

Greater Shepparton City Council

Katandra West Flood Scoping Study

Final Report



May 2023



Project	Katandra West Flood Scoping Study
Client	Greater Shepparton City Council
Client's Representative	Sharon Terry
Confluence Group Project Manager	Trevor Clark

Document History and Status

Rev. No.	Author	Reviewer	Distribution	Date Issued
1 (Draft)	Trevor Clark	Chris Dwyer	GSCC	31/3/2023
2 (Draft)	Trevor Clark	-	GSCC / PWG	17/4/2023
3 (Final)	Trevor Clark	-	GSCC	3/5/2023

Cover photograph – March 2012 flood event – view looking north-west across Katandra West (photograph taken by Shepparton News at 1.18pm on Thursday 1 March 2012).

Table of Contents

1	Introduction	1
2	Town and Surrounds Description.....	2
2.1	Overview	2
2.2	Terrain Description	2
2.3	Town Stormwater Drainage Infrastructure	5
2.4	Rural Drainage Infrastructure	5
3	Consultation.....	7
3.1	Steering Committee and Community Reference Group.....	7
3.1.1	Steering Committee	7
3.1.2	Community Reference Group	7
3.2	Government Agency Consultation.....	9
3.2.1	Greater Shepparton City Council	9
3.2.2	Goulburn Broken CMA.....	9
3.2.3	Victoria State Emergency Service	9
3.2.4	Goulburn-Murray Water.....	11
3.2.5	Goulburn Valley Water	11
3.2.6	County Fire Authority.....	11
3.3	Local Interest Groups.....	11
3.3.1	Katandra West Planning Committee.....	11
3.3.2	Katandra & District History Group	11
3.4	Resident Consultation Activities	12
3.4.1	Overview of Activities	12
3.4.2	Resident Questionnaire	12
3.4.3	On-site Resident Interviews.....	13
4	Flood Data Review	15
4.1	Streamflow Data	15
4.2	Historical Rainfall Data.....	15
4.3	Design Rainfall Data	15
4.4	Flood Heights	16
4.4.1	March 2012 Event Flood Heights.....	16
4.4.2	October 1993 Event Flood Height.....	17
4.5	Ground Elevation Data.....	21
4.6	Previous Reports.....	21
4.7	Rural Drainage Infrastructure	21

4.8	Stormwater Drainage Infrastructure	22
4.9	Review of March 2012 Flood Event	23
4.10	Review of October 1993 Flood Event	24
4.11	Review of October 2022 Flood Event	25
4.12	Review of Pre 1993 Events.....	27
4.13	Post March 2012 - Council Katandra West Flood Mitigation Project	27
4.14	Emergency Response Reports.....	28
4.14.1	GSCC – Township Local Knowledge & Information Guide (September 2013).....	28
4.14.2	GSCC - Flood Emergency Plan – A Sub-Plan of the MEMP (August 2018)	28
4.14.3	VICSES - Local Flood Guide – Katandra West (2020).....	29
5	Mapping	30
5.1	Approach.....	30
5.2	Point Flood Heights.....	30
5.3	Catchment Area	31
5.4	Flood Height Contours	32
5.4.1	Recreation Reserve Area.....	32
5.4.2	East Side of Queen Street – Between Hickey Road and Channel 2/24.....	34
5.4.3	East Side of Queen Street – North of Channel 2/24	34
5.4.4	West Side of Queen Street – South of Hickey Road	34
5.4.5	West Side of Queen Street – Between Hickey Road and Channel 2/24	34
5.4.6	West Side of Queen Street – Channel 2/24 and Drain 2/12	35
5.5	Discussion – Flood Risk in Future Development Areas	35
5.5.1	Property on north side Burgman Street Estate.....	35
5.5.2	Potential Development – Area bounded by Hickey Road, Union Road & Channel 24	36
6	Other Issues	37
6.1	Content for Future Updates to Flood Documents	37
6.2	Comments on 2012 Flood Response Actions.....	37
6.3	Need for Flood Overlays at Katandra West Township.....	37
6.4	Need for a Flood Study / Floodplain Risk Management Study	37
7	Summary and Recommendations.....	39
7.1	Description of Flooding.....	39
7.2	Flooding Influences	39
7.3	Flooding Impacts / Damages.....	40
7.4	Project Flood Data and Map Outputs	40
7.5	Future Studies and Mitigation Measures.....	41
7.6	Ongoing Flood / Drainage Management Activities.....	41

7.7	Other Outcomes.....	41
8	References	42
APPENDIX A	Flood Height Survey Data – 26 October 2022.....	43
APPENDIX B	Content for Future Updates to Flood Information Documents.....	52

List of Tables

Table 1	CRG Meeting 1 – Summary of Flood and Drainage Management Issues.....	8
Table 2	BOM Daily Rainfall Stations	15
Table 3	BOM 2016 Design Rainfall IFD Data	16
Table 4	March 2012 Flood - Recorded Flood Height Marks	19
Table 5	Rainfall Data – February / March 2012 Event.....	23
Table 6	Rainfall Data – October 1993 Event.....	25

List of Figures

Figure 1	Local Area Plan	3
Figure 2	LiDAR defined Ground Surface Contours.....	4
Figure 3	Stormwater Drainage & G-MW Drains at Katandra West.....	6
Figure 4	Aerial Photograph – March 2012 Flood	10
Figure 5	Photograph Supplied by Katandra West History Group	12
Figure 6	Photographs – March 2012 Flood Event	14
Figure 7	Surveyed Flood Height Marks.....	18
Figure 8	Stormwater Drainage Infrastructure (GSCC supplied plan).....	22
Figure 9	Photographs – October 2022 Flood Event.....	26
Figure 10	Catchment Plan.....	31
Figure 11	March 2012 Interpolated Flood Height Contours.....	33
Figure 12	Development Sites	36

1 Introduction

The township of Katandra West was most recently significantly impacted by flooding in March 2012 when parts of the town were subject to inundation. The town is also known to have been affected by flooding in 1919, 1939, 1956, 1974 and 1993. A minor flood also occurred in October 2022 during the course of this scoping study project. The 2022 flood was considerably less severe in comparison to the 2012 event.

The Goulburn Broken Regional Floodplain Management Strategy 2018 – 2028 (Goulburn Broken CMA, 2018) nominates the need for a flood scoping study at Katandra West.

The 2018 - 2028 Strategy notes that there are currently no flood overlays at Katandra West despite the occurrence of significant flooding in 2012. The recommendation for the scoping study is made with one of the main objectives being to generate improved flood mapping for Katandra West.

Flooding is generally categorised as either riverine flooding or local runoff flooding. Riverine flooding is typically associated with significant waterways and the runoff from their catchments. The nearest natural waterways to Katandra West are Guilfus Creek and Congupna Creek, located 4 and 6 km respectively south-west of the township. These creeks are not thought to impact Katandra West, given that the natural terrain in and around Katandra West falls in a due westerly direction towards these creeks.

Previous flooding at Katandra West township in 2012 and the other historical floods would therefore appear to be due to local runoff from the town and the local surrounding rural areas, particularly the rural area on the east side of town. The local and broader surrounding terrain is extremely flat. Man-made features such as irrigation supply channels and rural drains have the potential to significantly influence local flooding conditions.

This Scoping Study investigates the nature and influences of flooding conditions at the Katandra West township only. The study does not assess flooding conditions within the surrounding rural areas.

In summary the scoping study has been commissioned to:

- Investigate the nature of flooding conditions at the Katandra West township by reviewing all of the available data and consulting with the community regarding past observations and impacts.
- Preparation of rudimentary flood mapping for the township area using the available data.
- Documentation of the flood impacts / risks to existing development.
- Ascertain and make recommendations as to whether a detailed flood modelling and mitigation study is required for the Katandra West township.

2 Town and Surrounds Description

2.1 Overview

The township of Katandra West has a population of 230. The township occupies an area of approximately 60 hectares, centred at the cross roads of Union Road and Hickey Road (refer to Figure 1).

There are 100 residential dwellings (houses) within the town. Also present are:

- Katandra Recreation Reserve including the 2016 completed Community Centre, main oval, bowling green and pavilion, netball courts and pavilion.
- Katandra West Primary School and the Children's Centre.
- Commercial properties – Katandra West General Store, WB Hunter Rural Supplies, Katandra West Auto Panel, Katandra Godden's Garage.
- Country Fire Authority (CFA) facility.
- Catholic Church and Uniting Church.
- Men's Shed.

2.2 Terrain Description

The terrain within and surrounding the township of Katandra West falls in a predominantly westerly direction. The 2022 acquired LiDAR terrain elevation data (refer to Figure 2) shows the following:

- The average land fall is 1 in 700 (0.14%).
- The main north-south orientated road through Katandra (Union Road / Queen Street) approximately straddles the 114.0 m contour line.
- The eastern fringe of the township approximately straddles the 114.5 m AHD contour line.
- The western fringe of the township approximately straddles the 113.5 m AHD contour line.

There are no designated natural waterways within the township or immediate surrounds. The nearest waterways are located south west of the township as shown on Figures 1 and 2.

Guilfus Creek which originates from Congupna Creek flows in a north-westerly direction, approximately 4 km to the west of Katandra West. Congupna Creek located west of Guilfus Creek originates south of Dookie and has quite an extensive local catchment.

Typically in Broken River flood events, northern breakaway flows from the Broken River discharge into a network of creeks, notably O'Keefe Creek, Pine Lodge Creek, Daintons Creek and Congupna Creek. During the largest Broken River flood on record in October 1993, major flooding was experienced in these creek systems, driven by the incoming breakaway flows from the Broken River.

Flood levels in Guilfus Creek at the Shepparton-Katamatite Road, located 4 km west of Katandra West peaked at approximately 110 m AHD in both the 1993 and 2012 floods. Flooding from either Guilfus Creek or Congupna Creek does not therefore impact on the township of Katandra West where ground elevations vary from 113 to 115 m AHD (refer to Figure 2).

Flooding which occurs at Katandra West is associated with runoff from the rural area on the east side of the township and from within the township itself.

The rural area surrounding Katandra West is part of the Goulburn-Murray Water (G-MW) Shepparton Irrigation Area. Supply channels and drainage channels criss-cross the area. These channels can impact on local runoff conditions, although cross drainage structures are generally present at natural drainage crossing points.



Figure 1 Local Area Plan

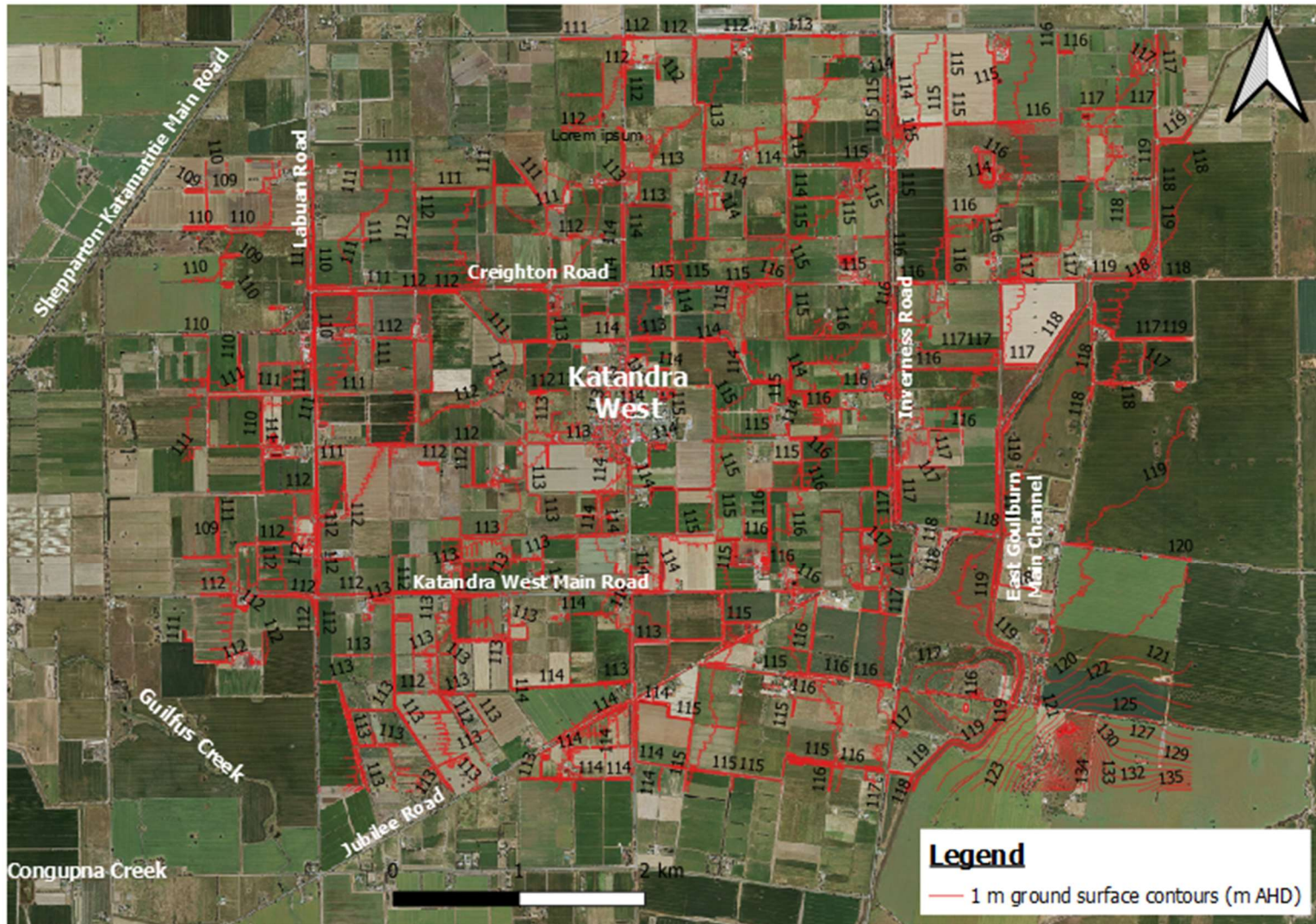


Figure 2 LiDAR defined Ground Surface Contours

2.3 Town Stormwater Drainage Infrastructure

A network of local drains is present within the township (refer to Figure 3). Notable stormwater features are listed as follows:

- Retarding basin located on the east side of the Recreation Reserve (referred to as the Hickey Road retarding basin in this report). Basin outflows are pumped into the adjoining G-MW Drain 3/12.
- Retarding basin located at the north end of Black Street (referred to as the Black Street retarding basin in this report). Basin outflows are pumped via a pipe drain to G-MW Drain 2/12.
- Retarding basin located at the south-western end of the Burgman Street estate (referred to as the Burgman Street retarding basin in this report). Basin outflows are pumped via the pump at the Black Street basin to G-MW Drain 2/12.
- Pipe drains in Hickey Road on the western side of the town discharge directly into G-MW Drain 3/12 located within the road reserve.

