

Horsham and Wartook Valley Flood Investigation

Data Collation & Review



December 2015

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Cover Photo: Inundation at the corner of Hamilton Street and Firebrace Street during January 2011
(Wimmera Region Flood Report, January 2011)

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1. INTRODUCTION

Wimmera CMA has engaged Water Technology to undertake the Horsham and Wartook Valley Flood Investigation. The objective of the study is to increase and update flood intelligence and protection measures along the Wimmera River at Horsham and the contributing tributaries that drain the northern section of the Grampians Mountain Ranges. Stormwater flooding Horsham and Haven will also be assessed.

As part of the initial scoping work, the data required for modelling and mapping was collated and reviewed. This report documents the data review findings and identifies gaps in the data.

2. STUDY AREA

The Wimmera River originates in the Pyrenees Ranges on the northern slopes of the Great Dividing Range and flows north west, intersecting Horsham. At this point the upstream catchment is over 4,000 km².

Approximately 25 km upstream of Horsham the Wimmera River splits to Yarriambiack Creek, a portion of which returns to the Wimmera River via Two Mile Creek further downstream. An overland flow path south of the Wimmera River also carries flood water breaking out from downstream of Drung to Riverside.

A number of tributaries feed the Wimmera River between Horsham and Quantong with runoff from the northern Grampians Mountain Ranges. These include: Burnt Creek; Bungalally Creek; MacKenzie River; Norton Creek; Darragan Creek; and Sandy Creek.

The MacKenzie River, which is fed by the Wartook Reservoir, is intricately linked to Burnt Creek and Bungalally Creek. Burnt Creek receives an effluent distribution from the MacKenzie River. Further along Burnt Creek similar distribution occurs to Bungalally Creek, which then flows back into the MacKenzie River.

The study area, including waterways to be mapped is shown in Figure 2-1.

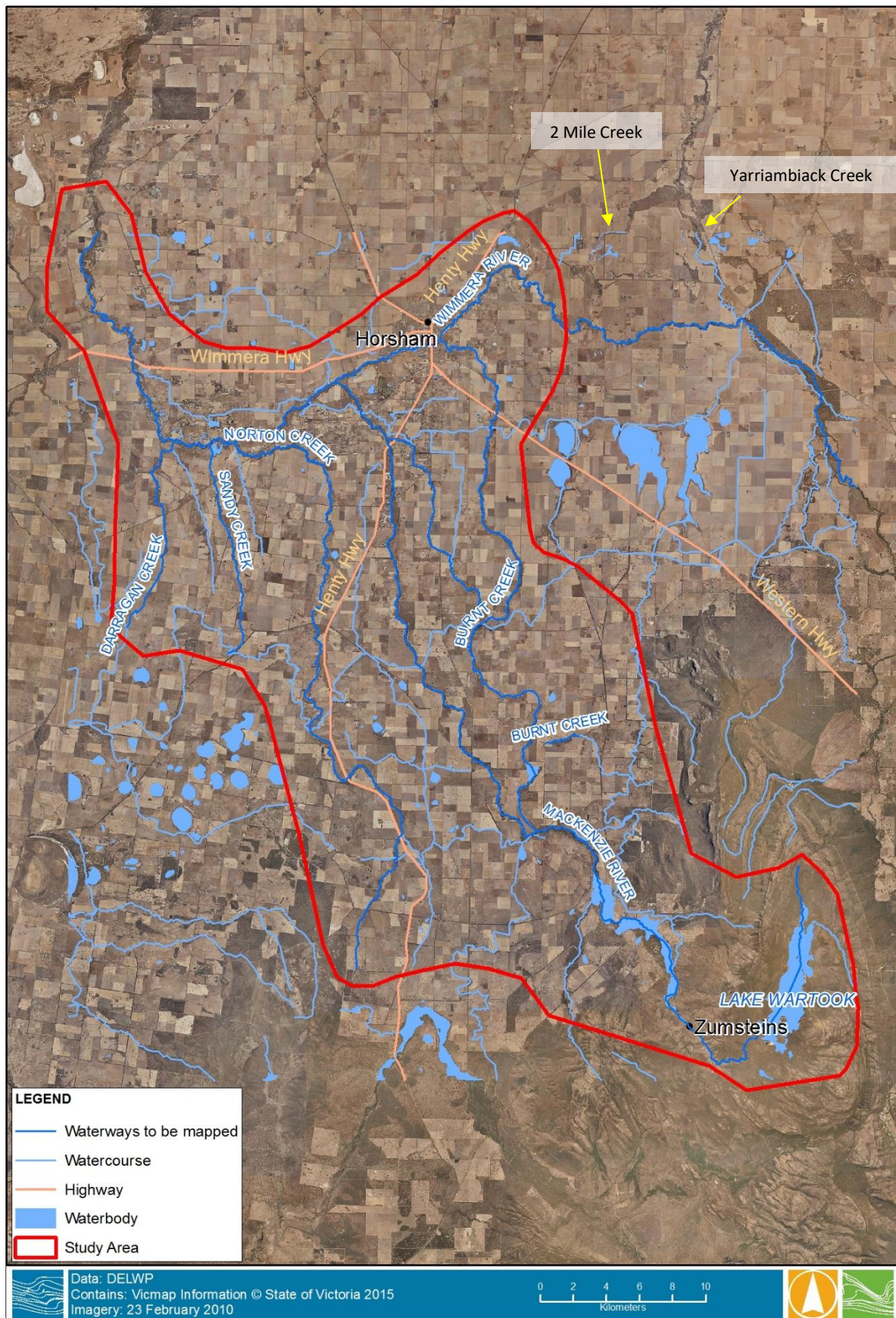


Figure 2-1 Study area

3. FLOOD RELATED STUDIES

Several studies have been completed within the study area, however there is no known study that considers the interaction between the Horsham River and the Grampians northern tributaries, and the subsequent implications on flood levels.

The following studies are specifically relevant to the current investigation and will be used to inform the current study:

- Lower Wimmera River Flood Mapping (Water Technology, ongoing)
- Wartook to Zumsteins Walking Track Flood Investigation (Water Technology, 2015)
- East Horsham Flood Plan (Water Technology, 2011)
- Wimmera CMA Flood Report – January 2011 (Water Technology, 2011)
- Yarriambiack Creek and Wimmera River Flows (Water Technology, 2009)
- Horsham Bypass Hydrology and Hydraulics Impact Study (Water Technology, 2012)
- East Horsham Channel Decommissioning (Water Technology, 2014)

3.1 Horsham Flood Study

3.1.1 Overview

The objective of the Horsham Flood Study was to better understand the impact of flooding post implementation of several flood mitigation works including a levee system and river widening. The Study modelled 20 %, 10 %, 5 %, 2 %, 1 % and 0.5 % AEP events. Model results were used as the basis for extent, depth and level mapping. They were also used for planning purposes and the basis of a series of recommendations. Calibration flows determined for the study were based on gauge recordings at the Wimmera River at Horsham (Walmer) and Burnt Creek at Wonwondah gauges, Flood Frequency Analysis was then used to determine peak design flows. The study also documented the existing levee systems within Horsham and historic flood events occurring along the Wimmera River at Horsham.

3.1.2 Relevant Findings

The calibration and design flow estimated used in the Horsham Flood Study will be reviewed and compared to estimates produced in this study. The FFA completed at each gauge determined the peak flows shown in .

Table 3-1 Peak flows determined by FFA at the Wimmera River at Horsham (Walmer) and Burnt Creek at Wonwondah East

AEP (%)	Wimmera River at Horsham (Walmer)		Burnt Creek at Wonwondah East	
	Peak flow (ML/d)	Peak flow (m ³ /s)	Peak flow (ML/d)	Peak flow (m ³ /s)
20	12,900	149	1,200	14
10	18,100	209	1,800	21
5	23,700	274	2,500	29
2	31,200	361	3,400	39
1	37,000	428	4,200	49
0.5	43,000	498	5,100	59

The levee systems and flood mitigation infrastructure highlighted will also be incorporated into the modelling undertaken in this project if appropriate. The main levee identified in the Horsham Flood Study was the Menadue St/Peppertree Lane levee, this was surveyed by Findlay Irrigation Services and BM Consulting Engineers for the then Department of Natural Resources and Environment in 1996. A long section from that survey is shown in Figure 3-1.

The location and condition of this levee will be assessed during a site inspection.

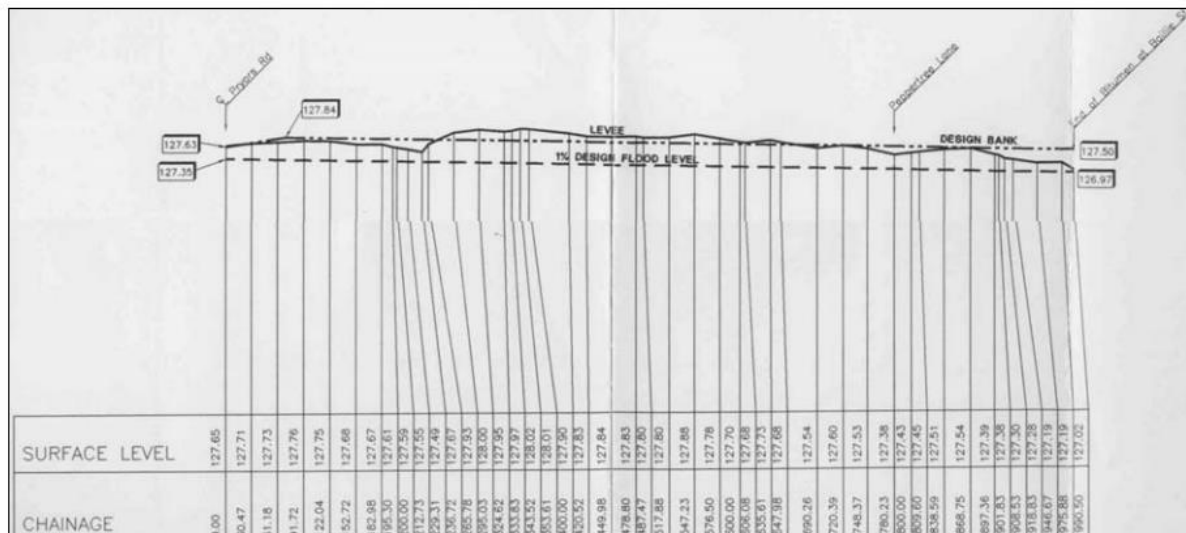


Figure 3-1 Menadue Street/Peppertree Lane levee longsection survey

3.2 Lower Wimmera River Flood Mapping

Overview

Water Technology is currently undertaking the Lower Wimmera River Regional Flood Mapping project, the objective of which is to develop regional scale flood mapping for the Lower Wimmera River between Quantong and Lake Hindmarsh. To provide meaningful flood information, the flood mapping is tied back to the Horsham (Walmer) gauge, which is of relevance to this study.

