WATER TECHNOLOGY
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Memo

To:	Paul Fennell	**From:**	Ben Hughes
Organisation:	Wimmera CMA	**Date:**	21/04/2016
Job Title:	Horsham and Wartook Valley Flood Investigation		
Subject	Data Verification		

Dear Paul,

We have completed a review of the January 2016 LiDAR commissioned as part of this study, comparing it to the 2004 Wimmera CMA Region LiDAR and 2010 Index of Stream Conditions (ISC) LiDAR. This comparison was completed to confirm the new LIDAR's accuracy for use as the base topography for the Horsham and Wartook Valley Flood Investigation.

This Memo documents the verification process undertaken. It also provides recommendations for the LiDAR data use in this project.

1. LIDAR DATA AVAILABILITY

Three LiDAR datasets are available within the study area, these datasets are as follows:

- 2016 Horsham LiDAR - Data was captured specifically for this project. Provided as a 1 m resolution grid, 0.2 m vertical accuracy, 0.3 m horizontal accuracy.
- 2004 WCMA LiDAR – Coverage of the Wimmera CMA management area, excluding Warracknabeal. Provided as a 2 m resolution grid, 0.5 m vertical accuracy, 1.5 m horizontal accuracy.
- 2010 ISC LiDAR – Coverage of major waterways within WCMA management area. Provided as a 1 m resolution grid, 0.2 m vertical accuracy, 0.3 m horizontal accuracy.

The 2004 Wimmera CMA LiDAR has been verified across numerous projects including:

- East Horsham Channel Decommissioning Modelling (Water Technology, 2013) (Commissioned by HRCC)
- Warracknabeal and Brim Flood Investigation (Water Technology, 2016) (Commissioned by Wimmera CMA)[1]

[1] Water Technology (2016), Warracknabeal and Brim Flood Investigation, Wimmera CMA

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- Dunmunkle Creek Flood Investigation (Water Technology, 2016) (Commissioned by Wimmera CMA)[2]
- Natimuk Flood Investigation (Water Technology, 2012) (Commissioned by Wimmera CMA)[3]

The 2010 ISC LiDAR data has not been used as the base topography in the above projects due to inconsistencies in the data, these have included datum shifts and water in the channel in several waterways. This is explained in detail in the Warracknabeal and Brim Flood Investigation[1] and Dunmunkle Creek Flood Investigation[2] data verification reports.

2. METHODOLOGY

The new 2016 LiDAR data was verified in a two-step process:

- Verification against feature survey
  - two road crests within Horsham
  - one road crest in East Horsham
- Comparison with the 2004 and 2010 datasets.

The focus of the verification was to determine which topographic dataset or combination of datasets is most appropriate for use in this project.

Feature survey is considered to be the most accurate representation of ground surface. Road crest feature survey was used for verification in this project. Transects along a road crest enables a visual comparison as well as a statistical analysis on a point by point basis such as mean, max and minimum difference.

Comparing the LiDAR to previous LiDAR datasets allows a topographic comparison across the entire overlapping area. This highlights any spatial topographic inconsistences such as large earth works, changes to agricultural management (removal of irrigation channels, drainage improvements) as well as areas which may have had consistent thick vegetation (mature crops or windrows) which may have led to the ground surface being misrepresented in the LiDAR. It can also highlight misrepresentations within a LiDAR dataset including “banding” where inconsistent elevations are present at the edge of LiDAR flight runs.

2.1 Feature Survey Comparison

2.1.1 Overview

Road crest feature survey was captured in three locations in Horsham, this data was provided to Water Technology by Horsham Rural City Council[4]. Road crest survey was also available for five road crests in East Horsham, this data was captured as part of the East Horsham Channel Decommissioning Project[5]. The road crests surveyed in Horsham were Kenny Road, Tucker Street and Lewis Street. Road crests surveyed in East Horsham were Riverside East Road, Browns Road, West Road and Rokeskys Road which was separated in to northern and southern sections either side of Browns Road.

Surveyed road crest location are shown in Figure 2-1.

[2] Water Technology (2016). Dunmunkle Creek Flood Investigation, Wimmera CMA
[3] Water Technology (2012), Natimuk Flood Investigation, Wimmera CMA
[4] Survey was captured as part of HRCC road upgrades, data was provided by Lyndon White.
[5] Water Technology (2013), East Horsham Channel Decommissioning, HRCC

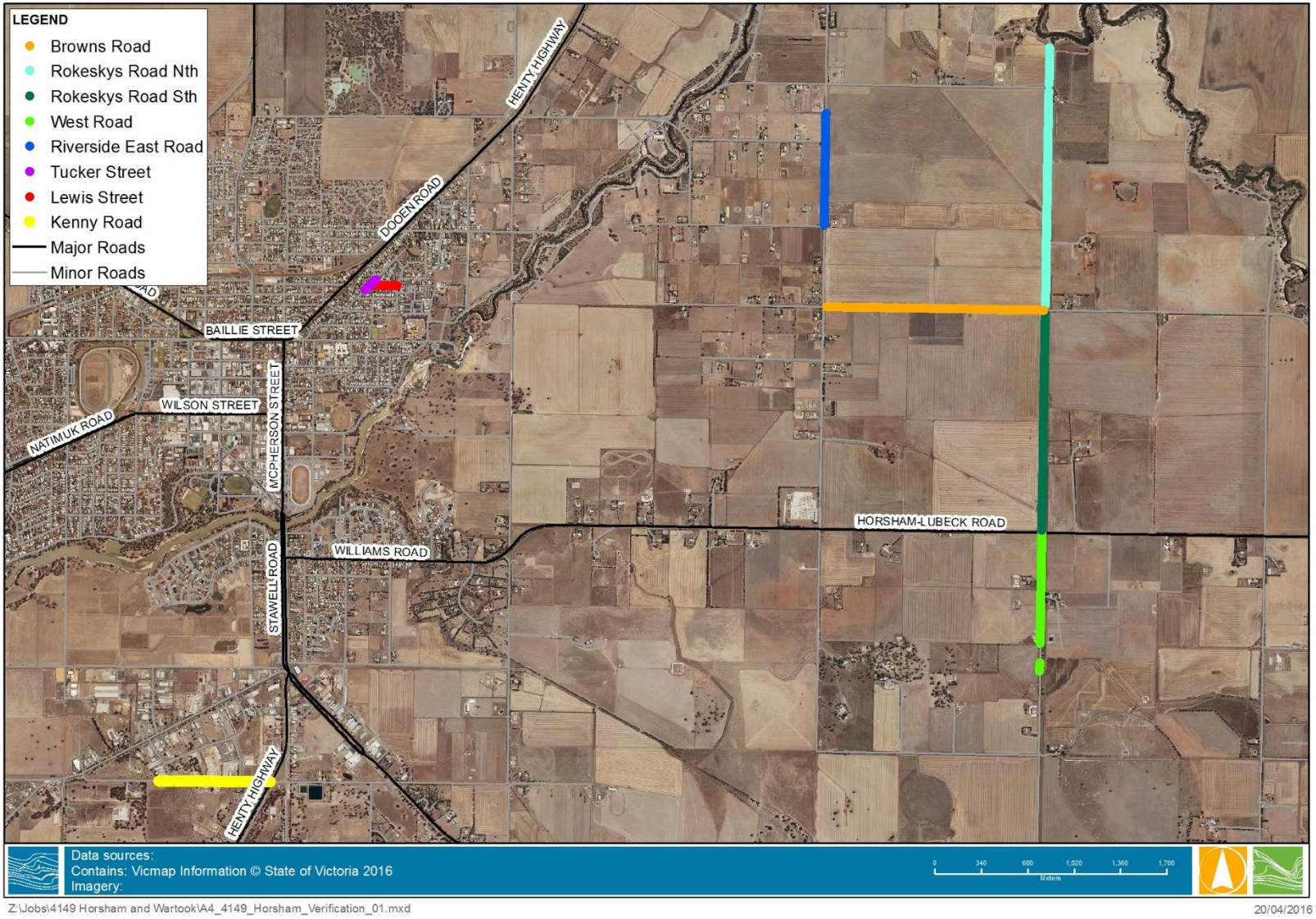


Figure 2-1 Verification survey locations

2.1.2 Horsham – Road crest survey

Comparison between the Horsham surveyed road crest levels was made against the 2016 LiDAR data at each location. A map of the survey locations along Lewis Street and Tucker Street is shown in Figure 2-2, with longsection comparisons shown in Figure 2-3 and Figure 2-4 respectively.

A map of the surveyed heights along Kenny Road is shown in Figure 2-5, with a longsection comparison between the survey and LiDAR data shown in Figure 2-6.