All of the town stormwater drains discharge into G-MW drains. Stormwater flows entering G-MW drains are required to be limited to 1.2 litres/sec/ha.

Council reports appear to indicate that the retardation basins have been designed to cater for the critical duration 20% annual exceedance probability (AEP) inflow volume, whilst limiting outflows to the G-MW allowable discharge.

2.4 Rural Drainage Infrastructure

The following G-MW drains are located in the vicinity of the town (refer to Figure 3):

- Drain 3/12 – this open drain approaches the township from the east within the Hickey Road reserve. It then deviates around the south side of the Recreation Reserve to Union Road, crosses under Union Road and is then aligned within the Hickey Road reserve to the west of town. Drain 3/12 flows through a small on-line dam opposite the north eastern corner of the Recreation Reserve.
- Drain 2/12 – this large open drain is aligned east-west across the north side of the town. It crosses under Union Road at the northern fringe of town, flowing westwards.
- Drain 2/2/12 – this small drain is located on the east side of Queen Street / Union Road between Bankin Street and Drain 2/12. It discharges into Drain 2/12 on the upstream side of Union Road.

Drains 2/12 and 3/12 both discharge westwards to Labuan Road and ultimately to Nine Mile Creek downstream of Wunghnu.

Pre 1990, G-MW drains were designed to drain over a period of 5 days the runoff from a rainfall event of 75 mm occurring within a 24 hour period. A 75 mm rainfall event in 24 hours is equivalent to approximately a 15 year average recurrence interval (ARI) Bureau of Meteorology (BOM) design rainfall event.

Current G-MW drain capacity design standards are for servicing runoff from a rainfall event of 50 mm over a 24 hour period. A 50 mm rainfall event in 24 hours is equivalent to approximately a 3 year ARI BOM design rainfall event.

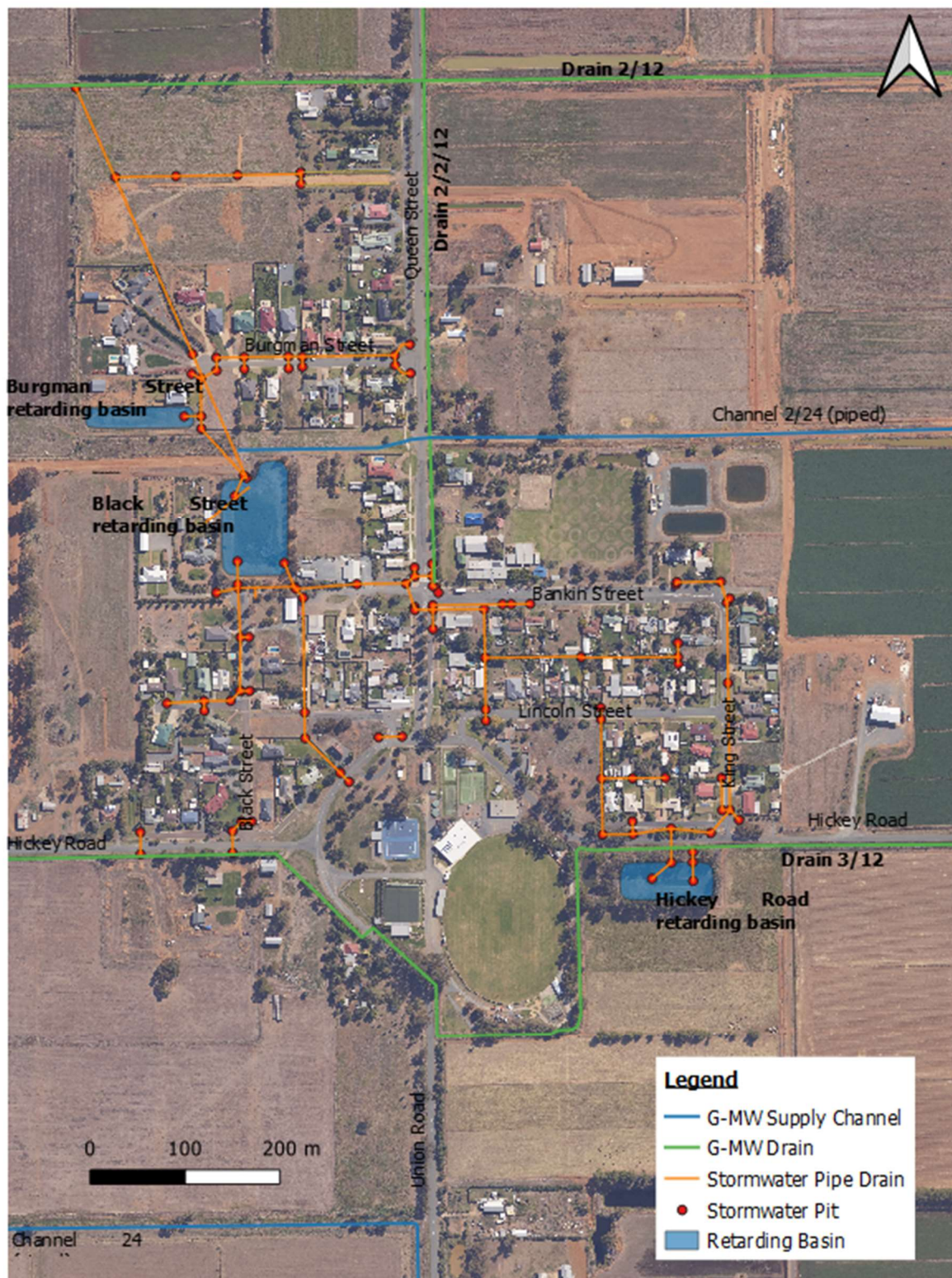


Figure 3 Stormwater Drainage & G-MW Drains at Katandra West

3 Consultation

3.1 Steering Committee and Community Reference Group

3.1.1 Steering Committee

A Steering Committee was established by Greater Shepparton City Council for the project. The Steering Committee consisted of representatives of:

- Council
- Goulburn Broken CMA
- Victoria State emergency Service (VICSES)

The full Steering Committee met on four occasions during the course of the project. Meetings were held as follows:

- Inception meeting Council and CMA only – 18 July 2022
- Steering Committee meeting 1 – 15 August 2022
- Steering Committee meeting 2 -12 December 2022
- Steering Committee meeting 3 – 10 March 2023
- Steering Committee meeting 4 – 14 April 2023

3.1.2 Community Reference Group

The Steering Committee oversaw the formation of a Community Reference Group (CRG). The CRG consisted of a mixture of government agency representatives and local residents as follows:

- Council – two members
- Goulburn Broken CMA – two members
- VICSES – one member
- G-MW – two members
- Community residents - seven members

The CRG met on two occasions at meetings held at the Community Centre at Katandra West. Meetings were held on:

- Meeting 1 – 14 September 2022
- Meeting 2 – 29 March 2023

Issues raised at the CRG Meeting 1 during the course of discussions are summarised in Table 1.

Table 1 CRG Meeting 1 – Summary of Flood and Drainage Management Issues

Issue Location	Issue Description / Comment (as raised at CRG meeting on 14/9/2022)
Whole town	Agreement from CRG that town is not impacted in any way by creek flooding.
Whole town	The drawdown of floodwater at Katandra West after the peak of the 2012 flood occurred over approximately a 5 day period. Local residents on the CRG consider this quite favourable.
Whole town	There has been no serious flooding impacts at Katandra West since the March 2012 flood.
Whole town	No serious flooding at Katandra West between 1993 and 2012.
Whole town	The 1993 flooding impacts were relatively benign, and less severe than 2012 flood.
Whole town	Study needs to review the response actions and other content for Katandra West within Council’s Municipal Flood Emergency Plan.
South west of town fringe	Possible future rezoning of existing rural zoned land to township zone for future residential development.
Netball Court pavilion	Pavilion flooded to above floor level in 2012 flood. The pavilion floor level is at ground level.
Retarding basin at north end of Black Street	The pump for discharging outflows from the Black Street retarding basin was not working during the 2012 flood. Local residents on the CRG consider that this significantly exacerbated flooding conditions.
195 Hickey Road	House at this address (western fringe of town) was within 0.05 m of above floor flooding in 2012.
G-MW Drain 3/12	This G-MW drain tends to clog up with debris / organic matter impacting adversely on its discharge capacity.
Inundation pool on the east side of the Black Street retarding basin.	Flooding exacerbated in this area due to the east side Black Street basin low level embankment obstructing flows. Inflow pipes installed since 2012 to address this.
2012 event rainfall comment	One of the CRG members asserted that rainfall at Katandra West in 2012 was characteristic of a single event, unlike the two dominant 24 hour rainfalls that were apparent elsewhere (not supported by the available rainfall data).
95 Union Road	The red roof house at this address was at risk of above floor flooding in 2012. Flood levels peaked within ‘2 to 3 inches’ of floor level. At this point, responders removed sand bags preventing flow across Hickey Road which lowered flood levels at 95 Union Road.
Corner of Bankin Street and Queen Street	Stormwater pipe network previously struggled to adequately convey flow to the Black Street detention basin. Ten to 15 mm of rainfall typically lead to pondage at the Bankin / Queen St intersection.
Rural catchment on east side of town	The rural catchment impacting on Katandra West extends as far as Inverness Road on the east side of town (2 km from town).

Issue Location	Issue Description / Comment (as raised at CRG meeting on 14/9/2022)
GMW Drain 2/12	In 2012, Drain 2/12 reached its capacity limit, preventing the outflow of stormwater at Katandra West. Perception that if the Black Street retarding basin pump had of been working, the stormwater runoff may have been drained prior to the influx of rural runoff.
GMW Drain 3/12	Needs regularly cleaning out.

3.2 Government Agency Consultation

3.2.1 Greater Shepparton City Council

Council is responsible for the provision of stormwater drainage services at Katandra West.

Stormwater system data supplied by Council is described in Section 4.8 of this report. The stormwater system caters for local runoff from the immediate township area. Pipe drains discharge runoff to three stormwater retardation basins. Basin outflows are then pumped / discharged to G-MW drains.

A significant issue in the March 2012 flood event was the failure of the pump discharging outflows from the retarding basin at the north end of Black Street. Council has advised that the basin pumps are now checked on-site at six monthly intervals and whenever more than 10 mm of daily rainfall is recorded.

3.2.2 Goulburn Broken CMA

The CMA is responsible for floodplain management. This includes the provision of flooding related advice upon request drawing on available flood related knowledge held by the CMA or others.

The CMA's 2018-2028 Goulburn Broken Regional Floodplain Strategy identified the need for this Scoping Study to develop improved knowledge of flooding conditions at Katandra West.

Flood Data supplied by the CMA includes flood height data (refer to Section 4.4 of this report) and copies of planning referral correspondence advice.

It was noted upon comparison of the surveyed elevations of the 2012 flood height marks with Council supplied GIS survey data that there were apparent inconsistencies associated with the surveyed flood height marks. A decision was consequently made to re-survey the CMA flood height marks as part of the scoping study survey component.

3.2.3 Victoria State Emergency Service

The VICSES is responsible for emergency management in flood events. This includes preparation, response and recovery related activities.

The SES provided a list of logged response calls relating to flooding for Katandra West and the surrounding rural area. All of the supplied logged calls were for attending incidents located outside the Katandra West township area (i.e. not directly relevant to the Scoping Study).

The SES also provided copies of aerial March 2012 flood photography originally obtained by Shepparton News. This includes the cover photograph of this report and the photograph shown in Figure 4.



Figure 4 Aerial Photograph – March 2012 Flood

3.2.4 Goulburn-Murray Water

G-MW supplied GIS data for their rural drainage and supply channel networks in the vicinity of Katandra West. G-MW also provided some details of Drainage Declaration Course (DCD) work undertaken for the Congupna and Guilfus Creeks.

3.2.5 Goulburn Valley Water

Goulburn Valley Water (GVW) were contacted in the early stages of the project. GVW advised that:

- Wastewater servicing within the township of Katandra West is by individual property private septic tank systems.
- GVW does not have any specific concerns or issues to raise in relation to flooding and drainage related conditions at Katandra West.

3.2.6 County Fire Authority

The captain of the local Country Fire Authority (CFA) who is a local resident at Katandra West served on the CRG for this project and provided input to reflect the CFA's interests.

3.3 Local Interest Groups

3.3.1 Katandra West Planning Committee

The Katandra West Planning Committee is a local community committee which has been active for more than 10 years in the promotion of activities to provide better facilities and services for the township of Katandra West. This includes overseeing the preparation of the 2012 Katandra West Community Plan, input into the implementation of Plan actions since 2012, the updated 2018 Community Plan and input into other local issues at Katandra West.

One of the goals nominated by the 2018 Community Plan is to *'continue to improve stormwater drainage in Katandra West to reduce the potential for flooding'*. Related actions nominated are to *'identify areas that are flood prone'* and *'work with Council to explore flooding and drainage issues'*.

A representative of the Planning Committee was contacted in the early stages of the project. The contacted person passed on some suggestions for community representatives to serve on the CRG.

3.3.2 Katandra & District History Group

The Katandra & District History Group was contacted. The History Group in response provide a copy of a photograph thought to have been taken in 1936 showing flooding of the main street at Katandra West (refer to Figure 5), which is the only flood related photograph or item held by the History Group.

The highest daily rainfall total recorded at the Katandra West station in 1936 was a relatively low 38 mm in late July. It is possible that the photography in Figure 5 relates to an event in October 1935 when 106 mm of rainfall was recorded at Katandra West.

