Lower Wimmera – Site Visit and Data Collation Report

January 2017

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PROJECT DETAILS

Project Name	Lower Wimmera Flood Investigation
Client	Wimmera CMA
Client Project Manager	Abdul Aziz
Water Technology Project Manager	Ben Tate
Report Authors	Ben Hughes
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Cover Photo: Dimboola Weir – The weir structure was replaced after damage caused during the January 2011 flood event (Photo captured during the site visit)

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1. BACKGROUND

The Wimmera River originates in the Pyrenees Ranges, near the township of Elmhurst, and flows generally westward, toward Horsham, and then northwards to Lake Hindmarsh where it terminates. The Lower Wimmera River study area extends downstream from Horsham and is characterised by a lower gradient than the upper catchment.

The catchment is dominated by agricultural land with floodplains of the Wimmera River and its tributaries containing a number of agricultural assets that are likely to be subject to inundation during large rainfall events. A number of residential areas are at risk also, including properties on the outskirts of Horsham, Quantong, Dimboola and Jeparit, as well as rural property at Duchembegarra, Arkona, Antwerp and Tarranyurk.

Rainfall across the Wimmera Catchment varies considerably, with the upper catchment generally receiving 500-600 mm/year and the lower catchment generally receiving 350-400 mm/year. Months with the highest average rainfall are typically June to August.

Historical records indicate that flow rates experienced in the lower section of the river are lower than those in the upstream/middle sections. This is due to attenuation and the presence of distributary waterways upstream (Swedes, Dunmunkle and Yarriambiack Creeks). The Mackenzie River and other tributaries provide inflow to the Wimmera River downstream of Horsham, however the dominant flood causing mechanism is the upper Wimmera River catchment flood flows.

There are a number of irrigation channels within the lower Wimmera River catchment, formerly used for stock and domestic supply. The construction of the Northern Mallee and Wimmera Mallee Pipelines has superseded these channels and a number of domestic water storages. These pipelines have increased water availability by reducing water losses in the supply system and have also increased the control of environmental flow releases.

The lower Wimmera River has experienced many historic flood events, with 1909 and 2011 the largest on record.

2. PROJECT PURPOSE

2.1 Overview

The overall objective of the study is to develop regional scale flood mapping for the Lower Wimmera River between Quantong and Jeparit. This mapping will be used to satisfy a range of business requirements from planning and emergency response to community awareness and insurance. The study area was extended upstream by Water Technology to the Wimmera River at Horsham (Walmer) gauge location. The original and extended study area is shown in Figure 2-1.

2.2 Project Scope

The project is further described by the following inclusions and exclusions as outlined in the scope of the tender specification. The key components are:

1. Engagement and consultation
2. Project planning and data collation
3. Hydrologic analysis
4. Hydraulic analysis
5. Provision of flood intelligence
6. Project reporting

The scope includes a number of exclusions relating to planning schemes, flood warning and flood mitigation.

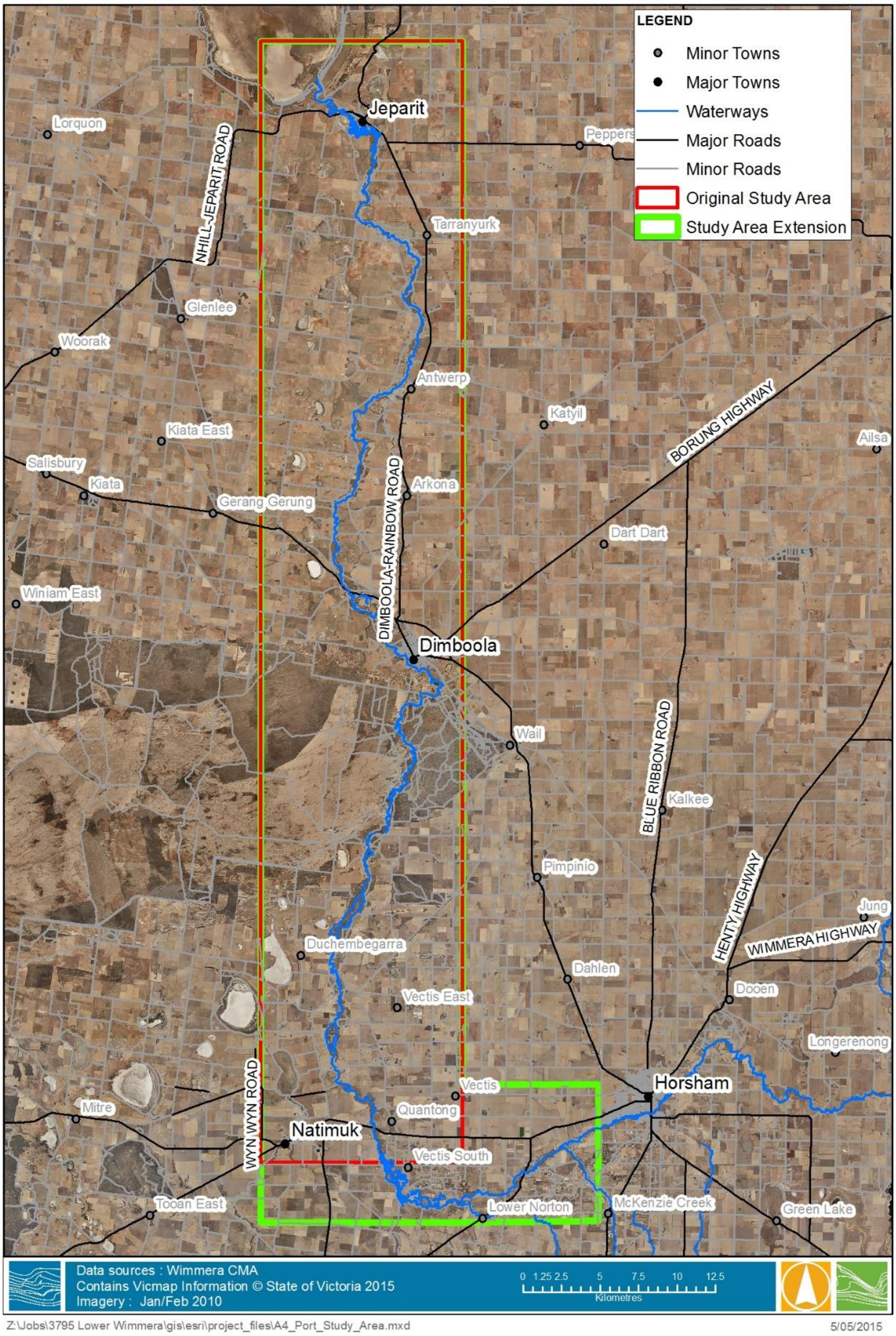

Figure 2-1 Original and extended study area

3. SITE VISIT

A site visit was undertaken on Friday 5th September, 2014 by Ben Tate, Tim Cooke and Ben Hughes (Water Technology).

The sites visited during inspection are listed below with reference to photographs shown in Appendix B:

- Horsham Weir (Photo 1)
- Wimmera River at Horsham (Walmer) streamflow gauge (Photo 2)
- Quantong
  - Quantong Railway Bridge (Photo 4)
  - Wimmera Highway Bridge over the Wimmera River at Quantong (Photo 3)
- Dimboola
  - Dimboola Weir (Photo 5)
- Melbourne to Adelaide Railway Bridge (Photo 6)
- Wimmera River at Tarranyurk (Photo 7)
- Jeparit
  - Jeparit Weir (Photo 8)
- Lake Hindmarsh
  - Lake bed (Photo 9)

The length of the Wimmera River from Horsham to Hindmarsh was driven to gain an understanding of the general floodplain features.

4. AVAILABLE INFORMATION

4.1 Overview

To gain a detailed understanding of the Lower Wimmera River this project identified all available sources of information and potential data gaps. The available information was reviewed and utilised where appropriate.

Flooding of the Lower Wimmera River is dominated by large rainfall totals in the Upper Wimmera River catchment. Wimmera River tributaries downstream of Mt William Creek do not contribute significantly to the peak flows or event volumes observed within the study area, the focus for the study is therefore gauges on the Wimmera River rather than contributing catchment areas downstream of Horsham. The influence of Mackenzie River on flood levels in the Wimmera River downstream of Horsham will be tested during this project.

4.2 Streamflow gauges

4.2.1 Overview

There are several streamflow gauges that provide information on the inundation potential along the Lower Wimmera River. Streamflow/flood height gauges within the study area include:

- Wimmera River at Horsham (Walmer)
- Norton Creek at Lower Norton
- Wimmera River at Quantong
- Wimmera River US Dimboola
- Wimmera River at Lochiel Railway Bridge
- Wimmera River at Tarranyurk
- Wimmera River at Jeparit

There are also several other gauges which are of relevance to the study but outside the study area, these include:

- Wimmera River at Glenorchy
- Wimmera River at Drung Drung
- Mackenzie River at Mackenzie Creek
- Burnt Creek at Wonwondah East

The location of the gauges within the study area is shown below in Figure 4-1, with their gauge number and period of gauge record shown in Table 4-1.

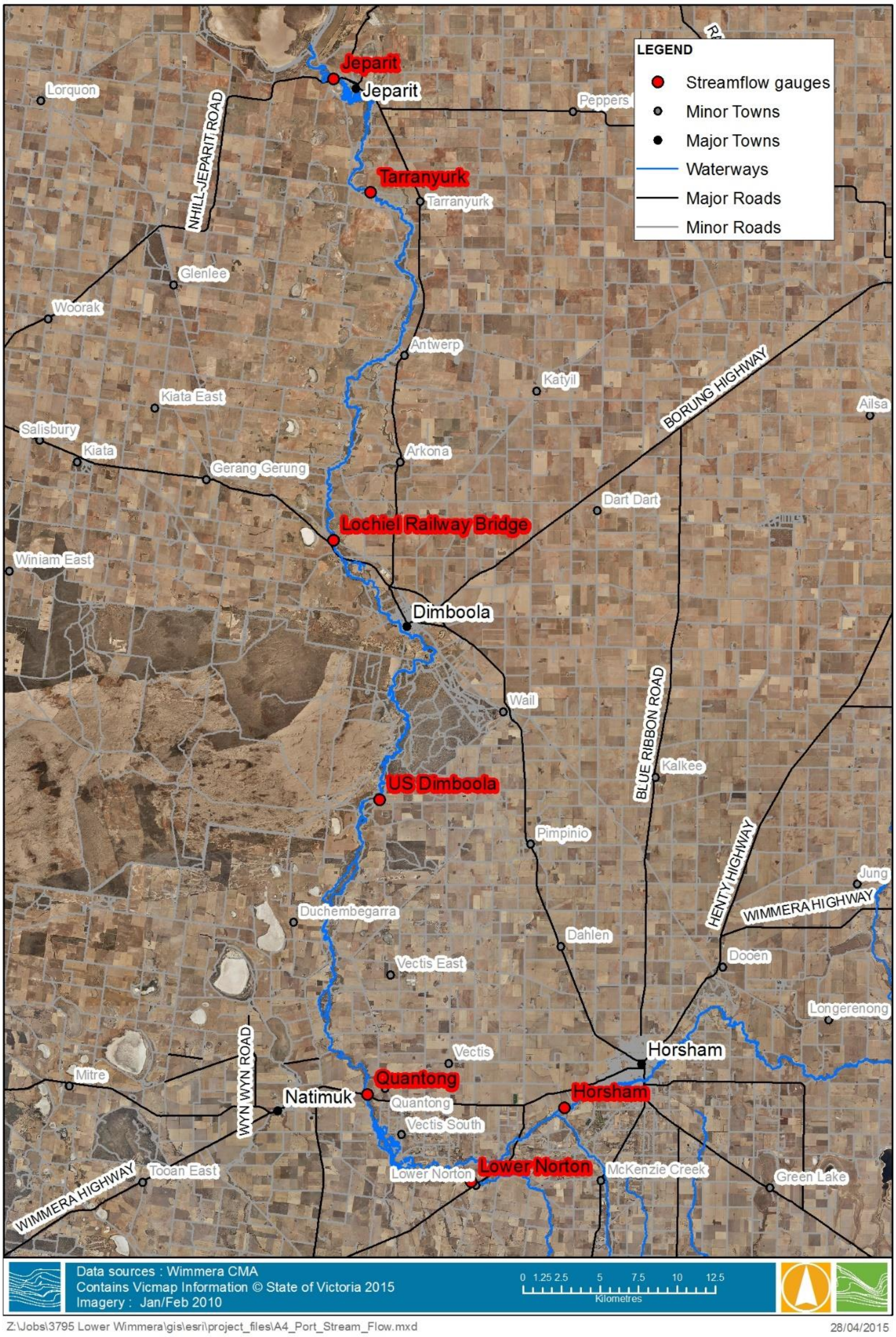

Figure 4-1 Streamflow gauges relevant to the study area

Table 4-1 Active streamflow gauges within the study area

Gauge Name	Gauge Number	Gauge Record
Wimmera River at Horsham (Walmer)	415200	1910 - Current
Norton Creek at Lower Norton	415273	2008 - Current
Wimmera River at Quantong	415261	2009 - Current
Wimmera River US Dimboola	415256	1989 - Current
Wimmera River at Lochiel Railway Bridge	415246	1987 - Current
Wimmera River at Tarranyurk	415247	1987 - Current
Wimmera River at Jeparit	415212	May 1998 – July 1998

Thiess Environmental Services Pty Ltd manage and maintain the streamflow gauging network across the Wimmera Catchment on behalf of the Water Monitoring Partnership. Along with flow and water level recordings Thiess also supply quality code information to provide guidance on the quality of their flow estimations. In general, data with a Quality Code above 100 must be treated with caution. The full set of Thiess Quality Code Classifications in the extracted datasets is shown in Table 4-2.

Table 4-2 Thiess Quality Code Classifications

Quality Codes (QC)	Description
1	Unedited data
2	Good quality data - minimal editing required. Drift correction
8	Pool reading only - no flow condition.
9	Pool dry? no data collected
15	Minor editing. >+/-10mm drift correction
77	Correlation with other station, same variable only.
82	Linear interpolation across gap in records. (<0.5 day)
100	Irregular data, Use with caution. Beyond QC=50 or unexplained
104	Records manually estimated.
149	Rating extrapolated within 1.5x Max Qm
150	Rating extrapolated due to insufficient gauging (see additional quality info)
151	Data lost due to natural causes / vandalism (see additional quality info)
180	Data not recorded, equipment malfunction.
254	Rating table exceeded
255	No data exists

Wimmera River gauges within the study are most significant to this project and particular focus was given to these gauges during the data review.

4.2.2 Wimmera River at Horsham (Walmer)

The Wimmera River streamflow gauge at Horsham (Walmer) has a long period of record with daily flow recorded from 1889 to 1910 and daily gauge height from 1910 to 1963, with flows determined based on a rating curve. There is increased uncertainty in the gauge flows determined prior to 1910. The instantaneous gauge recordings from 1963 to 2015. This leaves 124 years of complete annual record for completion of a Flood Frequency Analysis (FFA). The largest event within the instantaneous record occurred during January 2011, there were also a large events in 1909 and 1894.

Figure 4-2 shows the length of gauge record and the recorded Thiess Quality Code, the January 2011 event is highlighted.

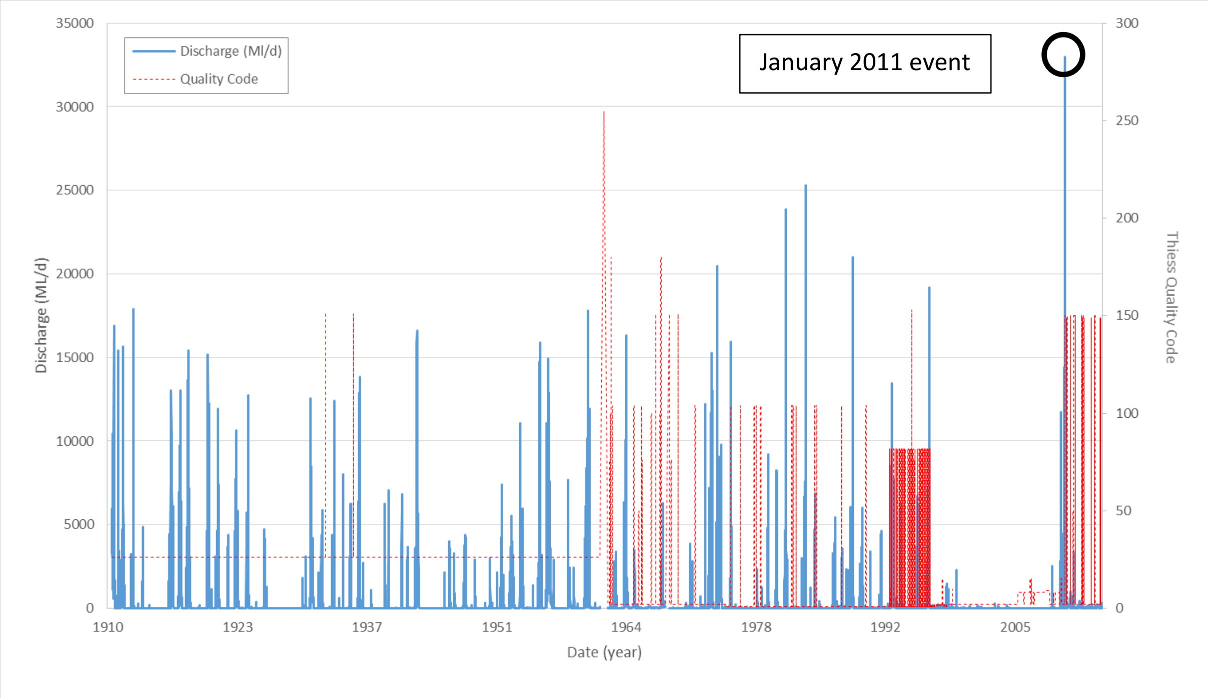

Figure 4-2 Gauge record at Wimmera River at Horsham (Walmer) showing flow and the Thiess Quality Code[1]

Several high flow events have been recorded by the gauge, the highest recoded flows based on gauge height and their respective years are shown in Table 4-3.

Table 4-3 Wimmera River at Horsham - Maximum recorded annual flows

Year	Maximum Discharge	
	ML/d	m^3/s
2011	32,971	382
1983	25,312	293
1981	23,879	276
1988	21,005	243
1974	20,466	237
1996	19,198	222
1912*	17,905	207
1960	17,802	206
1942*	16,632	193
1964	16,325	189

* Mean daily recording

[1] Data downloaded from the DWELP data management system.

The 1909 and 1894 events had recorded maximum flows of 43,860 and 44,249 ML/d, however as discussed previously there is some uncertainty in these estimates.

The January 2011 hydrograph is clearly the highest recorded event, a hydrograph of the event is shown in Figure 4-3, along with the recorded Thiess Quality Code.

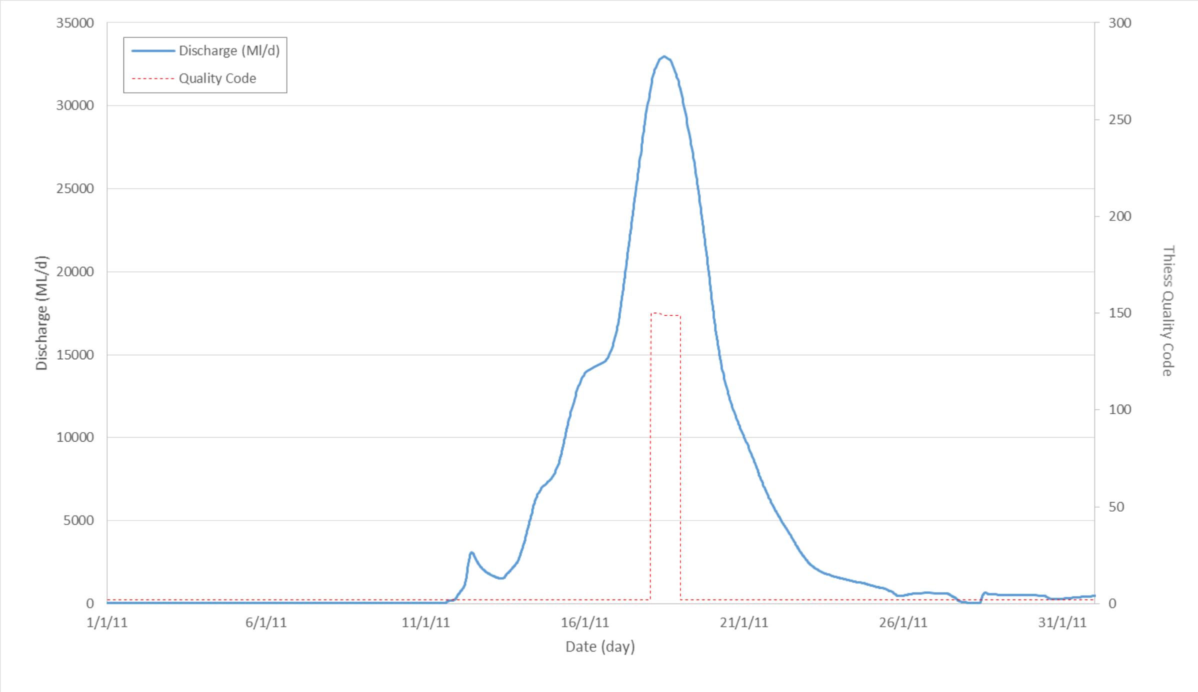

Figure 4-3 January 2011 hydrograph recorded at the Wimmera River at Horsham (Walmer) streamflow gauge

During January 2011, the Wimmera River flowrate was measured at the Western Highway Bridge 5.5 km upstream by Thiess Environmental[2], 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 4-4.