Relevant Findings

In developing the hydrology for the project, several discussions were had between Wimmera CMA, Ventia (formerly Thiess) and Water Technology regarding the recorded flow at Horsham (Walmer gauge) during the January 2011 flood event. It was determined the measured flow was as accurate as possible. This resolution was critical to the current project as all mapping will be tied back to a gauge level (and flow) at the Walmer gauge. Further details regarding the streamflow gauge at Horsham can be found in Section 4.1.1. The hydrological analysis undertaken for the Walmer gauge will be adopted in this project.

The Lower Wimmera River Flood Mapping project also considered the influence of concurrent flows in the MacKenzie River, and it was found that the MacKenzie River peak at Horsham generally arrives well before the Wimmera River peak. An analysis of streamflow data revealed that the Mackenzie River peaked between 2.5 and 3.5 days earlier than the Wimmera River at Horsham on all significant flood events where concurrent records were available (September 1988, October 1992, October 1996, September 2010 and January 2011). It was also found that the Mackenzie River flows had receded by the time the Wimmera River peak arrived. This indicates that the interaction between Northern Grampians tributaries and the Wimmera River is likely to have negligible impact on flood extents and levels, however this will still be tested in the hydraulic model.

3.3 Wartook to Zumsteins Walking Track

3.3.1 Overview

Horsham Rural City Council received funding for a proposed walking/cycling trail to link Wartook to Zumsteins car park in the north-west Grampians. A preferred alignment was selected for the design of the trail, following the 'Historic Back Track', approximately 9.5 km in length.

Water Technology undertook a flood analysis of the proposed alignment, modelling the 1% AEP flood event.

3.3.2 Relevant Findings

As part of the hydrological assessment for this project, a flood frequency analysis was undertaken for the MacKenzie River @ Wartook Reservoir gauge. This analysis is detailed further in Section 4.1.3, and will be adopted for the current study as an upstream boundary to the hydraulic model.

3.4 East Horsham Flood Plan

3.4.1 Overview

The East Horsham Flood Plan modelled the area from Riverside to west of the Yarriambiack Creek offtake from the Wimmera river. The 20 %, 10 %, 5 %, 2 % and 0.5 % AEP events were added to the already modelled 1 % AEP event. The project resulted in a Flood Intelligence Report, to allow for an update of the Horsham Rural City Council Flood Response Plan to include the area of East Horsham, and a Drainage Recommendations Report. Recommendations identified were predominately related to channel infrastructure and the potential impact of channel decommissioning. Some of these recommendations were addressed during the East Horsham Channel Decommissioning Project commissioned by GWMWater and completed by Water Technology. This project is detailed further in Section 3.8.

3.4.2 Relevant Findings

As many of the channels have now been decommissioned, flood mapping from this study will no longer represent the on ground conditions, however the general discussion around areas of concern will highlight where specific detail is required in the development of the hydraulic model. The report also details significant details regarding the January 2011 event which may be used in the model calibration process.

The East Horsham Flood Plan determined flows and peak flood heights for the Wimmera River @ Horsham gauge for each of the modelled AEP flood events, as shown in Table 3-2. These were considered in the hydrological analysis of the Lower Wimmera River Regional project, with hydrology for the Wimmera River at Horsham updated.

Table 3-2 Modelled peak flows and water levels at the Wimmera River at Horsham Gauge determined during the East Horsham Flood Plan

Event AEP (%)	Peak Level (m AHD)	Peak Flow (ML/d)	Peak Flow (m ³ /s)
20	123.41	10,109	117
10	123.43	10,454	121
5	123.80	22,291	258
2	124.10	30,326	351
1	124.11	34,646	401
0.5	124.46	42,854	496

There was significant floor level survey captured as part of the East Horsham Flood Plan, adding to that captured during the Horsham Flood Investigation (as discussed in Section 1.1). The extent of the captured floor level survey is shown in Figure 3-2, purple points indicate data captured during the Horsham Flood Study (2002) and yellow the East Horsham Flood Plan.

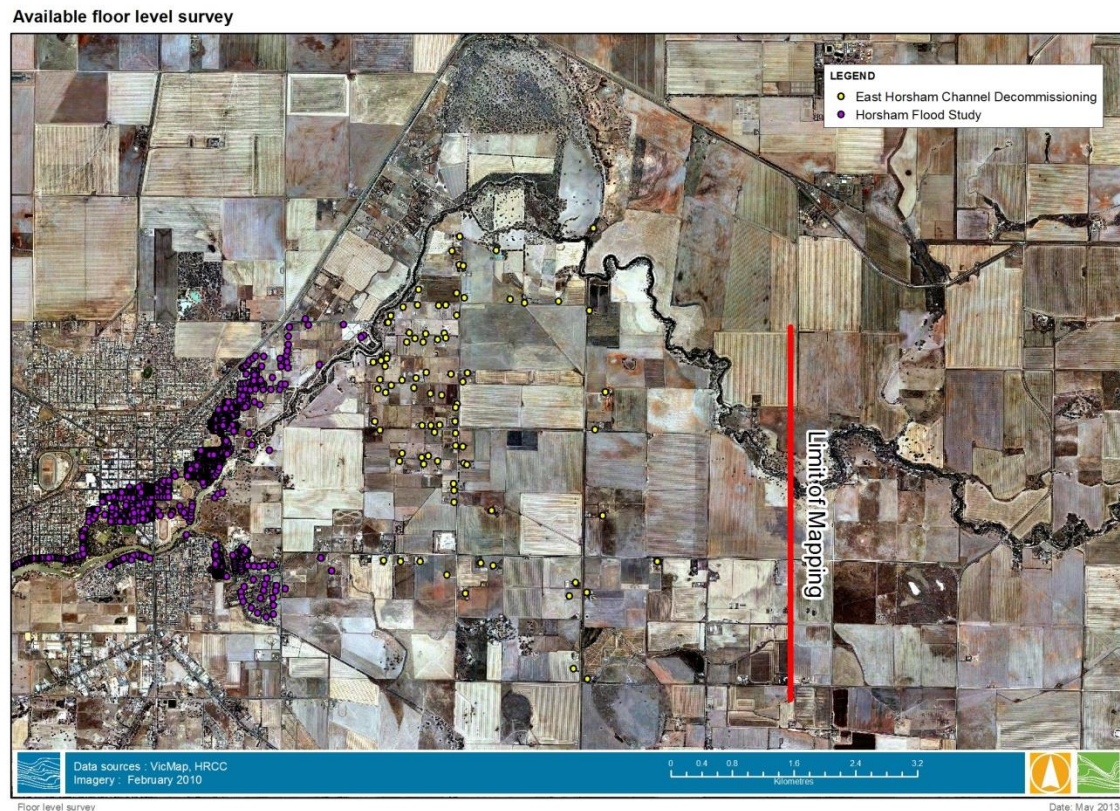


Figure 3-2 Floor level survey captured as part of the East Horsham Flood Plan

3.5 Wimmera CMA Flood Report – January 2011

3.5.1 Overview

The Wimmera Region Flood Report – January 2011 provides a summary of the flood event, reviews the actions that occurred, and provided recommendations to improve the approach to dealing with future floods.

Many of the recommendations from the Wimmera CMA Flood Report have since been actioned upon, including the commissioning of the following studies:

- Natimuk Flood Study
- Horsham and Wartook Valley Flood Investigation (including Norton Creek)
- Dunmunkle Creek Flood Investigation
- Mt William Creek Flood Investigation

3.5.2 Relevant Findings

The report provides a detailed account of flooding during the January 2011 flood event, including temporary mitigation measures and properties impacted. These will be used in the calibration phase to verify the hydraulic model.

This study will address the recommendation to undertake flood studies for MacKenzie River and Norton Creek, and the area south of Horsham including Burnt Creek.

3.6 Yarriambiack Creek Flows Study

3.6.1 Overview

The Wimmera River and Yarriambiack Creek Flow Modelling Study undertook hydrologic and hydraulic modelling of the Wimmera River and Yarriambiack Creek between Glenorchy, Horsham and Warracknabeal. Design flows into the hydraulic model were determined by an URBS model built by the BoM for flood warning purposes¹.

The complex nature of flow distribution of Wimmera River flows to Yarriambiack Creek resulted in the development and use of several hydraulic models. The project modelled 'current day' and 'pre-European settlement' scenarios.

3.6.2 Relevant Findings

An overland flow path where flow splits from the Wimmera River upstream of the Drung Drung gauge towards the south west was identified. This resulted in two Wimmera River inflows to the study area. The overland flow path intersects the Horsham-Drung South Road at approximately level with Domarchenz Road. The relationship for the proportional split of flows was established from hydraulic modelling for a range of incremental flows, and will be utilised for hydrology input to this study.

The study also analysed the distribution of flow from MacKenzie River to Burnt Creek at the distribution heads. Distribution Heads regulates low-medium flows from MacKenzie River and Moora Channel into Burnt Creek, the MacKenzie River and Old Natimuk Channel. The split was analysed for the 1983, 1988 and 1996 calibration events (observed data was available at Wonwondah East for these events). The result was highly variable, and as such an estimated ratio of 2:1 (MacKenzie River flows: Burnt Creek contribution) was applied for the design modelling.

3.7 Horsham Bypass Hydrology and Hydraulic Investigation

3.7.1 Overview

The Horsham Bypass Hydrology and Hydraulic Investigation was commissioned by VicRoads to review a series of bypass options for the Horsham Township. The study extended modelling completed during the Wimmera River and Yarriambiack Creek Flows Study to the south and west to ensure each of the potential bypass alignments were covered. The model covered from the upstream end (eastern) of

¹ 2004, BoM - URBS Model Developed by the BoM for flood forecasting purposes

this study area, at around School Road to downstream of the Mackenzie River and Wimmera River confluence. Each option was assessed for potential impact to floodplain inundation and the number/size of crossings required for the 10% and 1% AEP events.

3.7.2 Relevant Findings

The hydraulic model extent for the Horsham Bypass Hydrology and Hydraulics Investigation covers a large portion of the area that is of interest to this study. This includes almost all of the Wimmera River floodplain. Model results produced in the Horsham Bypass Hydrology and Hydraulics Investigation will be compared to those produced in this study.

