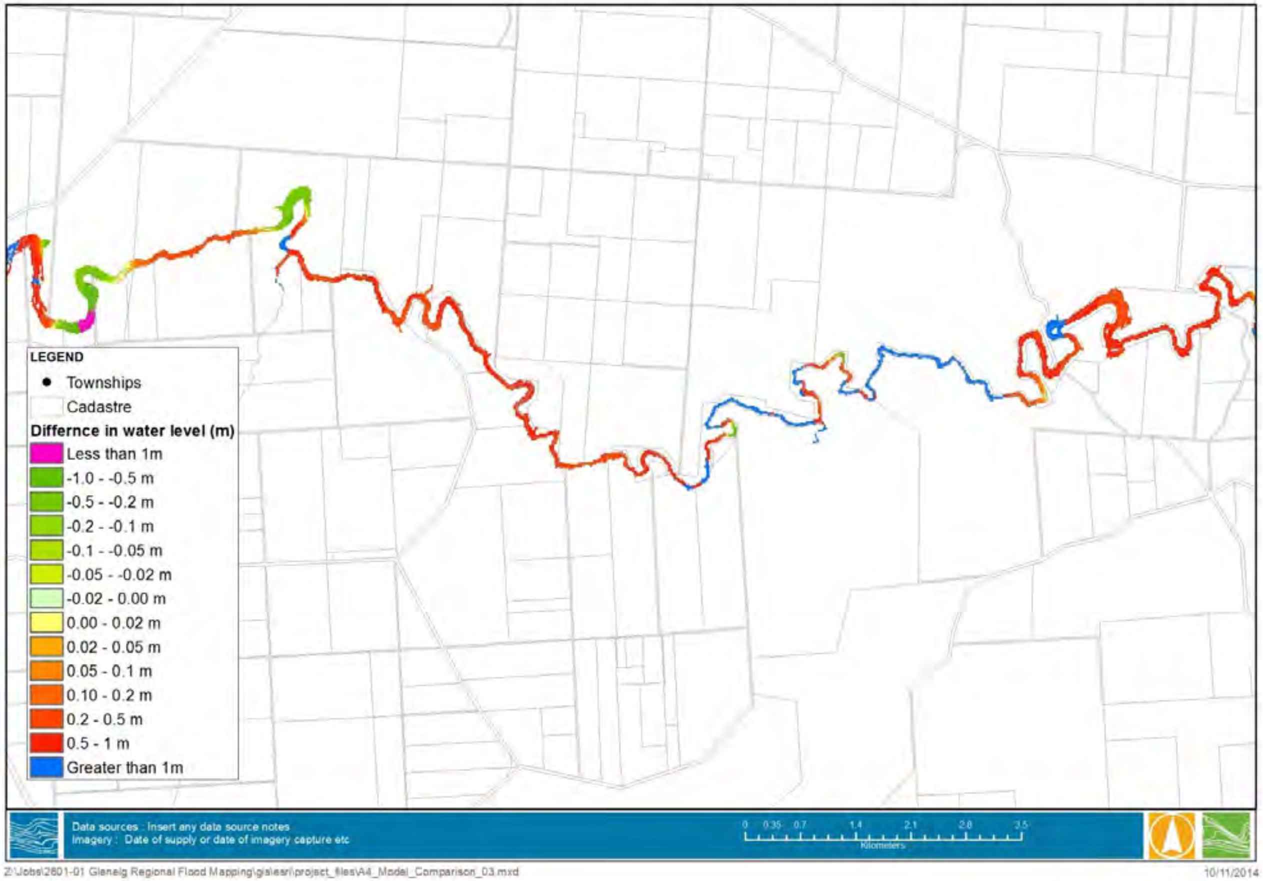


Figure 4-41 Comparison of the 1D and 2D water surface elevations along the most confined section of the Glenelg River

Over the 2D model extent there are differences in flood level both negative and positive. In general, the confined sections of waterway have the 2D model producing higher results and in broader sections of floodplain the 1D model produces higher results.

Larger discrepancies were also observed on large meanders where the density of cross sections in the 1D model may not be accurately representing water levels over the waterway length, with the 1D Triangulated Irregular Network (TIN) linearly interpolating across a meander bend without incorporating appropriate hydraulic losses.

4.6 Discussion

4.6.1 Flow

The compared hydraulic model flows at the Fulham Bridge and Harrow gauging stations showed similar peak values at the higher end of the modelled AEPs. However, at the smaller AEPs the 2D model flows were less than the 1D. This is likely to be due to the a more confined waterway and the channel form not as well represented with 20m topographic grid cells as compared to cross sections causing an artificial increase in the 2D attenuation. There may also be an increase in storage in the 2D model that results in increased attenuation and lower peak flows.

The shape and timing of the 1D and 2D hydrographs at Fulham Bridge were not significantly different with the 2D showing a slight delay in timing and a lower initial peak flow (Figure 4-35). However, at the Harrow gauging station the hydrograph shape and timing are significantly different with the secondary peak delayed and a larger double peak hydrograph. The 2D model attenuates flow along the Glenelg River significantly more than the 1D model.

4.6.2 Water level

Differences in water level between the 1D and 2D mapping varied according to the channel and floodplain shape. In general, confined sections of waterway yielded higher 2D model results, broader sections of floodplain higher 1D model results. The 1D model is likely to have represented the confined sections of waterway better, with the 2D model representing the larger floodplain areas better.

In confined sections of waterway an overestimation of water levels is not as relevant to planning overlays as the waterway is entirely confined within the waterway reserve. However, for the purpose of setting bridge deck heights, levels are more important. For extent mapping purposes the 2D model may give more accurate representation of the area inundated in broad floodplain areas.

5. MAPPING

5.1 Overview

As specified in the project brief VFD format extents and contours were produced for each of the modelled events for both modelling methodologies. This included water surface elevation contours, and inundation extents for the 1D model, and depth, elevation and velocity grids for the 2D model.

Each of these datasets was provided with appropriate metadata stating the source and methods, etc. but importantly linking it to relevant gauge heights for all active gauges.

The 1D and 2D model results require different processing methodologies to produce the required mapping outputs each of these methodologies are discussed below.

5.2 One dimensional model results

The 1D hydraulic model results were used to produce maps and GIS layers of extent, depth and water surface elevation. Depth extents and water surface elevation contours were developed inline with the VFD study outputs. A linear interpolation of the maximum water surface elevation reached at each cross section will be used to develop a spatial representation of the level reached along each of the modelled waterways. This will be completed using MapInfo's Vertical Mapper; the maximum triangle length will be varied to suit each section of waterway. The 1m ISC LiDAR grid (lowered by 0.32 m as discussed in Section 2.4.4) will then be subtracted from the water surface elevation grid giving refined depths and extents. The refined extent will be used to clip the results ensuring an accurate representation of the results is achieved.

It must be noted that the 1D model results do have some limitations as compared to 2D modelling, in that water surface elevations will be interpolated linearly between cross-sections, so if the river meanders between cross-sections this change of direction will not be accounted for. In addition velocities are cross-sectional average velocities so the results will not resolve the variable nature of flow velocity distributions across the river/floodplain cross-section.

5.3 Two dimensional model results

Mapping of the 2D results was directly exported to GIS grids and mapped for extent, depth, water surface elevation and velocity.

The 2D model results were exported directly from MikeFlood in a mappable format and no edits were required.

6. CONCLUSION

Developing flood extents and levels for an entire catchment requires several trade-offs in both the hydrologic and hydraulic components. Estimating flows for tributaries and the main river at different locations in the catchment can be challenging where gauge data is not available. Using a rainfall-runoff approach model parameters are required, these parameters may vary according to catchment characteristics and sub-area delineation.

Different hydraulic modelling approaches can be employed for a range of flood mapping scenarios and individual catchments. 2D hydraulic models must be maintained at a reasonable spatial dimension to ensure grid cell resolution adequately defines a waterway bed and banks while still covering the area of interest. 1D hydraulic models must maintain a cross section density high enough to ensuring all waterway hydraulic controls and broad floodplain areas are accurately represented. This can be difficult to achieve in highly sinuous systems.

This project has produced flood levels and extents using both 1D and 2D hydraulic models. The water levels produced by each model varied depending on the location on the waterway. How appropriately each model is predicting flood levels is largely dependent on location with no methodology necessarily better than the other in general terms. The use of each methodology is purely dependent on the system and range of flows to be modelled trading off the pros and cons of each.

Developing a complex 1D model was found to take longer than the equivalent 2D model, with more thought required in schematising a 1D model and more room for error. Although the 2D model was faster to setup, its run times were orders of magnitude slower. Other differences in the results were found in relation to the cross-sectional averaging of the 1D model as compared to the 2D model, with water breaking across meanders often behaving significantly differently in water level and velocity. Proper hazard mapping is not achievable using the 1D modelling approach due to the cross-sectional averaging not allowing for an accurate representation of velocity. The major limitation of the regional scale 2D model was found to be the grid scale, with a coarse grid unable to fully resolve the channel definition in confined and meandering sections of river. This has now been somewhat rectified by the implementation of GPU modelling, which is now available for use commercially, has been benchmarked and tested and is ready for use (dependent on the 1st order or 2nd order spatial discretisation schemes employed by the software).

The 1D project outputs are considered of sufficient accuracy for the development of Land Subject to Inundation Overlay (LSIO) and Flood Overlay planning scheme layers, however some caution must be used in using the water surface elevations for setting building floor level heights. The 2D model is also considered of sufficient accuracy to be used in the development of planning scheme layers. In the areas of model of overlap it is recommended both sets of model results be reviewed and the most appropriate water levels be used dependent on individual locations. Water levels in the modelled must also be treated with some caution.

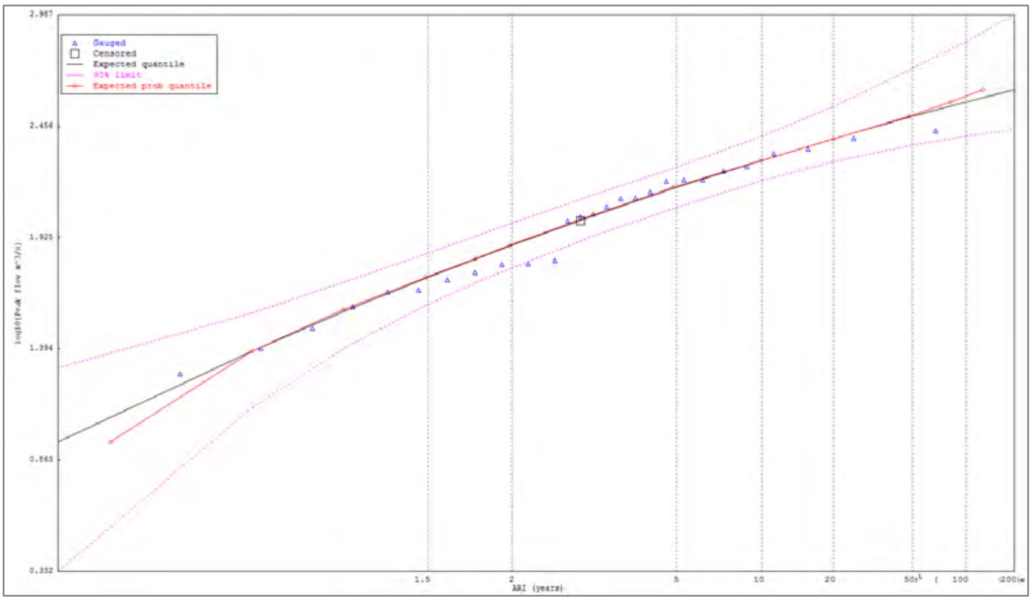
The modelled water levels, depths and extents are all appropriate for use in emergency response. The RORB model can be used for a reference for the timing of inundation rather than the 1D model due to its segregated nature. It is also always best to compare to raw historic events rather than relying on model predictions alone.

The extent mapping completed is suitable for use by insurance companies to assist in understanding flood risk for individual properties. Some caution must be used along the modelled Glenelg River tributaries and sites must be assessed for individual characteristics, however they will provide a guide better than any other information currently available.

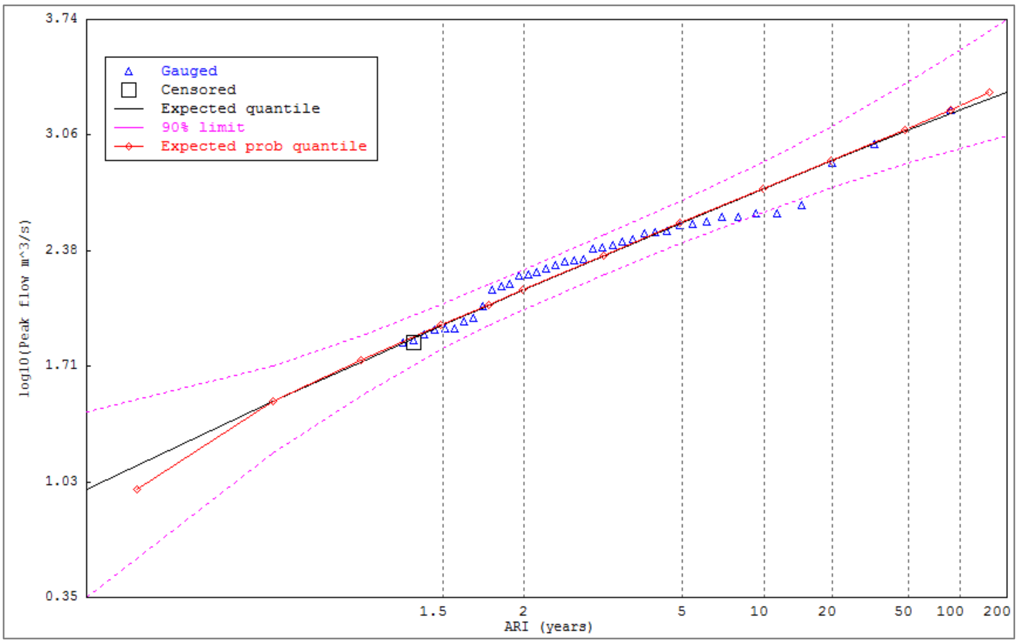
If Water Technology was to undertake this project again we would strongly encourage the use of MIKE 21 GPU, allowing finer grid resolutions and faster run times.

APPENDIX A FFA GRAPHS AND ANNUAL SERIES

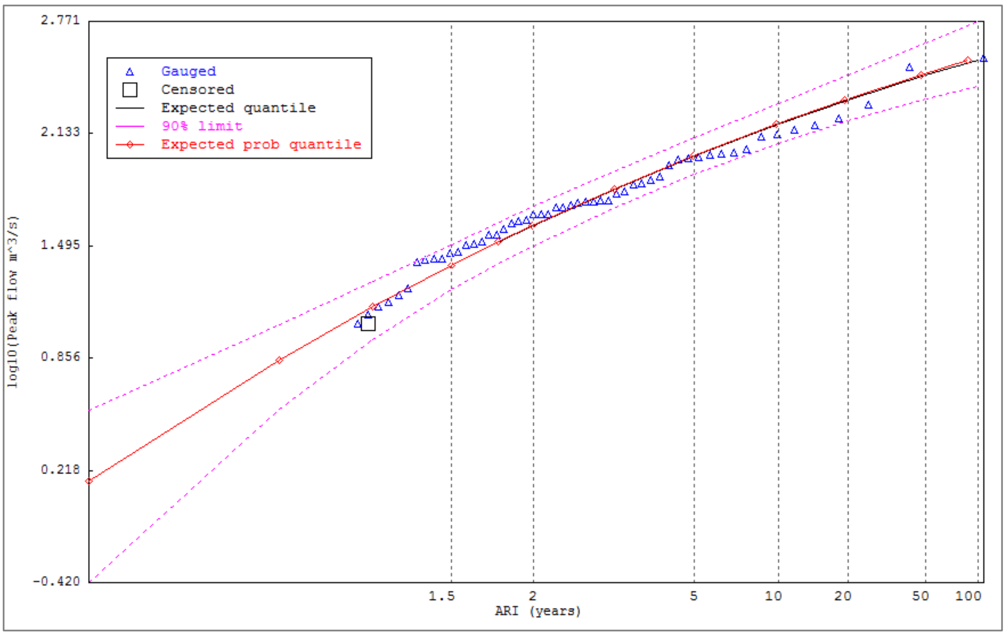
Glenelg River at Big Cord – Censored 2.38 m³/s



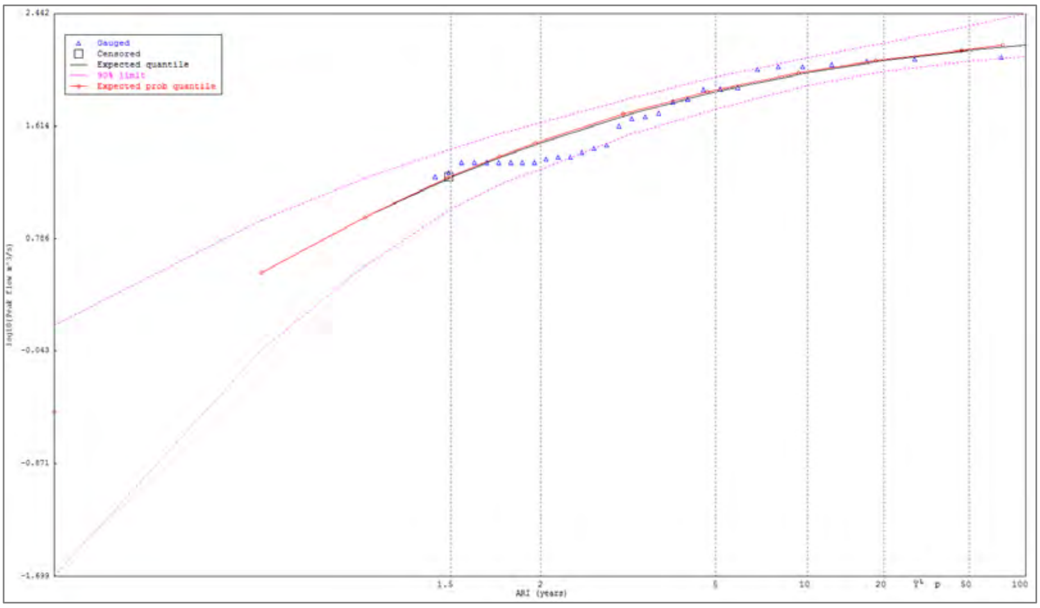
Glenelg River at Rocklands – Censored 2 m³/s



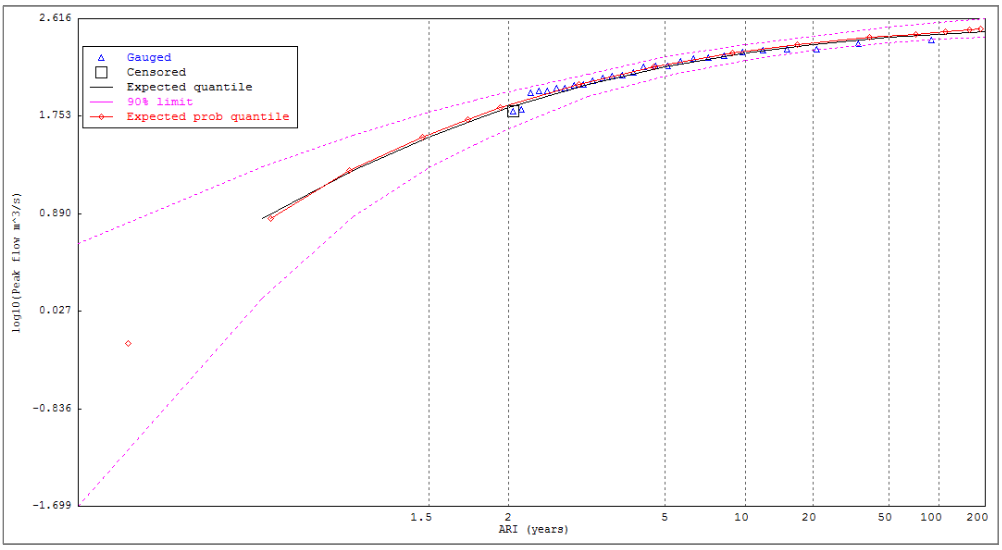
Glenelg River at Balmoral - Censored 11.27 m³/s