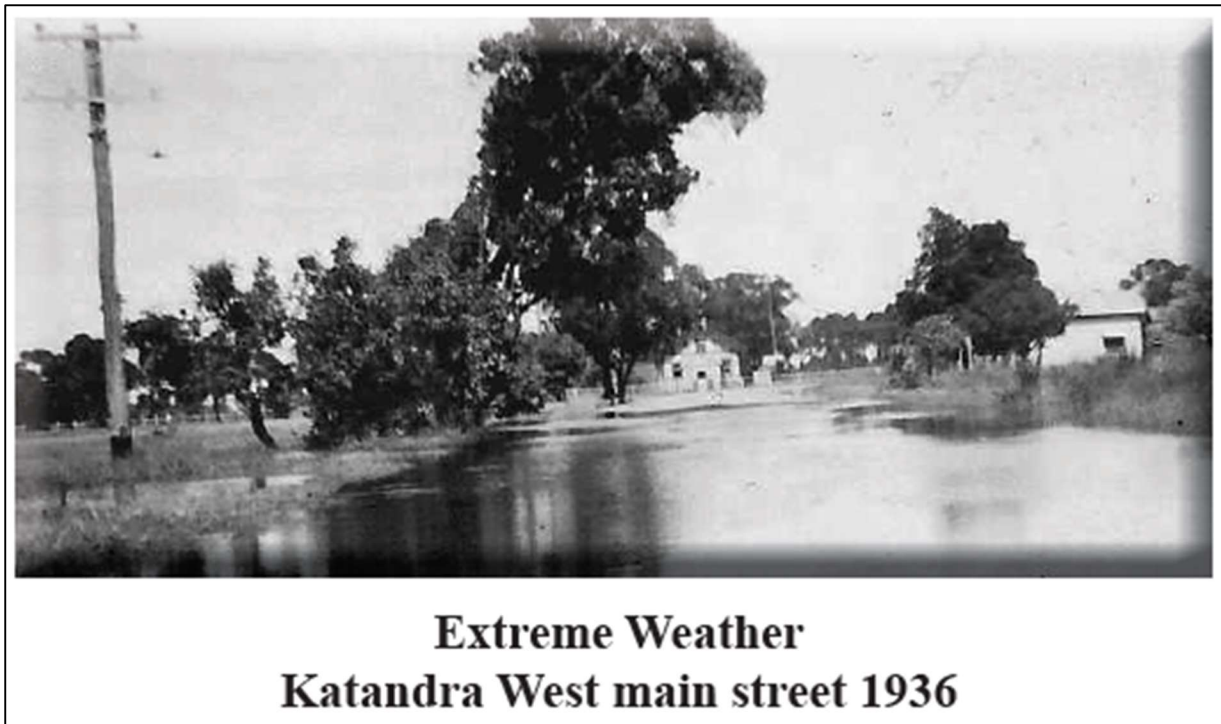


Figure 5 Photograph Supplied by Katandra West History Group

3.4 Resident Consultation Activities

3.4.1 Overview of Activities

Consultation with residents of Katandra West encompassed the following activities:

- Representation on the CRG (seven local residents on the 14 person CRG).
- Presentation of project information on Council's web site <https://shaping.greatershepparton.com.au>
- Project resident questionnaire distributed to all residential and other properties at Katandra West.
- Drop in project information exchange session held at Katandra West on the 14 September 2022.
- Follow up interviews with selected residents following the first CRG meeting, the receipt of the completed questionnaires and after the drop in session.

The purpose of the consultation activities was to develop an improved understanding of the impacts of flooding and what residents consider to be influencing these impacts. Working against this is the significant time which has elapsed since the most recent major flood in March 2012.

3.4.2 Resident Questionnaire

Questionnaires were distributed to all occupied properties at Katandra West. This amounted to:

- Approximately 100 residential properties
- Approximately 10 non residential properties

The questionnaire was also able to be accessed and filled out on-line at Council's web site.

A total of 12 questionnaire responses were received. Eleven of these were from persons living outside Katandra West in the surrounding rural area.

The only questionnaire response received from persons living in the town was from a property in Lincoln Street. They advised in their response that an apparent stormwater pipe system blockage in the vicinity of Bankin Street / Queen Street had in their view previously hampered drainage.

3.4.3 On-site Resident Interviews

Following the first CRG meeting and the receipt of completed questionnaires, individual residents were contacted to arrange for meetings on-site at Katandra West to discuss issues related to the project. These on-site meetings were conducted in late September and early October 2022.

Some residents provided photographs of past flooding. Example photographs are shown on Figure 6.



Photograph 1 – view east across the north end of the Black Street retarding basin



Photograph 2 – view west across the Black Street retarding basin



Photograph 3 – view north down Queen Street from Bankin Street



Photograph 4 – garage at corner of Bankin and Queen Streets



Photograph 5 - Entry road into General Store carpark from Hickey Road



Photograph 6 – View across Black Street at Hickey Road

Figure 6 Photographs – March 2012 Flood Event

4 Flood Data Review

4.1 Streamflow Data

There are no waterways and consequently no flood height and / or streamflow gauging stations located at Katandra West.

4.2 Historical Rainfall Data

There are no automatic weather stations (AWSs) located in the vicinity of Katandra West. The nearest AWS station is located approximately 20km away at Shepparton.

Daily manually read Bureau of Meteorology (BoM) rainfall stations are listed in Table 2. The station at Katandra West closed in 1996. The nearest open BOM station is located at Numurkah, 17 km to the north-west. Rainfalls at these stations are nominally read at 9am on each day (i.e. each daily total is for the 24 hours prior to 9am on that day).

The highest 24 hour total recorded at the Katandra West station is 106 mm in October 1935, followed by 91 mm in 1950, and 81 mm in 1966.

Table 2 BoM Daily Rainfall Stations

Station Number	Station Name	Period Operation	Distance from Katandra West (km)
081023	Katandra West	1927 - 1996	0.0
081022	Katandra North	1867 - 1954	5
081021	Invergordon	1897 - 1990	8
080101	Numurkah	1968 – still open	17
081051	Tungamah	1889 - 2015	32
081013	Dookie Agricultural College	1879 – still open	22

4.3 Design Rainfall Data

Design rainfall intensity frequency duration (IFD) data for Katandra West is given in Table 3. The design rainfall data was sourced from the BoM.

Table 3 BoM 2016 Design Rainfall IFD Data

Duration (hours)	Rainfall (mm)						
	50% AEP (1.4 yr ARI)	20% AEP (4.5 yr ARI)	10% AEP (9.5 yr ARI)	5% AEP (20 yr ARI)	2% AEP (50 yr ARI)	1% AEP (100 yr ARI)	0.5% AEP (200 yr ARI)
1	17	24	29	34	41	46	52
3	24	32	39	45	53	60	68
6	29	39	46	54	64	72	82
12	35	47	56	65	78	88	100
24	42	58	69	81	98	111	127
48	51	71	85	101	123	141	161
72	55	78	95	112	137	158	182

4.4 Flood Heights

4.4.1 March 2012 Event Flood Heights

Shortly after the March 2012 flood event, the Goulburn Broken CMA arranged for the survey of flood height marks for locations which included Katandra West.

The resultant 2012 surveyed flood height marks at Katandra West are those in Table 4 and Figure 7 (Marks 200 to 221). There are a total of 22 flood height marks that were surveyed in 2012. All of these flood height marks have since been uploaded to the Victorian Flood Database (VFD). The field sheets completed at the time of the survey describe these marks as follows:

- Reliability classified as Good – 1 mark (Mark 204)
- Reliability classified as Medium – 14 marks
- Reliability classified as Poor – 6 marks

Flood Mark 206 is described as 0.37 m above ground, however is located within an open drain. Based on the survey photograph, the actual height above the adjoining natural ground surface appears closer to 0.1 metre.

Of the other 21 marks, only FM221 in Lincoln Street (east) is more than 0.2 m above the natural ground level. The marks therefore indicate that flood depths in the town during the 2012 flood were shallow and did not generally exceed 0.2 m in depth.

A comparison of the elevation of the surveyed 2012 flood height marks with adjoining Council supplied GIS data elevations for stormwater pit finished surface levels revealed some anomalies. It was therefore decided to re-survey all of the 2012 flood height marks. The flood height mark elevations were subsequently re-surveyed in October 2022 as part of this scoping study. The newly obtained surveyed elevations are given in Table 4 and in some cases vary considerably from the originally surveyed elevations. The reason for this is unknown but most likely due to inaccuracies associated with the original survey.

Seven newly identified flood height marks associated with the March 2012 event were identified and subsequently surveyed in October 2022 as part of this project. Details for these additional flood height marks (KW1 to KW7) are given in Table 4 and shown on Figure 7. The additional marks have been identified via resident interviews and / or are based on a Shepparton News acquired aerial photograph taken on the 1 March 2012 (refer to cover photograph and Figure 4).

A landowner at Katandra West (10 Black Street) forwarded an email to the CMA in August 2012 questioning the accuracy of the surveyed flood height marks in the vicinity of Black Street, specifically the Mark 210 flood level (113.88 m AHD) at the north end of Black Street and Mark 201 flood level (114.08 m AHD) at the rear of 6 Black Street. In the email, the landowner asserts that if these flood heights are correct, this would have resulted in the complete inundation of 10 Black Street and the inundation of several houses in the surrounding area. The landowner asserts that this clearly did not happen and that therefore this flood height is in error, and that the actual peak flood height did not exceed 113.6 m AHD at the north end of Black Street.

The re-survey of flood height Mark 210 at the north end of Black Street identified a corrected elevation of 113.66 m AHD. The elevation of an adjoining newly identified flood height Mark KW6 located close to Mark 210 has an elevation of 113.48 m AHD. This is consistent with the above landowner assertions in regard to the height of floodwaters at the northern end of Black Street.

4.4.2 October 1993 Event Flood Height

There is one 1993 spot flood height at Katandra West within the VFD (refer to Figure 7). Details are:

- Located at the intersection of Hickey Road and Lincoln Road (Mark 4029)
- Elevation 114.27 m AHD
- Assessed reliability – Low

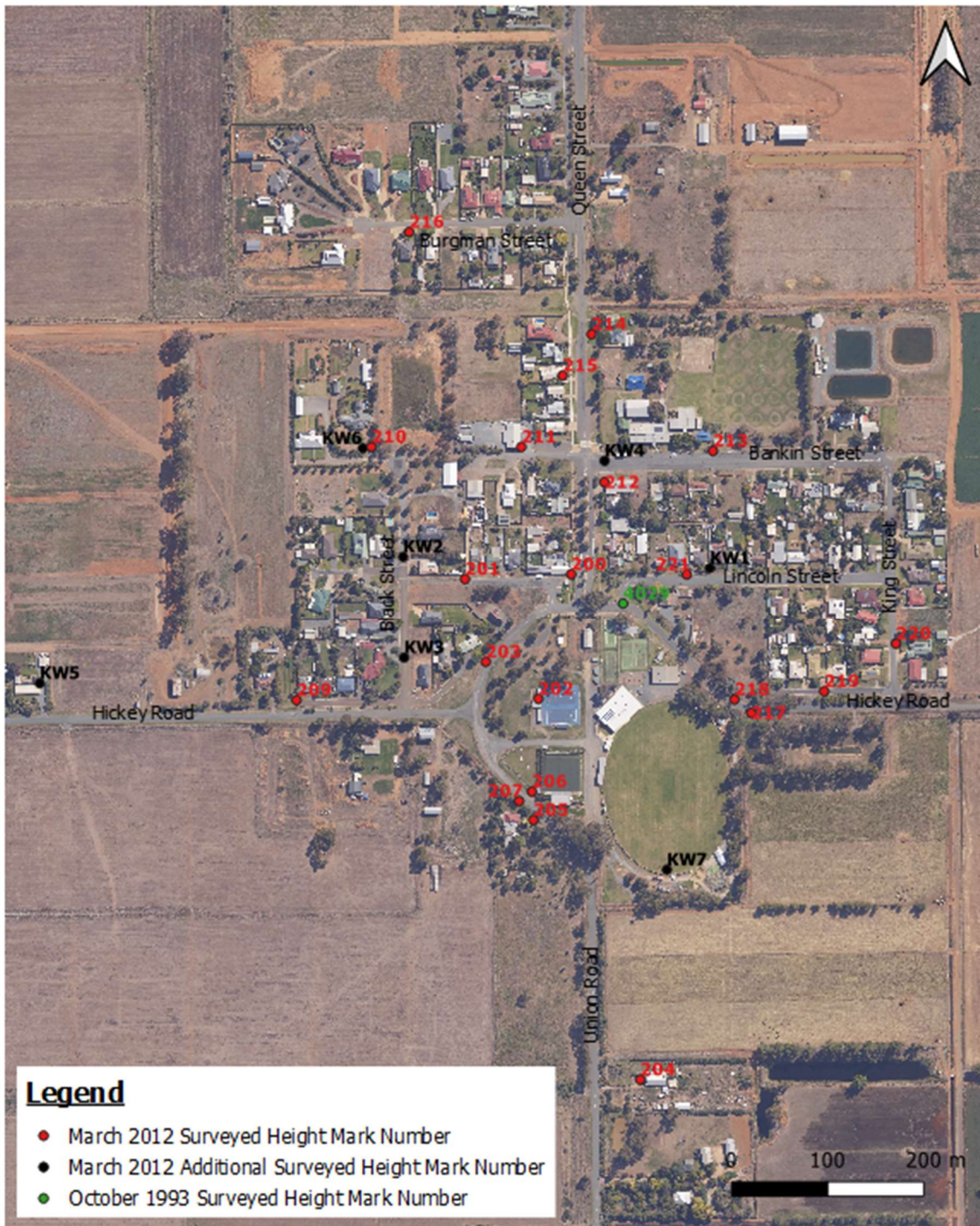


Figure 7 **Surveyed Flood Height Marks**

Table 4 March 2012 Flood - Recorded Flood Height Marks

Mark No.	Mark Description	Elevation (m AHD) Survey in March 2012	Elevation (m AHD) Re-Survey in October 2022	Reliability Assigned
200	Corner Lincoln & Queen St – mark on concrete at front of store	114.08	114.16 (+0.08m)	Medium
201	West end Lincoln St – water mark on traffic bollard	114.08	113.92 (-0.16m)	Poor
202	Water mark on brick wall of netball pavilion	114.34	114.38 (+0.04m)	Medium
203	On curve Hickey Rd opposite Bowling Club	114.42	114.29 (-0.13m)	Medium
204	East side Union Rd - water mark on house footing	114.34	- not accessible	Good
205	East side Union Rd - water mark on fence post 0.17 m above ground – close to 206 & 207	113.97	113.93 (-0.04m)	Medium
206	Debris in mesh fence – 0.37 m above ground – close to 205 & 207	114.24	- changed conditions	Medium
207	Water Mark on power pole 0.17 m above ground – close to 205 & 206	114.28	114.26 (-0.02m)	Medium
208	South side of town - debris mark on carport column 0.17 m above ground	114.38	114.46 (+0.08m)	Medium
209	Hickey Rd west side - debris on fence post 0.2 m above ground	114.19	113.79 (-0.40m)	Medium
210	Bankin St west side – flood extent line in garden – zero depth	113.88	113.66 (-0.22m)	Medium
211	Bankin St west side – same level as the concrete verandah of Hunter store	114.04	114.01 (-0.03m)	Medium
212	SE corner of Queen & Bankin Streets – water mark 0.15 m above ground on building wall	114.04	114.21 (+0.17m)	Medium
213	Bankin St east – school teacher advised of flood extent limit in street – zero depth	113.72	113.91 (+0.19m)	Poor
214	Queen Street east side – water mark on power pole 0.14 m above ground level	113.91	114.01 (+0.10m)	Medium
215	Queen St west side – water mark (flood extent) in driveway – zero depth	113.98	113.99 (+0.01m)	Medium
216	Burgman St – flood stain on lawn	113.56	113.27 (-0.29m)	Medium
217	Hickey Rd east – flood extent line on side of road – zero depth	114.60	114.91 (+0.31m)	Poor
218	Hickey Rd east – flood extent line on side of road – zero depth	114.04	114.27 (+0.23m)	Poor
219	Donohue St – flood extent line in road – zero depth	113.96	114.34 (+0.38m)	Poor
220	King St – flood extent line on side of road – zero depth	113.71	114.23 (+0.52m)	Poor
221	Lincoln St east – water mark on power pole – 0.35 m above ground	114.27	114.52 (+0.25m)	Medium
KW1	13 Lincoln Street – owners advised of peak extent in driveway	na	114.23	Medium
KW2	Black Street just north of Coleman Street – from Shepp News aerial flood photograph	na	113.56	Medium

Mark No.	Mark Description	Elevation (m AHD) Survey in March 2012	Elevation (m AHD) Re-Survey in October 2022	Reliability Assigned
KW3	Black Street north of Hickey Road – from Shepp News aerial flood photograph	na	113.74	Medium
KW4	Bankin Street just east of Queen Street – from Shepp News aerial flood photograph	na	114.07	Medium
KW5	195 Hickey Road – carport level	na	113.24	Medium
KW6	13 Bankin Street – flood height on garden edge board as per a photograph supplied by local landholder	na	113.48	Medium
KW7	South end of oval at Recreation Reserve - from Shepp News aerial flood photograph	na	114.20	Low

Note: Mark locations are shown on Figure 7.

