



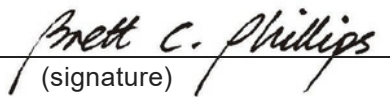
Keswick Estate Planning Proposal, Flood Impact Risk Assessment

Prepared for Dubbo Regional Council

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1 Introduction

This flood impact risk assessment (FIRA) was commissioned to determine the potential flood impacts, if any, of the proposed Keswick Estate Planning Proposal. The assessment was undertaken using a 1D/2D TUFLOW model that was developed to assess the flooding along the Western and Eastern floodways with Keswick Estate, Dubbo.

The potential impact of the development was assessed under the 2% Annual Exceedance Probability (AEP) (1 in 50 AEP), 1% AEP (1 in 100 AEP), 0.1% AEP (1 in 1000 AEP) and Probable Maximum Flood (PMF) events.

This report summarises the methodology and findings of the FIRA.

1.1 Background

The purpose of this report is to assess the flood impact of the Planning Proposal, if any, within Keswick Estate.

Dubbo Regional Council's Property and Land Development (PALD) branch is preparing a planning proposal (PP) for a change in land use and minimum lot size for some proposed future lots at Keswick Estate, as per the master plan. Part of the land to be rezoned is currently zoned as R2 – Low Density Residential and this is to be rezoned to R1 – General Residential. The PP also proposes to change R2 – Low Density Residential lot size from 600 m² to 200 m² (see **Figure 1**).

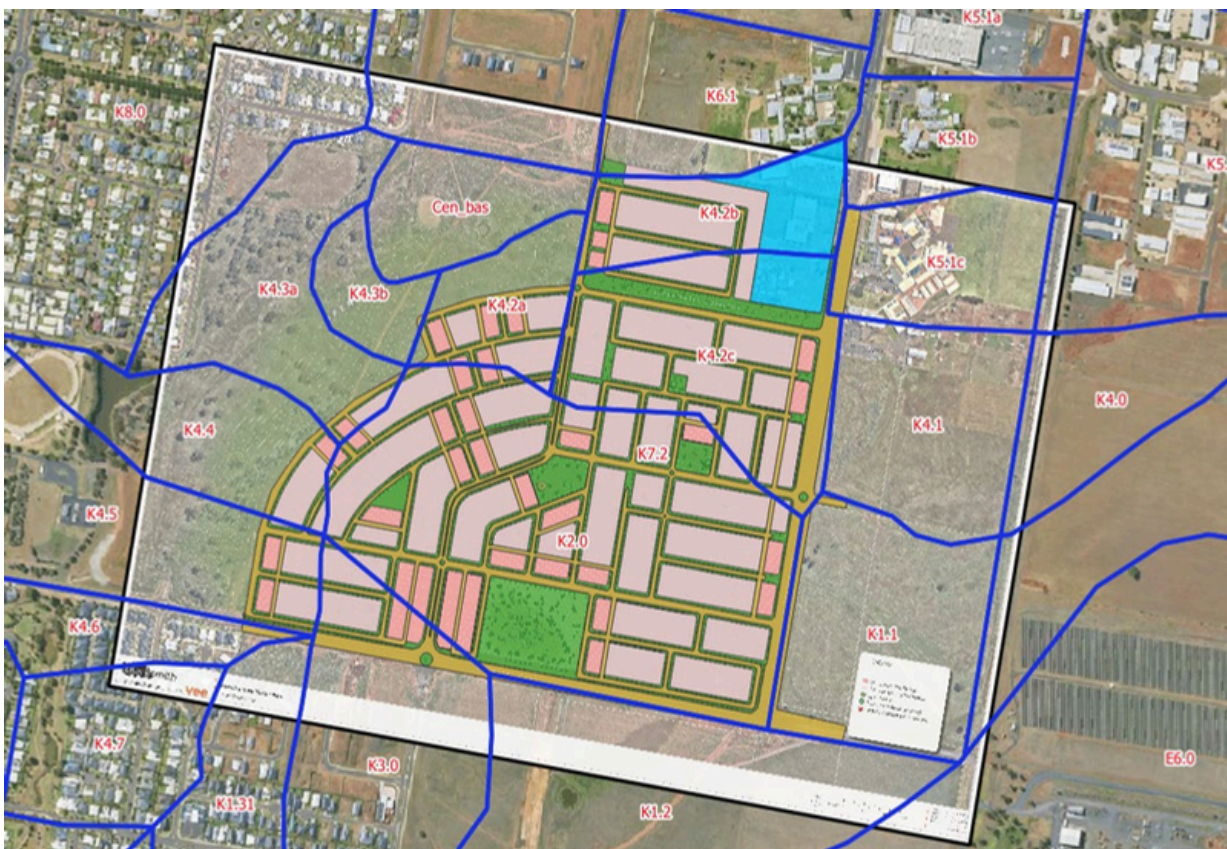


Figure 1 Planning Proposal and Subcatchment Boundaries

1.2 Guidelines

1.2.1 2005 Floodplain Development Manual

As advised in the Foreword, in part:

The primary objective of the NSW Government's Flood Prone Land Policy is to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods. At the same time, the policy recognises the benefits flowing from the use, occupation and development of flood prone land.

The policy promotes the use of a merit approach which balances social, economic, environmental and flood risk parameters to determine whether particular development or use of the floodplain is appropriate and sustainable.

The manual is concerned with the management of the consequences of flooding as they relate to the human occupation of the floodplain for both urban development and agricultural production. It addresses flood risk in full recognition of the fact that management decisions taken in respect of the human occupation of the floodplain need to satisfy the social and economic needs of the community as well as being compatible with the maintenance or enhancement of the natural ecosystems that the floodplain sustains.

1.2.2 2021 Evacuation Management Guideline

The 2014 Evacuation Management Guidelines published by NSW Resilience in 2021, in part, states:

The 2021 NSW State Flood Plans sets the Government's agenda for change in New South Wales. Of note, Goal 28 is to ensure NSW is ready to deal with major emergencies and natural disasters.

This guideline is prepared under the auspices of the EMPLAN, to compliment relevant sub and supporting plans.

It takes an all-hazards approach and outlines the key requirements and principles, authorities, responsibilities and mechanisms for the conduct of evacuations where formal emergency management arrangements are required.

The aim of this guideline is to inform and enhance existing emergency management arrangements for evacuations during actual and/or forecast emergencies. This guideline does not replace evacuation arrangements for specific hazards (eg. floods, bush fires) which are contained within individual Sub Plans and agency specific policies.

This guideline is intended to have a general, cross sector and all hazards' applications.

Combat Agencies and Functional Agencies can choose to employ or enhance its provisions within their respective internal policies.



1.2.3 2023 Flood Risk Management Guideline FB03

The Flood Risk Management Guideline FB03 Flood Hazard released in June 2023 states, in part:

This guideline builds on the advice provided in the [Flood risk management manual: the policy and manual for the management of flood liable land](#) (the manual; DPE 2023). It supports councils in their role in delivery of the NSW Flood prone land policy (the policy) through the flood risk management process outlined in the manual.

This guideline refers to the manual, policy and other flood risk management (FRM) tools and guidelines, relevant state agencies and legislation. Details on these are provided in the current version of [Administration arrangements: flood risk management guideline AG01](#) (FRM guideline AG01).

Hazardous flood conditions can exist without a flood risk. If floodplains were unoccupied and unused, flooding would still be hazardous but would not create a risk to the community. It is the human interaction with flooding that creates risk. Exposure can lead to the potential loss of life, injury, failure of buildings and infrastructure, and economic loss in future floods.

The degree of hazard varies with the severity of flooding and with flood extent, time and location. Understanding this is important to understanding and managing flood risk.

This guideline provides:

- *advice on uses of flood hazard information (Section 2)*
- *advice on flood hazard thresholds (Section 3)*
- *information on flood hazard categorisation based on the combination of flood velocity and depth (Section 4).*

1.2.4 2023 Flood Risk Management Guideline EM01

The Flood Risk Management Guideline EM01 Support for Emergency Management Planning released in June 2023 states, in part:

This guideline provides advice on how the flood risk management (FRM) framework and process described in the [Flood risk management manual: the policy and manual for the management of flood liable land](#) (the manual; DPE 2023) can consider and support flood emergency management (EM). It outlines how the NSW State Emergency Service (NSW SES) as the combat agency for flood, storm and tsunami, plans for flooding, as well as the key EM principles and strategies it uses when undertaking EM planning for the community.

The guideline also provides an understanding of:

- *how information from the FRM process is used to support flood EM planning;*
- *key EM constraints and how these may impact FRM for communities;*
- *the limitations of flood emergency response strategies and how these can inform decision-making.*

FRM involves partnerships between government agencies, local councils and communities. This provides for more effective and coordinated FRM to the community through the FRM framework and process, which are supported by the Floodplain Management Program.



The NSW SES is a key stakeholder in this partnership and in local council FRM committees (and technical working groups) that support the development of FRM plans through the FRM process. These plans provide the basis for strategic understanding, and effective consideration and management of EM and public safety risks to the community.

Through the FRM process the NSW SES can provide councils with:

- valuable knowledge of historical flooding and its impacts on the community that can assist councils during the FRM process
- advice on known EM constraints, response strategies or key limitations to effective emergency response by the community where flood plans are in place
- options that may improve the effectiveness of the emergency response, for example, this could include improvements to, or provision of, a total warning system for flood (TWSF) service to facilitate more effective warning and support community action.

Councils in turn can provide flood information developed through the FRM process to the NSW SES. This can inform the development and update of flood intelligence and local flood plans.

1.3 Flood Hazards

The 2023 Flood Risk Management Guideline FB03 released on 30 June 2023 by NSW DPE includes a plot of flood hazard vulnerability curves based on six hazard categories H1 – H6 (see **Figure 2**).

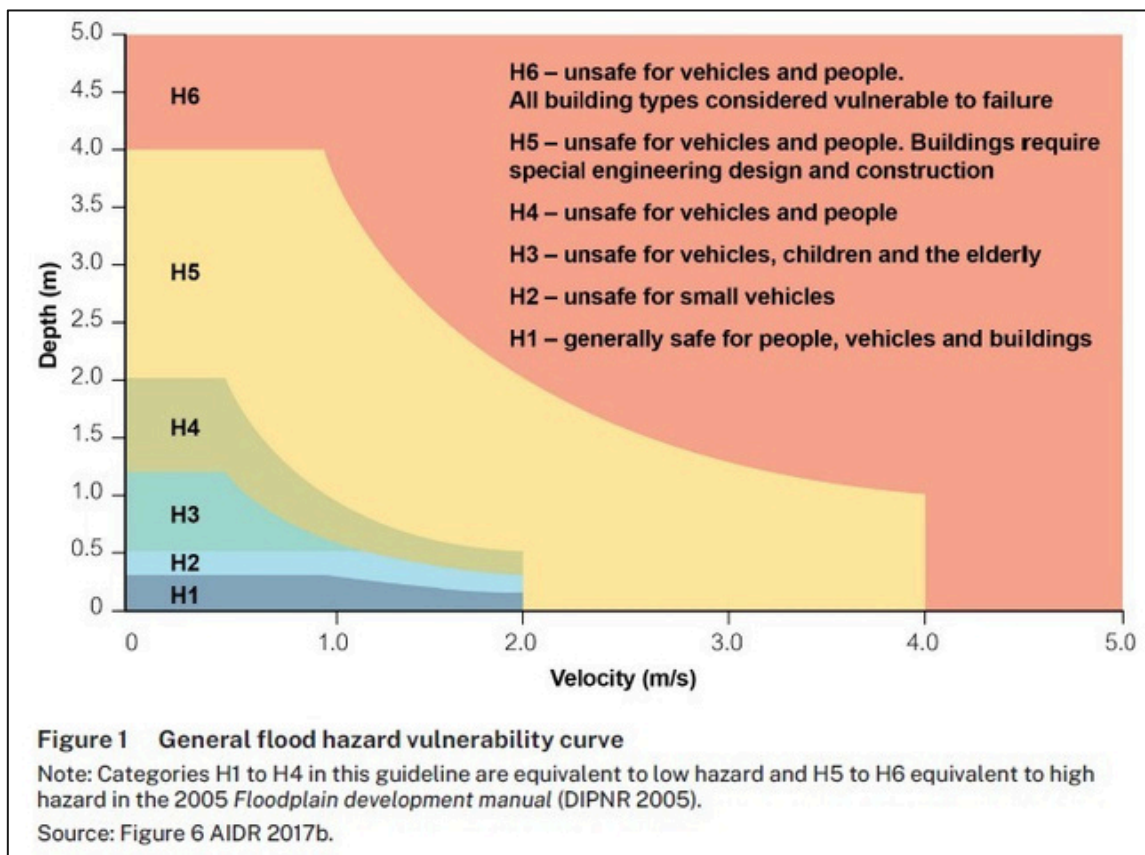


Figure 2 Flood Hazard Categories (Source: 2023 FRM Guideline FB03)

2 Previous Studies

Previous studies of Keswick Estate include the following:

2.1 2020 Review of Keswick Estate Trunk Drainage Scheme

On 15 October 2020 a Concept Design Report (Revision B) titled “Review of Keswick Estate Trunk Drainage Scheme” was submitted to Dubbo City Council. This report is summarised, in part, as follows:

The 2010 Keswick Drainage Review – Assessment of Trunk Drainage Requirements (Cardno, 2010), outlined a trunk drainage concept for the development of Keswick Estate. This report describes a revised trunk drainage concept and its component detention basins to manage stormwater flows through the Estate. The proposed concept has changed as the development layout and objectives for the Estate have changed, including:

- *The need to manage overland flows through the Fuzzy Box EEC zone located near Durum Circuit;*
- *The basin concept near Keswick Parkway; and*
- *The basin concept near Sheraton Road.*

Concept design of the latest Keswick Estate Trunk Drainage scheme has been undertaken based on hydrologic (XP-RAFTS) modelling and hydraulic (XP-SWMM) modelling using 2010 models which were updated to reflect the latest scheme.

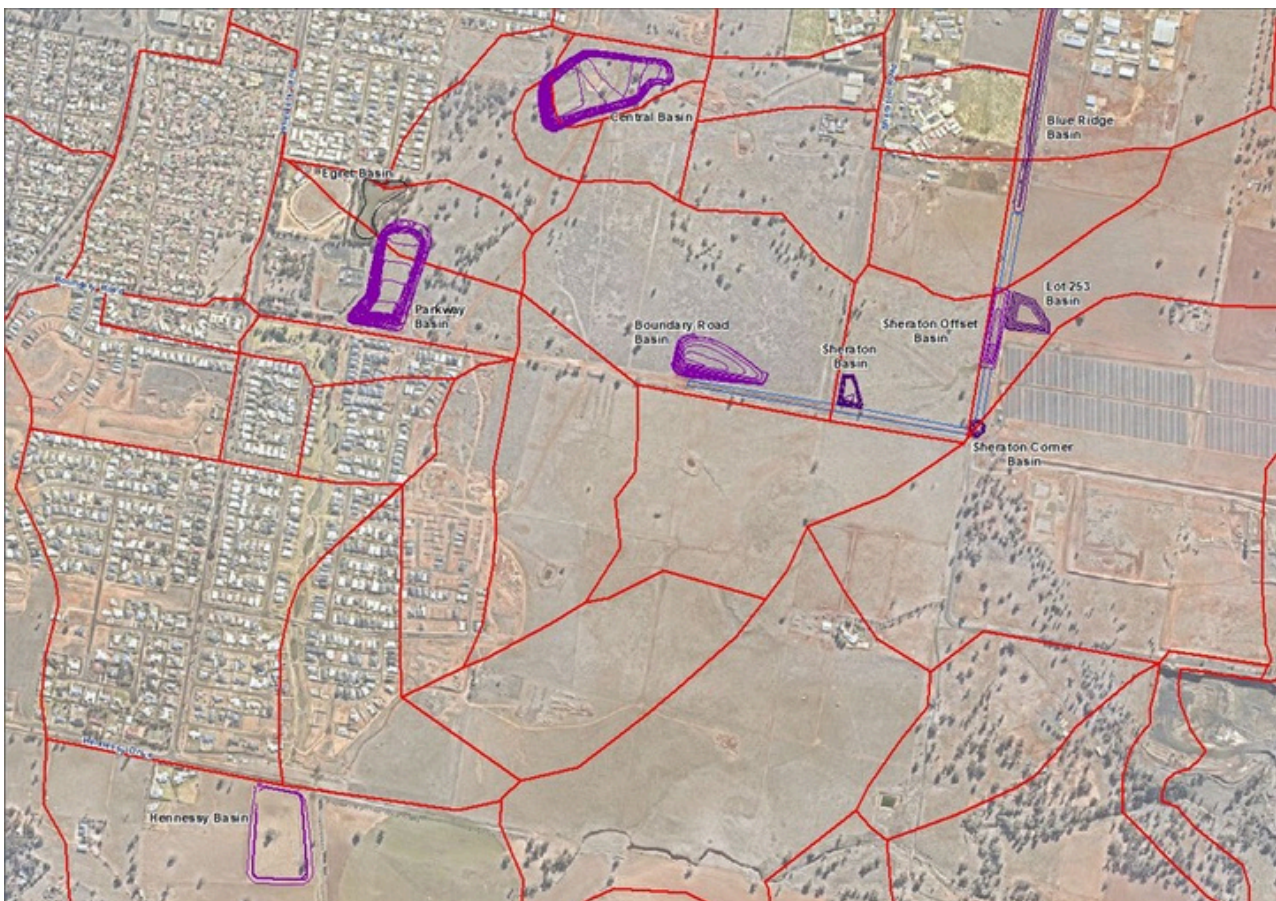


Figure 3 Keswick Estate Drainage Scheme (Aerial image from Nearmap) (Source: Cardno, 2020)

The concept design process required consideration of site constraints (including existing topographic, geotechnical, cadastral, heritage, and environmental considerations) and multiple iterations of basin layouts and geometry in discussion with Council.

Basin design revisions included, in part (refer **Figure 3**):

- *Sheraton Basins*
- *Channels*
- *Western Catchment – the current channel layout in the South Lakes area has not been explicitly modelled;*
- *Eastern Catchment – a conceptual configuration of a future channel between Sheraton Road and Hennessy Basin has been modelled.*

2.2 2020 Keswick Estate Channel and Basin Design Review - Mitchell Highway to Parkway Basin

Cardno prepared the Concept Design Report for the Review of Keswick Estate Trunk Drainage Scheme on 22 February 2019. Subsequently Council has prepared detailed design drawings for the proposed stormwater drainage channel and detention basins from Mitchell Highway to Boundary Road.

This Report is a review of the detailed design by Council for the main facilities:

- Keswick drainage channel (between Mitchell Highway and Keswick Parkway);
- Central Basin; and
- Parkway Basin.

A primary element of this review was updating the hydraulic model to represent the proposed design which has been refined from the concept design modelled for the 2019 Report. We advised Council of recommended changes to the design as our modelling and assessment progressed. This included revision of pipes from the basins and culverts under Keswick Parkway to balance discharge flowrates and peak water levels.

2.3 2021 Dambreak Assessment, Keswick Estate: Parkway Basin and Central Basin

The New South Wales Dam Safety Committee (DSC) require all new retarding basins to be assessed for incremental consequence of failure in order to prescribe a hazard rating for each basin. The 2021 report outlines the dam break analysis undertaken for the proposed basin in order to develop a hazard rating.

The objective of this study was to undertake a dam break study and to ascertain the appropriate Consequence Category for the embankments of the proposed Parkway Basin and Central Basin.



2.4 2021 Eastern Channel Revised Flow

Cardno previously provided XP-SWMM flows at Hennessy Road in 2010 and 2019 for the Keswick Estate Drainage Review. In the original 2010 assessment the flow was determined to be 21.1 m³/s for the 2hr 1% AEP event. After refinements to the model and inclusion of additional basins, channel data and culverts described in the 2019 review, the flow is reported to be 26.2m³/s for the 1hr 1% AEP event.

Additionally to the 2019 assessment a 2021 Dam break Assessment was undertaken for the Parkway and Central basins in Keswick Estate. As part of this assessment a TUFLOW hydraulic model was developed. The lower reach only of the Eastern Channel (well downstream of Boundary Road.) was included in the 2021 TUFLOW model.

3 Flood Risk Assessment

The 2019/2020 trunk drainage study assessed flooding in the 2 yr ARI, 50 yr ARI and 100 yr ARI events using a XP-SWMM 1D floodplain model. The 2021 dambreak study assessed the 2% AEP, 1% AEP, 0.1% AEP floods and PMF using a 1D/2D TUFLOW floodplain model of the Western Floodway up to Central Basin and of the lower reach of the Eastern Floodway.

While PALD identified the 5% AEP, 1% AEP, PMF and 0.5% AEP or 0.2% AEP events for assessment, the 1 in 50 AEP (2% AEP), 1 in 100 AEP (1% AEP), 1 in 1000 AEP (0.1% AEP) floods and PMF were adopted instead because these events have been assessed using a TUFLOW model previously.

3.1 Benchmark Conditions

The adopted Benchmark Conditions was the trunk drainage scheme assessed under ultimate development conditions as described in Sections 2.1, 2.2, 2.3 and 2.4..

As part of the 2021 Dam break Assessment which was undertaken for the Parkway and Central basins in Keswick Estate a 1D/2D TUFLOW hydraulic model was developed. The lower reach only of the Eastern Channel (well downstream of Boundary Road.) was included in the 2021 TUFLOW model.

The assessment tasks included:

- (i) Re-running the XP-RAFTS catchment models for the 1 in 50 AEP (2% AEP), 1 in 100 AEP (1% AEP), 1 in 1000 AEP (0.1% AEP) floods and PMF,
- (ii) Re-running 1D XP-SWMM models for the 1 in 50 AEP (2% AEP), 1 in 100 AEP (1% AEP), 1 in 1000 AEP (0.1% AEP) floods and PMF events (with the 2019 Boundary Basin configuration);
- (iii) Extend the 2021 TUFLOW floodplain model upstream along the Eastern Floodway based on supplied data;
- (iv) Run the extended 2021 1D/2D TUFLOW floodplain model for the 1 in 50 AEP (2% AEP), 1 in 100 AEP (1% AEP), 1 in 1000 AEP (0.1% AEP) floods and PMF.

3.2 Results

Given the variations in the critical storm burst duration in the Western and Eastern catchments both the 2 hour and 6 hour storm bursts were run and the maximum values of the two durations were mapped.

3.2.1 1 in 50 AEP Flood

The estimated 1 in 50 AEP flood levels and extents, flood depths, flood velocities and flood hazards are plotted respectively in **Figures E1, E2, E3 and E4** in **Appendix A**.

3.2.2 1 in 100 AEP Flood

The estimated 1 in 100 AEP flood levels and extents, flood depths, flood velocities and flood hazards are plotted respectively in **Figures E5, E6, E7 and E8** in **Appendix A**.

3.2.3 1 in 1000 AEP Flood

The estimated 1 in 1000 AEP flood levels and extents, flood depths, flood velocities and flood hazards are plotted respectively in **Figures E9, E10, E11 and E12** in **Appendix A**.



3.2.4 Probable Maximum Flood

The estimated PMF levels and extents, flood depths, flood velocities and flood hazards are plotted respectively in **Figures E13, E14, E15 and E16** in **Appendix A**.

3.3 Discussion

In a 1 in 50 AEP flood:

- Downstream of the Central Basin floodwaters spread out and are less confined than elsewhere in Keswick Estate. This attributed to the need to manage overland flows through the Fuzzy Box EEC zone located near Durum Circuit,
- The hazard category is H1 in this reach,
- Downstream of Boundary Road floodwaters are confined within the Western Floodway,
- The hazard categories of floodwaters conveyed down the Western Floodway vary and include intermittent zones of H5 hazard,
- Downstream of the Boundary Road Extension and Sheraton Road intersection the floodwaters are confined within the Eastern Floodway, and
- The hazard categories of floodwaters conveyed down the Eastern Floodway vary and include a central core of H5 hazard along the floodway.

In a 1 in 100 AEP flood:

- Downstream of the Central Basin floodwaters spread out and are less confined than elsewhere in Keswick Estate,
- The hazard category is primarily H1 in this reach with a fringing zone of H2 hazard upstream of Parkway Basin,
- Downstream of Boundary Road floodwaters are confined within the Western Floodway,
- The hazard categories of floodwaters conveyed down the Western Floodway vary and include intermittent zones of H5 hazard,
- Downstream of the Boundary Road Extension and Sheraton Road intersection the floodwaters are confined within the Eastern Floodway, and
- The hazard categories of floodwaters conveyed down the Eastern Floodway vary and include a central core of H5 hazard along the floodway.

In a 1 in 1000 AEP flood:

- Downstream of the Central Basin floodwaters spread out and are less confined than elsewhere in Keswick Estate,
- The hazard category remains primarily H1 in this reach with a fringing zone of H3 hazard upstream of Parkway Basin,
- Floodwaters spill from the Parkway Basin to the west,
- Downstream of Boundary Road floodwaters are largely confined within the Western Floodway,
- The hazard categories of floodwaters conveyed down the Western Floodway vary and include a core zone of H5 hazards,



- Downstream of the Boundary Road Extension and Sheraton Road intersection the floodwaters are confined within the Eastern Floodway, and
- The hazard categories of floodwaters conveyed down the Eastern Floodway vary and include a central core of H5 hazard with small intermittent zones of H6 hazard along the floodway.

In a PMF:

- Downstream of the Central Basin floodwaters spread out and spill through residential development in the southeast corner of Durum Circuit,
- The hazard category upstream of Parkway Basin varies up to H5 hazard,
- Floodwaters spill from Egret Basin and the Parkway Basin to the west of Parkway Basin,
- Floodwater spill across Boundary Road and flow through residential development either side of Southlakes Parade while being largely confined to the eastern side of the floodway,
- The hazard categories of floodwaters conveyed down the Western Floodway include a contiguous core zone of H6 hazard,
- Downstream of the Boundary Road Extension and Sheraton Road intersection the floodwaters spill overland to the south and west of the Eastern Floodway, and
- The hazard categories of floodwaters conveyed down the Eastern Floodway vary between H5 to H6 hazard while the overbank flows to the south and the west are primarily H1 except along a number of already established roads which experience H5 hazards.