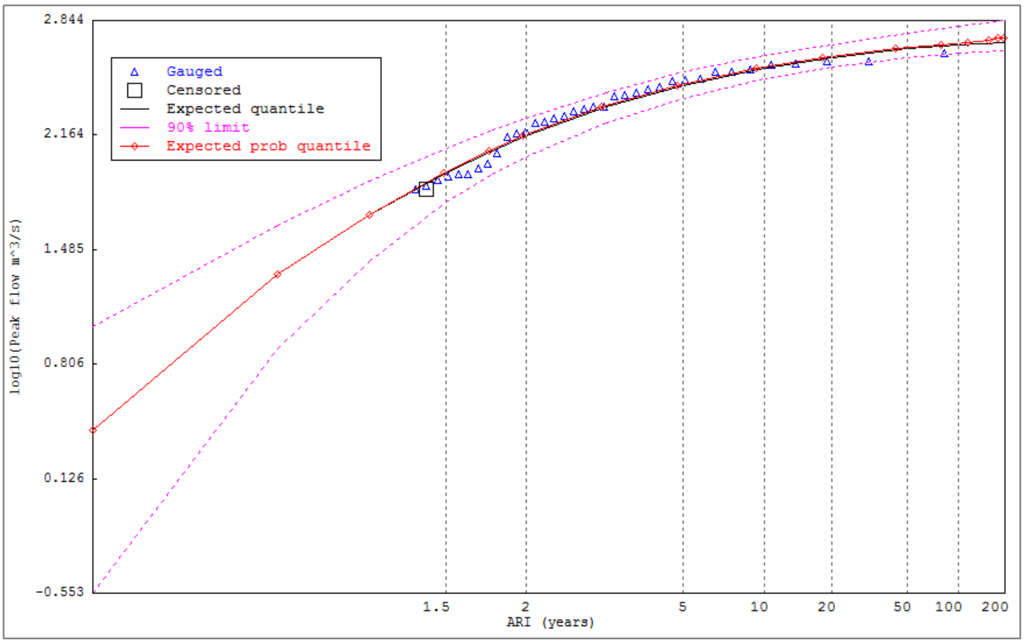
Glenelg River at Fulham Bridge – Censored 17m³/s



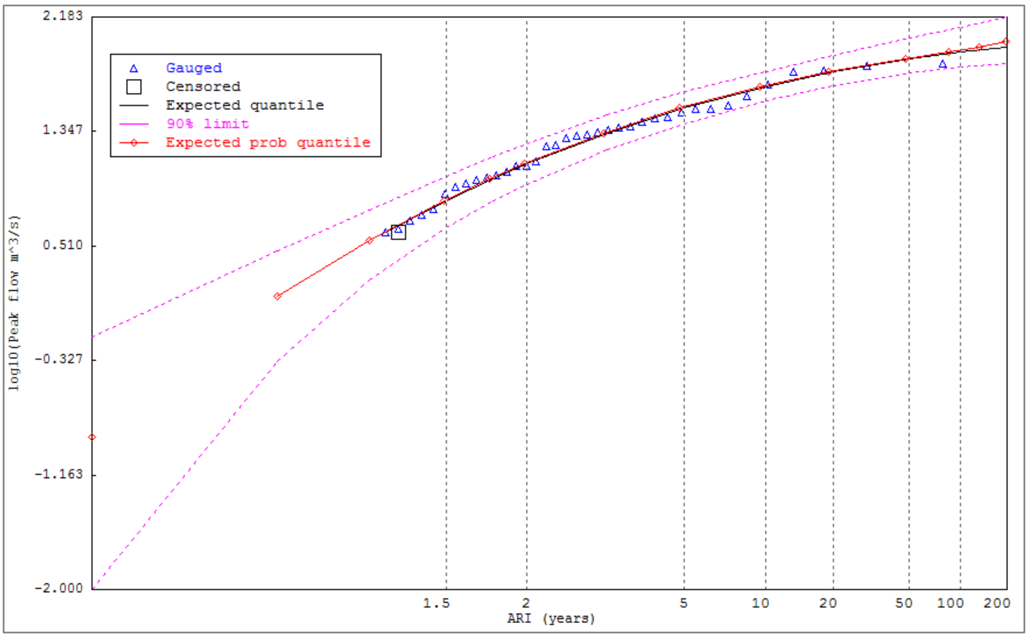
Glenelg River at Casterton



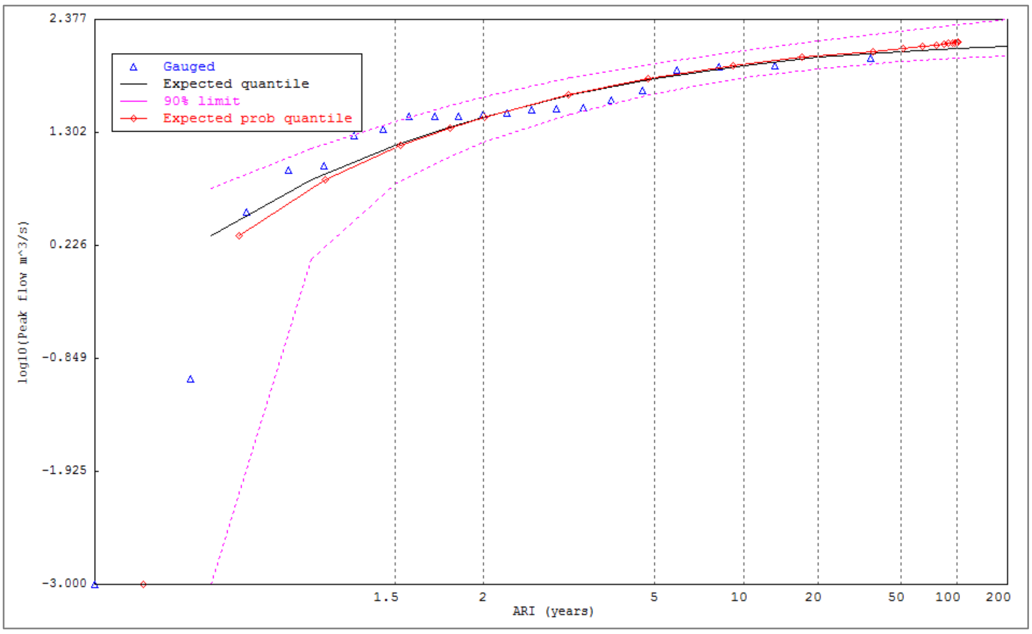
Glenelg River at Sandford - Censored at Low flow 70 m³/s, high flow 790 m³/s



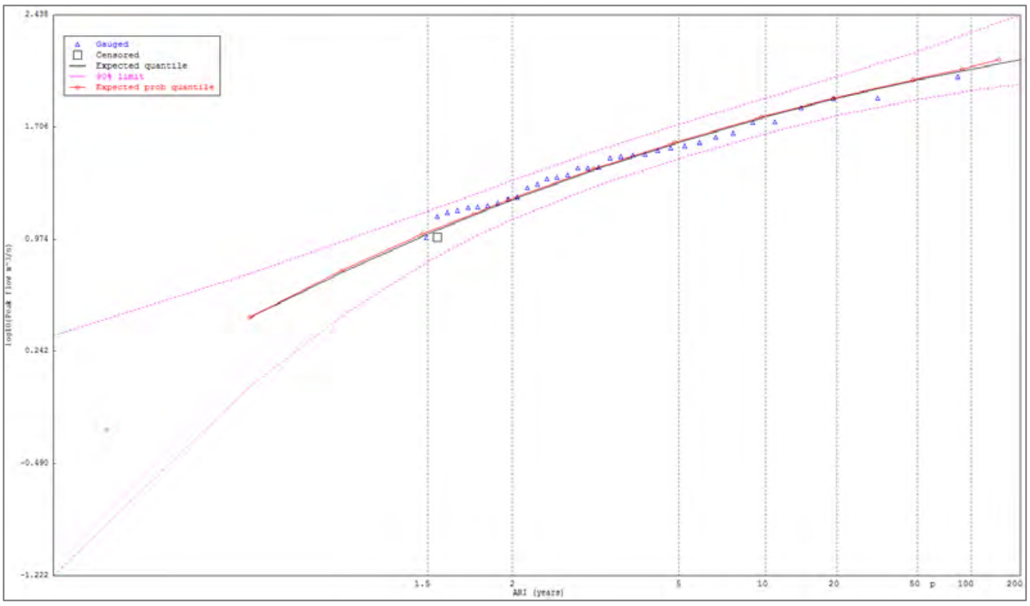
Chetwynd River at Chetwynd – Censored 4.11 m³/s