Figure 2-2 Tucker Street and Lewis Street surveyed points

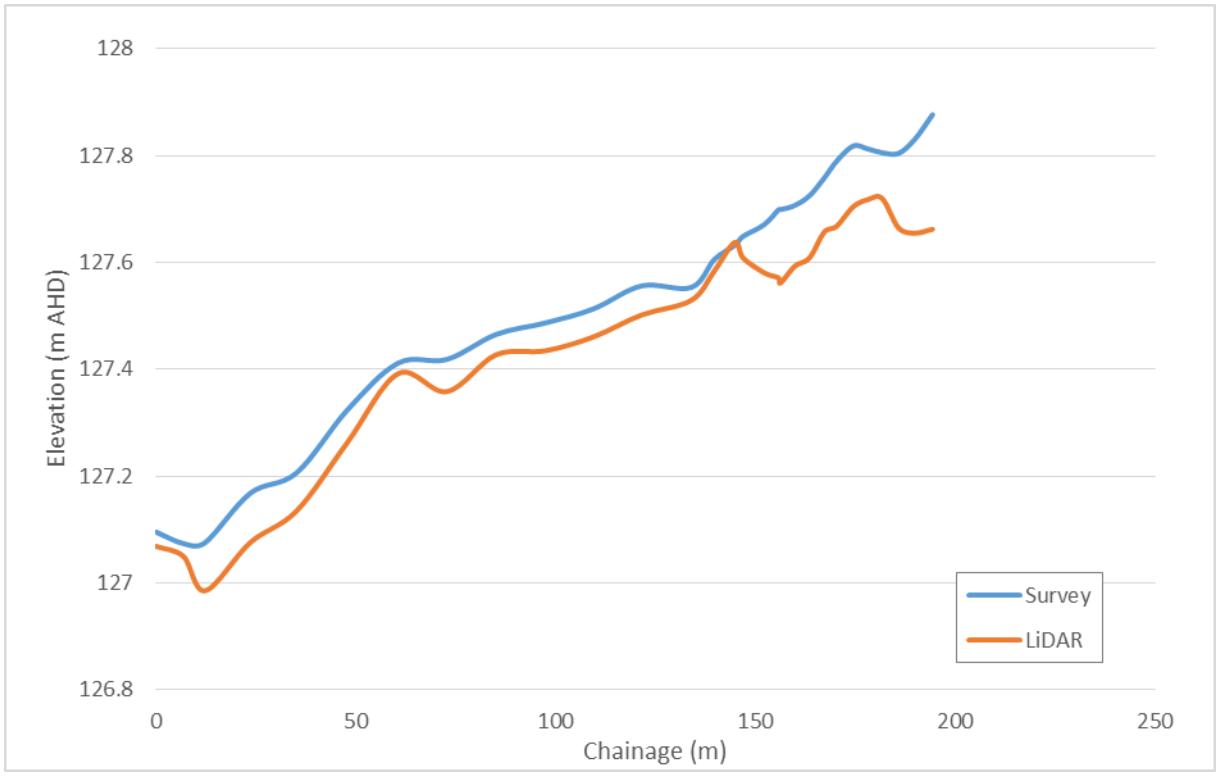


Figure 2-3 Lewis Street - Survey and 2016 LiDAR Data comparison

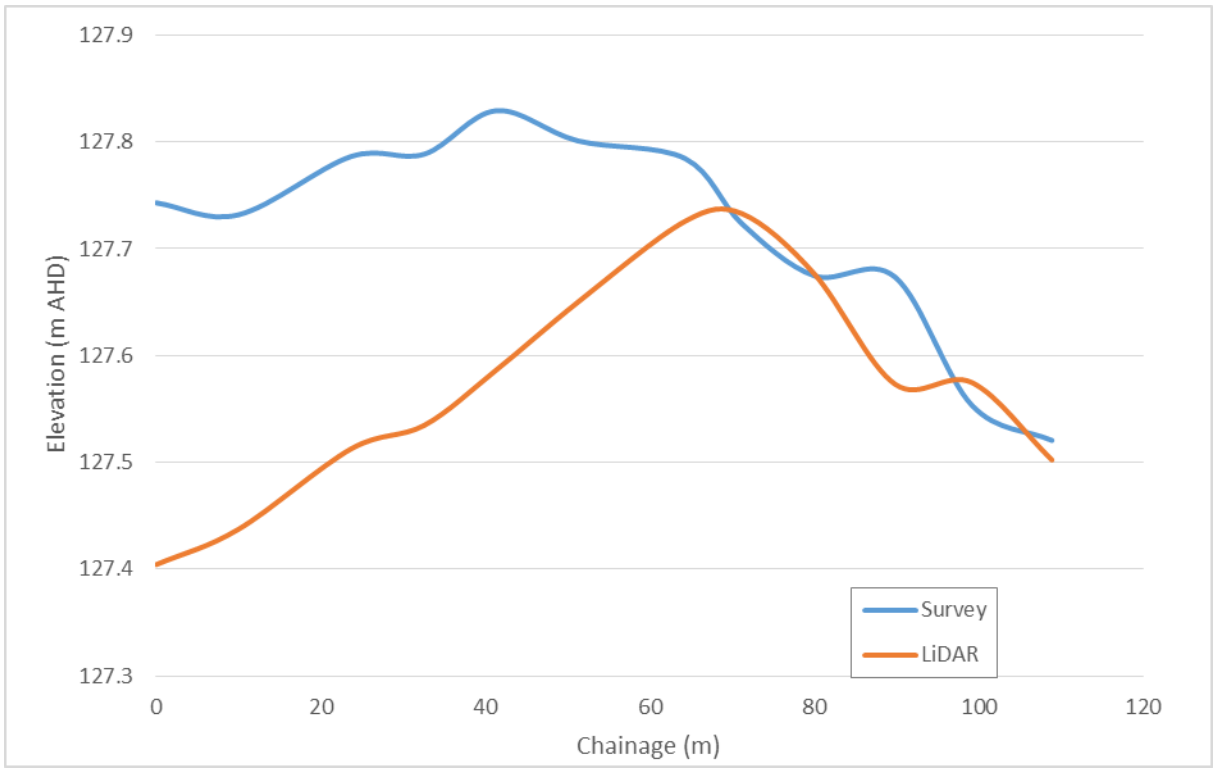


Figure 2-4 Tucker Street - Survey and 2016 LiDAR Data comparison

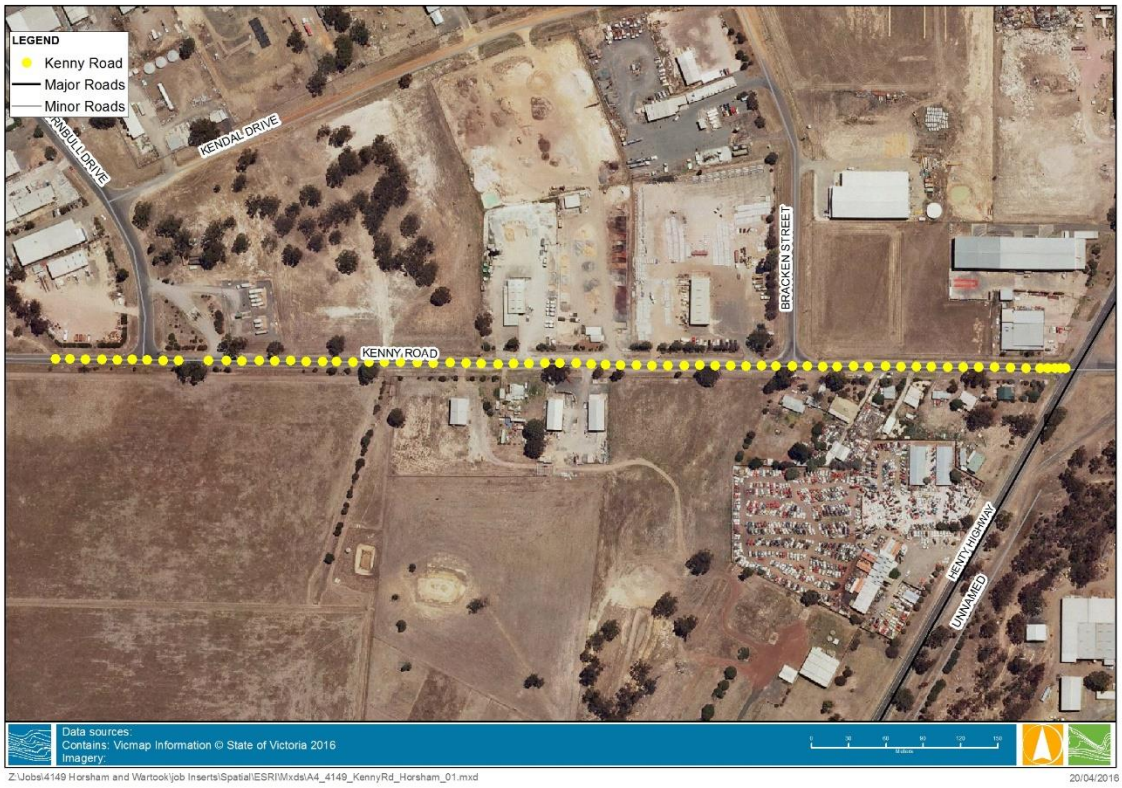


Figure 2-5 Kenny Road – Surveyed points

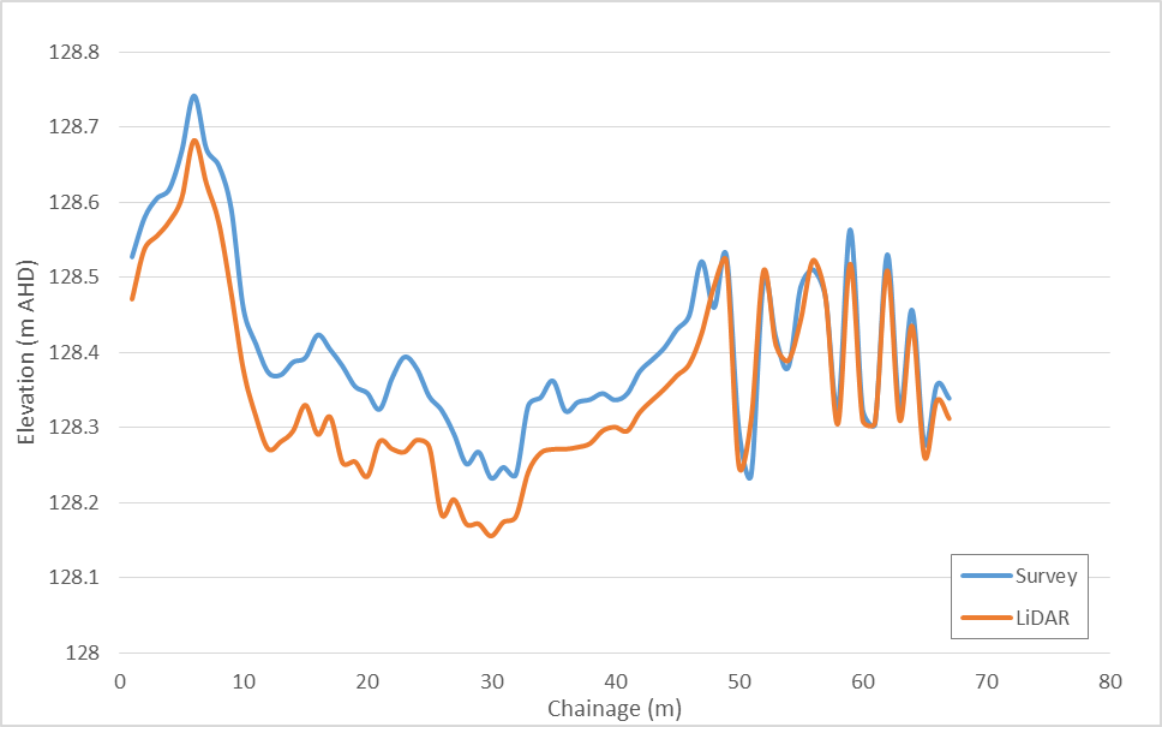


Figure 2-6 Kenny Road - Survey and 2016 LiDAR Data comparison

The difference between the survey and 2016 LiDAR survey levels was calculated for each survey point location. The difference in elevation along each transect was then averaged and the maximum and minimum difference calculated. These statistics are shown in Table 1.

Table 1 Mean, maximum, minimum and standard deviation differences between surveyed and 2016 LiDAR topography levels

Statistic	Elevation difference (LiDAR – Survey)		
	Lewis Street	Tucker Street	Kenny Road
Average (m)	-0.08	-0.14	-0.06
Max. (m)	0.01	0.02	0.07
Min. (m)	-0.21	-0.34	-0.14
Standard Deviation (m)	0.05	0.13	0.04

Discussion

Comparison of the 2016 LiDAR and road crest elevations in Horsham showed the 2016 LiDAR to be relatively accurate. The longsections showed the surveyed levels to be consistently higher across all locations. This was also represented in the average difference between the datasets. The Lewis Street and Kenny Road longsections showed the LiDAR matched the survey data well, this was particularly the case for Kenny Road at points 45-67 where there was considerable undulation in the road level represented in both datasets.

The Tucker Road longsection showed a disparity between the survey and LiDAR data levels for points 1-7, this difference is not considered to be an issue with the LiDAR data given its consistent nature, Horsham Rural City Council were contacted to determine whether road works had occurred along Tucker Street and it was confirmed the road was lowered by around 0.3m in late 2015[6].

The average difference between the LiDAR and surveyed levels for Lewis Street and Kenny Road is less than 0.08 m, well within the stated vertical accuracy of the data at 0.20 m.

2.1.3 East Horsham - Road crest survey

The surveyed road crest levels captured during the East Horsham Channel Decommissioning Project[5] were compared to the 2016 LiDAR. The survey locations are shown in Figure 2-7 with a comparison of the survey and LiDAR data levels for Riverside East Road, Browns Road, Rokeskys Road and West Road shown in Figure 2-8, Figure 2-9, Figure 2-10 and Figure 2-11 respectively.

[6] Pers. Comm. Lyndon White, Horsham Rural City Council.