In the case of PMF the assessment of flooding is idealised. As indicated in **Figure 3** the Blue Ridge basin captures runoff from Blue Ridge Estate and diverts this runoff south towards the intersection of the Boundary Road Extension and Sheraton Road. Likewise, the 1D XP-SWMM model which was used to generate the inflow to the TUFLOW model immediately downstream of the intersection of the Boundary Road Extension and Sheraton Road does not allow any runoff east of Sheraton Road to spill to the south directly towards Eulomogo Creek. Consequently, PMF flows from Blue Ridge Estate and south of the Estate are directed to the head of the Eastern Floodway. In extreme floods it is expected that runoff from Blue Ridge Estate will spill from the Blue Ridge Basin partially to the south and primarily to the west. Any spill to the west would be conveyed to the Central Basin. To identify the extent of flooding in the PMF it would be necessary to extend the domain of the 2D model up to and including the Blue Ridge Basin as well as land south of the Boundary Road extension.



4 Flood Impact Assessment

An update of the trunk drainage assessment reported in 2020 was undertaken to assess the impact of the planning proposal on the performance of 2024 trunk drainage scheme. The adopted Planning Proposal Conditions was based on the 2024 trunk drainage scheme.

4.1 Planning Proposal Conditions

The 2024 trunk drainage scheme reflects a number of changes as follows (Stantec, 2024).

4.1.1 2019 Trunk Drainage Basins

The following Basins remain unchanged from the 2019 Trunk Drainage Scheme (refer **Figure 4**):

- (i) Egret Basin
- (ii) Hennessy Basin

4.1.2 Mitchell Highway to Parkway Basin

The 2020 Keswick Estate Channel and Basin Design Review - Mitchell Highway to Parkway Basin overviewed in Section 1.2 above included changes to basins as follows (refer **Figure 4**):

- (i) Inclusion of new Channel Basin 1, Channel Basin 2, Channel Basin 3
- (ii) Reconfiguration of the Central Basin
- (iii) Adjustments to the Parkway Basin



Figure 4 2024 Keswick Estate Trunk Drainage Scheme

4.1.3 Boundary Road Basin Update

Under the Planning Proposal it is proposed to change land use and the minimum lot size for some proposed future lots at Keswick Estate (see **Figure 1**). To mitigate the impact of the Planning Proposal the 2019 Boundary Road Basin was re-sized to achieve the same outflows as adopted in 2019. In order to achieve that, the basin footprint was expanded while retaining the same basin outlets and same target peak depth and level.

In 2019 the estimated peak 1% AEP basin water level was at 284.6 m AHD with a peak water depth of 2.1m. It was found that to maintain the 2019 outflow that the basin storage volume needs to increase by 33% from 16.9 ML to 22.5 ML.

4.1.4 Capital Drive Extension Basins

Dubbo Regional Council is currently designing and documenting the upgrading of Boundary Road east from the Sheraton Road intersection and construction of an extension to connect to Capital Drive in Blue Ridge Estate.

As part of the design development hydrological and hydraulic modelling has been undertaken to provide information on current flooding of the road corridor to inform the design of flood resistant infrastructure and to assess a re-configured basin scheme with the aim of not increasing peak flows downstream of the proposed works nor adversely impact existing development upstream of the proposed works.

The changes to the basins east of the Boundary Road – Sheraton Road intersection assessed in 2020 include (refer **Figures 3 and 4**):

- (i) Augmentation of the Blue Ridge Basin,
- (ii) Inclusion of a new Triangular Basin
- (iii) Retention of the Lot 253 Basin
- (iv) Deletion of the Sheraton Offset Basin,
- (v) Deletion of the Sheraton Corner Basin, and
- (vi) Retention of the Sheraton Basin

4.1.5 Assessment Tasks

The assessment tasks included:

- (i) Updating the XP-RAFTS models based on the planning proposal;
- (ii) Running the updated XP-RAFTS catchment models for the 1 in 50 AEP (2% AEP), 1 in 100 AEP (1% AEP), 1 in 1000 AEP (0.1% AEP) floods and PMF,
- (iii) Updating the XP-SWMM model to incorporate all changes to the trunk drainage scheme,
- (iv) Running the updated 1D XP-SWMM models for the 1 in 50 AEP (2% AEP), 1 in 100 AEP (1% AEP), 1 in 1000 AEP (0.1% AEP) floods and PMF events (with the 2024 Boundary Basin configuration);
- (v) Run the 2024 1D/2D TUFLOW (Benchmark Conditions) floodplain model with updated inflows for the 1 in 50 AEP (2% AEP), 1 in 100 AEP (1% AEP), 1 in 1000 AEP (0.1% AEP) floods and PMF.



4.2 Results

Given the variations in the critical storm burst duration in the Western and Eastern catchments both the 2hour and 6 hour storm bursts were run and the maximum values of the two durations were mapped.

4.2.1 Hydrology

The impact of the Planning Proposal on subcatchment imperviousness on those subcatchments covered by the Planning Proposal is summarised in Table 1

Table 1 Impact of Planning Proposal on Subcatchment Imperviousness

Subcatchment	Imperviousness (%)		
	2019 Study	2024 Study	Increase due to PP
K2.0	50.0	60.1	10.1
K3.0	50.0	52.3	2.3
K4.2a	50.0	61.0	11.0
K4.2b	50.0	61.0	11.0
K4.2c	51.3	60.1	8.8
K4.3a	46.0	47.1	1.1
K4.3b	45.1	45.3	0.2
K4.4	0.0	10.1	10.1
K4.5	42.0	45.0	3.0
K4.6	31.9	33.1	1.2

The impact of peak flows in the Western Floodway and Eastern Floodway at Hennessy Road (without retarding basins which are included in the XP-SWMM model) are summarised in **Table 2**. These impacts on peak flows are an upper bound because regional basins mitigate these impacts on peak flows in floods up to the 100 yr ARI flood.

Table 2 Impact of Planning Proposal on Peak Flows (m³/s)

Node	ARI (yrs)	2019 Study	2024 Study	PeakFlow Difference (m ³ /s)
		Peak Flow (m ³ /s)	Peak Flow (m ³ /s)	
Western Floodway (WF2070)	50	51.82	53.14	1.32
	100	60.75	62.27	1.51
	1000	102.99	105.35	2.36
	PMF	470.84	470.57	-0.27
Eastern Floodway (K1.3)	50	42.85	45.12	2.27
	100	50.15	52.64	2.49
	1000	84.30	87.74	3.45
	PMF	325.23	336.65	11.42
Confluence of Floodways (WF2600)	50	90.24	96.12	5.88
	100	106.16	112.85	6.69
	1000	183.59	193.59	10.00
	PMF	833.80	845.60	11.80



4.2.2 1 in 50 AEP Flood

The estimated 1 in 50 AEP flood levels and extents, flood depths, flood velocities and flood hazards are plotted respectively in **Figures F1, F2, F3 and F4 in Appendix B.**

4.2.3 1 in 100 AEP Flood

The estimated 1 in 100 AEP flood levels and extents, flood depths, flood velocities and flood hazards are plotted respectively in **Figures F7, F8, F9 and F10 in Appendix B.**

4.2.4 1 in 1000 AEP Flood

The estimated 1 in 1000 AEP flood levels and extents, flood depths, flood velocities and flood hazards are plotted respectively in **Figures F13, F14, F15 and F16 in Appendix B.**

4.2.5 Probable Maximum Flood

The estimated PMF levels and extents, flood depths, flood velocities and flood hazards are plotted respectively in **Figures F19, F20, F21 and E22 in Appendix B.**

4.3 Flood Impact Assessment

A summary of flood impacts is provided below. The impacts (reductions) on flood levels and velocities in the Eastern Floodway are attributed to the changes to the basins upstream of the intersection of the Boundary Road extension and Sheraton Road (refer Section 4.1.4 above).

4.3.1 Flood Levels

The flood level difference plots (see **Figures F5, F11, F17 and F23 in Appendix B**) map the changes in flood levels due to the 2024 trunk drainage scheme incorporating the Planning Proposal. It is concluded that:

- In the 1 in 50 AEP event there are:
 - Minor increases in water levels in the Central Basin and Parkway Basin and nil impact on flood levels with the Western Floodway, and
 - Reductions in flood levels along the Eastern Floodway.
- In the 1 in 100 AEP event there is:
 - A minor spill from the Central Basin and minor increase in the flood level in the Parkway Basin with nil impact on flood levels with the Western Floodway, and
 - Reductions in flood levels along the Eastern Floodway.
- In the 1 in 1000 AEP event there is:
 - Minor increase in the flood level west of the Parkway Basin and downstream of Boundary Road within the Western Floodway with local minor increases in flood levels scattered along the Western Floodway, and
 - Reductions in flood levels along the Eastern Floodway.
- In the PMF there are:
 - Minor increase in flood levels in most areas inundated within the Western catchment; and
 - Reductions in flood levels in most areas inundated within the Eastern catchment.



4.3.2 Flood Velocity

The flood velocity difference plots (see **Figures F6, F12, F18 and F24 in Appendix B**) map the changes in flood levels due to the 2024 trunk drainage scheme incorporating the Planning Proposal. It is concluded that:

- In the 1 in 50 AEP event there is:
 - Nil impact on flood velocities with the Western Floodway, and
 - Some zones of local increase in velocity but primarily reductions in flood velocities along the Eastern Floodway.
- In the 1 in 100 AEP event there is:
 - A local increase in velocity at the toe of the Central Basin associated with the spill of flow from the basin,
 - Negligible impact on flood velocities with the Western Floodway, and
 - Some zones of local increase in velocity but primarily reductions in flood velocities along the Eastern Floodway.
- In the 1 in 100 AEP event there is:
 - Minor increase in the flood velocities west of the Parkway Basin and downstream of Boundary Road within the Western Floodway with a core zone of minor increases in flood velocities along the Western Floodway, and
 - Some zones of local increase in velocity but primarily reductions in flood velocities along the Eastern Floodway.
- In the PMF there are:
 - Minor increases in flood velocities in most areas inundated in the Western catchment; and
 - Reductions in flood velocities in most areas inundated within the Eastern catchment.

4.3.3 Flood Hazard

A comparison of **Figures E4, E8, E12, E16, F4, F10, F16 and F22** discloses that:

- In the 1 in 50 AEP event there are:
 - Nil impact on flood hazard with the Western Floodway, and
 - Minor reductions in flood hazards along the Eastern Floodway.
- In the 1 in 100 AEP event there is:
 - A local increase in the extent of H1 hazard downstream of the Central Basin associated with the spill of flow from the basin,
 - Negligible impact on flood hazards with the Western Floodway, and
 - Minor reductions in flood hazards along the Eastern Floodway.
- In the 1 in 100 AEP event there is:
 - Negligible impact on flood hazards with the Western Floodway, and
 - Minor reductions in flood hazards along the Eastern Floodway.
- In the PMF there are:
 - Negligible impact on flood hazards with the Western Floodway, and
 - Minor reductions in flood hazards along the Eastern Floodway.

4.3.4 Flood Storage

It was found that to maintain the 2019 outflow from the Boundary Road Basin that the basin storage volume needs to increase by 33% from 16.9 ML to 22.5 ML under the Planning Proposal.



5 Flood Emergency Management

The latest edition of Australian Rainfall and Runoff released in 2019 provides guidance on both pedestrian and vehicle stability in floods as does the 2023 Flood Risk Management Guideline FB03 released on 30 June 2023 by NSW DPE.

This guidance is outlined to inform the Planning Proposal.

5.1 Pedestrian Stability

The 2023 Flood Risk Management Guideline FB03 released on 30 June by NSW DPE includes a plot of thresholds for the stability of people in floods. This plot is presented in **Figure 5**.

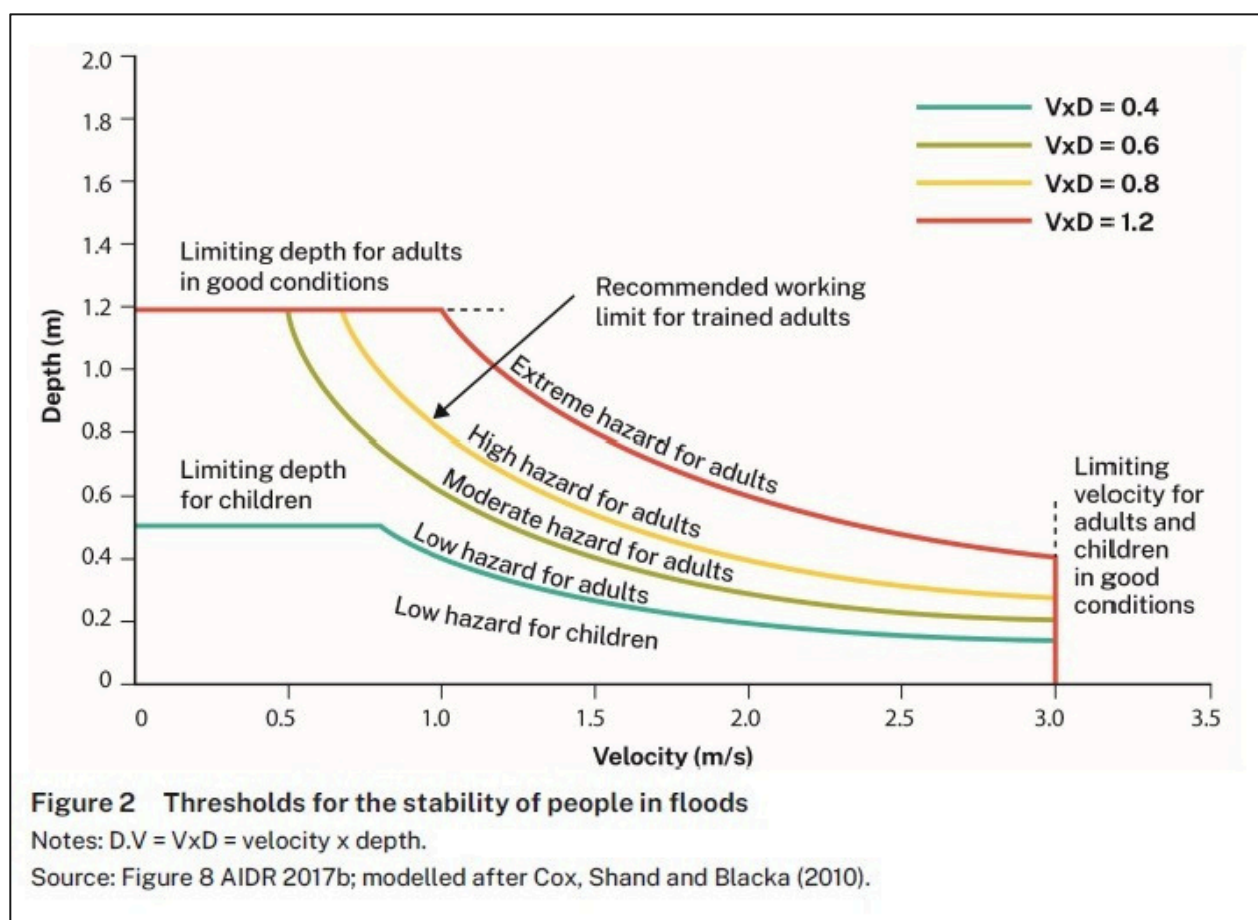


Figure 5 Thresholds for the stability of people in floods (Source: 2023 FRMM FB03)

5.2 Vehicle Stability

The 2023 Flood Risk Management Guideline FB03 released on 30 June by NSW DPE includes a plot of thresholds for vehicle stability in floods. This plot is presented in **Figure 6**.

H1 and H2 categories (refer **Figure 1**) are typically adopted as representative categories for vehicular stability respectively for small vehicles and large (4WD) vehicles.

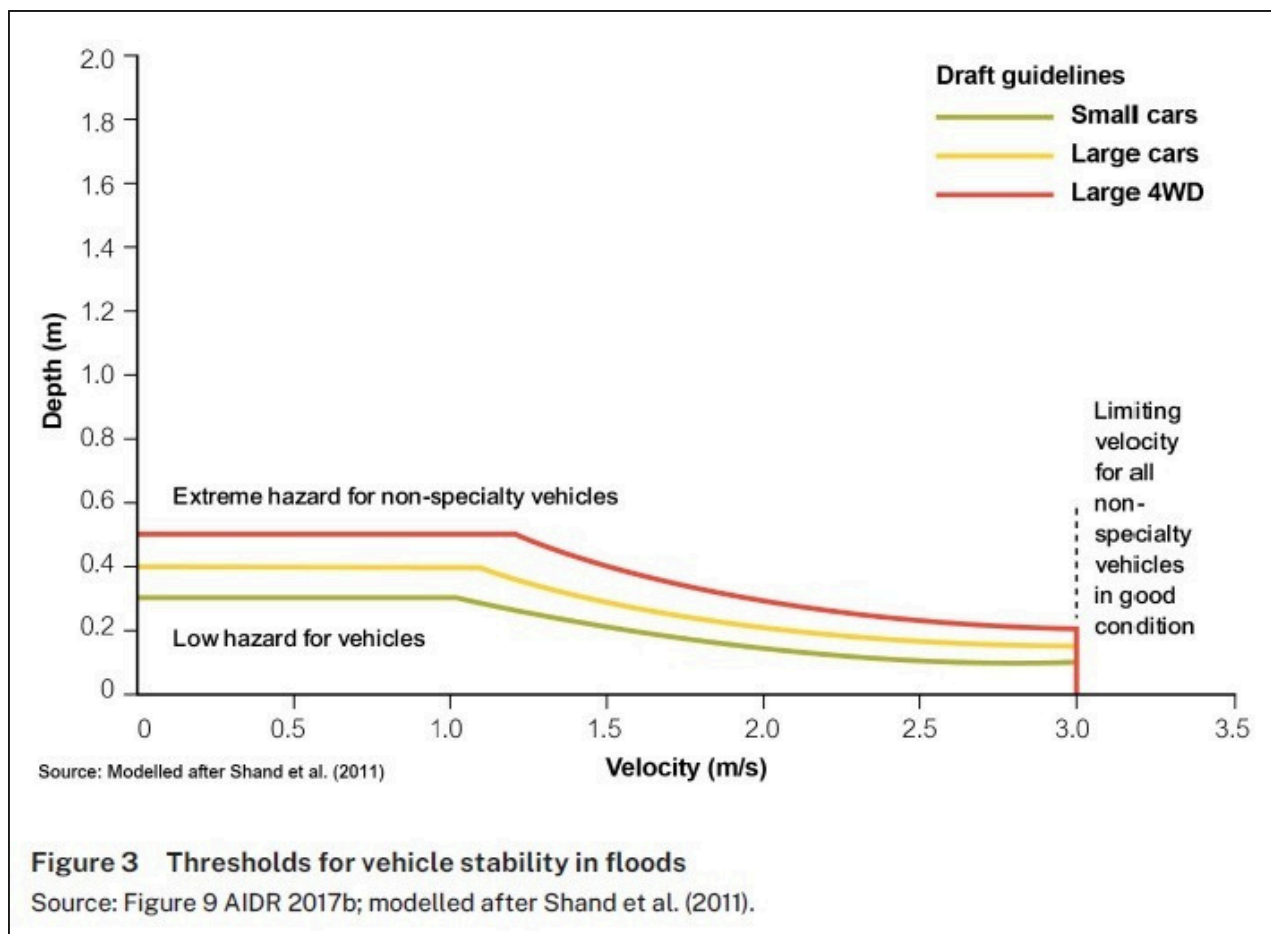


Figure 6 Thresholds for the stability of vehicles in floods (Source: 2023 FRMM FB03)

5.3 Potential Impacts of Basin Failure(s)

In 2020 a range of assessments of the Keswick Estate development were undertaken. This included the Keswick Estate Channel and Basin Design Review – Mitchell Highway to Parkway Basin (Cardno, 2020b).

As part of the 2020 review, an Initial Consequence Assessment of Parkway Basin was undertaken using the Consequence Screening Tool for Small Dams (released by the State of Victoria Department of Environment and Primary Industries, Melbourne, 2014). The assessment estimated that a Consequence Category of “High C or above” was applicable, as the Persons at Risk (PAR) was estimated to be greater than 10 (noting also that PAR is less than 1 km downstream of the embankment).

As such, it was recommended that a detailed dam safety assessment be undertaken for Parkway Basin and Central Basin. This assessment was undertaken in 2021 and reported in Cardno, 2021a.

As described, in part, by Cardno, 2021a:

A 1D/2D TUFLOW hydraulic model was then used to model the dam failure flood behaviour in the various dam break scenarios.

An assessment to determine the likely most critical dam failure mode that would produce the highest peak outflow from each dam was undertaken. The following dam break scenarios were modelled as part of this study:

1. *Embankment Failure due to piping - This is the failure from either seepage through an embankment, through the foundation or from the embankment into the foundation. This has been analysed for the 2% AEP and 1% AEP events assuming failure at the peak water level to represent the worst-case scenario. This is the most frequent event at which the dam crest is overtopped and is determined by assessing the peak water levels reached for a range of storm events. The 0.1% AEP event has been adopted as the dam crest flood for the hydraulic analysis.*
2. *Dam Crest Flood (DCF) Failure - The 0.01% AEP event has not been considered as the dam overtops in a 0.1% AEP event. The 0.01% AEP without dam failure was analysed in order to inform spillway design at a later stage of this study. Probable Maximum Flood Failure – This is the extreme flood for the catchment with the*

3. *maximum possible dam inflows. In this analysis, failure occurred when the PMF levels reached the Dam Crest level.*

In all three of the above listed dam break scenarios a further three combinations of dam failure were considered:

1. *Dam failure of the Central Basin only;*
2. *Dam failure of the Parkway Basin only; and*
3. *Cascading failure of the Central Basin with subsequent failure of the Parkway Basin.*

The Parkway Basin and Central Basin TUFLOW hydraulic models were run for the 1% AEP, 0.1% AEP and PMF design storm events with and without dam failure.

Flood maps for the various dam break and no dam break scenarios have been attached in the following Appendices :

- *No dam break scenario - **Appendix A** (in Cardno, 2021a);*
- *Central Basin dam break scenario - **Appendix B** (in Cardno, 2021a);*
- *Parkway Basin dam break scenario - **Appendix C** (in Cardno, 2021a);*
- *Cascading dam break scenario (both Central Basin and Parkway Basin failures) – **Appendix D** (in Cardno, 2021a).*

The flood maps include peak depth and level contours, velocities, flood hazard, water level difference and velocity difference. Results of the dam break analysis suggest the following:

- *The flood extents of the 1% AEP event for both the dam break and no dam break scenarios show flooding occurs in Durum Circuit north of Parkway Basin and south-west of the Central Basin. Flooding of this area is more extensive in the 0.1% AEP event and further still for the PMF for both dam break and no dam break scenarios. For the 0.1% AEP and PMF events the flooding extends into residential properties on Durum Circuit.*
- *Downstream of the Parkway Basin, there is overtopping of Boundary Road in the 1% AEP, 0.1% AEP and PMF events.*
- *A north-south open space corridor conveys floodwaters from the basins through the Southlakes precinct. The majority of floodwaters for the 1% AEP (under both dam break and*



no dam break scenarios) are contained within the open space corridor with limited flood affectation of residential properties in the Southlakes precinct. The flood extents of the dam break scenario are more extensive than the no dam break scenario but as noted above are still for the most part contained within the open space corridor.

- In the 0.1% AEP event, floodwaters in the no dam break scenario are mostly contained within the open space corridor, however under the dam break scenarios flows are diverted west into residential properties and along the Southlakes Parade corridor, however these flows are shallow (less than 0.3 metres deep). In the PMF floodwaters extend into residential areas of the Southlakes precinct under both the dam break and no dam break scenarios.*
- Other major road crossings downstream of the basin experience overtopping in most events under both dam break and no dam break scenarios. These road crossings include Azure Avenue, Argyle Avenue and Hennessy Avenue. The extent of road overtopping is typically greater under the dam break scenario than in the no dam break scenario.*

It was concluded (Cardno, 2021a) that the:

Results of the analysis suggest that the failure of Central Basin and Parkway Basin would cause significant but localised increases (greater than 0.3 metres) in downstream flood levels. However, there are no residential properties located within the dam break impact zone and thus the PAR is low ($PAR < 3.5$) and the PLL is not significant ($PLL < 0.1$).

Based on a consequence assessment, the hazard ratings for both the Central Basin and Parkway Basin are Low.

6 Council Flood Planning Policies

Dubbo Regional Council's flood planning policies are overviewed as follows.

6.1 Dubbo Local Environmental Plan 2013

In relation to flood planning the relevant clause in the Dubbo LEP 2011 are as follows:

5.21 Flood planning

(1) *The objectives of this clause are as follows—*

- (a) to minimise the flood risk to life and property associated with the use of land,*
- (b) to allow development on land that is compatible with the flood function and behaviour on the land, taking into account projected changes as a result of climate change,*
- (c) to avoid adverse or cumulative impacts on flood behaviour and the environment,*
- (d) to enable the safe occupation and efficient evacuation of people in the event of a flood.*

(2) *Development consent must not be granted to development on land the consent authority considers to be within the flood planning area unless the consent authority is satisfied the development—*

- (a) is compatible with the flood function and behaviour on the land, and*
- (b) will not adversely affect flood behaviour in a way that results in detrimental increases in the potential flood affectation of other development or properties, and*
- (c) will not adversely affect the safe occupation and efficient evacuation of people or exceed the capacity of existing evacuation routes for the surrounding area in the event of a flood, and*
- (d) incorporates appropriate measures to manage risk to life in the event of a flood, and*
- (e) will not adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of riverbanks or watercourses.*

(3) *In deciding whether to grant development consent on land to which this clause applies, the consent authority must consider the following matters—*

- (a) the impact of the development on projected changes to flood behaviour as a result of climate change,*
- (b) the intended design and scale of buildings resulting from the development,*
- (c) whether the development incorporates measures to minimise the risk to life and ensure the safe evacuation of people in the event of a flood,*
- (d) the potential to modify, relocate or remove buildings resulting from development if the surrounding area is impacted by flooding or coastal erosion.*

(4) *A word or expression used in this clause has the same meaning as it has in the Considering Flooding in Land Use Planning Guideline unless it is otherwise defined in this clause.*

(5) *In this clause—*

Considering Flooding in Land Use Planning Guideline means the Considering Flooding in Land Use Planning Guideline published on the Department's website on 14 July 2021.

flood planning area has the same meaning as it has in the Floodplain Development Manual.