Pigeon Ponds Creek at Pigeon Ponds – No censor

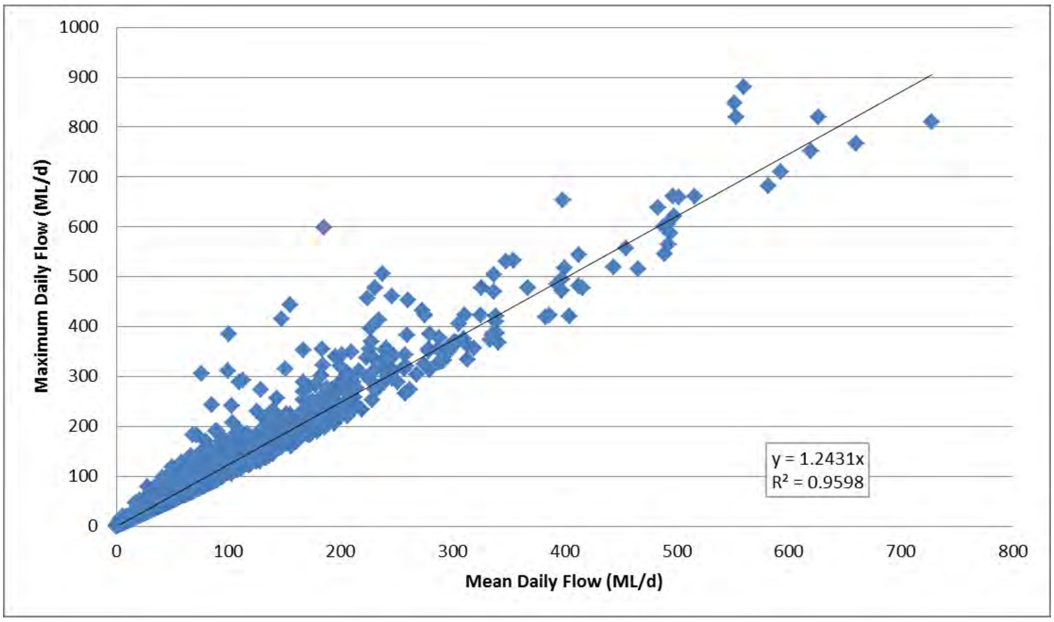


Wando River at Wando Vale – Censored 7 m³/s

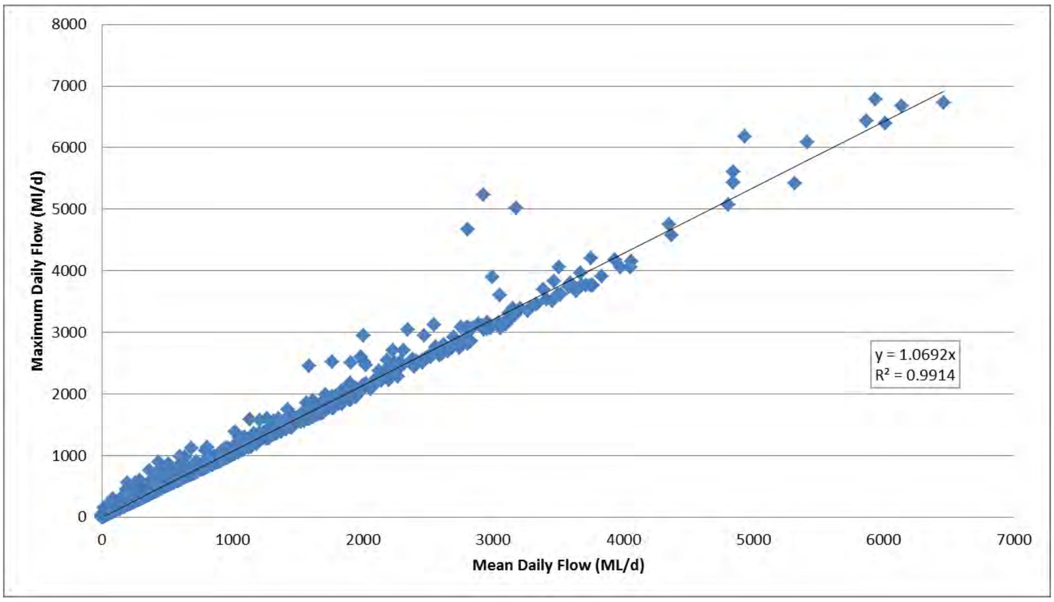


APPENDIX B REGRESSION ANALYSIS

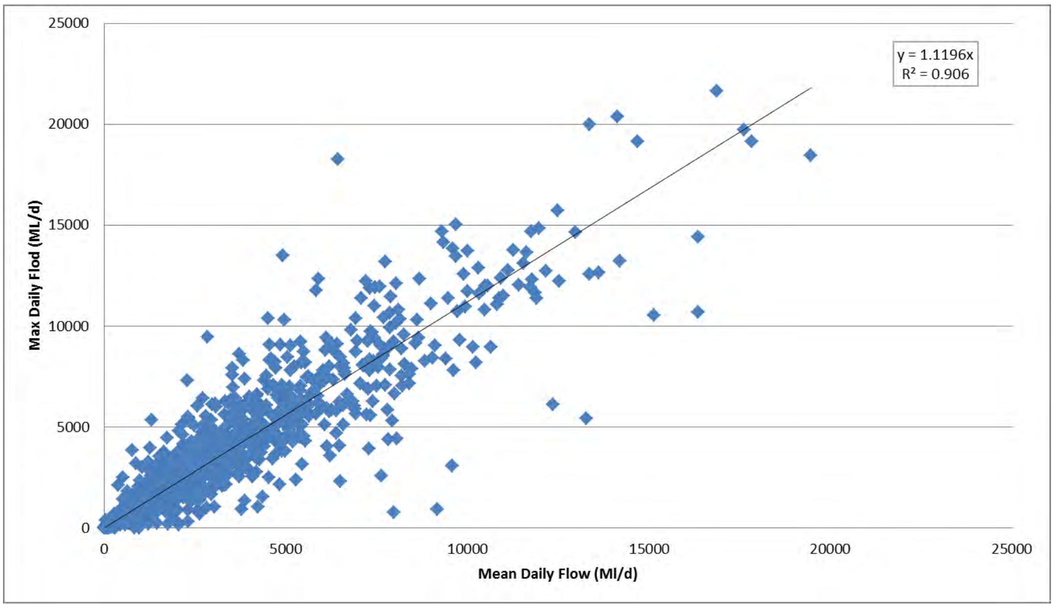
Glenelg River at Big Cord



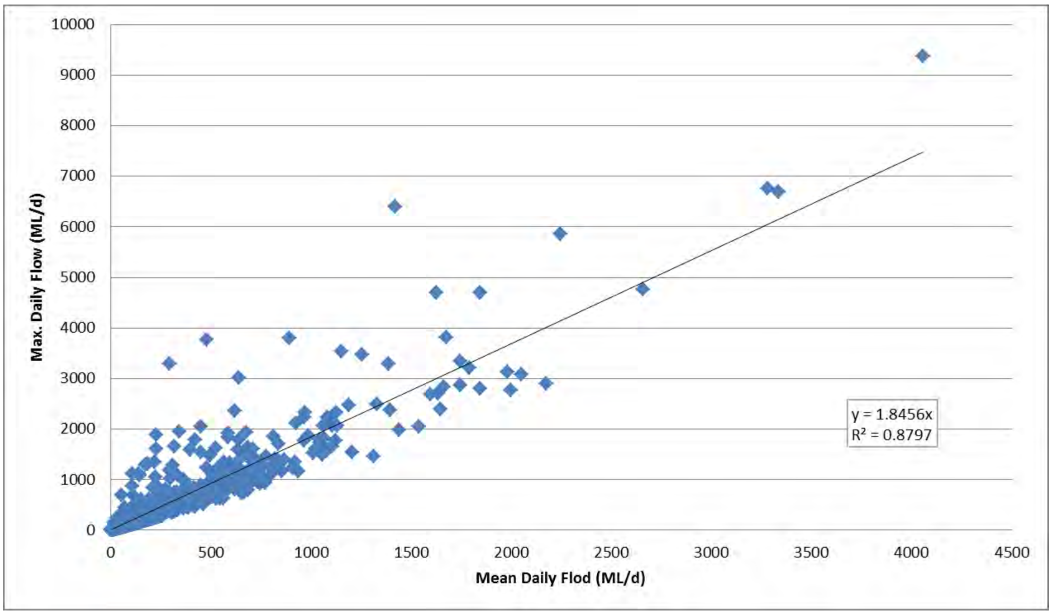
Glenelg River at Rocklands



Glenelg River at Casterton

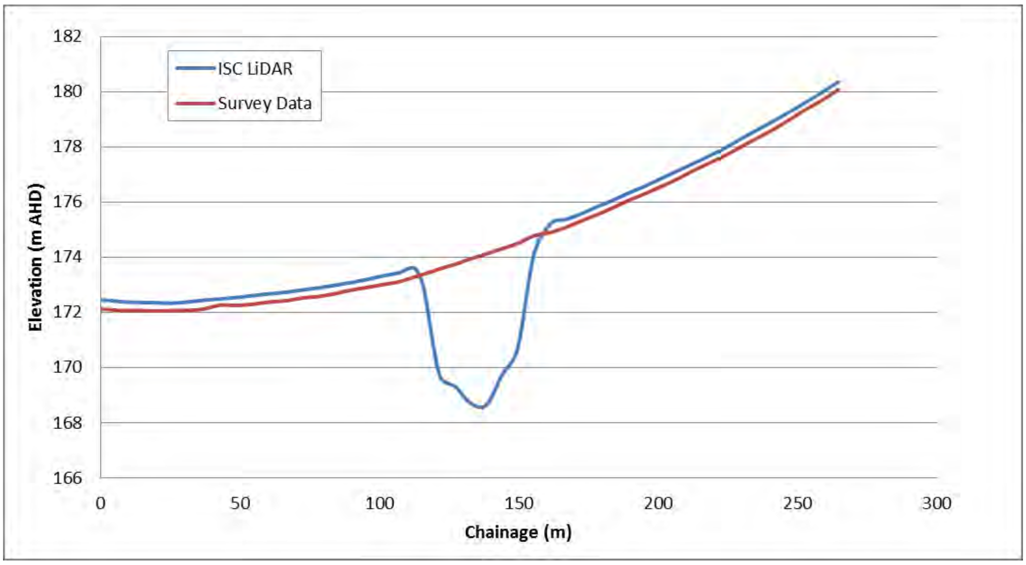


Wando River at Wando Vale

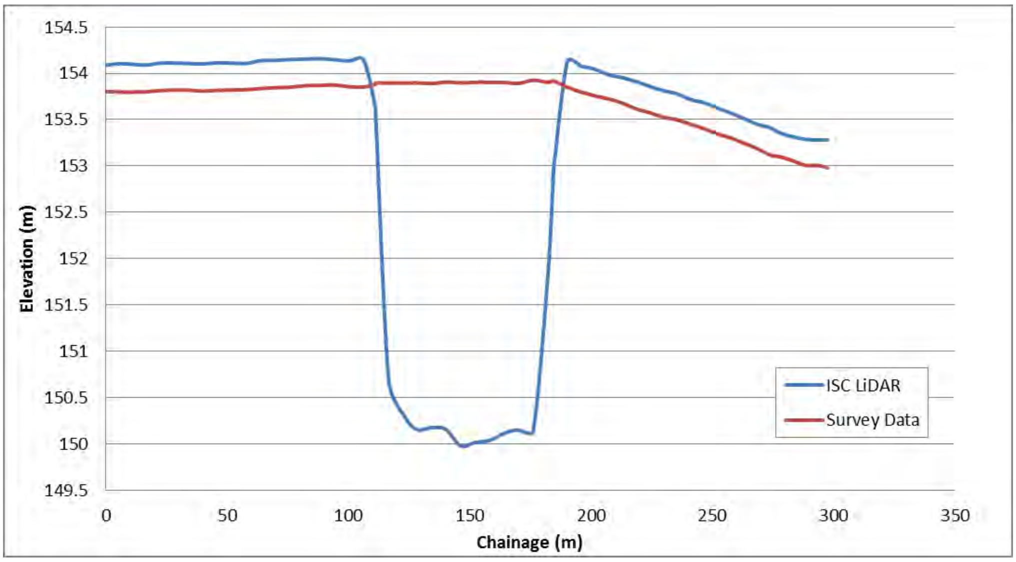


APPENDIX C LIDAR AND SURVEY DATA COMPARISON

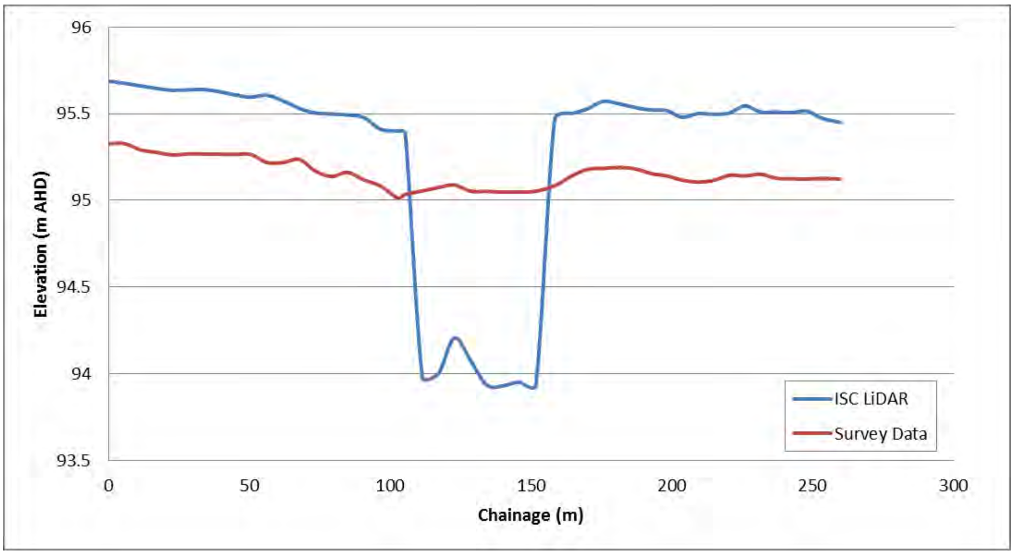
Rocklands Road, Balmoral



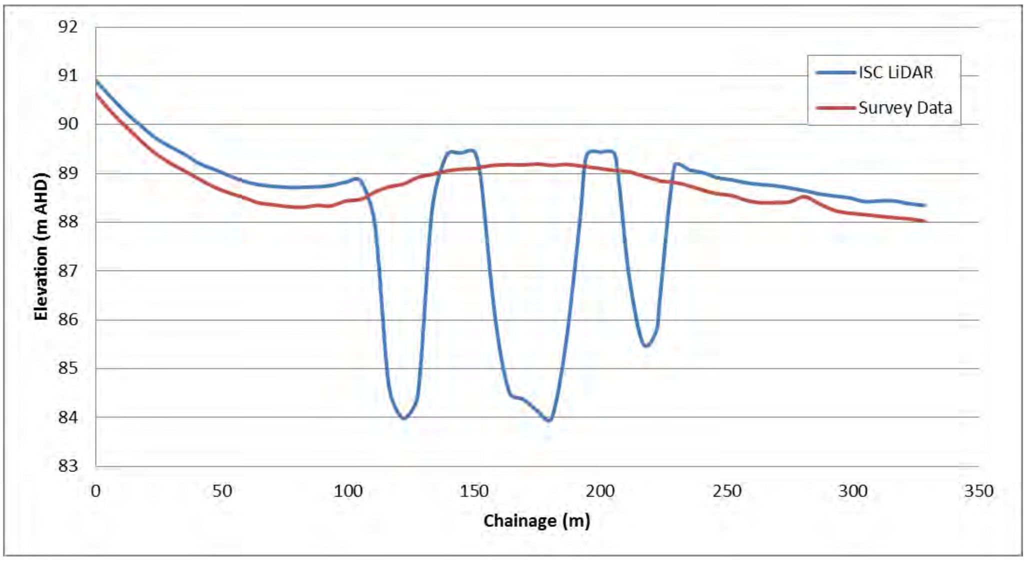
Natimuk Hamilton Road, Kanagulk



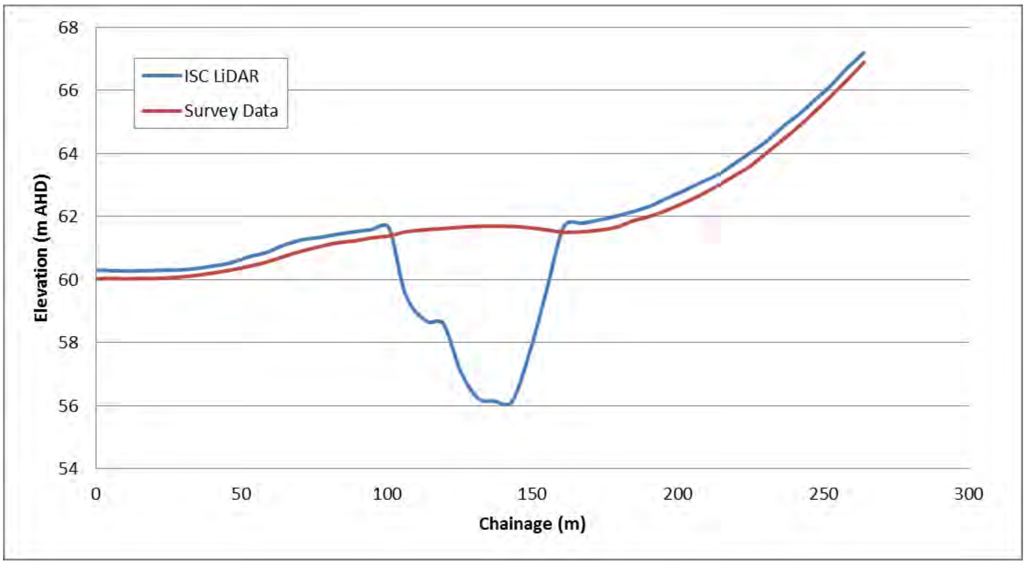
Coleraine Nareen-Moo Road - Culla



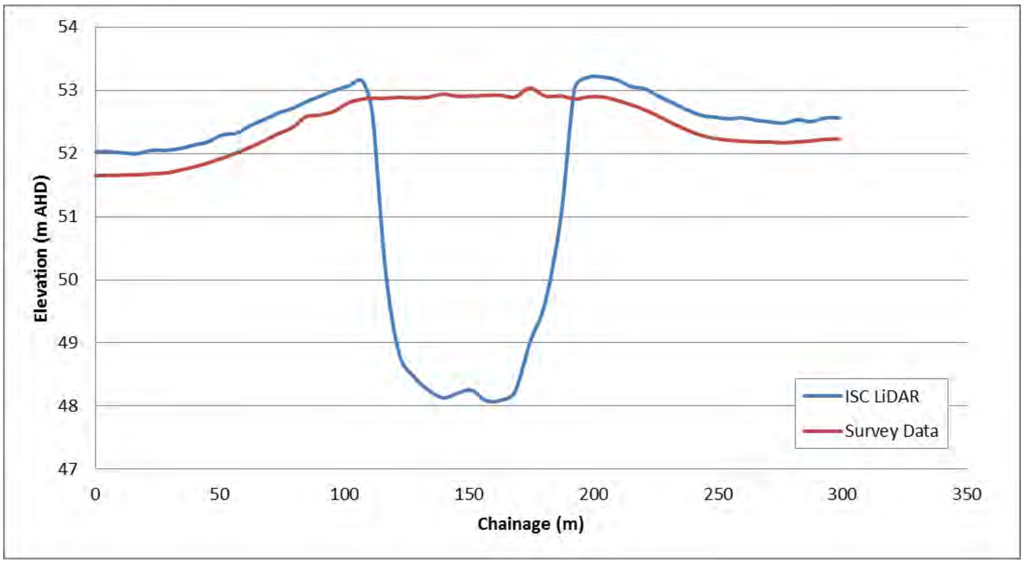
Casterton Edenhope Road - Chetwynd



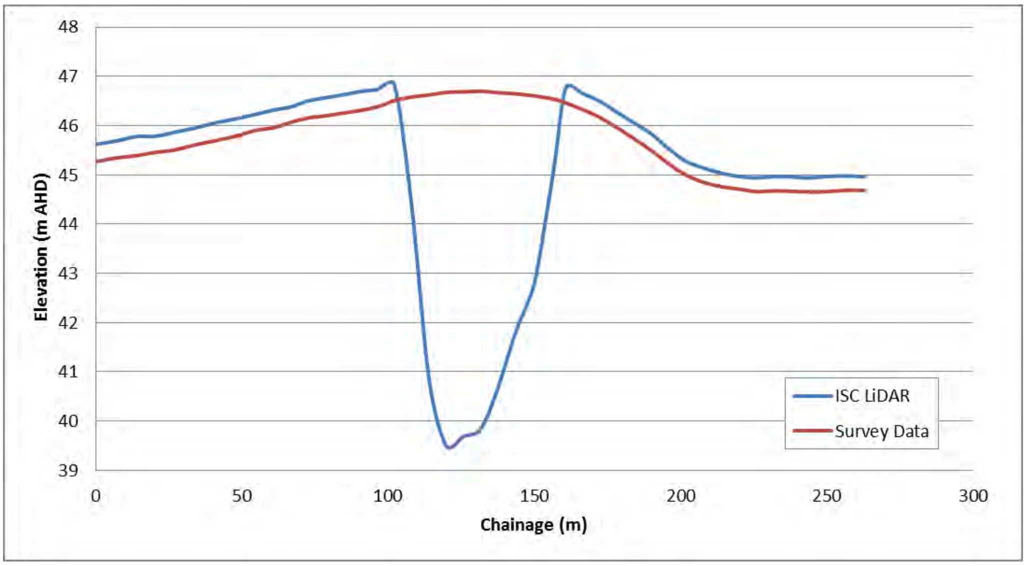
Warrock Road - Roseneath



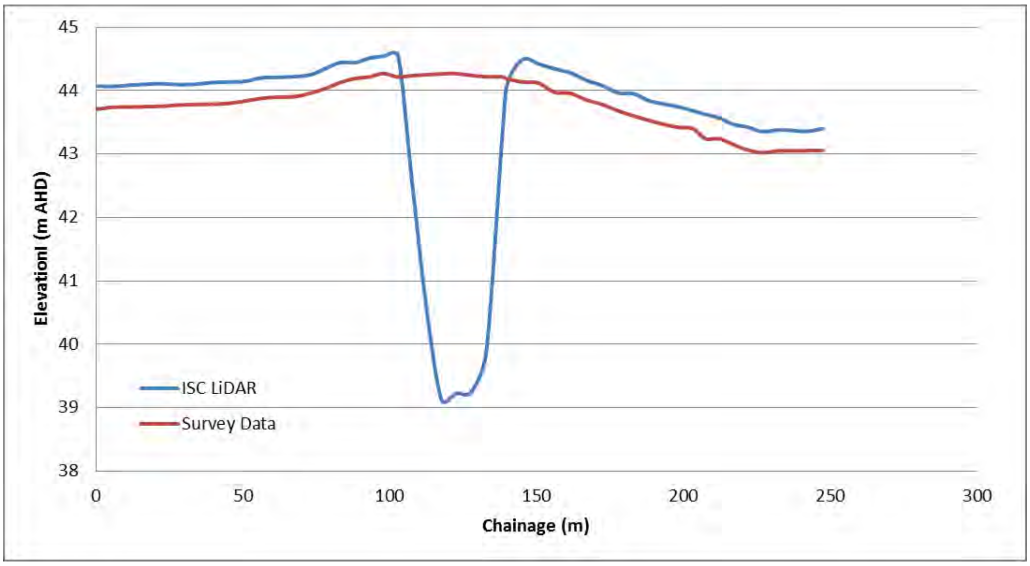
Section Road - Dunrobin



Glenelg Highway - Casterton



Andersons Road - Casterton



APPENDIX D FFA, RORB AND MIKE11 PEAK FLOW COMPARISONS

20% AEP

Location	Peak Flow (m^3/s)		
	FFA	RORB	M11
Fulham Bridge	73	77	78
Harrow	-	88	87
Dergholm	155	157	153
Casterton	-	153	

10% AEP

Location	Peak Flow (m^3/s)		
	FFA	RORB	M11
Fulham Bridge	101	103	104
Harrow	-	123	133
Dergholm	-	214	214
Casterton	207	207	207

5% AEP

Location	Peak Flow (m^3/s)		
	FFA	RORB	M11
Fulham Bridge	121	124	123
Harrow	-	140	153
Dergholm	-	258	266
Casterton	246	252	253

2% AEP

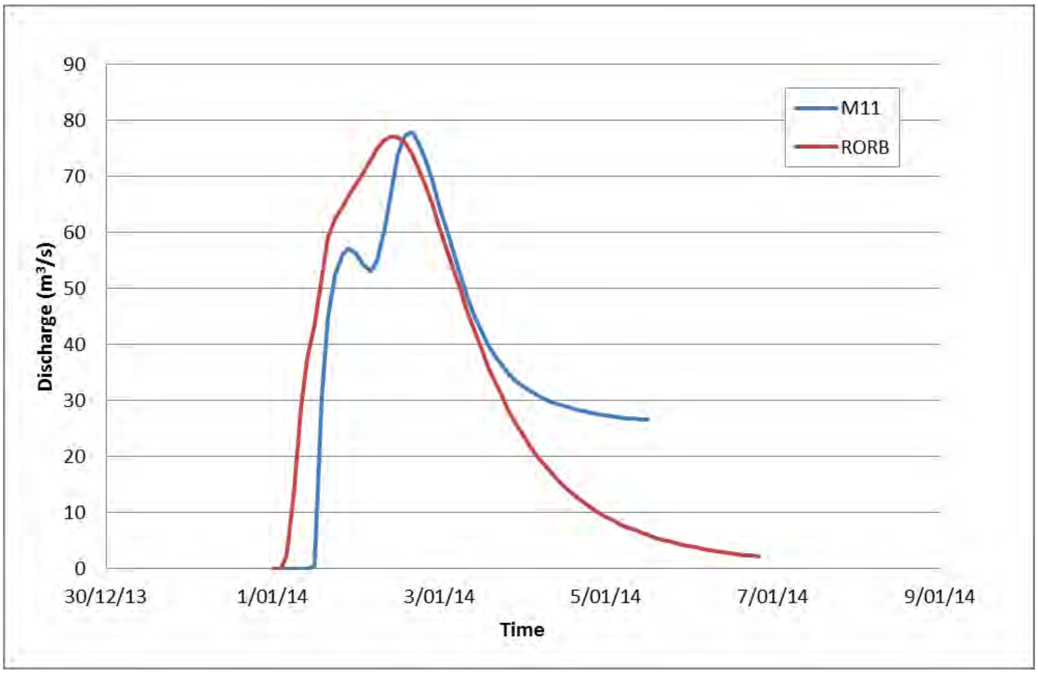
Location	Peak Flow (m^3/s)		
	FFA	RORB	M11
Fulham Bridge	137	139	139
Harrow	-	158	153
Dergholm	-	290	304
Casterton	283	283	272

0.5% AEP

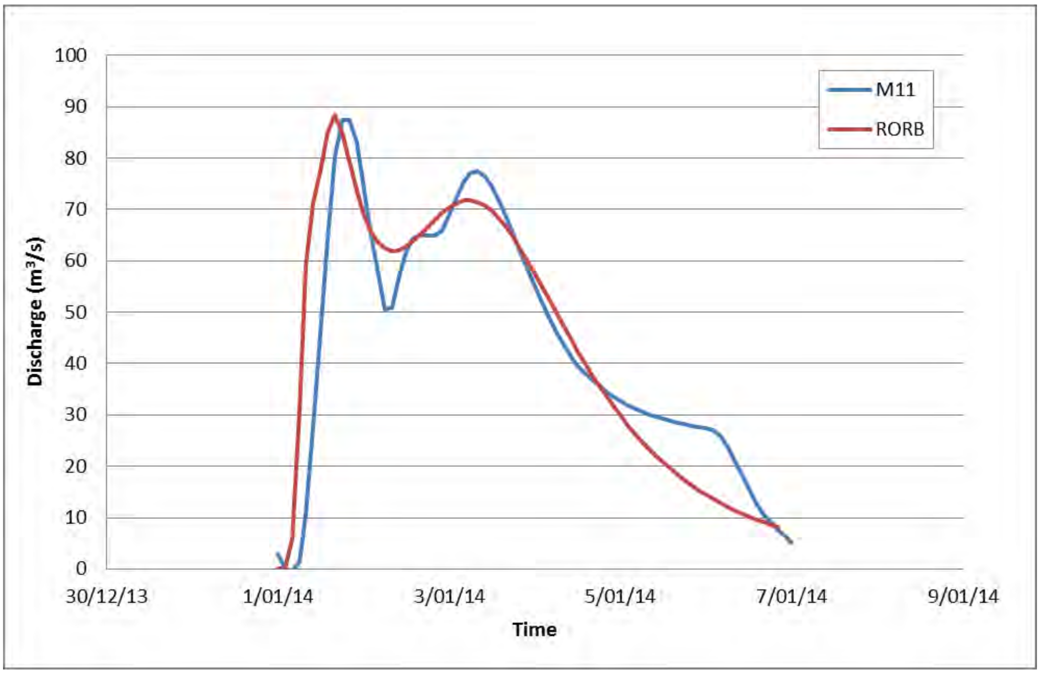
Location	Peak Flow (m^3/s)		
	FFA	RORB	M11
Fulham Bridge	150	150	150
Harrow	-	188	185
Dergholm	-	330	348
Casterton	316	320	322