Figure 2-7 Wimmera Highway transect locations

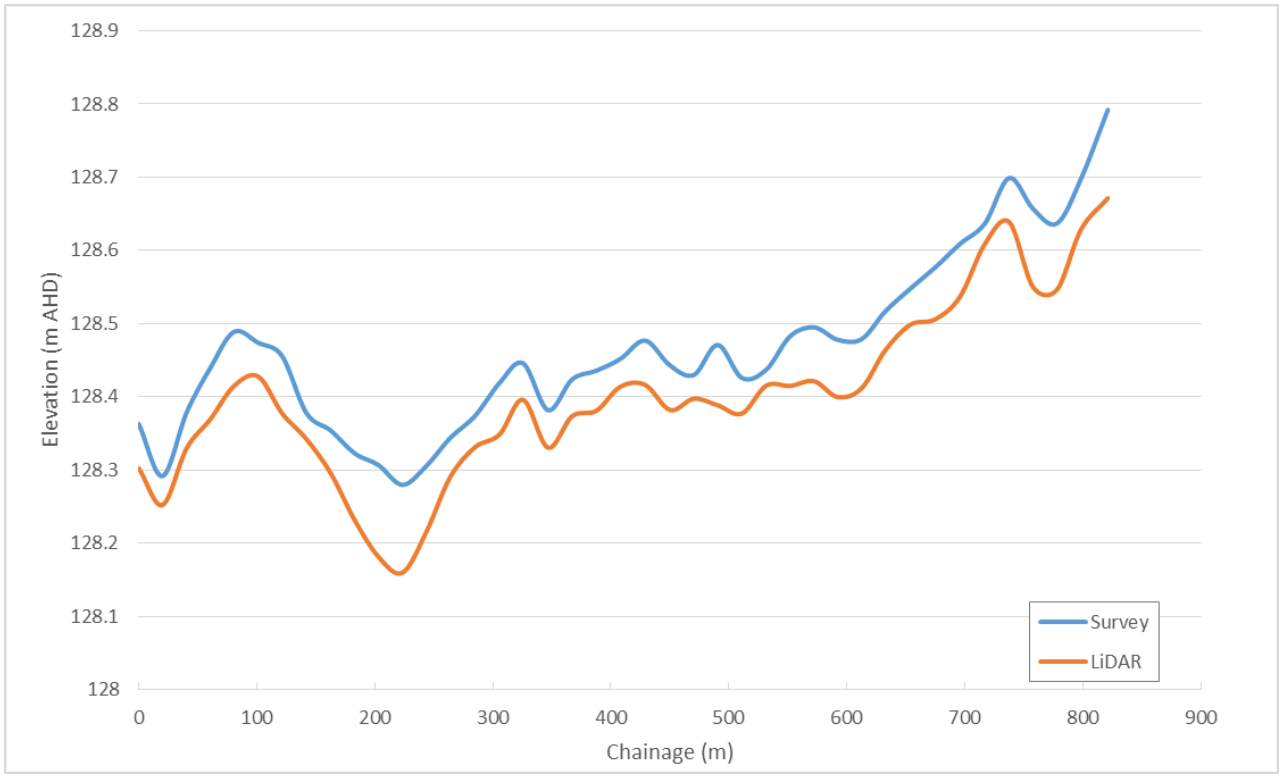


Figure 2-8 Riverside East Road - Survey and 2016 LiDAR Data comparison

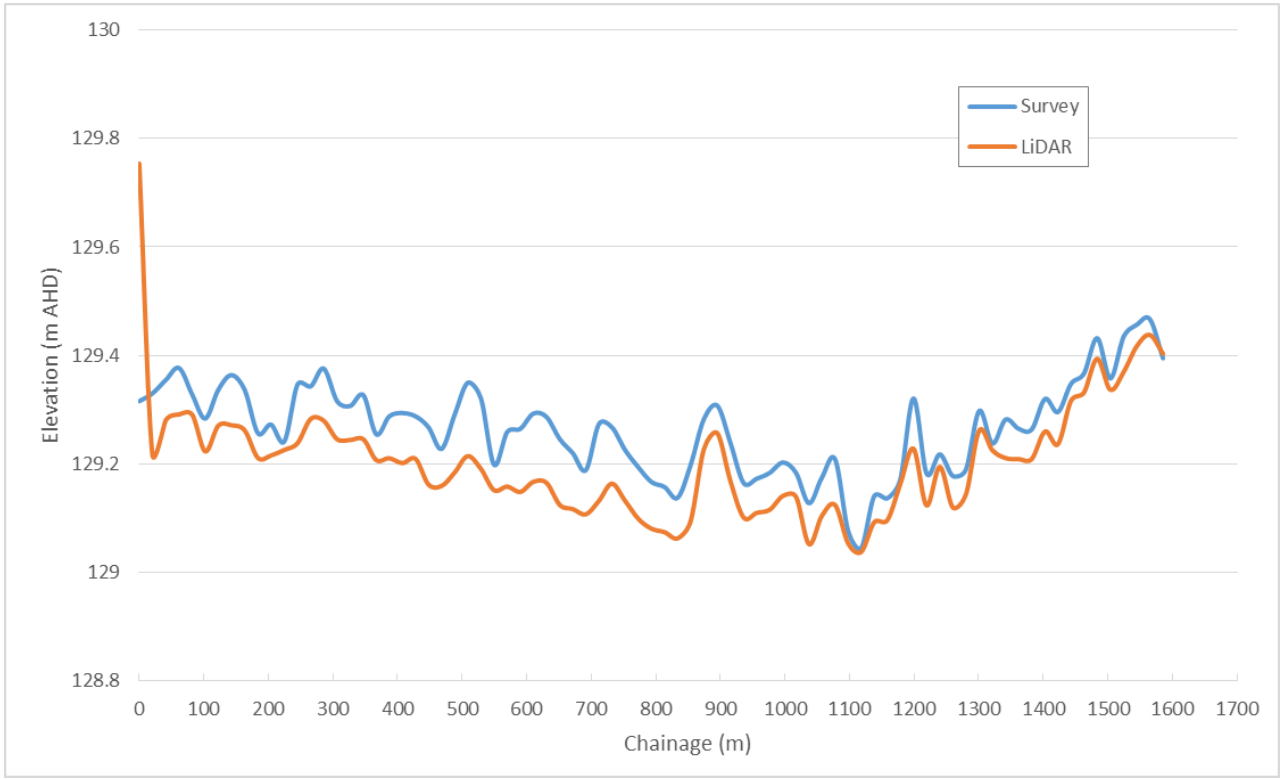


Figure 2-9 Browns Road - Survey and 2016 LiDAR Data comparison

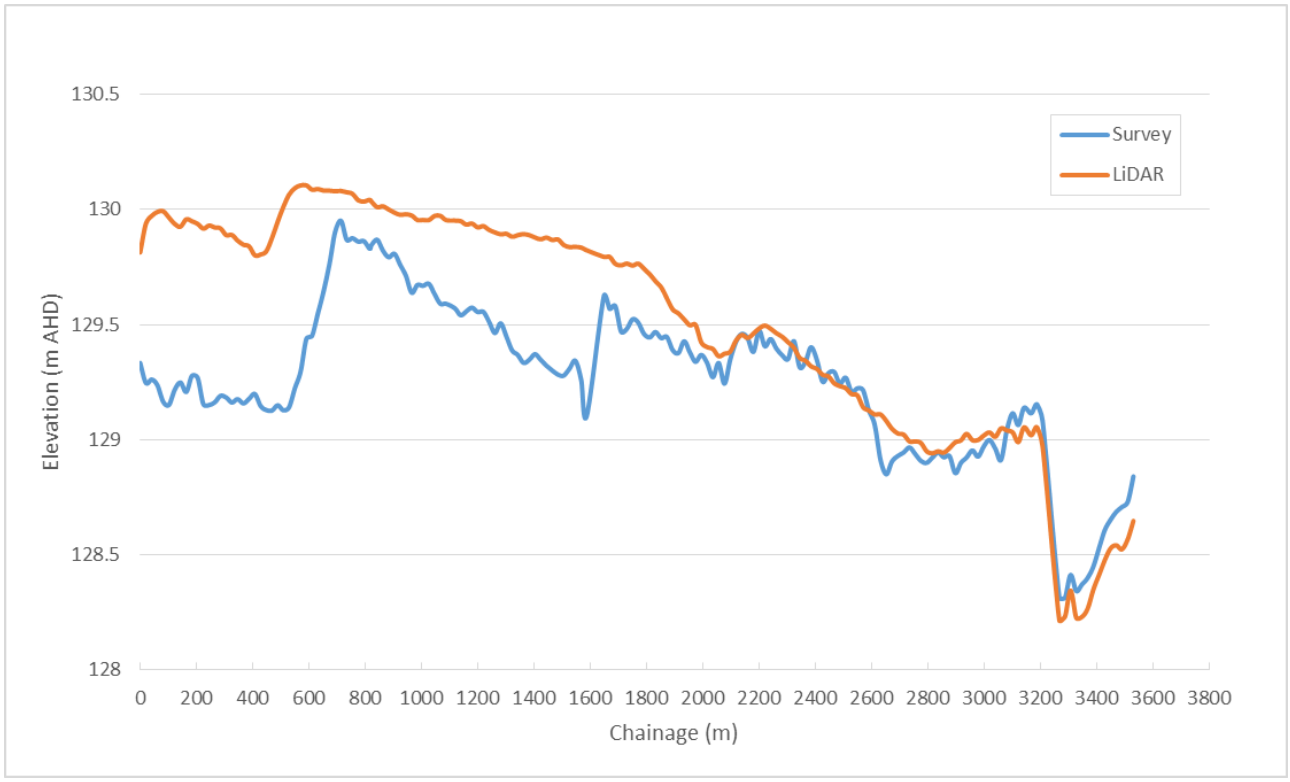


Figure 2-10 Rokeskys Road - Survey and 2016 LiDAR Data comparison

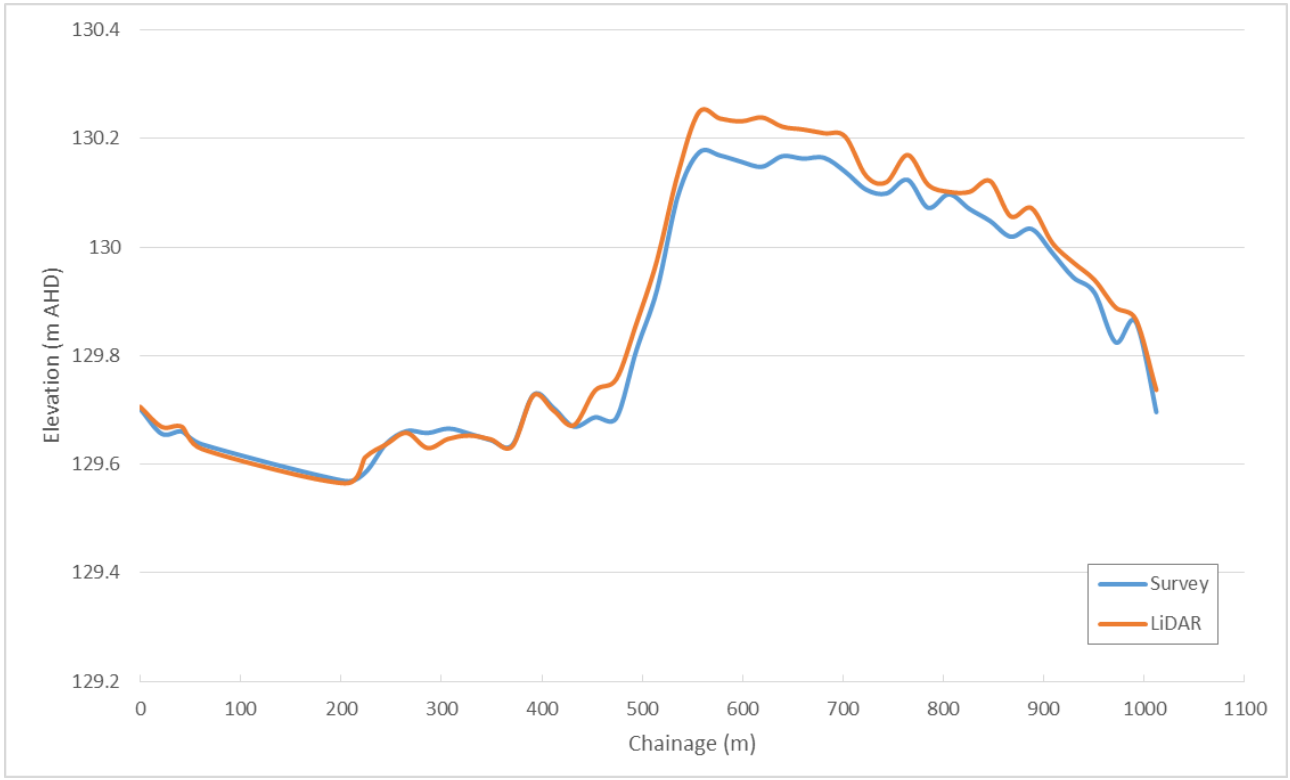


Figure 2-11 West Road - Survey and 2016 LiDAR Data comparison

The difference between the survey and the 2016 LiDAR was calculated at each survey point and the maximum, minimum and average difference for each location was calculated. The statistics are shown in Table 2.

Table 2 Mean, maximum, minimum and standard deviation differences between surveyed and 2016 LiDAR topography levels

Statistic	Elevation difference (LiDAR – Survey)			
	Riverside East Road	Browns Road	Rokeskys Road	West Road
Average (m)	-0.06	-0.03	0.16	-0.06
Max. (m)	-0.02	0.03	0.92	0.44
Min. (m)	-0.13	-0.09	-0.19	-0.14
Standard Deviation (m)	0.02	0.03	0.29	0.07

Discussion

The 2016 LiDAR and survey data comparison for Rokeskys Road was highly inconsistent, this is due to works undertaken by HRCC and GWMWater raising the road crest to replace Channel No. 3, which was decommissioned during the GWMWater Channel Decommissioning Program. The replacement was required to ensure no change in overland flow distribution was caused by the removal of the channel. The design of the increase in Rokeskys Road was designed by Water Technology and Driscoll Engineering. The change in Rokeskys Road pavement height between capture of the survey and LiDAR makes the comparison for data verification irrelevant. However, it does indicate the LiDAR data represents this change.