3.8 East Horsham Channel Decommissioning Modelling

3.8.1 Overview

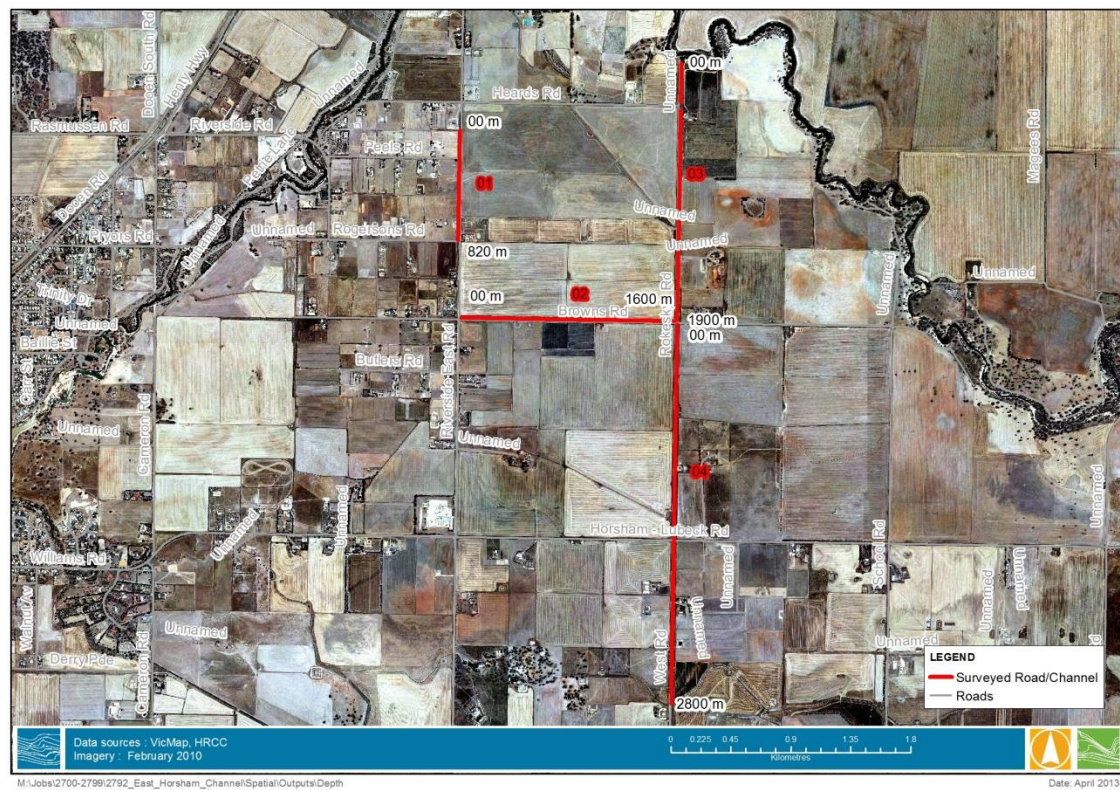
Due to completion of the Wimmera Mallee Pipeline Project GWMWater no longer had the need for their irrigation channel network across East Horsham, and as a result were decommissioning large portions of the channel network. A large number were located in the Wimmera River floodplain and interacted with overland flood flows from the Wimmera River. To better understand this potential impact GWMWater commissioned Water Technology to model the impact of the channel decommissioning across East Horsham. Modelling was completed using the model developed during the Horsham Bypass Hydrology and Hydraulics Assessment.

The initial modelling was followed by a range of mitigation scenarios to negate impact of the channel decommissioning and designs completed for the replacement of Channel No. 3 with a raised height of Rokeskys Road and a private levee protecting one landholder.

During the study there was significant road and channel crest height survey undertaken.

3.8.2 Relevant Findings

The road crest and channel embankment survey undertaken as part of the East Horsham Channel Decommissioning Modelling falls within the study area of this project. The areas surveyed are shown in Figure 3-3.



4. HYDROLOGICAL DATA

4.1 Streamflow

There are numerous streamflow gauges within the study area, as seen in Figure 4-1 and summarised in Table 4-1. These play a vital role in the development and calibration of hydrology and hydraulic model components to flood studies.



Figure 4-1 Streamflow gauges within the study area

Several gauges have a limited period of record, leading to a less confidence in the rating curve. In particular, Norton Creek at Lower Norton only estimates flows up to 160 ML/d, at a height of 0.6 m. Based on past events, this is often exceeded and is based on only 6 complete years of record.

In contrast, there are several gauges that have records spanning up to 104 years, providing large amounts of data on which to base the rating curve.

There was considerable investigation into the Wimmera River gauge at Horsham (Walmer) during the progression of the Lower Wimmera River Regional Mapping project. This investigation is detailed in the Lower Wimmera River Regional Mapping Hydrology Report, the calibration and design flow estimates determined will be used in this study.

The Wimmera River at Drung Drung gauge misses a portion of flow that branches from the Wimmera River upstream of the gauge and returns via Two Mile Creek.

All appropriate gauges will be useful for calibration of the hydrology and hydraulic models. It will be necessary to undertake calibration in tandem with the hydraulic model in order to ensure the MacKenzie River to Burnt Creek and Burnt Creek to Bungalally Creek flow distributions are accurately represented. These distributions can only be modelled hydraulically.

Table 4-1 Relevant streamflow gauges

ID	Gauge	Period of Record	Notes
415202	Mackenzie River @ Wartook Reservoir	1975 - current	Heavily influenced by Wartook outflows, FFA completed as part of the Wartook to Zumsteins Flood Assessment (HRCC).
415223	Burnt Creek @ Wonwondah East	1983 - current	Immediately downstream of the Burnt Creek distribution to Bungalally Creek
415249	Bungalally Creek @ McKenzie Creek	1988 - 1993	Very limited period of record. Water level information only.
415251	Mackenzie River @ McKenzie Creek	1988 - current	Upstream of the point where the Bungalally Creek enters the Mackenzie River
415239	Wimmera River @ Drung Drung	1978 - current	Misses a portion of the Wimmera River flow returning via Two Mile Creek. Water Level data only.
415200	Wimmera River @ Horsham	1910 - current	Known as the Walmer gauge. Was rigorously investigated as part of the Lower Wimmera Regional Mapping project.
415273	Norton Creek @ Lower Norton	2008 - current	Limited rating curve exceeded very often, only 6 years of complete record, influenced by backwater of the Wimmera River. Water level information only.
415261	Wimmera River @ Quantong	2009 - current	Water level information only. No rating curve.

4.1.1 Wimmera River at Horsham (Walmer)

Wimmera River inflows to the study area will be based on historic and design flows at the Walmer gauge. There have been numerous historic events recorded at the gauge, with daily flow recorded from 1889 to 1910 and daily gauge heights from 1920 to 1963, and instantaneous recordings from 1963 onwards. There is some concern regarding the quality of the data prior to 1910, however a number of large floods have occurred more recently. The annual peak flows and their source for the Horsham gauge are summarised in Table 4-2. The January 2011 hydrograph is the highest recorded event in recent record and the most representative of flows in modern catchment condition, however it is smaller than the 1909 event. A hydrograph of the January 2011 event is shown in Figure 4-2, along with the recorded Thiess Quality Code.

Table 4-2 Wimmera River at Horsham - Maximum recorded annual flows

Year	Source and comments	Peak Flow	
		ML/d	m ³ /s
1889	Horsham Flood Study (1979)	21,168	245
1893	Horsham Flood Study (1979)	13,306	154
1894	Significant uncertainty, the DELWP gauge records 44,249 ML/d but is most likely incorrect, adopted flow from Horsham Flood Study (1979) and written gauge book records (sourced by Abdul Aziz of Wimmera CMA).	24,792	287
1903	Historical society document showing 1903 having similar level on Firebrace Street as 1956, 1960 and 1964, adopted average of the three other flows.	16,848	195
1906	Historical society document showing 1906 having similar level on Firebrace Street as 1942	14,342	166
1909	Significant uncertainty, the DELWP gauge records 43,860 ML/d but is most likely incorrect, adopted flow from Horsham Flood Study (1979).	38,880	450
1910	Horsham Flood Study (1979)	14,515	168
1911	Horsham Flood Study (1979)	20,650	239
1912	Horsham Flood Study (1979)	15,293	177
1915	Horsham Flood Study (1979)	27,648	320
1916	Horsham Flood Study (1979)	23,242	269
1918	Horsham Flood Study (1979)	13,478	156
1920	Horsham Flood Study (1979)	13,306	154
1923	Horsham Flood Study (1979)	25,056	290
1924	Horsham Flood Study (1979)	21,254	246
1936	Horsham Flood Study (1979)	12,355	143
1942	Horsham Flood Study (1979)	14,342	166
1955	Horsham Flood Study (1979)	17,107	198
1956	Horsham Flood Study (1979)	16,416	190
1960	DELWP gauge	17,802	206
1964	DELWP gauge	16,325	189
1973	DELWP gauge	15,266	177
1974	DELWP gauge	20,466	237
1975	DELWP gauge	15,951	185
1981	DELWP gauge	23,879	276
1983	DELWP gauge	25,312	293
1988	DELWP gauge	21,005	243
1992	DELWP gauge	13,480	156
1996	DELWP gauge	19,198	222
2010	DELWP gauge	11,723	136
2011	Gauging was undertaken at Western Highway at the peak of the event	33,000	382

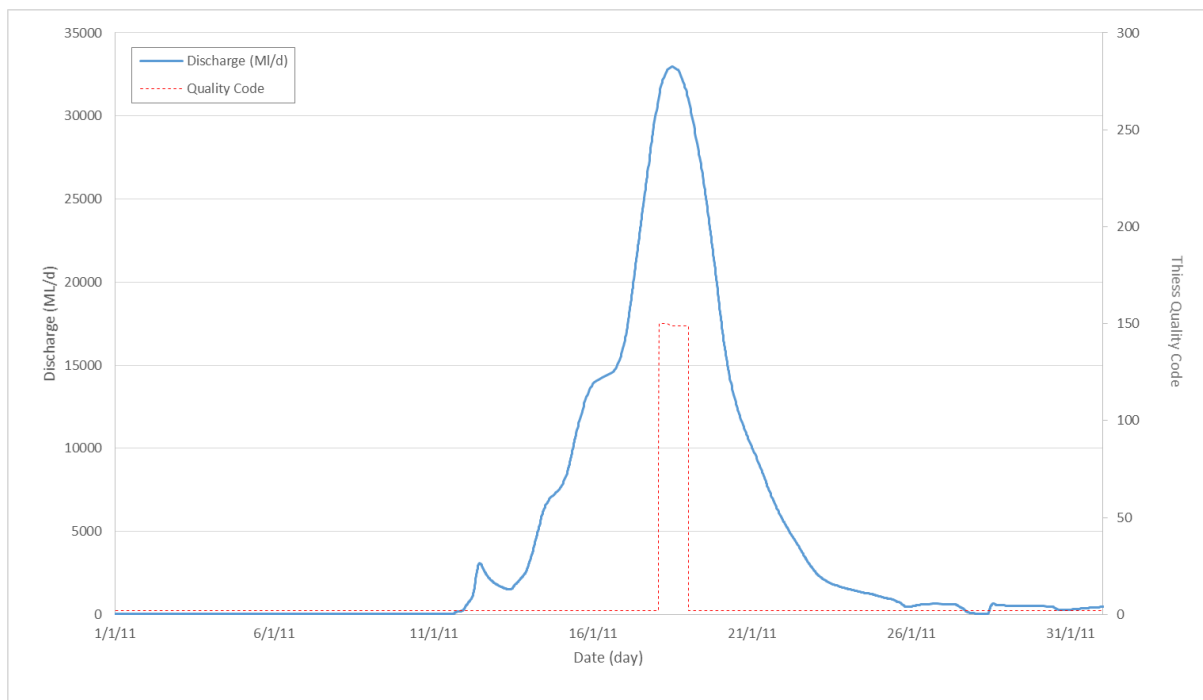


Figure 4-2 January 2011 hydrograph recorded at the Wimmera River at Horsham (Walmer) streamflow gauge

During January 2011, the Wimmera River flowrate was measured at the Western Highway Bridge 5.5 km upstream by Ventia (Formerly Thiess Environmental², the gauging was completed at this location due to the Horsham gauge being too dangerous for Thiess staff to access. The location of the Horsham gauge (Walmer) and the Western Highway Bridge are shown in Figure 4-3.