4.5 Ground Elevation Data

LiDAR data obtained in 2022 as part of a broad scale Victorian State Government program (Coordinated Imagery Program) became available for use in this project in early February 2023.

During the re-survey of flood height marks undertaken in October 2022 as part of this scoping study, the finished surface levels (cover levels) of stormwater pits located close to flood height marks were obtained for comparison with Council's GIS data. All of the October 2022 surveyed stormwater pit cover levels were found to be within +/- 0.04 m of the Council GIS data levels confirming the accuracy of the October 2022 survey points collected.

The October 2022 survey also obtained some additional elevation points for comparison with the 2022 LiDAR data. The points obtained for this purpose are located at the netball courts at the Recreation Reserve and road surface points in Bankin Street. This comparison exercise identified that the LiDAR elevations are between 0.00 and 0.05 m higher than the October 2022 surveyed elevations, confirming the accuracy of the acquired LiDAR ground elevation data.

Keele & Drape imperial contour plans dating back to the first half of the 1900s show a semi uniform ground slope fall of 1 in 700 in a due westerly direction for the area surrounding the Katandra West township. This is also consistent with the 2022 LiDAR data.

4.6 Previous Reports

The following reports of relevance to flooding and / or drainage at Katandra West were sourced.

- Broken River Catchment Floods – October 1993 (HydroTechnology, March 1995). This report documents the October 1993 flood event within the Broken River catchment including the creek system north of the Broken River, east of Shepparton.
- Katandra West – Stormwater Retardation Basin Investigation (Chris Smith & Associates, November 2007) This report documents water quantity sizing details for various options for a retarding basin at the site of the existing basin at the north end of Black Street.
- Katandra West – Stormwater Retardation & Water Quality Improvement Investigation (Chris Smith & Associates, January 2008). This report documents water quality and quantity sizing details for various options for a retarding basin at the site of the existing basin at the north end of Black Street.
- Guilfus Congupna Catchment Drainage Course Declaration Management Plan (Goulburn-Murray Water, April 2020). This report documents details relating to the declaration of a drainage course over Guilfus Creek and Congupna Creek, both located to the west of Katandra West.

4.7 Rural Drainage Infrastructure

G-MW supplied GIS data for their rural drainage and supply channel networks in the vicinity of Katandra West.

G-MW also provided some details of Drainage Declaration Course (DCD) work undertaken for the Congupna and Guilfus Creeks. The DCD project involves the declaration of natural drainage courses under the Victorian Water Act which then allows identified flow obstructions to be removed to restore flow along natural flow paths to that which occurred under natural conditions. A DCD Management Plan has been prepared for Guilfus and Congupana Creeks (Goulburn-Murray Water, April 2020).

4.8 Stormwater Drainage Infrastructure

GSCC supplied data for their stormwater drainage infrastructure at Katandra West. Stormwater drainage infrastructure is shown on Figure 8. Details are described as follows:

- Hickey Road Basin catchment (6 ha):
 - Pipe stormwater drains servicing the east end of Bankin Street east, King Street, Lincoln Street east and Donohue Street discharge to a retarding basin on the south side of Hickey Road adjoining the Recreation Reserve.
 - Outflows from the basin are pumped via a 150 mm diameter pipe into G-MW Drain 3/12 on the north side of the basin at Hickey Road.
- Black Street Basin catchment (18 ha):
 - Pipe drains from Lincoln Street, Bankin Street, Queen Street, Coleman Street and Black Street discharge to a retarding basin at the northern end of Black Street.
 - Outflows from the basin are pumped via a pipe drain north-westwards to G-MW Drain 2/12.
- Burgman Street Basin catchment (5 ha – part of Black Street basin catchment)
 - Pipe drainage in Burgman Street drains into a basin located north west of the Black Street basin. Outflows from this basin are pumped via the Black Street basin pump to G-MW Drain 2/12.
- Properties on either side of Hickey Road west of Union Road drain into G-MW Drain 3/12. These are shown as Kat3 and Kat 4 in Figure 8.

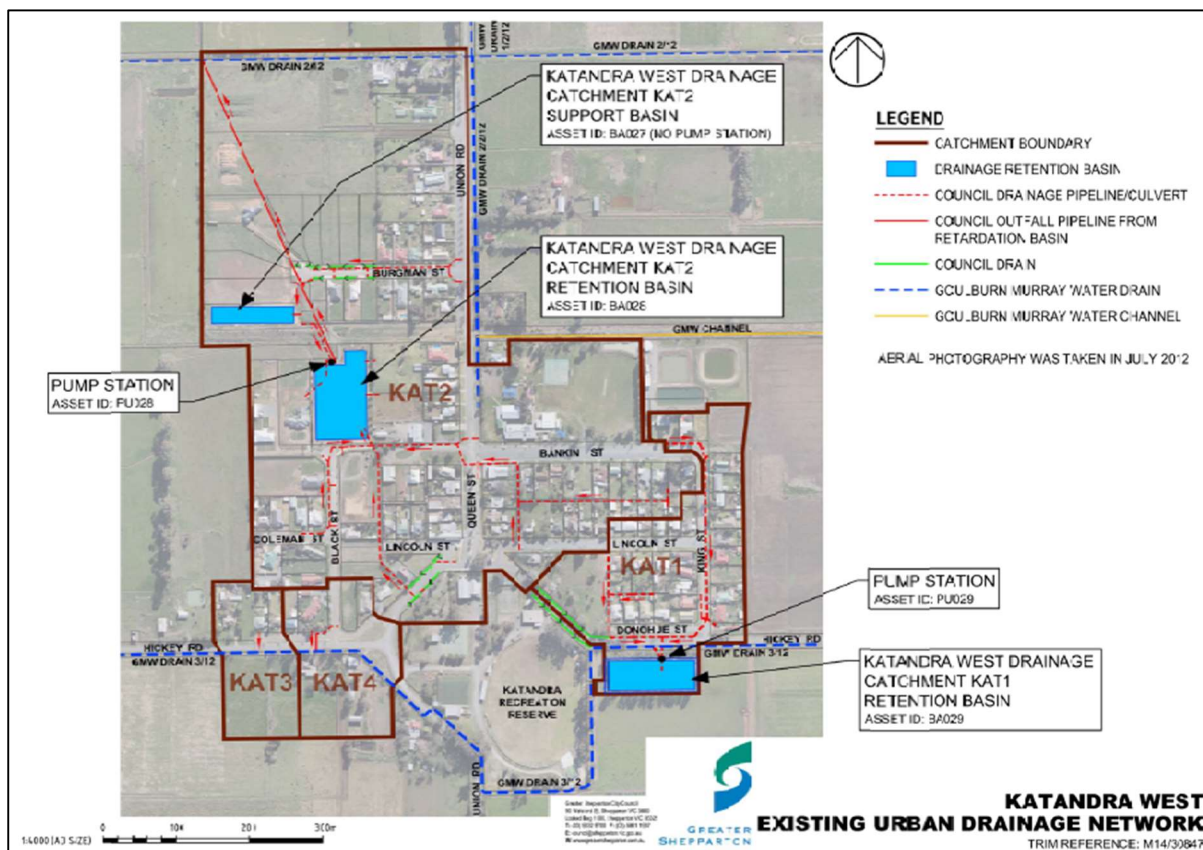


Figure 8 Stormwater Drainage Infrastructure (GSCC supplied plan)

Council has advised that:

- Hickey Road basin has been enlarged since the 2012 flood event.
- Black Street basin was upgraded in 2019/20.
- The pipe drain works west of the property between 199 and 201 Union Road were completed prior to 2022.

4.9 Review of March 2012 Flood Event

The March 2012 flood was a widespread event across northern and north eastern Victoria. It was particularly notable for having some of the highest ever recorded cumulative seven day rainfall totals of up to 300 mm.

Tungamah located 30 km to the east of Katandra West recorded a seven day cumulative total of 300 mm between the 27 February and the 4 March. This notably included 124 mm on the 28 February and 103 mm on the 1 March (to 9am on these days), with no rainfall on the 29 February leap year day between these two peak rainfall days.

By comparison, Dookie Agricultural College located 20 km south-east of Katandra West recorded 92 mm on the 28 February and 81 mm on the 1 March. Numurkah located 17 km north-west of Katandra West recorded 100 mm on the 28 February and 79 mm on the 1 March.

Flooding in March 20012 was severe in the creek systems north of Katandra West including the Nine Mile Creek, Boosey Creek and Broken Creek.

Rainfall data from the nearest BOM daily read stations to Katandra West are summarised in Table 5. The highest 24 hour totals occurred in the preceding 24 hours to 9am on the 28 February (between 92 and 124 mm) and the 24 hours to 9am on the 1 March (between 79 and 103 mm). No rainfall was recorded for the 24 hours to 9am on the 29 February (2012 being a leap year).

Table 5 Rainfall Data – February / March 2012 Event

Source Station	Date	Rainfall to 9am (mm)
Numurkah	28.2.2012	100.0
	29.2.2012	0.0
	1.3.2012	79.0
	2.3.2012	0.0
Tungamah	28.2.2012	124.4
	29.2.2012	0.0
	1.3.2012	103.6
	2.3.2012	8.4
Dookie Agricultural College	28.2.2012	92.6
	29.2.2012	0.0
	1.3.2012	81.8
	2.3.2012	0.2

The owner/occupant of 205 Davy Road, located 3 km north east of Katandra West, advised of daily rainfall totals recorded during the February / March 2012 event as follows:

- 28 February - 142 mm
- 29 February – 0 mm
- 1 March – 92 mm
- 2 March – 0 mm

The above privately recorded rainfall figures for 2012 indicate that the rainfall experienced at Katandra West was typical of the surrounding area for the 1 March daily total and even higher than the surrounding areas for the 28 February daily total. The seven day cumulative total (27 February to 4 March inclusive) at 205 Davy Road was 270 mm, exceeded only by the cumulative total at Tungamah of 300 mm.

A comparison of the available 2012 rainfall event data with design IFD data (refer to Table 4) reveals the following:

- Assuming a 72 hour cumulative total of 230 mm at Katandra West for the 2012 event, this is equivalent to well in excess of a 1% AEP 72 hour duration design rainfall event.
- Assuming a 24 hour total of 140 mm at Katandra West, this is also well in excess of a 1% AEP 24 hour duration design rainfall event.

Given the above, it is inevitable that the capacities of both the stormwater drainage system and the G-MW drains will have been exceeded during the February/March 2012 event.

Although rainfall for the 24 hours to 9am on the 1 March was not as high as that compared to the 24 hours to 9am on the 28 February, flooding at Katandra West is expected to have been more severe on the 1 March due to the catchment being in a saturated condition prior to the rainfall. Media reports at the time would appear to support this. Shepparton News acquired aerial photographs taken just after 1pm on the 1 March 2022 show widespread inundation in parts of the town (refer to Figure 4). Anecdotal accounts would suggest that the aerial photography was taken close to the peak of flooding.

4.10 Review of October 1993 Flood Event

The October 1993 flood was a widespread event in northern and north eastern Victoria. Flooding recorded for the Broken River was the most severe on record. Consequently there were record amounts of breakaway flows into the creek network north of the Broken River on the east side of Shepparton. This resulted in severe flooding along Daintons Creek, Pine Lodge Creek and Congupna Creek resulting in extensive rural flooding along these creek routes.

Congupna Creek overflows into Guilfus Creek which is the closest waterway to Katandra West. Flooding along both Congupna Creek and Guilfus Creek was extensive but had no bearing on flooding conditions at the township of Katandra West.

There was some flooding at Katandra West township during the October 1993 flood. This will have been due to local runoff from the rainfall that occurred in the 24 hours prior to 9am on the 4 October.

Rainfall data from the nearest BOM daily read stations is summarised in Table 6. No data is available at Katandra West.

Regional data strongly suggests that the majority of rainfall in this event occurred in the 24 hours prior to 9am on the 4 October. Assuming a total of 100 mm at Katandra West for this period (high end estimate), this would be equivalent to a 2% AEP 24 hour duration design rainfall event. Given this, some flooding at Katandra West from local runoff would therefore be expected.

Table 6 Rainfall Data – October 1993 Event

Source Station	Date (rainfall to 9am on given date)	Rainfall (mm)
Tungamah	1.10.1993	4.0
	2.10.1993	18.8
	3.10.1993	3.6
	4.10.1993	60.8
Dookie Agricultural College	1.10.1993	5.4
	2.10.1993	11.6
	3 and 4.10.1993	111.4

4.11 Review of October 2022 Flood Event

A widespread flood occurred across large parts of Victoria in October 2022. Over a 40 hour period commencing on the morning of Wednesday 12 October 2022, a total of 76 mm of rainfall was recorded at Katandra West (private gauge recorded total). Surrounding area BoM recorded totals were similar (Shepparton 76 mm, Yarrawonga 67 mm, Wangaratta 66 mm).