The remaining road crest comparisons show similar trends to that observed in Horsham, with surveyed road crest levels generally higher than that of the LiDAR.

The general shape of the longsections is matched very closely for each dataset with a slight uniform shift. The uniform shift at each comparison location is reflected in the average differences. A maximum average difference of -0.06 m was observed at the Riverside East Road and West Road transects, this was within the stated vertical accuracy of the LiDAR data at 0.2 m.

2.2 LiDAR Data Comparison

Comparing the available LiDAR datasets can be used to isolate any spatial differences between LiDAR datasets e.g. changes to topography, water in lakes or waterways etc. It can also highlight “banding” where the processing and merging of LiDAR flight paths can influence the final topography data produced.

The 2016 LiDAR dataset was compared to the 2010 ISC and 2004 WCMA region LiDAR datasets. The comparison was made by subtracting each of the 2010 and 2004 data sets from the 2016 data, calculated as follows:

Difference = 2016 LiDAR - 2010 ISC LiDAR or 2004 LiDAR

This calculation results in a positive value when the 2016 data is higher, and a negative value when the 2016 data is lower. Figure 2-12 and Figure 2-13 show the difference between the 2016 LiDAR data and 2010 ISC and 2004 WCMA region LiDAR datasets respectively.

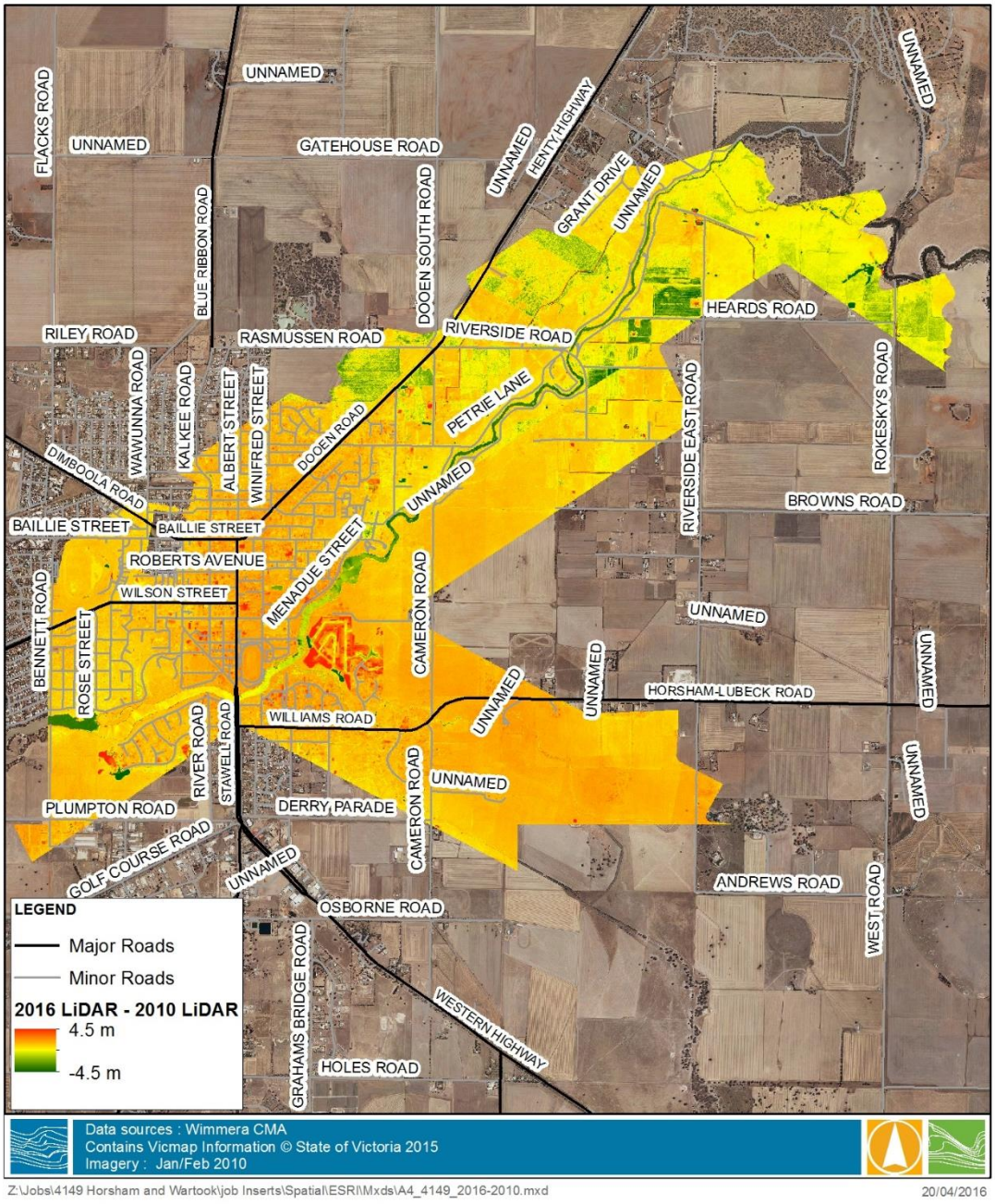


Figure 2-12 Differences between the 2016 and 2010 ISC datasets (2016-2010)