Using the gauged water levels at the Horsham gauge and the recorded flow at the Western Highway Bridge the Wimmera River at Horsham (Walmer) gauge rating curve was revised by Thiess Environmental, with significant changes at high flows.

The current (revised) Wimmera River at Horsham (Walmer) gauge streamflow rating curve and historic measurements are shown in Figure 4-4, with the previous and current rating curves shown in Figure 4-5.

The change between the current rating curve and the rating curve in use prior to the January 2011 gauging was significant, especially at high flows. At the maximum level reached during the January 2011 event (4.277 m), the current rating table estimates a flow of 382 m³/s (33,000 ML/d), whereas the previous rating was exceeded at 3.65 m. For all levels above m on the gauge, the current rating curve produces lower flow estimates than the previous rating curve.

Ventia measured the January 2011 flow at a very confined location (Western Highway Bridge) with the use of an acoustic doppler which produced velocity distributions across the river profile. In consideration of the velocity profiles and site conditions, the hydrographers attributed these gaugings with a level of accuracy of 3.4% and as a result there is a high level of confidence in the 33,000 ML/d flow measurement.

Based on the best available annual series for the Horsham gauge the Lower Wimmera Regional Flood Mapping Project determined the peak design flow estimated using FFA shown in Table 4-3.

² Pers. Comm. - Thiess Environmental (Rebekah Webb)

Table 4-3 Wimmera River at Horsham – FFA determined design flow peaks

AEP (%)	Peak Flow (ML/d)	Peak Flow (m3/s)
20	13,100	152
10	19,200	222
5	25,000	289
2	31,900	369
1	36,500	423
0.5	40,700	471
0.2	45,400	525



Figure 4-3 Wimmera River at Horsham (Walmer) gauge and Western Highway January 2011 measurement locations

Department of Environment and Primary Industries

HYGPLOT V146 Output 16/04/2015

415200 WIMMERA RIVER @ HORSHAM

Gaugings from 26/10/1909 to 08/10/2014

Rating Table 18.00 18.00

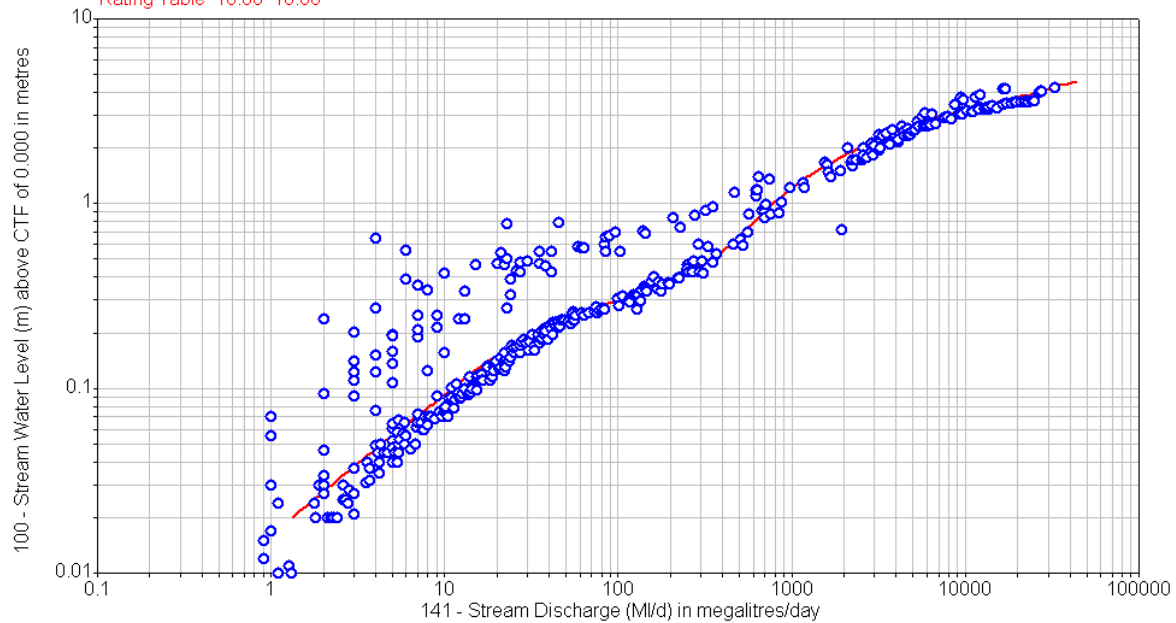


Figure 4-4 Wimmera River at Horsham streamflow gauge rating curve and measurements³

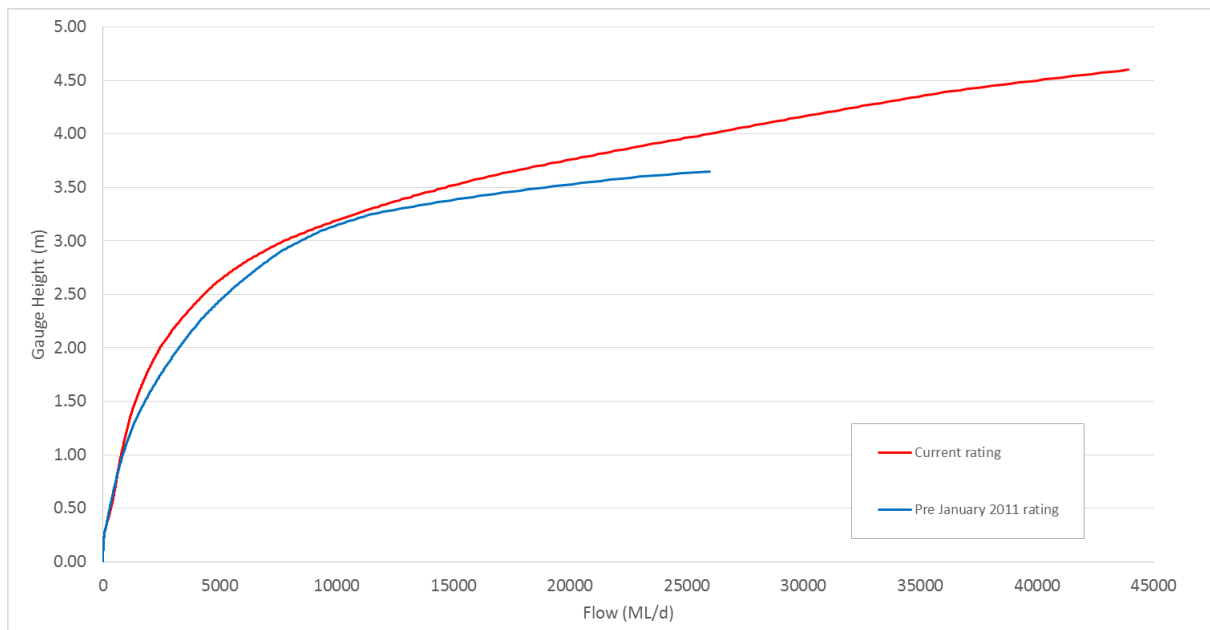


Figure 4-5 Wimmera River at Horsham current and previous rating curves

4.1.2 Norton Creek at Lower Norton

This gauge has known rating curve limitations, with records spanning only from May 2008 to present day. The 6 years of complete annual records is insufficient for any high flow statistical analysis. Water levels above 0.4 m are extrapolated, and the extent of the rating curve is only to 0.6 m. For

³ DEPI - Water Measurement Information System (Accessed 27/10/2014)

comparison, the largest event on record was in January 2011, where the gauge recorded a peak height of 2.56 m on the 18th January. This is over six times the extent of the rating curve.

Figure 4-6 shows the stream height gauge record and the rating curve limit. Given the rating table is exceeded very frequently it is unlikely the gauge flow record will be useful for assessing high flows. However, the gauge height record will give an indication of timing comparative to Wimmera River gauges.

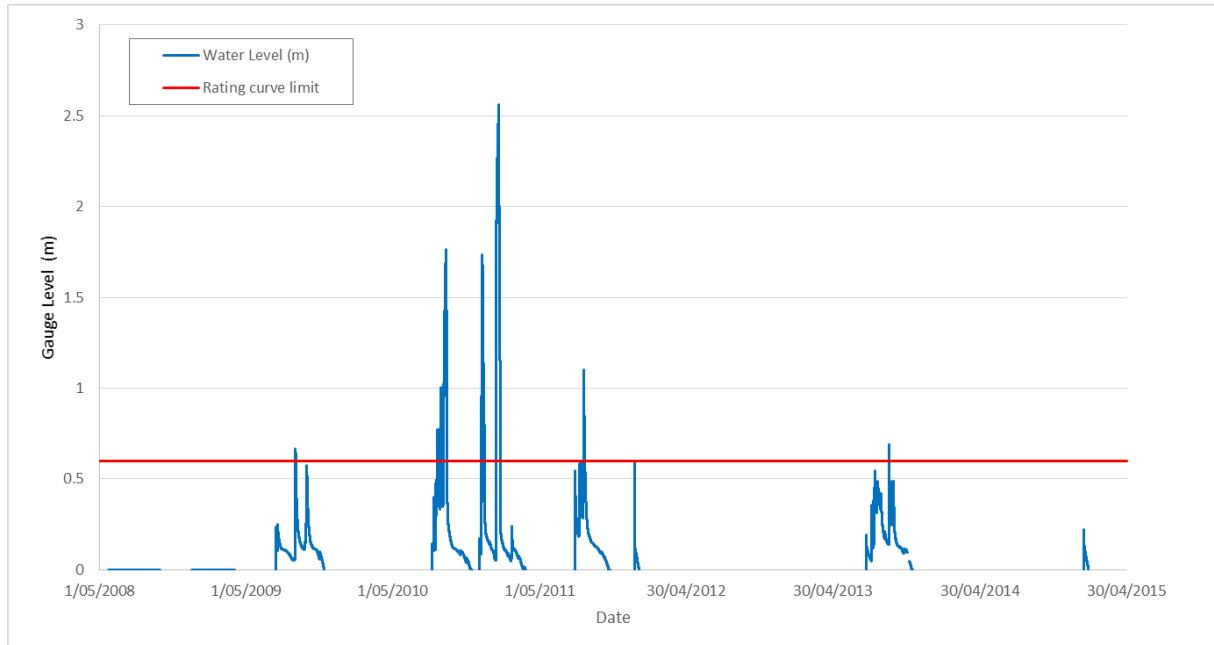


Figure 4-6 Gauge record at Norton Creek at Lower Norton showing water level and limit of extrapolated section of the rating curve

4.1.3 MacKenzie River at Wartook Reservoir

The streamflow gauge for MacKenzie River at Wartook Reservoir is located immediately downstream of Lake Wartook. The gauge had instantaneous flow records spanning from May 1975 to present day, with average daily flows back to 1887. The gauge is missing data for the January 2011 flood peak, but has been estimated by GWM Water as 3,780 ML/d⁴ based on a peak level of 1.992 m recorded on the 13th January at approximately 6pm.