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 4-5, with the previous and current rating curves shown in Figure 4-6.

The change between the current rating curve and the rating curve in use prior to the January 2011 gauging is 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 m^3/s (33,000 ML/d), whereas the previous rating was exceeded at 3.65 m. For all levels above 1 m on the gauge, the current rating curve produces lower flow estimates than the previous rating curve.

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

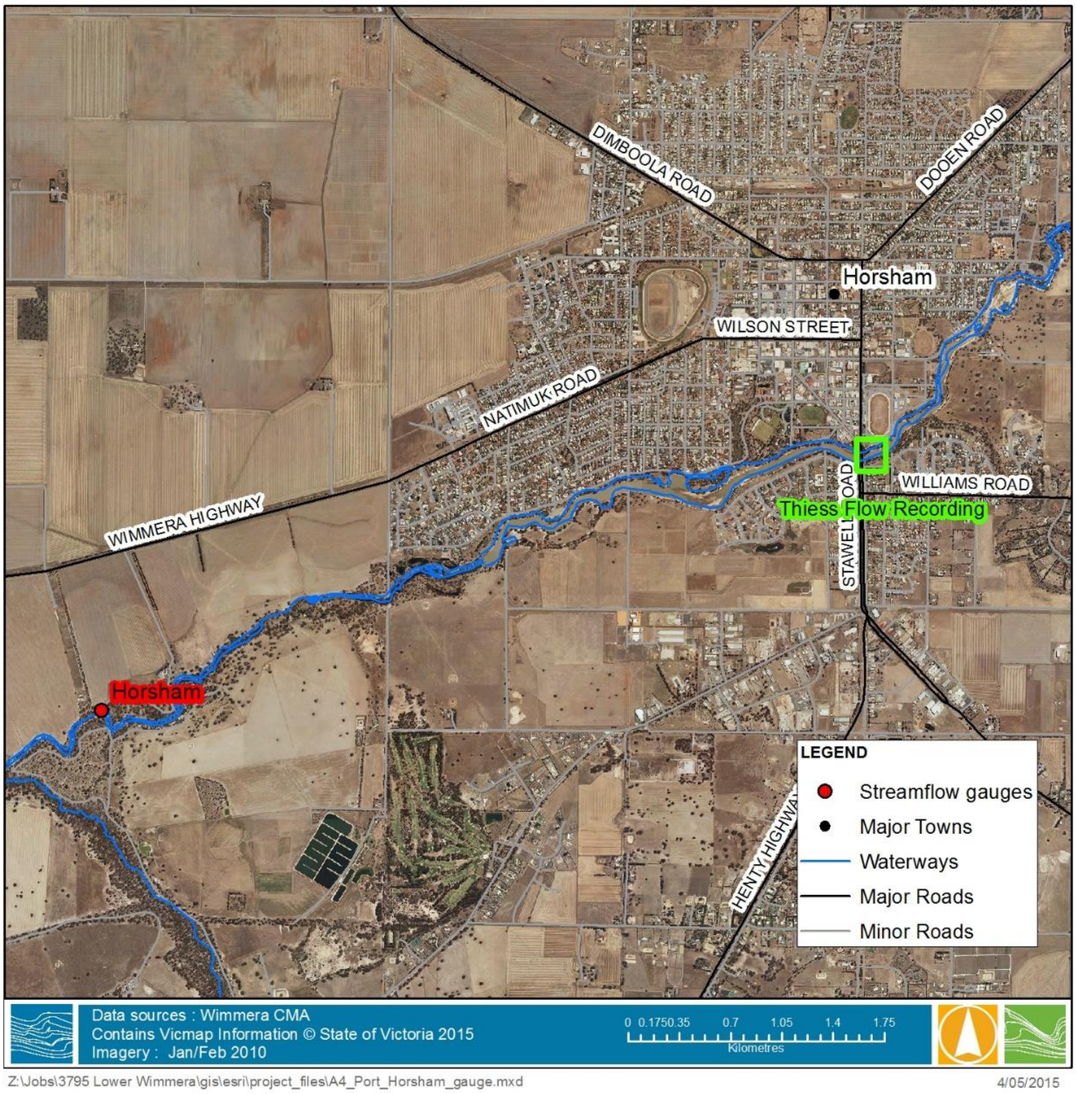

Figure 4-4 **Wimmera River at Horsham (Walmer) gauge and Western Highway January 2011 measurement locations**

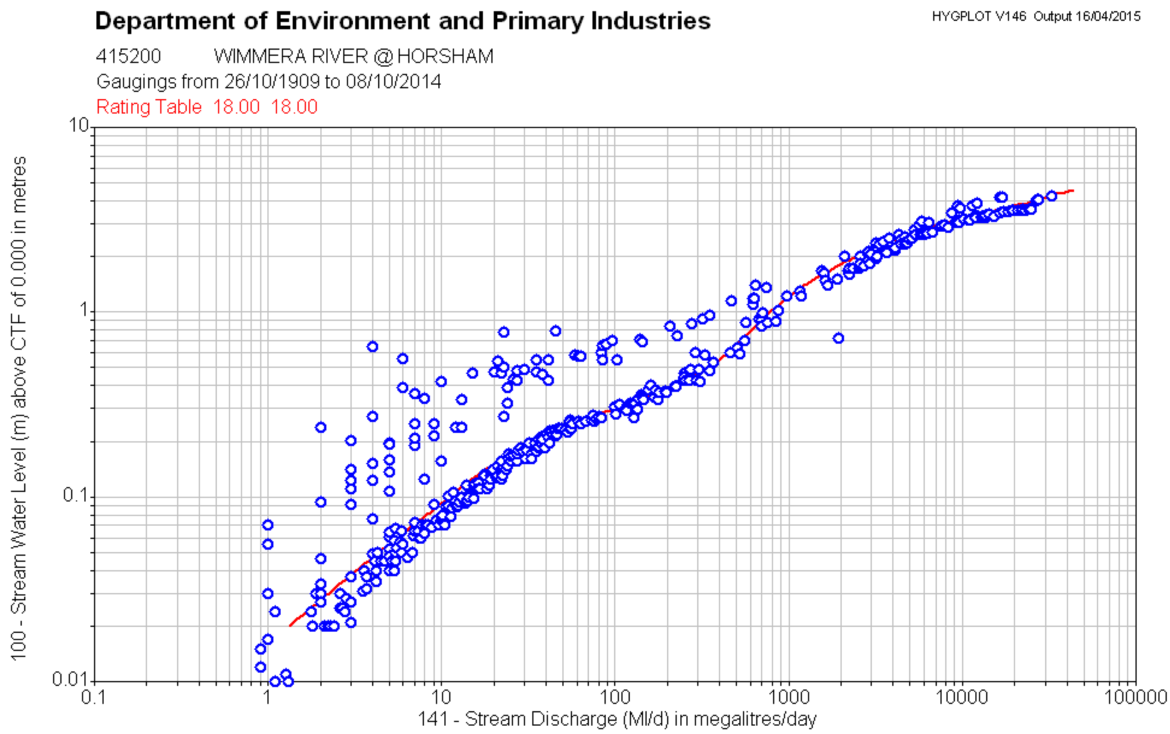

Figure 4-5 **Wimmera River at Horsham streamflow gauge rating curve and measurements[3]**

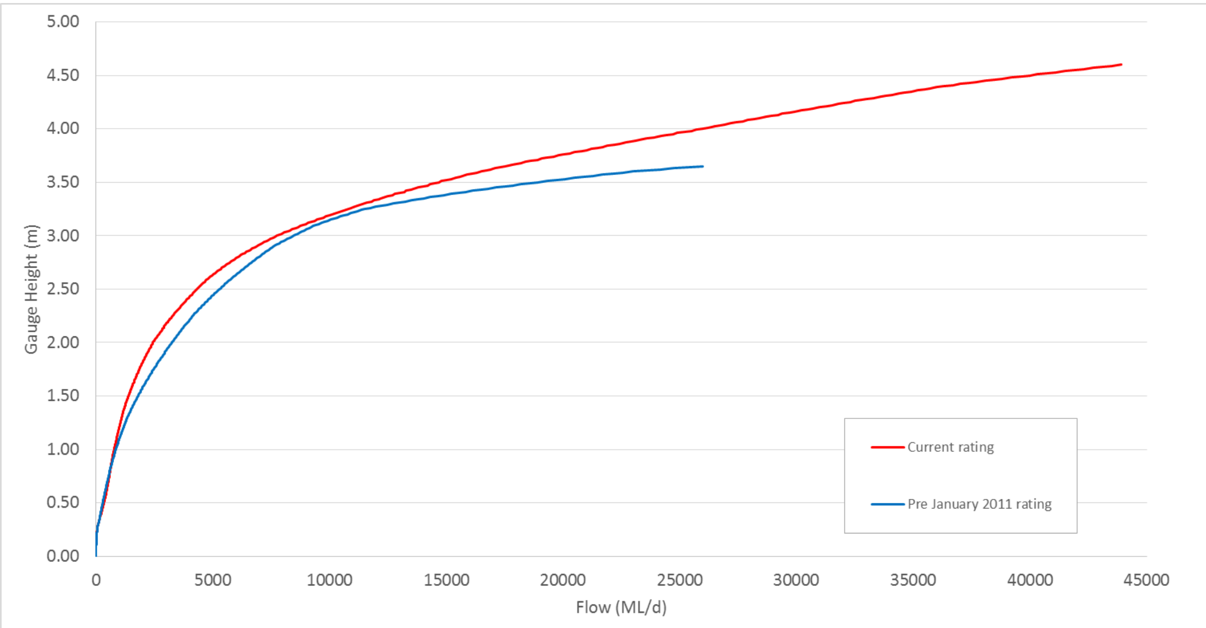

Figure 4-6 **Wimmera River at Horsham current and previous rating curves**

4.2.3 Norton Creek at Lower Norton

The Norton Creek streamflow gauge at Lower Norton has a record spanning from May 2008 to March 2015. This results in 6 years of complete annual record. Insufficient for any high flow statistical

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

analysis. The largest event on record was in January 2011, with a peak gauge height of 2.562 m recorded on the 18th January 2011

The gauge rating curve tables indicate the gauge rating is extrapolated from 0.4 m and terminates at 0.6 m. The gauge record has exceeded a height of 0.6 m six times in the short gauge record.

Figure 4-7 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.

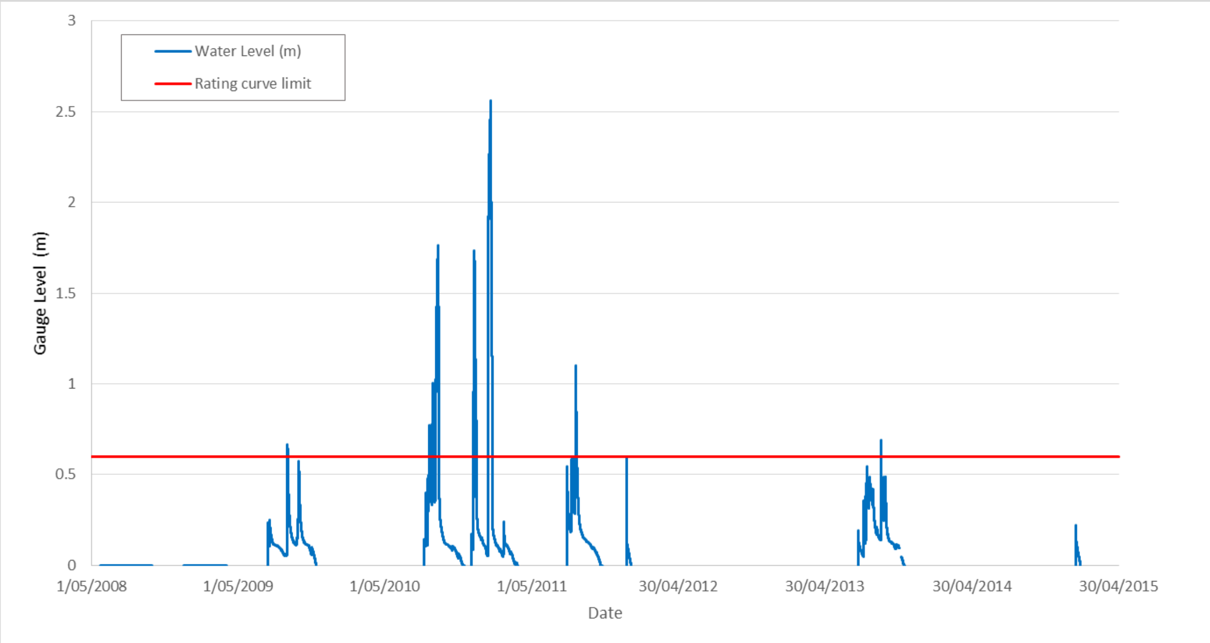

Figure 4-7 Gauge record at Norton Creek at Lower Norton showing water level and limit of extrapolated section of the rating curve

4.2.4 Wimmera River at Quantong

The Wimmera River at Quantong is a water level gauge only. The gauge has a record spanning from July 2009 to March 2015. The gauge record shows the highest recorded level was 7.364 m on 18th January 2011. This event had a Thiess Quality Code of 15, indicating minor editing. There is a small period of gauge record where no heights were recorded due to equipment malfunction in September, October and November 2011. The gauged heights and Thiess Quality Codes are shown in Figure 4-8.

Given lack of flows and short period of available record no high flow statistical analysis can be completed at the Quantong Gauge, however, the record will be useful for calibrating the hydraulic model to height and timing.

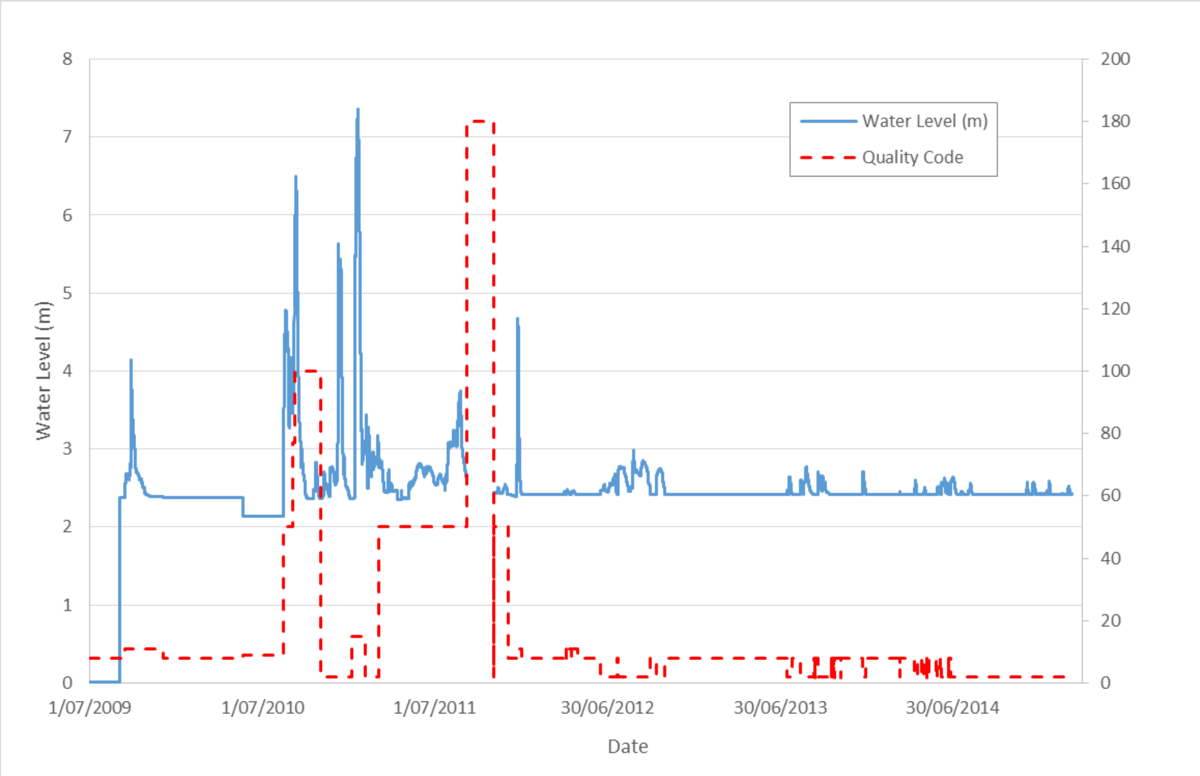

Figure 4-8 **Gauge record at Wimmera River at Quantong showing gauge level and Thiess Quality Codes**

4.2.5 Wimmera River US Dimboola

The Wimmera River streamflow gauge at US Dimboola has a gauge record spanning from May 1989 to March 2015, giving 24 years of complete annual record. The highest level recorded at the gauge was 5.819 m (29,979 ML/d), recorded 4pm, 19th January 2011.

The gauge rating curve shows flows are interpolated after 6.0 m and the rating table is exceeded at 7.5 m. The rating curve and the gaugings on which it is based are shown in Figure 4-9. The gaugings match the rating curve closely at flows greater than 1,000 ML/d with some scatter for gaugings less than this flow.

The gauge flows and Thiess Quality Codes over the gauge record are shown in Figure 4-10. The January 2011 event is clearly the largest event in the gauge record and is within the reliable section of the rating curve. Other high flow events in the gauge record include October 1996 (18,010 ML/d), October 1992 (12,048 ML/d) and September 2010 (11,775 ML/d).

The US Dimboola gauge flow and water level records will be used during the calibration process to compare observed and modelled timing, water levels and flows for the chosen calibration events. Give there is a moderate period of record a FFA could be completed but used with caution.