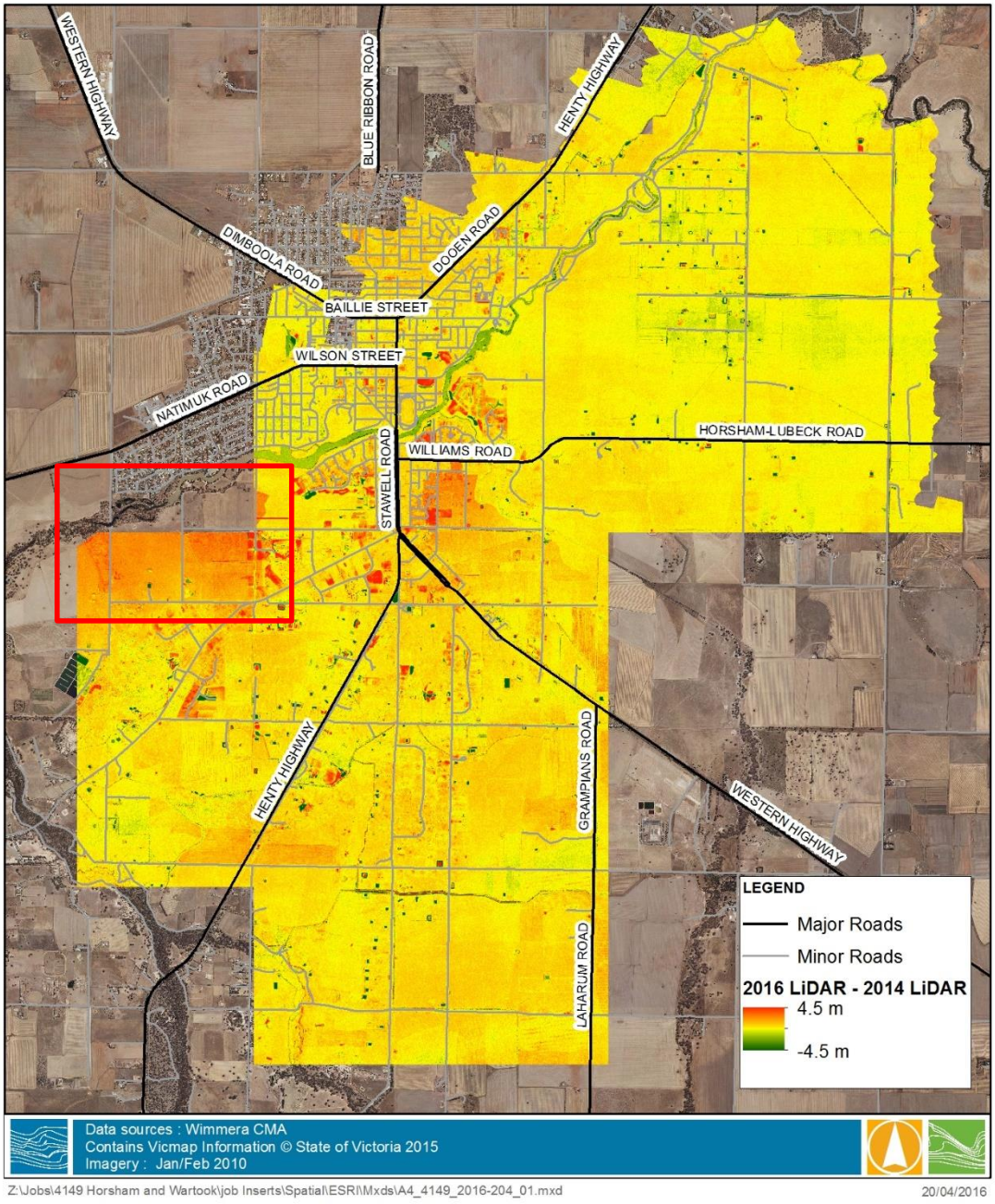


Figure 2-13 Differences between the 2016 and 2004 WCMA Region LiDAR (2016-2004)

2.2.1 Discussion

The LiDAR comparison between the 2016 and 2010 datasets showed several differences. Areas showing particularly high or low differences were north of Heards Road and Water Links Estate north of Williams Road. These areas are shown in more detail in Appendix A.

Differences at the Water Links Estate are due to the cut and fill placed in the development area as part of raising several lots and lowering of the internal road network. Differences north of Heards Road are due to thick vegetation, most likely pasture. This is most likely in the older 2010 ISC dataset which was not present when the 2016 data was captured. The Wimmera River channel is also lower in the 2016 dataset with less water in the channel at the time it was flown. Across the broader comparison area

the 2016 LiDAR is generally higher than the 2010 data, this can be observed by the orange areas in the colour pallet indicating a difference of 0.1 to 0.2 m.

It was also noted there was a localised difference at Heards Road which wasn't continuous, with the 2016 LiDAR lower than the 2010 data in the green areas shown in Figure 2-14.

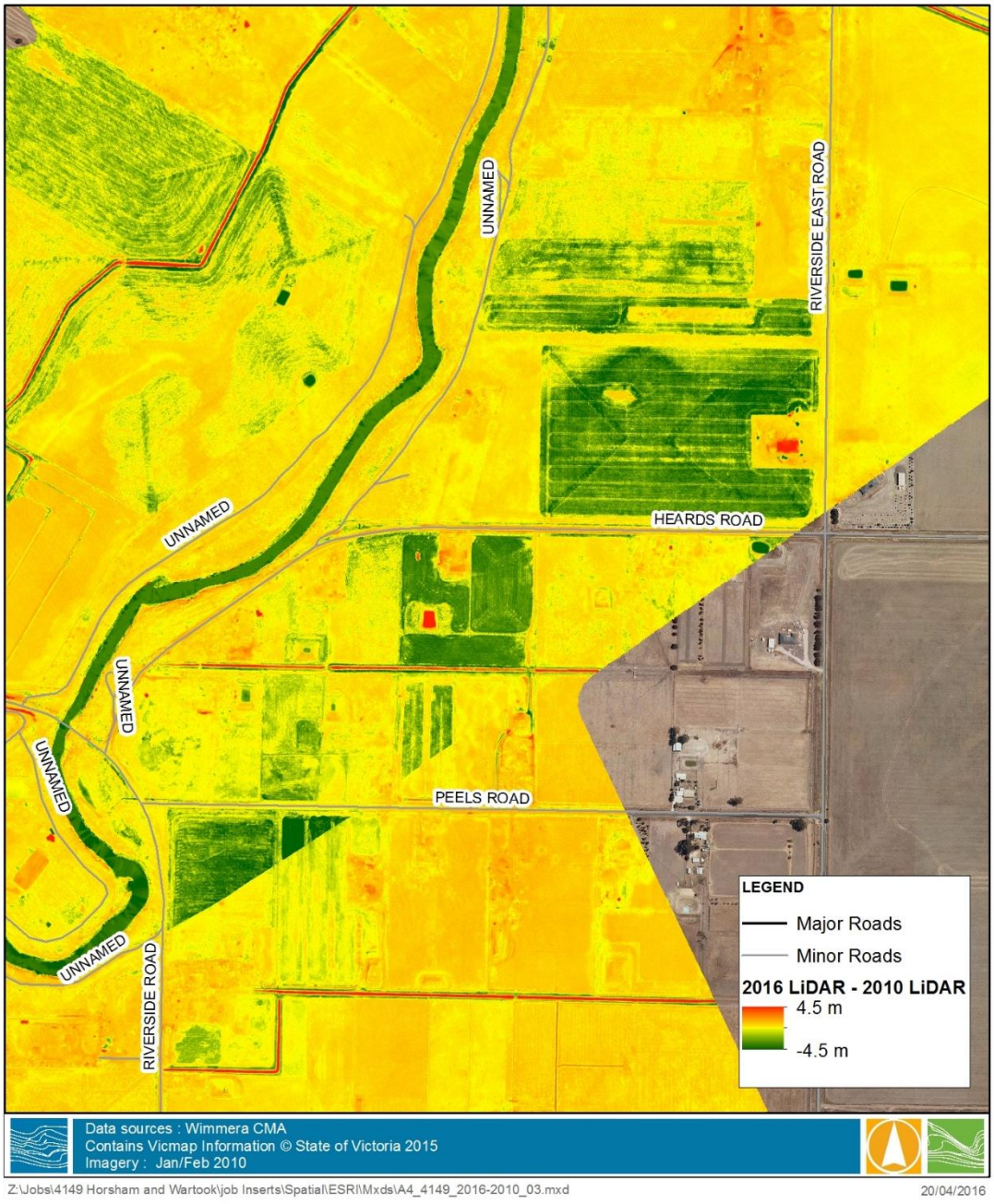


Figure 2-14 Differences between the 2016 and 2004 WCMA Region LiDAR (2016-2010) at Heards Road

Some of these differences are due to pasture or crops present in the 2010 data but not the 2016, however the area highlighted in Figure 2-14 indicates an area that in not consistent. Half of two paddock appear to have had a crop or this pasture in them with a diagonal cut through them. It is thought the paddocks must have been harvested or cut between LiDAR flight swaths.

Comparison between the 2016 and 2004 datasets showed a much closer general match across the comparison area than the 2010 data. Similar to the 2010 comparison there were a number of specific areas where changes in topography between 2004 and 2016 show differences. The majority of these are due to GWMWater or private channel and dam decommissioning in East Horsham. There are also several increases in the industrial area of Horsham along Golf Course Road. On the western side of the comparison there is an area where the 2016 data is a reasonable amount higher than the 2010 data, as highlighted in Figure 2-14, the cause of this is unknown, however it may be due to thick grass being present at the time the 2016 data was flown, and bare earth during 2010.