Rainfall intensities for this event were generally only moderate. Based on the Shepparton AWS data, the maximum one hour rainfall was only 5 mm, occurring on the Thursday evening towards the later part of the event.

Significant rainfall ceased at about midnight on the Thursday. A comparison with BOM design IFD data (refer to Table 3) revealed the following equivalent rainfall severity for the event:

- 76 mm of rainfall in 40 hours is equivalent to a 15 % AEP design rainfall event (8 year ARI event).
- 57 mm of rainfall in 24 hours is equivalent to a 20% AEP design rainfall event (4.5 year ARI event).

An on-site inspection at Katandra West between 4pm and 6pm on the 13 October (Thursday afternoon) at which point approximately 53mm of rainfall had occurred revealed the following:

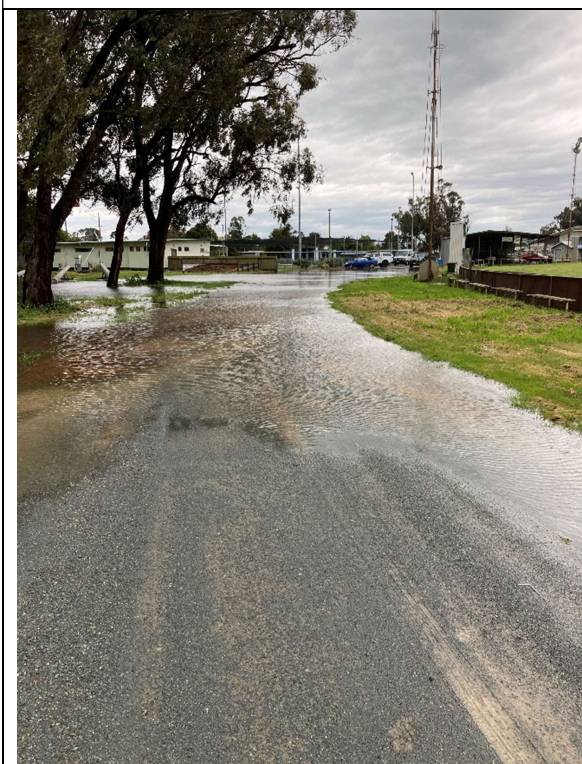
- Black Street retarding basin was at most 20% full (refer to Figure 9 - Photograph 1), Burgman Street basin was empty and the Hickey Road basin was less than a third full.
- The pumps at the Black Street and Hickey Road basins were both in operation.
- The intersection of Queen Street and Bankin Street was free of flooding.
- Flows in G-MW drains confined to in-bank. Drain 3/12 flowing close to full (refer to Figure 9, Photograph 2).
- A considerable amount of surface water was present at the south eastern corner of the Bowling Club (refer to Figure 9 – Photograph 3), covering the internal road and surrounds, but not impacting on any buildings.



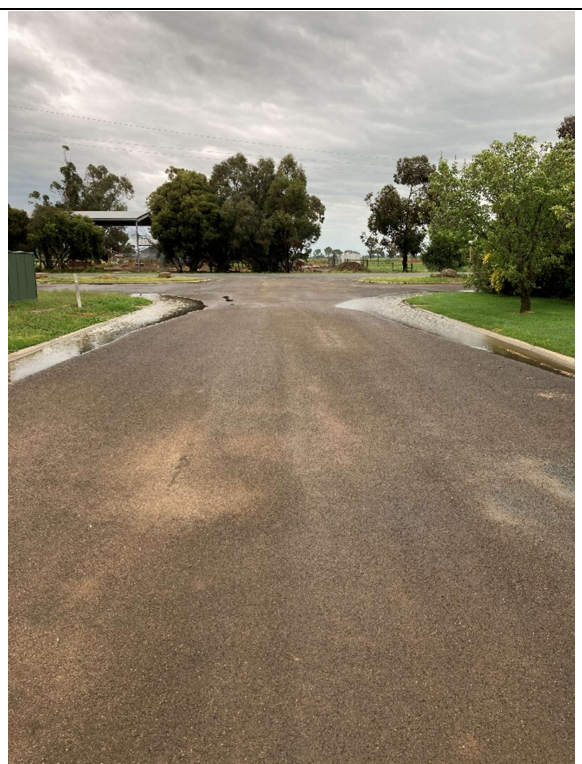
Photograph 1 – Black Street retarding basin – basin 20% full



Photograph 2 – G-MW Drain 3/12 looking west across Union Road



Photograph 3 – Recreation Reserve – view towards Bowling Club



Photograph 4 – Black Street at Hickey Road – minor roadway flooding

Figure 9 Photographs – October 2022 Flood Event

- Local backwater flooding from Drain 3/12 present at the SEPs at the south end of Black Street (refer to Figure 9 – Photograph 4).
- Nuisance level flooding at the western end of Bankin Street.

Advice from a local resident based on their observations on the Friday morning (14 October 2022) approximately 8 hours after the cessation of rainfall was:

- Black Street retarding basin no more than 33% full.
- G-MW Drain 3/12 did not overtop Union Road at any time.
- The intersection of Queen Street and Bankin Street was free of flooding.
- No serious flooding issues / impacts within the town.

The above observations indicate that past drainage problems evident at the corner of Queen Street and Bankin Street appear to have been rectified by Council stormwater improvement works undertaken in recent years.

4.12 Review of Pre 1993 Events

Other flood years prior to 1993 which have been previously nominated as significant floods at Katandra West are 1919, 1939, 1956 and 1974. These events are described as follows:

- **1919 Event.** A review of available BOM daily rainfall data for 1919 does not reveal any 24 hour rainfall totals over 50 mm. A total of 46 mm was recorded for the 24 hours to 9am on the 18 February at Invergordon.
- **1939 Event.** The Katandra West BOM rainfall station was operating during 1939. The highest 24 hour total recorded in 1939 was 49 mm on the 14 April. Consecutive day totals of 42 mm and 45 mm were recorded on the 26 and 27 February.
- **1956 Event.** The Katandra West rainfall station was operating during 1956. The highest 24 hour total recorded in 1956 was 60 mm on the 13 March. The next highest 24 hour total was 45 mm on the 16 May.
- **1974 Event.** The Katandra West rainfall station was operating during 1974. The highest 24 hour total recorded in 1974 was 38 mm on the 15 May, following 30 mm the preceding day.

No further detailed accounts are available for the above events.

4.13 Post March 2012 - Council Katandra West Flood Mitigation Project

GSCC undertook a flooding and drainage improvement project following the February / March 2012 flood event. Available documentation suggests that the project commenced with a community meeting at Katandra on the 30 April 2012, at which residents in attendance made suggestion and comments in relation to possible actions to alleviate flooding and drainage issues.

Council subsequently implemented or were in the process of implementing all of the identified actions by mid 2013 as revealed by Council reports. Actions implemented included:

- Installation of new culverts at requested locations.
- Installation of flap (non return) gates to prevent backflow flooding (e.g. at stormwater discharge points into G-MW drains).
- Clearing of blocked drains.
- Development of an access flood plan with G-MW to include strategic access to G-MW irrigation and drainage channels during extreme emergency flood events.

- Development of a township ‘Flood Plan’ that outlines details, procedures, operational requirements and thresholds for actions in future events. The document ‘Katandra West – Township Local Knowledge & Information Guide’ (September 2013) represents the output of this action.
- Investigation into a possible upgrade of the Black Street retarding basin. Council’s investigation concluded that the basin was not designed to cope with an influx of rural runoff from outside the town. No further retardation works were deemed required (as at mid 2013).
- Investigation for increasing the bank height of Channel 2/24 to prevent overflow back into Queen Street. Marked as completed.
- Investigation into the diversion of rural runoff on the east side of town. Works were subsequently undertaken in early 2013 – regrading of Hickey Road north side table drain, replacement culvert installed at Hickey Road entrance with one way flap.

4.14 Emergency Response Reports

4.14.1 GSCC – Township Local Knowledge & Information Guide (September 2013)

This 2013 document includes a description of rainfall threshold impacts which is based on discussions with local residents and their knowledge of past flood events. The report includes the following descriptions:

- March 2012 flood – described as a flash flood which resulted in the inundation of the town.
- September 2010, December 2010 and October 1993 – report states that Katandra West township was not flooded. Creek system flooded in 1993 (as a result of inflows from Broken River) but does not impact on the town.
- Possible impacts for varying rainfall levels:
 - The first 50mm or so of localised rainfall should not cause any significant flooding.
 - 75mm+ over a wide area may cause minor flooding.
 - 125mm+ of localised rainfall may cause widespread minor to moderate flooding.
 - 150mm+ of localised rainfall may cause moderate flooding and some major flooding.
 - 200mm+ of localised rainfall will most likely result in major flooding.
- Actions during flood events:
 - Check that the pumps from the Hickey Road detention basin and the Bankin Street detention basin are operating.
 - Check that the flap gate on the pipe outlet into the GMW drain at Union Road is operating.
 - Consider delivery of 80 m³ of sand and 2,000 sandbags to the carpark in front of the Recreation Reserve.

4.14.2 GSCC - Flood Emergency Plan – A Sub-Plan of the MEMP (August 2018)

Appendix C6 of this 2018 document is specific to Katandra West. It draws heavily on the 2013 Township Local Knowledge and Information Guide. It documents:

- Overview of flooding consequences. States that flooding at Katandra West is due to local runoff (town runoff and adjoining farmland runoff), not creek flooding.
- Flood history focusing on March 2012 and October 1993 events. March 2012 described as a flash flood event. The other flood years nominated are 1919, 1939, 1956 and 1974. Indicates that no homes in the town ‘should be inundated’.
- Flood Impacts for rainfall thresholds of 50, 75, 125, 150 and 200mm (based on local knowledge) as per the 2013 Township Local Knowledge & Information Guide report.

4.14.3 VICSES - Local Flood Guide – Katandra West (2020)

The Local Flood Guide – Katandra West covers:

- A description of flooding (major overland flow).
- Katandra West rainfall thresholds and expected impacts (50 mm, 75 mm, 125 mm, 150mm and 200 mm) as per the 2013 Township Local Knowledge & Information Guide report.
- Explanation of generic BOM and SES warnings / alerts.
- Generic guidelines for preparing for floods.

5 Mapping

5.1 Approach

This scoping study project has not encompassed any hydraulic modelling. Modern flood studies use two dimensional hydraulic modelling techniques to simulate flooding conditions, producing a flood surface for a range of flow conditions. Outputs include the varying flood height, depth, velocity and extent within the model area.

The intent of this scoping study was to produce some rudimentary flood mapping outputs with the available data, without going to the extent of undertaking hydrologic and hydraulic modelling as is the case for a flood study.

One of the principal outputs of a flood study is the 1% AEP flood heights. The 1% AEP flood heights are commonly used for setting minimum floor level elevations for new development.

Given the absence of detailed historical flood data at Katandra West, it is not possible to definitively assign the March 2012 event as equivalent to a specific AEP event. Based however on the available rainfall data for the 2012 event and the clear anecdotal accounts that indicate the event to be the most severe flooding that has occurred at Katandra West in living memory, it is reasonable to conclude that the Katandra West 2012 flood was equivalent to in the vicinity of a 1% AEP event. The rainfall data review of the 2012 event supports this assertion (refer to Section 4.9).

Mapping undertaken as part of this scoping study has therefore focused on generating flood height contours using the available March 2012 flood height data points.

5.2 Point Flood Heights

Flood height data available at Katandra West is limited to the following March 2012 data (refer to Section 4.4.1):

- 22 flood height marks originally surveyed in 2012 shortly after the flood event and re-surveyed in October 2022 as part of the current project.
- 7 flood height marks identified and surveyed in October 2022 as part of the current project.

The location of the above flood height marks is shown on Figure 7. The flood height mark elevations are given in Table 4.

The re-survey of the 22 previously surveyed 2012 event flood height marks identified significant differences. Differences exceeding 0.10 m were found at the following flood marks:

- FM201 – 0.16 m lower
- FM203 – 0.13 m lower
- FM209 – 0.40 m lower
- FM210 – 0.22 m lower
- FM212 – 0.17 m higher
- FM213 – 0.19 m higher
- FM214 – 0.10 m higher
- FM216 – 0.29 m lower
- FM217 – 0.31 m higher
- FM218 – 0.23 m higher
- FM219 – 0.38 m higher
- FM220 – 0.52 m higher

- FM221 – 0.25 m higher

The above are significant differences and indicate that there were some problems associated with the accuracy of the previous survey undertaken in the aftermath of the March 2012 flood.

5.3 Catchment Area

Flooding at Katandra West is due to runoff from the immediate township area and the surrounding rural area which is draining towards the town. Given the rural land surrounding Katandra West falls in a westerly direction, the local catchment area is limited to the rural area on the east side of the town.

The indicative catchment area draining to Katandra West is shown on Figure 10 as defined using the LiDAR data. An indicative catchment area of up to 160 ha drains to G-MW Drain 3/12. A catchment area of up to 60 ha drains to Drain 2/2/12.

The catchment area of Drain 3/12 extends as far east as the East Goulburn Main Channel, located 3km east of Katandra West. In reality, some runoff from this catchment may be diverted by the roadside drains (e.g. Inverness Road) and the farm supply channel and drainage channel infrastructure present. Many farms have reuse systems (open drains and storages) set up for rainfall runoff and irrigation runoff reuse. An example of a farm reuse storage is located 200 m south of the Recreation Reserve.

The catchment area of Drain 2/2/12 is shown to extend as far east as the Inverness Road, located 2km east of Katandra West. The actual catchment area is likely to be smaller given diversions due to farm infrastructure.