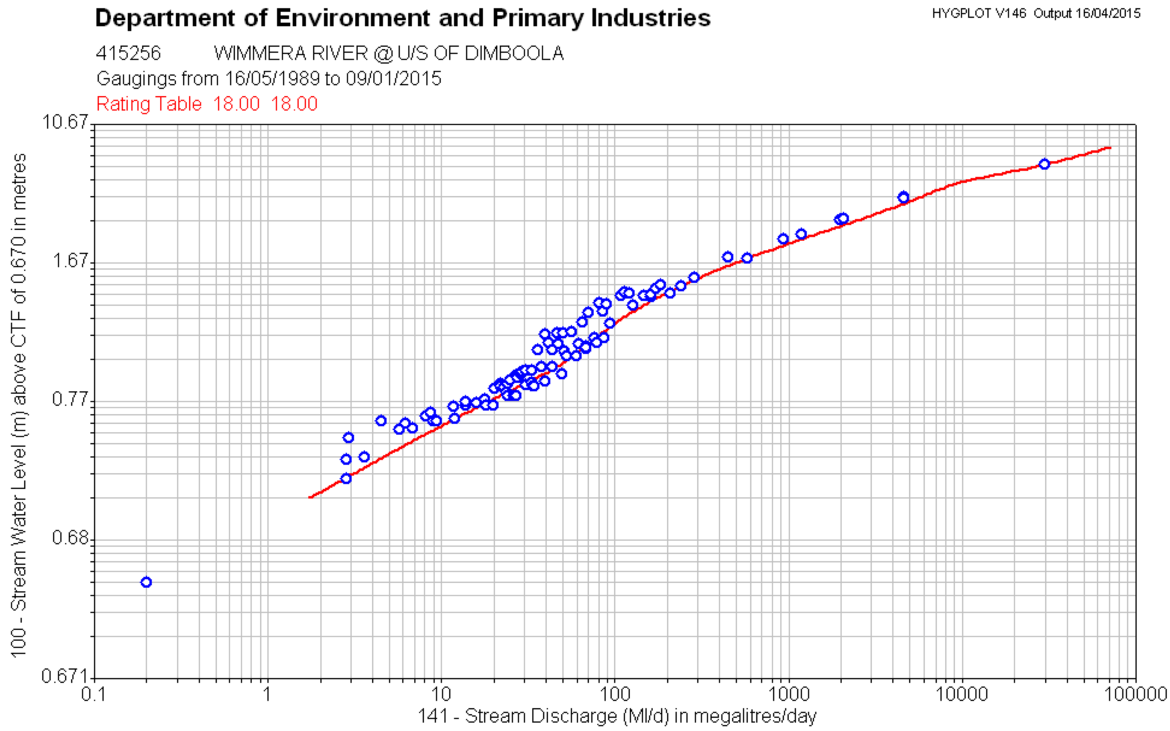

Figure 4-9 Wimmera River at US Dimboola rating curve and gaugings

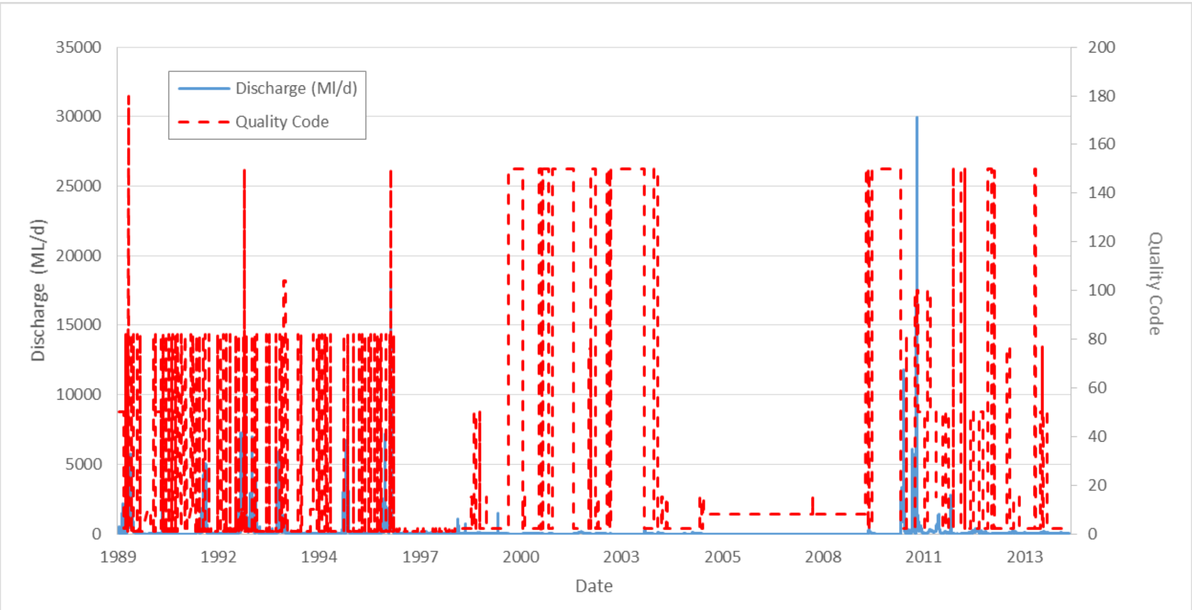

Figure 4-10 Wimmera River at US Dimboola flows and Thiess Quality Codes

4.2.6 Wimmera River at Lochiel Railway Bridge

The Wimmera River at Lochiel Railway Bridge has a gauge record spanning from February 1987 to March 2015. The largest event in the gauge record was January 2011, peaking at 4.617 m (28,933 ML/d) at 3pm, on the 20th January 2011.

The gauge rating curve interpolates flow once a level of 4.9 m is exceeded and the rating table limit is 5.0 m. There were 132 gaugings which form the basis of the rating curve, captured between 1987 and 2014. The gauge rating curve and the measured flows and heights on which it is based is shown in Figure 4-11, with the gauge flow record and Thiess Quality Code shown in Figure 4-12.

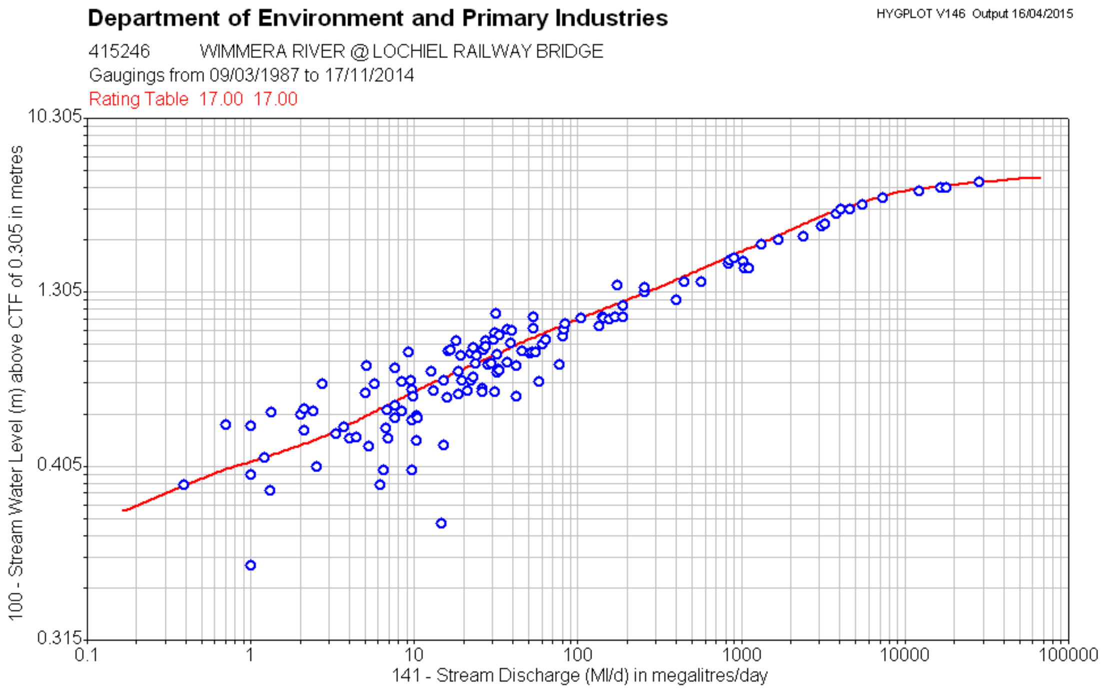

Figure 4-11 Wimmera River at Lochiel Railway Bridge rating curve and gaugings

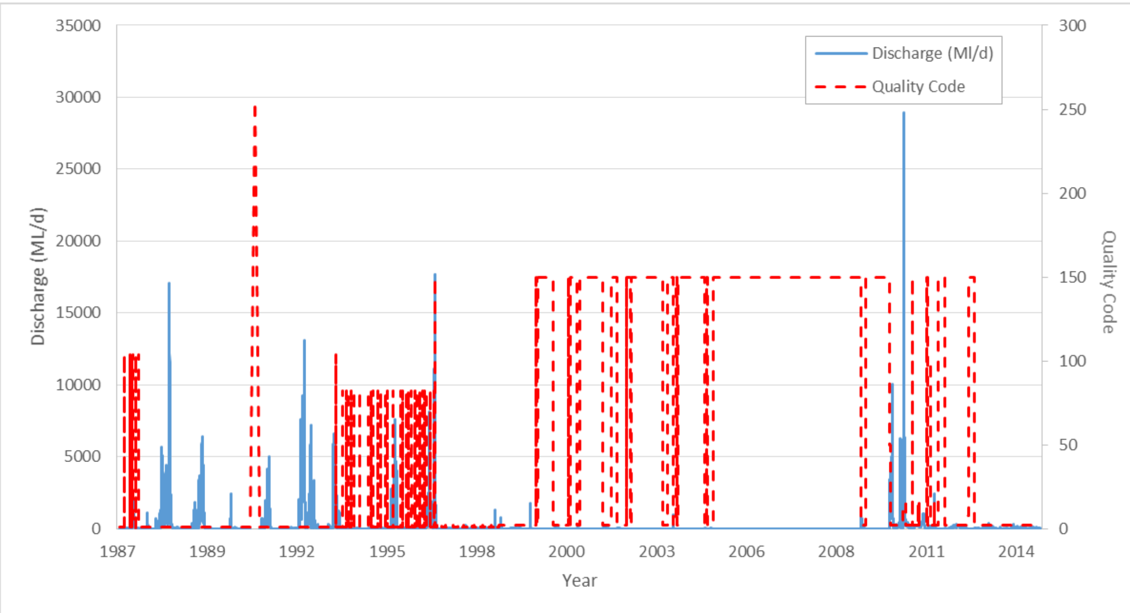

Figure 4-12 Wimmera River at Lochiel Railway Bridge flows and Thiess Quality Codes

The gauge rating curve matches the observed ratings reasonably well at higher flows, however at flows less than 1000 ML/d there is some scatter amongst the points. The flow and quality code comparison shows the gauge accurately recorded the January 2011 event, which is clearly the highest within the gauge record. It also shows long periods of time with a quality code of 150, where the rating table has been extrapolated. This extrapolation is in the low flow section of the rating curve and not relevant to this study.

Similar to Dimboola the Lochiel Railway Bridge gauge flow and water level records will be used during the calibration process to compare observed and modelled timing, water levels and flows for the chosen calibration events. Give there is a limited complete number of years a FFA may not be possible.

4.2.7 Wimmera River at Tarranyurk

The Wimmera River gauge at Tarranyurk has a gauge height record spanning from February 1987 to March 2015. However the flow record ceases in March 2010 with the rating discontinued. The highest gauge height recorded at the gauge was 5.752 m, on 21st January 2011, however there is not predicted flow for this height due to the discontinued rating curve. The highest recorded flow at the gauge was 16,288 ML/d on 8th October 1996. This flow was reached at a height of 5.195 m, significantly lower than that recorded during January 2011.

Flow and height measurements captured at the gauge are shown in Figure 4-13 with the gauge flows and Thiess Quality Code date shown in Figure 4-14. The gauge flow and quality codes show the October 1996 event as a clear standout, however there are long periods of no flow recording, including the period prior to 1992.

The scatter shown in the observed flows and water levels is not unexpected given they are all at low flows, less than 1000 ML/d and a rating based on these recordings is unlikely to capture an accurate rating at higher flows.

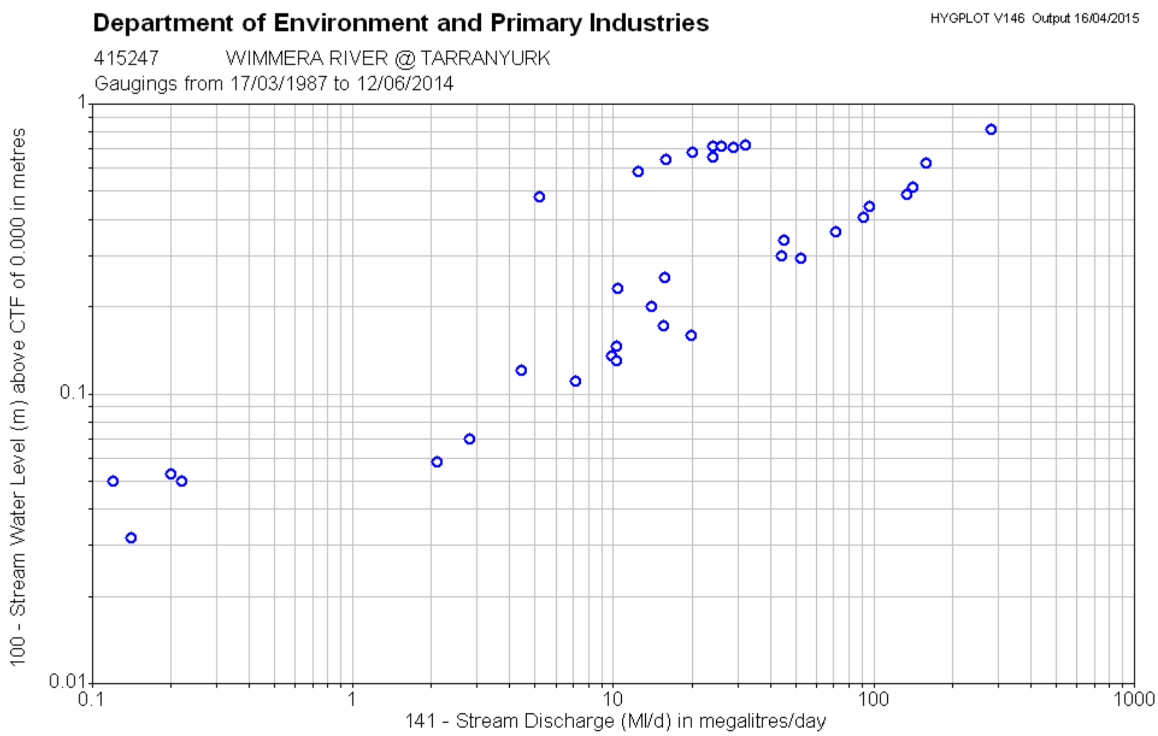

Figure 4-13 Wimmera River at Tarranyurk flows and Thiess Quality Codes

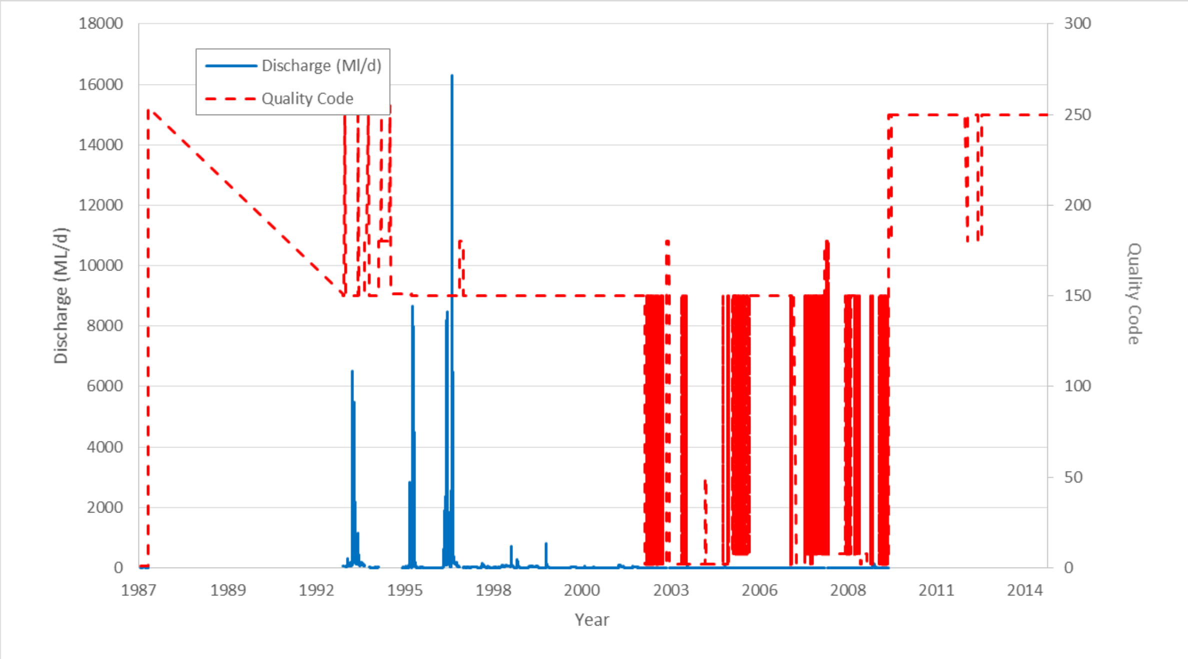

Figure 4-14 Wimmera River at Tarranyurk flows and Thiess Quality Codes

The Wimmera River at Tarranyurk gauge will be used for water level calibration only for historic events. This will provide information on water levels and timing.

4.2.8 Wimmera River at Jeparit

The Wimmera River gauge at Jeparit has a very short water level record, only spanning from May to July 1998. This short period of record limits the gauge's use. Additionally there were no real high flow events recorded during this time.

4.2.9 Gauge Summary

The seven gauges within the study area all have different periods of record, some recording water level and estimating flow, with others only water level. A summary of how each gauge will be used in this study is shown below:

- Wimmera River at Horsham (Walmer) – Excellent period of gauge record, some uncertainty in the gauge rating. The gauge will be the primary source of inflows to the model for calibration and design for the study. The gauge rating curve will be reviewed using a local detailed hydraulic model.
- 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.
- Wimmera River at Quantong – Water level gauge only, the gauge record begins in 2009 and accurately captured the January 2011 event. The gauge will be used for a calibration of water level and timing.
- Wimmera River US Dimboola – Both flow and water level gauge, has 24 years of complete record since 1989. The gauge recorded the January 2011 and October 1996 events. The gauge will be used for a calibration of flow, level and timing.

- Wimmera River at Lochiel Railway Bridge – Both flow and water level gauge, has 23 years of complete annual record since 1987. The gauge recorded the January 2011 and October 1996 events. The gauge will be used for a calibration of flow, level and timing.
- Wimmera River at Tarranyurk – Historically, both flow and water level gauge. However flow predictions are limited and not fit for use in this study. The gauge has 23 years of complete water level record since 1987. The gauge recorded the January 2011 and October 1996 events. The gauge will be used for a calibration of level and timing.
- Wimmera River at Jeparit – Both flow and water level gauge, however very limited gauge record with only 2 months with no high flow events. Gauge is unlikely to be used.

4.3 Previous Studies

The Wimmera River has been subject to numerous hydrologic and hydraulic investigations. These investigations were utilised in the development of this project. The most relevant investigations to this project are shown below:

- Bureau of Meteorology (BoM) - Wimmera River Basin URBS Model (2004)
- Water Technology – Wimmera River and Yarriambiack Creek Flow Modelling Study (2009)
- Water Technology – Horsham Flood Study (2003)
- Water Technology - Dimboola Flood Study (2003)
- Water Technology – Horsham Bypass Hydrologic and Hydraulic Investigation (2013)
- Water Technology – East Horsham Channel Decommissioning Hydraulic Assessment (2013)
- Water Technology – Jeparit Flood Study (2008)

The Wimmera River and Yarriambiack Creek Flow Modelling Study, Horsham Bypass Hydrologic and Hydraulic Investigation, Horsham and Dimboola Floodplain Management Plan and Jeparit Flood Study were of most use in this project as they contain the most recent and relevant information. They are summarised in the following sections of this report.

4.3.1 Wimmera River and Yarriambiack Creek Flow Modelling Study[4]

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. Both current and “pre-European” catchment-waterway-floodplain conditions were assessed. The study was completed with two specific flow regimes in mind, both low-medium flows and high flood flows.

The review and summary of the Wimmera River and Yarriambiack Creek Flow Modelling Study focused on the current (2009) catchment-waterway-floodplain conditions, with high flood flow regime.

The complex nature of flow distribution of Wimmera River flows to Yarriambiack Creek resulted in the development and use of several hydrologic and hydraulic models. A hydrologic model was developed for the Wimmera River and a series of 1D/2D hydraulic models were developed from Glenorchy to Horsham to Warracknabeal. The numerous hydraulic model extents are shown in Figure 4-15. The models of primary interest to this study is the Horsham model, covering the Horsham township.

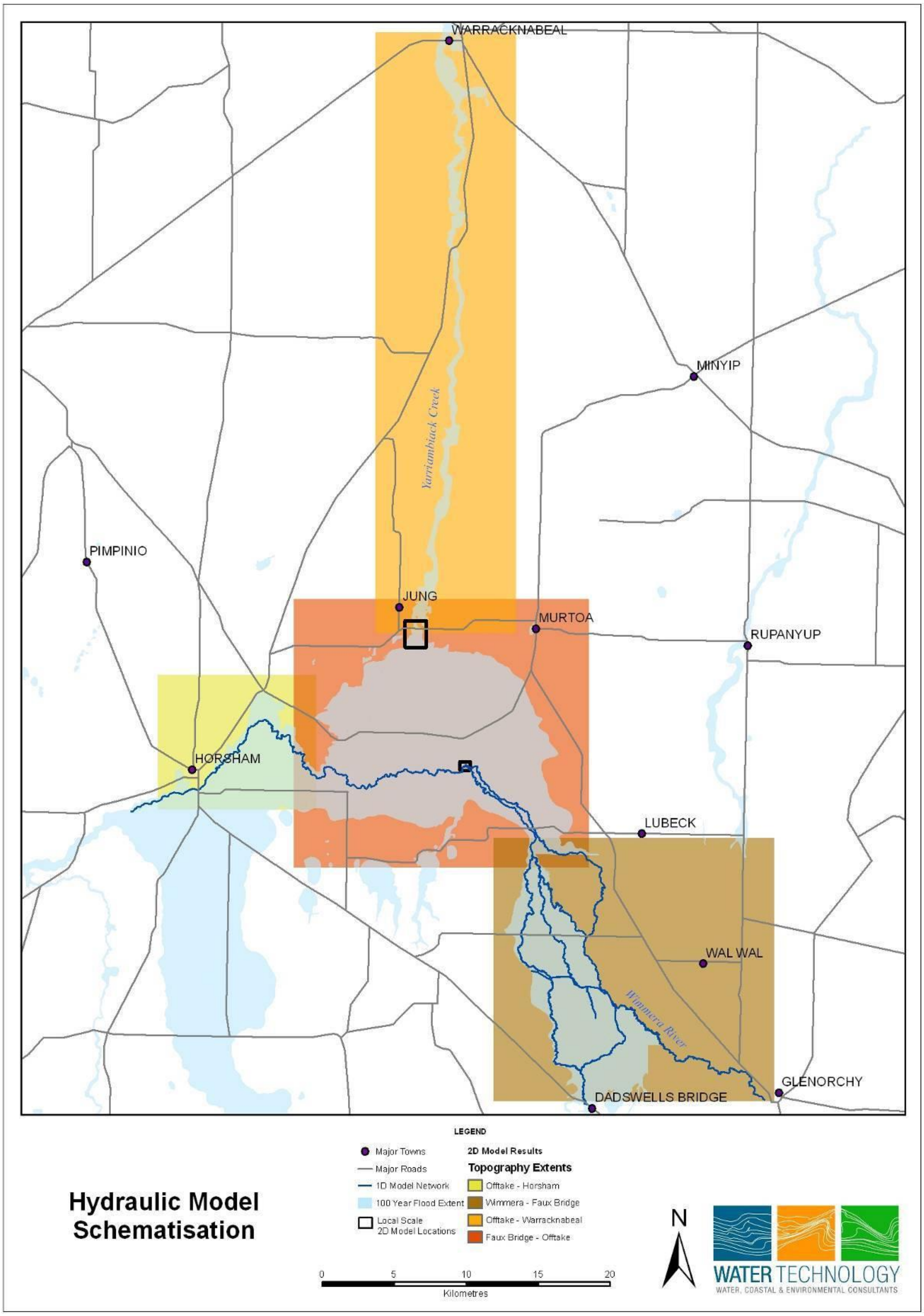

Figure 4-15 Separate hydraulic model extents from previous study[4]

[4] Water Technology – Wimmera River and Yarriambiack Creek Flows Study (2009)

4.3.2 Horsham Bypass Hydrology and Hydraulic Investigation[5]

Overview

The Horsham Bypass Hydrology and Hydraulic Investigation was commissioned by VicRoads to review a series of bypass options for the Horsham Township, ranking the proposed options based on the potential for floodplain impact. The proposed Horsham Bypass options assessed are shown in Figure 4-16.