Floodplain Development Manual means the Floodplain Development Manual (ISBN 0 7347 5476 0) published by the NSW Government in April 2005.



6.2 Dubbo DCP 2013

The relevant performance criteria and acceptable solutions for commercial development are set out, in part, in Element 7 of Section 2.1.3 Subdivision Controls under Residential Development and Subdivision in the Dubbo DCP 2013 as follows.

Element 7: Stormwater management

Objectives

- To provide major and minor drainage systems which:
 - Adequately protect people and the natural and built environments to an acceptable level of risk and in a cost effective manner in terms of initial costs and maintenance; and
 - Contribute positively to environmental enhancement of catchment areas.
- To manage any water leaving the site (during construction and operation) with stormwater treatment measures.

Performance criteria The stormwater management objectives may be achieved where:		Acceptable solutions The acceptable solutions illustrate one way of meeting the associated performance criteria:	
P1	Post development peak flows (up to 100 year ARI storm events) are limited to 'pre-development' levels.	A1.1	Water sensitive urban design or onsite bio-retention in the form of rain gardens, swales and absorption trenches are amalgamated into the design of the road network.
		A1.2	In areas where there is high salinity, infiltration shall not be used.
P2	The stormwater drainage system has the capacity to safely convey stormwater flows resulting from the relevant design storm under normal operating conditions, taking partial minor system blockage into account.	A2.1	The design and construction of the stormwater drainage system is in accordance with the requirements of Australian Rainfall and Runoff 1987 and Aus-Spec (DCC version) Development Specification Series – Design and Development Specification Series – Construction.
		A2.2	Construction Certificate plans for subdivisions shall show all minor and major stormwater systems clearly defined and identified. Minor systems for residential areas are designed to cater for the 1 in 100 year storm event. These systems are to be evident as 'self-draining' without impacting on flooding of residential houses etc.
P3	Natural streams and vegetation are retained wherever practicable and safe, to maximise community benefit.	A3.1	Natural streams and vegetation are incorporated into the stormwater drainage system for the subdivision and open space requirements.
P4	The stormwater system/drainage network is designed to ensure that there are no flow paths which would increase risk to public safety and property.	A4.1	While addressing the statutory requirements stated above, the incorporation of sports grounds and other less flood-sensitive land uses into the drainage corridor and the appropriate placement of detention basins.
P5	The system design allows for the safe passage of vehicles at reduced speeds on streets which have been affected by run-off from the relevant design storm.	A5.1	The system allows for the safe passage of vehicles at reduced speeds on streets which have been affected by run-off from a 20% AEP event.
Site drainage			
P6	Subdivision design and layout provides for adequate site drainage.	A6.1	Where site topography prevents the discharge of stormwater directly to the street gutter or a Council controlled piped system, inter-allotment drainage is provided to accept run-off from all existing or future impervious areas that are likely to be directly connected.



Performance criteria The stormwater management objectives may be achieved where:	Acceptable solutions The acceptable solutions illustrate one way of meeting the associated performance criteria:
	A6.2 The design and construction of the inter-allotment drainage system are in accordance with the requirements of Australian Rainfall and Runoff (1987) and Aus-Spec (DCC version) Development Specification Series – Design and Development Specification Series – Construction.
Flooding P7.1 Where residences (new or existing) are proposed in flood-affected areas, these shall be protected from flood waters. P7.2 Flood-ways are developed in a manner which ensures that there is a low risk of property damage.	A7.1 Ground floors of residences are located at or above the 'flood planning level' to provide protection to life and property in accordance with the accepted level of risk.
References	
<ul style="list-style-type: none"> Australian Rainfall and Runoff 1987; Aus-Spec (DCC version) Development Specification Series – Design and Development Specification Series – Construction; and AMCORD (1995) Part 3: Stormwater and Integrated Catchment Management. 	

The Dubbo DCP 2013 also defines the Flood Planning Level as follows:

Flood planning level means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 m freeboard.

6.3 2013 Dubbo Flood-Prone Land Policy

As stated, in part, in the Introduction to the Flood Prone Land Policy:

It is important that any potential developer of land and Council, as the consent authority and custodian of land, acknowledge the risk of flooding and consider the economic, environmental, social and safety implications and seek to mitigate the effect of development on flooding and vice-versa.

With these considerations in mind, this chapter has been prepared with the aim of setting out Council's requirements for subdivision, building and other development proposals where they apply to flood-prone land in urban Dubbo.

Appendix B: Cross Sections – Macquarie and Talbragar Rivers includes Table 1 – Planning flood levels along the Macquarie River (refer to Figure 6). The relevant sections and flood levels from this table are given in Table 3 (refer to Figure 7 for cross section locations).

The planning flood levels reported in the policy are based on flood levels estimated in 1992.

Table 3 Flood Planning Levels along the Macquarie River
(Source: Table 1, Appendix B, 2013 Dubbo Flood Prone Land Policy)

Cross Section (Number)	Chainage (KM)	Location	1% AEP (m AHD)	1% AEP + 0.5m (m AHD)	Extreme Flood (m AHD)
24	14.98		264.2	264.7	269.1
26	15.70		264.4	264.9	269.2
26.0	16.80		264.7	265.2	269.4
27.0	17.68		264.9	265.4	296.6

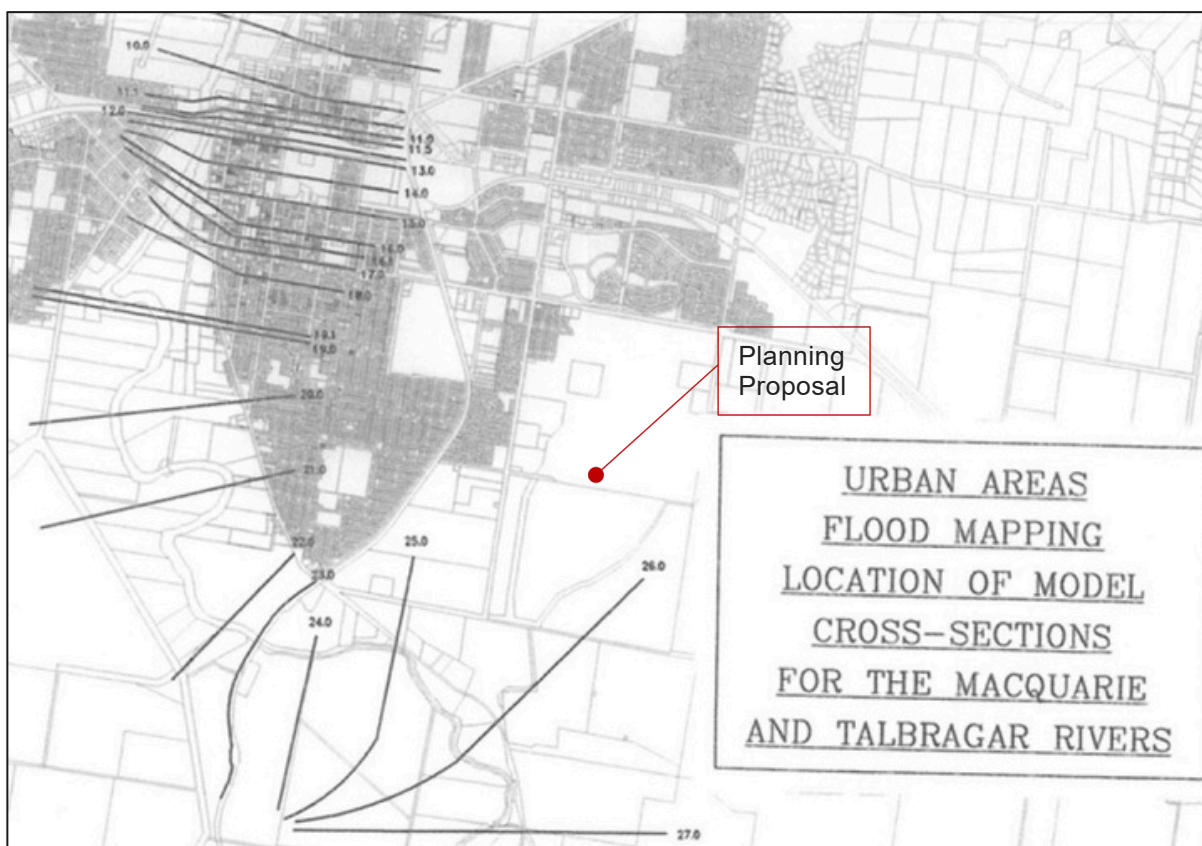


Figure 7 Location of Cross Sections referenced in the Dubbo Flood-Prone Land Policy

(Source: Figure 6, 2013 Dubbo Flood-Prone Land Policy)

It is noted that Section 25 is mis-labelled as Section 26 in **Table 3**.

The design flood levels through Dubbo across a range of floods up to the PMF with Dambreak conditions were reported in 2012, 2019 and 2021 with the reference locations identified in **Figure 8**. The Macquarie River dominant 1% AEP, 0.5% AEP and PMF levels at Locations 410 and 409 estimated in 2012, 2019 and 2021 are compared in **Table 4**.

Table 4 Comparison of 2012, 2019 and 2021 Flood Levels at Selected Locations

Location	1% AEP (m AHD)	0.5% AEP (m AHD)	PMF No Dambreak (m AHD)	Comment
410	264.78	265.49	271.33	2012 Floodplain Model
410	264.91	265.89	271.76	2019 Floodplain Model
410	264.85	265.85	271.24	2021 MR3 Model 2019-
	0.13	0.40	0.43	2012 Difference (m) 2021-
	-0.06	-0.05	-0.51	2019 Difference (m)
409	264.78	265.49	271.34	2012 Floodplain Model
409	264.91	265.90	271.77	2019 Floodplain Model
409	264.85	265.85	271.23	2021 MR3 Model 2019-
	0.13	0.40	0.43	2012 Difference (m) 2021-
	-0.06	-0.05	-0.53	2019 Difference (m)

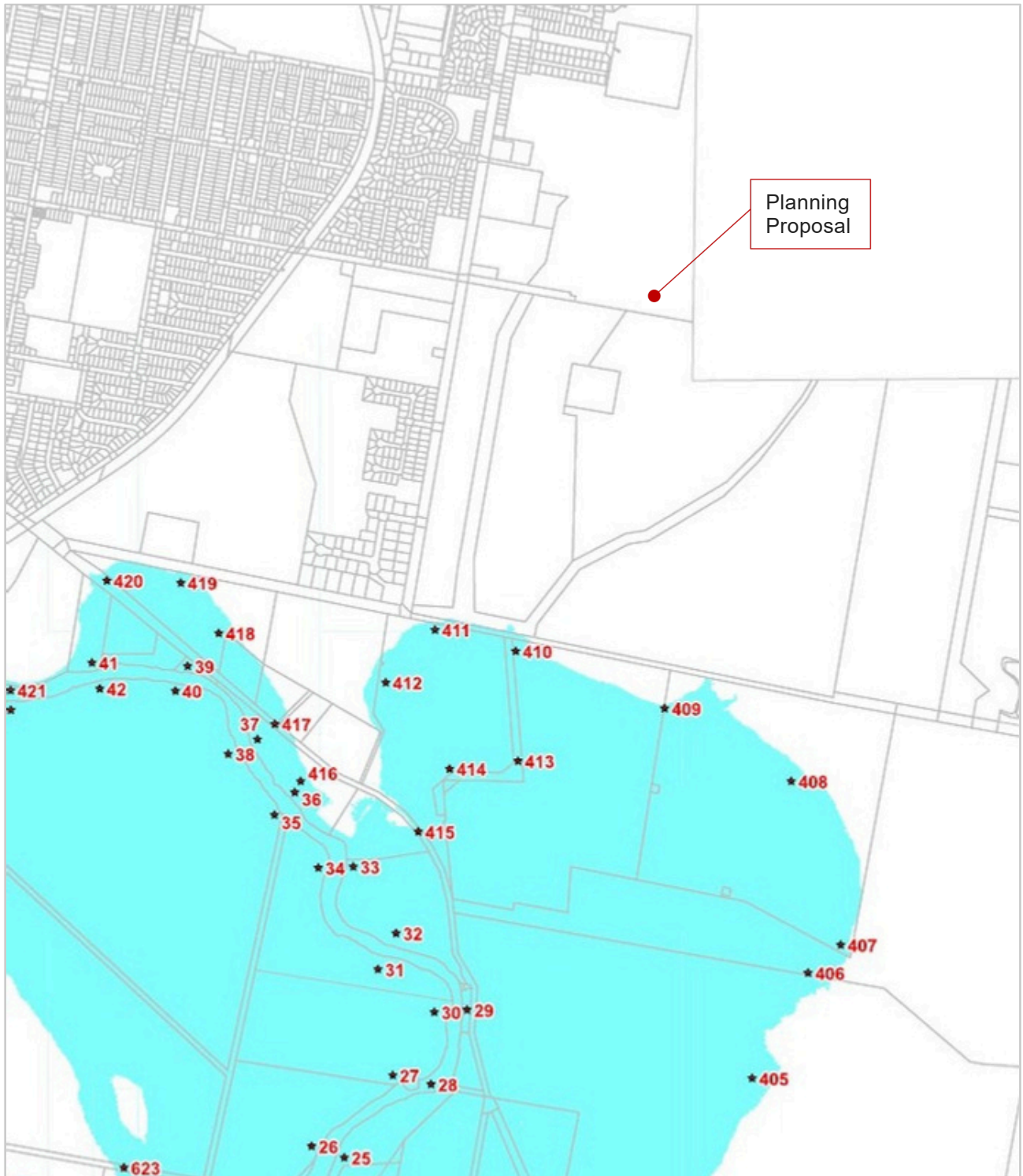


Figure 8 Reference Locations in the vicinity of 1-11 Bultje St, Dubbo

It is noted from Tables 3 and 4 that the 1% AEP flood level reported in the 2013 Dubbo Flood Prone Land Policy is within 150 mm of the 1% AEP Macquarie River mainstream flood levels estimated in 2012, 2019 and 2021.

It is further noted that the 1% AEP Macquarie River mainstream flood extent reaches Hennessy Road but does not extend into Keswick Estate. In relation to the Planning Proposal the proposed development is located on ground well above the Macquarie River mainstream PMF level.

7 Conclusions

This flood impact risk assessment (FIRA) was commissioned to determine the potential flood impacts, if any, of the proposed Keswick Estate Planning Proposal. The assessment was undertaken using a 1D/2D TUFLOW model that was developed to assess the flooding along the Western and Eastern floodways with Keswick Estate, Dubbo.

The potential impact of the development was assessed under the 2% Annual Exceedance Probability (AEP) (1 in 50 AEP), 1% AEP (1 in 100 AEP), 0.1% AEP (1 in 1000 AEP) and Probable Maximum Flood (PMF) events.

The assessed impact of the Planning Proposal and conclusions are as follows.

7.1 Flood Risk Assessment

The 2019/2020 trunk drainage study assessed flooding in the 2 yr ARI, 50 yr ARI and 100 yr ARI events using a XP-SWMM 1D floodplain model. A 2021 dambreak study assessed the 2% AEP, 1% AEP, 0.1% AEP floods and PMF using a 1D/2D TUFLOW floodplain model of the Western Floodway up to Central Basin and of the lower reach of the Eastern Floodway.

While PALD identified the 5% AEP, 1% AEP, PMF and 0.5% AEP or 0.2% AEP events for assessment, the 1 in 50 AEP (2% AEP), 1 in 100 AEP (1% AEP), 1 in 1000 AEP (0.1% AEP) floods and PMF were adopted instead because these events have been assessed using a TUFLOW model previously.

The adopted Benchmark Conditions was the trunk drainage scheme assessed under ultimate development conditions as described in Sections 2.1, 2.2, 2.3 and 2.4.

For the purpose of this assessment the 2021 TUFLOW floodplain model was extended upstream along the Eastern Floodway to the intersection of the Boundary Road Extension and Sheraton Road based on supplied data.

Given the variations in the critical storm burst duration in the Western and Eastern catchments both the 2 hour and 6 hour storm bursts were run and the maximum values of the two durations were mapped.

The estimated 1 in 50 AEP, 1 in 100 AEP, 1 in 1000 AEP and PMF flood levels and extents, flood depths, flood velocities and flood hazards are plotted in **Appendix A**

In the case of PMF, the assessment of flooding is idealised. As indicated in **Figure 3**, the Blue Ridge basin captures runoff from Blue Ridge Estate and diverts this runoff south towards the intersection of the Boundary Road Extension and Sheraton Road. Likewise, the 1D XP-SWMM model which was used to generate the inflow to the TUFLOW model immediately downstream of the intersection of the Boundary Road Extension and Sheraton Road does not allow any runoff east of Sheraton Road to spill to the south directly towards Eulomogo Creek. Consequently, PMF flows from Blue Ridge Estate and south of the Estate are directed to the head of the Eastern Floodway. In extreme floods it is expected that runoff from Blue Ridge Estate will spill from the Blue Ridge Basin partially to the south and primarily to the west. Any spill to the west would be conveyed to the Central Basin. To identify the extent of flooding in the PMF it would be necessary to extend the domain of the 2D model up to and including the Blue Ridge Basin as well as land south of the Boundary Road extension.



7.2 Flood Impact Assessment

An update of the trunk drainage assessment reported in 2020 was undertaken to assess the impact of the planning proposal on the performance of 2024 trunk drainage scheme. The adopted Planning Proposal Conditions was based on the 2024 trunk drainage scheme described in Section 4.1.

The estimated 1 in 50 AEP, 1 in 100 AEP, 1 in 1000 AEP and PMF flood levels and extents, flood depths, flood velocities and flood hazards are plotted in **Appendix B**.

A summary of flood impacts is provided below. The impacts (reductions) on flood levels and velocities in the Eastern Floodway are attributed to the changes to the basins upstream of the intersection of the Boundary Road extension and Sheraton Road (refer Section 4.1.4 above).

7.2.1 Flood Levels

The flood level difference plots (see **Figures F5, F11, F17 and F23 in Appendix B**) map the changes in flood levels due to the 2024 trunk drainage scheme incorporating the Planning Proposal. It is concluded that:

- In the 1 in 50 AEP event there are:
 - Minor increases in water levels in the Central Basin and Parkway Basin and nil impact on flood levels with the Western Floodway, and
 - Reductions in flood levels along the Eastern Floodway.
- In the 1 in 100 AEP event there is:
 - A minor spill from the Central Basin and minor increase in the flood level in the Parkway Basin with nil impact on flood levels with the Western Floodway, and
 - Reductions in flood levels along the Eastern Floodway.
- In the 1 in 1000 AEP event there is:
 - Minor increase in the flood level west of the Parkway Basin and downstream of Boundary Road within the Western Floodway with local minor increases in flood levels scattered along the Western Floodway, and
 - Reductions in flood levels along the Eastern Floodway.
- In the PMF there are:
 - Minor increase in flood levels in most areas inundated within the Western catchment; and
 - Reductions in flood levels in most areas inundated within the Eastern catchment.

7.2.2 Flood Velocity

The flood velocity difference plots (see **Figures F6, F12, F18 and F24 in Appendix B**) map the changes in flood levels due to the 2024 trunk drainage scheme incorporating the Planning Proposal. It is concluded that:

- In the 1 in 50 AEP event there is:
 - Nil impact on flood velocities with the Western Floodway, and
 - Some zones of local increase in velocity but primarily reductions in flood velocities along the Eastern Floodway.
- In the 1 in 100 AEP event there is:
 - A local increase in velocity at the toe of the Central Basin associated with the spill of flow from the basin,



- Negligible impact on flood velocities with the Western Floodway, and
- Some zones of local increase in velocity but primarily reductions in flood velocities along the Eastern Floodway.
- In the 1 in 100 AEP event there is:
 - Minor increase in the flood velocities west of the Parkway Basin and downstream of Boundary Road within the Western Floodway with a core zone of minor increases in flood velocities along the Western Floodway, and
 - Some zones of local increase in velocity but primarily reductions in flood velocities along the Eastern Floodway.
- In the PMF there are:
 - Minor increases in flood velocities in most areas inundated in the Western catchment; and
 - Reductions in flood velocities in most areas inundated within the Eastern catchment.

7.2.3 Flood Hazard

A comparison of **Figures E4, E8, E12, E16, F4, F10, F16 and F22** discloses that:

- In the 1 in 50 AEP event there are
 - Nil impact on flood hazard with the Western Floodway, and
 - Minor reductions in flood hazards along the Eastern Floodway.
- In the 1 in 100 AEP event there is:
 - A local increase in the extent of H1 hazard downstream of the Central Basin associated with the spill of flow from the basin,
 - Negligible impact on flood hazards with the Western Floodway, and
 - Minor reductions in flood hazards along the Eastern Floodway.
- In the 1 in 100 AEP event there is:
 - Negligible impact on flood hazards with the Western Floodway, and
 - Minor reductions in flood hazards along the Eastern Floodway.
- In the PMF there are:
 - Negligible impact on flood hazards with the Western Floodway, and
 - Minor reductions in flood hazards along the Eastern Floodway.

7.2.4 Flood Storage

It was found that to maintain the 2019 outflow from the Boundary Road Basin that the basin storage volume needs to increase by 33% from 16.9 ML to 22.5 ML under the Planning Proposal.

7.3 Flood Emergency Management

The latest edition of Australian Rainfall and Runoff released in 2019 provides guidance on both pedestrian and vehicle stability in floods as does the 2023 Flood Risk Management Guideline FB03 released on 30 June 2023 by NSW DPE. This guidance is outlined to inform the Planning Proposal.

A 2021 dambreak study of the Parkway Basin and Central Basin was undertaken to assess:

.... the likely most critical dam failure mode that would produce the highest peak outflow from each dam was undertaken. The following dam break scenarios were modelled as part of this study:



1. Embankment Failure due to piping
2. Dam Crest Flood (DCF) Failure
3. Probable Maximum Flood Failure

In all three of the above listed dam break scenarios a further three combinations of dam failure were considered:

1. Dam failure of the Central Basin only;
2. Dam failure of the Parkway Basin only; and
3. Cascading failure of the Central Basin with subsequent failure of the Parkway Basin.

It was concluded (Cardno, 2021a) that the:

Results of the analysis suggest that the failure of Central Basin and Parkway Basin would cause significant but localised increases (greater than 0.3 metres) in downstream flood levels. However, there are no residential properties located within the dam break impact zone and thus the PAR is low ($PAR < 3.5$) and the PLL is not significant ($PLL < 0.1$).

Based on a consequence assessment, the hazard ratings for both the Central Basin and Parkway Basin are Low.

7.4 2013 Dubbo Flood-Prone Land Policy

As stated, in part, in the Introduction to the Flood Prone Land Policy:

It is important that any potential developer of land and Council, as the consent authority and custodian of land, acknowledge the risk of flooding and consider the economic, environmental, social and safety implications and seek to mitigate the effect of development on flooding and vice-versa.

With these considerations in mind, this chapter has been prepared with the aim of setting out Council's requirements for subdivision, building and other development proposals where they apply to flood-prone land in urban Dubbo.

It is noted from Tables 3 and 4 that the 1% AEP flood level reported in the 2013 Dubbo Flood Prone Land Policy is within 150 mm of the 1% AEP Macquarie River mainstream flood levels estimated in 2012, 2019 and 2021.

It is further noted that the 1% AEP Macquarie River mainstream flood extent reaches Hennessy Road but does not extend into Keswick Estate. In relation to the Planning Proposal the proposed development is located on ground well above the Macquarie River mainstream PMF level.



8 References

- Cardno (2020a) "Review of Keswick Estate Trunk Drainage Scheme", *Concept Design Report*, Rev A, prepared for Dubbo Regional Council, October.
- Cardno (2020b) "Keswick Estate Channel and Basin Design Review -Mitchell Highway to Parkway Basin", *Letter Report*, prepared for Dubbo Regional Council, July.
- Cardno (2021a) "Dambreak Assessment, Keswick Estate: Parkway Basin and Central Basin", *Final Report*, Rev 1, prepared for Dubbo Regional Council, April.
- Cardno (2021b) "Eastern Channel Revised Flow", *Letter Report*, prepared for Dubbo Regional Council, July.
- NSW Government (2005). *Floodplain Development Manual, The management of flood liable land*, April, 29 pp + Apps
- NSW Government (2023a)"*Flood Risk Management Manual, The Policy and Manual for the Management of Flood Liable Land*", prepared by the Environment and Heritage Group, NSW Department of Planning and Environment.
- NSW Government (2023b) "*Flood Risk Management Guideline FB03 Flood Hazard*", prepared by the Environment and Heritage Group, NSW Department of Planning and Environment.
- NSW Government (2023c) "*Flood Risk Management Guideline EM01 Support for Emergency Management Planning*", prepared by the Environment and Heritage Group, NSW Department of Planning and Environment.
- NSW Resilience (2021) "*State Emergency Management Plan, Evacuation Management Guidelines*", Version 1.0, prepared by the SEMC Working Group, March 2014.
- Stantec (2024) "Stormwater Management under the Keswick Estate Planning Proposal, Dubbo", *Letter Report*, prepared for Dubbo Regional Council, August.