The rating curve for the MacKenzie River gauge is based on 206 ratings and is considered of sufficient accuracy for completion of flood frequency analysis (FFA), incorporating the January 2011 flow estimate. A flood frequency analysis was undertaken as part of the Wartook to Zumsteins Walking Track Flood Investigation.

For the period of record, no outliers (low flows) were detected, however the analysis clearly indicated a change in distribution for flows greater than 500 ML/d, which is the maximum regulated outflow from Lake Wartook.

The Log Normal distribution was found to be the best representing distribution for the annual peak flow data set, determined by a FFA completed during the Wartook to Zumsteins Walking Track project, and can be seen in Figure 4-7. The distribution estimates a 1% AEP flow of 3,570 ML/d which is in line

⁴ Water Technology, 2011 – Wimmera Region Flood Report – January 2011

with anecdotal evidence of the January 2011 event in the Wimmera region being between a 2% and 0.5% flood event⁵.

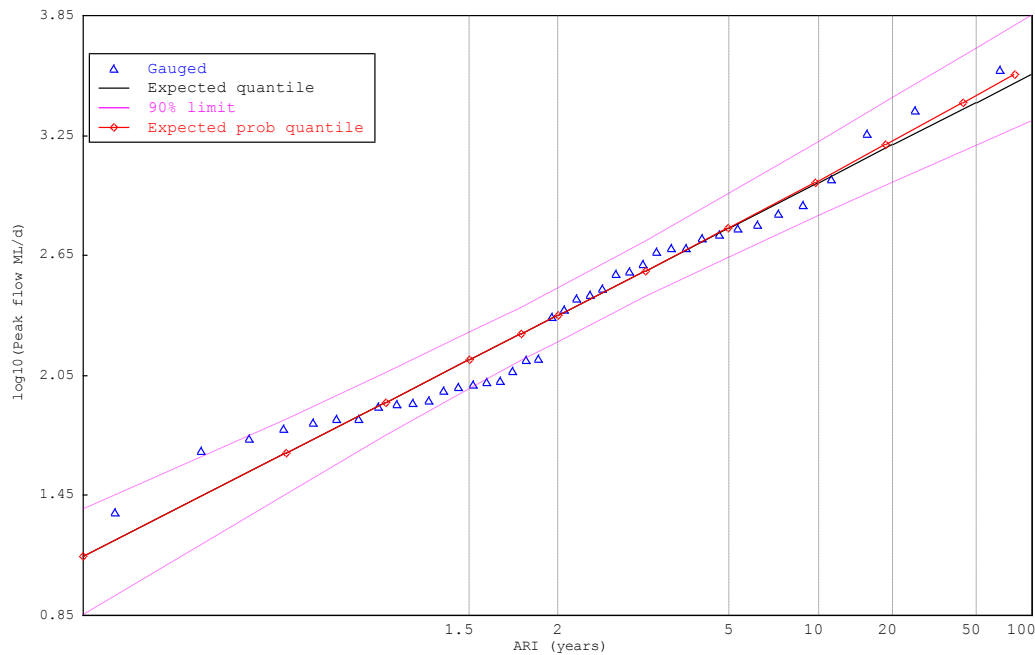


Figure 4-7 MacKenzie River maximum discharge flood frequency distribution (Log Normal)

Historical records for the gauge indicate for floods greater than 10% AEP a typical flood duration of 8 days can be expected. This is summarised in Table 4-4. Given this relatively consistent event duration, during the Wartook to Zumsteins Walking Track study a FFA was completed on 8 day volume with a 1% AEP flood volume of 18,200 ML determined.

Table 4-4 MacKenzie River at Wartook Reservoir Historical Flood Events

Start	End	Peak Flow, ML/d	Flood length, days
8/10/1975	18/10/1975	1805	10
23/10/1975	4/11/1975	1627	12
31/8/1983	30/9/1983	1027	30
30/8/1992	07/09/1992	1345	8
11/9/1992	17/9/1992	1173	6
21/9/1992	26/9/1992	1429	5
28/9/1992	1/10/1992	1156	3
7/10/1992	16/10/1992	1660	9
21/11/1992	24/11/1992	1218	3
18/12/1992	25/12/1992	2373	7
MEAN FLOOD LENGTH			9.3
MEDIAN FLOOD LENGTH			7.5

⁵ Water Technology – Natimuk Flood Investigation (2012), Horsham Bypass Hydrology and Hydraulics Study (2013), Warracknabeal and Brim Flood Investigation Hydrology and Hydraulics Report (2015)

4.1.4 Burnt Creek at Wonwondah East

The Burnt Creek gauge at Wonwondah East is located approximately 16 km downstream of the confluence with the Mackenzie River, and immediately downstream (~ 400 m) of the confluence with Bungalally Creek. The rating table is based on 200 gaugings, and is valid for flows up to 1,950 ML/d. Flows up to 4,000 ML/d are extrapolated. For the period of record, the rating curve has not been exceeded, and flows have been extrapolated on only a handful of occasions.

Over the gauge record spanning from 1983 to present day the largest flood recorded at the gauge is the January 2011 flood, during which the water level peaked at 1.07 m, equivalent to a flow of 1,596 ML/d on the 14th January at 5:45am.

This gauge is considered reliable and will be used to verify modelling of the flow split into Bungalally Creek.

4.1.5 MacKenzie River at McKenzie Creek

The MacKenzie River gauge is located approximately 3.5 km upstream of the confluence with Bungalally Creek, and 8.5 km upstream of the Wimmera River.

In January 2011, the recorded water level exceeded the rating curve, with a water level of 2.357 m, with an equivalent (extrapolated) flow of 4,269 ML/d on the 15th at approximately 8:30am.

The gauge record spans from 1983 to present day. The gauge is considered to be an accurate representation of flows, and will be used in the verification of hydrology and hydraulic modelling.

4.1.6 Summary

The five gauges discussed above all have different periods of record, and vary considerably in their reliability. A summary of how each gauge will be used in this study is given below:

- Wimmera River at Horsham (Walmer) – Significantly investigated in the Lower Wimmera Regional Mapping project. Discussions with Ventia, Wimmera CMA and Water Technology staff has resulted in consensus regarding a revised rating curve and estimates of historic flows. The hydrological analysis from the Lower Wimmera Regional Mapping project will be adopted for this study.
- Norton Creek at Lower Norton – No ability to record high flows with the rating curve maximum height being exceeded at relatively low flows (six times since 2008). Gauge flows are unlikely to be used in this study, however timing of peak levels will be used to determine the timing of any Norton Creek contribution to the Wimmera River.
- McKenzie Creek at Wartook Reservoir – Assessed as part of the Wartook to Zumsteins Walking Trail Flood Study. The flood frequency analysis developed during this study will be adopted as an upstream boundary to the hydraulic model.
- Burnt Creek at Wonwondah East – Reasonably reliable gauge. Historic level records will be used to verify the hydraulic model and validate flow split relationships.
- MacKenzie River at McKenzie Creek – Reasonably reliable gauge, but with application in this study. Flow and level records will be used to verify the hydrology and hydraulic models.

4.2 Rainfall

There are numerous daily rainfall gauges within or nearby the study area, as well as four pluviograph stations. Rainfall gauges that are of relevance to this study are shown in Figure 4-8, with details of available data summarised in Table 4-5 and Table 4-6.

The average annual rainfall varies throughout the study catchment, reaching 600 mm at the headwaters of Mt William Creek and as low as 330 mm near north of Horsham. Daily rainfall gauges will be used to develop a spatial pattern across the study area, for input to the hydrology model, while the pluviograph rainfall stations will be used to derive temporal patterns for the calibration rainfall events.

