



# **Warrumbungle Shire Council**

## WSC - Baradine Town Levee Preliminary Design Report

May 2018

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WATER | ENERGY & RESOURCES | ENVIRONMENT | PROPERTY & BUILDINGS | TRANSPORTATION

# Table of contents

|     |  |    |
|-----|--|----|
| 1.  | Introduction.....                              | 1  |
| 1.1 | Project Background.....                        | 1  |
| 1.2 | Purpose of this report.....                    | 1  |
| 1.3 | Scope and Limitations.....                     | 1  |
| 1.4 | Assumptions and Qualifications.....            | 2  |
| 2.  | Design Basis .....                             | 3  |
| 2.1 | Background Information.....                    | 3  |
| 2.2 | Design codes, regulations and standards.....   | 3  |
| 2.3 | Reference reports .....                        | 4  |
| 3.  | Flood modelling.....                           | 5  |
| 3.1 | Model Compilation .....                        | 5  |
| 3.2 | Flood Model Simulations and Results .....      | 5  |
| 4.  | Flood Levee Design .....                       | 6  |
| 4.1 | Scope.....                                     | 6  |
| 4.2 | Alignment.....                                 | 6  |
| 4.3 | Embankment.....                                | 6  |
| 4.4 | Spillways .....                                | 6  |
| 4.5 | Drainage .....                                 | 7  |
| 4.6 | Services .....                                 | 7  |
| 4.7 | Existing Levee.....                            | 7  |
| 4.8 | Lowering the Teridgerie Creek Flood Plan ..... | 7  |
| 5.  | Retaining Wall .....                           | 8  |
| 5.1 | Scope.....                                     | 8  |
| 6.  | Road Design .....                              | 9  |
| 6.1 | Introduction .....                             | 9  |
| 6.2 | Basis of Design .....                          | 9  |
| 7.  | Risks and Opportunities .....                  | 13 |
| 7.1 | Project Footprint.....                         | 13 |
| 7.2 | Biodiversity and Vegetation Impacts.....       | 13 |
| 7.3 | Land Acquisition and Easements .....           | 13 |
| 7.4 | Maintenance .....                              | 13 |
| 7.5 | Lowering the existing Teridgerie Creek .....   | 13 |
| 7.6 | Impact to Existing Railway Line .....          | 13 |
| 7.7 | Freeboard to spillway.....                     | 14 |

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## Table index

|           |   |    |
|-----------|---|----|
| Table 2-1 | Background information supplied by WSC .....                        | 3  |
| Table 2-2 | Reference Reports .....   | 4  |
| Table 3-1 | Flood Levels (mAHD) at key locations .....                          | 5  |
| Table 5-1 | Preliminary geotechnical design parameters for retaining wall ..... | 8  |
| Table 6-1 | Road Upgrade Summary .....  | 11 |

## Figure index

|            |                                      |   |
|------------|--------------------------------------|---|
| Figure 5-1 | Typical Retaining Wall Section ..... | 8 |
|------------|--------------------------------------|---|

## Appendices

Appendix A – Flood mapping figures

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# 1. Introduction

## 1.1 Project Background

The town of Baradine is located in the North West Slopes area of NSW, 45 km north of Coonabarabran. It is bordered along the east by Baradine Creek and the west by Teridgerie Creek. Flooding from Teridgerie Creek, the focus of this project, causes inundation and damage to properties in the urban area of Baradine.

A Floodplain Risk Management Study and Plan was completed in May 2012. Since then Warrumbungle Shire Council (WSC) has investigated levee options and in June 2016 a final Concept Design Report for a levee was completed.

GHD has been engaged by WSC to complete detailed design of the preferred concept levee option which generally consists of a 3.1 km long earth levee, 80 m retaining wall, adjustments to road heights, spillway design, new table drains, a relief drain (750 m) and lowering of the existing Teridgerie Creek by 250 mm.

## 1.2 Purpose of this report

The purpose of this report is to define and document the design basis of the Preliminary Design of the Baradine Levee Project. This includes key design criteria, assumptions and issues identified through design development.

## 1.3 Scope and Limitations

This report: has been prepared by GHD for Warrumbungle Shire Council (WSC) and may only be used and relied on by Warrumbungle Shire Council for the purpose agreed between GHD and the Warrumbungle Shire Council as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Warrumbungle Shire Council arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (section 1.4 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Warrumbungle Shire Council and others (Lyll and Associates and Michael Adler and Associates) who provided information to GHD, which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.