[5] Water Technology – Horsham Bypass Hydrology and Hydraulic Investigation (2012)

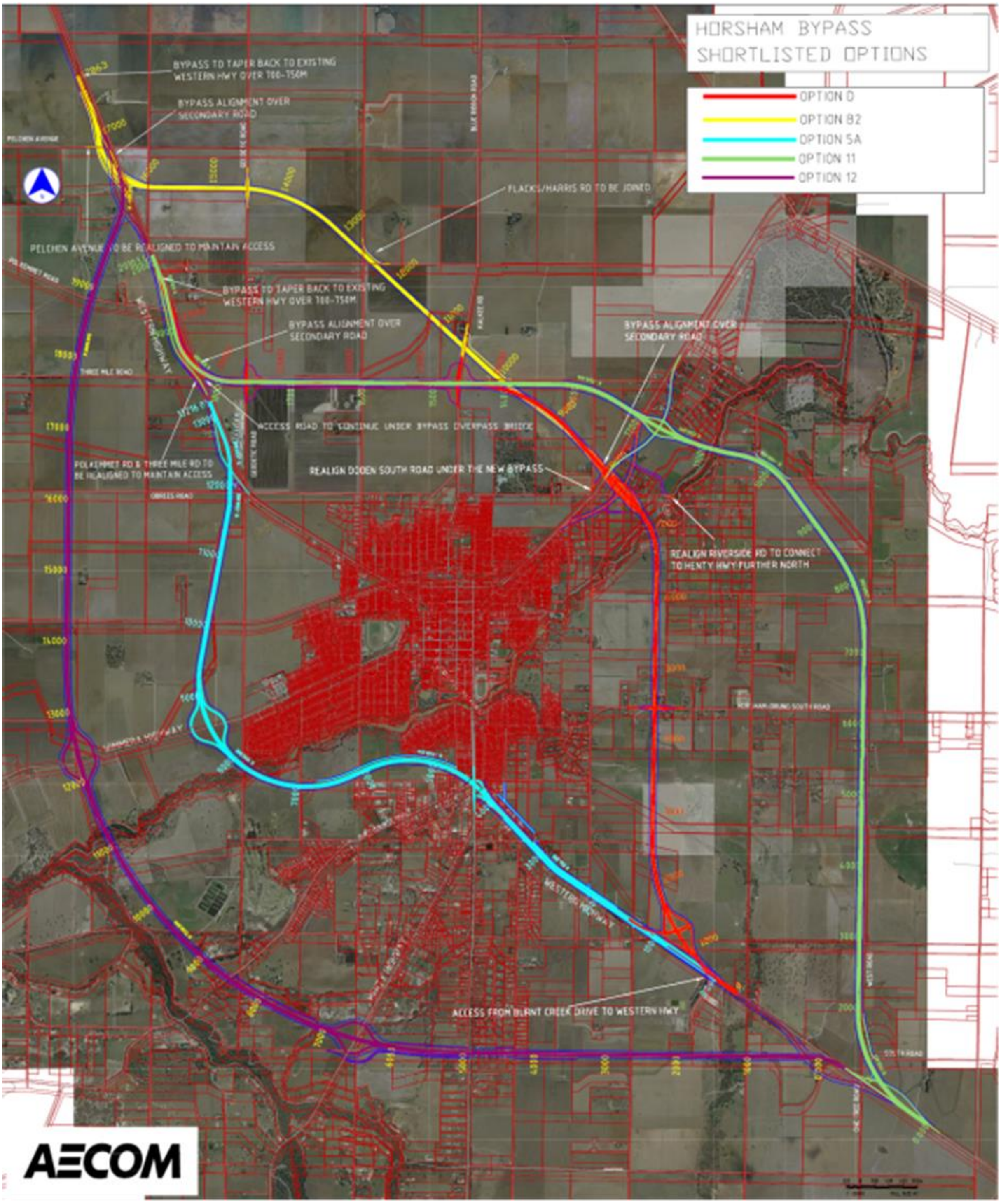

Figure 4-16 Horsham Bypass – Options Assessed as part of the Hydrology and Hydraulics Assessment[5]

Hydrology

Flows used during the Horsham Bypass Hydrology and Hydraulics Investigation were initially determined in the Wimmera River and Yarriambiack Creek Flows Study. Flows were developed using a Unified River Basin Simulator (URBS) model, estimating flood hydrographs at each of the model inflow points.

The URBS model was originally developed by the Bureau of Meteorology (BoM) in 2004[6] but was adapted to enhance its ability to accurately predict flood flows at model inflow points by inserting hydrograph output locations at the hydraulic model boundaries. The model covered the Wimmera Basin to Dimboola.

Hydraulics

The study hydraulic assessment was completed by extending the hydraulic model previously developed during the Wimmera River and Yarriambiack Creek Flows Study to the south and west, as shown in Figure 4-17. During the extension of the existing MikeFlood hydraulic model, additional inflow points were required on the Mackenzie River and Bungalally Creek. The Burnt Creek boundary was also extended to further upstream than the Western Highway. The Wimmera River inflow boundary remained downstream of the Drung-Jung Road Bridge. The project modelled the 1% AEP event only.

[6] BoM – Wimmera Flood Warning URBS model (2004)

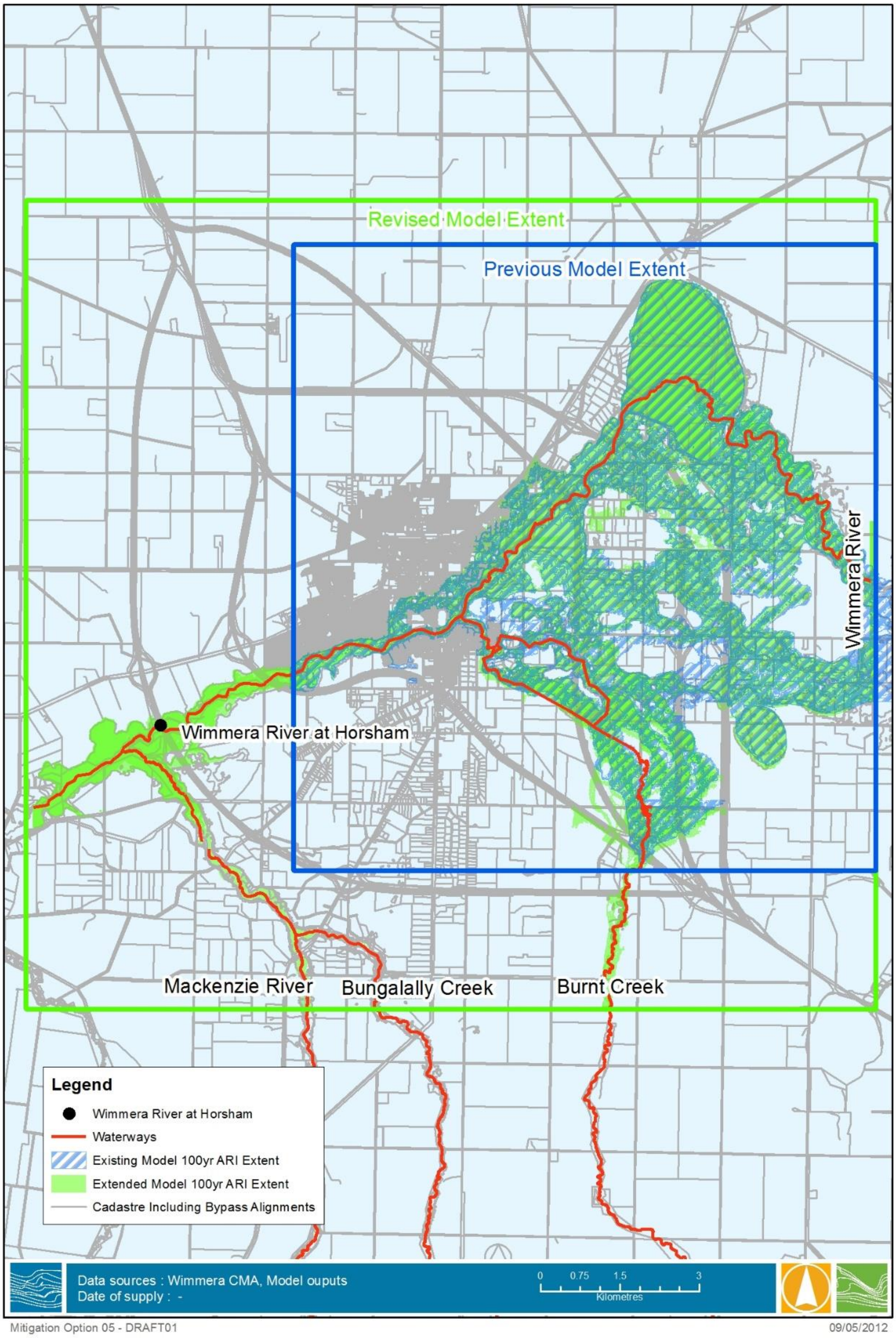

Figure 4-17 Horsham Bypass Hydrology and Hydraulics assessment model area

Discussion

The Horsham Bypass Hydrology and Hydraulics Study covered part of the current projects study area, from the Wimmera River at Horsham (Walmer) streamflow gauge to downstream of the Mackenzie River confluence.

4.3.3 East Horsham Flood Plan

Overview

The East Horsham Flood Plan was commissioned by Horsham Rural City Council (HRCC). The project had two major deliverables, the East Horsham Flood Intelligence Report and the East Horsham Drainage Recommendations Report. The Flood Intelligence Report was written to be used as an update to the Horsham Rural City Municipal Flood Emergency Plan (MFEP) Appendices A, B, C, D, E and F to include the communities of Riverside, St Helen's Plains, Drung Drung and Longerenong. The Drainage Recommendations Report was a practical document to advise HRCC on potential improvements that could be made across East Horsham to reduce the impact of future flood events.

Hydrology

The East Horsham Flood Plan adopted flows determined during the Wimmera River and Yarriambiack Creek Flows Study. Further detail on how these flows were generated is discussed in Section 4.3.1.

Hydraulics

Hydraulic modelling undertaken for the East Horsham Flood Plan was an extension of that carried out during the Horsham Bypass Hydrology and Hydraulics Study, using the extended model to model the 20 %, 10 %, 5 %, 2 % and 0.5 % AEP events. Previous modelling was completed of the 1 % AEP event only and the results provided a full set of design events to use in the East Horsham Flood Intelligence Report.

Discussion

The East Horsham Flood Plan added 20 %, 10 %, 5 %, 2 % and 0.5 % AEP events to the already modelled 1 % AEP event. As discussed in Section 4.3.2, the model area overlaps with the current investigation's study area and comparisons of flow and modelled water levels will be made to determine an understanding of the flows and water levels at the Wimmera River at Horsham Gauge.

The study determined the flows and peak flood heights at the Wimmera River at Horsham for each of the modelled AEP events shown in Table 4-4.

Table 4-4 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

4.3.4 Horsham Flood Study[7]

Overview

The Horsham Flood Study was commissioned by Wimmera CMA and completed by Water Technology. The Study was commissioned 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.

The study covered the Wimmera River and Burnt Creek from downstream of Dooen's Swamp to downstream of the Horsham residential area. The study area extent is shown in Figure 4-18.

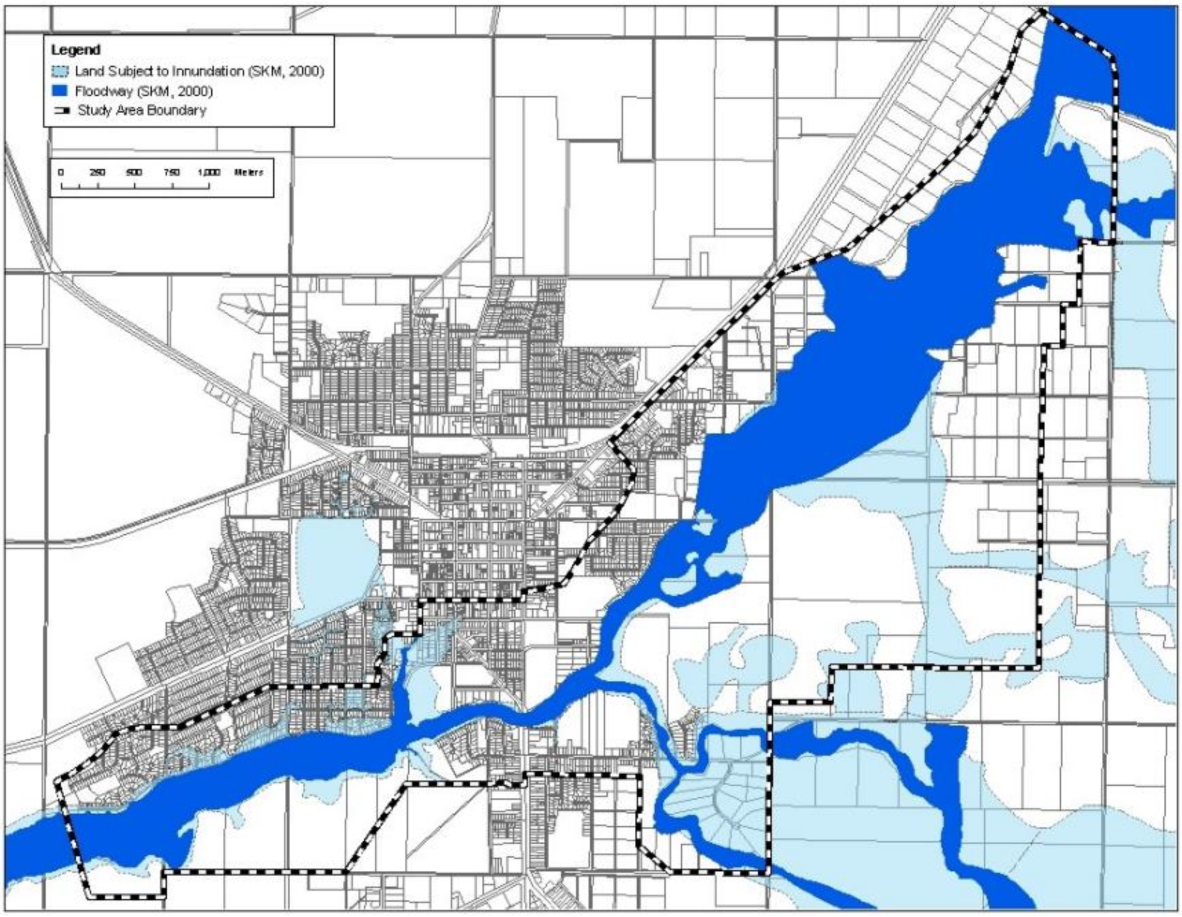

Figure 4-18 Horsham Flood Study Extent

Hydrology

Calibration flows for the study were recorded at the Wimmera River streamflow gauge at Horsham (Walmer) and the Burnt Creek streamflow gauge at Wonwondah East. Design flows were primarily based on a FFA completed at the Wimmera River and Burnt Creek streamflow gauges. The FFA completed at each gauge determined the peak flows shown in Table 4-5.

[7] Water Technology – Horsham Flood Study (2003)

Table 4-5 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

Hydraulics

A hydraulic model covering the study extent was constructed using DHI's MikeFlood incorporating both 1D and 2D components. Photogrammetry captured by AAM was used as the base topographic data. The photogrammetry was modified to a regular 10 m resolution grid with the inclusion of key features captured during feature survey. The hydraulic model calibration was completed using September 1988 as the primary event due to the availability of observed levels and anecdotal information.

Discussion

There are no overlapping areas between the current study and the Horsham Flood Study, however the design flows determined at Walmer will be used as a comparison in this studies hydrologic analysis.

4.3.5 Dimboola Flood Study[8]

Overview

The Dimboola Flood Study was commissioned by Wimmera CMA and completed by Water Technology. The Study was commissioned to determine flood levels and extents for the 20%, 5%, 2%, 1% AEP and PMF events. Preliminary recommendations for flood mitigation options were developed.

Hydrology

Hydrology for the Dimboola Flood Study was primarily based on that completed during the Horsham Flood Study, discussed in Section 4.3.4. The peak flows determined during the Horsham Flood Study FFA were adopted.

Hydraulics

Hydraulic modelling completed during the Dimboola Flood Study was completed in DHI's Mike21. The model's topography was based on photogrammetry captured by AAM. The raw data was modified to a regular 10 m resolution grid for the hydraulic model topography. Survey of key features (e.g. levees, waterway cross sections) was also captured and inserted into the model topography. The hydraulic model covered from upstream of St Leonards Ave to Swallows Lane. The hydraulic model topography is shown in Figure 4-19.

[8] Water Technology - Dimboola Flood Study (2003)

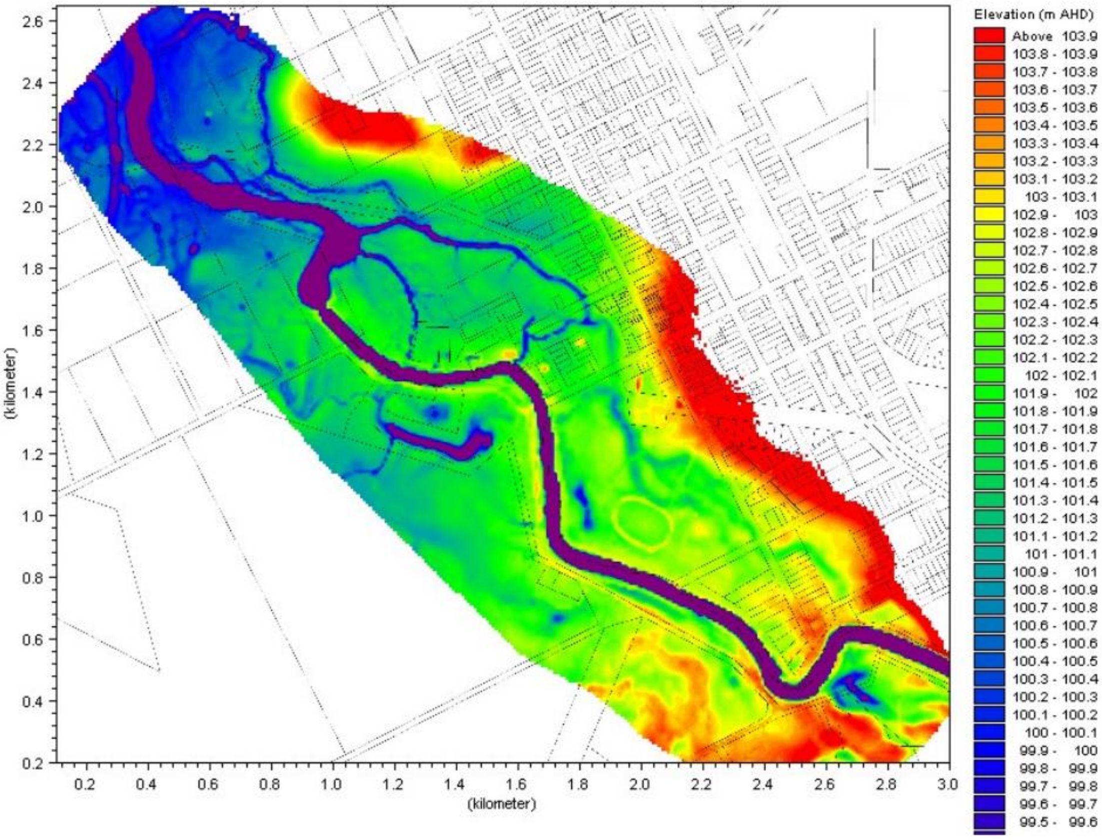

Figure 4-19 Dimboola Flood Study hydraulic model topography

The calibration events adopted during the study were 1909, 1981 and 1986. The 1981 event was used as the primary calibration event, however no streamflow gauges in direct vicinity to Dimboola were operational.