APPENDIX E RORB AND MIKE11 HYDROGRAPH COMPARIONS

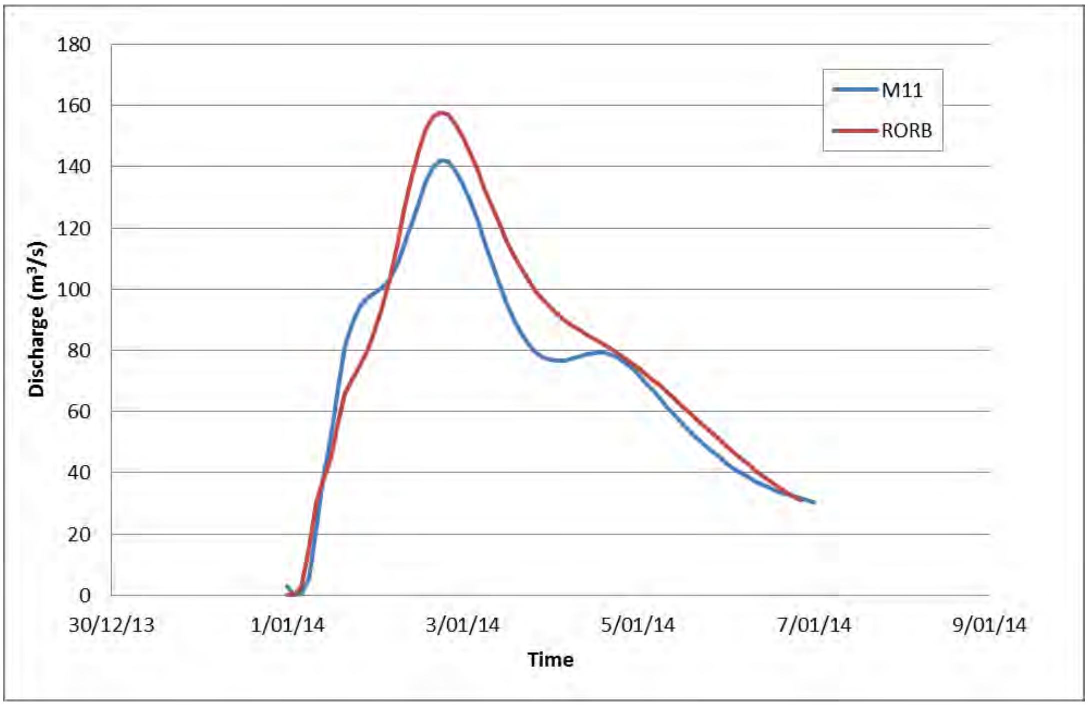
20% AEP Fulham Bridge



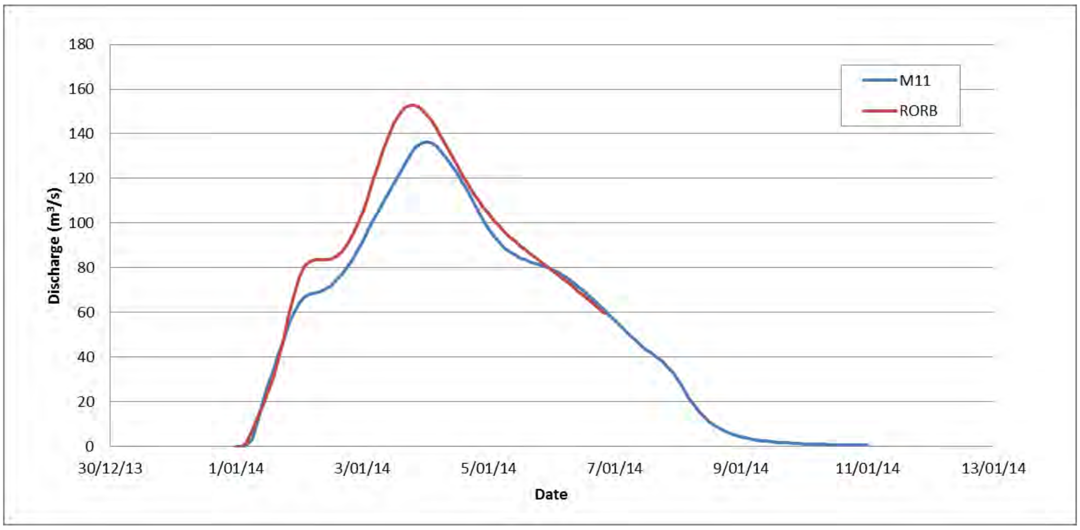
20% AEP Harrow



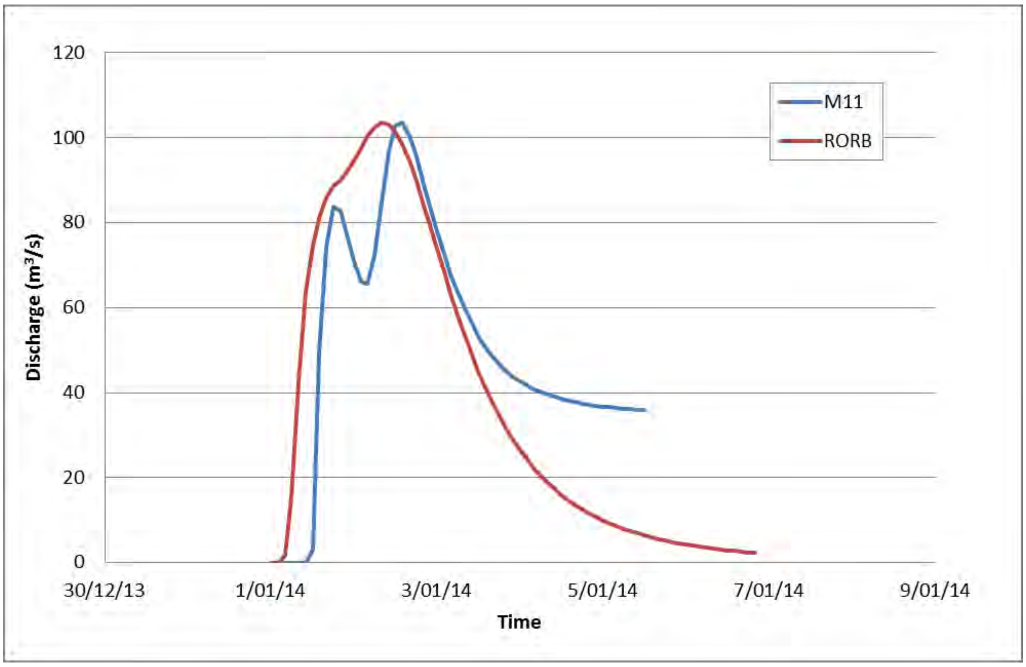
20% AEP Dergholm



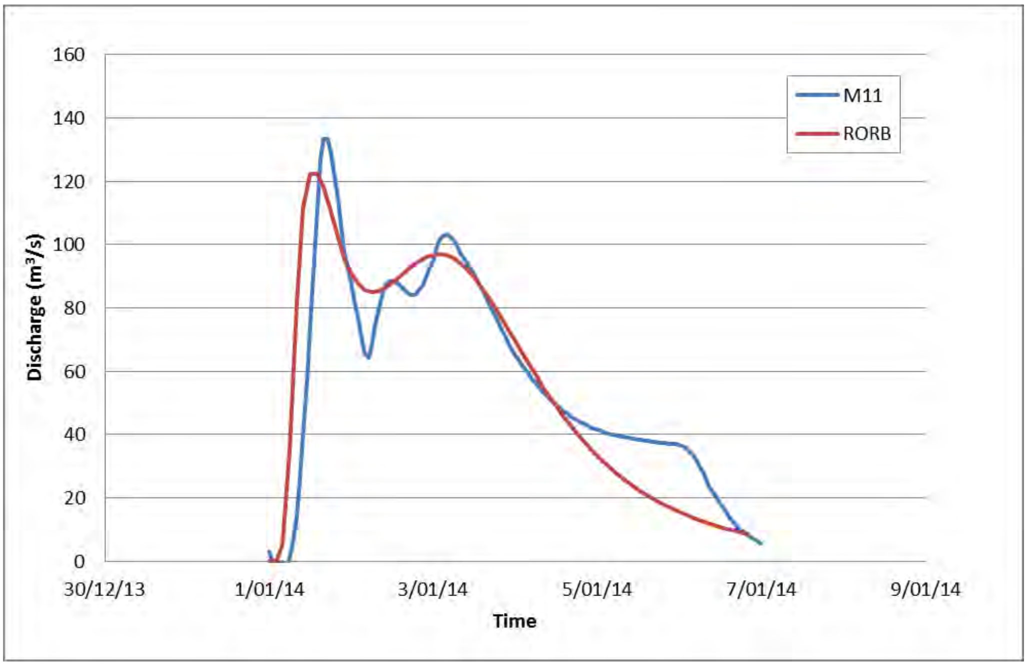
20% AEP Casterton



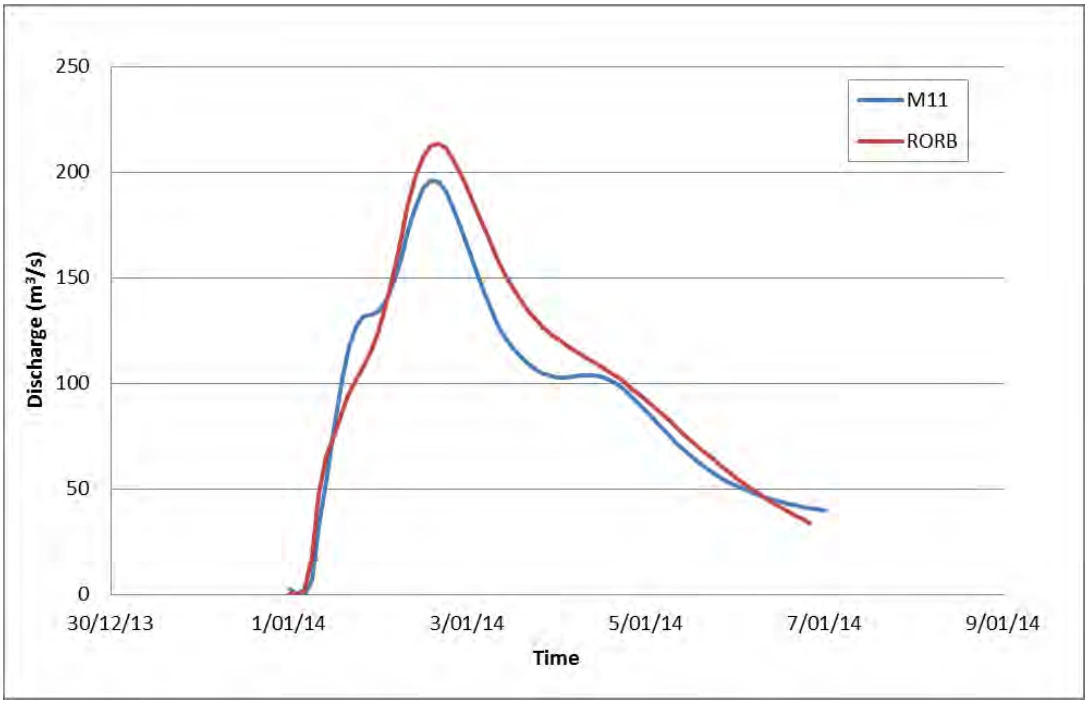
10% AEP Fulham Bridge



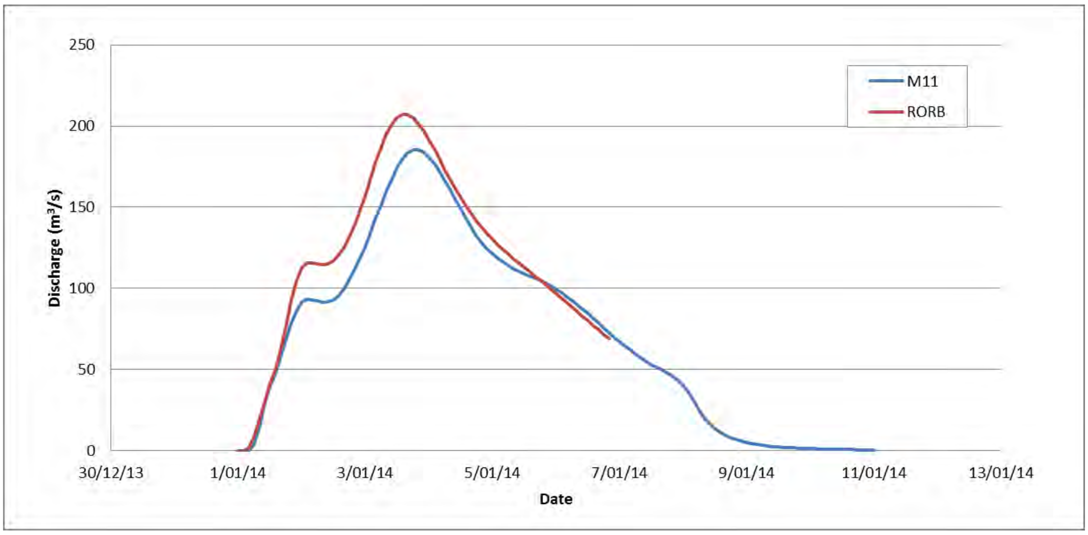
10% AEP Harrow



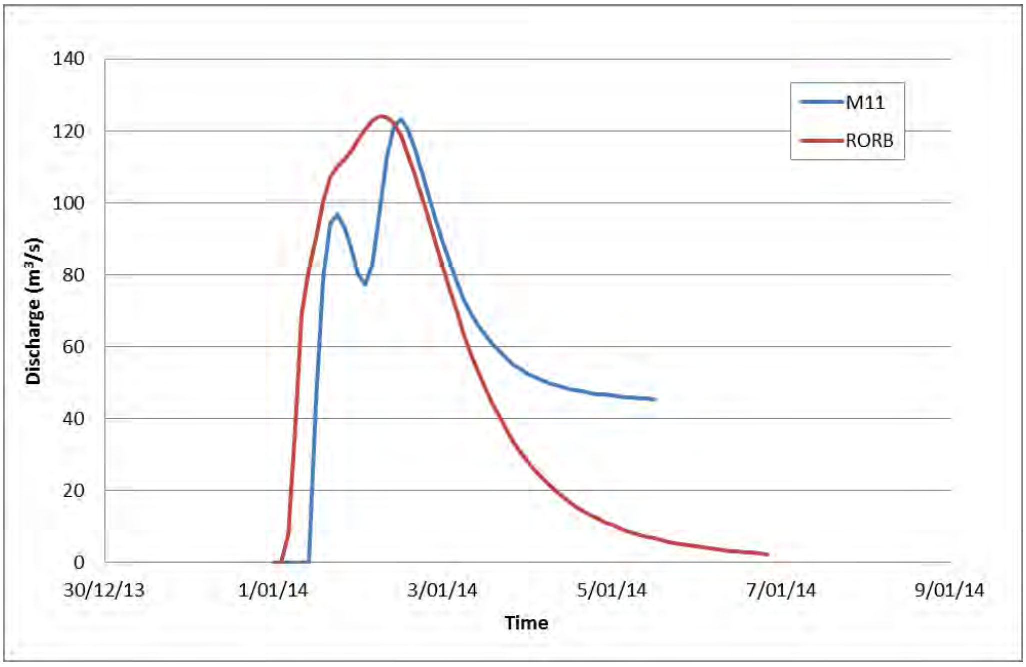
10% AEP Dergholm



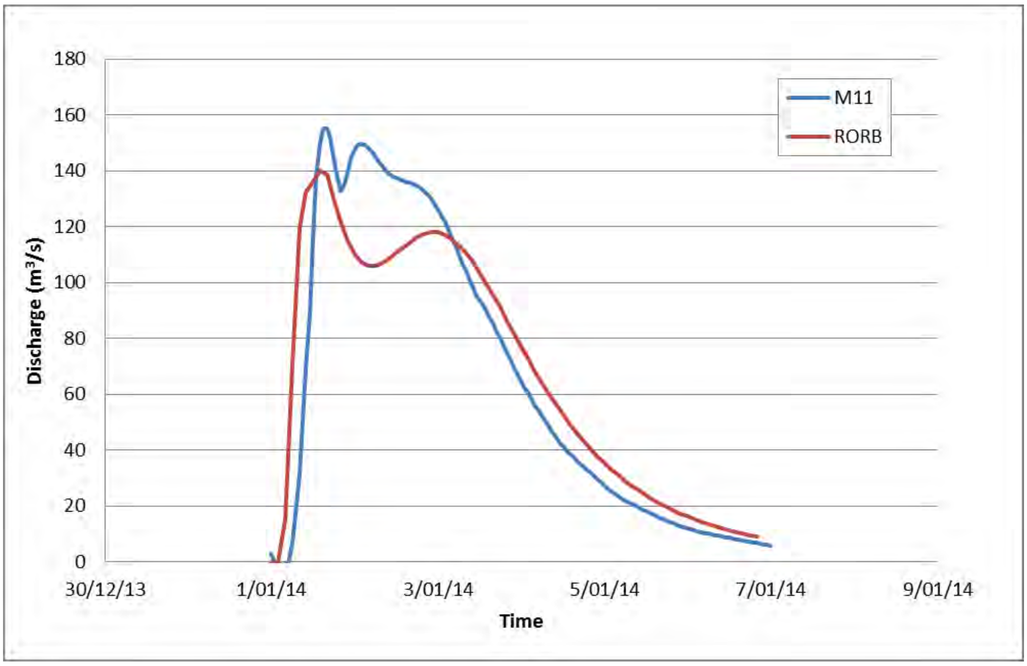
10% AEP Casterton



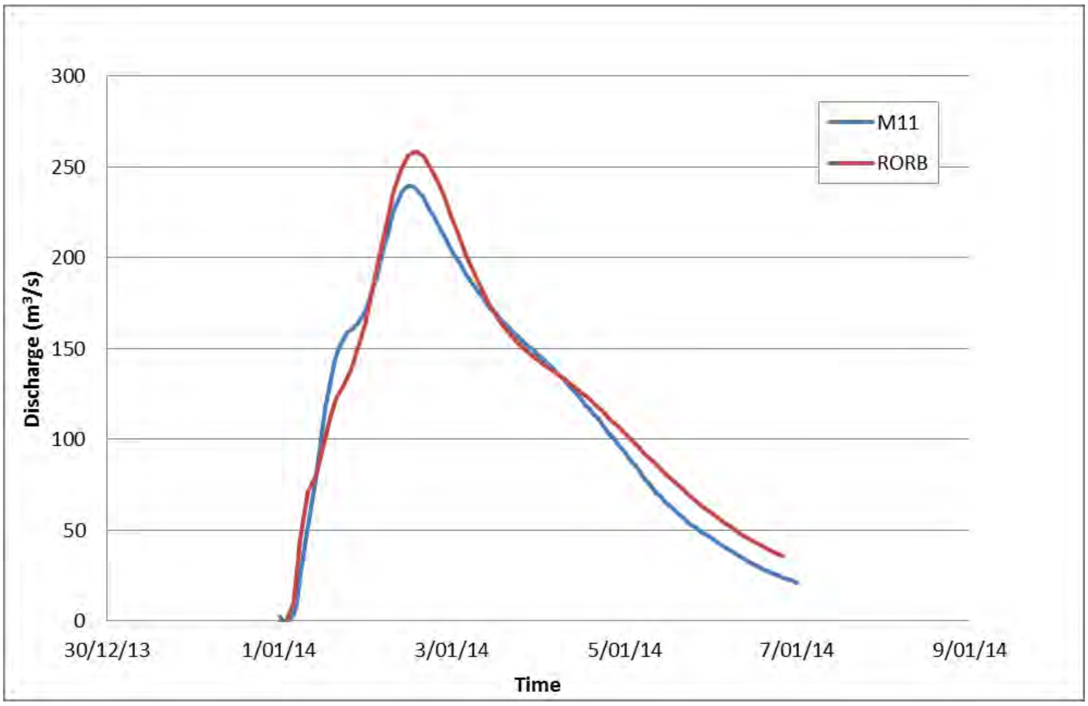
5% AEP Fulham Bridge



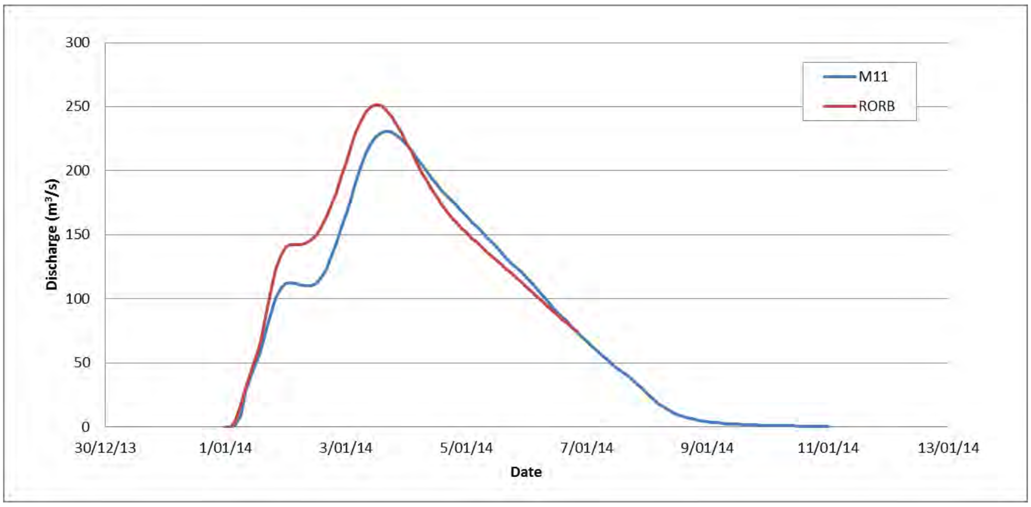
5% AEP Harrow



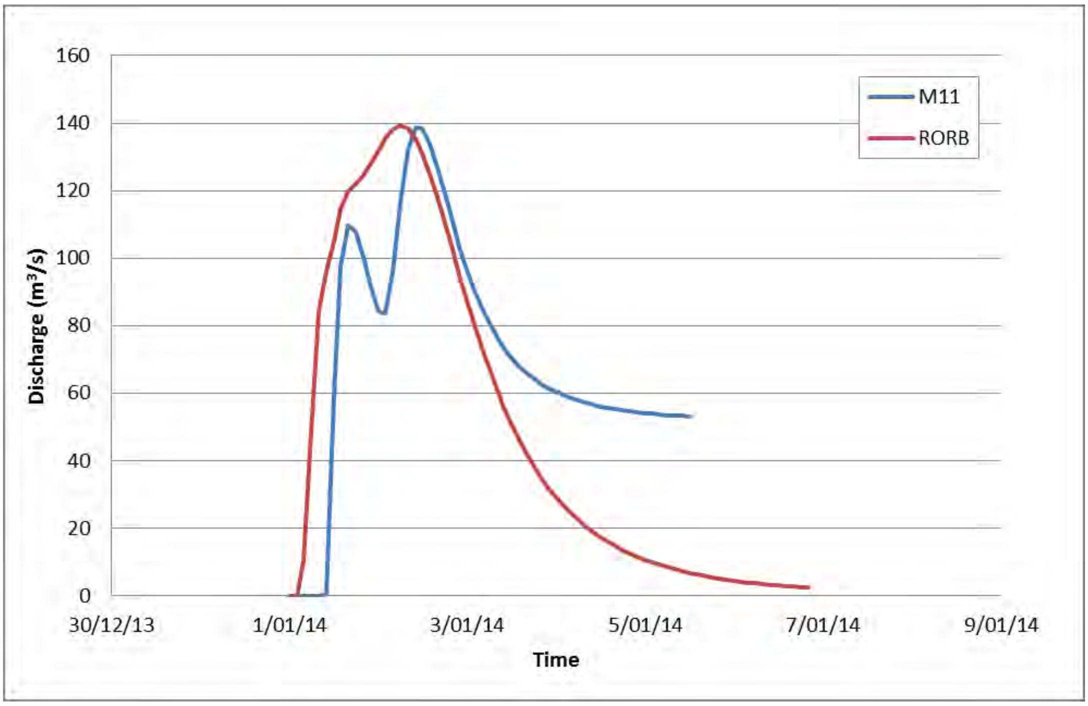
5% AEP Dergholm



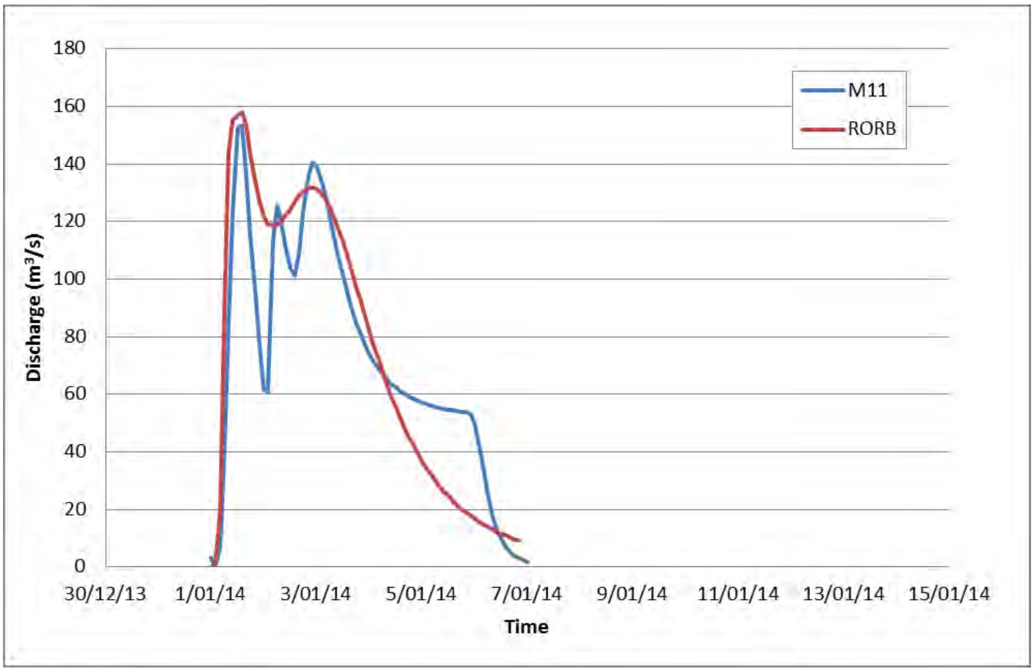
5% AEP Casterton



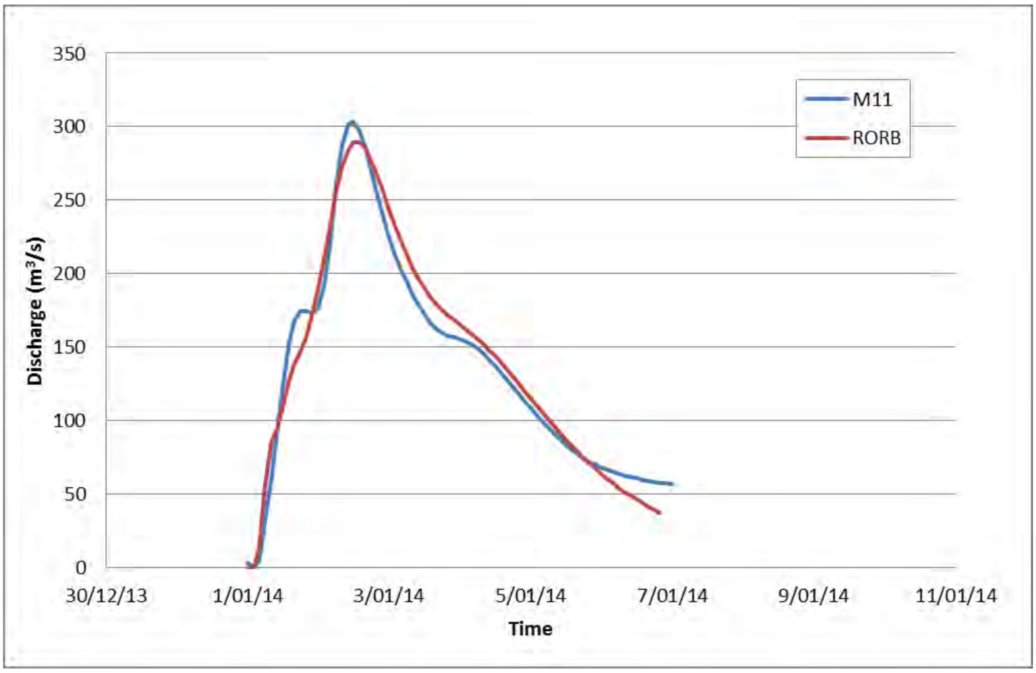
2% AEP Fulham Bridge



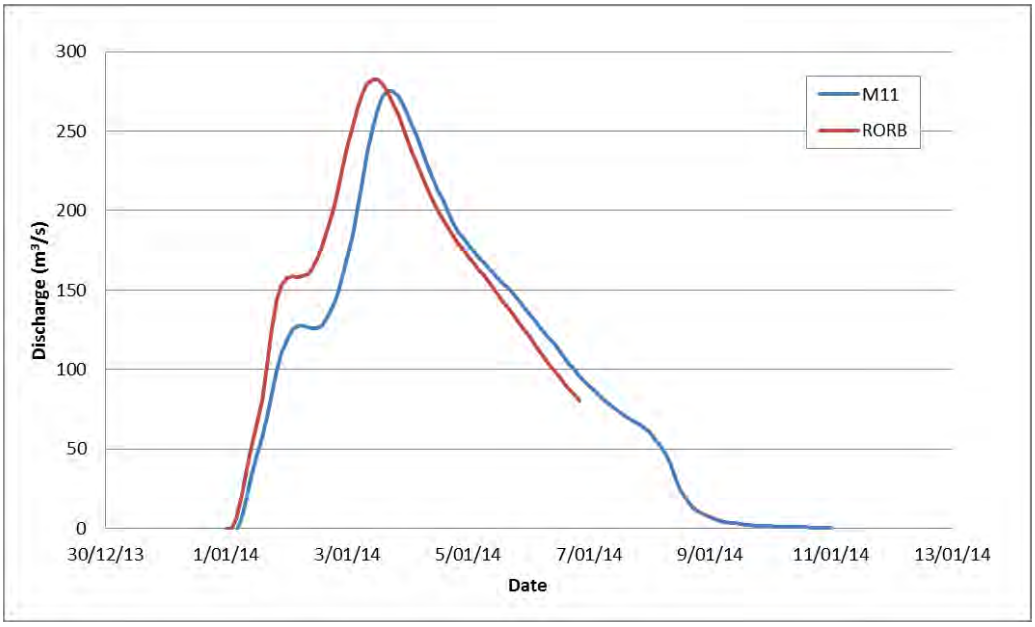
2% AEP Harrow



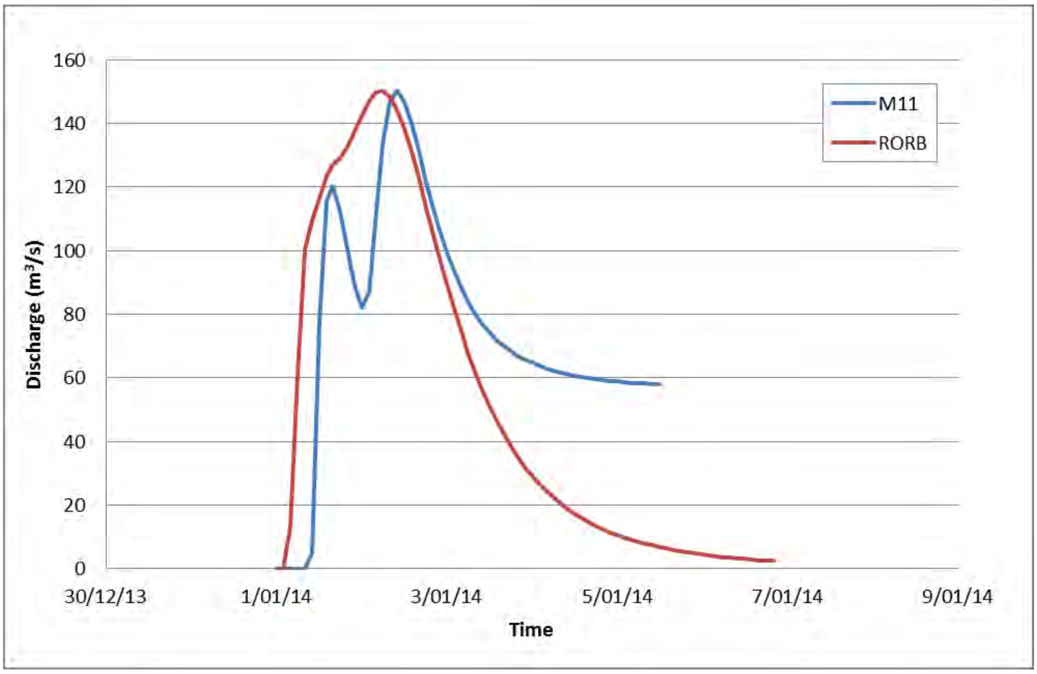