Appendix A Benchmark Conditions



List of Benchmark Conditions Flood Maps:

Figure E1 1 in 50 AEP Flood Extents and Flood Levels - Benchmark Conditions

Figure E2 1 in 50 AEP Flood Depths - Benchmark Conditions

Figure E3 1 in 50 AEP Flood Velocities - Benchmark Conditions

Figure E4 1 in 50 AEP Flood Hazards - Benchmark Conditions

Figure E5 1 in 100 AEP Flood Extents and Flood Levels - Benchmark Conditions

Figure E6 1 in 100 AEP Flood Depths - Benchmark Conditions

Figure E7 1 in 100 AEP Flood Velocities - Benchmark Conditions

Figure E8 1 in 100 AEP Flood Hazards - Benchmark Conditions

Figure E9 1 in 1000 AEP Flood Extents and Flood Levels - Benchmark Conditions

Figure E10 1 in 1000 AEP Flood Depths - Benchmark Conditions

Figure E11 1 in 1000 AEP Flood Velocities - Benchmark Conditions

Figure E12 1 in 1000 AEP Flood Hazards - Benchmark Conditions

Figure E13 PMF Flood Extents and Flood Levels - Benchmark Conditions

Figure E14 PMF Flood Depths - Benchmark Conditions

Figure E15 PMF Flood Velocities - Benchmark Conditions

Figure E16 PMF Flood Hazards - Benchmark Conditions





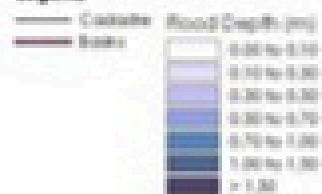
Flood Depths

1 in 50 AEP
Benchmark Conditions

Project: Kewick Estate Planning Proposal
Client: Oxbow Regional Council
Project Code: 200204064
Drawn By: SHP, Checked By: ST
Date: (2024-08-22)
Figure No: 02



Legend



Notes

1. Map displayed in EPSG:28355

References

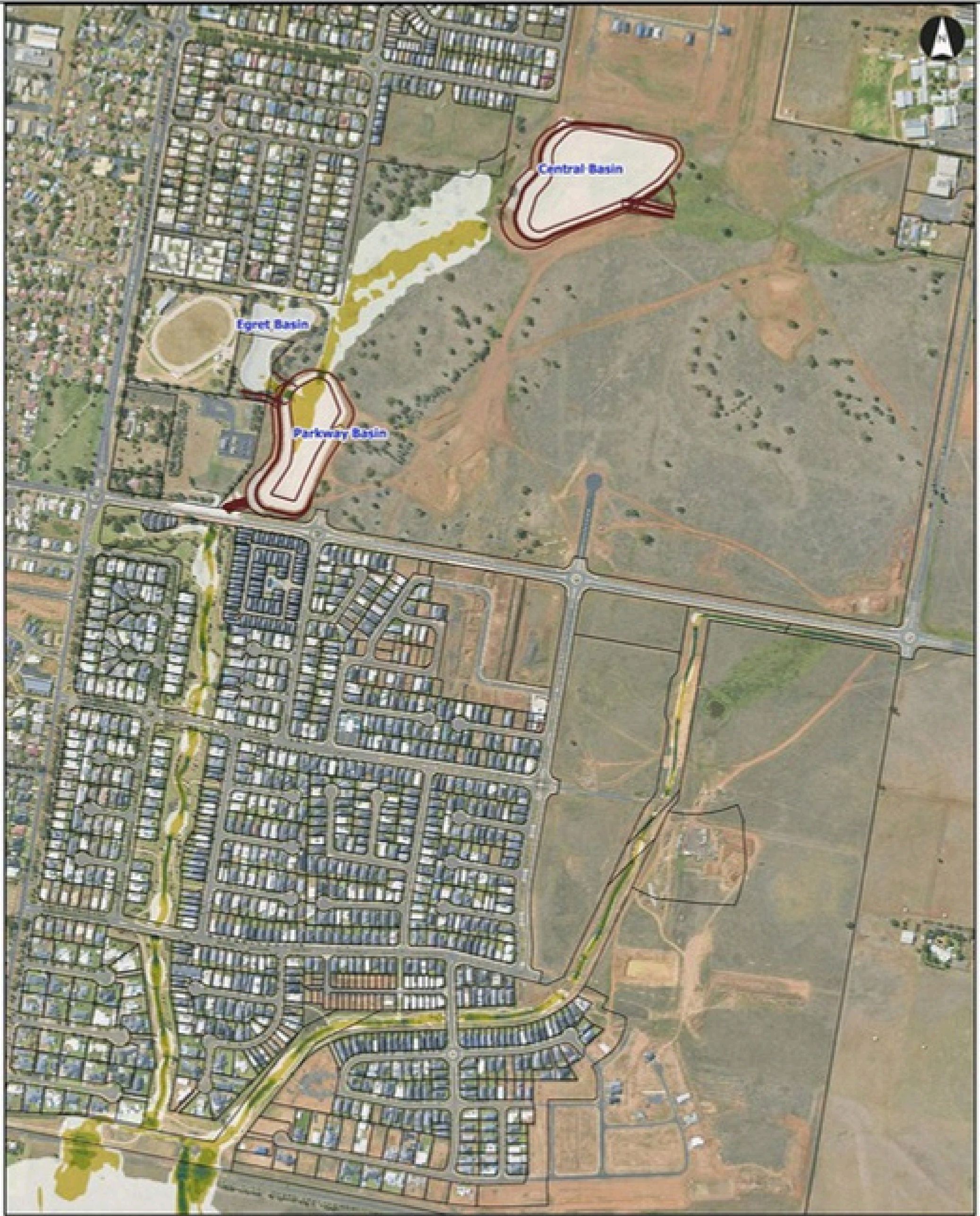
1.
2.

DRAFT - Not For Construction



Scale of A3: 1:7000





Flood Velocities

1 in 50 AEP
Benchmark Conditions

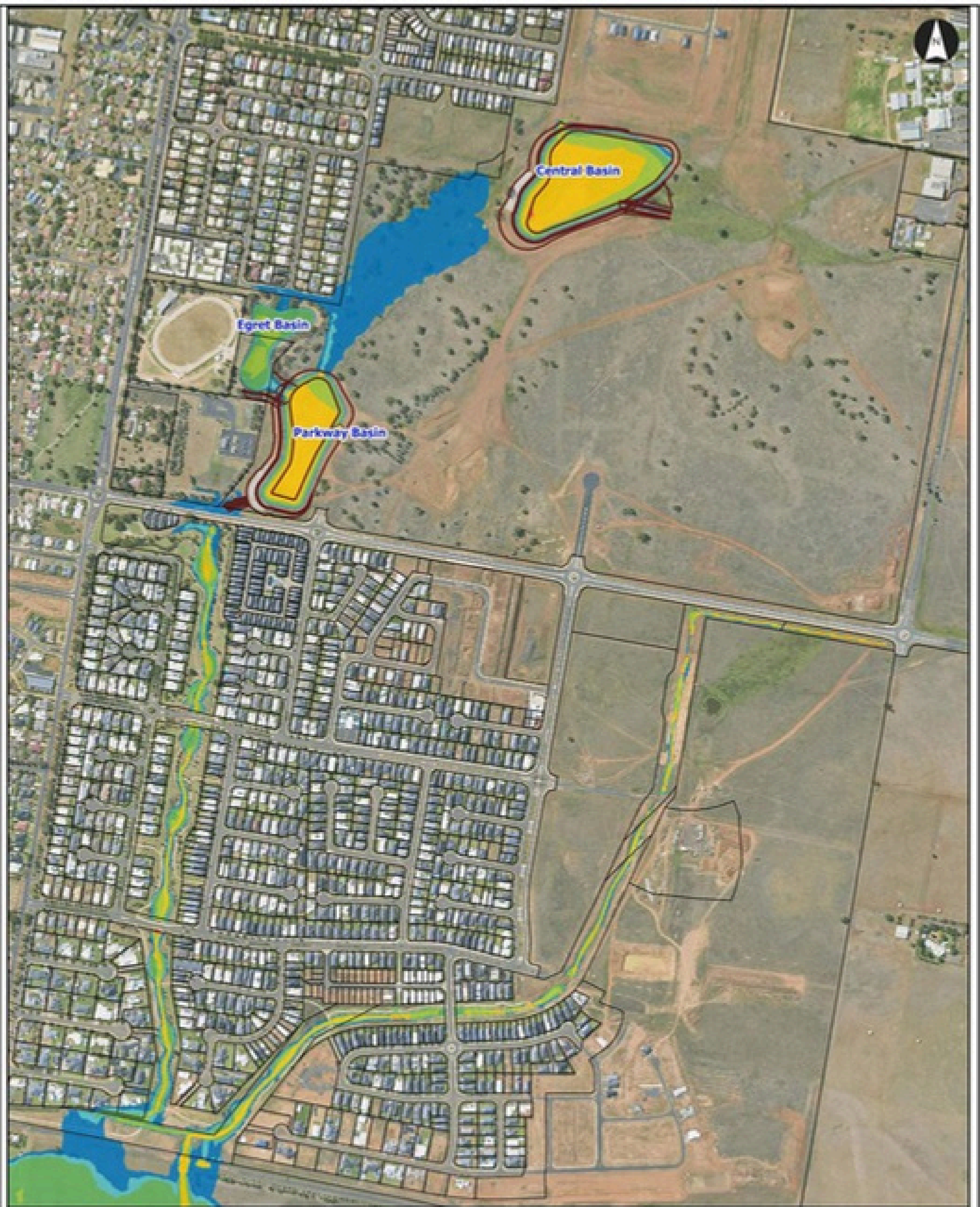
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Client: Oxbow Regional Council
Project Code: 200204064
Drawn By: SHP, Checked By: ST
Date: (2024-08-22)
Figure No: 03



Notes:
1. Map displayed in EPSG:28355

References:
1.
2.





Flood Hazard 1 in 50 AEP Benchmark Conditions

Project: Kewick Estate Planning Proposal
Client: Oudoo Regional Council
Project Code: 200204064
Drawn By: SHP, Checked By: ST
Date: (2024-08-22)
Figure No: 04



Legend

- Contour
- Road
- Hazard Category**
- Blue - Generally safe for vehicles, people and buildings
- Light Blue - Unsafe for small vehicles
- Green - Unsafe for vehicles, children and the elderly
- Yellow - Unsafe for vehicles and people
- Orange - Unsafe for vehicles and people
- Red - All buildings vulnerable to structural damage. Some low-rise buildings vulnerable to failure
- Dark Red - Unsafe for vehicles and people
- Dark Red - All building types considered vulnerable to failure.

Notes:
1. Map displayed in EPSG:28353

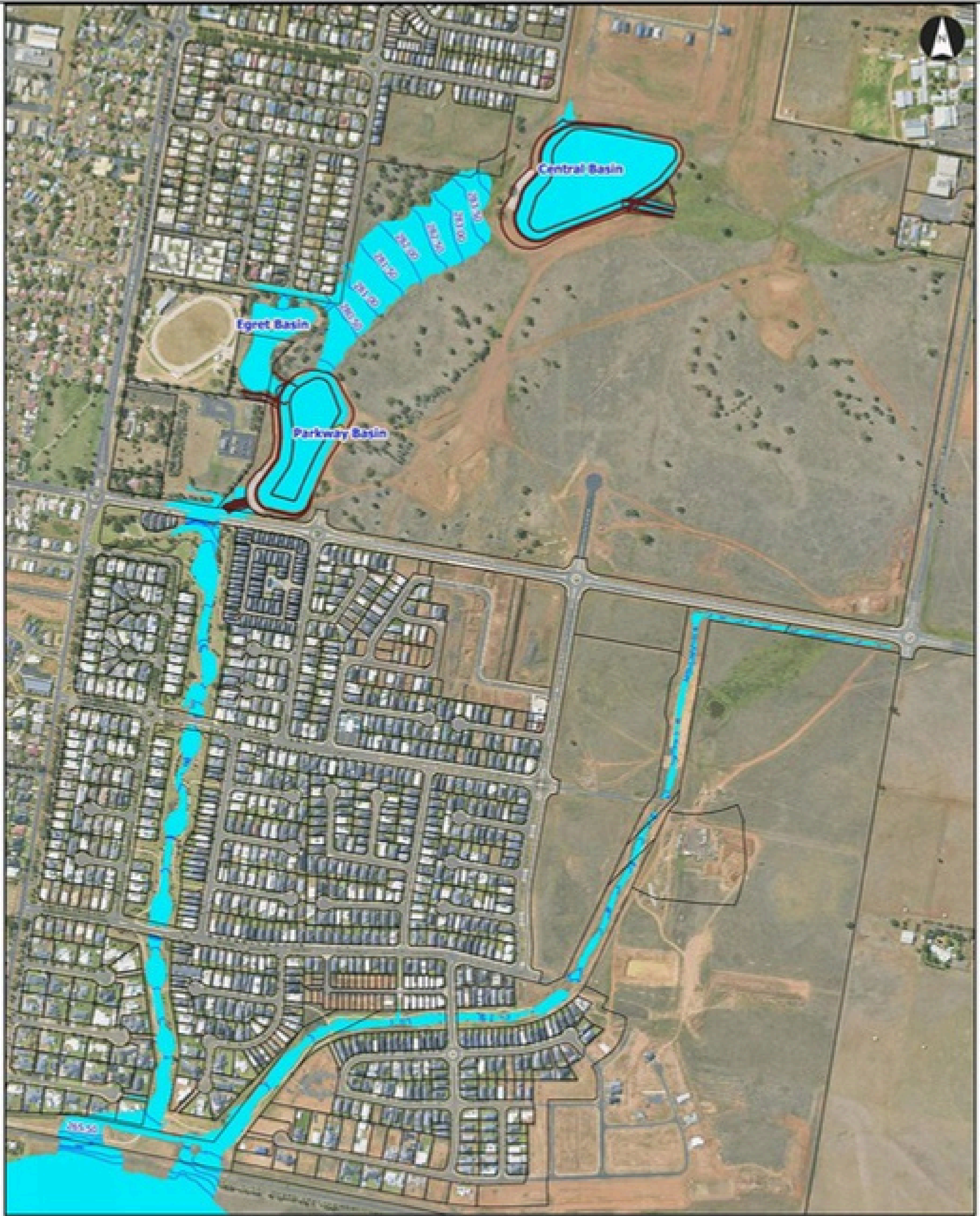
References:
1.
2.

DRAFT - Not For Construction



Scale of A3: 1:7000





Flood Extents & Flood Levels

1 in 100 AEP
Benchmark Conditions

Project: Kewick Estate Planning Proposal
Client: Oxbow Regional Council
Project Code: 200204064
Drawn By: SHP, Checked By: SH
Date: (2024-08-22)
Figure No: 85



Legend

— Contour — 0.5m Water Level Contours (mRLD)
— Banks
— Flood Extent

Notes

1. Map displayed in EPSG:28355

References

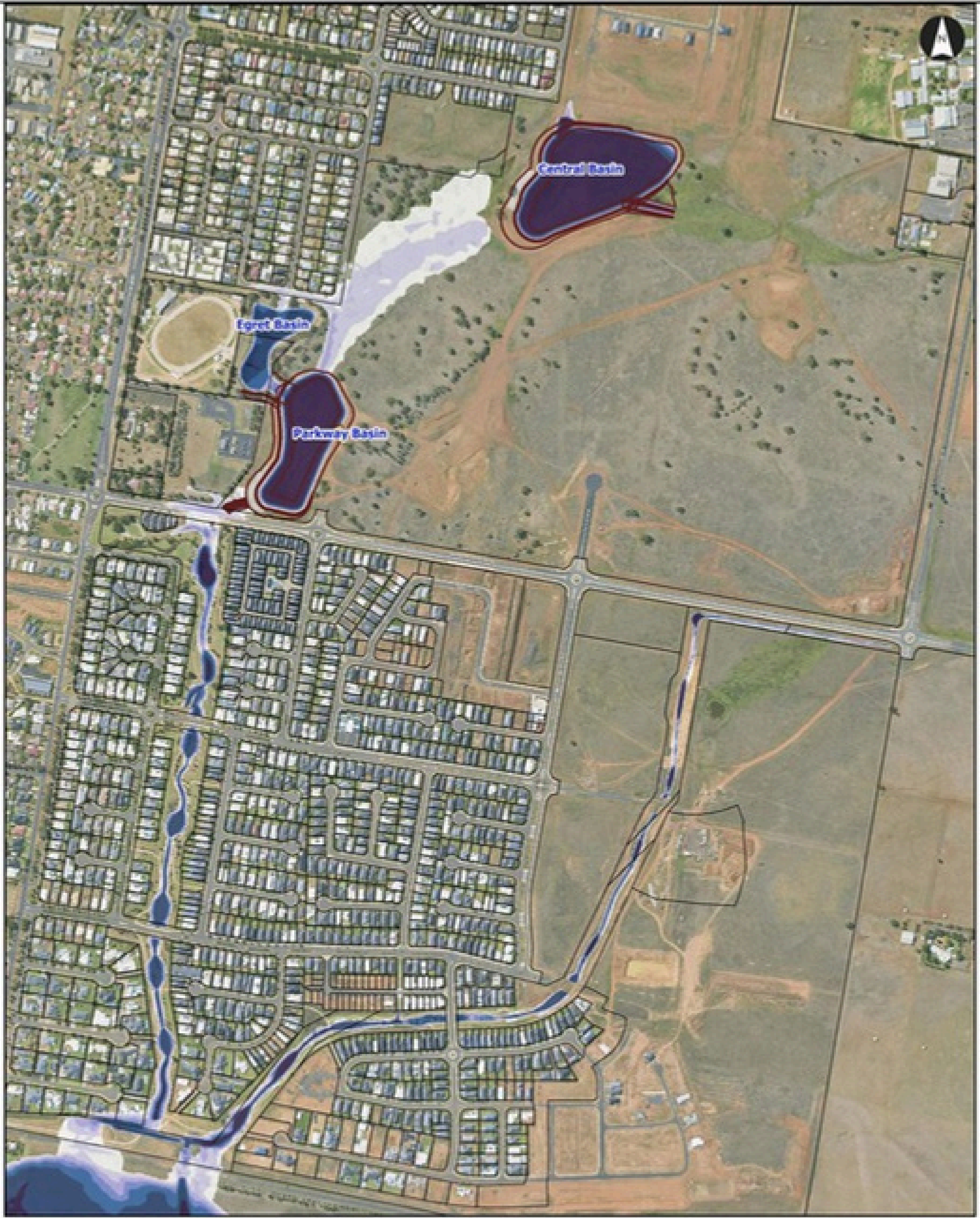
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DRAFT - Not For Construction



Scale of A3: 1:7000





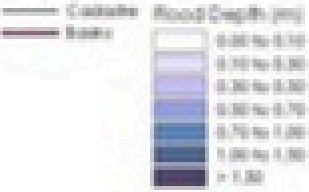
Flood Depths

1 in 100 AEP
Benchmark Conditions

Project: Kewick Estate Planning Proposal
Client: Oxbow Regional Council
Project Code: 200204064
Drawn By: SHP, Checked By: ST
Date: (2024-08-22)
Figure No: 64



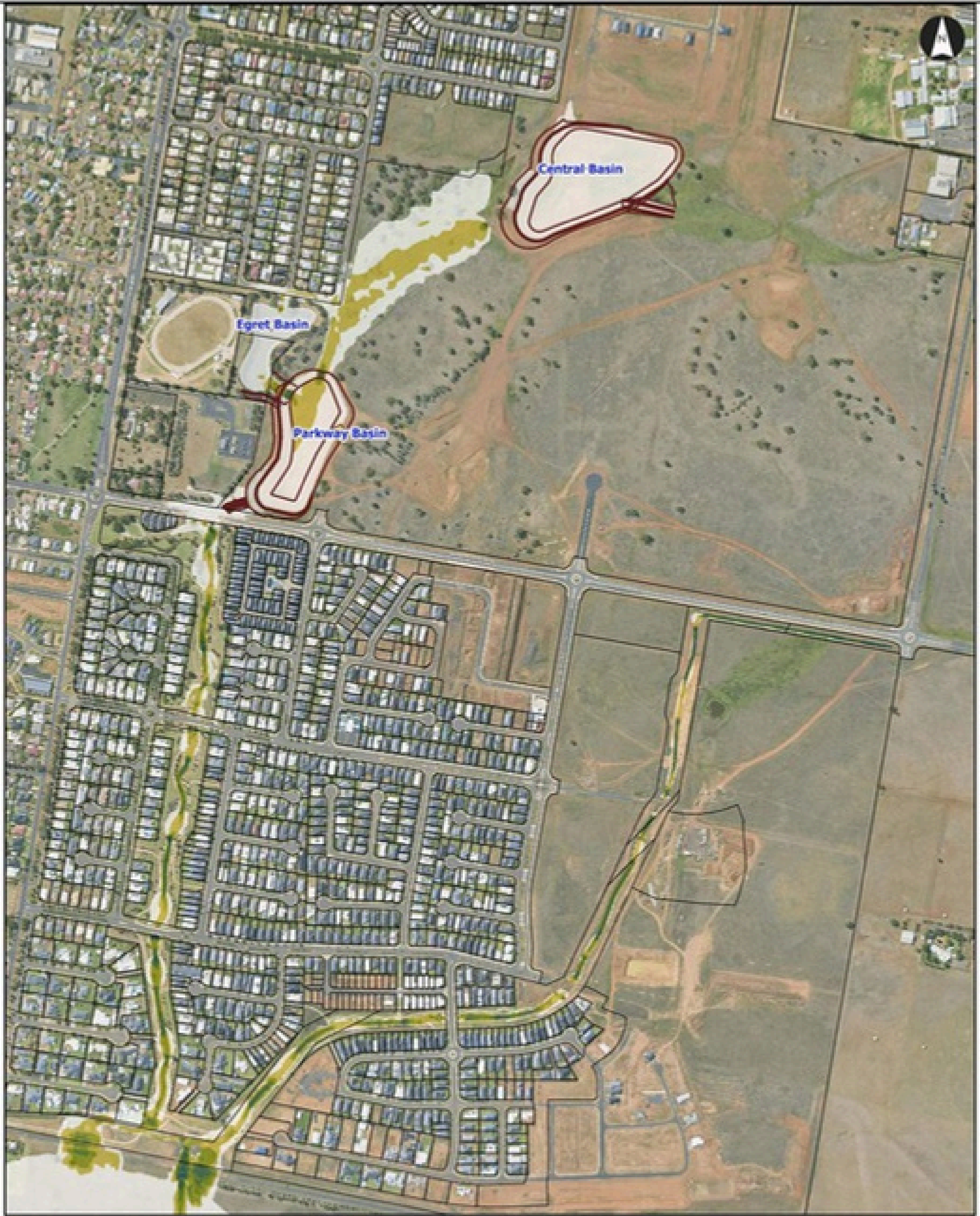
Legend



Notes:
1. Map displayed in EPSG:28355

References:
1.
2.





Flood Velocities

1 in 100 AEP
Benchmark Conditions

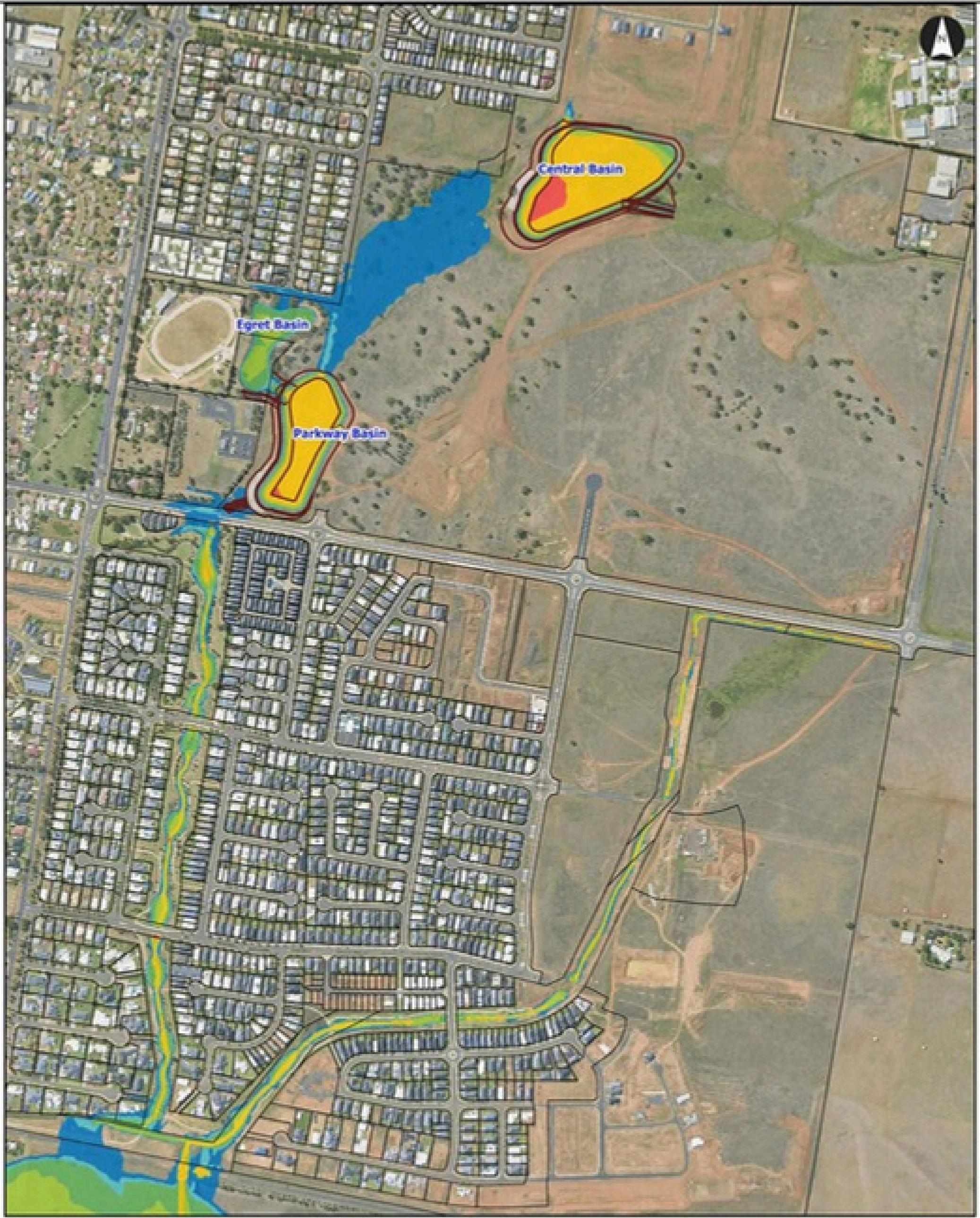
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Client: Oxbow Regional Council
Project Code: 200204064
Drawn By: SHP, Checked By: ST
Date: (2024-08-22)
Figure No: 07



Notes:
1. Map displayed in EPSG:28355

References:
1.
2.