## 1.4 Assumptions and Qualifications

The following assumptions have been made in developing the preliminary design report:

- The concept design arrangement of the Flood Levee has been adopted. At preliminary design stage no amendment to the alignment has been made. This is consistent with the original scope of works. Risks and Opportunities identified during Preliminary Design have been included in Section 7.
- Areas outside of the original scope of works boundaries may not have detailed survey available and therefore levels and features have been based on lidar data and aerial imagery.
- Existing service information has been obtained from Dial Before You Dig data. No service proving has been conducted.

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## 2. Design Basis

### 2.1 Background Information

The following background information supplied by Warrumbungle Shire Council has been used to inform the preliminary design.

**Table 2-1 Background information supplied by WSC**

| Document Title   | Type                          | Author/Owner                    | Date Received |
|--|-------------------------------|---------------------------------|---------------|
| Levee_Option_1_Final   | 12d                           |                                 | 06/02/2018    |
| Relief_Drain_upgrade_3   | 12d                           |                                 | 06/02/2018    |
| Design of Baradine Town Levee<br>Concept Design Report<br>Volume 1 - Report      | PDF                           | Lyall & Associates              | 01/06/2018    |
| Design of Baradine Town Levee<br>Volume 2 - Figures                              | PDF                           | Lyall & Associates              | 01/06/2018    |
| Geotechnical Investigation for<br>Concept Design<br>Proposed Baradine Town Levee | PDF                           | Michael Adler and<br>Associates | 12/02/2018    |
| Baradine Property Survey and<br>photos.  | Excel                         |                                 | 12/02/2018    |
| Teridgerie Creek at Baradine,<br>Flood Study Report March 2012                   | PDF                           | Lyall & Associates              | 06/02/2018    |
| Baradine Survey 2014   | PDF, 12d,<br>Excel and<br>DWG |                                 | 06/04/2018    |
| TUFLOW Flood Modelling   | Excel and<br>model            | Lyall & Associates              | 12/02/2018    |

### 2.2 Design codes, regulations and standards

The preliminary design drawings for WSC have been prepared in accordance with, but not limited to, the following standards, manuals and guidelines:

- Austroads Guide to Road Design.
- RMS Supplements to Austroads Road Design Guidelines.
- Pilgrim, DH, (ed)., Australian Rainfall and Runoff – A Guide to Flood Estimation, Institution of Engineers, Australia, Barton, ACT, 1987.
- Floodplain Development Manual, The Management of Flood Liable Land, NSW Government, 2005.

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- Hydraulic Design of Energy Dissipaters for Culverts and Channels, Hydraulic Engineering Circular Number 14 (HEC-14), Third Edition US Department of Transport – Federal Highway Administration, Virginia, USA, Thompson, PL & Kilgore, RT; 2006.

### 2.3 Reference reports

The following reports should be read in conjunction with the design basis report.

**Table 2-2 Reference Reports**

| Title  |
|--|
| Baradine Town Levee Geotechnical Investigation Report (April 2018) |
| Baradine Town Levee Review of Environmental Factors (April 2018)   |
| Baradine Town Levee Noise and Vibration Assessment (April 2018)    |
| Baradine Town Levee Biodiversity Assessment (May 2018)             |

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## 3. Flood modelling

### 3.1 Model Compilation

The Teridgerie Creek at Baradine, Flood Study Report March 2012 defined flows in Teridgerie Creek using the RORB runoff-routing modelling software and then converted these flows to peak flood levels and flow velocities using the HEC-RAS (L&A, 2012b) and UNET (L&A, 2014) one- and quasi two-dimensional hydraulic modelling software packages.

Following the 2012 study, the availability of LiDAR survey allowed the development of a detailed hydraulic model for the Teridgerie Creek floodplain using the two dimensional TUFLOW software (Design of Baradine Town Levee Concept Design Report, 2016). In addition, a new hydrologic RAFTS model was developed of the Teridgerie Creek and Bugaldie Tributary catchments, replacing the RORB model. A comparison of the peak flow estimates generated by the RAFTS and RORB models showed reasonable agreement of peak flows and shape of the discharge hydrographs for Teridgerie Creek, however the RAFTS model generated higher peak flows when compared to the RORB model on Bugaldie Tributary.

The TUFLOW model of the Teridgerie Creek floodplain was compiled on a 5 m grid spacing. A nested 2 m grid arrangement was incorporated in the TUFLOW model to adequately define the waterway area of the Relief Drain. Field survey was used to obtain details of pipes and box culverts in the local stormwater system. Main stream and overland flow hydrographs were applied at the upstream boundaries of the TUFLOW model. In parts of the two-dimensional model domain, inflow hydrographs were applied over specific local areas. Over the urbanised village area, rainfalls were directly applied to the model grid. There is no historic flood level data available to calibrate the model for Mannings roughness was estimated from site inspection, past experience and values contained in the engineering literature.