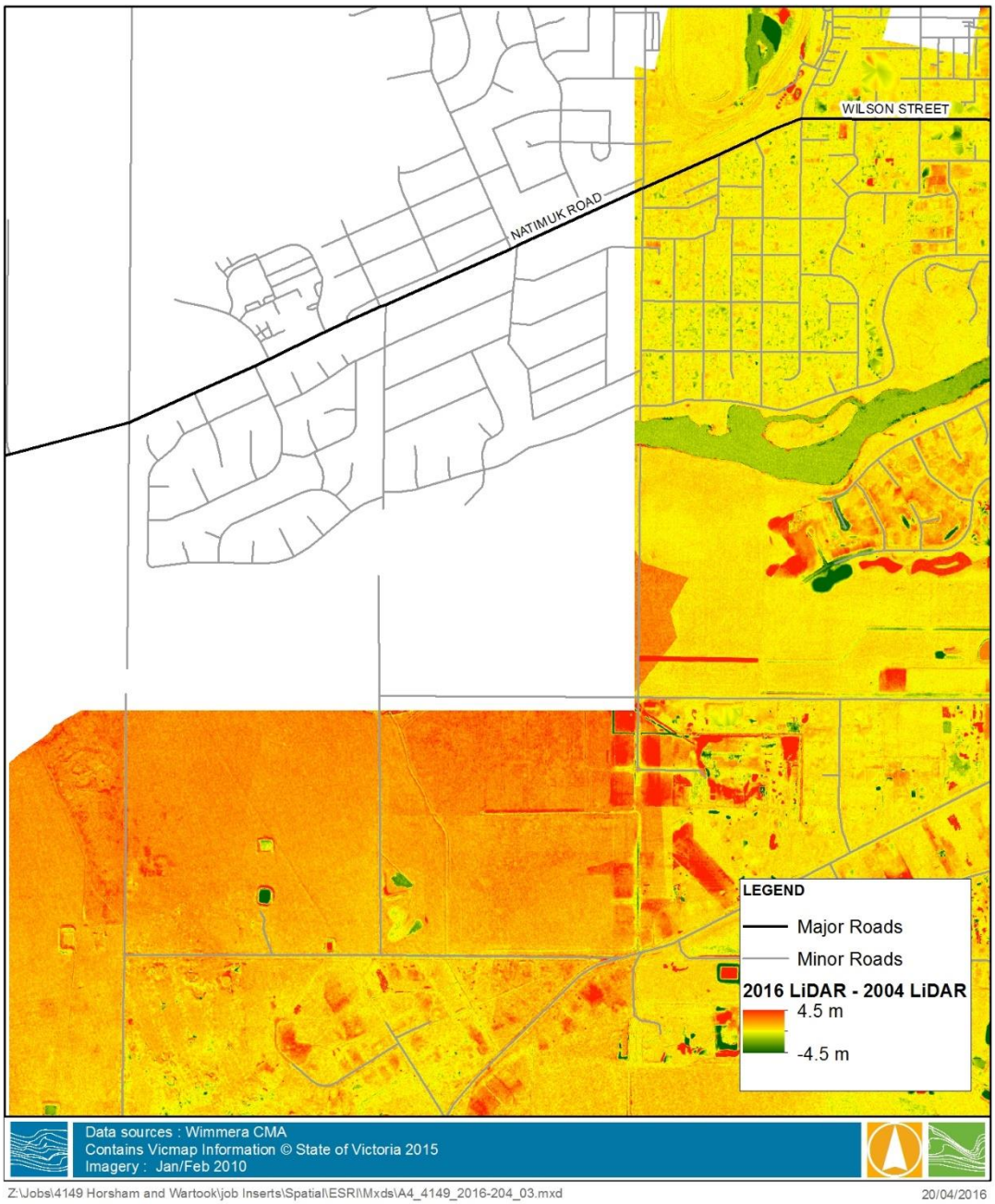


Figure 2-15 Differences between the 2016 and 2004 WCMA Region LiDAR (2016-2004) at west of Horsham

Additional areas of discrepancy due to land use are shown in more detail in Appendix A.

Statistics were extracted for each LiDAR data comparison, calculated across the overlapping topography extent, these statistics are shown in Table 3.

Table 3 Differences between 2016 and 2010/2004 LiDAR topography levels

Road transect	Elevation difference (m) [2016 LiDAR – 2010 or 2004 LiDAR]	
	2010 ISC LiDAR	2004 WCMA LiDAR
Mean (m)	-0.20	0.01
Max. (m)	4.76	6.13
Min. (m)	-4.39	-5.99
Standard Deviation (m)	0.19	0.19

Statistics on each LiDAR comparison confirm the visual assessment with large minimum and maximum differences as explained above. The mean differences also indicate the 2010 ISC data is consistently lower than the 2016 data, whereas the 2004 data is generally very similar. The difference observed in the 2010 ISC LiDAR is similar to differences observed in 2004 and 2010 LiDAR described in past projects[1 and 2].

3. DISCUSSION AND RECOMMENDATIONS

Comparison of the 2016 LiDAR data to surveyed levels has shown the LiDAR to be within the stated error bounds. The extracted longsections showed the LiDAR data is representing varying topography well. The LiDAR also showed raising of Rokeskys Road is well represented in the data.

Comparison of the LiDAR datasets showed the 2016 data picks up numerous developments in Horsham and changes in the East Horsham topography due to the decommissioning of the channel system and associated dams.

The close match between the 2016 LiDAR data and feature survey, and general match between the 2016 and 2004 datasets, has determined that the 2016 data is fit for use in this project.

The 2004 data has been verified to feature survey across several projects and will be used in areas not covered by the 2016 data. The 2010 ISC LiDAR will not be used in this study.