Flood Hazard

1 in 100 AEP
Benchmark Conditions

Project: Kewick Estate Planning Proposal
Client: Oudoo Regional Council
Project Code: 20020404
Drawn By: SHP, Checked By: ST
Date: (2024-08-22)
Figure No: 08



Legend

- Contour
- Road
- Hazard Category**
- Blue - Generally safe for vehicles, people and buildings
- Light Blue - Unsafe for small vehicles
- Green - Unsafe for vehicles, children and the elderly
- Yellow - Unsafe for vehicles and people
- Orange - Unsafe for vehicles and people
- Red - All buildings vulnerable to structural damage. Some low-rise buildings vulnerable to failure
- Dark Red - Unsafe for vehicles and people
- Dark Red - All building types considered vulnerable to failure.

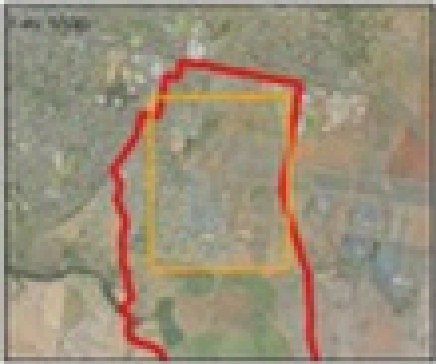
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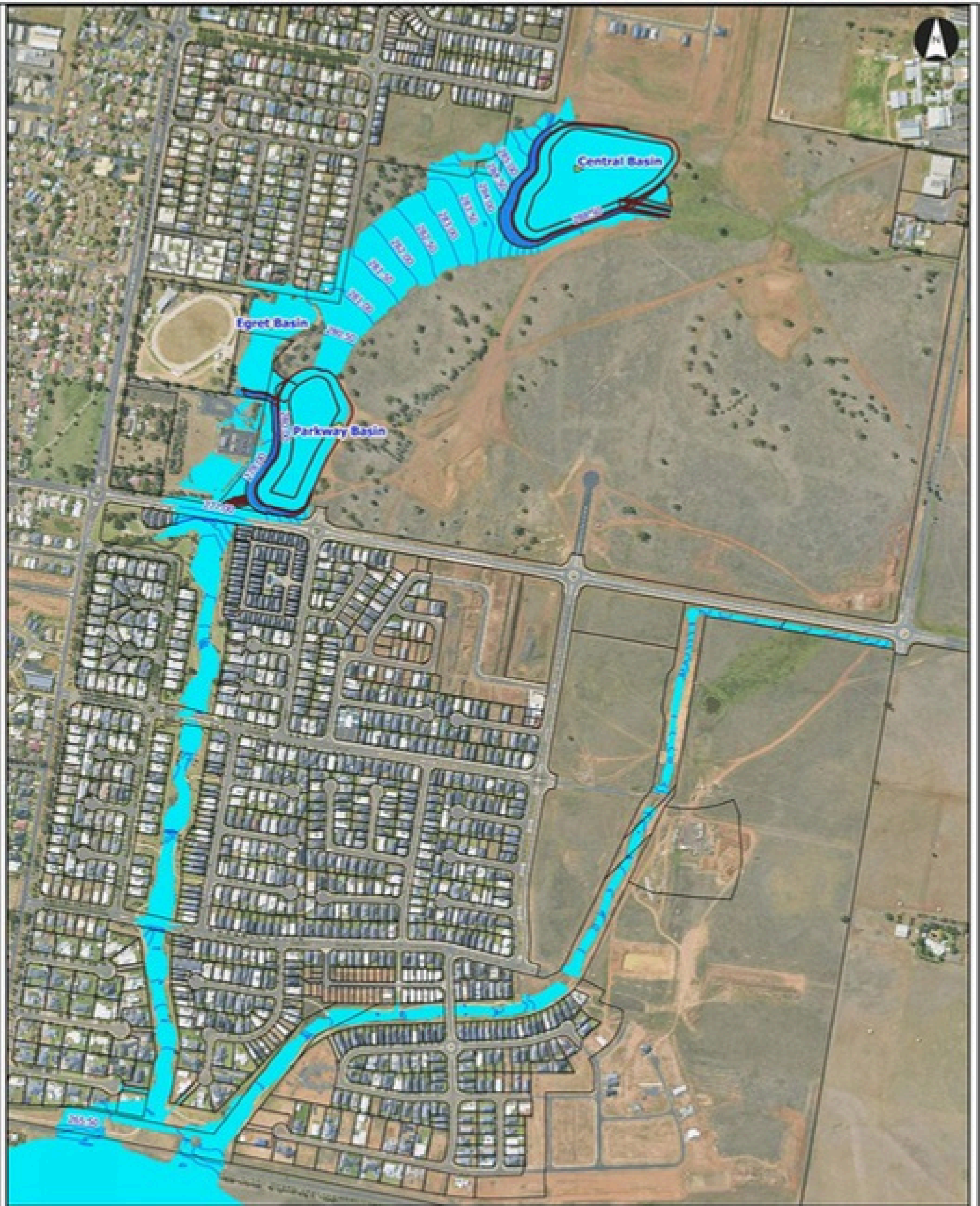
References:
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2.

DRAFT - Not For Construction



Scale of A3: 1:7000





Flood Extents & Flood Levels

1 in 1000 AEP

Benchmark Conditions

Project: Kewick Estate Planning Proposal

Client: Oxbow Regional Council

Project Code: 200204064

Drawn By: SHP, Checked By: SH

Date: (2024-08-22)

Figure No: 09



Legend

- Contour
- Banks
- Flood Extent
- 0.5m Water Level Contours (mRLD)

Notes

1. Map displayed in EPSG:28355

References

- 1.
- 2.

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Scale of A3: 1:7000





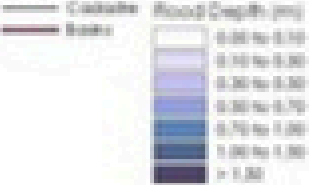
Flood Depths

1 in 1000 AEP
Benchmark Conditions

Project: Kewick Estate Planning Proposal
Client: Oudoo Regional Council
Project Code: 200204064
Drawn By: SHP, Checked By: ST
Date: (2024-08-22)
Figure No: 010



Legend



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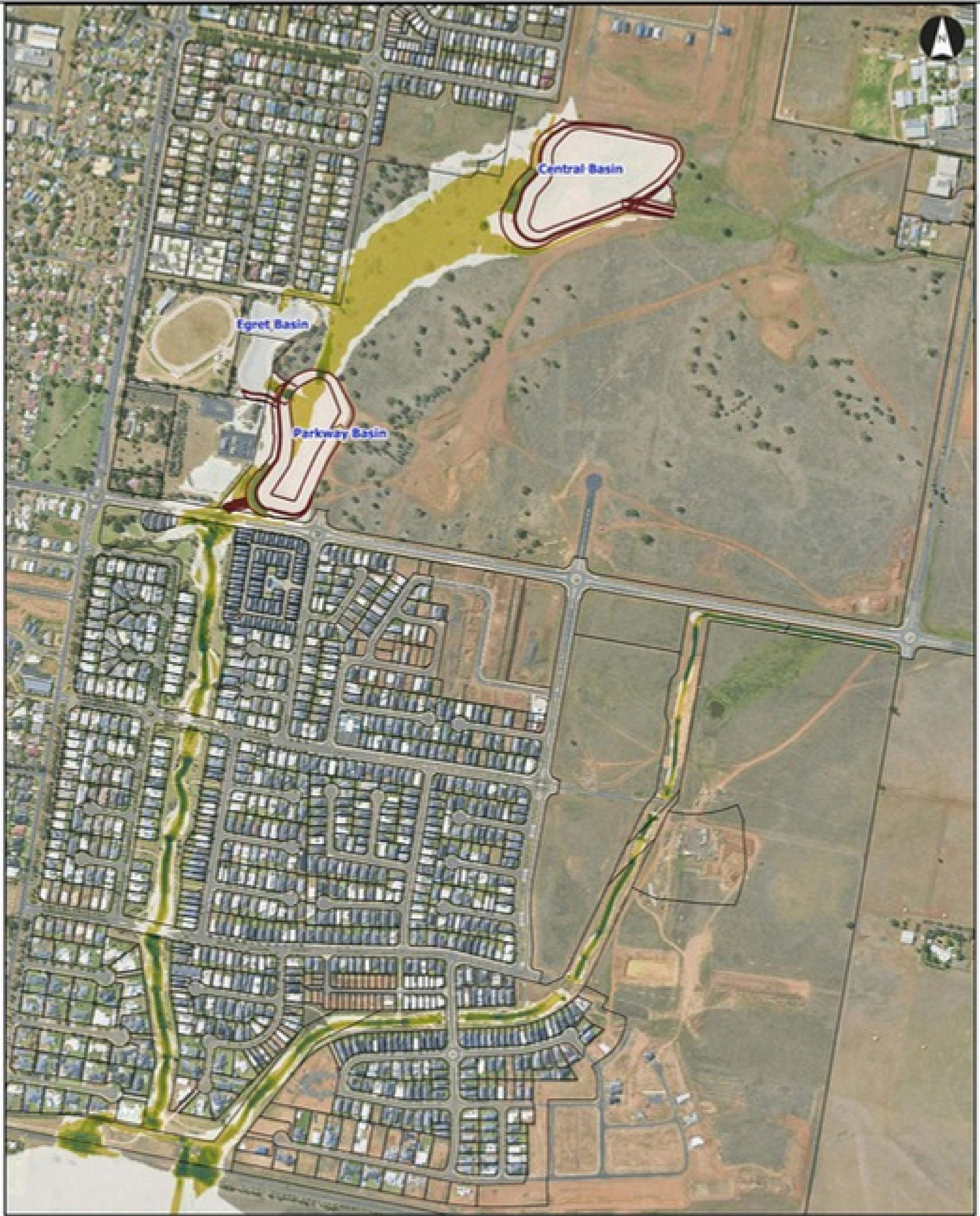
References:
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2.

DRAFT - Not For Construction



Scale of A3: 1:7000





Flood Velocities

1 in 1000 AEP
Benchmark Conditions

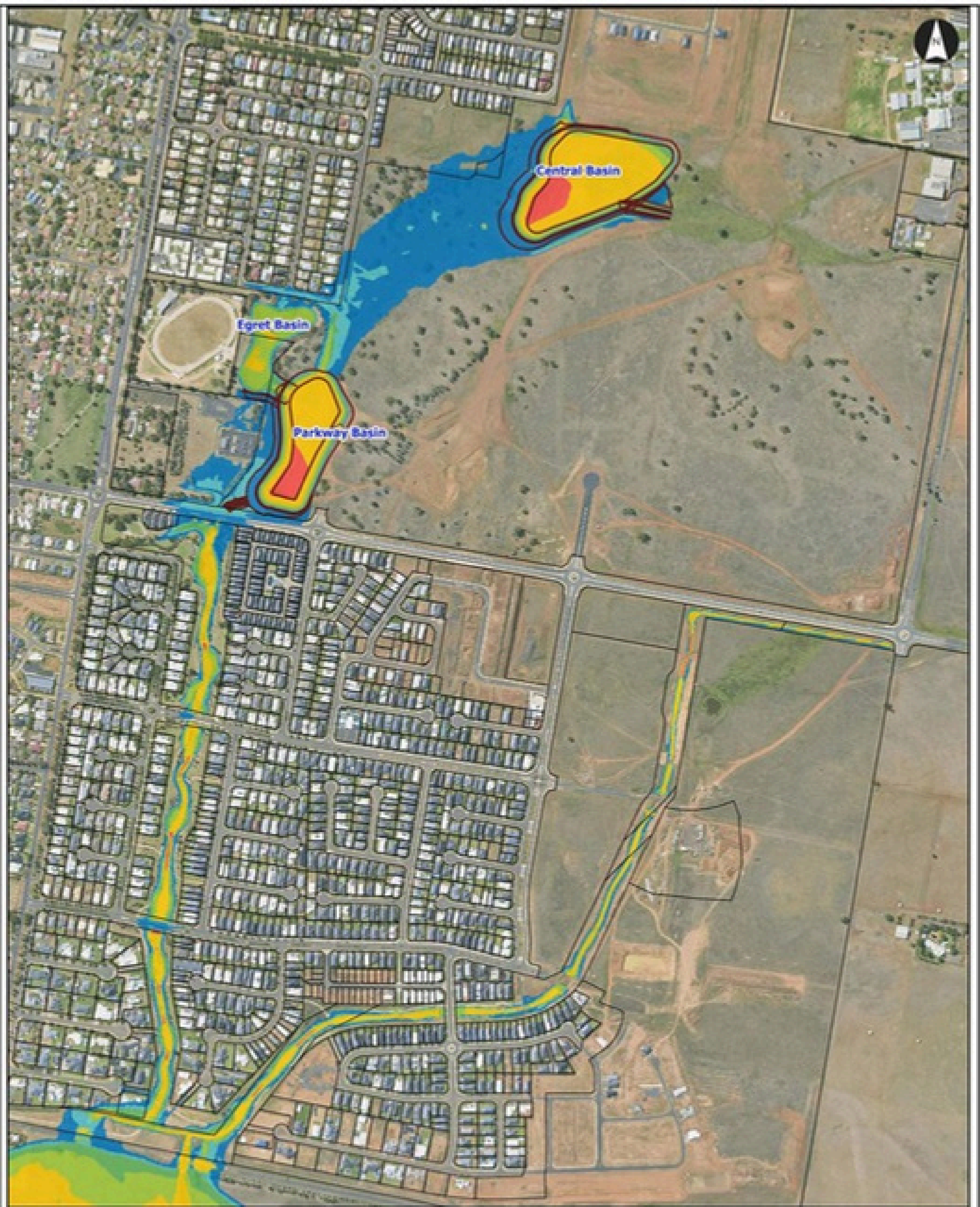
Project: Kewick Estate Planning Proposal
Client: Oudoo Regional Council
Project Code: 200204064
Drawn By: SHP, Checked By: ST
Date: (2024-08-22)
Figure No: 011



Notes:
1. Map displayed in EPSG:28355

References:
1.
2.





Flood Hazard 1 in 1000 AEP Benchmark Conditions

Project: Kewick Estate Planning Proposal
Client: Oudoo Regional Council
Project Code: 20020404
Drawn By: SHP, Checked By: ST
Date: (2024-08-22)
Figure No: 012



Legend

- Contour
- Road
- Hazard Category**
- Blue - Generally safe for vehicles, people and buildings
- Green - Unsafe for small vehicles, children and the elderly
- Yellow - Unsafe for vehicles and people
- Red - Unsafe for vehicles and people, all buildings vulnerable to structural damage. Some low-rise buildings vulnerable to failure
- Red - Unsafe for vehicles and people, all building types considered vulnerable to failure.

Notes:
1. Map displayed in EPSG:28353

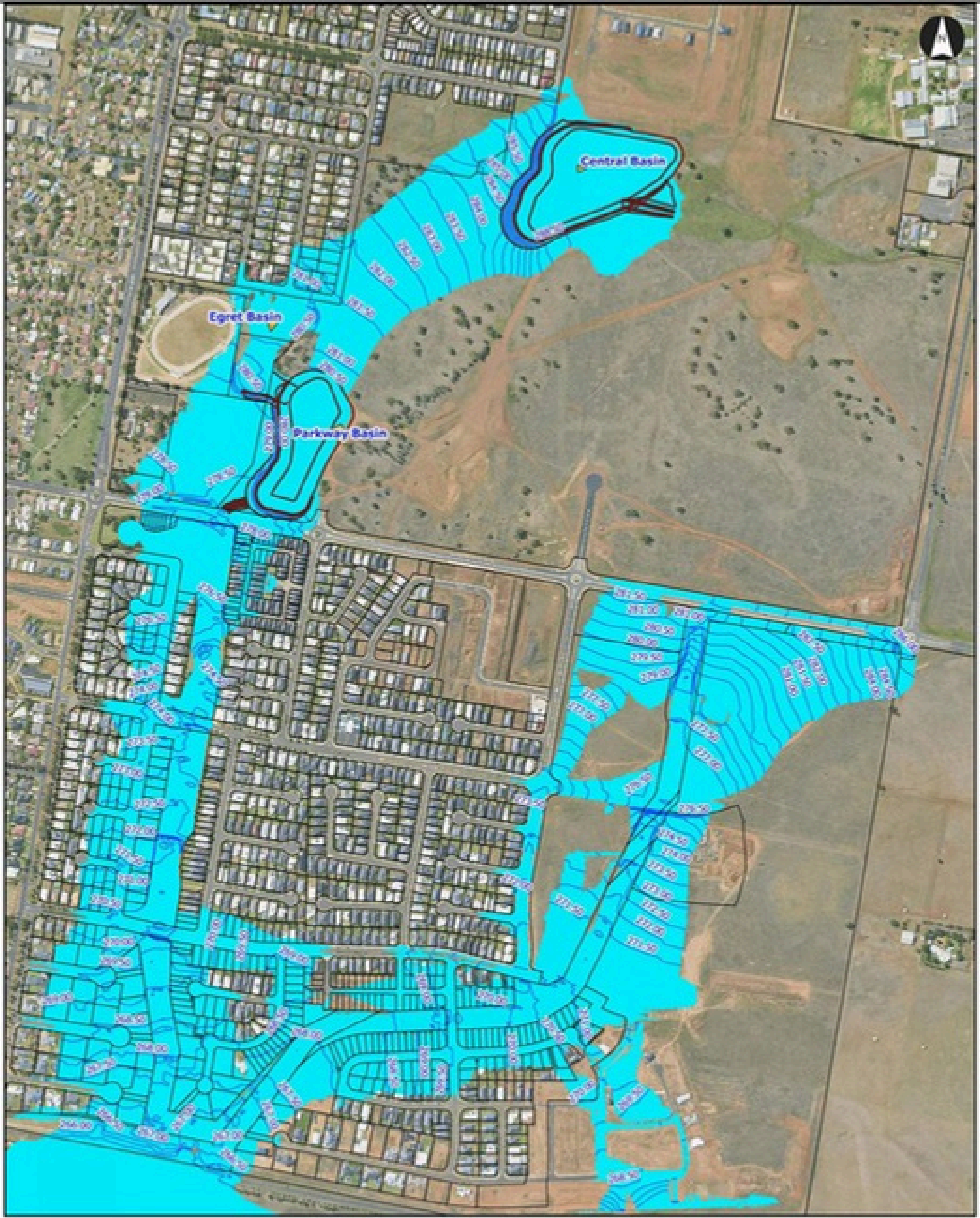
References:
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Scale of A3: 1:7000





Flood Extents & Flood Levels

Plan
Benchmark Conditions

Project: Kawick Estate Planning Proposal
Client: Oxbow Regional Council
Project Code: 200204064
Drawn By: SHP, Checked By: ST
Date: (2024-08-22)
Figure No: 013



Legend
--- Contour
--- Basin
Kawick_EST12_BAS1_Plan_Flood_Max_Max
Flood Extent

0.5m Water Level Contour (m)

Notes:
1. Map displayed in EPSG:28355

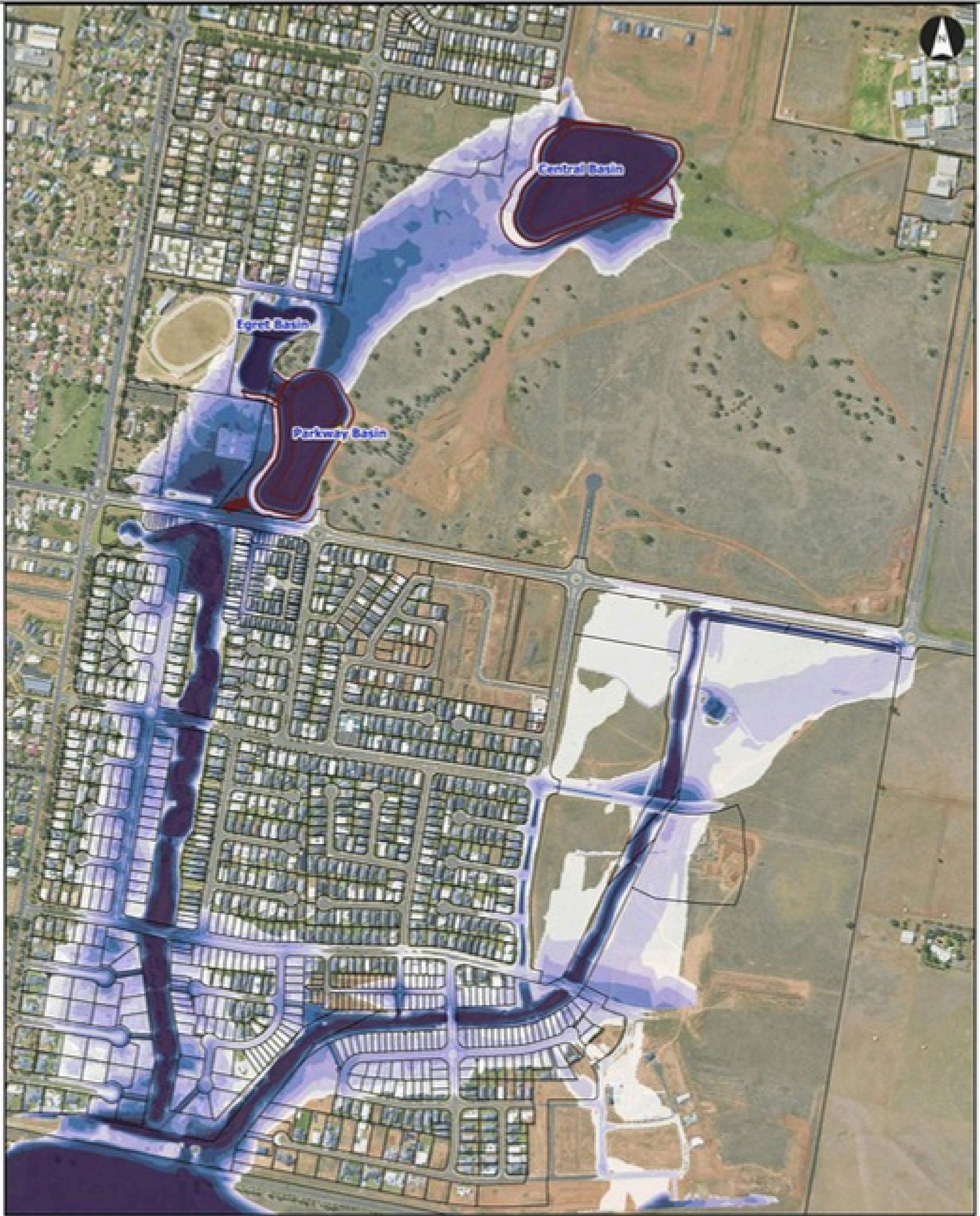
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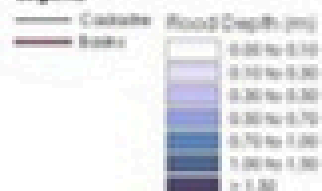
Flood Depths

Map
Benchmark Conditions

Project: Kewick Estate Planning Proposal
Client: Oxbow Regional Council
Project Code: 200204064
Drawn By: SHP, Checked By: ST
Date: 2024-08-22
Figure No: 014



Legend



Notes

1. Map displayed in EPSG:28355

References

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Scale of A3: 1:7000





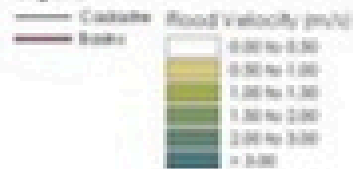
Flood Velocities

PIR
Benchmark Conditions

Project: Kewick Estate Planning Proposal
Client: Oubou Regional Council
Project Code: 20020404
Drawn By: SHP, Checked By: ST
Date: (2024-08-22)
Figure No: 011



Legend



Notes

1. Map displayed in EPSG:28355

References

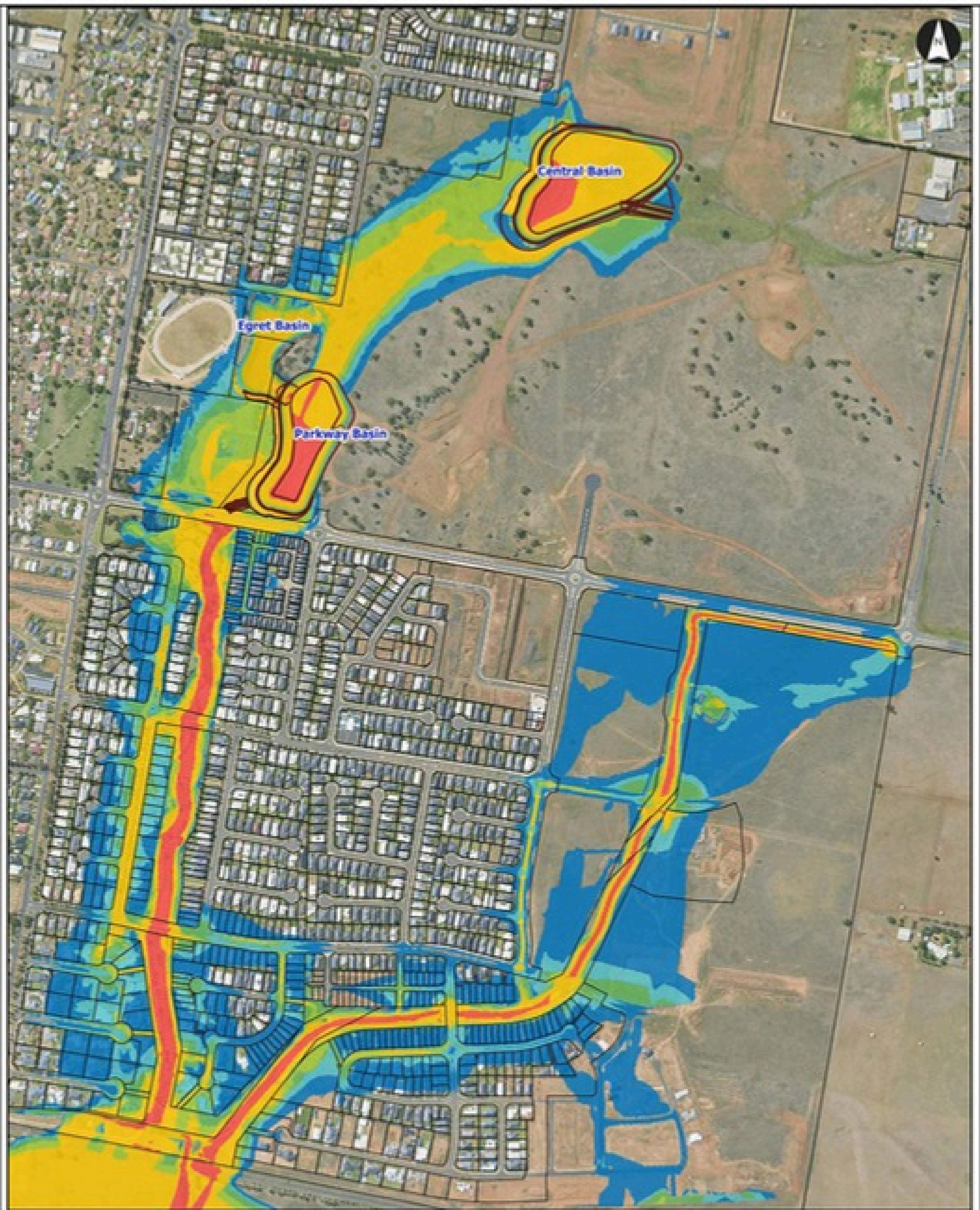
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Scale of A3: 1:7000





Flood Hazard

Plan
Benchmark Conditions

Project: Kewick Estate Planning Proposal
Client: Oubou Regional Council
Project Code: 200204064
Drawn By: SHP, Checked By: SH
Date: (2024-08-22)
Figure No: E14



Legend

- Cadastre
- Roads
- Hazard Category**
 - Blue - Generally safe for vehicles, people and buildings
 - Green - Unsafe for small vehicles
 - Yellow - Unsafe for vehicles, children, and the elderly
 - Orange - Unsafe for vehicles and people
 - Red - Unsafe for vehicles and people, all buildings vulnerable to structural damage. Some low-rise buildings vulnerable to failure
 - Red - Unsafe for vehicles and people, all building types considered vulnerable to failure.