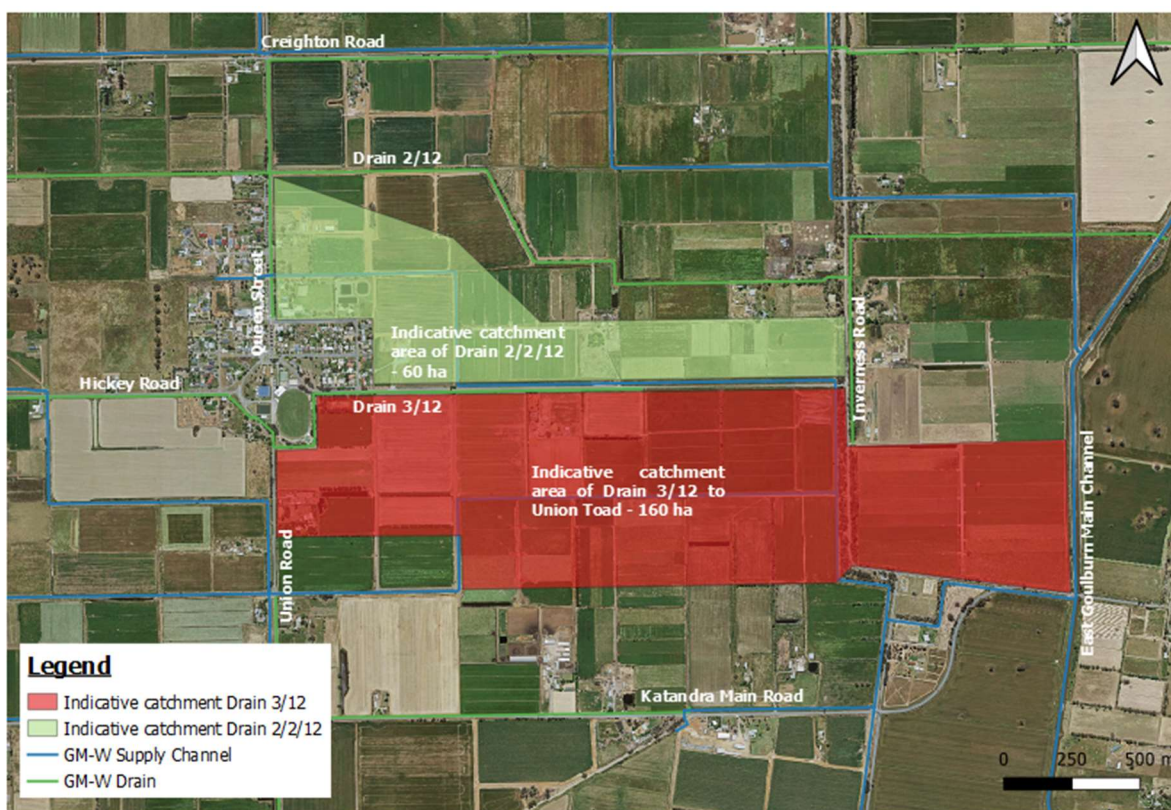


Figure 10 **Catchment Plan**

Comments on man-made features impacting on the discharge of rural runoff into Katandra West are provided as follows:

- G-MW Drains (refer to Figures 3 and 10). The capacity of the G-MW drains at Katandra West (Drain 3/12, Drain 2/2/12 and Drain 2/12) are not designed to service a 1% AEP rainfall event. Consequently in events as severe as the March 2012 flood, the drains will have insufficient capacity to confine inflows to within the open channel drains.
- Stormwater Drains (refer to Figure 3). The Katandra West stormwater infrastructure consists of a pipe and pit collector network discharging into three retarding basins. The basins are designed such that the pumped peak outflows are reduced to avoid overloading the receiving G-MW drain. The capacity of the stormwater system infrastructure has not been analysed as part of this study, however the pipe system is likely to have at most 20% AEP (1 in 4.5 year ARI) capacity.

Given the above drainage system capacity constraints, it is inevitable that some surface flooding will occur in severe rainfall events such as the March 2012 flood.

5.4 Flood Height Contours

The available flood height data was used to define interpolated flood height contours.

The draft flood height contours are shown in Figure 11. Comments on the flood height contouring process follows below.

5.4.1 Recreation Reserve Area

Outflows from the Recreation Reserve area are via a stormwater pipe outlet (300 mm diameter) under Hickey Road located 100 m north of the road entry point into the reserve. This pipe was blocked off as part of flood response measures in 2012 to alleviate downstream flooding impacts. Sand bagging of the west side of Hickey Road confined outflows from the Recreation Reserve to strategic locations.

Flood levels within the Recreation Reserve appear to have pooled to approximately 114.2 to 114.3 m AHD based on flood height marks 303, 206, 207 and KW7 (refer to Figure 7 and Table 4). Mark 202 is considered to be suspect (too high) at 114.38 m AHD.

Consequently a flood height contour of 114.3 m AHD has been adopted through the Recreation Reserve, reducing to 114.2 m AHD at Union Road / Hickey Road.

Impacts in this area in 2012 included above floor flooding of the netball pavilion (floor level of the pavilion is at ground level – approximately 114.05 m AHD). No other buildings are known to have been flooded to above floor level in this area.

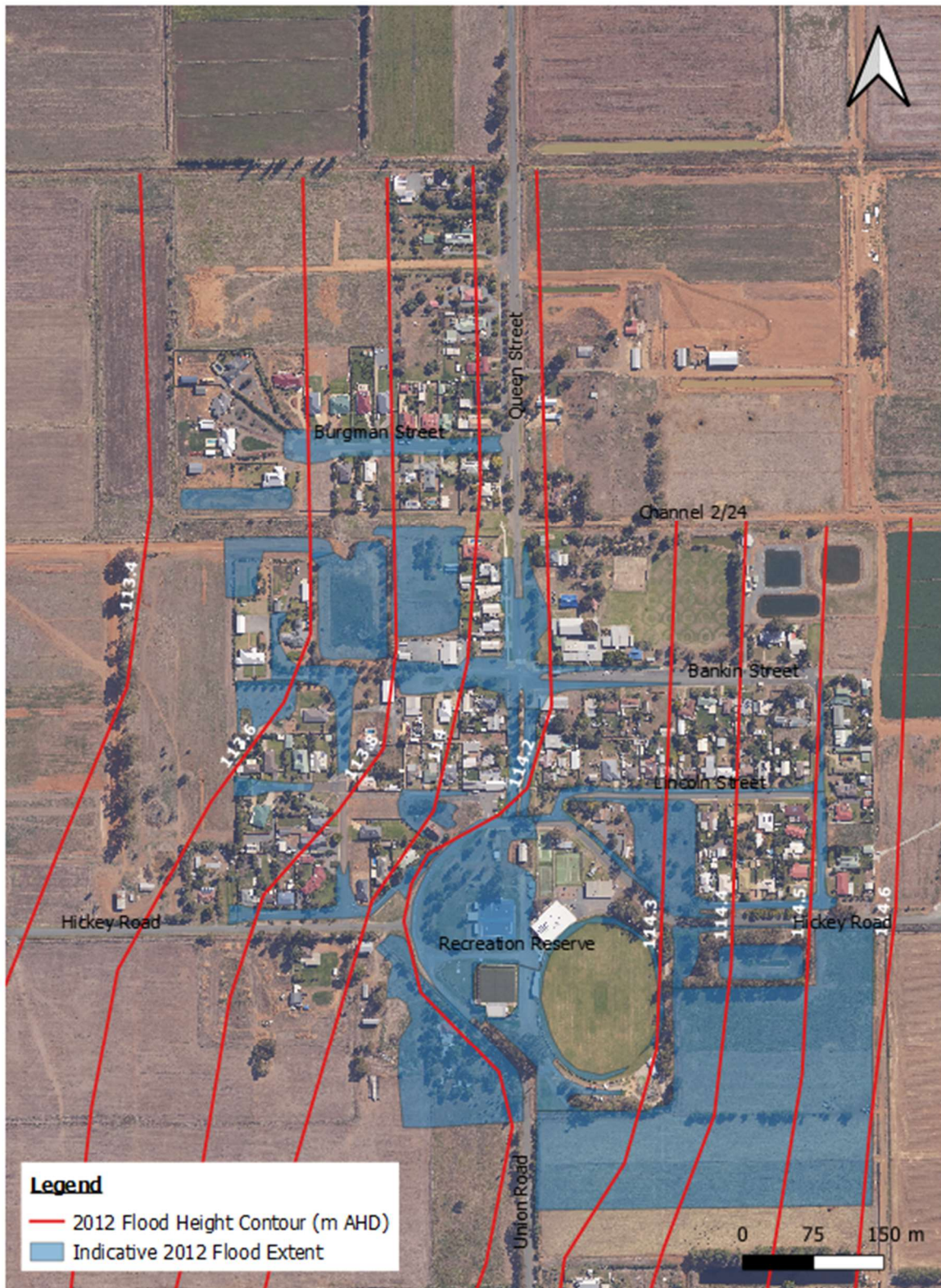


Figure 11 March 2012 Interpolated Flood Height Contours

5.4.2 East Side of Queen Street – Between Hickey Road and Channel 2/24

Flood height mark 221 in Lincoln Street appears to be high in comparison with marks KW1, 212, 218, 219 and 220 (refer to Figure 7 and Table 4).

A flood height contour of 114.2 m AHD has been adopted on the east side of Queen Street, coinciding with an indicative flood depth of 0.2m. A flood height contour of 114.6 m AHD has been adopted on the eastern side of King Street, coinciding with an indicative depth of 0.1m.

There are no known instances of above floor flooding in this area. There are no obvious low points at higher risk of serious flooding impacts.

The remnants of the banks at Channel 2/24 are elevated at 114.5 m AHD, separating any surface flows on either side of the east-west channel route (open supply channel was replaced with a supply pipe prior to 2012).

5.4.3 East Side of Queen Street – North of Channel 2/24

This area is zoned rural. There are no available flood height marks in this area. Flood height contours have not been defined for this area.

The terrain in this area slopes gently from east to west towards Queen Street / Union Road. Runoff reaching Queen Street discharges into a small G-MW drain (Drain 2/2/12) which conveys flows northwards and into Drain 2/12 (refer to Figure 3).

Any surface flooding in this area is expected to be shallow (less than 0.2 m deep) and relatively slow moving, consistent with flooding conditions in the broader surrounds.

5.4.4 West Side of Queen Street – South of Hickey Road

This area is zoned rural. Although there are no available flood height marks in this area, flood height contours have been defined based on the local ground surface levels and the flood height marks north of Hickey Road.

The house on the west side of Union Road opposite the Bowling Club was close to being subject to above floor flooding in 2012. This may have been marginally exacerbated by the sandbagging along Hickey Road. Once flood respondents became aware of the risk to the house opposite the Bowling Club, they allowed outflows through the sandbag line in the vicinity of Lincoln Street.

Given the terrain conditions present (gentle westerly fall), any surface flooding of this area is expected to be shallow (less than 0.2 m deep) and slow moving.

5.4.5 West Side of Queen Street – Between Hickey Road and Channel 2/24

Flood height contours have been defined for this area. Flood levels fall from approximately 114.0 m AHD on the west side of Queen Street to approximately 113.6 m AHD on the western fringe of the township zone.

Based on the assigned flood height contours, flood depths are generally less than 0.2 m except for:

- North end of Black Street within the road reserve (up to 0.5 m).
- Within the west side roadside drain in Queen Street north of Bankin Street (up to 0.4 m)
- Area on east side of the Black Street retarding basin (up to 0.3 m).

The Black Street retarding basin itself (base level 111.4 m AHD) has an overflow level of approximately 113.6 to 113.7 m AHD. The basin overflows informally at its north west corner. It is noted that there were earthworks undertaken during 2022 along the basin overflow path which have occurred after the LiDAR data was obtained.

There is no known above floor flooding in this area. Infill development is continuing in this area.

5.4.6 West Side of Queen Street – Channel 2/24 and Drain 2/12

This area is township zoned. The north western part of this area is being developed.

The only flood height mark in this area is mark 216 (113.27 m AHD) in Burgman Street. The western half of Burgman Street is depressed relative to the surrounding area, with the potential to pool to as high as 113.8 m AHD. The lower recorded flood height in 2012 suggests that this is unlikely, due to the stormwater pipe system capacity.

The Burgman Street retarding basin (base level – 112.3 m AHD) has an overflow level of 113.4 m AHD. The basin will not threaten any of the houses in Burgman Street with backwater flooding (all houses are located on ground at least 113.8 m AHD high).

Ground levels within the area under development north of the Burgman Street estate vary from 113.8 to 113.4 m AHD. Flooding in this area is expected to be limited to shallow, slow moving inundation, typically less than 0.2 m deep.

5.5 Discussion – Flood Risk in Future Development Areas

5.5.1 Property on north side Burgman Street Estate

Residential development is currently occurring in the north western corner of the town, on the north side of the Burgman Street estate (refer to Figure 12). This 4.7 ha area is zoned Township. Ground level elevations generally vary from 113.8 to 113.4 m AHD.

There are no recorded flood height marks in this area. The nearest recorded flood height mark is located in Burgman Street (mark 216 – 113.27 m AHD – Figure 7 and Table 4).

An aerial photograph of the March 2012 flood (refer to Figure 4) shows this property to not be subject to inundation at the time the photograph was taken, which is thought to have been close to when peak flooding occurred.

No flood based development controls therefore appear warranted for this property.



Figure 12 Development Sites

5.5.2 Potential Development – Area bounded by Hickey Road, Union Road & Channel 24

The 30 ha area bounded by Hickey Road, Union Road and Channel 24 (refer to Figure 12) was flagged as a possible future development zone at the CRG meeting held during September 2022. Parts of this site are visible in an aerial photograph of the March 2012 flood. Shallow flooding is evident adjoining Union Road, with overflows across Union Road in the vicinity of the G-MW Drain 3/12 culvert crossing.

Ground level elevation fall in a westerly direction from approximately 114.0 m AHD at Union Road to 113.2 m AHD at the western limit of this area.

Flood height contours are defined for most of this zone (refer to Figure 11), based on the nearest 2012 recorded flood height marks (Mark 204 – 114.34 m AHD, Mark 207 – 114.26 m AHD and Mark 209 – 113.79 m AHD, as per Figure 7 and Table 4).

Given the relatively benign flooding conditions associated with local runoff, future rezoning and residential development is considered likely to be acceptable subject to minimum floor level controls based on the available 2012 flood height marks and defined flood height contours.

6 Other Issues

6.1 Content for Future Updates to Flood Documents

Suggested content for adding to future updates of the following documents is provided in Appendix B:

- Local Flood Guide – Katandra West (undated).
- Flood Emergency Plan – A Sub-Plan of the Municipal Emergency Management Plan (August 2018).

The content in Appendix B draws on the knowledge derived from this scoping study.

6.2 Comments on 2012 Flood Response Actions

Flood response actions in 2012 included sandbagging of the north side of Hickey Road around the north western side of the Recreation Reserve, with outflows limited to controlled release through openings in the sandbag line at strategic locations.

It is not clear whether the sandbagging in Hickey Road prevented the occurrence of above floor flooding. This may or may not have been the case.

A minor issue noted is that the surface inlet to the 300 mm diameter pipe drain under Hickey Road, 80 m north of the entrance to the Recreation Reserve was purposely blocked off in 2012, partly due to the Black Street retarding basin pump being inoperable. This pipe inlet would be better left open in future floods.

It is important that the pumps at both the Hickey Road retarding basin and the Black Street retarding basin are operating during flood events. This was not the case in 2012. Council are understood to now have mandatory on-site checks of pumps at six monthly intervals and same day inspections whenever in excess of 10 mm of rainfall is recorded.