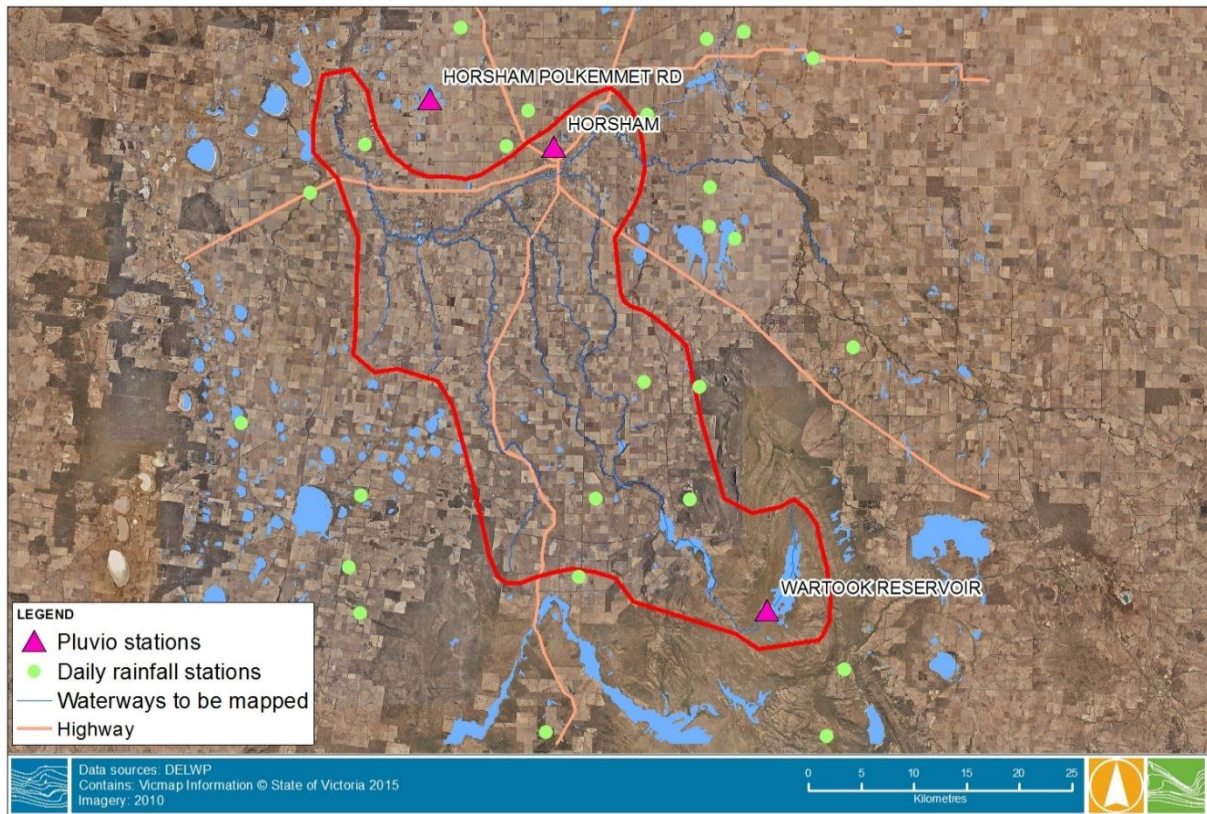


Figure 4-8 Rainfall gauge locations with respect to the study area

Table 4-5 Rainfall gauges within the Horsham and Northern Grampians catchments

Gauge No.	Location	Period	Years
78016	JUNG	1935 - 2009	74
78017	JUNG JUNG	1886 - 1952	66
78057	JUNG JUNG NORTH	1897 - 1924	27
78063	PIMPINIO	1913 - 1922	9
79008	CLEAR LAKE	1903 - 2013	110
79010	DRUNG DRUNG	1905 - 2013	108
79020	HALLS GAP	1876 - 1963	87
79023	HORSHAM POLKEMMET RD	1873 - 2012	139
79028	LONGERENONG	1863 - 2013	150
79035	MURTOA	1883 - 2013	130
79036	NATIMUK	1889 - 2013	124
79044	TELANGATUK (SCHOLFIELD)	1901 - 1951	50
79045	TOOLONDO	1934 - 1946	12
79046	WARTOOK RESERVOIR	1890 - 2013	123
79047	WARTOOK POST OFFICE	1888 - 1966	78
79049	WONWONDAH (MOUNT ZERO)	1900 - 1961	61
79055	JUNG (DOOEN NORTH)	1928 - 1934	6
79063	NATIMUK (JILPANGER)	1938 - 1949	11
79064	HORSHAM (LAURISTON DOLLAN)	1920 - 1941	21
79067	STAWELL (NATTA WALLA)	1905 - 1911	6
79070	WALMER	1901 - 1921	20
79074	HALLS GAP	1958 - 2013	55
79077	DADSWELLS BRIDGE	1968 - 2013	45
79078	TELANGATUK EAST (MILINGIMBI)	1968 - 2013	45
79082	HORSHAM	1958 - 2013	55
79098	PINE LAKE	1983 - 1987	4
79100	HORSHAM AERODROME	1997 - 2013	16
79106	LAH-ARUM (MT STAPYLTON)	1997 - 2004	7
89057	GLENISLA	1905 - 1918	13

Table 4-6 Relevant pluviography stations

Gauge No.	Location	Period
79023	Horsham Polkemmet Rd	1873 - 2015
79046	Wartook Reservoir	1890 - 2015
79052	Rocklands Reservoir	1948 - 2015
79082	Horsham	1958 - 2015

4.3 Storages

Lake Wartook, constructed in 1887, is the only managed storage within the study catchment. It is located within the Grampians National Park, and is the most southern edge of the study area.

The Lake has a full supply volume of 29,300 ML and receives average annual inflows of 26,000 ML/y from the 75 km² contributing catchment (the catchment is extremely efficient as a result of the rock formations).

Flow releases are currently managed up to 500 ML/d, though historically (prior to 1992) releases were up to 800 ML/d. The reservoir has two spillways. The primary spillway has been designed to handle spills up to a 1% AEP event; once this is exceeded the secondary spillway comes into operation. This did occur during the January event indicating that outflows from Lake Wartook were in excess of a 1% AEP event.

At the beginning of January 2011 the lake contained 27,980 ML (95.5%). During the January event, Lake Wartook is thought to have peaked at a storage volume of approximately 32,120 ML (109.6%). Due to the flood height, gauge readings were unable to be taken during the peak of the event on Friday 14th January. Readings continued on Saturday the 15th.

GWMWater have supplied inflow, outflow and water level hydrographs of the January event for Lake Wartook as shown in Figure 4-9.

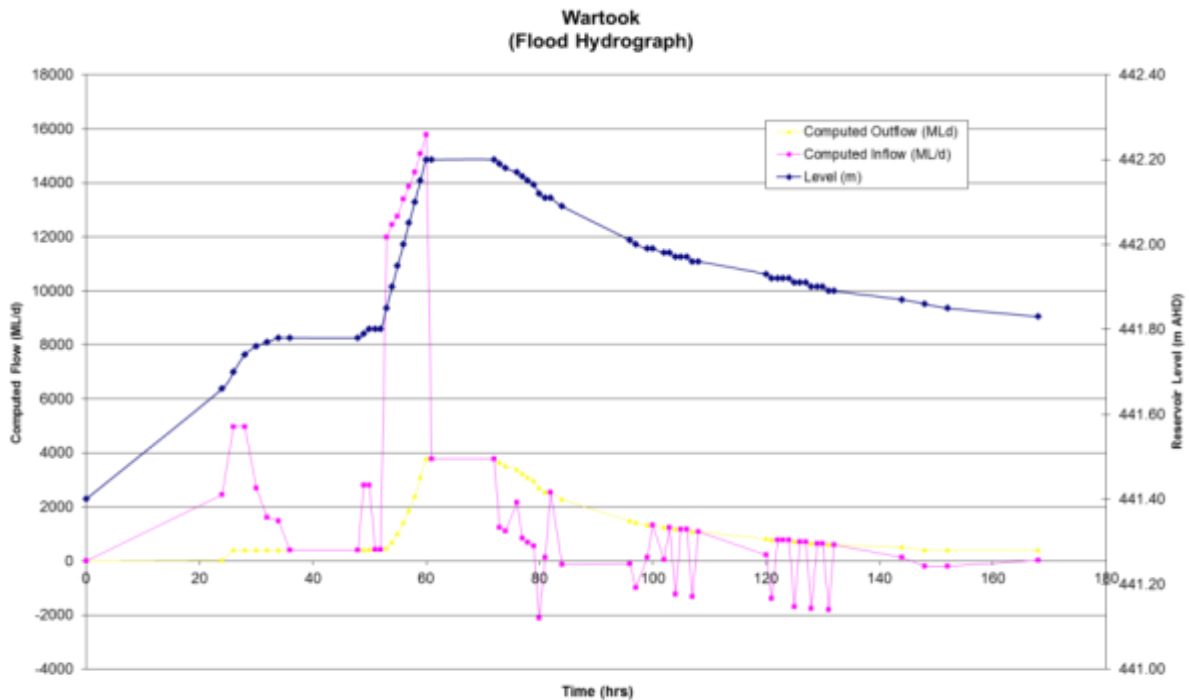


Figure 4-9 Inflow, outflow and level of Lake Wartook in January 2011

The hydrograph shows the maximum inflow at 15,780 ML/d with a maximum outflow of 3,780 ML/d. This indicates the peak flow through Lake Wartook was attenuated by approximately 12,000 ML/d. A reduction in the maximum flow of 12,000 ML/d has substantially reduced the potential flood impacts downstream of Lake Wartook.

5. FLOOD RECORDS

Flooding of Horsham from the Wimmera River has been a regular feature, with around 21 large floods occurring between 1889 and 2011. The largest of these was the 1909 event, followed by January 2011. The January 2011 event will be used as the primary calibration event within the study as it gives the best representation of flooding with today's catchment conditions and it also has a large amount of calibration data available. This, along with several other major events for which records exist, are discussed in further detail.

5.1 January 2011

The January 2011 flood is the largest recent flood on record for the Wimmera River. It is estimated to have been between a 1 % and 0.5% AEP event in areas upstream of Horsham and between a 2 % and 1 % AEP event downstream of Horsham. It was estimated in Horsham there were approximately 15 houses inundated above floor level and that 31 shops were affected by floodwaters⁴.

High rainfall totals were recorded across the Wimmera River catchment on Wednesday the 12th and Friday the 14th of January. Both the Horsham Aerodrome and Polkemmet Road rainfall gauges recorded around 100 mm in the 24 hours prior to 9 am on Friday the 14th. Prior to the heavy rainfall in January and in response to forecasts, the boards were fully removed from the Horsham weir on Monday 10th January.

Flooding observed within the study area prior to the 16th can be attributed to direct runoff or rainfall in the Wimmera River tributaries (Burnt Creek, MacKenzie River etc.), while flooding post the 16th is predominately attributed to rainfall in the upper and mid Wimmera River catchment.

Flooding from Burnt Creek on Friday the 14th closed Williams Road. Properties along much of the Creek were sandbagged. The Burnt Creek at Wonwondah East gauge peaked on the afternoon of Saturday the 15th. At the same time the Wimmera River was rising and recorded a gauge level of 3.32 m at Walmer, approximately 1 m below its eventual flood peak level. In the days preceding the maximum water level in the Wimmera River there was a substantial amount of inundation through suburban streets and riverine areas. Some suburban areas were inundated by water backing up through urban stormwater drains and into the street.

Media outlets reported that Horsham was completely cut by floodwaters on Tuesday the 18th with no access to the town from the east (Melbourne side) due to floodwater inundating Hamilton Street from the river to Firebrace Street. The Wimmera River also started breaking out upstream of Peppertree Lane. Septic systems associated with homes on the outskirts of Horsham were affected on Wednesday 19th January with reports of raw sewerage entering floodwaters.

It is estimated that there were approximately 141 properties affected in Horsham, 260 properties without power and 500 properties isolated. Within Horsham there were 15 houses inundated above floor. This compares to the predicted 35 during a 1% AEP event and 111 in a 0.5% AEP event, as estimated in the Horsham Flood Study (Water Technology, 2009). The Horsham North Kindergarten incurred structural damage, and 31 shops were affected by floodwaters. Within Horsham there were two aged care facilities evacuated, along with other Municipal facilities and one Caravan Park. Horsham Rural City Council pushed up a levee on the Western Highway and in the Burnt Creek drain to keep water in the creek corridor and flowing towards the Wimmera River.

The Western Highway was fully re-opened on Wednesday 19th January.

Riverside, located to the east of the main Horsham township, was also affected by flooding from the Wimmera River and Burnt Creek. Aerial photography sourced from NearMap shown in Figure 5-1 shows overland flow in the Riverside area on the 18th January, with substantial inundation occurring

from Burnt Creek and the Wimmera River prior to it flowing through Horsham. The Riverside area had numerous houses isolated and 9 inundated.