Notes:
1. Map displayed in EPSG:28353

References:
1.
2.

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Scale of A3: 1:7000



Appendix B Planning Proposal conditions



List of Planning Proposal Conditions Flood Maps:

Figure F1 1 in 50 AEP Flood Extents and Flood Levels –Planning Proposal

Figure F2 1 in 50 AEP Flood Depths - Planning Proposal

Figure F3 1 in 50 AEP Flood Velocities - Planning Proposal

Figure F4 1 in 50 AEP Flood Hazards - Planning Proposal

Figure F5 1 in 50 AEP Level Differences - (Planning Proposal – Benchmark Conditions)

Figure F6 1 in 50 AEP Velocity Differences - (Planning Proposal – Benchmark Conditions)

Figure F7 1 in 100 AEP Flood Extents and Flood Levels –Planning Proposal

Figure F8 1 in 100 AEP Flood Depths - Planning Proposal

Figure F9 1 in 100 AEP Flood Velocities - Planning Proposal

Figure F10 1 in 100 AEP Flood Hazards - Planning Proposal

Figure F11 1 in 100 AEP Level Differences - (Planning Proposal – Benchmark Conditions)

Figure F12 1 in 100 AEP Velocity Differences - (Planning Proposal – Benchmark Conditions)

Figure F13 1 in 100 AEP Flood Extents and Flood Levels – Planning Proposal

Figure F14 1 in 1000 AEP Flood Depths - Planning Proposal

Figure F15 1 in 1000 AEP Flood Velocities - Planning Proposal

Figure F16 1 in 1000 AEP Flood Hazards - Planning Proposal

Figure F17 1 in 1000 AEP Level Differences - (Planning Proposal – Benchmark Conditions)

Figure F18 1 in 1000 AEP Velocity Differences - (Planning Proposal – Benchmark Conditions)

Figure F19 PMF Flood Extents and Flood Levels - Planning Proposal

Figure F20 PMF Flood Depths - Planning Proposal

Figure F21 PMF Flood Velocities - Planning Proposal

Figure F22 PMF Flood Hazards - Planning Proposal

Figure F23 PMF Level Differences - (Planning Proposal – Benchmark Conditions)

Figure F24 PMF Velocity Differences - (Planning Proposal – Benchmark Conditions)





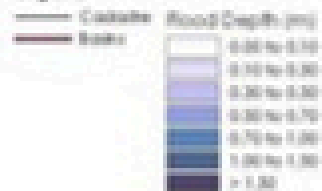
Flood Depths

1 in 50 AEP
Planning Proposal

Project: Kewick Estate Planning Proposal
Client: Oxbow Regional Council
Project Code: 200204064
Drawn By: SHP, Checked By: ST
Date: (2024-08-22)
Figure No: P2



Legend



Notes

1. Map displayed in EPSG:28355

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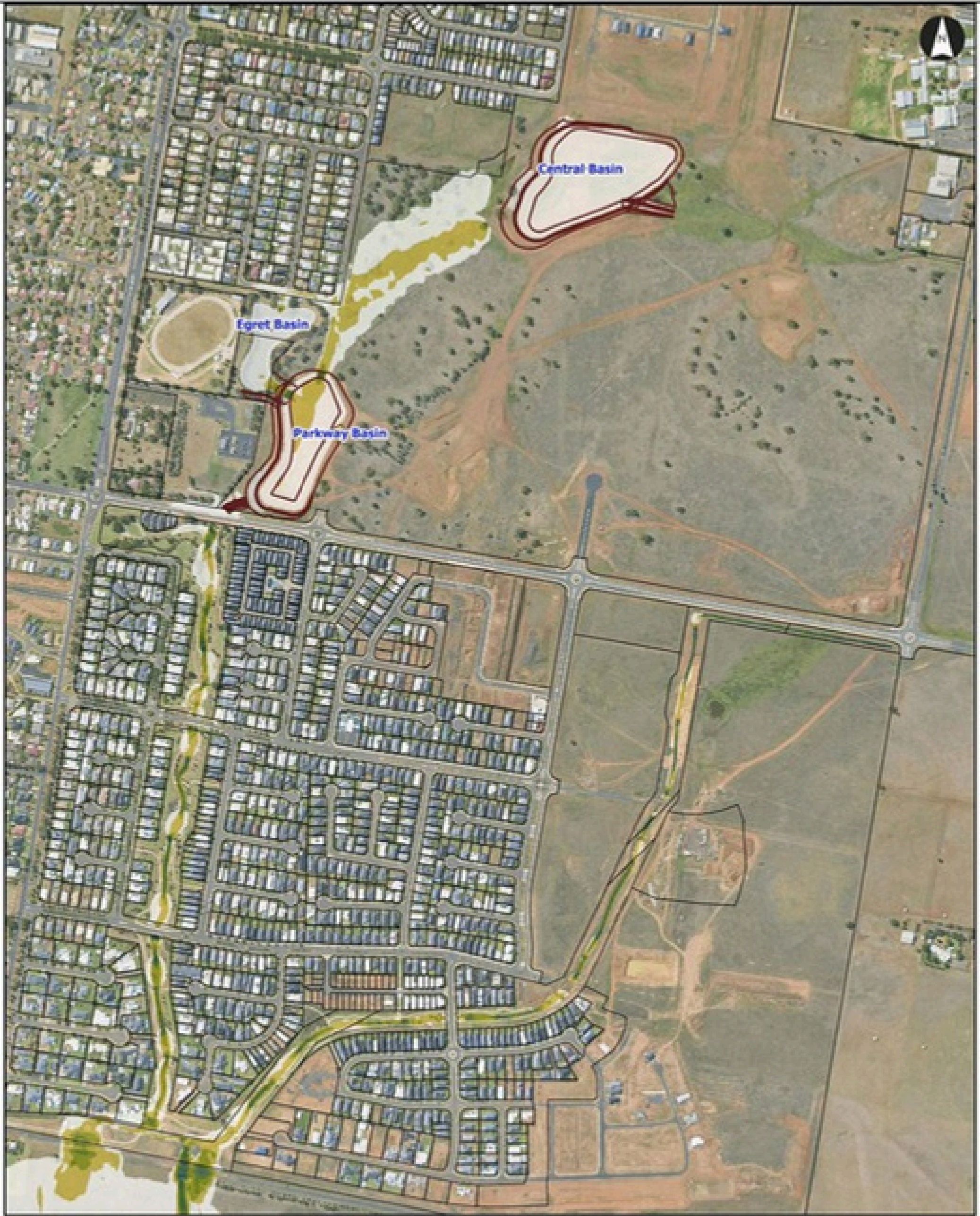
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Scale of A3: 1:7000





Flood Velocities

1 in 50 AEP
Planning Proposal

Project: Kewick Estate Planning Proposal

Client: Oxtoby Regional Council

Project Code: 200204064

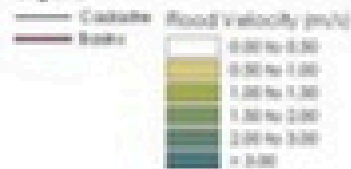
Drawn By: SHP, Checked By: ST

Date: (2024-08-22)

Figure No: F3



Legend



Notes

1. Map displayed in EPSG:28355

References

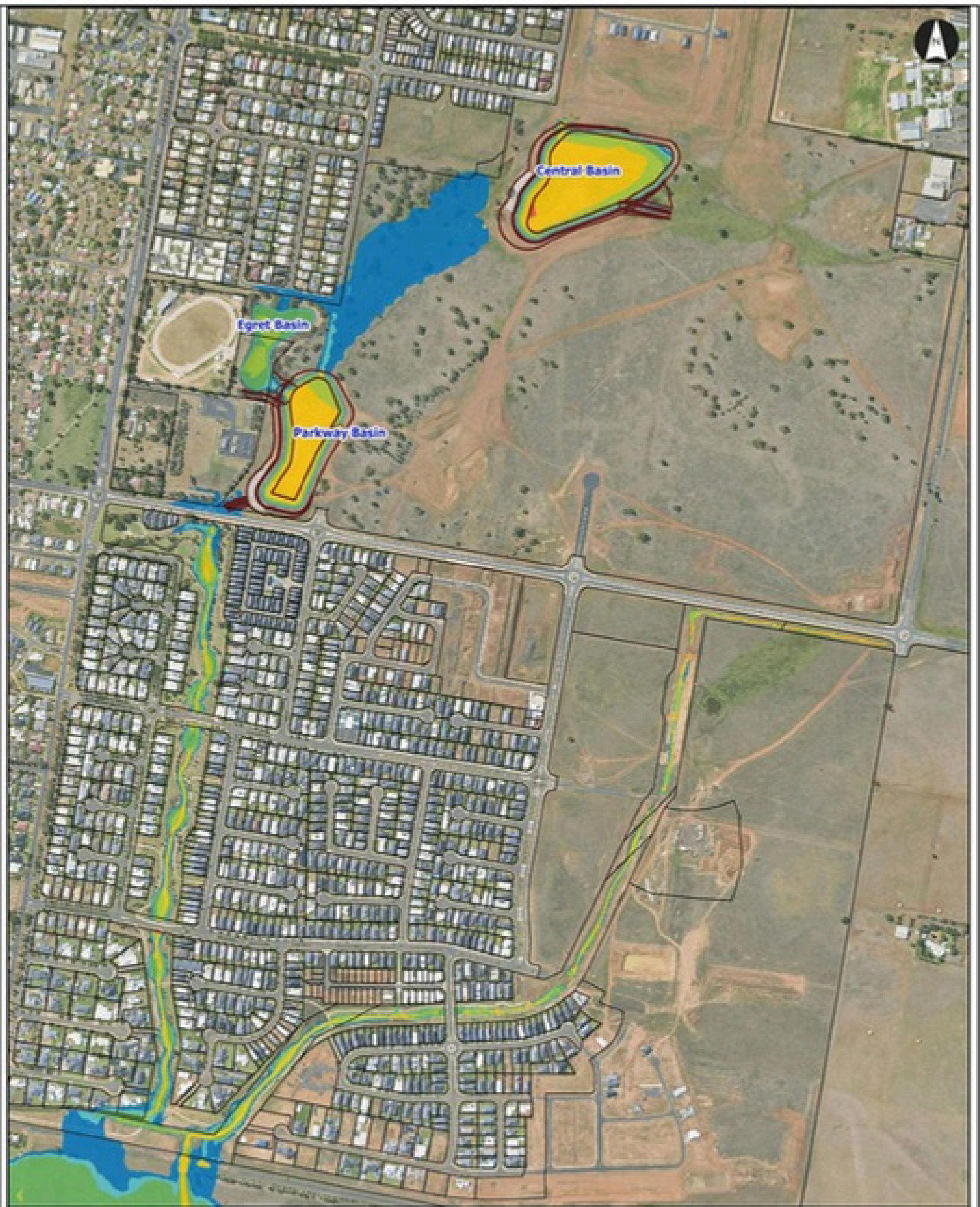
- 1.
- 2.

DRAFT - Not For Construction



Scale of A3: 1:7000





Flood Hazard

1 in 50 AEP
Planning Proposal

Project: Kewick Estate Planning Proposal

Client: Oudine Regional Council

Project Code: 20020404

Drawn By: SHP, Checked By: ST

Date: (2024-08-22)

Figure No: 14



Legend

- Catchment
- Basin
- Hazard Category**
 - Blue - Generally safe for vehicles, people and buildings.
 - Green - Unsafe for small vehicles.
 - Yellow - Unsafe for vehicles, children and the elderly.
 - Red - Unsafe for vehicles and people.
- All buildings vulnerable to structural damage. Some less robust buildings vulnerable to failure.
- All buildings vulnerable to failure.
- All building types considered vulnerable to failure.

Notes

1. Map displayed in EPSG:28355

References

- 1.
- 2.

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Scale of A3: 1:7000





Water Level Difference

1000

Planning Proposal - Base Network Conditions

Project 2: Canada's Energy Planning Process

Client: Dublin Regional Council

Project: **Chickadee** **2000-2001**

Document No.: 0097, Checksum No.: 28

Center: (202) 462-2222

Figure	Page	Fig.
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Figure 4	13	Fig. 4
Figure 5	14	Fig. 5
Figure 6	15	Fig. 6
Figure 7	16	Fig. 7
Figure 8	17	Fig. 8
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Figure 10	19	Fig. 10
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Figure 12	21	Fig. 12
Figure 13	22	Fig. 13
Figure 14	23	Fig. 14
Figure 15	24	Fig. 15
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Figure 30	39	Fig. 30
Figure 31	40	Fig. 31
Figure 32	41	Fig. 32
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Figure 45	54	Fig. 45
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Figure 50	59	Fig. 50
Figure 51	60	Fig. 51
Figure 52	61	Fig. 52
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Figure 54	63	Fig. 54
Figure 55	64	Fig. 55
Figure 56	65	Fig. 56
Figure 57	66	Fig. 57
Figure 58	67	Fig. 58
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Figure 62	71	Fig. 62
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Figure 74	83	Fig. 74
Figure 75	84	Fig. 75
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Figure 77	86	Fig. 77
Figure 78	87	Fig. 78
Figure 79	88	Fig. 79
Figure 80	89	Fig. 80
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Figure 82	91	Fig. 82
Figure 83	92	Fig. 83
Figure 84	93	Fig. 84
Figure 85	94	Fig. 85
Figure 86	95	Fig. 86
Figure 87	96	Fig. 87
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Figure 89	98	Fig. 89
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Figure 97	106	Fig. 97
Figure 98	107	Fig. 98
Figure 99	108	Fig. 99
Figure 100	109	Fig. 100
Figure 101	110	Fig. 101
Figure 102	111	Fig. 102
Figure 103	112	Fig. 103
Figure 104	113	Fig. 104
Figure 105	114	Fig. 105
Figure 106	115	Fig. 106
Figure 107	116	Fig. 107
Figure 108	117	Fig. 108
Figure 109	118	Fig. 109
Figure 110	119	Fig. 110
Figure 111	120	Fig. 111
Figure 112	121	Fig. 1



100

- Control
 ———— Biotic
 Wet & Dry Analysis
 ———— High Wet, High Dry
 ———— High Dry, High Wet



Key Messages

3. Acetyl-chloroacetate in EPIC-10000

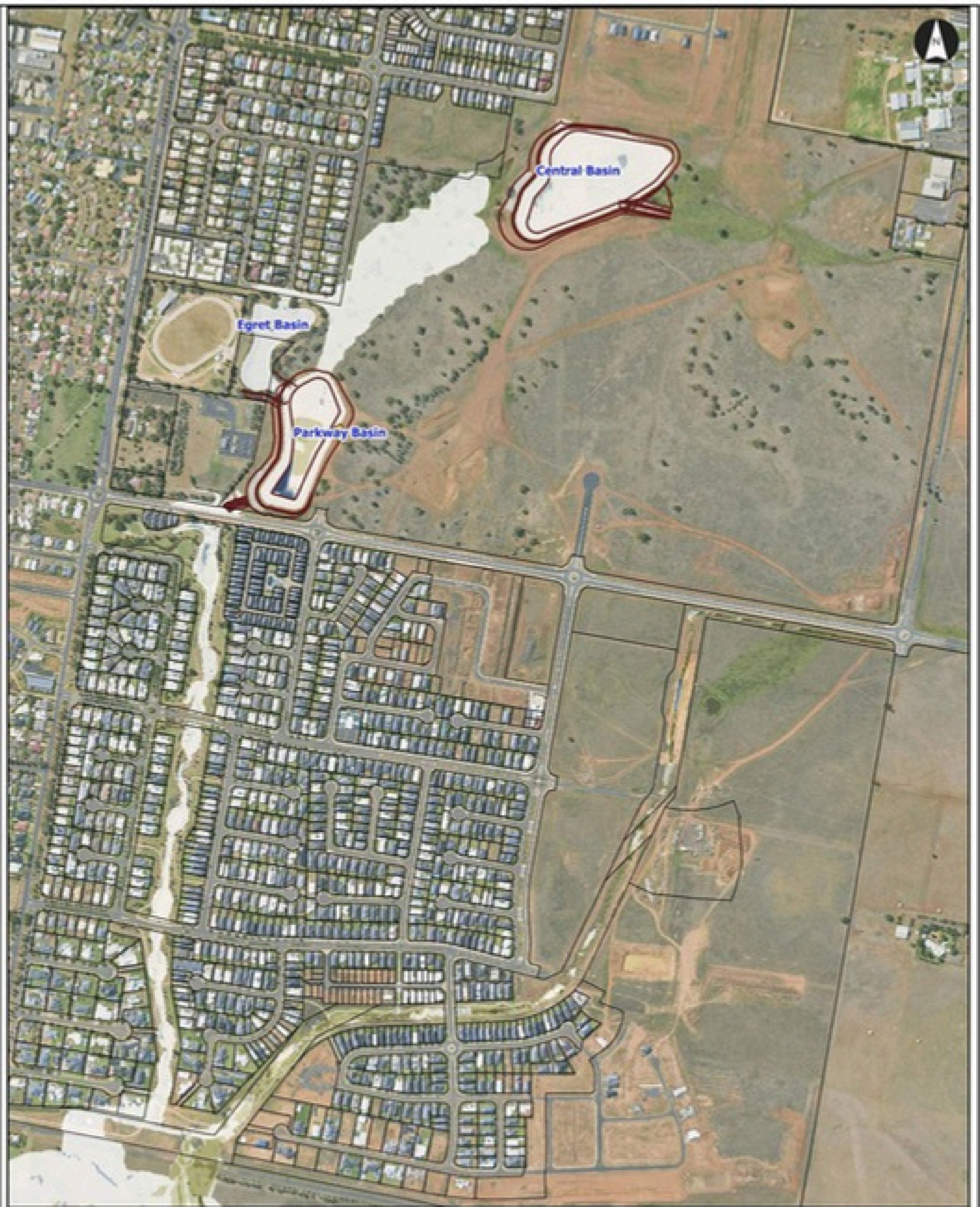
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Received 10 July 2003; accepted 10 September 2003

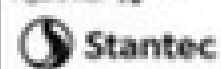




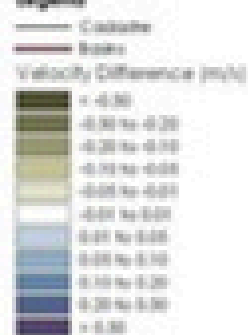
Velocity Difference

1 in 50 AEP
Planning Proposal - Benchmark
Conditions

Project: Kewick Estate Planning Proposal
Client: Oubou Regional Council
Project Code: 200204064
Drawn By: SHP, Checked By: ST
Date: (2024-08-22)
Figure No: F6



Legend



Notes

1. Map displayed in EPSG:28353

References

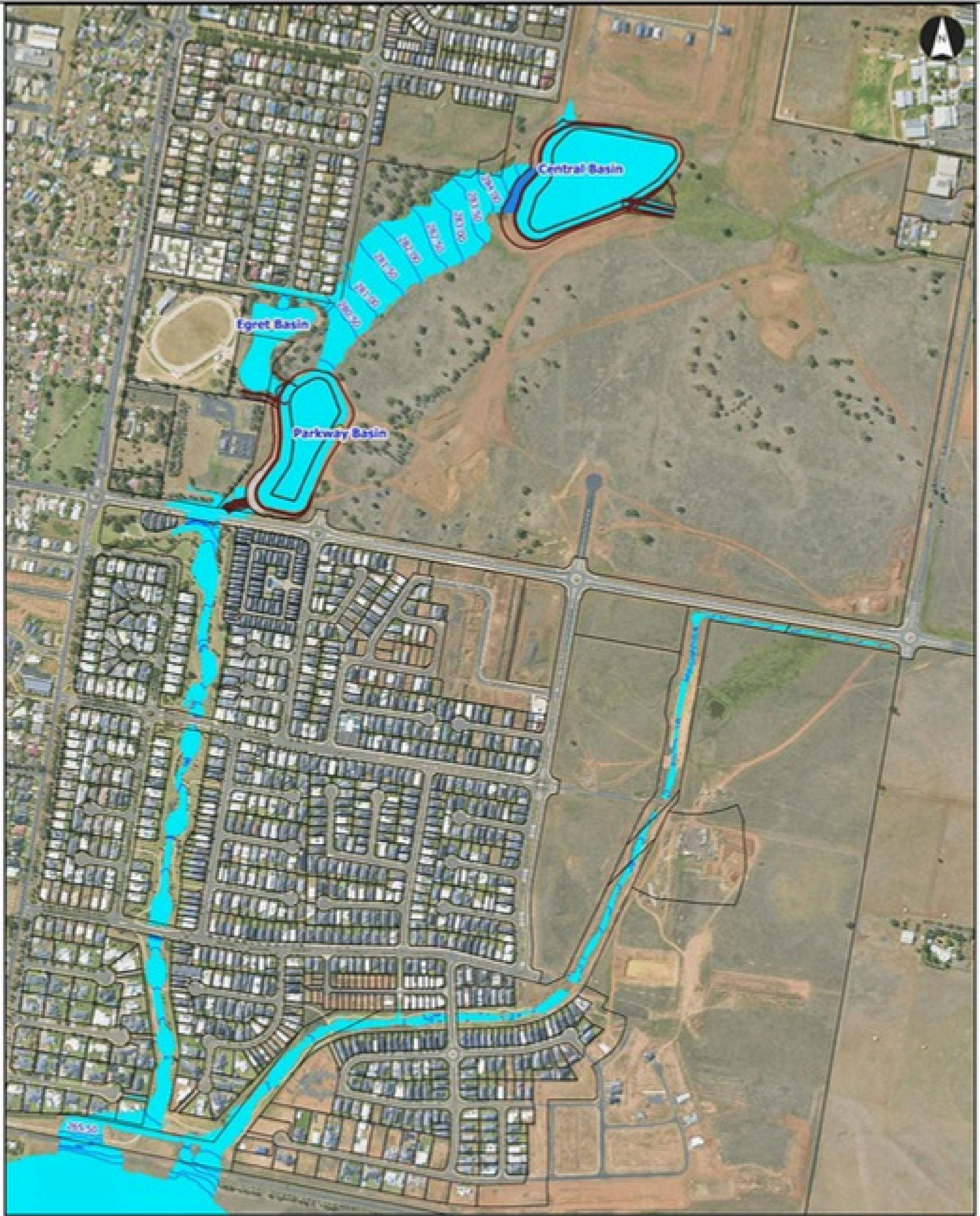
1.
2.