2% AEP Dergholm



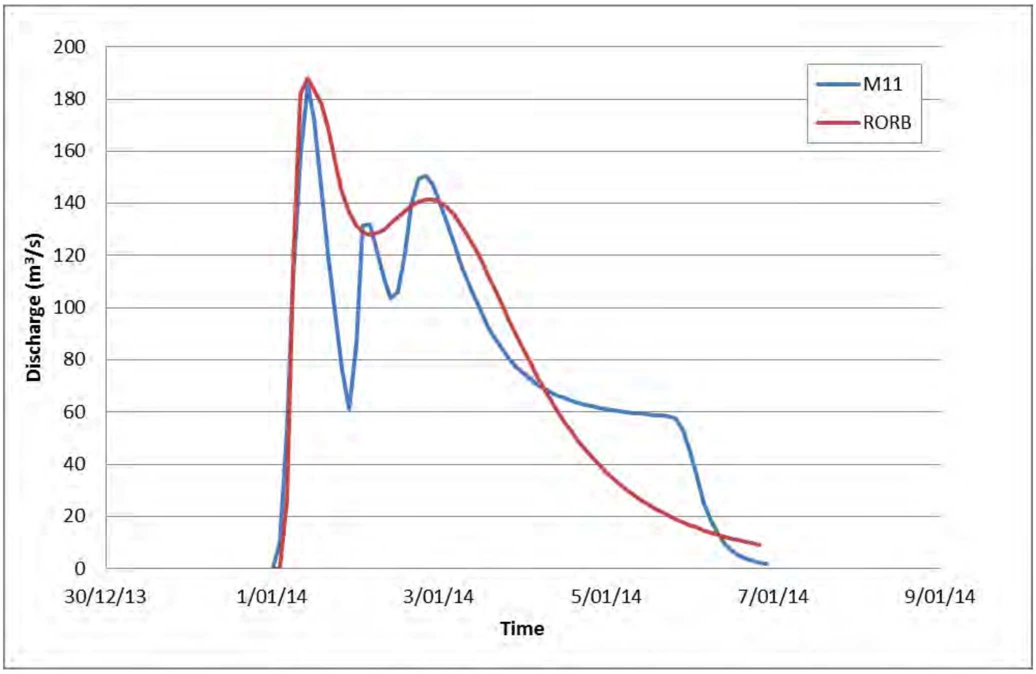
2% AEP Casterton



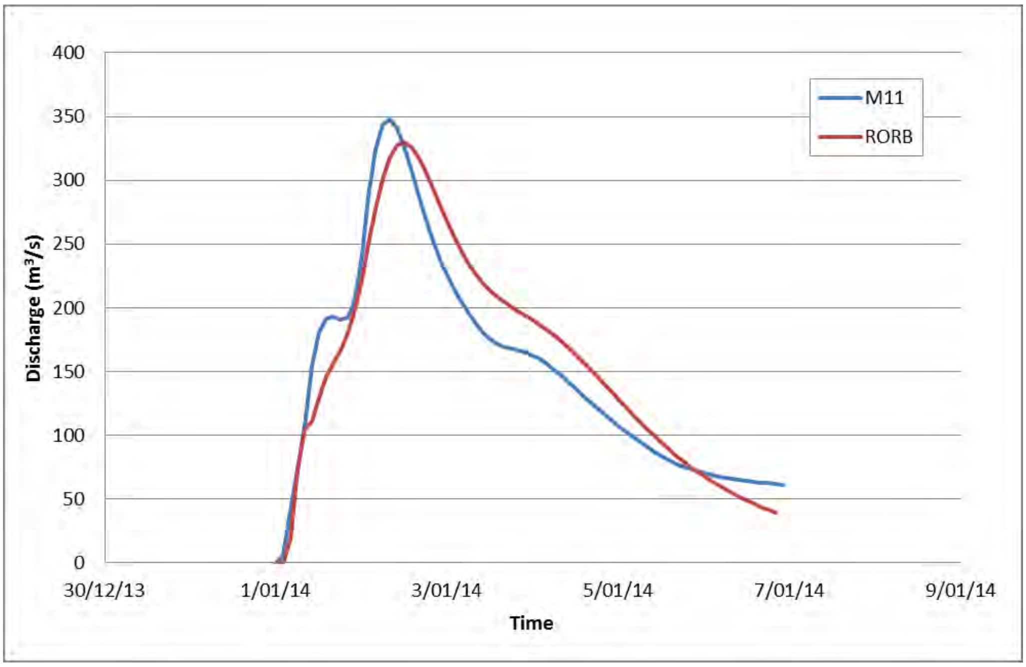
0.5% AEP Fulham Bridge



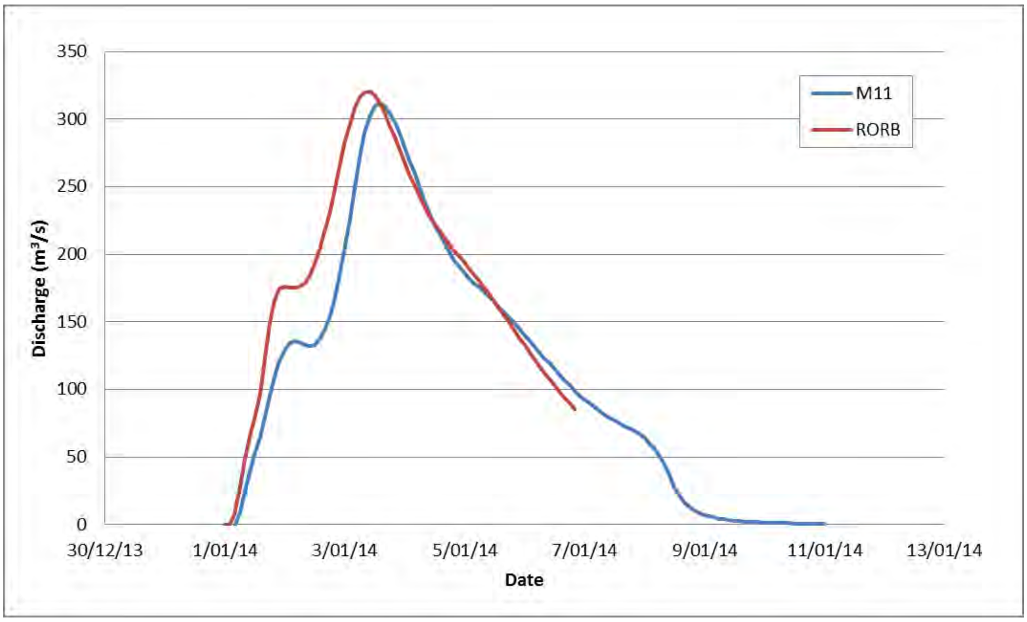
0.5% AEP Harrow



0.5% AEP Dergholm



0.5% AEP Casterton



APPENDIX F FFA, RORB, MIKE11 AND M21 PEAK FLOW COMPARISONS

20% AEP

Location	Peak Flow (m^3/s)			
	FFA	RORB	M11	M21
Fulham Bridge	73	77	78	63
Harrow	-	88	87	67

10% AEP

Location	Peak Flow (m^3/s)			
	FFA	RORB	M11	M21
Fulham Bridge	101	103	104	92
Harrow	-	123	133	100

5% AEP

Location	Peak Flow (m^3/s)			
	FFA	RORB	M11	M21
Fulham Bridge	121	124	123	94
Harrow	-	140	153	127

2% AEP

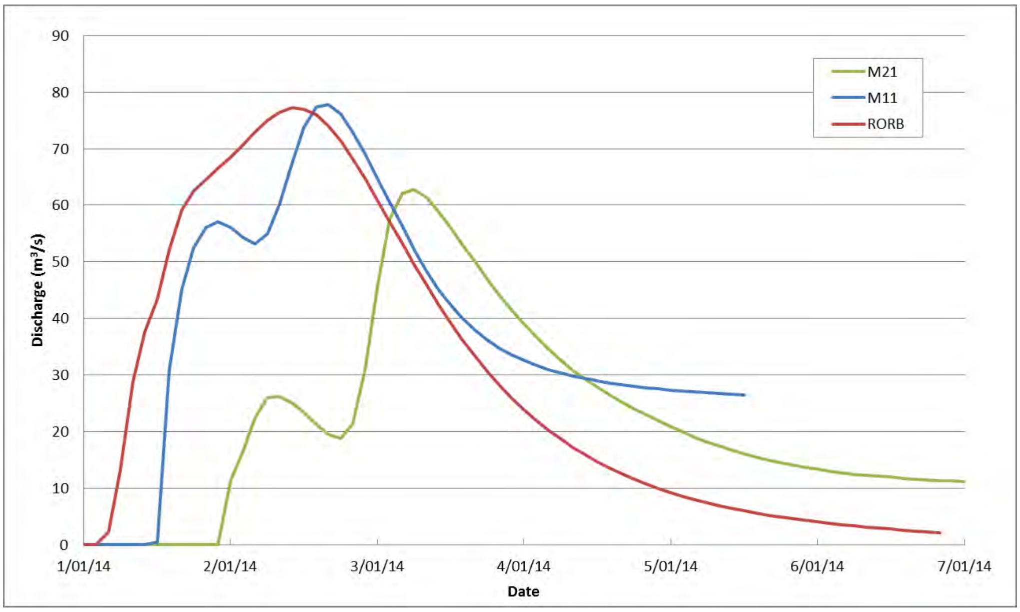
Location	Peak Flow (m^3/s)			
	FFA	RORB	M11	M21
Fulham Bridge	137	139	139	139
Harrow	-	158	153	147

0.5% AEP

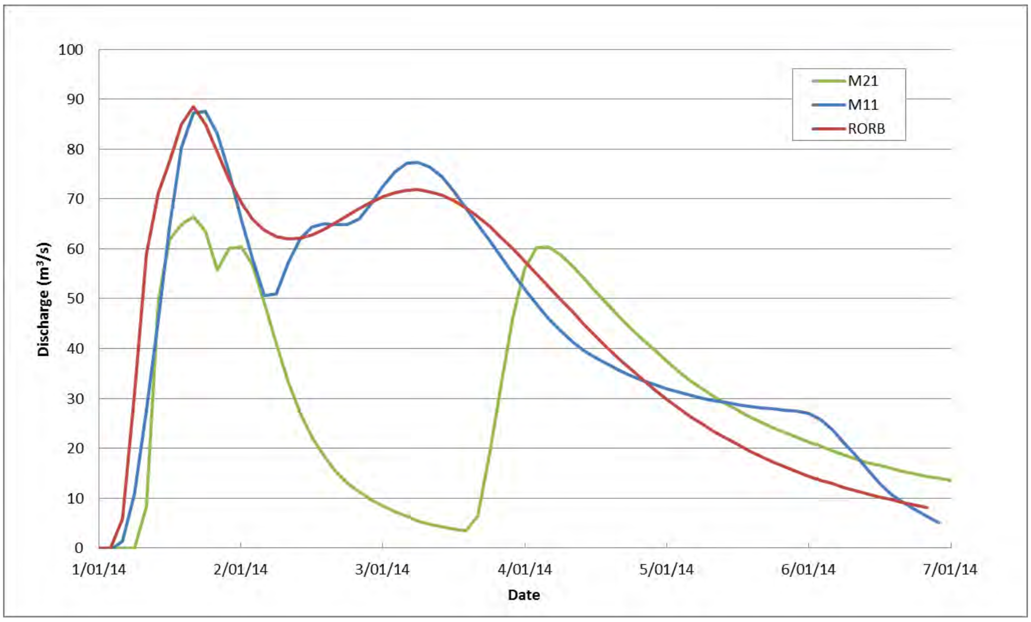
Location	Peak Flow (m^3/s)			
	FFA	RORB	M11	M21
Fulham Bridge	150	150	150	152
Harrow	-	188	185	182