6.3 Need for Flood Overlays at Katandra West Township

Areas subject to inundation during the 2012 flood within or fringing the township area are shown on Figure 10. These areas have been largely defined using the available aerial photography of this event (refer to report cover photograph and Figure 4).

None of the areas inundated would be described as representative of 'Floodway' conditions, with the possible exception of the retarding basins and the G-MW drains. The inundated areas are representative of 'Land Subject to Inundation Overlay' (LSIO) type conditions (i.e. relatively shallow depth and low velocity).

Council and the Goulburn Broken CMA could consider adding the defined inundated areas shown on Figure 11 as new Land Subject to Inundation Overlay areas when the planning scheme overlays are next updated.

6.4 Need for a Flood Study / Floodplain Risk Management Study

No houses are known to have flooded to above floor level at the Katandra West township in the 2012 flood. Given that the 2012 flood appears to be the most severe flood on record, and that not everything went right during the flood (e.g. pump at the Black Street retarding basin was not working), the flood risks to existing development at Katandra West township can be described as low.

Flood studies and subsequent floodplain risk management studies are generally initiated as a result of serious flooding impacts being present (e.g. confirmed above floor flooding of habitable buildings). This scoping study has confirmed that is not the case at Katandra West.

If the absence of serious flooding impacts was due to the 'by chance' absence of severe rainfall events over a protracted timeframe, then this would still give cause to consider commissioning a flood study. This is not the case however at Katandra West, as the rainfall data for the 2012 event suggests that the 2012 event was equivalent to in excess of a 1% AEP design rainfall event.

The other factor which may have prompted consideration for initiating a flood study is if future development at Katandra West is located in areas where the flood risk is higher and / or not well defined. Again this is not the case at Katandra West.

The above conclusions are primarily the result of the relatively benign flooding conditions present. There is no riverine flooding at Katandra West township. The local runoff flooding is limited by the relatively small catchments (refer to Figure 10) and the flat terrain conditions. The flat terrain does not result in notable concentration of flows within depressed confined flow paths, which if present would lead to higher depths and velocities.

This scoping study therefore concludes that a flood study / floodplain risk management study is not required at Katandra West.

Flood mitigation measures are also not required. The focus should be on the ongoing maintenance of the stormwater drainage infrastructure and the receiving G-MW drains. Maintenance should target keeping the system relatively free of blockage (including culverts, flap gates) and having the basin pumps in good working order.

There is no riverine flooding at Katandra West township. Additional flood height and / or flow monitoring warning gauges are not therefore needed or practical.

This scoping study has not reviewed flooding issues for those rural areas within the broader Katandra West district impacted by the Congupna and Guilfus Creeks. There would however appear to be a considerable number of manually read gauges on both these creeks which could offer good intelligence in advance of impending flooding. A review of rural flooding issues is however outside the scope of this project.

7 Summary and Recommendations

7.1 Description of Flooding

This scoping study has assessed flooding conditions within the Katandra West township area only. An assessment of flooding issues in the surrounding rural areas was outside the scope of this project.

A review of the available data, including the additional flood height marks obtained during the scoping study revealed the following flooding conditions at Katandra West township:

- LiDAR terrain data obtained in 2022 has confirmed that the predominant land fall at Katandra West is to the west, at an average gradient of 1 in 700. Floodwater consequently generally discharges from east to west through the town, following the land fall gradient.
- The township of Katandra West is not subject to riverine flooding. The nearest waterway is Guilfus Creek located 4 km to the west of the town. Flooding impacts from Guilfus Creek are limited to low lying rural areas adjoining the creek route.
- Flooding at the Katandra West township is caused by local runoff from the immediate township area and runoff from the rural area on the east side of the town (refer to Figure 10).
- The March 2012 flood event appears to be the most severe historical flood since at least the early 1900s. Based on the available recorded rainfall, the March 2012 event can be attributed as equivalent to in excess of a 1% AEP event.
- Areas subject to flooding within the township are typically shallow (less than 0.2 m deep) and slow moving (velocities less than 0.3 m/s).
- The town stormwater drainage system infrastructure and the receiving G-MW drains have insufficient capacity to confine the volume of local runoff generated in an event as severe as the 2012 flood.
- Flooding inundation durations will vary markedly depending on the intensity and duration of the rainfall. The inundated areas within the township would typically be expected to recede within one to 48 hours after the main rainfall ceases. The 2012 rain event continued for multiple days with the resultant inundation extending over this same timeframe.
- Access from the town to outside the local district was restricted for at least 2 to 3 days after the 2012 rain event ceased due to the closure of the surrounding flood affected local and main roads. This can be even longer during flood events where overflows from the Broken River discharge into the creek system east of Shepparton as occurred in 1993. Under these conditions, external roadway flooding can continue for a week or more after the main rain event.

7.2 Flooding Influences

The dominant influences of flooding conditions at the Katandra West township are summarised as follows:

- Flat terrain with little concentration of flows due to the absence of depressed overland flow paths.
- Absence of natural waterways resulting in the absence of riverine flooding.
- The capacity of the drainage system servicing the township which consists of the stormwater system infrastructure (pits, pipes, retarding basins, basin pumps) and the receiving G-MW drains (refer to Figure 3).
- Any blockages or other factors compromising the drainage system (e.g. retarding basin pump not being operable as was the case in 2012).

7.3 Flooding Impacts / Damages

Investigations did not identify any confirmed instances of above floor flooding of the approximately 100 houses at Katandra West in the 2012 flood, or any other historical flood. Anecdotal accounts suggest that flood levels in 2012 peaked within 50 to 75 mm below the floor level of two houses.

The relatively shallow widespread inundation does not therefore cause serious flooding impacts (e.g. above floor flooding of houses). Flooding impacts are more characteristic of nuisance level impacts, which typically can include:

- Restriction of access both locally and outside the local district (e.g. impacts on people commuting from Katandra West to outside towns for work).
- Deposition of sediment and small debris leading to the need for extensive clean up works after flooding.
- Flooding of minor buildings (e.g. sheds, garages and carports) and damages to the contents of those buildings.

Given the severity of the 2012 event, and the lack of resulting serious flooding impacts in this event, the flood risk at Katandra West township can be described as low.

7.4 Project Flood Data and Map Outputs

The GBCMA obtained 22 flood height marks at Katandra West in the aftermath of the 2012 flood (e.g. peak flood marks on walls, fence posts, power poles etc). The CMA has largely relied on these marks since 2012 for issuing flood advice in response to requests.

As part of this scoping study project, a new survey was undertaken of seven newly identified flood height mark locations, as identified through interviews with local residents and / or drawing on the available aerial 2012 flood photography. The same survey also re-surveyed the previous 22 flood height marks given that there were some apparent discrepancies in the data.

Outputs from the survey included:

- Confirmation of the accuracy of the 2022 acquired LiDAR data.
- Significant adjustments to the elevations for the 22 original 2012 surveyed flood height marks.
- Elevations for the seven new flood height marks.

Details for the above flood height marks are provided in Figure 7 and Table 4.

Some rudimentary flood mapping data was prepared utilising the available flood height marks and the LiDAR terrain data. Mapping outputs prepared consisted of:

- Interpolated flood height contours within the township area. These are shown on Figure 11. The flood height contours are representative of 2012 flooding conditions which in turn are representative of indicative 1% AEP flooding conditions.
- Indicate flood extents within the township area. These are also shown on Figure 11. The extents are representative of 2012 flooding conditions.

The above interpreted flood data outputs will be useful for the following purposes:

- Provision of flood advice by the GBCMA for planning referrals and in response to requests for site flood information.
- Possible future inclusion of the extents as additions to the LSIO within GSCC's planning scheme maps.

7.5 Future Studies and Mitigation Measures

Flood studies and subsequent floodplain risk management studies are generally initiated by authorities as a result of serious flooding impacts being present (e.g. confirmed above floor flooding of habitable buildings). This scoping study has confirmed that this is not the case at Katandra West.

This scoping study therefore concludes that a future flood study / floodplain risk management study is not required for Katandra West.

Similarly flood mitigation measures are not required given the absence of riverine flooding and the benign nature of the local runoff flooding.

7.6 Ongoing Flood / Drainage Management Activities

Activities for which GSCC are responsible for which assist with ensuring that flooding impacts are minimised are the maintenance of the stormwater system infrastructure (refer to Figure 3). This includes:

- Clearing of any blockages in the pit and pipe collector network. Repairs to any defects.
- Upkeep and monitoring of the operating condition of the pumps at the Hickey Road and Black Street retarding basins.
- Clearing of any blockages in the pipe drains between the retarding basins and the receiving G-MW drains.

Activities for which G-MW are responsible for which similarly assist in ensuring that flood impacts are minimised are the maintenance of the drains which receive the stormwater inflows (i.e. Drains 2/12, Drain 2/2/12 and Drain 3/12 – refer to Figure 3). This includes:

- Clearing of any excessive blockages in the open drains including sediment deposition, organic matter deposition, debris deposition.
- Similarly keeping clear and repairing any defects for structures along the drain routes including road crossing culverts, property access culverts.

7.7 Other Outcomes

Included in Section 6.1 of this report is some content which can be added to the 'Local Flood Guide – Katandra West' when it is next scheduled to be updated.

Similarly in Section 6.2 of this report is some content which can be added to the GSCC Flood Emergency Plan (which is a sub plan of the Municipal Emergency Management Plan) when it is next scheduled for update.

8 References

Chris Smith & Associates (November 2007). Katandra West – Stormwater Retardation Basin Investigation. Prepared for Greater Shepparton City Council.

Chris Smith & Associates (January 2008). Katandra West – Stormwater Retardation & Water Quality Improvement Investigation. Prepared for Greater Shepparton City Council.

Goulburn Broken Catchment Management Authority (2018). Goulburn Broken Regional Floodplain Management Strategy 2018-2028.

Greater Shepparton City Council (September 2013). Katandra West – Township Local Knowledge & Information Guide.

Greater Shepparton City Council (updated December 2021, Version 2.5). Greater Shepparton City Council Flood Emergency Plan – A Sub-Plan of the Municipal Emergency Management Plan.

HydroTechnology (1995). Documentation and Review of 1993 Victorian Floods – Broken River Catchment Floods October 1993 – Volume 4. Prepared for the Department of Conservation and Natural Resources.

VICSES (updated 2020). Local Flood Guide – Katandra West.

APPENDIX A Flood Height Survey Data – 26 October 2022

Survey was undertaken on site at Katandra West on the 26 October 2022. Surveyor – Chem Smith – SPIIRE Shepparton, Engineer – Trevor Clark – Confluence.

Vertical datum are derived from GNSS observations vide Katandra PM37 (RL113.990)

Horizontal datum are derived from GNSS Vicpos observations checked onto Katandra PM60

Vicpos co-ordinates are grid co-ordinates on MGA94

Point ID	Easting	Northing	Elevation	Date	Comments
200	370519.09	5989913.80	114.16	26/10/2022	Level on Concrete (Store)
201	370408.42	5989906.53	113.92	26/10/2022	Level on Bollard
202	370484.91	5989781.22	114.38	26/10/2022	Level on Pavilion Wall
203	370430.12	5989819.77	114.29	26/10/2022	Level on Bituman
205	370479.59	5989655.82	113.76	26/10/2022	Level at Fence Line G.L.
206	370478.09	5989685.26	113.83	26/10/2022	Level in Grass (Drain)
207	370464.96	5989675.28	114.26	26/10/2022	Level on Power Pole
208	370582.43	5989004.26	114.46	26/10/2022	Level on Carport
209	370233.35	5989780.09	113.79	26/10/2022	Level on Fence Post
210	370312.17	5990043.65	113.66	26/10/2022	Level in Garden Bed
211	370467.10	5990044.03	114.01	26/10/2022	Level on Concrete (Hunters)
212	370554.31	5990007.23	114.06	26/10/2022	Level on Concrete G.L. (Building)
213	370666.48	5990039.93	113.91	26/10/2022	Level on Carpark line (Lip of Kerb)
214	370540.11	5990161.07	114.01	26/10/2022	Level on Power Pole
215	370510.00	5990118.07	113.99	26/10/2022	Level on Gravel Driveway
216	370342.74	5990267.32	113.27	26/10/2022	Level on Lawn (Burbank Street)
217	370702.13	5989767.51	114.91	26/10/2022	Level on Shoulder of road (Sign)
218	370688.69	5989780.46	114.27	26/10/2022	Level on Edge of Bitumen
219	370832.77	5989789.95	114.34	26/10/2022	Level on Centre of Bitumen
220	370856.47	5989838.56	114.23	26/10/2022	Level on Lawn (5 King Street)
221	370639.00	5989911.25	114.52	26/10/2022	Level on Power Pole

Point ID	Easting	Northing	Elevation	Date	Comments
KW1	370663.19	5989916.01	114.23	26/10/2022	Level on Concrete
KW2	370344.46	5989937.65	113.56	26/10/2022	Level on Centre of Bitumen
KW3	370345.39	5989824.01	113.74	26/10/2022	Level on Centre of Bitumen
KW4	370553.90	5990029.59	114.07	26/10/2022	Level on Centre of Bitumen
KW5	369966.74	5989798.60	113.24	26/10/2022	Level on Concrete
KW6	370305.42	5990042.45	113.48	26/10/2022	Level on Wood Retaining Wall
KW7	370619.74	5989604.08	114.20	26/10/2022	Level in Grass (Oval)

Point ID	Easting	Northing	Elevation	Date	Comments
300	370522.89	5989757.29	114.23	26/10/2022	Level on Netball Court
301	370507.53	5989764.63	114.20	26/10/2022	Level on Netball Court
302	370492.43	5989756.85	114.11	26/10/2022	Level on Netball Court
303	370491.87	5989791.65	114.11	26/10/2022	Level on Netball Court
304	370507.22	5989784.33	114.19	26/10/2022	Level on Netball Court
305	370522.36	5989792.08	114.16	26/10/2022	Level on Netball Court
306	370485.79	5989781.18	114.03	26/10/2022	Level on Concrete (Floor Level)
307	370544.88	5989765.40	115.24	26/10/2022	Level on Concrete (Pavilion)
308	370407.29	5989907.59	113.76	26/10/2022	Level on Side Entry Pit
309	370234.00	5989780.91	113.54	26/10/2022	Level on Side Entry Pit
310	369951.74	5989796.08	113.18	26/10/2022	Level on Concrete
311	370340.94	5989792.57	113.57	26/10/2022	Level on Side Entry Pit
312	370340.29	5989930.20	113.50	26/10/2022	Level on Side Entry Pit
313	370336.70	5990038.53	113.21	26/10/2022	Level on Side Entry Pit
314	370340.42	5990047.72	113.87	26/10/2022	Level on Top of Bank (Basin)
315	370544.88	5990039.17	113.95	26/10/2022	Level on Side Entry Pit
316	370343.36	5990270.28	113.09	26/10/2022	Level on Grated Pit (Burbank Street)
317	370779.78	5990037.25	114.39	26/10/2022	Level on Carpark line
318	370798.38	5990037.50	114.40	26/10/2022	Level on Carpark line
319	370822.53	5990037.85	114.48	26/10/2022	Level on Carpark line
320	370833.50	5990038.00	114.52	26/10/2022	Level on Carpark line
321	370597.81	5989910.26	114.03	26/10/2022	Level on Side Entry Pit
322	370854.71	5989804.75	113.91	26/10/2022	Level on Side Entry Pit
323	370475.16	5989678.95	114.03	26/10/2022	Level on Headwall