DRAFT - Not For Construction



Scale of A3: 1:7000





Flood Extents & Flood Levels

1 in 100 AEP
Planning Proposal

Project: Kawick Estate Planning Proposal
Client: Oxbow Regional Council
Project Code: 200204064
Drawn By: SHP, Checked By: SH
Date: (2024-08-22)
Figure No: #7



Legend

——— Contour
——— Basin
Kawick_EST12_Dev1_100yr_H_Maps_Map
Flood Extent

0.5m Water Level Contour

Notes

1. Map displayed in EPSG:28355

References

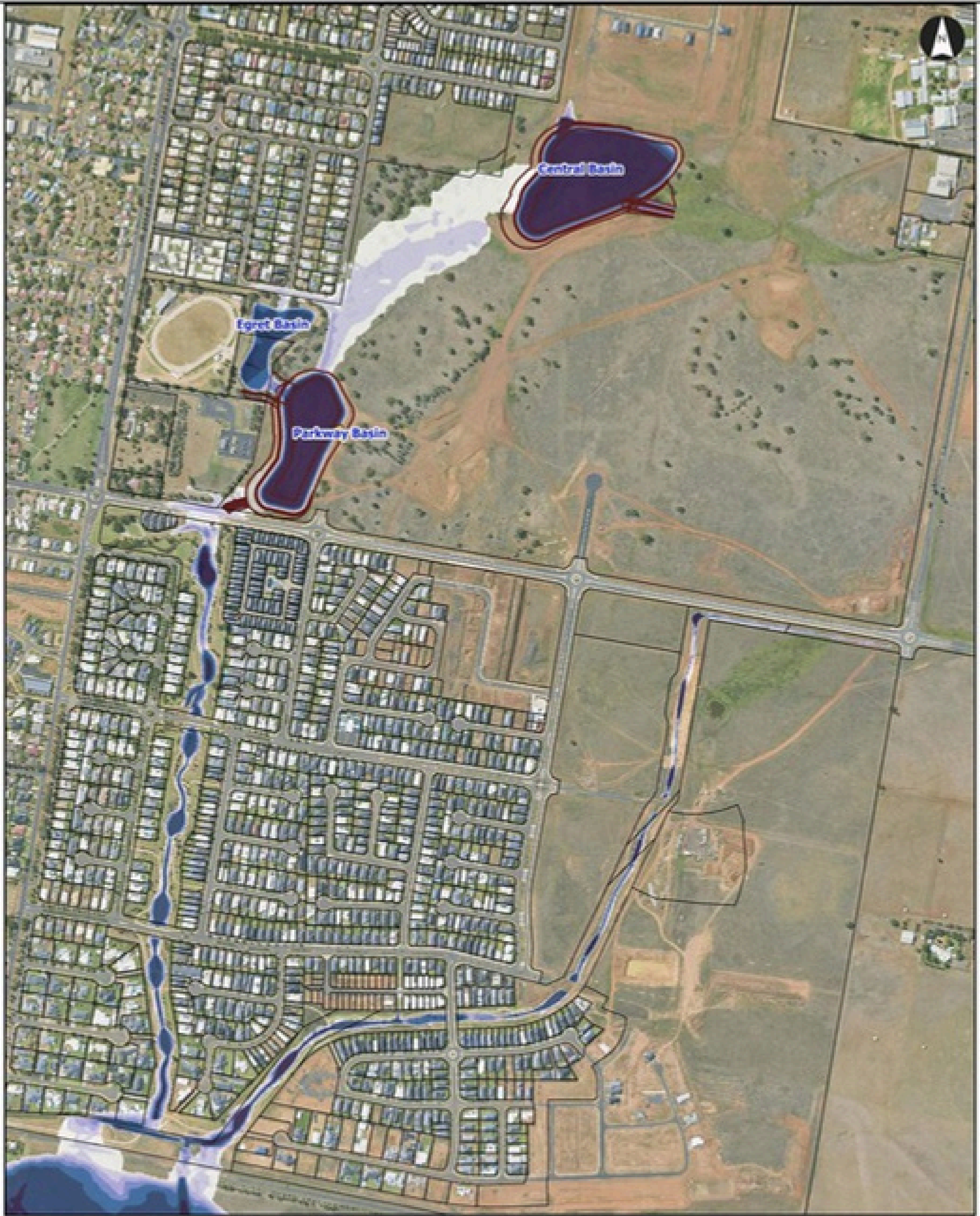
1.
2.

DRAFT - Not For Construction



Scale of A3: 1:7000





Flood Depths

1 in 100 AEP
Planning Proposal

Project: Kewick Estate Planning Proposal
Client: Oxbow Regional Council
Project Code: 200204064
Drawn By: SHP, Checked By: ST
Date: (2024-08-22)
Figure No: PB



Legend

— Catchment
— Basin

Flood Depth (m)
0.00 to 0.10
0.10 to 0.20
0.20 to 0.30
0.30 to 0.50
0.50 to 0.70
0.70 to 1.00
1.00 to 1.50
≥ 1.50

Notes

1. Map displayed in EPSG:28355

References

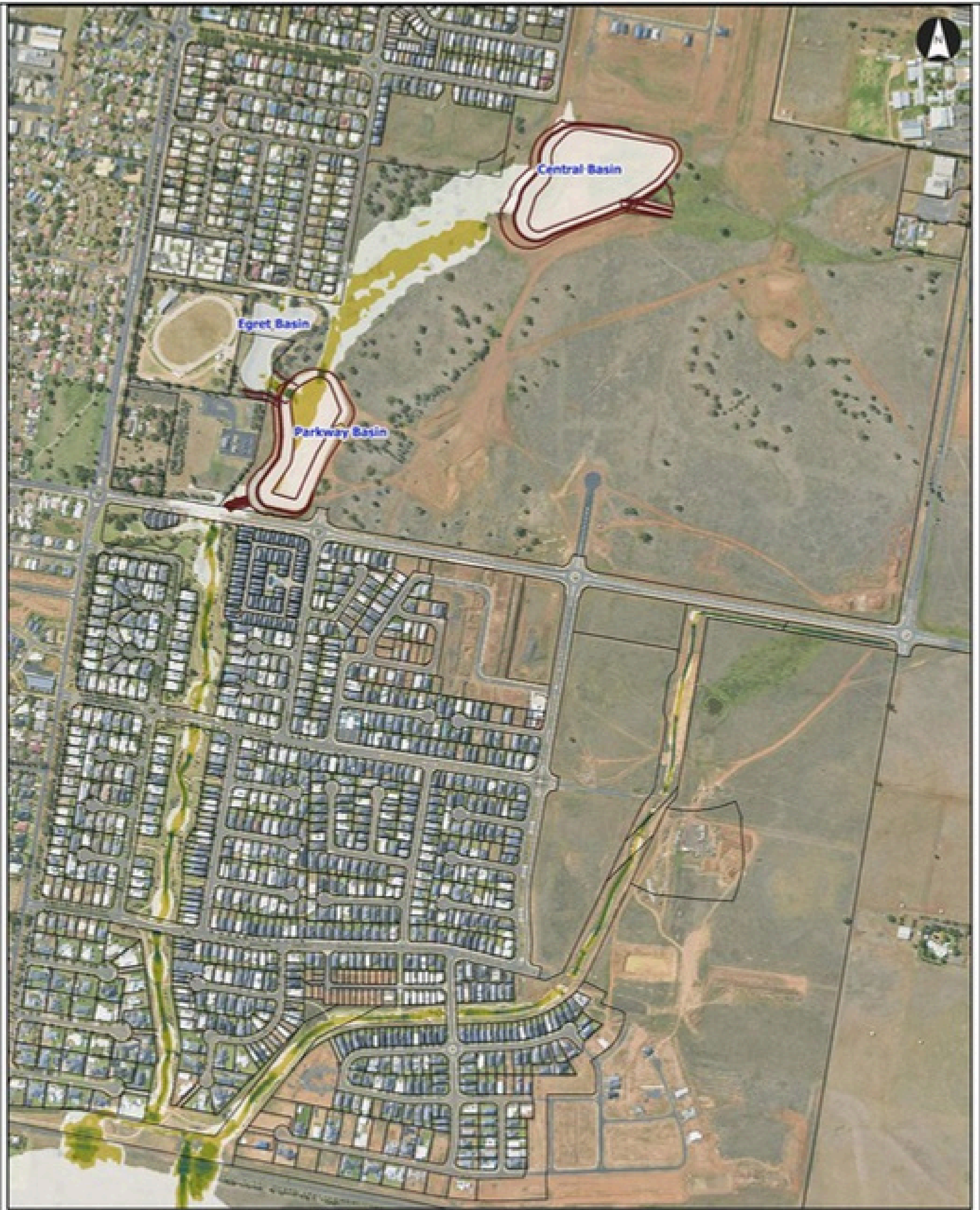
1.
2.

DRAFT - Not For Construction

0 50 100 150 200 250 m

Scale of A3: 1:7000





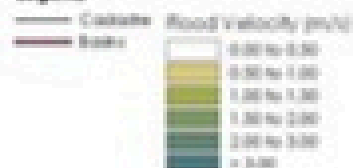
Flood Velocities

1 in 100 AEP
Planning Proposal

Project: Kewick Estate Planning Proposal
Client: Oudoo Regional Council
Project Code: 200204064
Drawn By: SHP, Checked By: ST
Date: (2024-08-22)
Figure No: 19



Legend



Notes

1. Map displayed in EPSG:28355

References

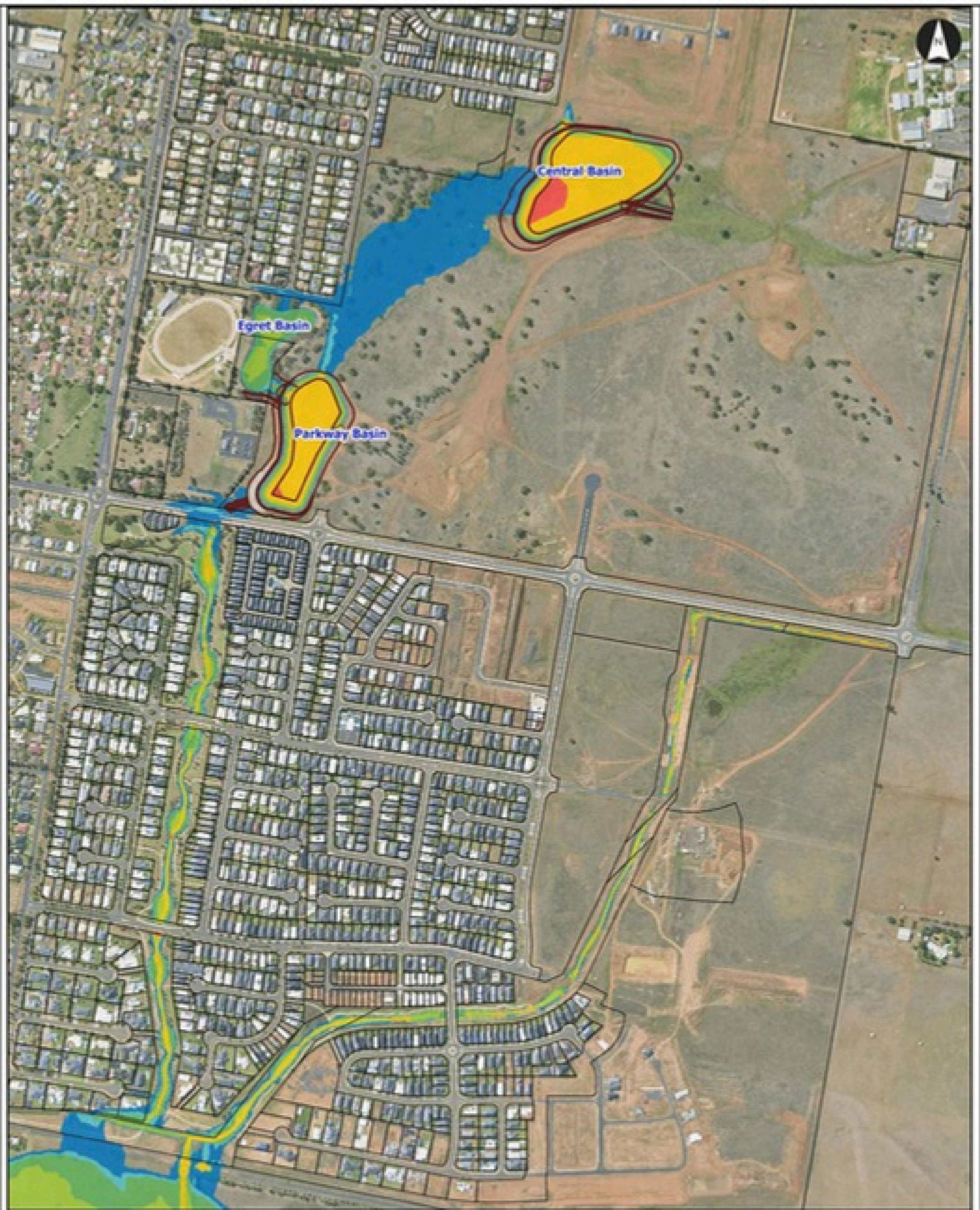
1.
2.

DRAFT - Not For Construction



Scale of A3: 1:7000





Flood Hazard

1 in 100 AEP

Planning Proposal

Project: Kewick Estate Planning Proposal

Client: Oudine Regional Council

Project Code: 20020404

Drawn By: SHP, Checked By: ST

Date: (2024-08-22)

Figure No: F10



Legend

- Contour
- Road
- Hazard Category**
- Blue - Generally safe for vehicles, people and buildings
- Light Blue - Unsafe for small vehicles
- Green - Unsafe for vehicles, children and the elderly
- Yellow - Unsafe for vehicles and people
- Orange - Unsafe for vehicles and people
- Red - All buildings vulnerable to structural damage. Some low-rise buildings vulnerable to failure
- Dark Red - Unsafe for vehicles and people
- Dark Red - All building types considered vulnerable to failure.

Notes

1. Map displayed in EPSG:28355

References

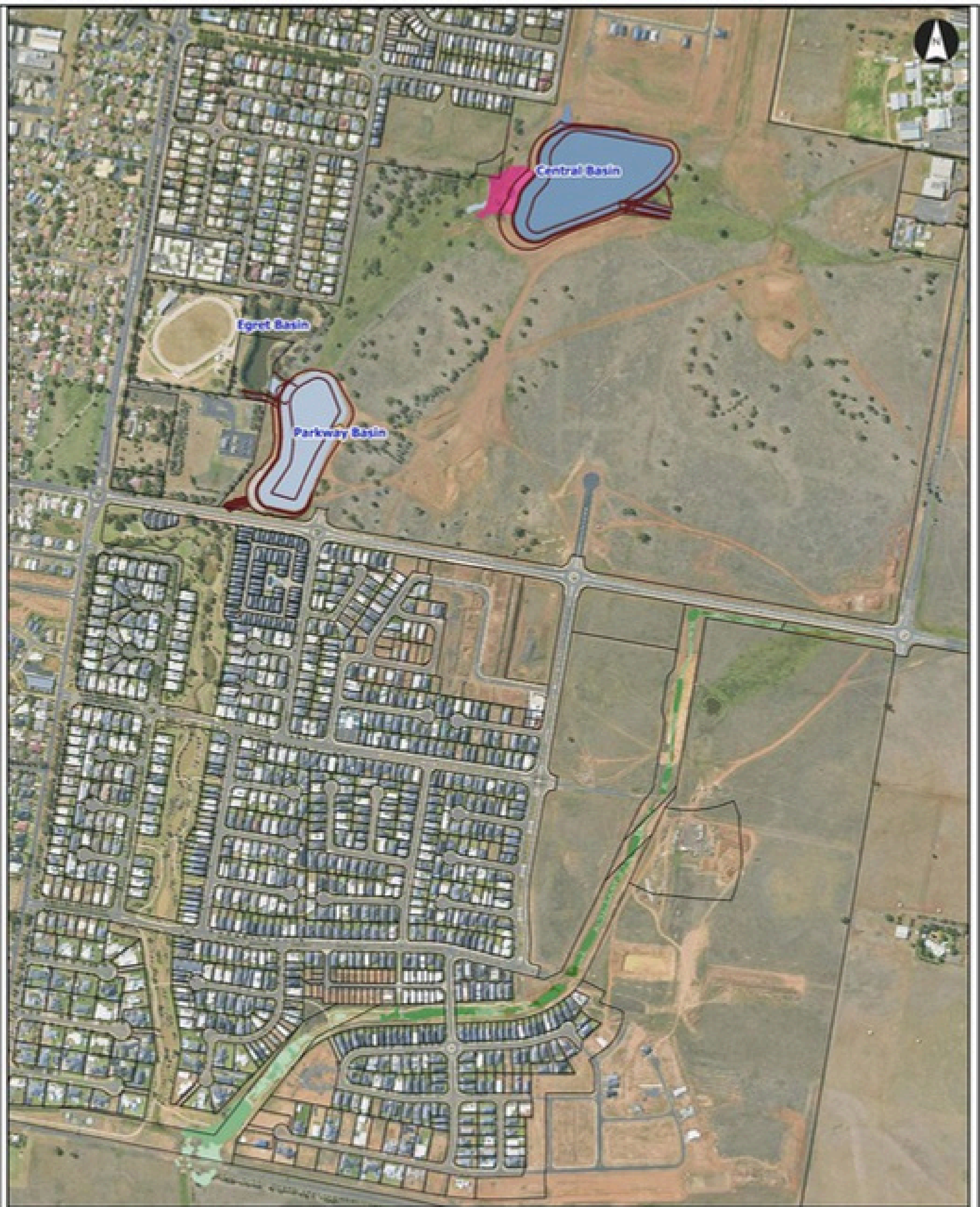
- 1.
- 2.

DRAFT - Not For Construction



Scale of A3: 1:7000





Water Level Difference

1 in 100 AEP
Planning Proposal - Benchmark
Conditions

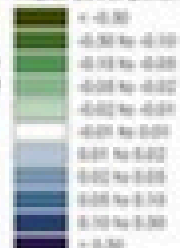
Project: Kewick Estate Planning Proposal
Client: Oubou Regional Council
Project Code: 200204064
Drawn By: SHP, Checked By: ST
Date: 2024-08-22
Figure No: #11



Legend

- Contour
- Boundary
- Wet & Dry Analysis
- Wet Wet, New Dry
- Wet Dry, New Wet

Water Level Difference (m)



Notes

1. Map displayed in EPSG:28355

References

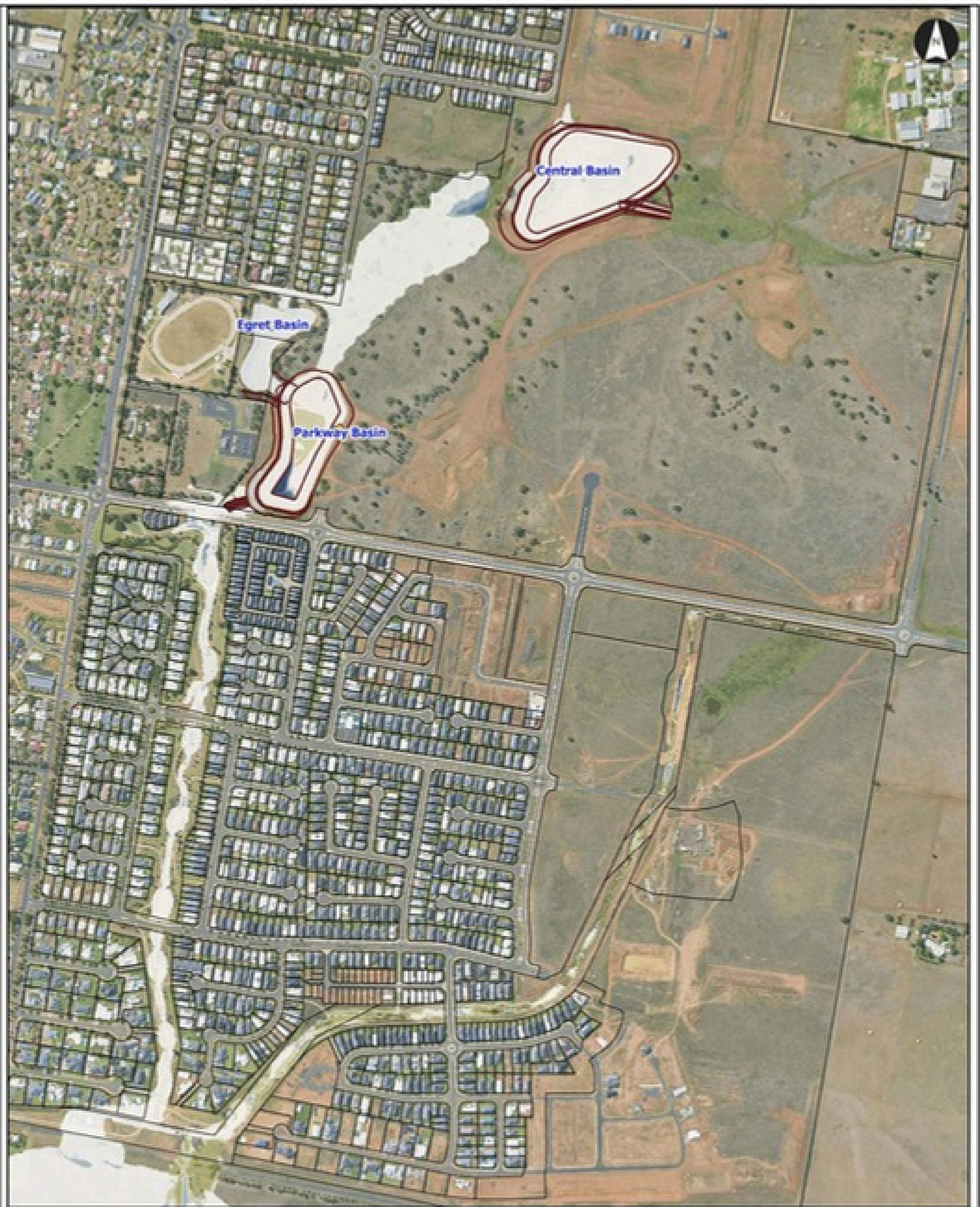
- 1.
- 2.

DRAFT - Not For Construction



Scale of A3: 1:7000

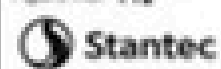




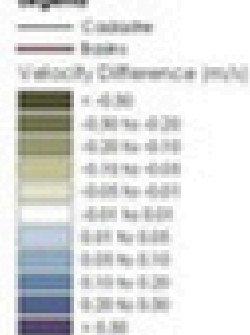
Velocity Difference

1 in 100 AEP
Planning Proposal - Benchmark
Conditions

Project: Kewick Estate Planning Proposal
Client: Oxbow Regional Council
Project Code: 200204064
Drawn By: SHP, Checked By: SH
Date: (2024-08-22)
Figure No: F12



Legend



Notes

1. Map displayed in EPSG:28353

References

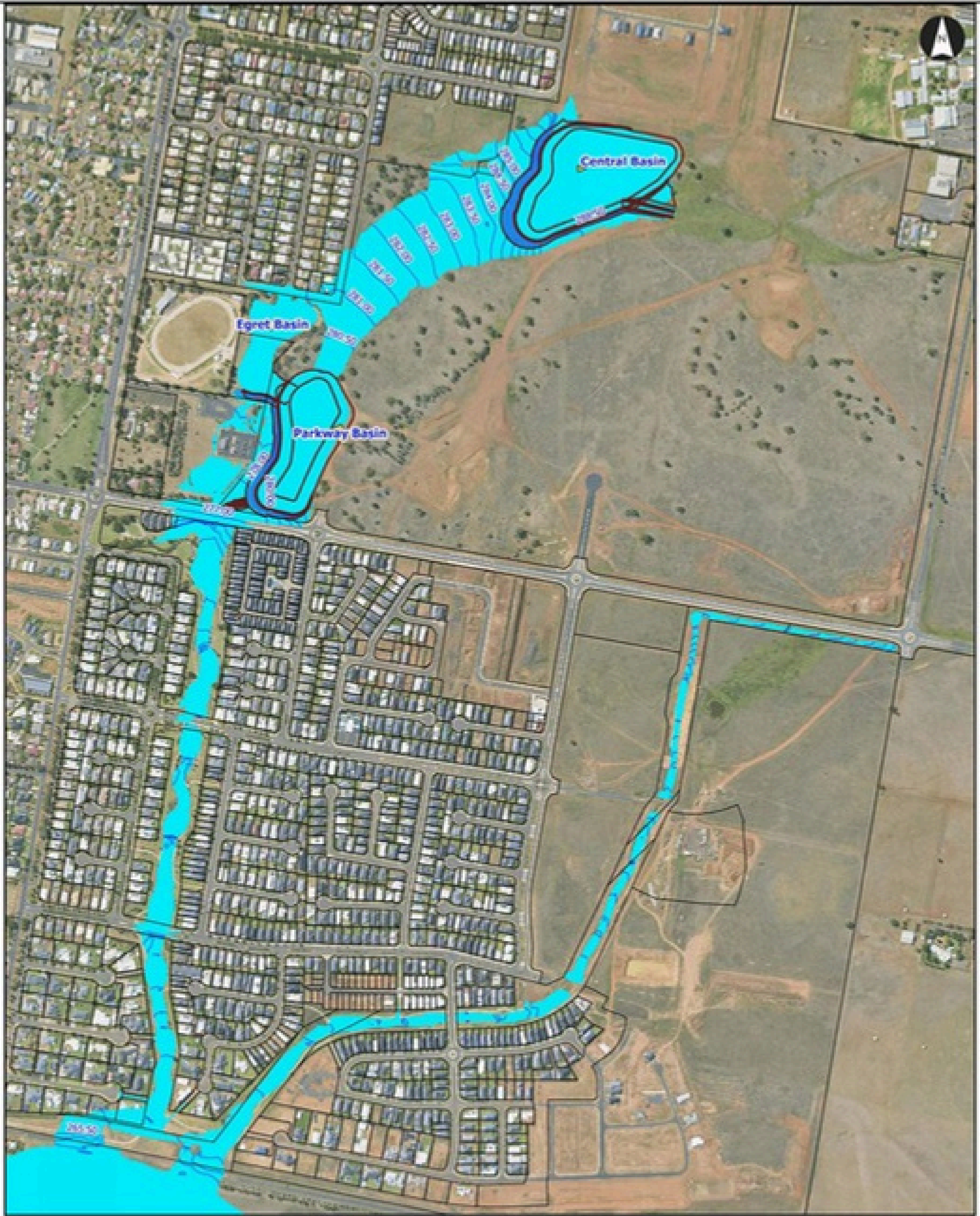
1.
2.

DRAFT - Not For Construction



Scale of A3: 1:7000





Flood Extents & Flood Levels

1 in 1000 AEP
Planning Proposal

Project: Kewick Estate Planning Proposal
Client: Oudoo Regional Council
Project Code: 200204064
Drawn By: SHP, Checked By: SH
Date: (2024-08-22)
Figure No: F13



Legend

— Contour
— Basin
— 0.5m Water Level Contours (mRLD)

Flood Extent

Notes

1. Map displayed in EPSG:28355

References

1.
2.