Discussion

The Dimboola Flood Study hydraulic model area is within the current projects study area. The calibration and design water levels determined in the hydraulic model will be compared to those determined in this study during the model calibration and verification process.

4.3.6 Jeparit Flood Study[9]

Overview

The Jeparit Flood Study was commissioned by Wimmera CMA and completed by Water Technology. The Study was commissioned to provide information on flood levels and flood risks within the township for riverine and stormwater flooding. The project also assessed mitigation options and produced draft Land Subject to Inundation (LSIO) and Flood Overlay (FO) planning layers.

[9] Water Technology –Jeparit Flood Study (2008)

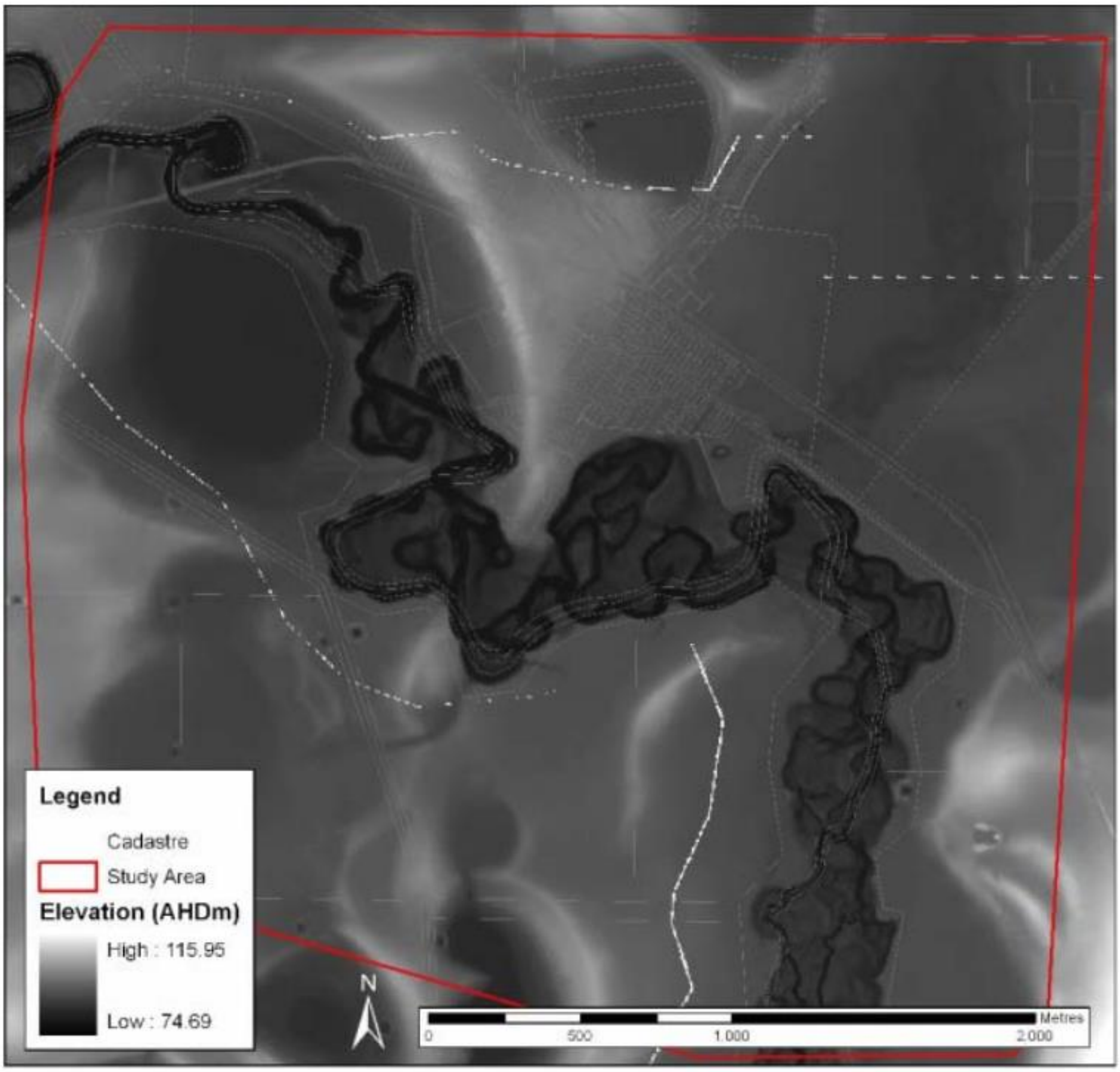

Figure 4-20 Dimboola Flood Study hydraulic model topography

Hydrology

Flows at Jeparit were determined using a calibrated URBS model. The model was initially constructed by the BoM in 2004 as part of the Wimmera River flood warning system to Dimboola. The model developed by the BoM was modified during this study, extending it to Jeparit. The model was extended by adding the additional reach length from Dimboola to Jeparit without the inclusion of the additional catchment area. This approach was thought reasonable given the limited catchment contribution made to the Wimmera River downstream of Dimboola. The URBS model extent is shown in Figure 4-21.

The URBS model was calibrated using the August 1992, June 1995 and September 1996 events. These events were chosen because of their available concurrent streamflow and pluviograph records. Downstream of Horsham the URBS model was calibrated to three streamflow gauges on the Wimmera River; US Dimboola, Lochiel Railway and Tarranyurk.

A comparison of the recorded and modelled peak flows at each gauge is shown in Table 4-6.

Design flows were determined for Jeparit using the URBS model and design rainfall depths and temporal patterns recommended in Australian Rainfall and Runoff[10].Design flows determined by the URBS model at Dimboola were compared to those determined during the Dimboola Flood Study. This comparison is shown in Table 4-7.

The final peak flows determined at Jeparit are shown in Table 4-8.

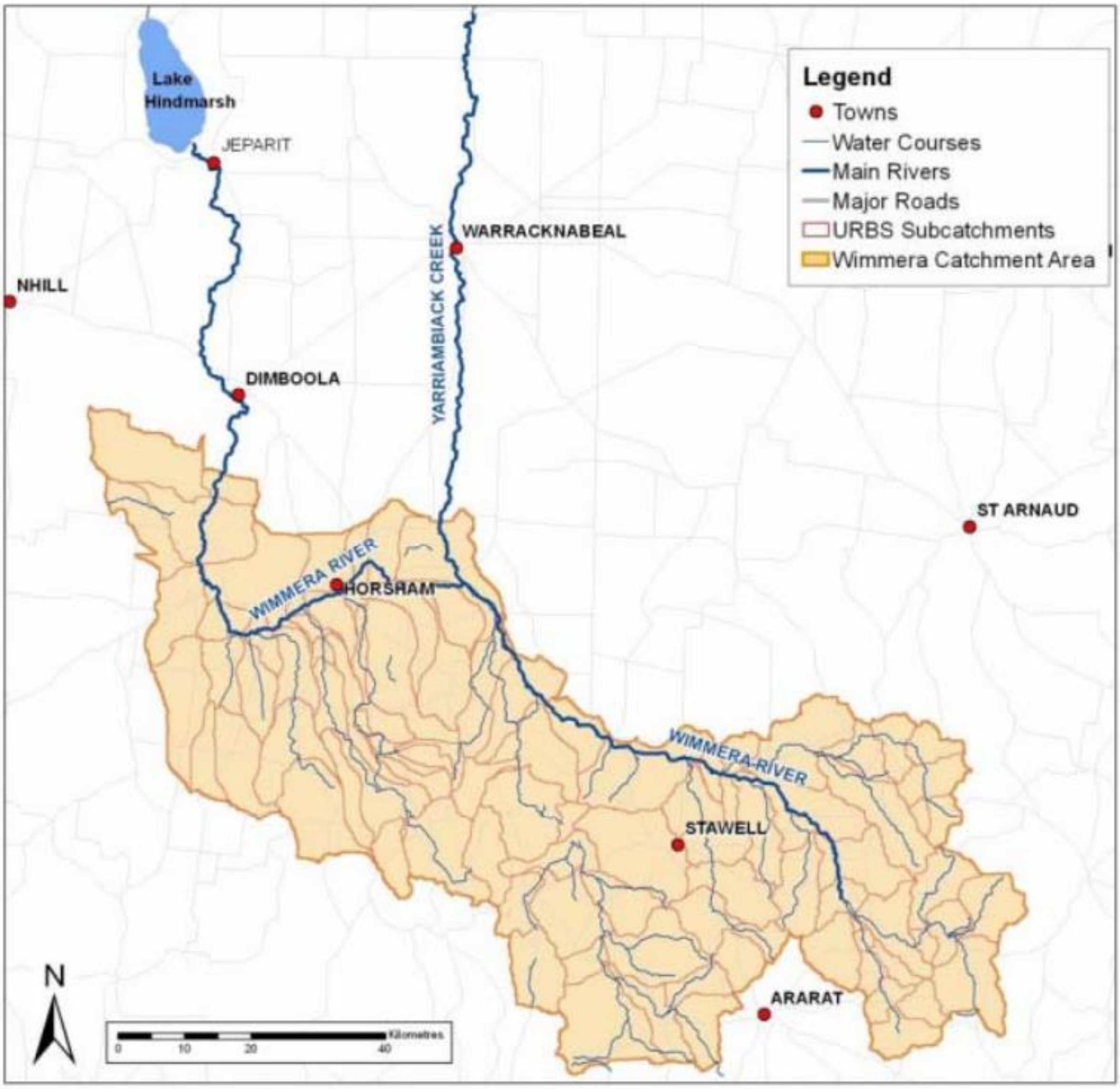

Figure 4-21 Jeparit Flood Study – URBS model structure

[10] Engineers Australian - Australian Rainfall and Runoff (1987)

Table 4-6 URBS model calibration – Modelled and observed peak flows

Event	Wimmera River at US Dimboola		Wimmera River at Lochiel Railway		Wimmera River at Tarranyurk	
	Recorded	Modelled	Recorded	Modelled	Recorded	Modelled
August 1992	98.9	96.2	88.4	88.1	-	-
June 1995	34.4	35.8	32.3	32.8	32.7	30.4
September 1996	207.9	224.0	204.3	205.4	188.5	193.1

Table 4-7 Dimboola Design Flows – URBS and Dimboola Flood Study comparison

Event	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP
Dimboola Flood Study	149	209	274	361	428	498
URBS Model (α = 0.3 & β= 3.5 IL 25 mm CL 3.0 mm/h)	149	210	276	362	429	498

Table 4-8 Peak flows determined by the URBS model at Jeparit

AEP (%)	Wimmera River at Jeparit (township)	
	Peak flow (ML/d)	Peak flow (m^3/s)
20	10,200	118
10	14,860	172
5	20,045	232
2	26,620	308
1	33,350	386
0.5	37,065	429

Hydraulics

A hydraulic model of the study area was constructed using DHI's MikeFlood incorporating both 1D (culverts, bridges etc.) and 2D (surrounding floodplain) components. LiDAR captured in October 2004 was used for the model's base topography. A 5 m regular grid was chosen for the topographic resolution.

During the design modelling the Nhill-Jeparit Road bridge was used as a reference point for flood levels. The depth and level reached in the Wimmera River at the structure for the modelled design events is shown in Table 4-9.

Table 4-9 Design flood levels at the Nhill – Jeparit Road bridge on the Wimmera River

AEP (%)	Depth (m)	Surface Elevation (m AHD)
10	3.66	80.35
5	3.89	80.58
2	4.17	80.86
1	4.43	81.12
0.5	4.51	81.20

Discussion

The Jeparit Flood Study used the BoM URBS model to determine flows for the study area, these flows will be compared to those determined by the hydraulic model in this study.

The Jeparit Flood Study hydraulic model area is within the current project study area. The calibration and design water levels determined in the hydraulic model will be compared to those determined in this study during the model calibration and verification process.

4.4 January 2011

4.4.1 Rainfall

Rainfall in mid-January 2011 caused widespread flooding across Victoria with the Wimmera Region particularly impacted. Rainfall began on the 9th January as significant rain fell across north-western Victoria. The rainfall moved south across the catchment, with Warracknabeal Museum recording its highest ever daily maximum of 77.4 mm on Monday 10th January.

As the rainfall moved south east it intensified over the period Wednesday the 12th to Friday the 14th, breaking previous records at Rupanyup, Longerenong, Navarre and the Horsham gauges. Horsham (Polkemmet Rd) surpassed its previous record from 1886 by 22.6 mm. Halls Gap and Mount William in the Grampians recorded heavy rain on Monday the 10th and Wednesday the 12th, with cumulative totals of 146.6 mm and 132.8 mm for the gauge respectively. Halls Gap and the Grampians also recorded the highest monthly rainfall in the state with 297.0 mm and 289.6 mm respectively. This rainfall was particularly intense with 12.4 mm recorded from 12pm-1pm and 10.6 mm recorded from 4pm-5pm on the 13th at the Grampians gauge. On Thursday the 13th the system progressed eastward moving rainfall to the north, central and eastern areas of Victoria. On the evening of Friday the 14th the low pressure system cleared the state.

Table 4-10 shows the daily and monthly rainfall record for January 2011.

Table 4-10 January 2011 rainfall records

Location	January 2011		
	Monthly Total	Daily Max.	Day of the month
North Wimmera			
Dimboola	155	104.2	12
Donald	194.8	81	14
Jeparit	202.2	34.2	11
Kaniva	67	44.8	14
Nhill Aerodrome	106.6	65.4	12
Warracknabeal Museum	165.8	77.4	10
South Wimmera			
Apsley (Post Office)	145	115	14
Drung Drung	123	57	3
Edenhope Airport	110.2	62.8	12
Goroke (Post Office)	94.8	46.4	12
Grampians (Mount William)	289.6	134.6	12
Harrow (Post Office)	48	45	1
Horsham Aerodrome	159.2	101.4	12
Horsham Polkemmet Rd	146.2	98	12
Kanagulk	130.2	89.2	10
Longerenong	159.6	97	12
Natimuk	150.6	115.2	13
Navarre	167.3	76.2	14
Pyrenees (Ben Nevis)	170.2	67.8	12
Rupanyup (Post Office)	200.6	90	14
Stawell Aerodrome	172.4	86.6	14

Note: Highlighted gauges broke daily or monthly statistical records during the event.

4.4.2 Stream Flows

As discussed in Section 4.2, the Wimmera River experienced high streamflows during January 2011. Table 4-11 shows the maximum water levels and flows achieved during January 2011 as well as the timing of the peak level for all Wimmera River and tributary waterway gauges.

Table 4-11 January 2011 streamflow records

Location	Gauge No.	January 2011		
		Peak level (m)	Peak flow (ML/d)	Date/Time of peak level
Wimmera River at Eversley**	415207C	5.837	30,845	14/01/2011 0815hrs
Mt. Cole Creek at Crowlands**	415245A	3.440	-	14/01/2011 0915hrs
Wattle Creek at Navarre	415238A	4.68	5,542	14/01/2011 9:23
Wimmera R at Glynwylln*	415206B	8.630	34,983	14/01/2011 1745hrs
Concongella Creek at Stawell**	415237A	5.050	-	14/01/2011 630hrs
Wimmera River at Glenorchy Weir (Tail Gauge)	415201B	5.026	31,522	15/01/2011 0730hrs
Fyans Creek at Lake Bellfield	415214C	1.175	413	13/01/2011 1745hrs
Fyans Creek at Grampians Rd Bridge ***	415217A	-	-	-
Fyans Creek at Fyans Creek	415250	4.230	4,140	13/01/2011 23:11hrs
Mt William Creek at Lake Lonsdale (Tail Gauge)	415203D	2.654	38,527	14/01/2011 2145hrs
Mt William Creek at Mokepilly**	415252B	4.798	-	14/01/2011 0800hrs
Yarriambiack Creek @ Wimmera Highway Bridge	415241	1.72	1,294	19/01/2011 16:43:46
Wimmera River at Drung Drung**	415239A	4.710	-	16/01/2011 1815hrs
Burnt Creek at Wonwondah East	415223B	1.070	1,596	14/01/2011 0545hrs
Mackenzie River at Wartook Reservoir****	415202C	1.993	-	13/01/2011 1815hrs
Mackenzie River at Mckenzie Creek **	415251A	2.357	-	15/01/2011 0830hrs
Wimmera River at Horsham (Walmer)	415200D	4.277	32,971	18/01/2011 1130hrs
Wimmera River at Quantong *****	415261A	7.364	-	18/01/2011 2130hrs
Wimmera River US Dimboola	415256A	5.752	23,788	19/01/2011 1600hrs
Wimmera River at Lockeil Railway Bridge	415246A	4.617	22,639	20/01/2011 1500hrs
Wimmera River at Tarrenyurk ****	415247B	5.752	-	21/01/2011 1415hrs

* Gauging station failed to record levels during peak of January event

** Water level exceeded rating curve, peak levels recorded, no flows displayed

*** No flows available **** No flows have been determined ***** No rating curve

There are five gauges on the Wimmera River within the study area, three recording flow and water level. Recorded flows at Horsham, US Dimboola and Lochiel show a slight reduction in the peak flow moving downstream in the January 2011 event. The peak flow rate reduced by approximately 10% between Horsham and US Dimboola, with relatively minor attenuation between Dimboola and Lochiel.

The time for the flood wave to propagate down through the study area is significantly long. In January 2011 the time between the peak at Horsham and Tarranyurk was approximately 75 hours.

The peak level, flow and timing of each Wimmera River gauge in the study area is shown in Table 4-12, with hydrographs for Horsham, Dimboola and Lochiel shown in Figure 4-22.

Table 4-12 January 2011 – Peak level, flow and timing

Gauge	Max. Level (m)	Max. Flow (ML/d)	Time/Date	Time (hrs)
Horsham (Walmer)	4.277	32,971	18/01/2011 11:30	0
Quantong	7.364	-	18/01/2011 21:30	10
US Dimboola	5.819	29,979	19/01/2011 16:00	28.5
Lochiel	4.617	28,933	20/01/2011 15:00	51.5
Tarranyurk	5.752	-	21/01/2011 14:15	74.75

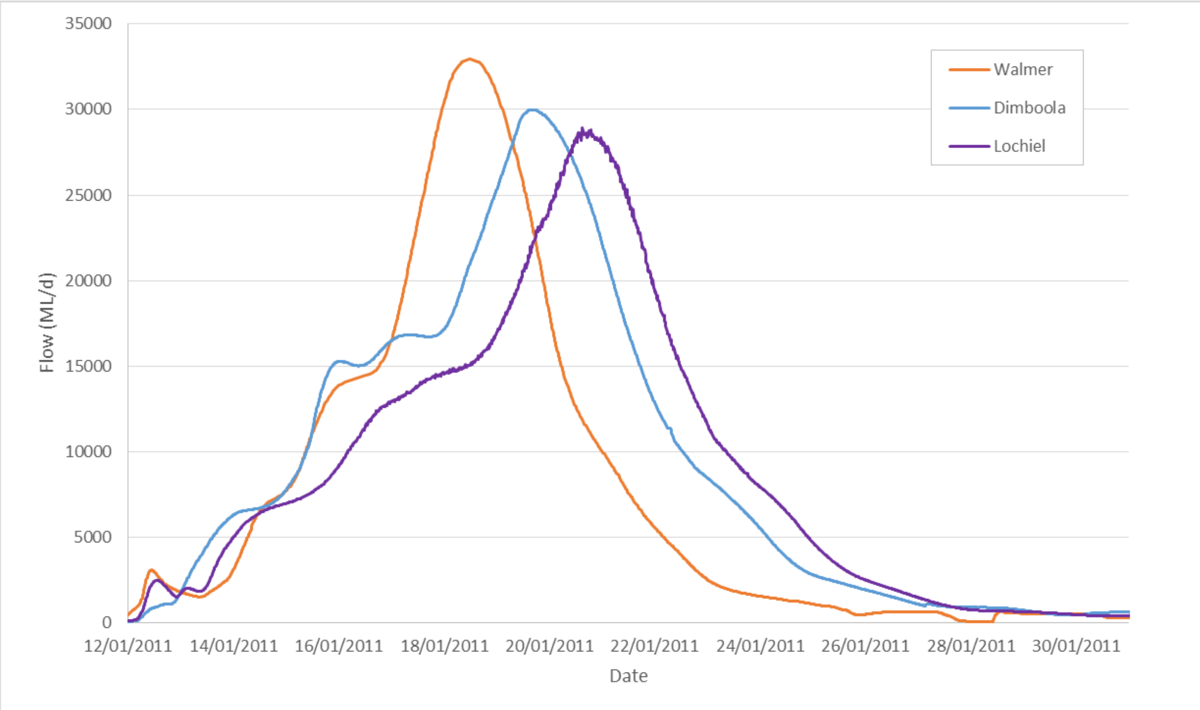

Figure 4-22 January 2011 lower Wimmera River hydrographs

4.4.3 Inundation

The January 2011 event was the largest flood on record in many townships throughout the Wimmera region, causing significant flood related damage. Townships which received the most notable damage within the study area were Dimboola and Jeparit.