Flood Height Marks – KW1 to KW7

Flood Mark No.	FM2022-KW1
Date of interview / Inspection	29 September 2022
Name of Property Owner	Marjorie and Les Earl
Telephone	-
Address	13 Lincoln Street marjearl@bigpond.com
Flood Description	Marjorie and Les Earl advised that floodwater did not encroach up their driveway beyond approximately their property boundary.
Reliability	Medium
Flood Level (m AHD)	114.23
MGA Zone 55 Coordinate - easting	370663
MGA Zone 55 Coordinate - northing	5989916



Flood Mark No.	FM2022-KW2
Date of interview / Inspection	28 September 2022
Name of Property Owner	Gary Warner
Telephone	-
Address	7 Black Street
Flood Description	Showed Gary the aerial photo taken at 1.20pm on 1.3.2012. He advised that this will have been close to peak. Location of mark at flood extent edge as per aerial photo.
Reliability	Medium
Flood Level (m AHD)	113.56
MGA Zone 55 Coordinate - easting	370344
MGA Zone 55 Coordinate - northing	5989938



Flood Mark No.	FM 2022-KW3
Date of interview / Inspection	29 September 2022
Name of Property Owner	-
Telephone	-
Address	229 Hickey Road
Flood Description	This site is in Black Street. Flood mark location coincides with flood extent as can be seen on the 1.20pm – 1.3.2012 aerial photograph. Owner/occupier of adjoining 229 Hickey Road has only lived there for 3 years so not able to comment.
Reliability	Medium
Flood Level (m AHD)	113.74
MGA Zone 55 Coordinate - easting	370345
MGA Zone 55 Coordinate - northing	5989824



Flood Mark No.	FM2022-KW4
Date of interview / Inspection	29 September 2022
Name of Property Owner	-
Telephone	-
Address	10 Bankin Street
Flood Description	This site coincides with the flood extent edge as can be seen on the 1.20pm 1.3.2012 aerial photograph. Crown of road is above water line.
Reliability	Medium
Flood Level (m AHD)	114.07
MGA Zone 55 Coordinate - easting	370554
MGA Zone 55 Coordinate - northing	5990030



Approx. location of flood extent in Bankin Street opposite the now closed garage.

Flood Mark No.	FM 2022-KW5
Date of interview / Inspection	29 September 2022
Name of Property Owner	Steve Hickey
Telephone	-
Address	195 Hickey Road
Flood Description	Kevin Teague identified the site of this mark having spoken to Steve Hickey. Steve not at home at time. Steve later confirmed the mark location.
Reliability	Medium
Flood Level (m AHD)	113.24
MGA Zone 55 Coordinate - easting	369967
MGA Zone 55 Coordinate - northing	5989799



Flood Mark No.	FM2022-KW6
Date of interview / Inspection	6 October 2022
Name of Property Owner	Gary Sutherland
Telephone	-
Address	13 Bankin Street
Flood Description	This flood height mark coincides with the water level present on a photograph taken by Linda Wilkie (March 2012 flood). The water level is part way up a timber garden edge board on the left hand side of the driveway – see photo below.
Reliability	Medium
Flood Level (m AHD)	113.48
MGA Zone 55 Coordinate - easting	370305
MGA Zone 55 Coordinate - northing	5990042



Flood Mark No.	FM2022-KW7
Date of interview / Inspection	6/10/2022
Name of Property Owner	- (Recreation Reserve)
Telephone	-
Address	-
Flood Description	Flood height mark location based on the Shepp News aerial photograph 1.20pm on 1/3/2022. Flood extent midway between goal posts and the oval fence.
Reliability	Medium
Flood Level (m AHD)	114.20
MGA Zone 55 Coordinate - easting	370619
MGA Zone 55 Coordinate - northing	5989604



APPENDIX B Content for Future Updates to Flood Information Documents

VICSES 'Local Flood Guide – Katandra West'

The 2020 'Local Flood Guide – Katandra West' is not specific to Katandra West township. Its target audience is the broader Katandra West district, parts of which are subject to riverine flooding from the Congupna and Guilfus Creeks to the west of the Katandra West township.

The following content could be inserted into the next update of the Local Flood Guide. The information below draws on the outcomes of this project.

Are you at risk of flood?

The Katandra West district has experienced flooding in previous years including 1919, 1939, 1956, 1974, 1993, 2012 and most recently 2022.

Flooding in October 2022 (75 mm in 40 hours) led to mainly nuisance level flooding within the Katandra West township, including minor flooding of roads and property grounds.

Flooding in March 2012 (230 mm in 72 hours) led to more serious flooding within the township, with several houses close to being flooded to above floor level. Travel out of Katandra West was severely restricted for two to three days after the rain event was over.

During significant flooding, Congupna and Guilfus Creeks to the west of Katandra West township will begin to fill and may overflow, leading to flooding of the surrounding rural farming properties. Flooding from these creeks will however not impact on the township of Katandra West. Creek flooding may commence anywhere from a few hours to up to 3 days after the flood inducing rainfall. The flood commencement time is shorter if the floodwater charging the creeks originates from runoff from the Dookie Hills as it did in 2012. The response time is longer if the floodwater originates from breakaway Broken River flows as it did in 1993.

The township of Katandra West is subject to flooding from local runoff originating from the rural areas to the east side of town, and from runoff within the township itself. Flooding from local runoff to the east of town will occur generally from 1 to 6 hours after the flood inducing rainfall. Flash flooding is also possible from high intensity rainfall generating high levels of runoff from within the town itself. Flash flooding can occur during or immediately after the flood inducing rainfall.

Local runoff flooding has in the past caused the town's drainage system to be overwhelmed by the sheer volume of floodwater. Locations affected by flooding in this way include properties in King Street, Bankin Street, Lincoln Street, Donohue Street, Hickey Road, Queen Street, Black Street, Coleman Street and Burgman Street.

Floods in the past are not known to have resulted in homes at Katandra West township being flooded to above floor level. Floods can however result in protracted road closures and possible isolation, which may severely limit travel from the Katandra West district to external areas for days or even one to two weeks after the cessation of rainfall.

Rainfall levels and flooding

The following tables provide an indication of what rainfall levels appear likely to cause flooding in the Katandra West district. The impact of rainfall can vary significantly due to a number of factors including how wet the ground is prior to the rainfall and how quickly the rainfall falls.

Rainfall	Expected Impacts
50 millimetres	Not likely to cause any significant flooding in the area
75 millimetres	May cause minor flooding impacts such as: <ul style="list-style-type: none"> ▪ Reaching the top of the creek banks ▪ Covering local roads, tracks and low level bridges ▪ Spreading across rural land and into outer buildings on some farms ▪ Spreading onto the grounds of some properties within town ▪ Coming up through stormwater drains and partly flooding town streets
125 millimetres	May cause moderate to major flooding impacts such as: <ul style="list-style-type: none"> ▪ Creek banks spilling over and spreading across low-lying farmland areas ▪ Requiring evacuation in some rural farmland areas ▪ Covering main roads in addition to minor roads ▪ Possible above floor flooding of houses in low lying rural / farming areas ▪ Widespread flooding of town streets ▪ Flooding of some sheds, carports and garages within town ▪ Restricted access to outside the Katandra West district due to road closures
200 millimetres	Likely to result in widespread significant flooding such as occurred in 2012: <ul style="list-style-type: none"> ▪ Extensive protracted flooding of farmland and some township areas ▪ Threatening more houses in rural areas ▪ Evacuations of occupants in rural areas ▪ Disrupting major roads and transport routes ▪ Severe access restrictions to outside the district lasting for up to 2 weeks ▪ Widespread flooding of minor buildings in the township ▪ No above floor flooding of houses within the township

GSCC 'Flood Emergency Plan'

The latest version of this Plan (GSCC Flood Emergency Plan – A Sub-Plan of the Municipal Emergency Management Plan) is dated December 2021. Appendix C6 of the plan is specific to Katandra West.

The following content could be inserted into Appendix C6 when the Flood Emergency Plan is next updated. The information below draws on the outcomes of this project.

Overview of Flooding

The township of Katandra West is located 20 km north east of Shepparton. The township has a population of 230. The broader Katandra West district had a population of 492 at the time of the 2020 census.

The township includes approximately 100 houses, a Recreation Reserve serving a number of different sports, a primary school and children's centre, CFA facility, Catholic and Uniting Churches, Men's Shed and multiple commercial businesses.

The town itself is located at the crossroads of Hickey and Union Rods. The town is relatively compact occupying an area of approximately 60 hectares. The surrounding area is farmland located within the Goulburn-Murray Water Shepparton Irrigation Area.

The predominant land fall at Katandra West is in a westerly direction at an average grade of 1 in 700.

There are no natural waterways located within 4 km of the township. The nearest natural waterway, Guilfus Creek, is located 4 km south west of the township. Riverine flooding associated with Guilfus Creek impacts on rural properties on either side of the creek. Guilfus Creek does not impact on the Katandra West township itself as a result of ground levels at Katandra West being more than 3 m higher than the ground levels adjoining Guilfus Creek.

The township of Katandra West is subject to flooding from local runoff originating from the rural areas to the east side of town, and from runoff within the township itself. Flooding from local runoff to the east of town will occur generally from 1 to 6 hours after the flood inducing rainfall. Flash flooding is also possible from high intensity rainfall generating high levels of runoff from within the town. Flash flooding can occur during or immediately after the flood inducing rainfall.

All rainfall runoff from the township discharges into G-MW Drains. Stormwater drainage infrastructure at Katandra West managed by Greater Shepparton City Council includes:

- A pit and pipe collector network servicing for transferring runoff to the three retarding basins or directly into G-MW drains.
- A retarding basin and pump located off the south side of Hickey Road, on the west side of the Recreation Reserve. This basin pumps into G-MW Drain 3/12 located within Hickey Road.
- A second retarding basin and pump located at the north end of Black Street. This basin pumps into G-MW Drain 2/12 located on the north side of the township.
- A third retarding basin located south of Burgman Street. This basin also discharges to Drain 2/12.

The G-MW drains also convey runoff from the rural areas on the east side of the township. Drains 2/12 and 3/12 discharges westwards, ultimately draining to Nine Mile Creek.

Flood History

The Katandra West district has experienced notable reported flooding in 1919, 1939, 1956, 1974, 1993, 2012 and 2022.

- Minor localised flooding was observed at Katandra West in October 2022. This followed 75 mm of rainfall within a 40 hour period. Impacts were mainly in the form of nuisance level flooding of property grounds and local roads.
- Available data suggests that the March 2012 flood event would appear to have been the most severe historical flood in terms of impacts on the Katandra West township. The 2012 flood resulted from approximately 230 mm of rainfall within a three day period. This resulted in widespread, generally shallow (less than 0.2 deep) inundation within parts of the town. No houses are known to have flooded to above floor level in 2012. Access to outside the district was severely hampered for a number of days after the event due to the closure of local and main roads.
- The October 1993 flood event was largely influenced by breakaway flows from the Broken River into the creek system east of Shepparton. This led to severe flooding of farmland along the creek routes. Both Guilfus Creek and Congupna Creek flooded severely in 1993, impacting on rural properties to the west of the Katandra West township, but not the township itself. Flooding from local runoff did occur within the township in 1993 but was not as severe as 2012.
- There is very little data associated with the earlier floods dating back to 1919. Rainfall data suggests that they were not as severe as the 2012 flood.

Flood Warning Time

The timing of flooding relative to the timing of the flood inducing rainfall within the Katandra West district can vary significantly.

The term 'flash flooding' is associated with flooding caused by local runoff. Flooding within the township of Katandra West is due to local runoff flooding. The runoff is generated from within the town itself, and the rural areas on the east side of the township which falls westwards towards the town.

Flash flooding at the township can therefore commence as soon as sufficient runoff is generated, which can be during the actual rain event. Flooding at Katandra West township can therefore commence during, immediately after and for a few hours after the flood inducing rainfall, and would be expected to peak within a period of between 1 and 12 hours once the main rainfall ceases.

The time for flooding of Guilfus and Congupna Creeks to peak is far more protracted than local runoff flooding. In 1993, peak flooding in these creeks did not occur until approximately two days after the lower Broken River peaked. The creeks can also flood due to inflows from their local catchments, in which case they would be expected to peak within 24 hours of the flood inducing rainfall.

Flood Warnings – Flash Flooding / Local Runoff

The BoM will issue warnings in relation to potential flash flooding (i.e. for those areas where high intensity rainfall is predicted). Flash flooding is often caused by high intensity, short duration, localised thunderstorms. Where and when thunderstorms occur is not easily predicted, hence residents should not expect any definitive warnings that relate to impending flash flooding from thunderstorm events at Katandra West.

The March 2012 event was associated with the highest ever seven day cumulative rainfall totals in parts of northern and north eastern Victoria. The flooding at Katandra West was towards the end of this seven day period. The BoM issued numerous flood warnings during the 2012 event for all towns in the region impacted by the widespread protracted and severe rainfall, including Katandra West.

Flood Warnings – Creek / Riverine Flooding

The BoM issues flood warnings associated with riverine flooding.

Depending on the forecast severity of flooding for the Broken River, warnings may be issued for the creek system east of Shepparton, which includes the Guilfus and Congupna Creeks. These Broken River related warnings will be issued days in advance of floodwater peaking in Guilfus Creek.

There are multiple river height gauges on the Broken River including gauges located at:

- Benalla
- Casey's Weir
- Orrvale

Flood warnings issued for the Broken River at Benalla and Caseys Weir will give an indication of the possibility and potential size of breakaway flows into the creek system which includes Guilfus and Congupna Creeks. The 1993 Broken River flood was the most severe flood for that river since at least 1870 by a considerable margin.

Historic Flood Levels

Flood levels at the Katandra West township based on a survey of identified flood height marks in the aftermath of the March 2012 event are documented in the Katandra West Flood Scoping Study report (Confluence Group, 2023).