DRAFT - Not For Construction



Scale of A3: 1:1000





Flood Depths

1 in 1000 AEP

Planning Proposal

Project: Kewick Estate Planning Proposal

Client: Oxbow Regional Council

Project Code: 200204064

Drawn By: SHP, Checked By: ST

Date: 2024-08-22

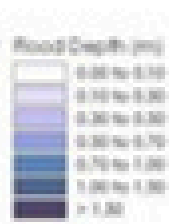
Figure No: F14



Legend

— Catchment

— Basin



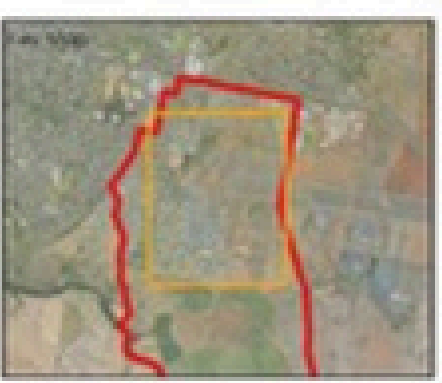
Notes

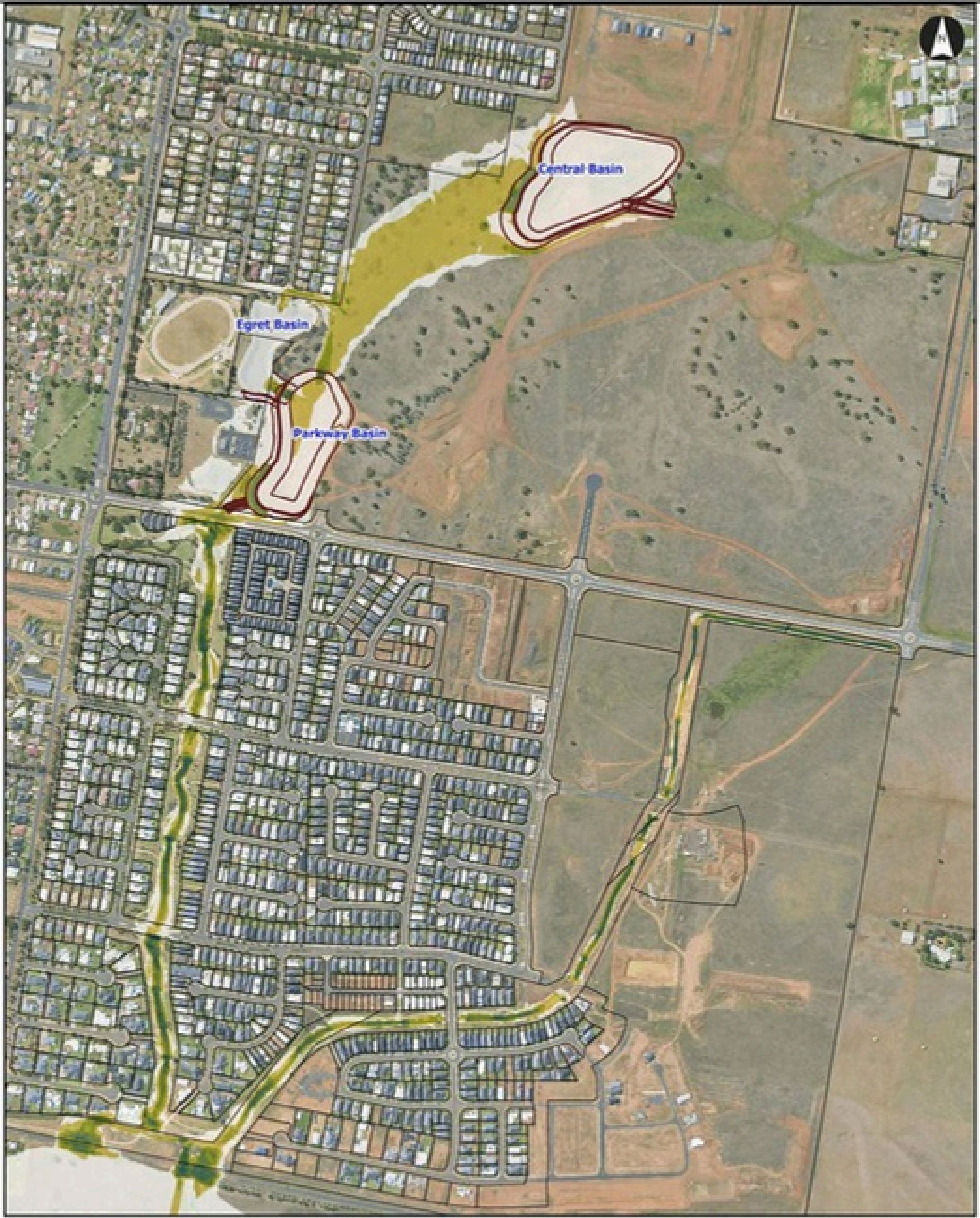
1. Map displayed in EPSG:28355

References

1.

2.





Flood Velocities

1 in 1000 AEP
Planning Proposal

Project: Kewick Estate Planning Proposal
Client: Oudoo Regional Council
Project Code: 200204064
Drawn By: SHP, Checked By: ST
Date: (2024-08-22)
Figure No: F15



Notes:
1. Map displayed in EPSG:28355

References:
1.
2.





Water Level Difference

1 in 1000 AEP

Planning Proposal - Benchmark
Conditions

Project: Kewick Estate Planning Proposal

Client: Oxbow Regional Council

Project Code: 200204064

Drawn By: SHP, Checked By: ST

Date: 2024-08-22

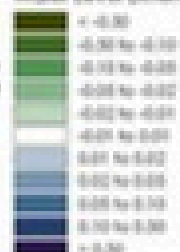
Figure No: F17



Legend

- Contour
- Basin
- Wet & Dry Analysis
- Wet Wet, New Dry
- Wet Dry, New Wet

Water Level Difference (m)



Notes

1. Map displayed in EPSG:28355

References

- 1.
- 2.

DRAFT - Not For Construction



Scale of A3: 1:7000





Velocity Difference

1 in 1000 AEP

Planning Proposal - Benchmark
Conditions

Project: Kewick Estate Planning Proposal

Client: Oubou Regional Council

Project Code: 200204064

Drawn By: SHP, Checked By: ST

Date: 2024-08-22

Figure No: F18

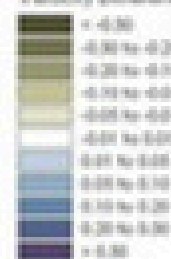


Legend

— Catchment

— Basin

Velocity Difference (m/s)



Notes:

1. Map displayed in EPSG:28353

References:

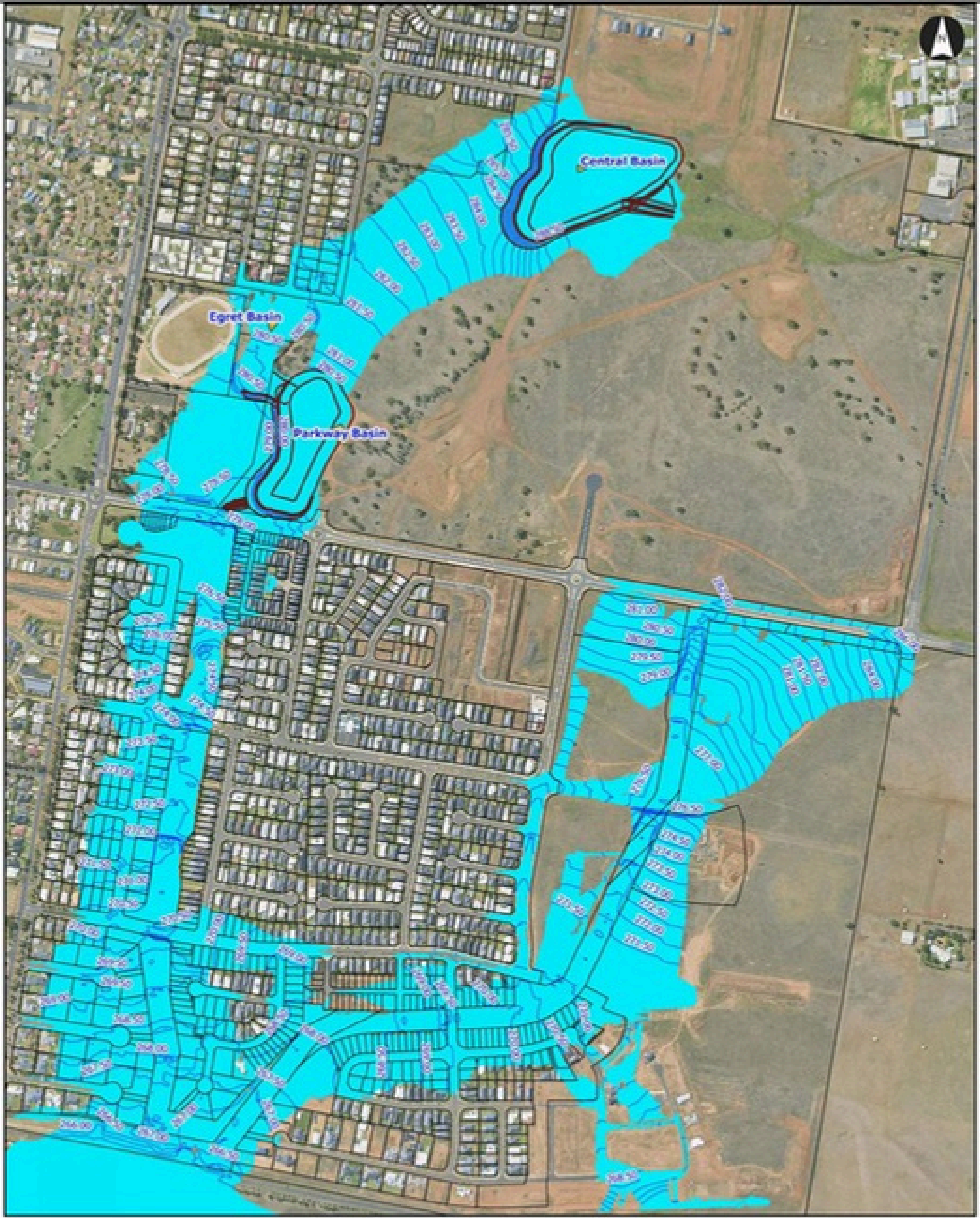
1,
2.

DRAFT - Not For Construction



Scale of A3: 1:7000





Flood Extents & Flood Levels

Plan
Planning Proposal

Project: Kewick Estate Planning Proposal
Client: Oxbow Regional Council
Project Code: 200204064
Drawn By: SHP, Checked By: SH
Date: 2024-08-22
Figure No: F19



Legend

--- Contour --- 0.5m Water Level Contours (mRLD)

--- Roads ---

--- Flood Extent ---

Notes

1. Map displayed in EPSG:28355

References

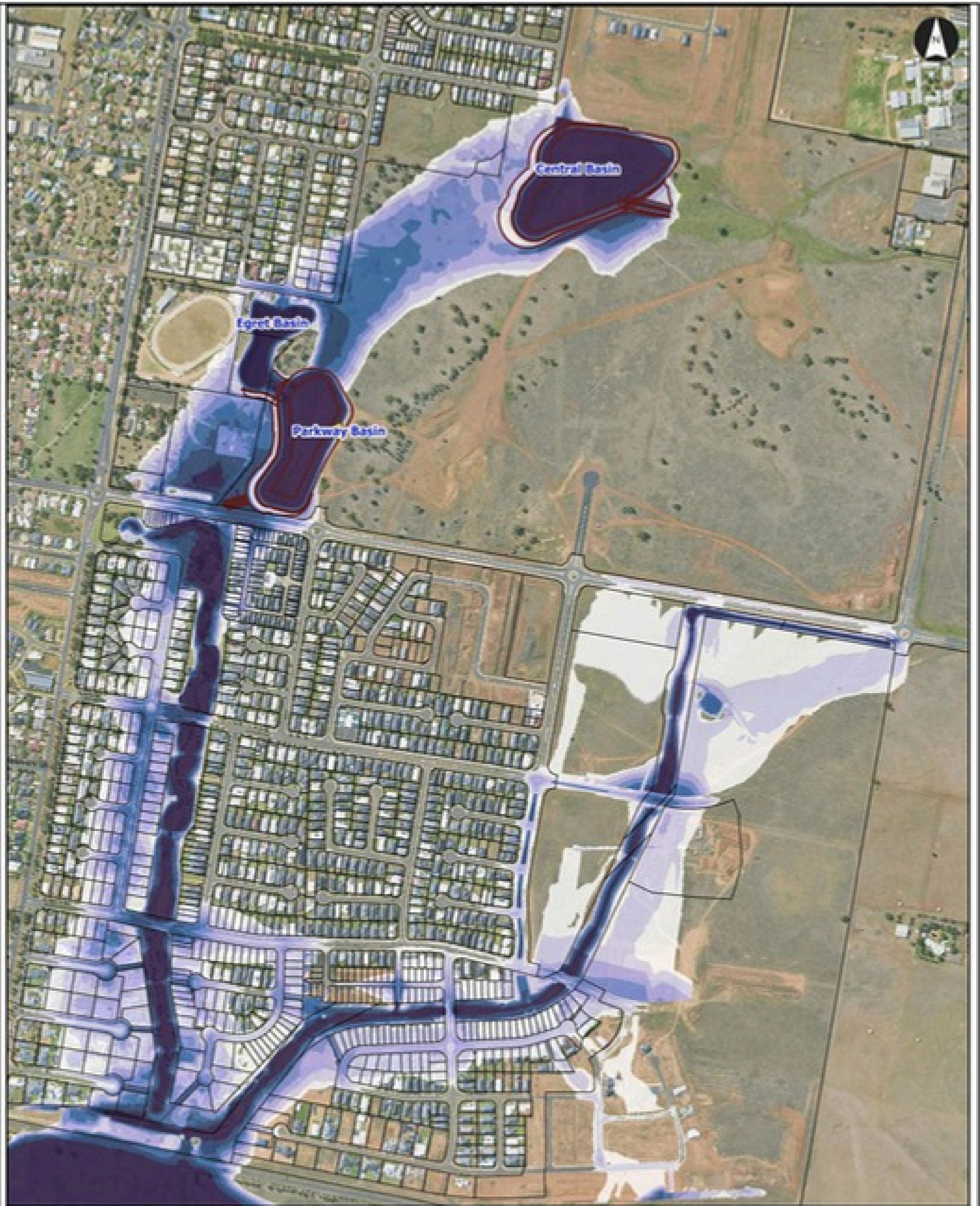
1.
2.

DRAFT - Not for Construction



Scale of A3: 1:1000





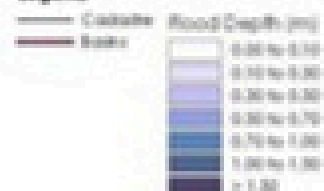
Flood Depths

Plan
Planning Proposal

Project: Kewick Estate Planning Proposal
Client: Oxbow Regional Council
Project Code: 200204064
Drawn By: SHP, Checked By: ST
Date: 2024-08-22
Figure No: P20



Legend



Notes

1. Map displayed in EPSG:28355

References

1.
2.

DRAFT - Not For Construction



Scale of A3: 1:7000

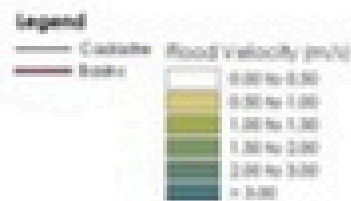




Flood Velocities

Plan
Planning Proposal

Project: Kewick Estate Planning Proposal
Client: Oudoo Regional Council
Project Code: 200204064
Drawn By: SHP, Checked By: ST
Date: (2024-08-22)
Figure No: #21



Notes:
1. Map displayed in EPSG:28355

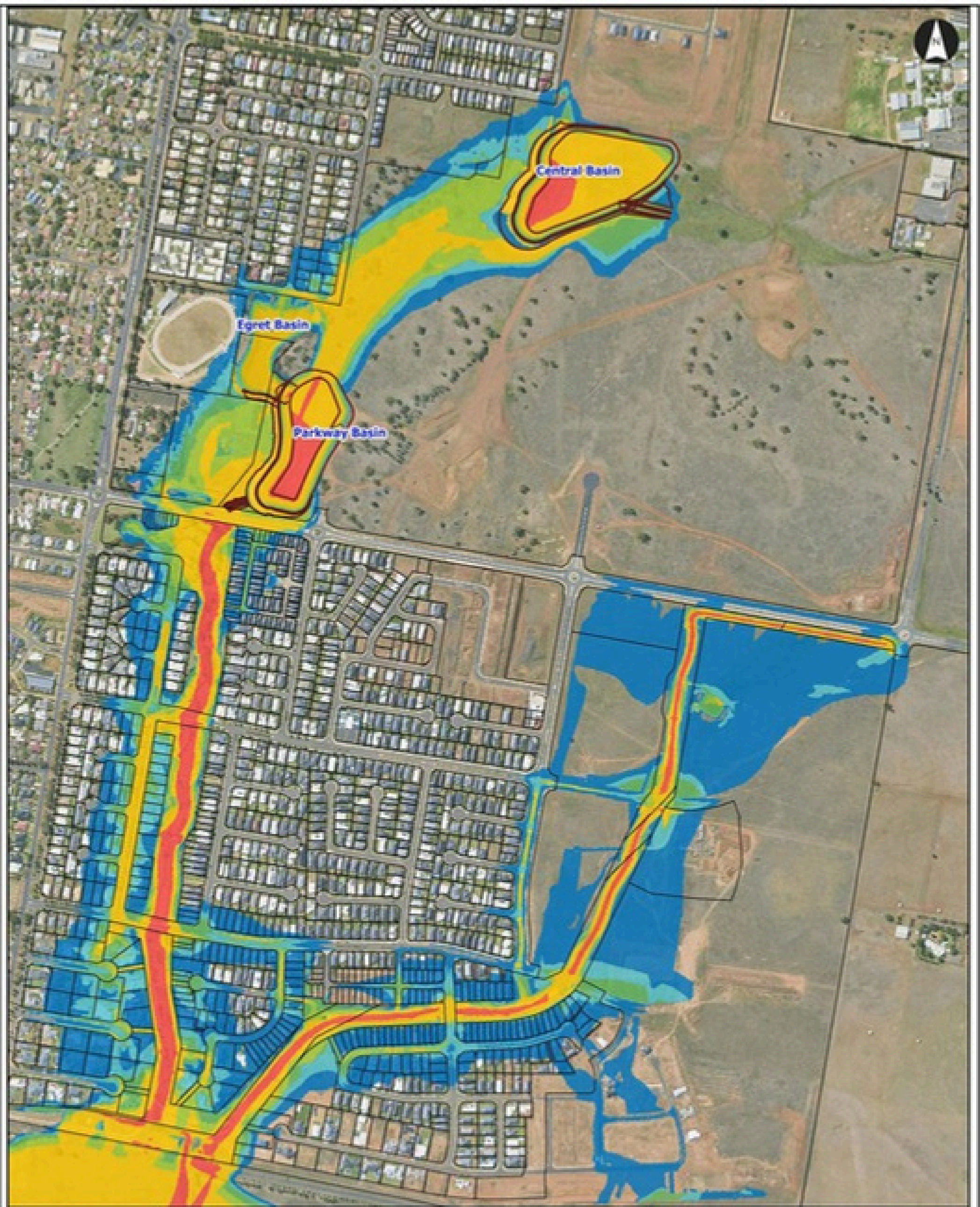
References:
1.
2.

DRAFT - Not For Construction



Scale of A3: 1:7000





Flood Hazard

Plan
Planning Proposal

Project: Kewick Estate Planning Proposal
Client: Oubou Regional Council
Project Code: 200204064
Drawn By: SHP, Checked By: SH
Date: (2024-08-22)
Figure No: P22



Legend

- Cadastre
- Roads
- Hazard Category**
 - Blue - Generally safe for vehicles, people and buildings
 - Green - Unsafe for small vehicles
 - Yellow - Unsafe for vehicles, children, and the elderly
 - Orange - Unsafe for vehicles and people
 - Red - Unsafe for vehicles and people, all buildings vulnerable to structural damage, some less robust buildings vulnerable to failure
 - Red - Unsafe for vehicles and people, all building types considered vulnerable to failure.

Notes

1. Map displayed in EPSG:28353

References

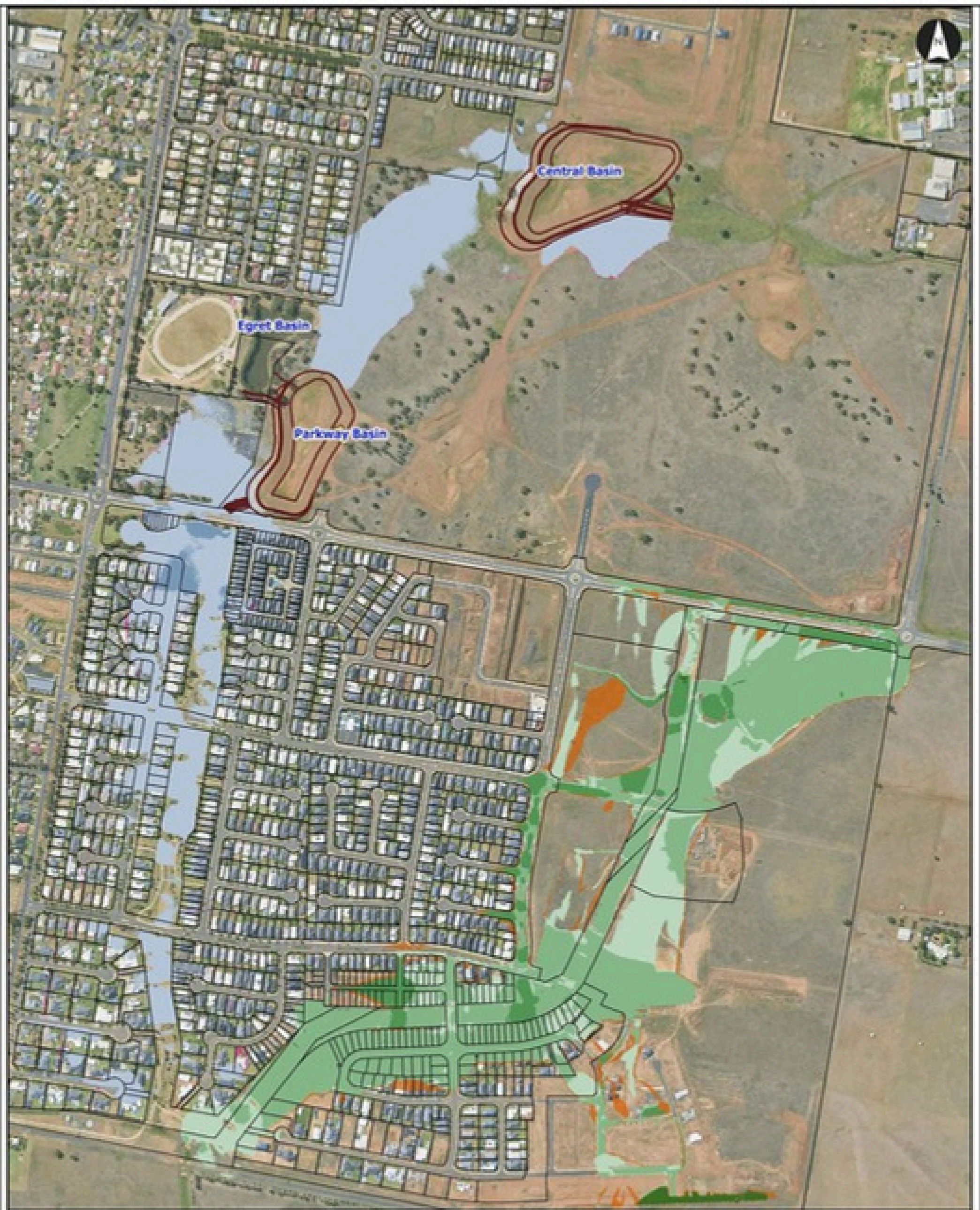
1.
2.

DRAFT - Not for Construction



Scale of A3: 1:7000





Water Level Difference

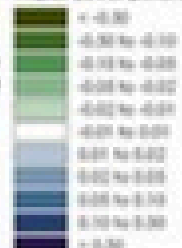
Plan
Planning Proposal - Benchmark
Conditions

Project: Kewick Estate Planning Proposal
Client: Oxbow Regional Council
Project Code: 200204064
Drawn By: SHP, Checked By: ST
Date: (2024-08-22)
Figure No: P23

Legend

- Contour
- Banks
- Wet & Dry Analysis
- Wet Wet, New Dry
- Wet Dry, New Wet

Water Level Difference (m)



Notes

1. Map displayed in EPSG:28355

References

- 1.
- 2.

DRAFT - Not for Construction



Scale of A3: 1:7000





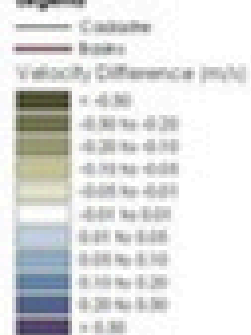
Velocity Difference

Plan
Planning Proposal - Benchmark
Conditions

Project: Kewick Estate Planning Proposal
Client: Oxbow Regional Council
Project Code: 200204064
Drawn By: SHP, Checked By: SH
Date: (2024-08-22)
Figure No: P24



Legend



Notes

1. Map displayed in EPSG:28355

References

1.
2.

DRAFT - Not For Construction



Scale of A3: 1:7000





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Sydney NSW 2000

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We care about the communities we serve—because they're our communities too. This allows us to assess what's needed and connect our expertise, to appreciate nuances and envision what's never been considered, to bring together diverse perspectives so we can collaborate toward a shared success.

We're designers, engineers, scientists, and project managers, innovating together at the intersection of community, creativity, and client relationships. Balancing these priorities results in projects that advance the quality of life in communities across the globe.

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Design with community in mind