Regards

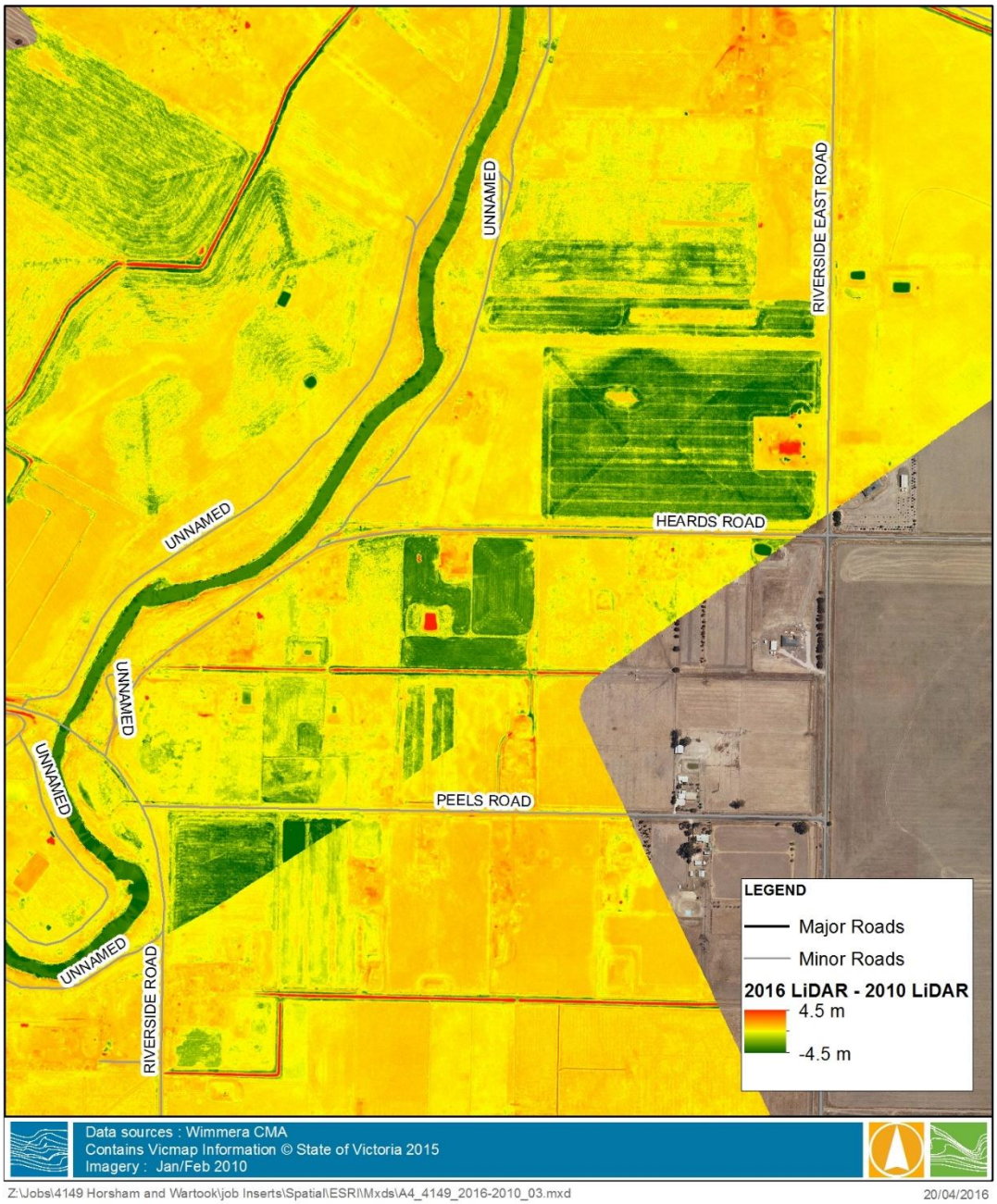
Water Technology Pty Ltd

Regards,

Ben Hughes

Senior Engineer

APPENDIX A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RIVERSIDE EAST ROAD
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Major Roads
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2016 LiDAR - 2010 LiDAR
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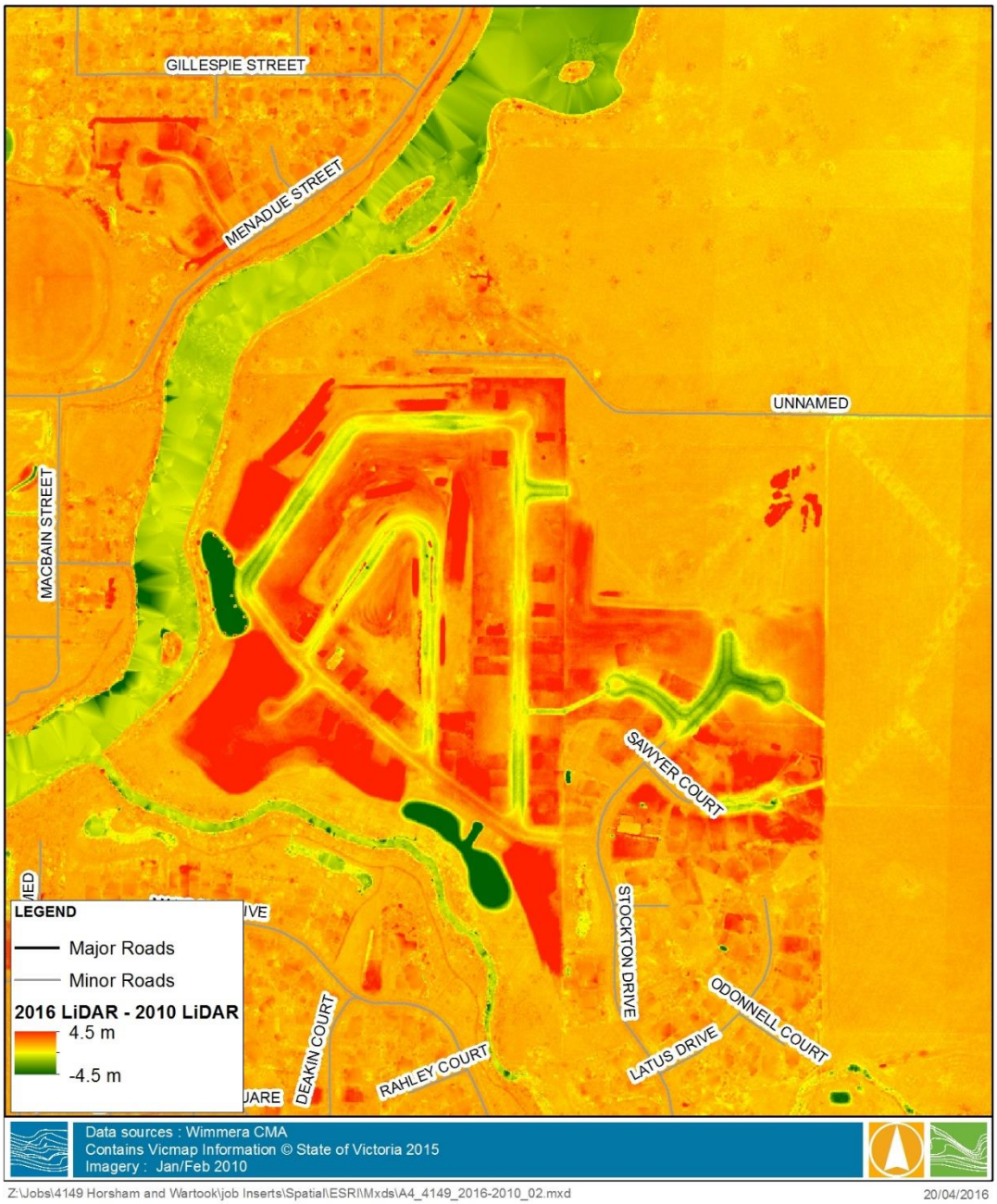
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ODONNELL COURT
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DEAKIN COURT
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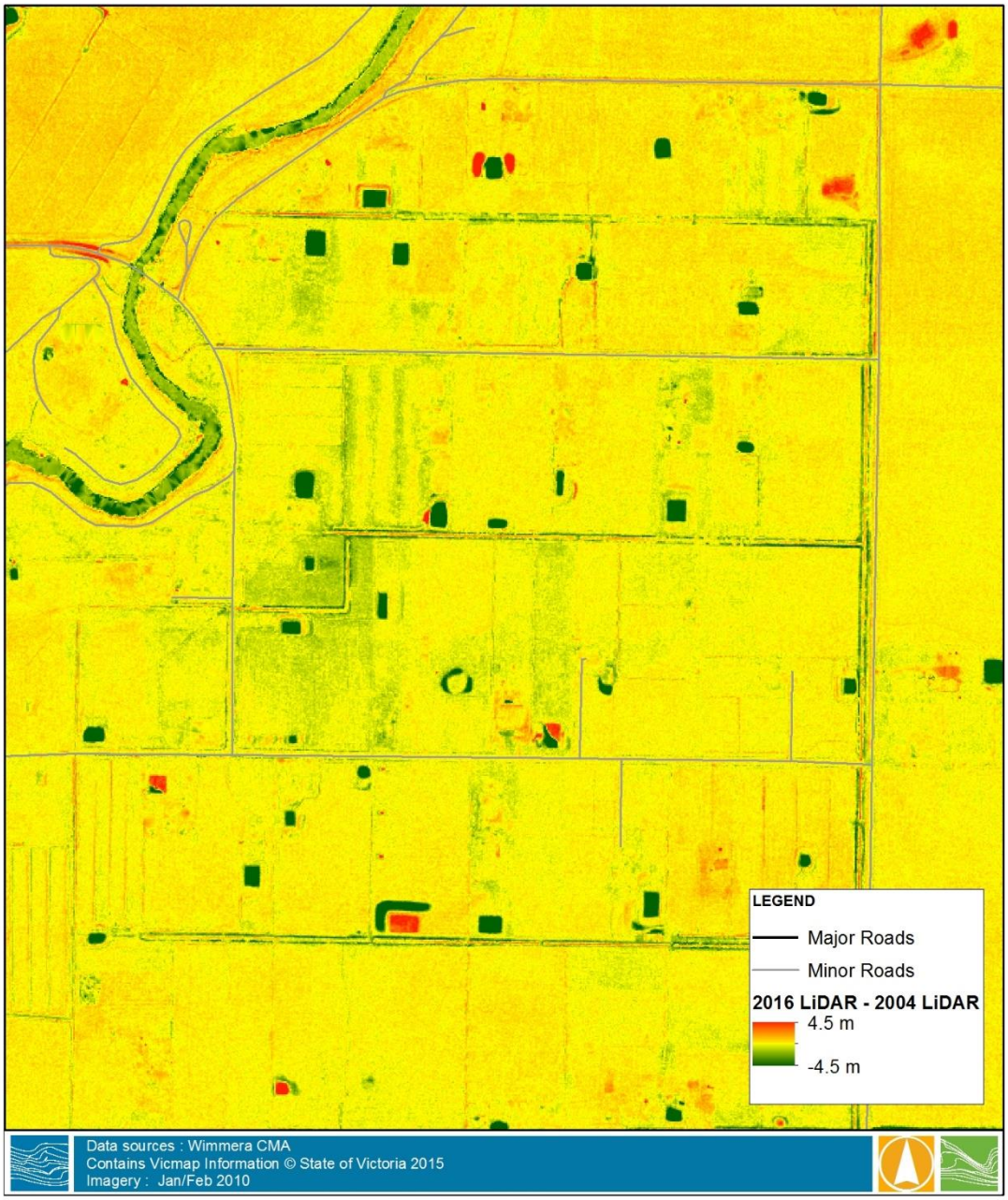
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