Flooding in Dimboola began on Tuesday the 18thJanuary. Within the Dimboola township, 9 houses were inundated above floor level. This compares to the estimated 4 houses in the Dimboola flood study for the 100 year ARI event and 10 house for the 200 year ARI event.

The Dimboola weir was fully opened, with two bays remaining closed due to a walkway being constructed above them meaning the boards could not be removed. The weir was damaged during January 2011 with floodwater washing away sections of the walkway and affecting the electronic systems. The weir has since been repaired and redesigned.

Localised flooding was observed in Jeparit immediately after the initial rainfall with flooding from the Wimmera River arriving on Wednesday the 19th January and peaking on Friday 21st January. Flooding caused damage to the railway line at Arkona and the Jeparit Weir but no houses were inundated above floor level. Within Jeparit there were 6,000 sandbags distributed. Victoria Police closed Lake Road after floodwaters overtopped the road.

Lake Hindmarsh begun January 2011 relatively empty and had a capacity to receive substantial inflows and therefore had no effect on flooding throughout Jeparit.

The Jeparit weir was damaged during January with sections of the walkway washed away. A diversion was put in place allowing water past the weir. This diversion has since been formalised with a rock spillway.

4.5 Observed peak flood heights and extents

Within the study area there are a number of surveyed peak flood heights, and an accurate representation of the January 2011 flood extent. The peak flood heights are available for the following events:

- January 2011 - 33 surveyed points spread over the study area extent, reaching as far north as Arkona
- September 2010 - 37surveyed points evenly spread over the entire study extent
- 1909 - 13 surveyed points focused around Dimboola and Jeparit
- 1946 - 1 surveyed point at Dimboola
- 1981 -4 surveyed points at Dimboola
- 1983 - 1 surveyed point at Dimboola

The location of the available peak flood heights and January 2011 recorded extent is shown in Figure 4-23. The January 2011 extent was derived from aerial images, linescan data, ground based photography and anecdotal evidence. The information is considered the best available but some areas must be treated with caution.

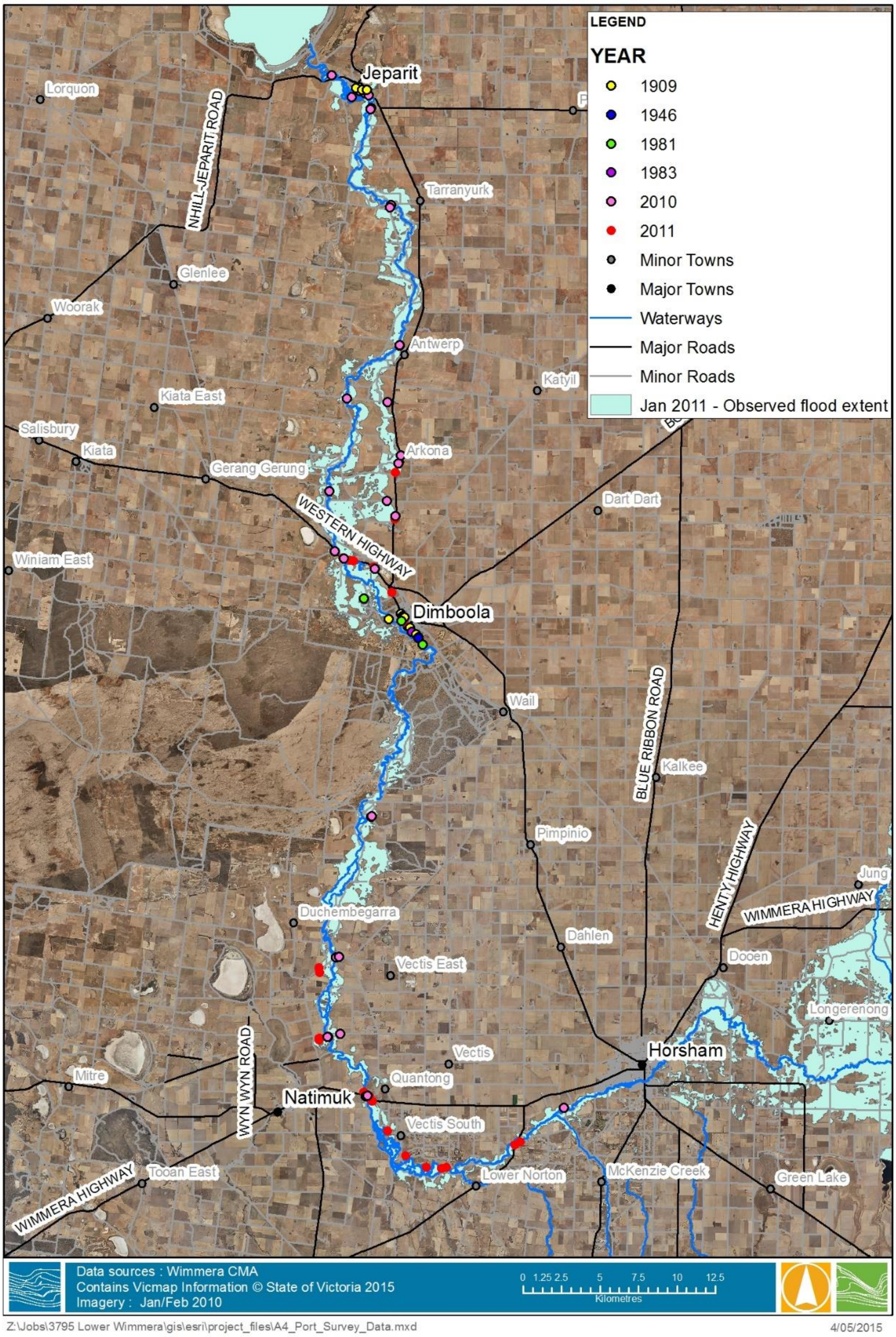

Figure 4-23 Peak flood height survey data

4.6 Topographic data and feature 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 4-13 and the extents of the four datasets within the Lower Wimmera study area are shown in Figure 4-24.

Table 4-13 Key metadata for LiDAR datasets

Dataset	Source	Date of Capture	Vertical accuracy (1 sigma)	DTM resolution
2005 Wimmera CMA Zone 1	LiDAR	Jan 2005	0.15 m	2 m
2005 Wimmera CMA Zone 2	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

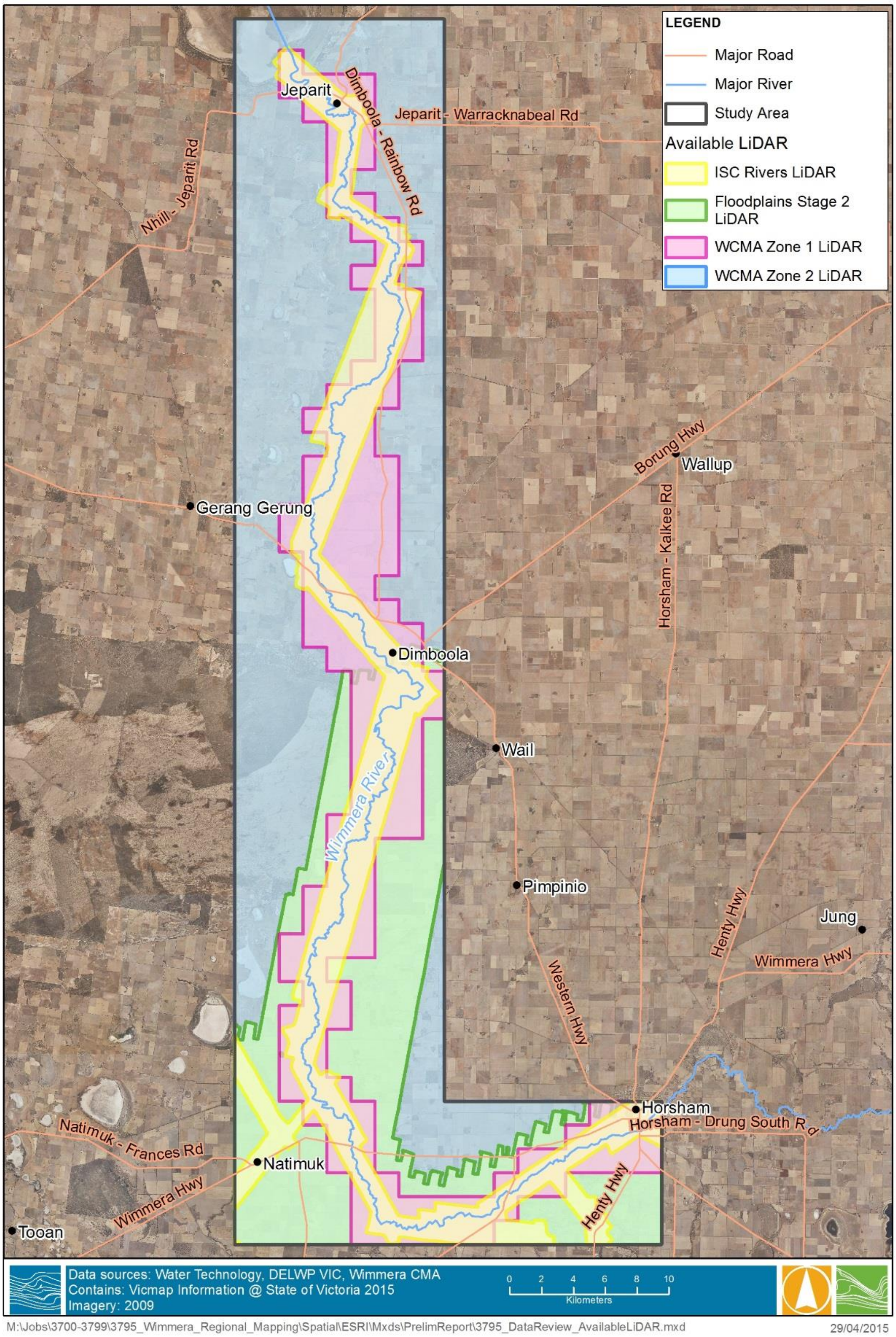

Figure 4-24 Available LiDAR extents

4.6.1 LiDAR Comparison

A comparison was undertaken between the four LiDAR datasets where they have a significant overlap, with the key differences between the datasets being shown in Table 4-14.

Table 4-14 Key differences between the LiDAR datasets

Dataset	Mean difference	Std. Dev. of difference	Minimum difference	Maximum difference
Rivers minus Floodplains Stage 2	**0.175m**	0.316m	-7.800m	4.400m
Rivers minus WCMA Zone 1	**0.214m**	0.242m	-14.902m	4.449m
Floodplains minus WCMA Zone 1	**0.022m**	0.201m	-15.018m	8.147m
Floodplains minus WCMA Zone 2	**-0.007m**	0.258m	-5.698m	4.846m

The comparison between the Rivers and Floodplains Stage 2 datasets is shown in Figure 4-24.

As the results in Table 3-2 show there is a systematic offset between the two datasets, with the Rivers being on average 0.175 m higher. This shows up as light red areas on Figure 3-3. The Rivers dataset is also higher within much of the Wimmera River channel, showing up as dark red areas on the first inset of Figure 3-3. However a close inspection along the Wimmera River reveals that in some places the Rivers dataset better represents the river channel, especially at Horsham. This is clearly evident showing up as dark blue in the second inset on Figure 4-26.

The differences in river channel definition are due to varying water levels in the river when each LiDAR project was flown. LiDAR is unable to penetrate water and therefore cannot give a true representation of the channel bathymetry if there is water at the time of capture.

The comparison between the Rivers and WCMA Zone 1 datasets is shown in Figure 3-3. As the comparison results show, the Rivers dataset is generally higher with an average vertical offset of 0.214 m, which again is clearly visible as light red areas in the figure. And again the insets on the figure suggest that the definition of the river channel is mixed, with the Rivers LiDAR being higher in most of the Wimmera channel, but there are areas where it is lower.

The comparison between the Floodplains Stage 2 LiDAR and the WCMA Zone 1 shows that overall these two datasets agree well, with a mean difference of 0.022m, but there are still some differences in river channel definition which are visible on Figure 3-4.

Finally the comparison between the Floodplains Stage 2 dataset and the WCMA Zone 2 dataset reveals an overall good general agreement with a mean difference of 0.007 m. This comparison is shown on Figure 3-5.