Figure 5-1 Riverside area showing inundation on the 18th January, 2011⁶

Post January 2011 Wimmera CMA had a series of peak flood height levels surveyed to use as the basis for hydraulic model calibrations. Within the study area there were 83 flood heights surveyed, as shown in Figure 5-2. There are 46 in the direct vicinity of Horsham, 7 on the Mackenzie River upstream of the Burnt Creek offtake and 4 downstream, 8 on Norton Creek, 4 on Darragan Creek and 14 on the Wimmera River between Walmer and Quantong. Linescans were also flown over the Horsham area capturing the extent of inundation. This comprehensive spread of calibration data will make the January 2011 event an excellent choice for use in the model calibration.

⁶ NearMap

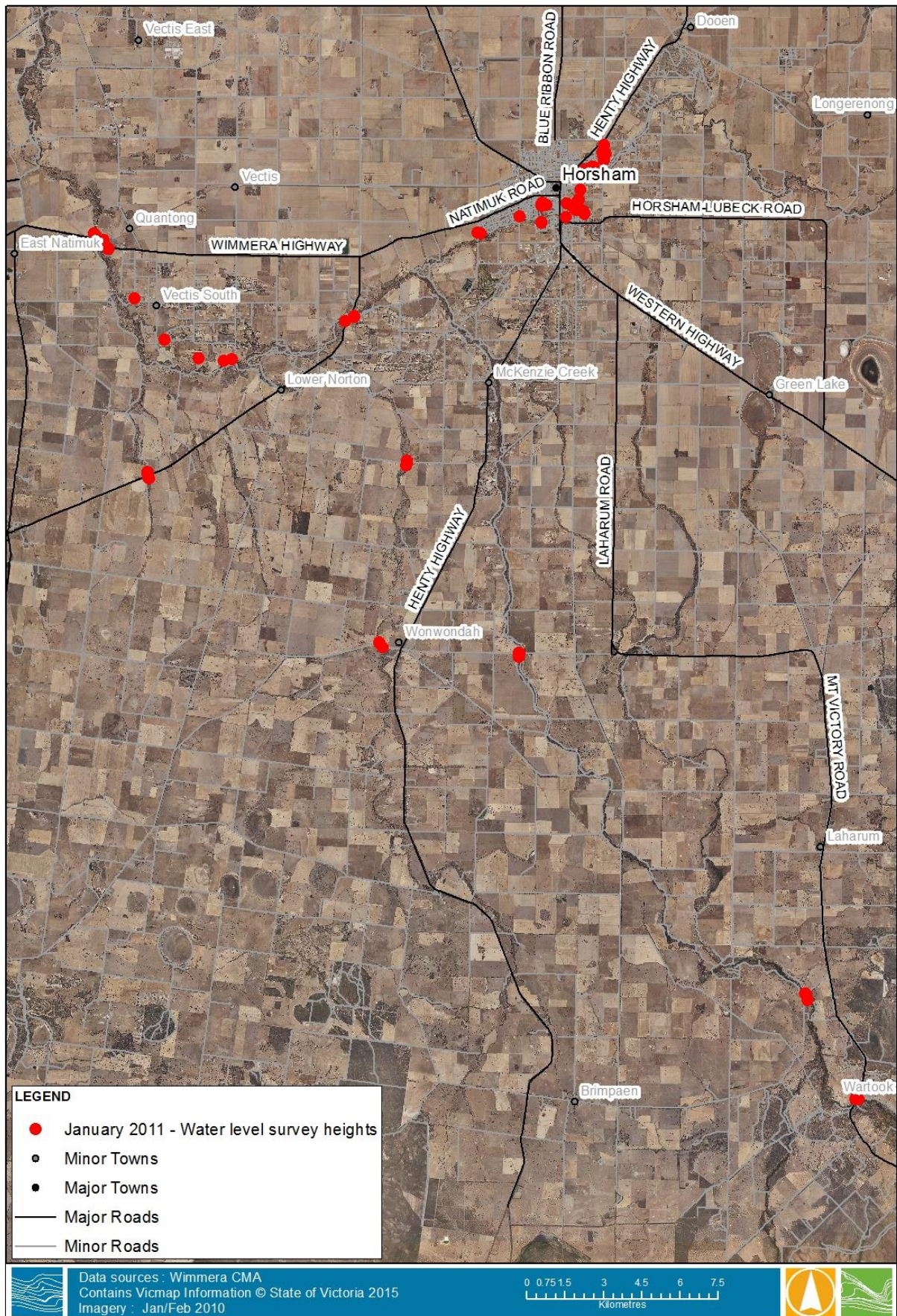


Figure 5-2 Peak flood heights surveyed by Wimmera CMA within the study area

5.2 Observed peak flood heights and extents

Detailed contour and flood information has been captured for a number of historical events extending from 1981 to 2011. The flood event that occurred in January 2011 is the most extensively captured flood on record, with 83 flood heights surveyed within the study area. These are critical to the hydraulic model calibration. However, there are also numerous peak flood heights available for the September 2010, October 1996 and October 1983 events.

shows the distribution of historic flood information capture within the study area.

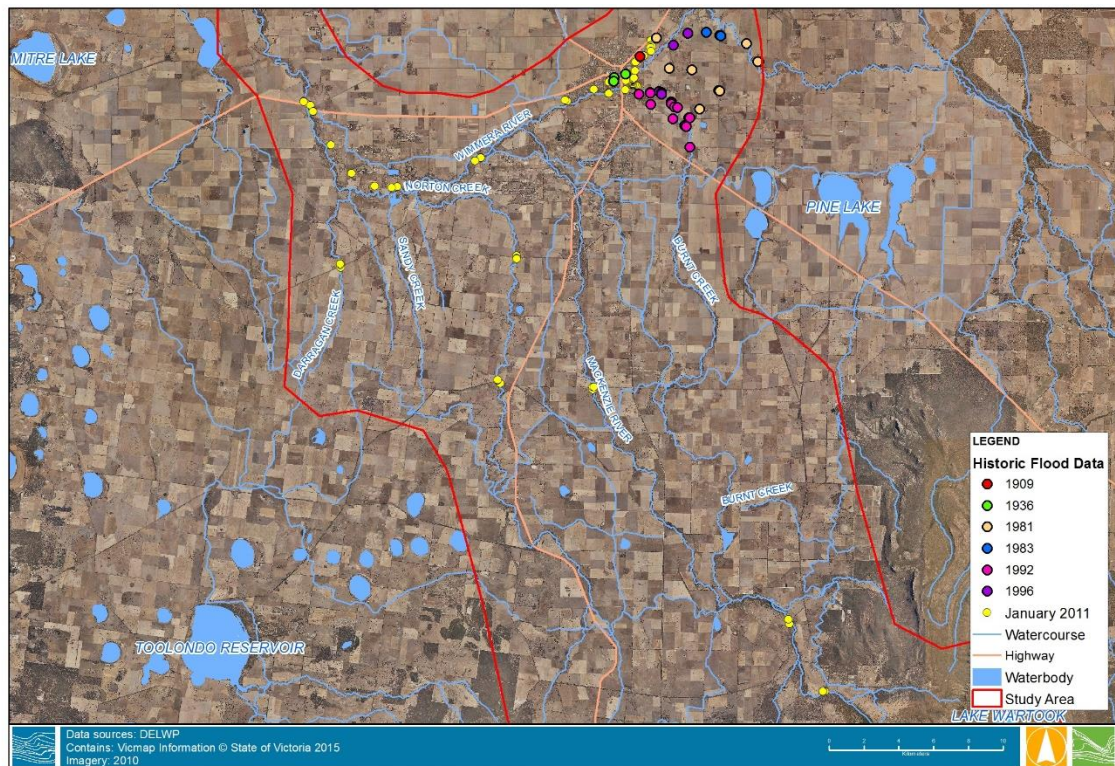


Figure 5-3 Historic flood data capture

6. PHYSICAL FEATURES

6.1 Topographic survey

The following LiDAR datasets are available for the study area:

- 2005 Wimmera CMA LiDAR Project Zone 1 (Wimmera River and Yarriambiack Creek trenches)
- 2005 Wimmera CMA LiDAR Project Zone 2 (Remaining Wimmera CMA area)
- 2009-10 Victorian State Wide ISC Rivers LiDAR Project
- 2010-11 Floodplains Stage 2 LiDAR Project

Key metadata for the four datasets is given in Table 6-1 and the extents of the four datasets across the study area are shown in Figure 6-1.

Table 6-1 Key metadata for LiDAR datasets

Dataset	Source	Date of Capture	Vertical accuracy (1 sigma)	DTM resolution
2005 Wimmera CMA Zone 1 (WCMA LL)	LiDAR	Jan 2005	0.15 m	2 m
2005 Wimmera CMA Zone 2 (WCMA HL)	LiDAR	Jan 2005	0.50 m	2 m
2009-10 ISC Rivers LiDAR	LiDAR	Dec 2009-Oct 2010	0.20 m	1 m
2010-11 Floodplains Stage 2 LiDAR	LiDAR	Jul-Aug 2011	0.10 m	1m

Significant development and channel decommissioning has occurred since much of the LiDAR was captured. Water Technology has identified key areas of concern, where on ground conditions are unknown, predominately east and south of Horsham. It is recommended that Wimmera CMA commission updated LiDAR capture of these areas. Extents identified by Water Technology in collaboration with Wimmera CMA for additional capture is shown in Figure 6-2.