APPENDIX G RORB, MIKE11 AND M21 HYDROGRAPH COMPARISONS

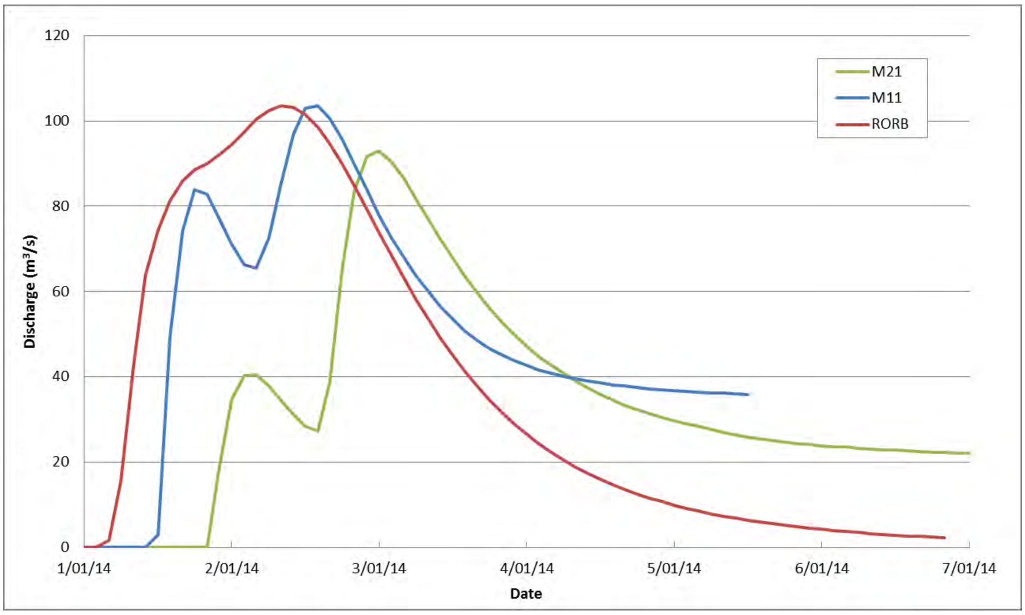
20% AEP – Fulham Bridge



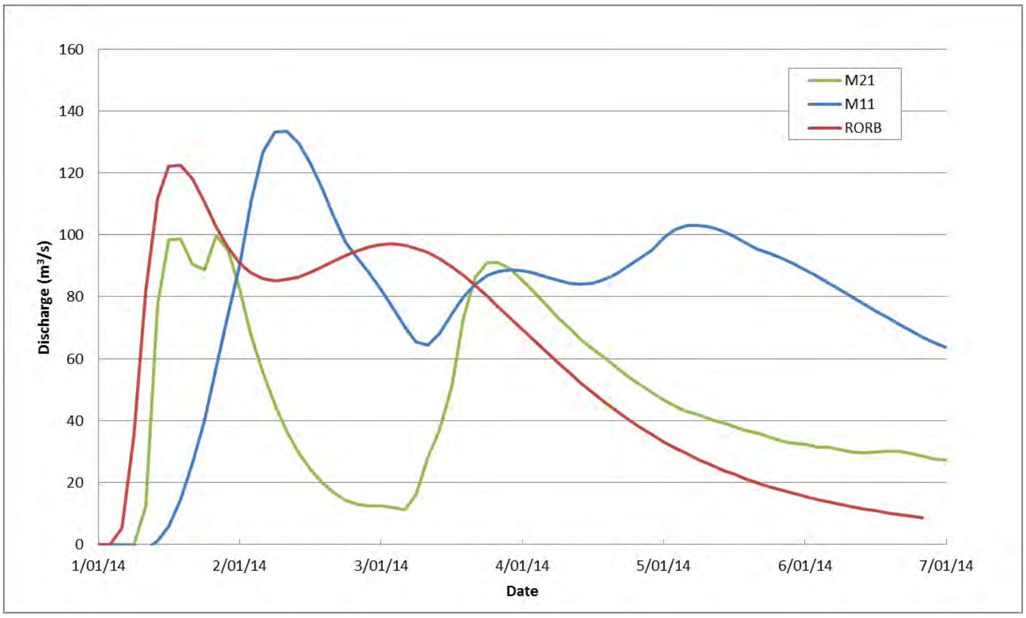
20% AEP - Harrow



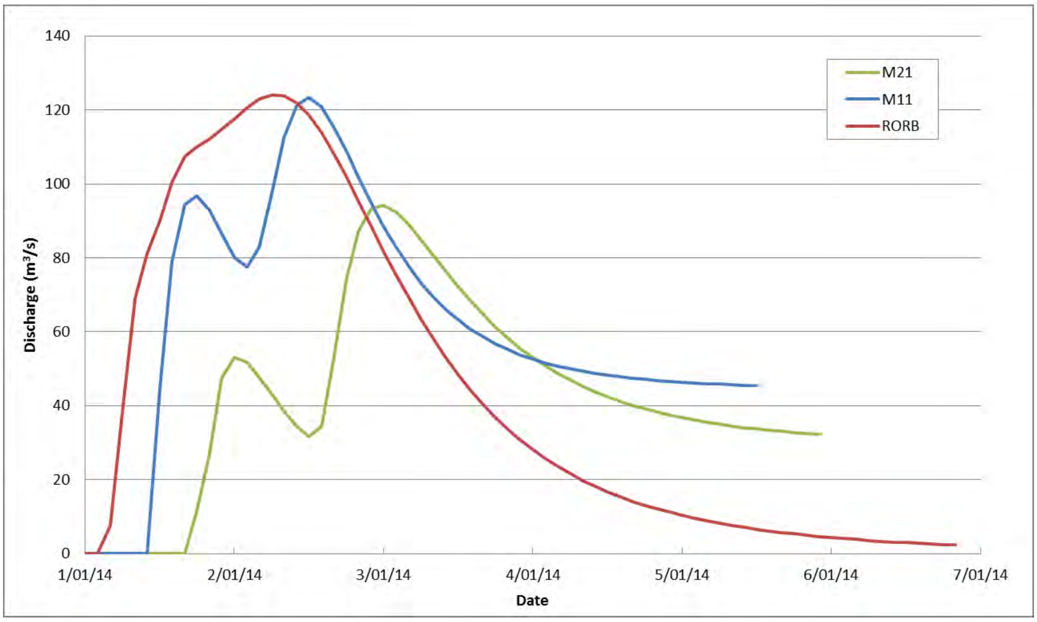
10% AEP – Fulham Bridge



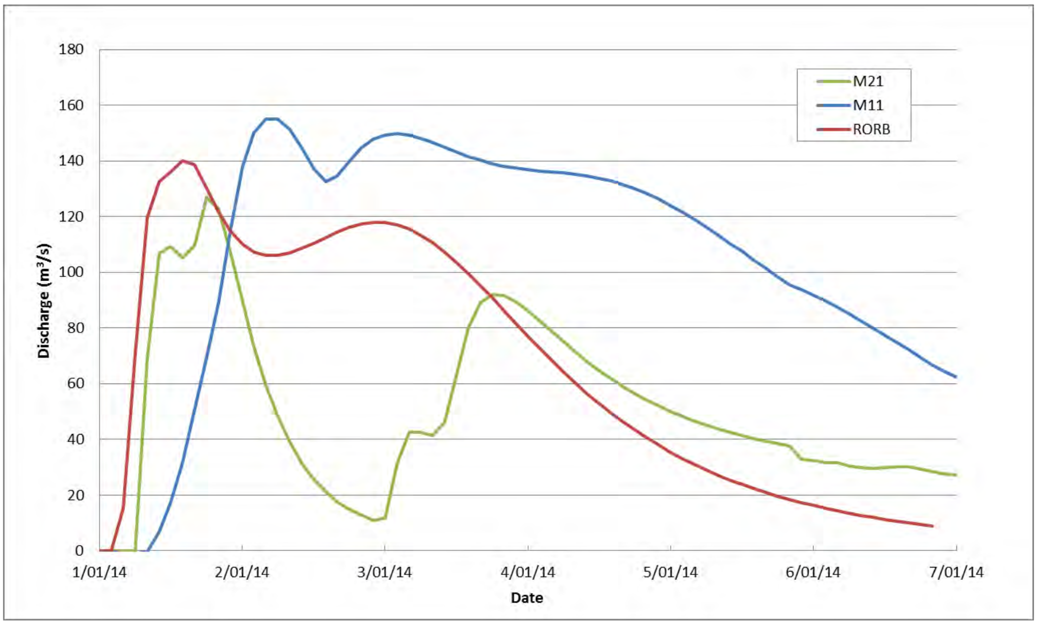
10% AEP - Harrow



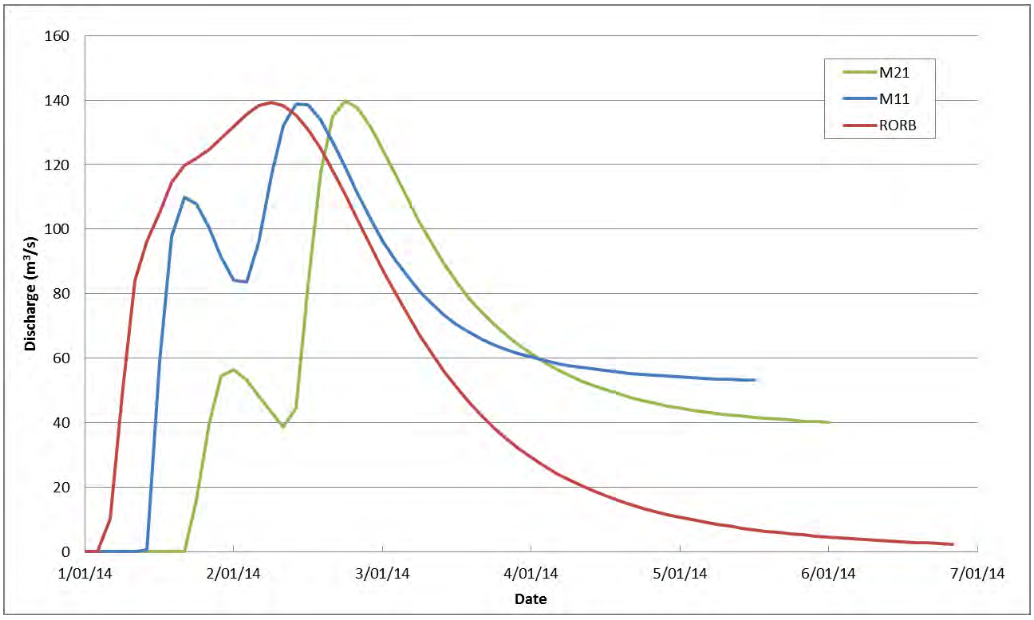
5% AEP – Fulham Bridge



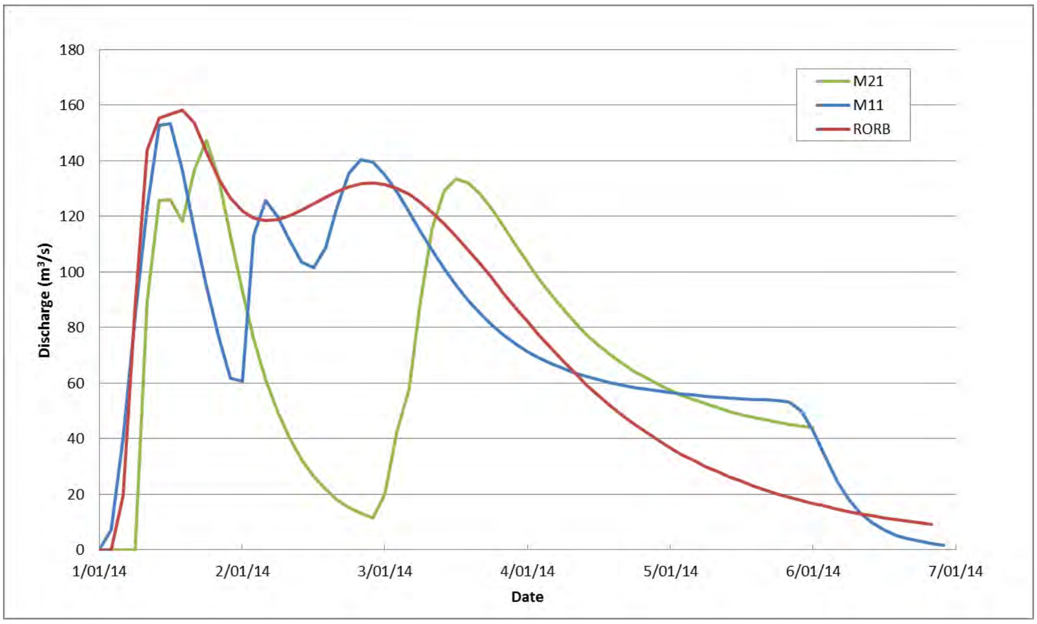
5% AEP - Harrow



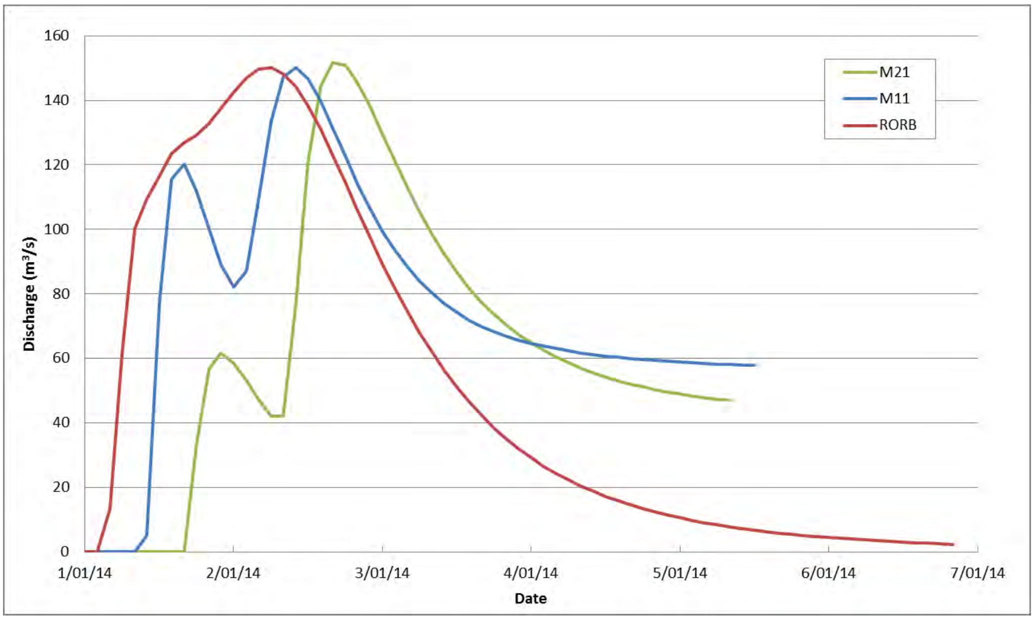
2% AEP – Fulham Bridge



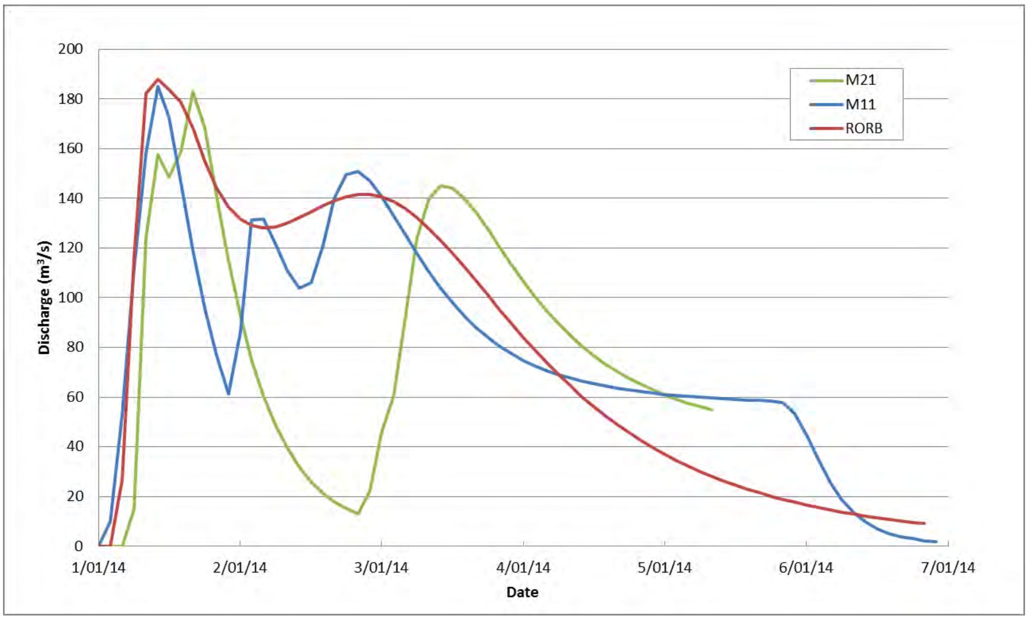
2% AEP - Harrow

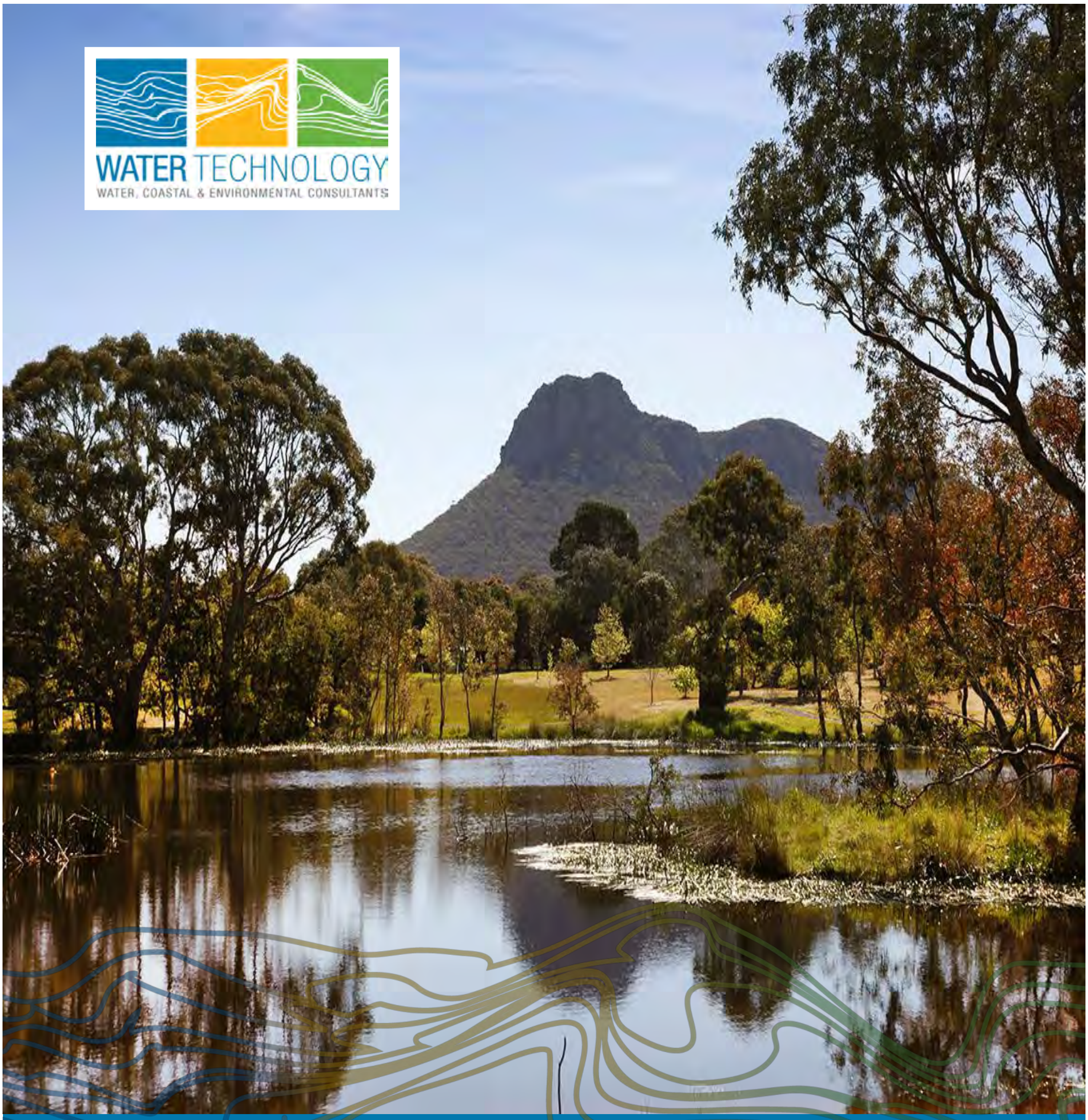


0.5% AEP


M21
M11
RORB
Discharge (m³/s)
160
140
120
100
80
60
40
20
0
1/01/14
2/01/14
3/01/14
4/01/14
5/01/14
6/01/14
7/01/14
Date

0.5% AEP


M21
M11
RORB
Discharge (m³/s)
200
180
160
140
120
100
80
60
40
20
0
1/01/14
2/01/14
3/01/14
4/01/14
5/01/14
6/01/14
7/01/14
Date



Overlay Development Report

Dunkeld Flood Planning Scheme Amendment

Southern Grampians Shire Council

18 August 2023

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Document Status

Version	Doc type	Reviewed by	Approved by	Date issued
01	Draft	Ben Hughes	Ben Hughes	25/05/2023
02	Final	Ben Hughes	Ben Hughes	18/08/2023

Project Details

Project Name	Dunkeld Flood Planning Scheme Amendment
Client	Southern Grampians Shire Council
Client Project Manager	Parvesh Siroha
Water Technology Project Manager	Alex Barton
Water Technology Project Director	Ben Hughes
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Document Number	R01V02_23010020_FloodModelingPSASummary.docx

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18 August 2023

Parvesh Siroha
Senior Strategic Planner
Southern Grampians Shire Council
1 Market Place
Hamilton, Victoria 3300

Via email: psiroha@sthgrampians.vic.gov.au

Dear Parvesh

Dunkeld Flood Planning Scheme Amendment

Please see the attached report detailing the modelling undertaken for the development of flood related planning scheme layers for Dunkeld.