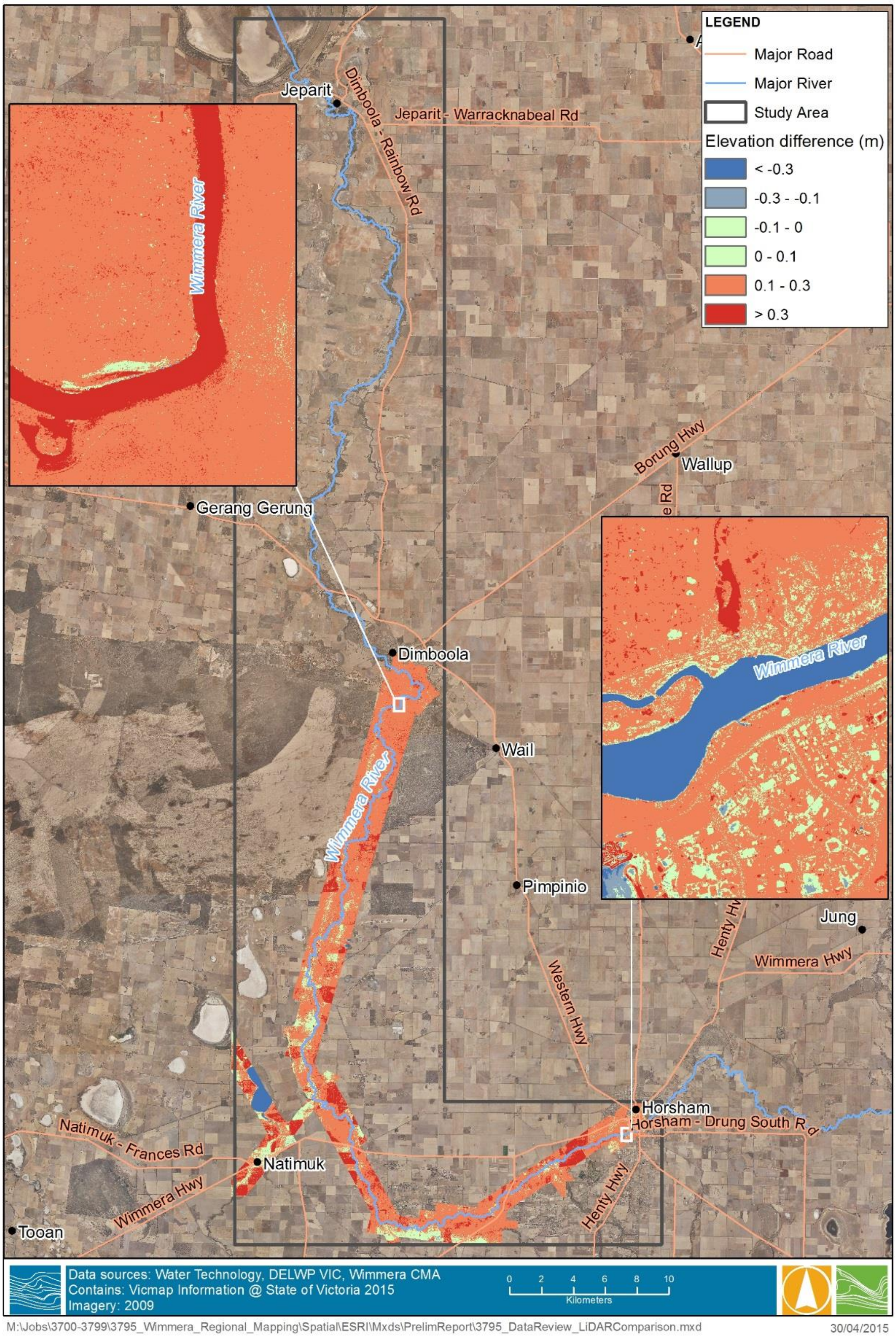

Figure 4-25 LiDAR comparison – Rivers LiDAR minus Floodplains Stage 2 LiDAR

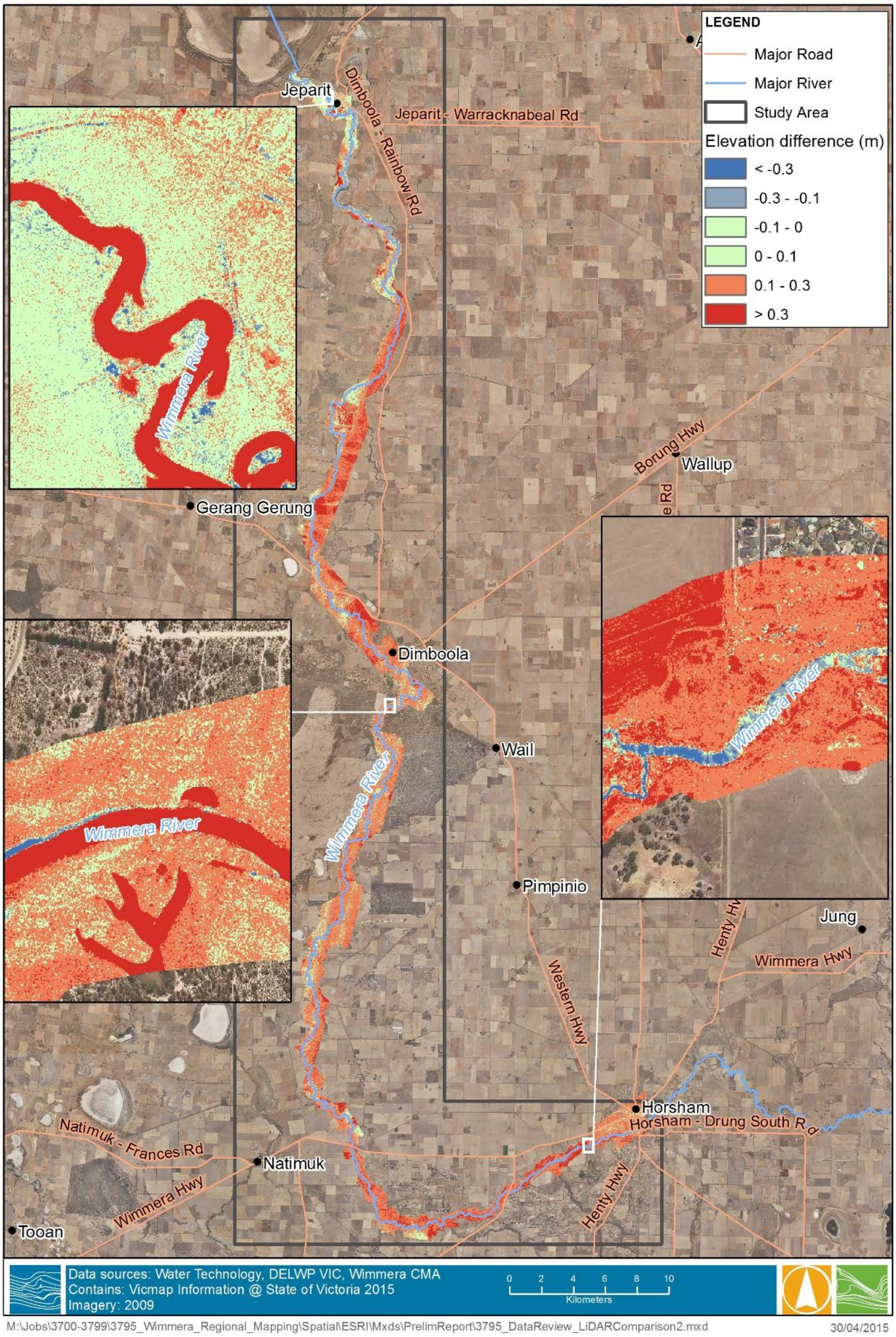

Figure 4-26 LiDAR comparison – Rivers LiDAR minus WCMA Zone 1 LiDAR

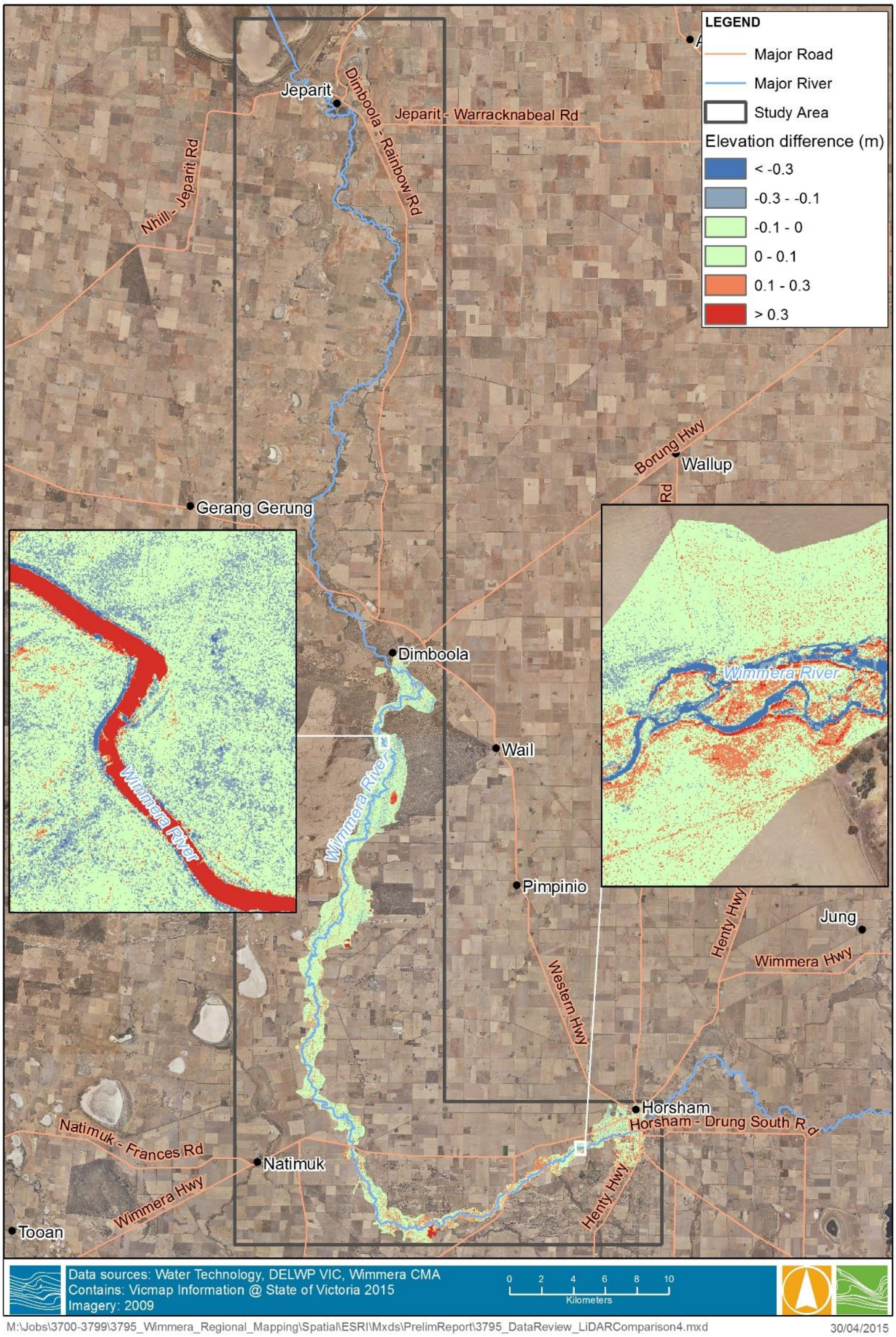

Figure 4-27 LiDAR comparison – Floodplains Stage 2 LiDAR minus WCMA Zone 1 LiDAR

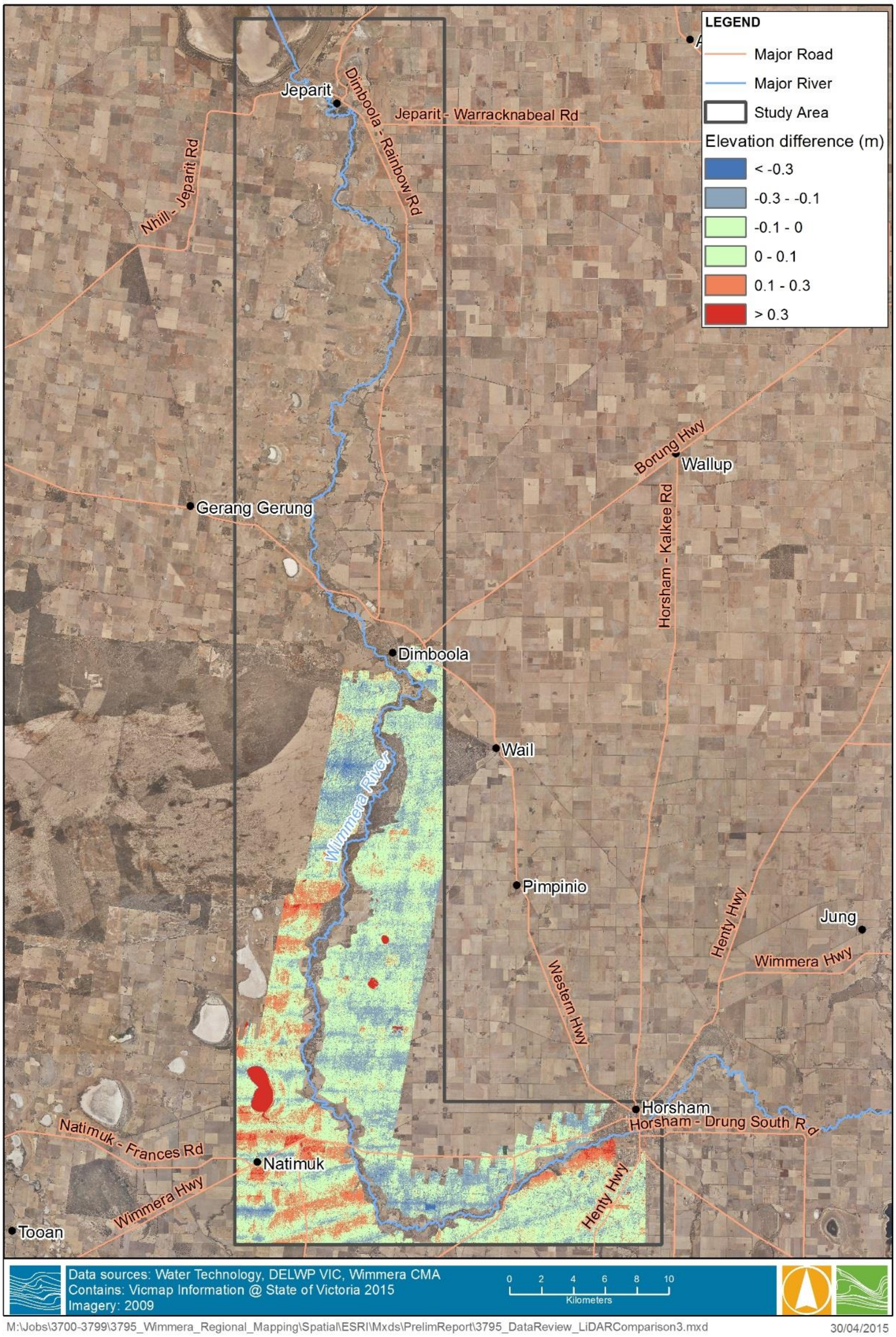

Figure 4-28 LiDAR comparison – Floodplains Stage 2 LiDAR minus WCMA Zone 2 LiDAR

Cross sections were extracted from the LiDAR at several locations along the Wimmera River to give a better understanding of how the river channel is represented by the LiDAR datasets. The location of the extracted cross sections is shown in Figure 4-29.

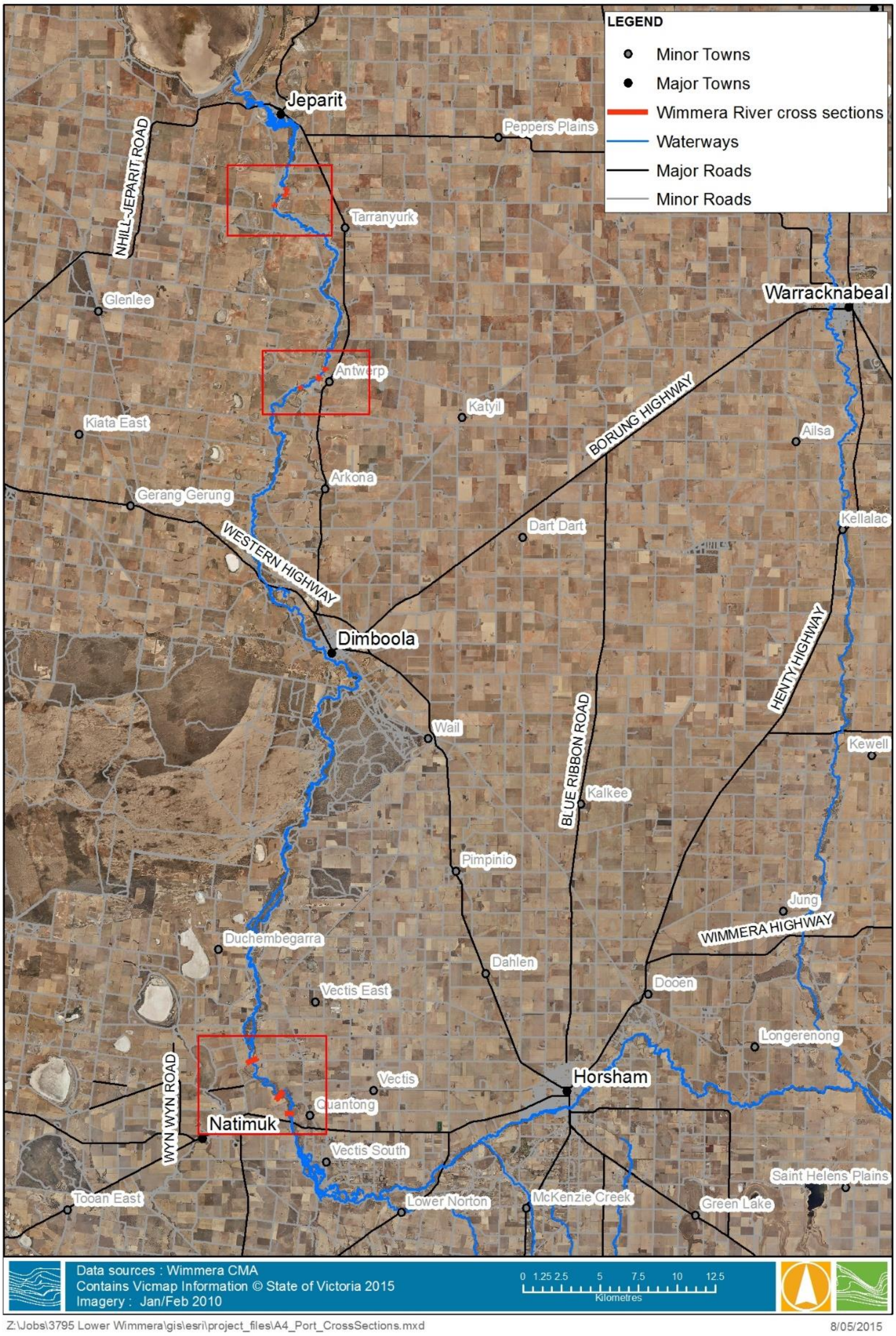

Figure 4-29 **Wimmera River cross section locations**

Example cross sections shown in Figure 4-30, Figure 4-31 and Figure 4-32. These cross sections are located immediately downstream of Quantong.

The cross sections clearly demonstrate the mixed channel definition which should be addressed when a final combined DEM is generated for modelling. The flat-bottomed nature of the cross sections shown in Figure 4-31 and Figure 4-32, suggests water in the channel in all LiDAR datasets. This is variable depended on location along the Wimmera River. The cross sections also clearly show the ISC data to be higher than the WCMA LiDAR data.

In some locations the Wimmera River channel form will dictate how much water represented in the LiDAR data. In some areas deeper pools will exist while other areas will be free from water. An example of this at Antwerp is shown in

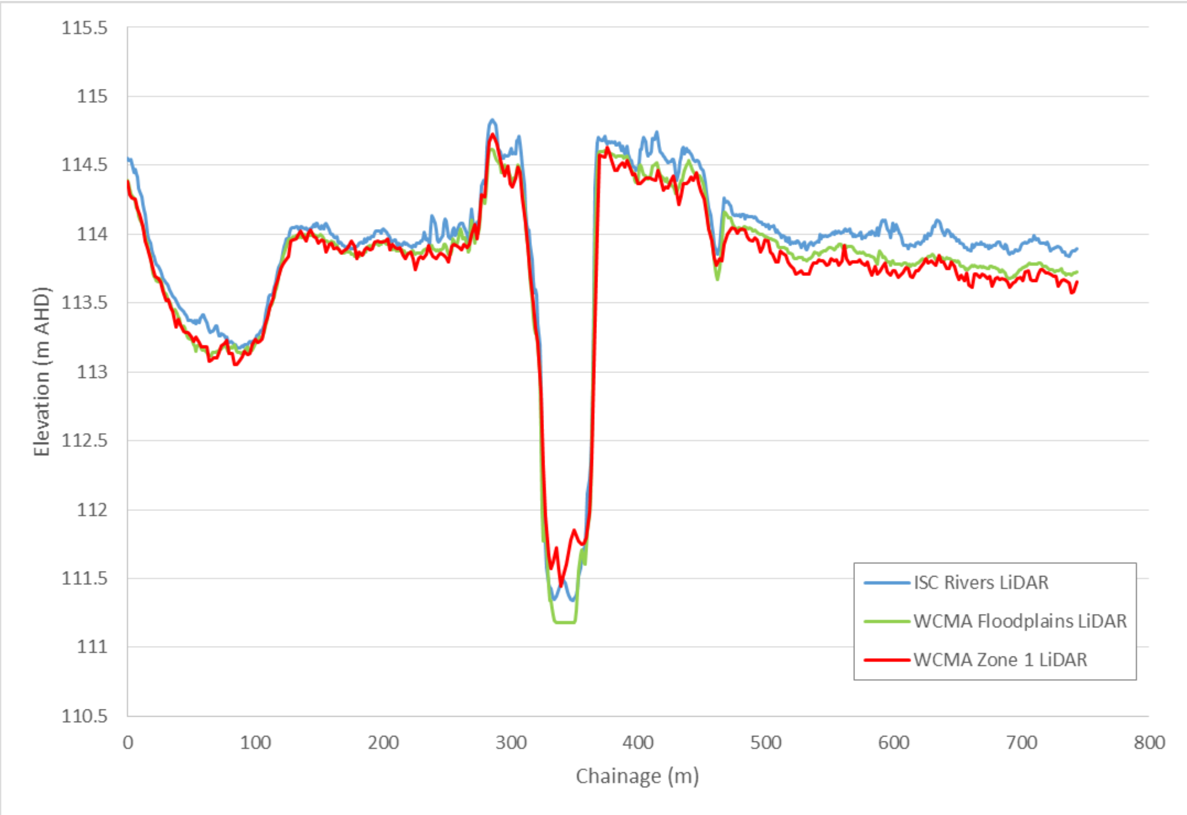

Figure 4-30 Wimmera River DS Quantong 01

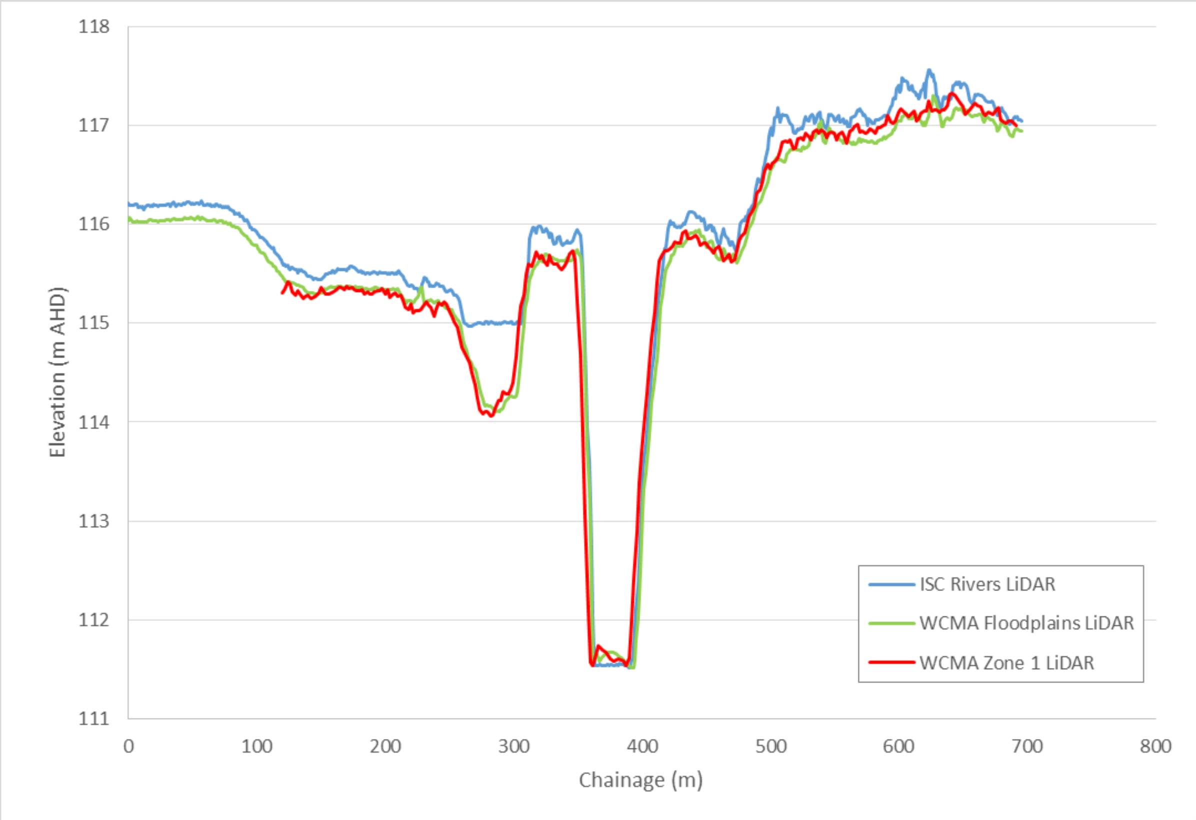

Figure 4-31 Wimmera River DS Quantong 02

Figure 4-32 Wimmera River DS Quantong 03

Figure 4-33 Wimmera River at Antwerp

4.6.2 LiDAR Verification

Topographic levee survey data was available for the Jeparit township and was used to verify three of the LiDAR datasets. The location of the available survey data is shown in Figure 4-34, with the results of the comparison shown in Table 4-15. The mean differences between the survey data and the LiDAR datasets are all within the vertical accuracy specifications of the LiDAR.

Figure 4-34 Jeparit survey data

Table 4-15 Comparison of levee survey data with LiDAR datasets - Jeparit

	Survey elevations minus Rivers LiDAR	Survey elevations minus WCMA Zone 1 LiDAR	Survey elevations minus WCMA Zone 2 LiDAR
Mean difference	-0.106m	0.007m	0.297m
Std. Dev. of difference	0.076m	0.137m	0.297m
Minimum difference	-0.318m	-0.193m	-0.131m
Maximum difference	0.159m	0.773m	1.311m

Topographic spot heights were available along the centre of bitumen roads in the Dimboola township and were used to verify three of the LiDAR datasets. The results of this verification are presented in Table 4-16. Again, the mean differences between the survey data and the LiDAR datasets are all within the vertical accuracy specifications of the LiDAR.

Table 4-16 Comparison of spot heights along roads with LiDAR datasets - Dimboola

	Survey elevations minus Rivers LiDAR	Survey elevations minus Floodplains Stage 2 LiDAR	Survey elevations minus WCMA Zone 1 LiDAR
Mean difference	-0.091m	0.100m	0.091m
Std. Dev. of difference	0.039m	0.053m	0.021m
Minimum difference	-0.182m	-0.019m	0.052m
Maximum difference	0.016m	0.297m	0.148m

4.6.3 Discussion

The LiDAR comparison suggests that the Floodplains LiDAR generally agrees well with the two WCMA datasets, whereas the Rivers LiDAR appears to have a systematic vertical offset of ~0.1 – 0.2m higher. The survey verification confirms that the Rivers dataset is ~0.1m high.

Which LiDAR dataset is best defining the Wimmera River channel is dependent on water levels at the time of capture, this will be considered when generating a single model DEM and a location specific approach taken. A simple approach to generating the river bathymetry may be to merge the datasets along the river channel, taking the lowest elevation as the final model DEM elevation. Then manually lowering the combined DEM to compensate for the water present in the weir pools.