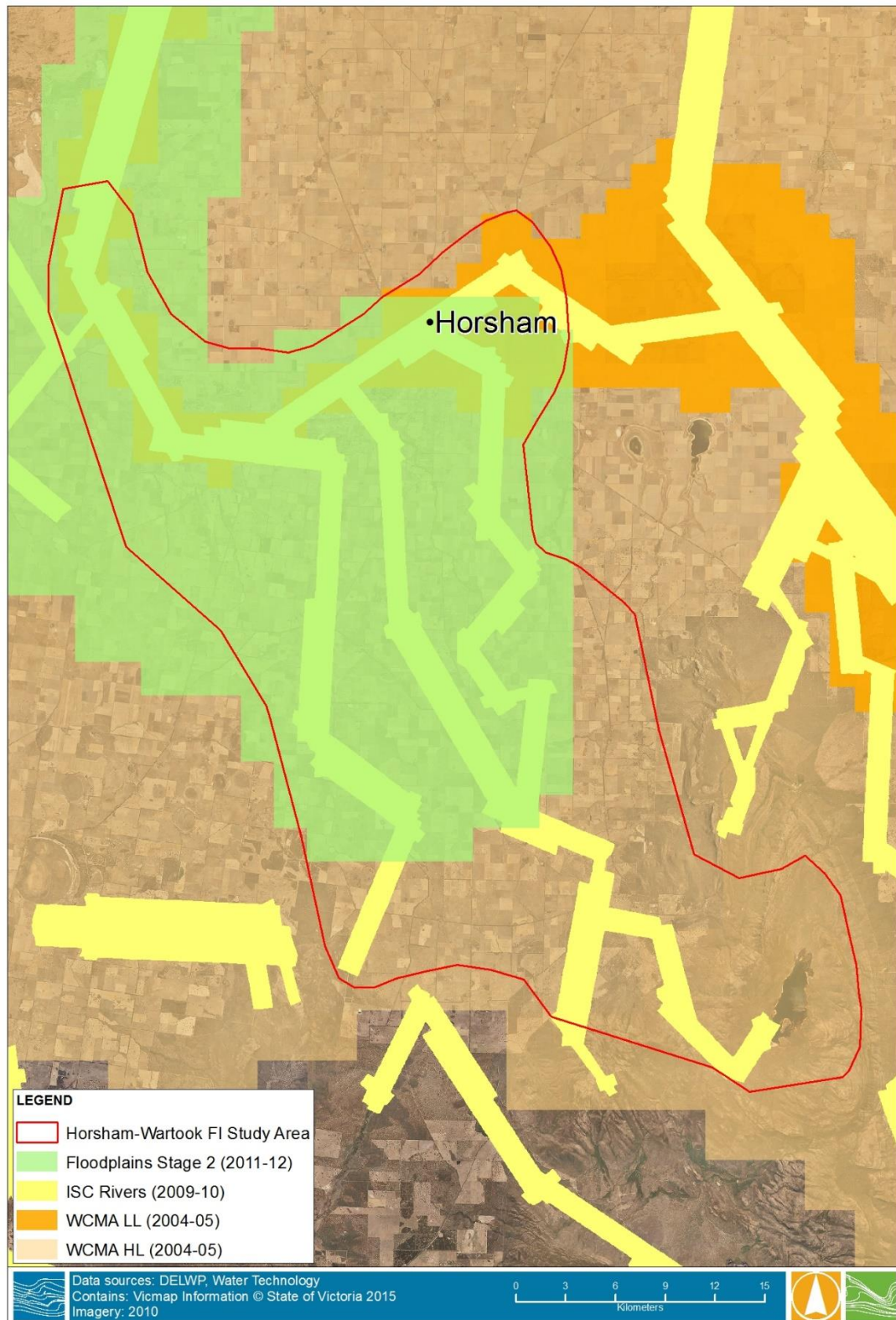


Figure 6-1 Available LiDAR

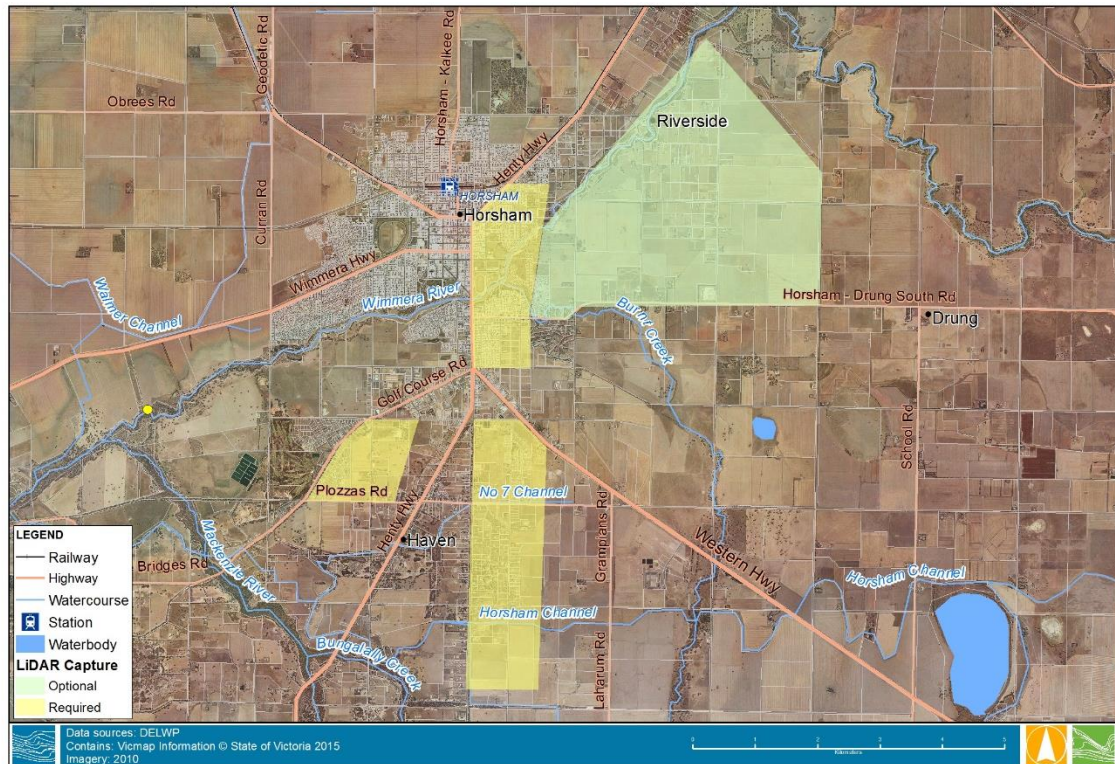


Figure 6-2 Recommended areas of additional LiDAR capture

6.2 Floor level and feature survey

Previous floor level survey was undertaken in Horsham, as part of the Horsham Flood Study. A total of 909 levels (residential and commercial) have been captured, as seen in Figure 6-3.

On completion of the 0.5% AEP design hydraulic modelling, floor level survey will be commissioned with all properties within 0.5% AEP captured, if required.

Details of 5 culverts in East Horsham were acquired as part of the East Horsham Culvert Assessment⁷, however the recommendation was for replacement of some of these existing structures and hence details may no longer be accurate.

⁷ Water Technology, 2013 - East Horsham Culvert Assessment Modelling

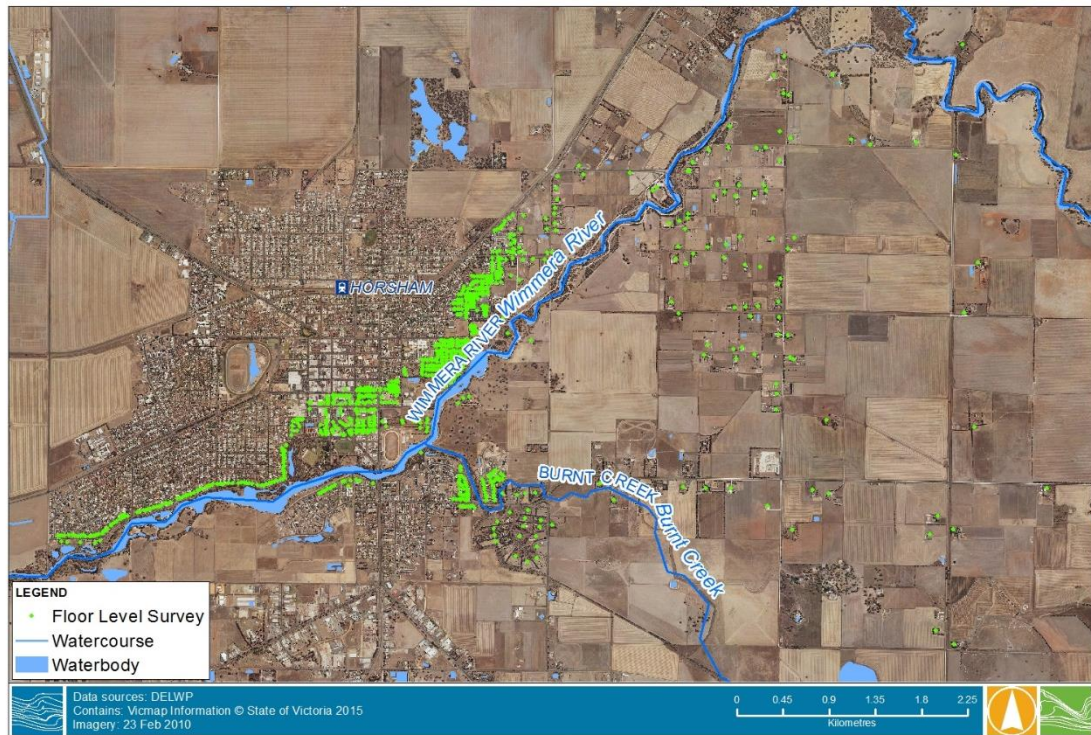


Figure 6-3 **Location of available floor level survey data**

7. SITE VISIT

A site visit was undertaken by Water Technology on the 24th November 2015, with key hydraulic structures along the tributaries to the Horsham River investigated.

A number of photos were taken during the site visit, as well as approximate dimensions of culverts. Key features can be seen in Figure 7-1 below.



a) Burnt Creek / MacKenzie River confluence



b) Grahams Bridge, MacKenzie River



c) Bungalally Creek Crossing with Laharum Rd



d) Rocklands channel near Bungalally Creek



e) Bungalally Creek near confluence with MacKenzie River



f) Burnt Creek / MacKenzie River confluence

Figure 7-1 Selected photos from site visit, 24 November 2015

8. DATA GAPS AND RECOMMENDATIONS

The data collated to date is sufficient to begin construction of the RORB hydrology model and the Mike Flood hydraulic model. However the following data will be required to provide an accurate representation of the hydraulics:

- Updated LiDAR capture of areas identified within Horsham that have undergone significant development, and areas where channel decommissioning may have occurred (as identified in Figure 6-2).
- Details of key hydraulic structures, where major roads/rail cross the Wimmera River or any of its tributaries. Water Technology suggests incorporating all bridges and culverts within the study area that are eligible for Level 2 Bridge/Culvert assessments, if information is available through the Horsham Rural City Council.

On completion of the updated LiDAR dataset Water Technology will complete a Data Verification Report documenting the accuracy of the LiDAR data with comparison to the available feature survey. It is also possible further feature survey will be commissioned.

The primary calibration event is intended to be the January 2011 event with one further event used for verification. This may be either the 2010 or 1996 event. The final calibration events will be determined post the initial community meeting where community views and anecdotal evidence on historic flood events will be collated.

Further survey is likely be required to determine floor levels of at-risk properties within the study area, however the extent of this survey is dependent on any additional properties that may have been missed or have been constructed since the two available floor level datasets were collated and the extent of at risk properties in the areas that have not previously been subject to a flood investigation (Haven, Wartook Valley etc.). Water Technology will provide a survey scope once the 1% and 0.5% AEP flood extents are known.

It is recommended that details of key hydraulic structures, where major roads/rail cross the Wimmera River or any of its tributaries be confirmed. Water Technology suggests incorporating all bridges and culverts within the study area that are eligible for Level 2 Bridge/Culvert assessments, if information is available through the Horsham Rural City Council (HRCC), a data request for this information has been sent to HRCC.