If you have any queries, please don't hesitate to contact me.

Yours sincerely

Alex Barton
Senior Engineer
Alex.barton@watertech.com.au
WATER TECHNOLOGY PTY LTD

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1 INTRODUCTION

1.1 Overview

The township of Dunkeld, located in the Southern Grampians Shire Council in Victoria, is at risk of inundation by several tributaries of the Wannon River. In recent years, severe weather events have caused significant damage to properties and infrastructure in the town, leading to a need for accurate flood mapping to aid in emergency planning and response.

This report presents the results of a flood mapping study conducted for Dunkeld. The report provides a summary of the methodology and key findings from the original flood mapping project[1] undertaken by Water Technology in 2018.

The report also includes recommendations for development of Land Subject to Inundation Overlay (LSIO) and Floodway Overlay (FO) layers based on the identified inundation across the township. The recommendations in combination with the municipal flood emergency plan aim to mitigate the potential damage caused by future flooding events and to enhance the town's resilience to climate change and extreme weather conditions.

1.2 Study Area

The study area encompasses the township of Dunkeld and its surrounding catchment area to the Wannon River. The catchment area covers approximately 16.75 km² and includes a range of land uses, including semi-urban, rural, farmland and naturally vegetated regions.

The topography of the study area is characterized by sloping terrain from the east towards the Wannon River in the west. A map of the study area is shown in Figure 1-1.

[1] Preliminary Flood Modelling, Dunkeld Reservoir - Structural Integrity Assessment and Restoration Plan, Water Technology, 2018

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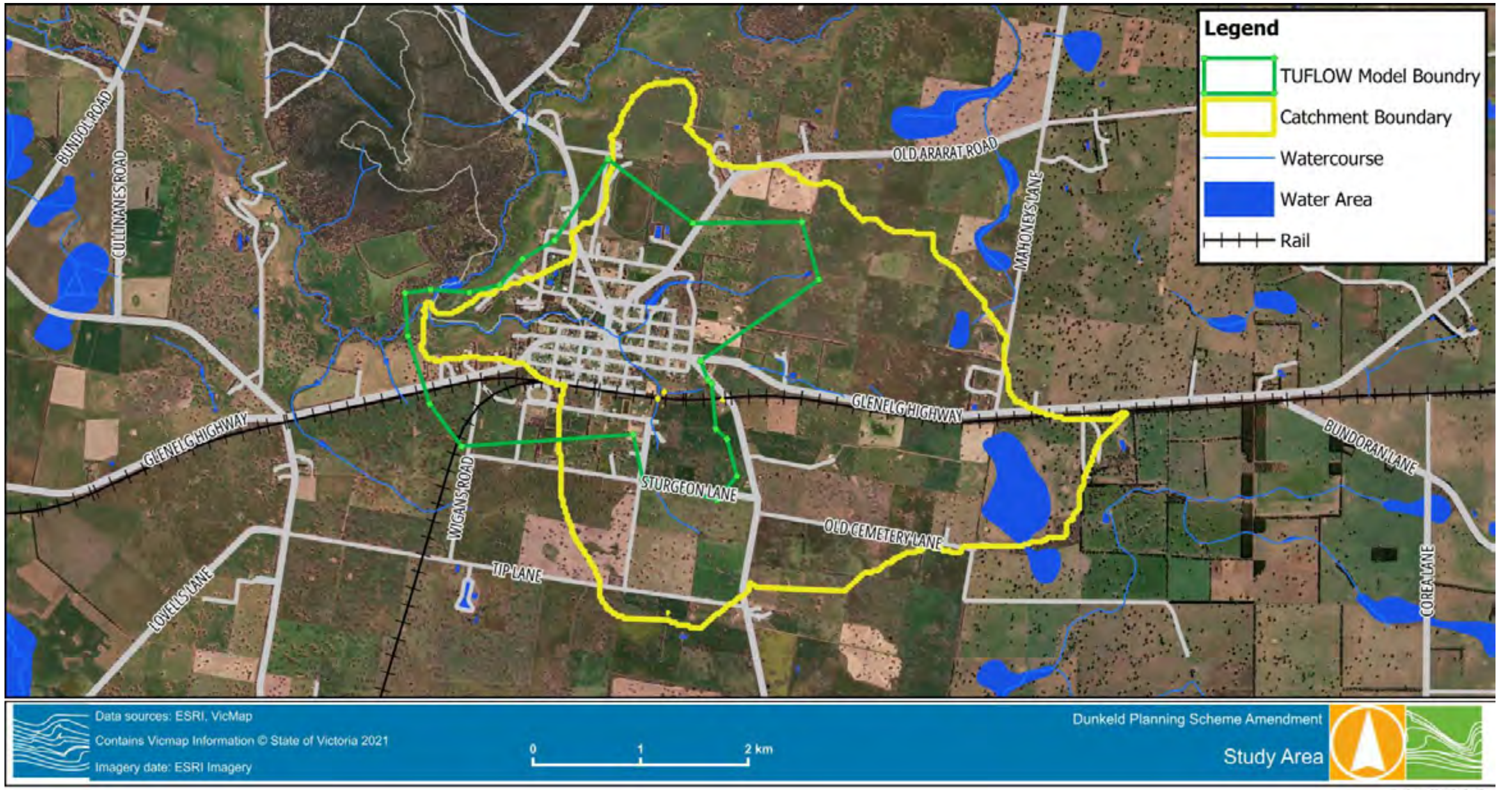

Figure 1-1 Study Area

2 HYDROLOGY AND HYDRAULICS SUMMARY

2.1 Overview

Hydrological and hydraulic models were previously created by Water Technology in 2018 for the Dunkeld Reservoir - Structural Integrity Assessment and Restoration Plan. This plan focused on the 1% Annual Exceedance Probability (AEP) event. The purpose of the current assessment was to produce the 0.5%, 1%, 2%, 5%, 10% and 20% AEP to inform the Southern Grampians Shire Planning Scheme Amendment.

2.2 Hydrology Summary

The RORB hydrology model from the Dunkeld Reservoir - Structural Integrity Assessment and Restoration Plan was used for this assessment. The critical durations for this catchment were previously determined and are summarised in Table 2-1. The catchment is subject to flash flood (durations less than 6 hours), with the critical durations for the AEPs modelled ranging from 2-6 hours.

Table 2-1 Summary of critical durations

Event (AEP)	Duration	Temporal Pattern
0.5%	2hrs	28
1%	2hrs	25
2%	3hrs	27
5%	3hrs	16
10%	3hrs	16
20%	6hrs	8

The RORB model was developed by Water Technology[2] in 2018. A summary of the adopted parameters is shown in Table 2-2. This model underwent a calibration process to anecdotal data including images and point flood height survey information from the 2011 flood event, further detail can be sourced from the study report.

Table 2-2 Adopted parameters

Kc	Initial Losses (mm)	Continuing Losses (mm/hr)	m
11.30	22.0	4.7	0.8

[2] Preliminary Flood Modelling, Dunkeld Reservoir - Structural Integrity Assessment and Restoration Plan, Water Technology, 2018

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2.3 Hydraulics Summary – Dunkeld Reservoir Updates

The hydraulic TUFLOW model was developed in 2018[3] and has been adopted with updates to the Dunkeld Reservoir. This upgrade resulted in changes to the dam wall height and spillway arrangement. The changes to the dam are shown in Figure 2-1, and were implemented into the TUFLOW model as z-shapes. The final digital elevation model is shown in Figure 2-2.

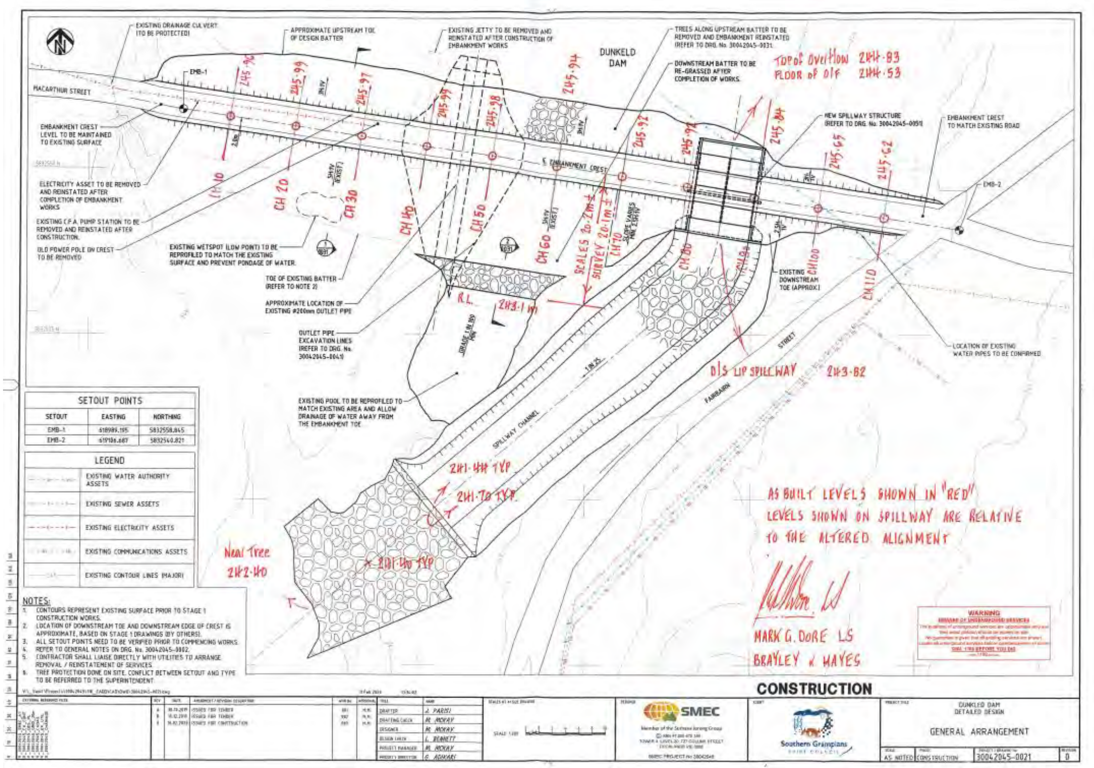

Figure 2-1 As built levels for Dunkeld Reservoir

[3] Preliminary Flood Modelling, Dunkeld Reservoir - Structural Integrity Assessment and Restoration Plan, Water Technology, 2018

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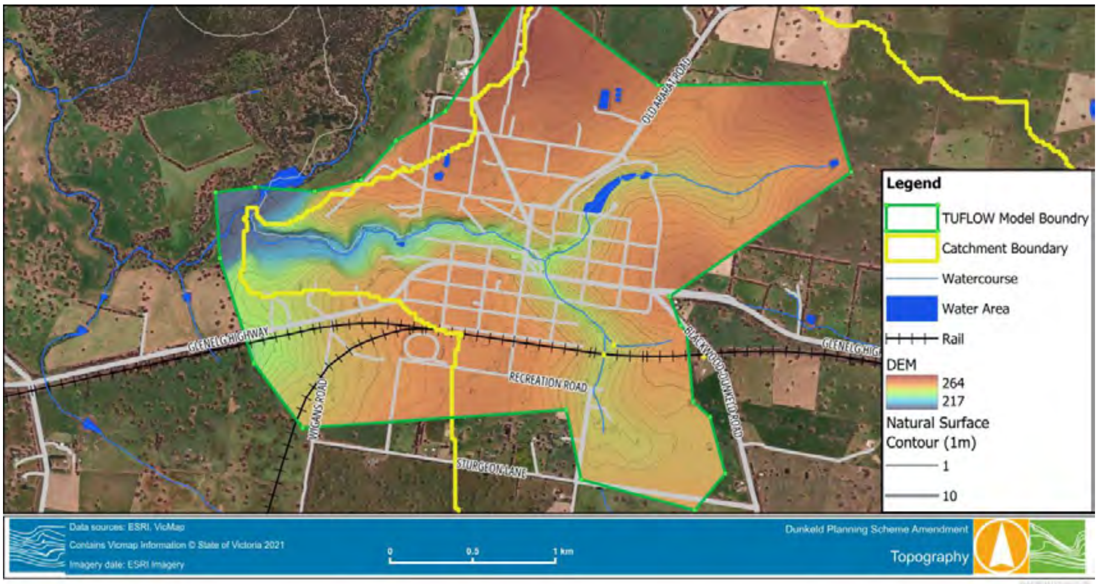

Figure 2-2 Final Digital Elevation Model

3 PLANNING SCHEME AMENDMENT RECCOMENDATIONS

3.1 Existing Controls

Currently, no flood related planning controls exist in the Dunkeld township (LSIO, SBO, FO, UFZ).

3.2 Land Subject to Inundation (LSIO) and Floodway Overlay (FO) layer development

The LSIO layer has been prepared in accordance with Glenelg Hopkins Catchment Management Authority guidelines. The LSIO was created from the 1% AEP flood extent with smoothing at the edge of the extent to remove pixilation from the raw model results. The draft LSIO layer is shown in Figure 3-1.

The FO layer, shown in Figure 3-2, has been prepared in accordance with Glenelg Hopkins Catchment Management Authority guidelines. Floodway Overlay is characterised by the ‘floodway’ portion of the 1% AEP floodplain which is determined by the following characteristics:

(i) Depths of, or exceeding, 0.5 metres; or

(ii) Hazard of, or exceeding, 0.4 m2 /s

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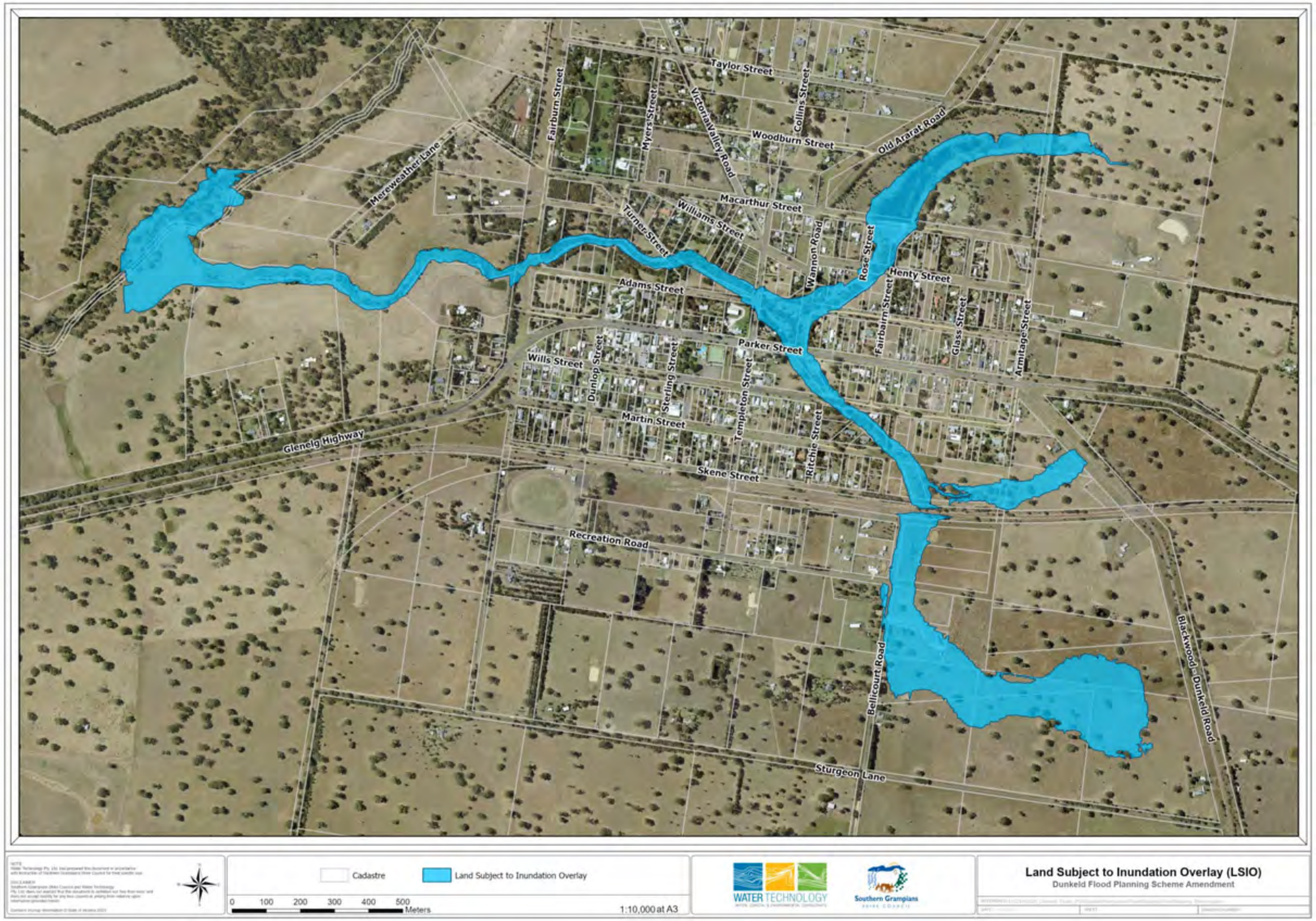

Figure 3-1 Draft Land Subject to Inundation Overlay (LSIO)

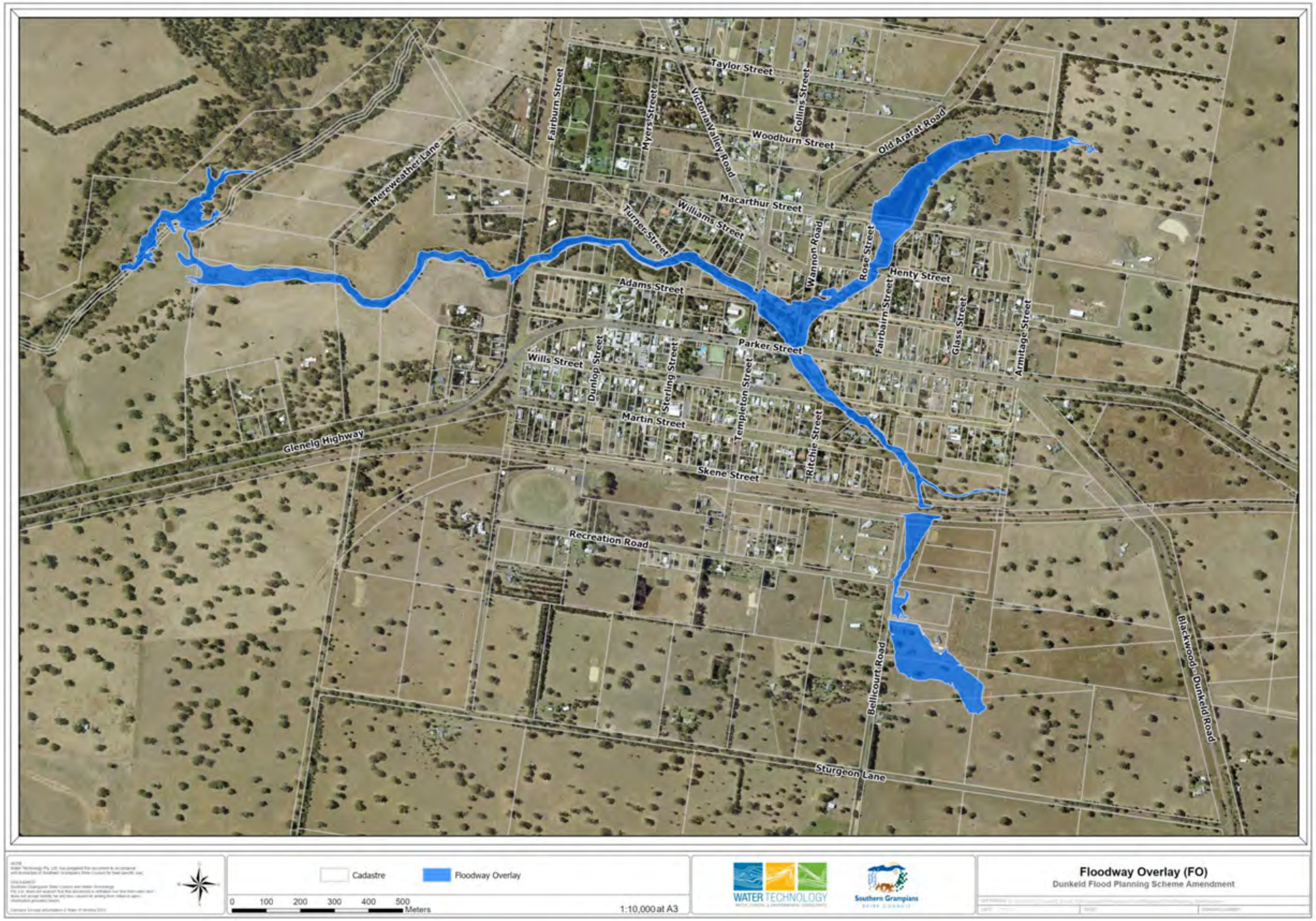

Figure 3-2 Draft Floodway Overlay (FO)