As the Floodplains LiDAR is the most recently captured and was flown to a higher vertical accuracy, this dataset will be used as the base dataset. The Floodplains dataset will then be combined with the WCMA Zone 1 dataset which will give full coverage of the Wimmera River floodplain.

The Rivers dataset may then be added to provide additional DEM coverage (if necessary), however given there are some reservations about the datasets accuracy it is recommended additional feature survey be captured to verify the LiDAR levels.

4.7 Structure Details

4.7.1 VicRoads

VicRoads have provided details of all their structures within the study area, these include:

- Nhill-Jeparit Road
- Western Highway
- Wimmera Highway
- Horsham-Noradjuha Road

The details provided give structure width, length and spans. However they do not provide level information to Australian Height Datum.

The location of the provided structure details is shown in Figure 4-35.

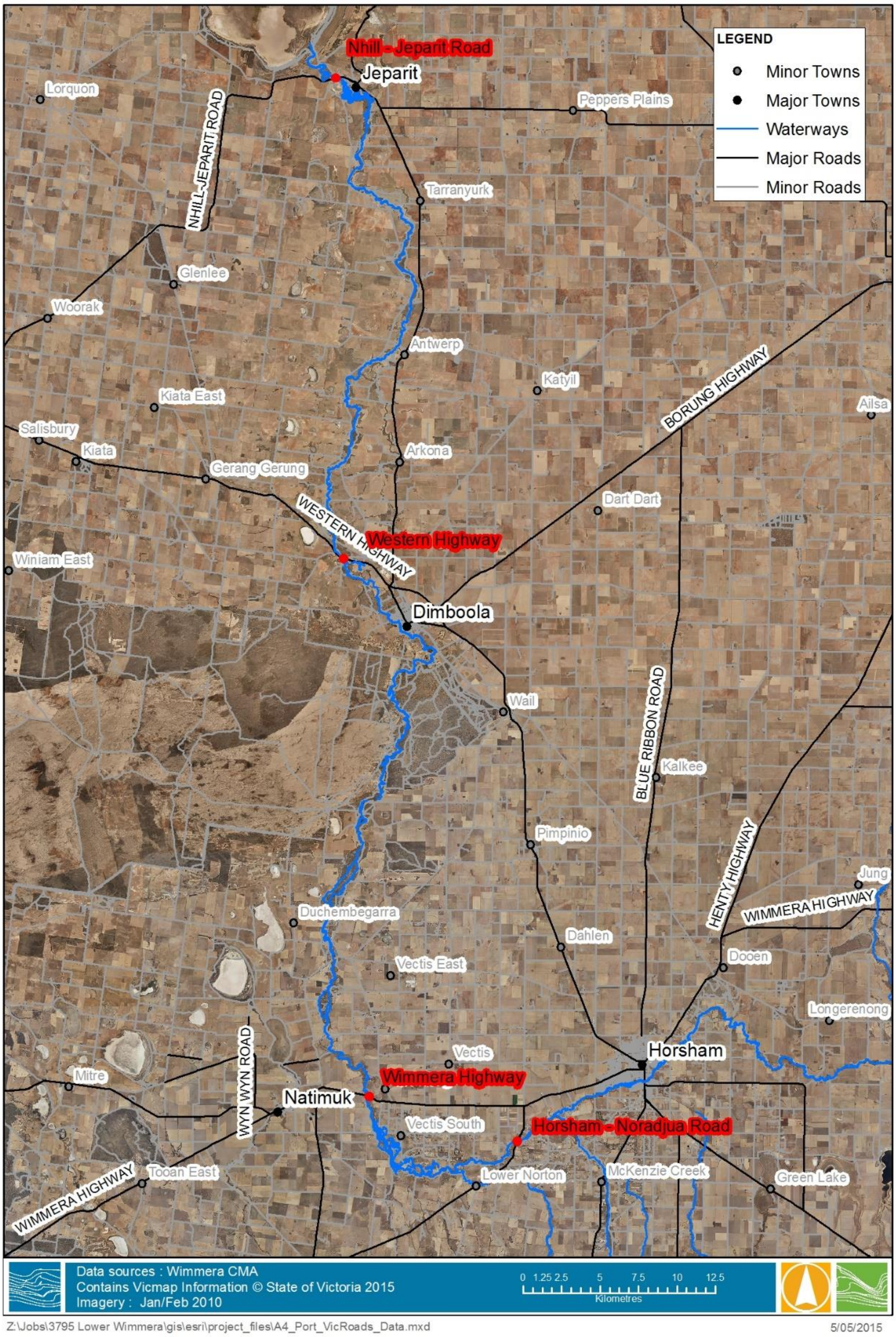

Figure 4-35 VicRoads structure details – Structure locations

4.7.2 VicTrack

There are several railway lines within the study area, including the Western SG and Yaapeet Lines. There is only one crossing of the Wimmera River on the Western SG Line downstream of Dimboola.

The January 2011 observed extent comes in close proximity to the Western SG line downstream of Dimboola on the eastern side of the Wimmera River indicating the potential for some interaction.

The railway lines that may be of significance to the study area shown in Figure 4-36.

The Wimmera River railway structure was visited by Water Technology during the site assessment and preliminary measurements were taken. A photo of the structure is shown in Appendix A, Photo 6.

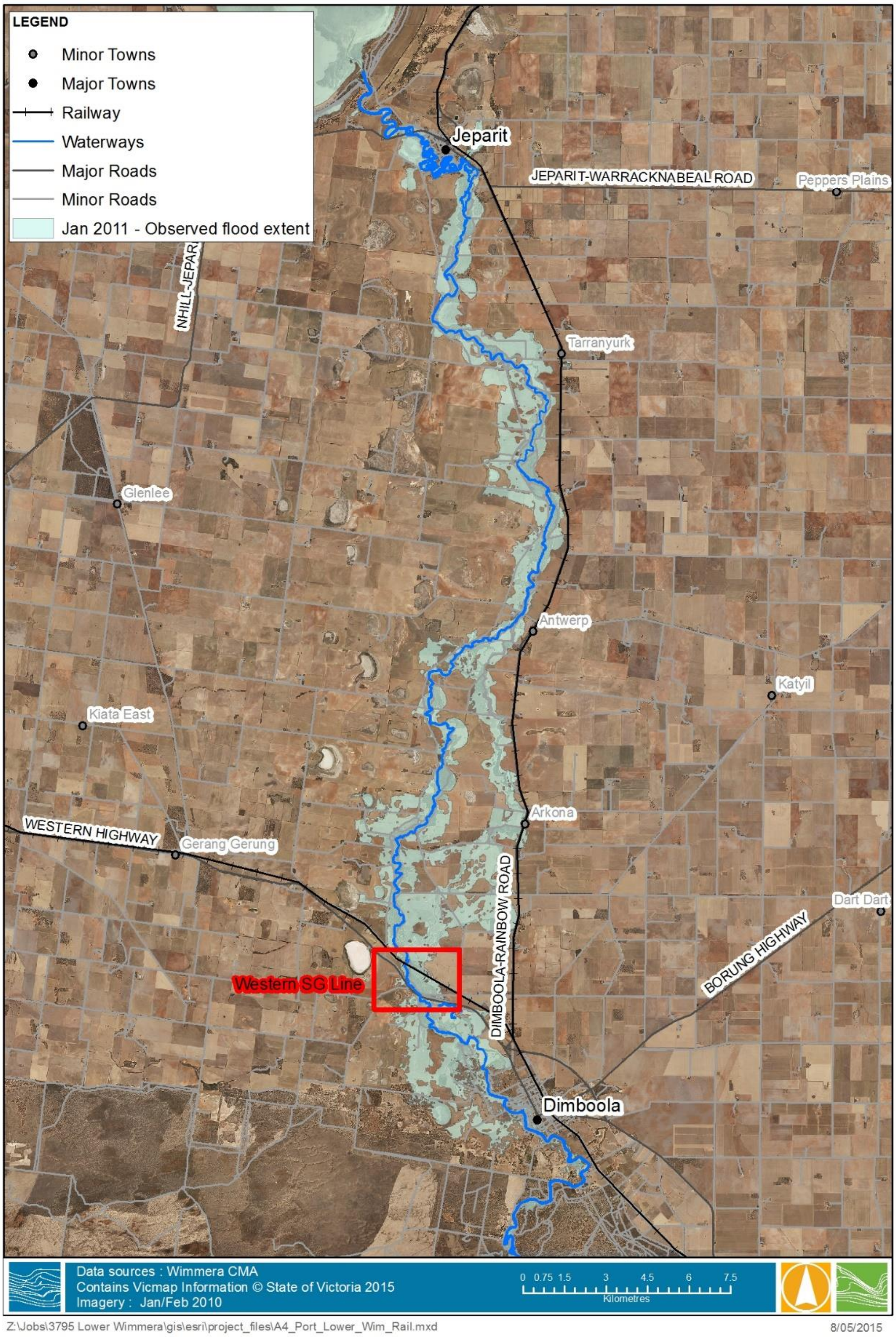

Figure 4-36 VicTrack structure – Structure locations

4.7.3 Weir Structures

There are two major weir structures within the study area; Dimboola and Jeparit. As discussed in Section 4.4 both were damaged during the January 2011 flood event have since been repaired. As constructed plans of the weirs have been provided by GWMWater and Hindmarsh Shire Council. The weir locations are shown in Figure 4-37.

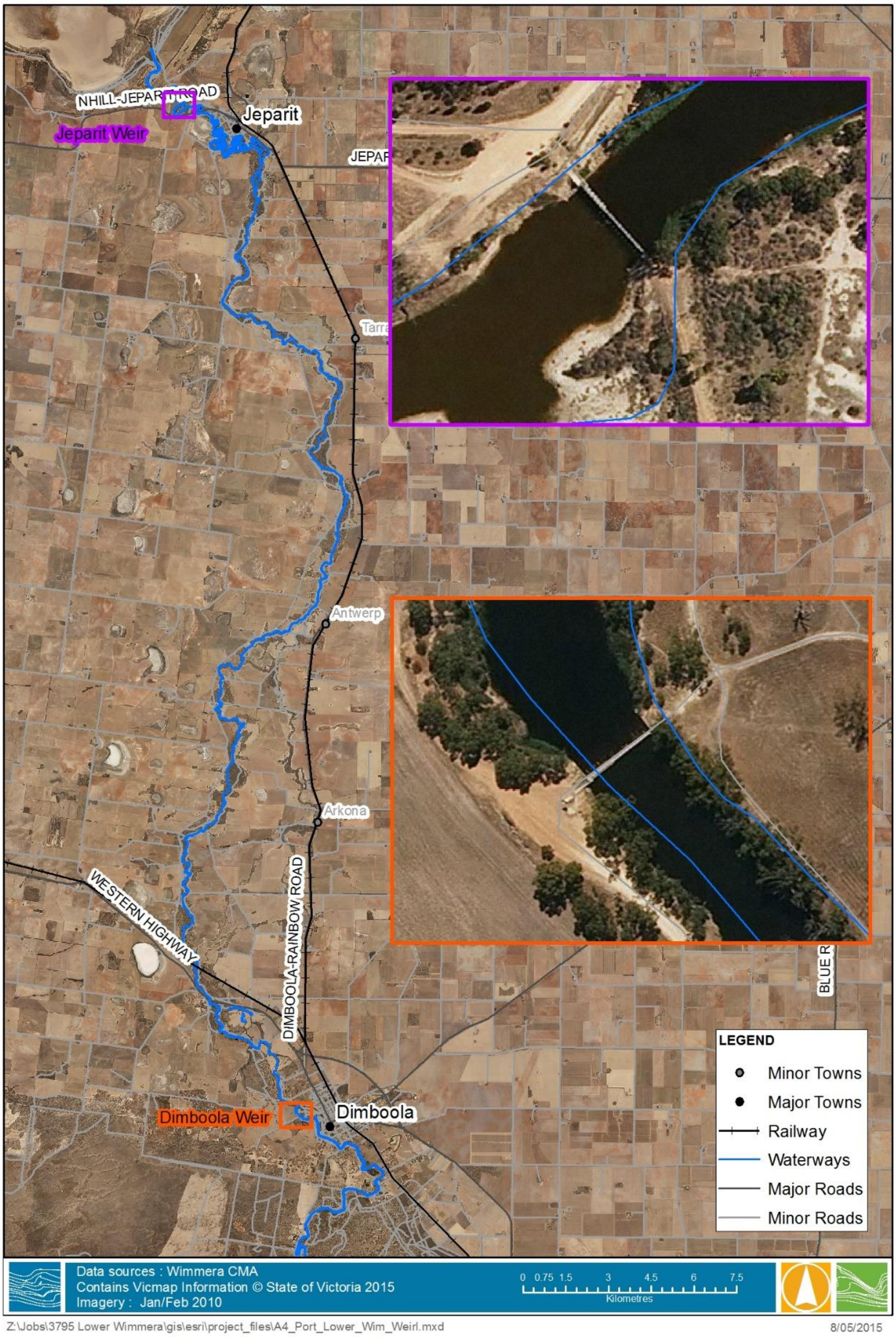

Figure 4-37 Weir Locations – Dimboola and Jeparit

5. MODELLING APPROACH

5.1 Hydrology

Flooding of the lower Wimmera catchment is dominated by incoming flows from the upper catchment. Previous investigations undertaken by Water Technology have identified that peak flood levels in the lower catchment occur 5-7 days after peak flows in the upper catchment. Given this significant time lag, local catchment flows become negligible. For this reason, the hydrology investigations are focused on gauged flows at the Wimmera River at Horsham gauge and Flood Frequency Analysis.

The recent change to the rating curve at the Horsham (Walmer) gauge will be investigated via a localised hydraulic model of the Horsham gauge area and discussion with the hydrographers. The modelling of the gauge area and review of the rating curve will assist in an improved understanding of the gauge performance in high flow events. It will assist in ongoing discussions regarding the suitability of the current rating curve.

A preliminary hydraulic model of the Horsham gauge was built and a preliminary rating curve developed. The modelled, current and pre-January 2011 rating curves are shown in Figure 5-1.

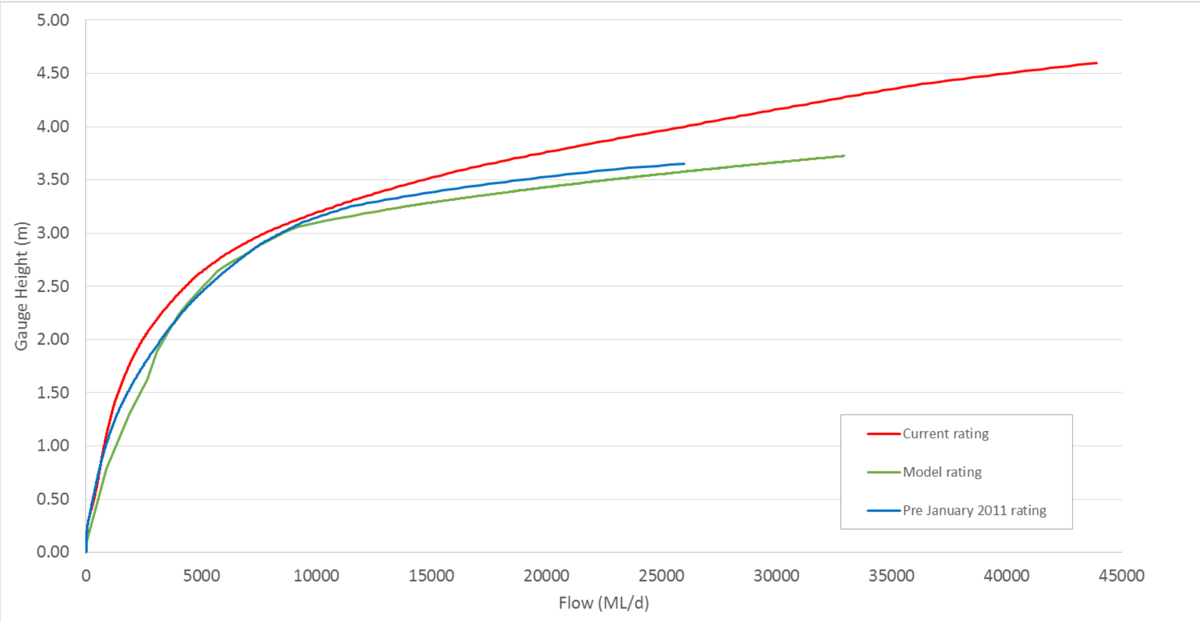

Figure 5-1 Preliminary Wimmera River at Horsham rating curve

Early modelling of the Wimmera River at the Horsham gauge was better matching the older rating curve determined prior to January 2011. However, with detailed modelling considering a range of roughness values later in the project Water Technology demonstrated that the current rating curve which was adopted after the January 2011 gauging event was indeed accurate. The Hydrology Report (R02) discusses this in detail.

It is recognised that the Wimmera River receives inflows from the Mackenzie River, Norton Creek and other tributaries between Horsham and Jeparit. While these waterways contribute flow to the Wimmera River, they peak several days prior to the Wimmera River peak. Given the lack of suitable gauge data, and differing peak timing, it has been deemed appropriate to incorporate the impacts of these inflows as an appropriate initial condition to the hydraulic model. The impact of the timing of Mackenzie River flows on water levels in the Wimmera River have been discussed in the past and will be tested further during this study. The Hydrology Report (R02) and the Hydraulics Report (R03) discuss this further.

5.1.1 Calibration

Given the Wimmera River at Horsham (Walmer) gauge is located at the upper most end of the study area, calibration flows will be extracted directly from the gauge record. The gauge record may be amended based on the revised rating curve determined from the localised hydraulic modelling. As discussed previously, Wimmera River tributary inflows downstream of this point are likely to have significant timing difference to that of the Wimmera River. These tributaries will be assessed for their potential contribution using the available gauge record.

5.1.2 Design

A Flood Frequency Analysis will be used to determine peak flow for the range of modelled design events. A typical historical hydrograph will be scaled to match the peak and volume characteristics of the design FFA.

Water Technology will model a range of design events including the 50%, 20%, 10%, 5%, 2%, 1%, 0.5%, 0.2% AEP and PMF flood events as described in the project brief. Design events will be fully checked for sensitivity to various assumptions and will be validated against alternative methods as described earlier.

It was originally intended that the PMF would be estimated using the Quick Method of Nathan et al. (1994). This method applies a set of empirical equations to compute a triangular PMF hydrograph based on the catchment area. The equations are applicable to southeast Australian catchments from 1 to 10,000 km^2. This method was later deemed unacceptable and an alternative was adopted. The Hydrology Report (R02) documents this further.

5.2 Hydraulics

Hydraulic modelling covering the study area will be completed in Mike Flexible Mesh GPU. The model will be developed with a mesh based topography. The mesh will be based on all available datasets provided by Wimmera CMA with a location and feature specific approach taken. The mesh will include breaklines to pick up key topographic features such as road and rail crests, levee and channel banks, etc.

The hydraulic model will be run for the calibration and design events as discussed above.

6. RECOMMENDATIONS

6.1 Event Selection

Given the availability of gauge and peak flood height information the January 2011 event was chosen as the primary calibration event. The January 2011 event was also very recent and will provide the Lower Wimmera community excellent context for comparison against design events and allow them to provide significant anecdotal evidence.

The secondary calibration event will most likely be September 2010. This event has the largest availability of surveyed peak flood heights and has a better availability of stream flow and height information than any of the observed flood events, with the majority of them located in regional areas, the focus of this project. The September 2010 event recorded a peak flow of 11,723 ML/d (135 m^3/s) at the Horsham gauge ranked 26th in the gauge record. However, it recorded a peak flow of 11,775 ML/d at Dimboola and was the 4th largest event on record and was sufficient to cause out of bank inundation between Dimboola and Jeparit as shown by the surveyed levels. The FFA completed during the Horsham Flood Study indicates this flow is around a 10% AEP event at the Horsham gauge. The final decision on the secondary calibration event will not be made until the completion of the project hydrology and initial calibration.

6.2 Survey Data

It is recommended feature survey be undertaken of the road pavement at each VicRoads structure. This will give the structure details provided by VicRoads an AHD level to reference to and allow for more accurate incorporation into the hydraulic model. If the transects are extracted a reasonable distance either side of the bridge structures it will also provide topographic data that can be used in comparison against the LiDAR data further verifying the LiDAR levels. The structures are well spread over the study area for this purpose.

A budget of $10,000 Ex GST has been allowed for survey purposes, this may allow for additional survey of the VicTrack infrastructure or Wimmera River cross sections.

APPENDIX A DATA REGISTER

Provided as attachment

APPENDIX B SITE VISIT PHOTOS

Photo 01 – Horsham Weir

Photo 02 – Wimmera River at Horsham (Walmer)

Photo 03 – Wimmera River Bridge at Quantong

Photo 04 – Disused railway at Quantong

Photo 05 – Dimboola Weir – Post repairs by GWMWater

Photo 06 – Melbourne to Adelaide Railway

Photo 07 – Wimmera River at Tarranyurk gauge

Photo 08 – Jeparit Weir

Photo 09 – Lake Hindmarsh