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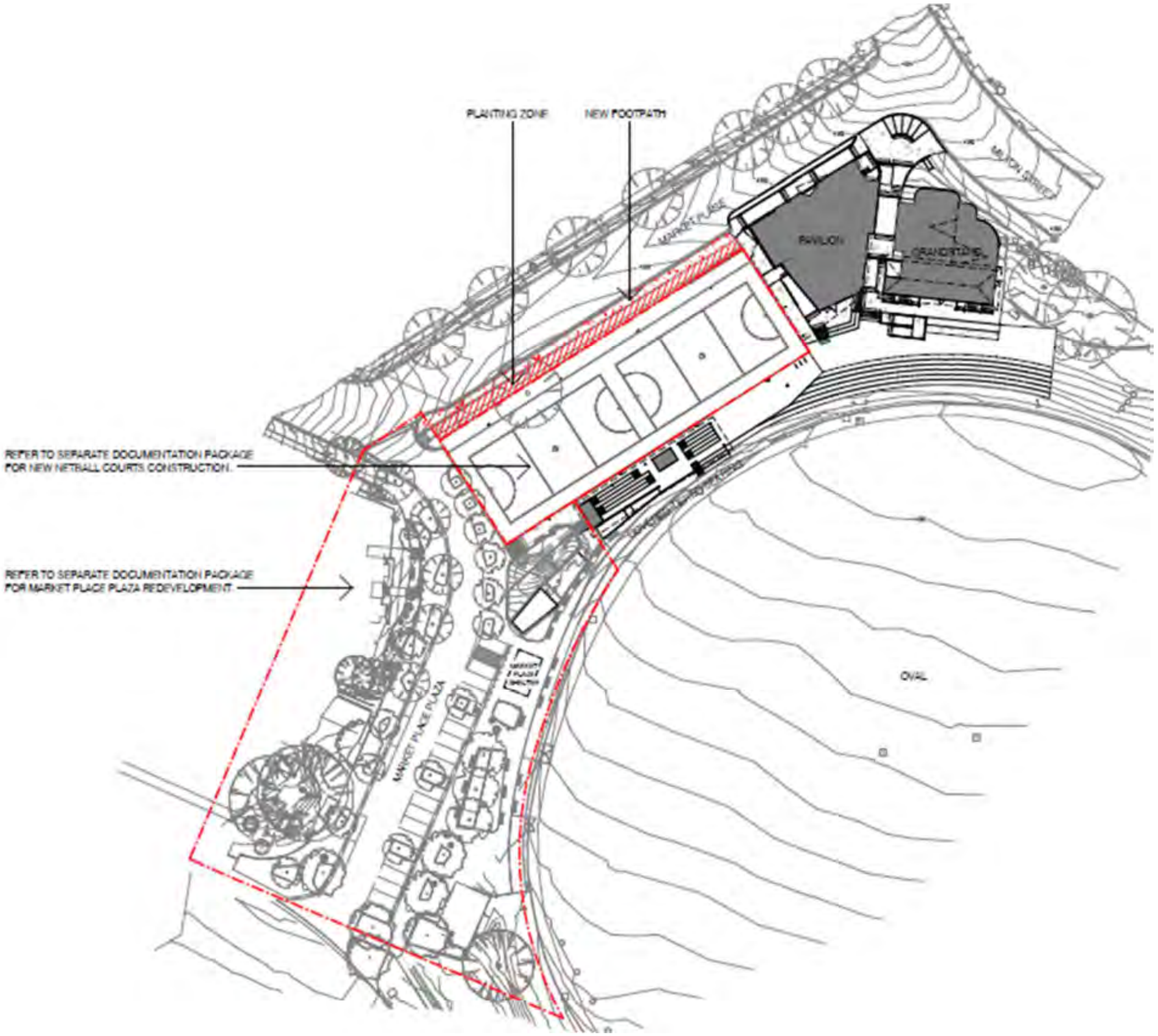
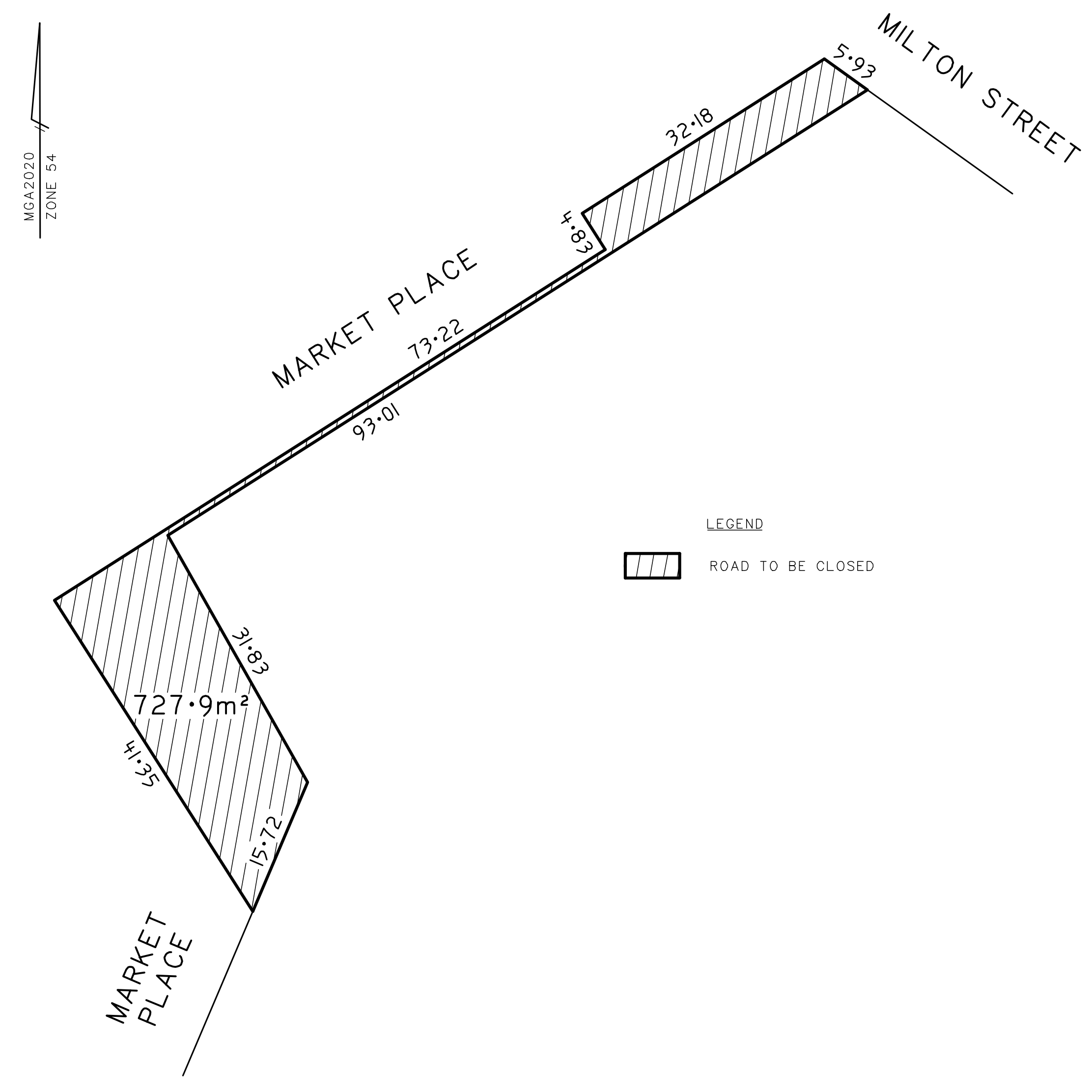

PLANTING ZONE
NEW FOOTPATH
REFER TO SEPARATE DOCUMENTATION PACKAGE
FOR NEW NETBALL COURTS CONSTRUCTION.
REFER TO SEPARATE DOCUMENTATION PACKAGE
FOR MARKET PLACE PLAZA REDEVELOPMENT
PAVILION
GRANDSTAND
OVAL
MARKET PLACE PLAZA

PLAN FOR ROAD DISCONTINUANCE PURPOSES

Pursuant to Clause 3(a) of Schedule 10 of the Local Government Act 1989

Location of Land	NOTATIONS
Parish: HAMILTON NORTH Township: HAMILTON Section: ——— Crown Allotments: ——— Title References: ——— Last Plan References: ———	SEE SURVEYORS REPORT AND ABSTRACT OF FIELD RECORDS FOR DATUM DETAILS. MGA2020 Co-ordinates: E 589 985 N 5 822 520 Zone 54



ORIGINAL SHEET SIZE: A3	CERTIFICATION BY SURVEYOR	SHEET 1 OF 1
SCALE 1:500 — 5 0 10 20 LENGTHS ARE IN METRES		
SURVEYORS FILE REF: 22111 VERSION 1 20/02/23 VERSION 2 21/02/23		
BRAYLEY & HAYES LAND & ENGINEERING SURVEYORS 85 KENNEDY STREET, HAMILTON, 3300 PHONE: (03) 5571 9171 EMAIL: admin@brayleyandhayes.com.au	MARK G. DORE / VERSION 2	

Southern Grampians
SHIRE COUNCIL

Planning Committee Minutes

3 July 2023

To be held at 12:15pm in the
Martin J Hynes Auditorium
5 Market Place, Hamilton

Contents

1. PRESENT

Councillors

Cr Mary Ann Brown
Cr Albert Calvano

Officers

Ms Susannah Milne, A/g Director Wellbeing Planning and Regulation
Ms Marg Scanlon Director Infrastructure and Sustainability
Mr Andrew Nield, Acting Manager Shire Strategy and Regulation

Minutes

Ms Sharon Clutterbuck, Executive Assistant – Director Wellbeing Planning and Regulation

2. WELCOME

3. APOLOGIES

Mr Rory Neeson Director, Wellbeing Planning and Regulation

4. CONFIRMATION OF MINUTES

Minutes of the Meeting held on 14 June 2023 have been circulated

RECOMMENDATION

That the Minutes of the Planning Committee meeting held on 14 June 2023 be confirmed as a correct record.

COMMITTEE RESOLUTION

That the Minutes of the Planning Committee meeting held on 14 June 2023 be confirmed as a correct record.

Moved: **Ms Marg Scanlon**
Seconded **Cr Calvano**

Carried

5. DECLARATION OF INTEREST

Nil

6. MATTERS FOR DECISION

6.1 Planning application TP/133/2022 for 111 Bell Street, Penshurst

Attachment 1 – Planning Report

Attachment 2 – Southern Grampians Domestic Wastewater Plan

Attachment 3 – Form 4 Planning Permit

Attachment 4 – Adaptive Wastewater Solutions for Penshurst

Summary

Planning application TP/133/2022 proposes the re-alignment of a boundary at 111 Bell Street, Penshurst. Pursuant to Clause 32.05-5 (Township Zone), a permit is required to subdivide land. The application proposes the existing dwelling be located on proposed Lot 1 which has an area of 1,106 square metres (sqm) and the existing sheds to be located on proposed Lot 2 with an area of 1,948sqm. One shed, which would straddle the proposed boundary is proposed to be removed from the land. Due to the size of the lots, insufficient space is available for the continual storage and treatment of wastewater generated by the dwelling. The existing sheds, too, would not be able to have any toilets, wash facilities or other water fixtures as there is insufficient space to accommodate wastewater within the lot. The application fails to demonstrate that wastewater can be stored and treated according to current industry standards and therefore it is recommended that the application be refused.

Context

The subject site is located on the southern side of Bell Street, at the corner of Burchette Street. The surrounding area comprises lots of around 1,000-2,500sqm, with some smaller lots, such as 31 Burchett Street having a smaller area of around 630sqm (this particular lot appears to be developed with a shed). Lots are typically of a rectangular shape, fitting the grid-like pattern delineated by the road network. Road reserves are wider than average and Bell Street, to the front of the site, is sealed and has angled parking.

The subject site is a near-rectangular shaped site comprising of two lots. Both lots are in common ownership. An existing dwelling is situated on the western side of the site, within what is currently Crown Allotment 9 Section 13 Township of Penshurst Parish of Boramboram. Five sheds and a cellar are also established on this lot. This shed is used for storage of materials and equipment associated with the owner's carpentry business. The lot to the east is known as Lot 1 on Plan of Subdivision 348776T and contains two drainage easements which run north-south along the western boundary (the eastern edge of the largest shed).

The owner lives nearby but not on the subject site and would like to sell the dwelling on what is proposed to be Lot 1 and continue to access the sheds on proposed Lot 2.

There are two existing vehicle crossovers at Bell Street which could be used for access for the respective lots proposed.

Figure 1 Site within context, Pozi

<u>Site History</u>

Planning permit TP/102/2015 was issued on 9 March 2016 for the re-subdivision of two lots (boundary realignment). Condition 1 of the permit required the owner/applicant to submit a Land Capability Assessment for approval by the responsible authority prior to a statement of compliance being issued for the submission. This condition was not satisfied and the permit has since expired.

Planning requirements

Pursuant to Clause 32.05-5, a permit is required to subdivide land. This includes changes to boundary alignments where the number of lots is not increased. An application to subdivide land, other than an application to subdivide land into lots each containing an existing dwelling or car parking space, must meet the requirements of Clause 56 and must meet all the relevant objectives in the table at Clause 32.05-5 and should meet all of the specified standards. The application has been accompanied by a response to each of these matters and generally the proposal is compliant.

No overlays apply to the land.

Clause 66.01 Subdivision Referrals specifies that a boundary re-alignment does not require external referrals but sets out requirements for permits where granted. Clause 66.01-1 specifies that an application that does not require referral under Clause 66.01 must contain conditions relating to the supply of water, drainage and sewerage facilities, electricity and gas (where proposed). The plan of subdivision must also be referred to the relevant authorities for such utilities and easements, roads and sites for utility services must be set aside on the plan.

Discussion

The subject site has a total area of 3,055sqm and is developed by a dwelling on the western side of the site and multiple sheds. Lot 2 proposed would have the largest and second largest sheds established on it. A third shed, shown on the proposed subdivision plan to the south of the site, straddles the proposed boundary line and would need to be removed to ensure there is no future conflict with ownership. The western wall of the largest shed abuts the proposed boundary line and would require the installation of a fire rating wall to meet current building regulations. The shed appears to be well worn and the cost effectiveness to bring the building into compliance with the building regulations may be prohibitive.

A further issue with the location of the sheds is the potential for land use conflicts. If the realignment were approved, the main shed would be located on the boundary to the lot with the existing dwelling. The dwelling could be sold to a new owner and this owner may be unaware of the use of the shed. Whilst the shed is currently used for storage of goods, it could be used for other purposes that could impact future residents of the dwelling.

The key issue for this proposal, however, is the inability of the site to meet current wastewater requirements. Penshurst currently has no reticulated water services and is not located within a Wannon Water sewer district. This means that despite Lot 2 having an existing sewerage easement (E-1), wastewater from each property must be retained and treated within the boundaries of the lot. The implication of this is that properties, such as the subject site, have limited capacity for intensified use or for changes to the lots.

Lot 1 proposed has an area of 1,106sqma and Lot 2 an area of 1,948sqm. The *Southern Grampians Shire Domestic Wastewater Management Plan (2019)* (the 'Wastewater Management Plan') identifies onsite wastewater management systems are unable to maintain long term sustainability on unsewered allotments of less than 2,000sqm. This is regardless of the land capability. The Wastewater Management Plan details a minimum lot size of 4,000sqm for long term sustainable management of wastewater. Given the total lot size is less than 4,000sqm (being 2,008sqm), the site is highly constrained and unlikely to be capable of safe and sustainable, long term onsite wastewater management.

It is proposed that the lot comprising the existing dwelling would be reduced from 2,023sqm to 1,106sqm, significantly reducing the area available for wastewater requirements of that dwelling. Retention of the outbuildings on that lot would further reduce the area of available land, and wastewater system have setbacks that need to be met.

The application has been accompanied by a Land Capability Assessment (LCA) from 2016 and no recent information has been supplied to demonstrate that the site can accommodate wastewater sustainably. The LCA report proposes the use of an Environment Protection Authority (EPA) -approved secondary treatment plan with subsurface drip irrigation directed to the lawn. This irrigation area would use essentially all the 'backyard' space of the lot and wrap around the eastern side and back of the sheds. Lot 2 would be provided with a 3,000 litre (L) septic tank with waste treated and directed to a Evopotranspiration trenches east of the lot.

The application has been referred to Council's Environmental Health Officer (EHO) who has provided advice around the wastewater requirements that apply in the Southern Grampians. The EHO has identified issues with the proposal, summarised as follows:

- Both proposed lots are less than 2,000sqm and are therefore highly constrained and unlikely to be capable of safe and sustainable on-site wastewater management in the long term.
- The site generally does not have sufficient available area to fit an adequately sized onsite wastewater system, whilst meeting recommended setback distances to waterways, ground water bores and other sensitive receiving environments.
- High hazard sites, such as the subject site, are problematic as individual and/or cumulative hazards significantly elevate the likelihood and/or consequences of septic system failure.
- Minimum lot size for long term sustainable onsite wastewater management is 4,000sqm of useable land (area free from dams, watercourses and other such constraints).
- Penshurst has shallow permeable soils and sensitive groundwater environment beneath the town (see *Adaptive Wastewater Solutions for Small Towns – Penshurst and Cudgee Options Analysis Report (2020)*).
- Generally, a dwelling generates more wastewater than a shed and therefore the proposed boundary re-alignment, which seeks to reduce the area of land for the dwelling, is not appropriate.
- The application, including the LCA, has not addressed –
    - How the proposal will prevent impacts on human health and the environment (specifically the environmental protection principles in the *Environment Protection Act* 2017) ('EPA 2017').
    - How the proposal is consistent with the *EPA 2017* and *Environmental Protection Regulations 2021 ('*EP Regulations 202*1')* requirements.
    - How the proposal meets guidance and good industry practices for managing and minimising public health and environmental risks, noting the LCA report from 2016 predates Council's Wastewater Management Plan, the *EPA 2017* and *EP Regulations 2021*.

The deficiencies of the application and the constraints of the site have been communicated to the permit application leading up to this recommendation, with sufficient time being provided for an up to date LCA or other assessments to be provided. The application fails to demonstrate that, in the absence of reticulated sewers, the wastewater generated from each lot can be safely and sustainably treated and retained within each lot.

MEETING PROCESS

The meeting was held in accordance with standard meeting procedures.

RECOMMENDATION

That the Committee Refuse planning application TP/133/2022 for a Boundary re-alignment at 111 Bell Street on the grounds set out as follows:

1. The application fails to demonstrate that each lot can safely and sustainably accommodate on-site wastewater systems, in accordance with the Southern Grampians Shire Domestic Wastewater Management Plan (2019) and Environmental Protection Authority Code of Practice for On-site Wastewater Management.

COMMITTEE RESOLUTION

That the Committee Refuse planning application TP/133/2022 for a Boundary re-alignment at 111 Bell Street on the grounds set out as follows:

1. The application fails to demonstrate that each lot can safely and sustainably accommodate on-site wastewater systems, in accordance with the Southern Grampians Shire Domestic Wastewater Management Plan (2019) and Environmental Protection Authority Code of Practice for On-site Wastewater Management.

Moved: **Marg Scanlon**
Seconded **Susannah Milne**

Carried

7. CLOSE OF BUSINESS

Meeting closed at 12.48pm