### 3.2 Flood Model Simulations and Results

Flood model simulations have been undertaken for the proposed Option 1 design simulating the 5-, 20-, 100-, 200- and 500-year ARI events. The flood mapping is provided in Appendix A. Table 3-1 below summarised key flood level results, in Teridgerie Creek immediately west of the levee. The simulation show that none of the events surcharge the proposed levee or the spillways. Referring to the figures in Appendix A, the following is noted:

- Flood waters are directed west of the levee design for all events.
- Minor flooding is shown to occur east of the levee alignment, however this is due to the rainfall on grid which simulates floodwater accumulating in town.
- There are a number of locations with elevated flood velocities, in particular along the levee toe and at culverts and road overflows.

**Table 3-1 Flood Levels (mAHD) at key locations**

| Location        | 5-year                | 20-year               | 100-year | 200-year | 500-year |
|-----------------|-----------------------|-----------------------|----------|----------|----------|
| Ashby Road      | Not inundated         | At point of inundated | 304.45   | 304.48   | 304.52   |
| Walker Street   | 301.22                | 301.40                | 301.58   | 301.65   | 301.73   |
| Namoi Street    | 299.69                | 299.93                | 300.18   | 300.27   | 300.39   |
| Lachlan Street  | 299.30                | 299.45                | 299.80   | 299.92   | 300.07   |
| Worrigal Street | At point of inundated | 298.31                | 298.55   | 298.63   | 298.73   |



## 4. Flood Levee Design

### 4.1 Scope

Construction of a new 3.1 km long earth levee which will extend from Ashby Road to Worrigal Street and protect existing development located to the east from main stream flooding for all events up to 100 year ARI (the adopted design standard of the levee). The alignment and arrangement of the levee have been adopted from the Concept Design Report, in accordance with the project scope.

The scope includes construction of a short 80 m long section of levee immediately upstream of Namoi Street.

### 4.2 Alignment

The alignment for the levee embankment matches the alignment modelled at Concept Design. Opportunities may exist to reduce land acquisition and environmental impacts by realigning sections of the levee. These opportunities will be discussed with Council following preliminary design.

### 4.3 Embankment

Detailed Geotechnical information can be found in the Geotechnical Investigation for Concept Design report compiled by Michael Adler and Associates, April 2015.

The embankment height varies between 1.2 m to 2 m high with a crest width of 3 m. The embankment batter slopes are 1(V):4(H), with 150 mm thick layer of topsoil to allow vegetation. The crest of the embankment falls towards the Teridgerie Creek side of the levee to allow the surface to be free draining.

A cut-off trench below the centre of the embankment, a minimum of 600 mm depth and 2 m width, has been provided to prevent water seepage.

A minimum 150 mm thick layer of topsoil to allow vegetation to establish should be provided on all surfaces.

### 4.4 Spillways

Provision of three armoured spillways which will control overtopping of the levee during floods that exceed its design standard (during floods that are greater than 100 year ARI). The spillways do not overtop in storms up to and including the 500 year ARI event.

Spillways are incorporated into the design to minimise the damage to and cost of repairs to the levee structure, as well as to control the location of overtopping/spilling. Ideally, a spillway must be designed with enough width and freeboard to allow the storage area on the protected side of the levee to fill in the time it takes for the flood waters to rise from the spillway level to the crest level of the levee. However, in the case of the town levee, water levels in Teridgerie Creek rise too rapidly to allow sufficient volume of floodwaters to surcharge a reasonably sized spillway and fill the relatively large storage area behind the levee.



## **4.5 Drainage**

### **4.5.1 The Relief Drain**

The existing Relief Drain runs north south along the eastern-side of the railway line. The capacity of the Relief Drain is constrained by the small diameter pipes that are located beneath the road crossings of Wellington, Lachlan, Macquarie and Worrigal Streets.

The Relief Drain is designed to cater for local stormwater runoff which cannot discharge to Teridgerie Creek via the railway culverts in times of flood.

The upgraded drain has a 4 m wide base with batter slopes between 1V:2H and 1V:4H. The existing culverts along the relief drain are being upgraded to 2100 mm (wide) by 900 mm high.

### **4.5.2 Culverts and Drainage Pipes**

Large box culverts have been placed through the levee embankment to allow to the town side of the levee to drain to Teridgerie Creek. All pipe penetrations through the levee will be fitting with non-return valves to prevent back flooding of the protected parts of town during periods of elevated water levels in Teridgerie Creek.

Box culverts are expected to be designed, constructed and installed in accordance with Australian Standard AS1597 Precast reinforced concrete box culverts.

## **4.6 Services**

At this preliminary stage, initial Dial Before You Dig investigations was undertaken on 9 April 2018 to include all services within the specified project area. Two service providers were notified to provide service details; Essential Energy and Telstra NSW, North. Both asset owners responded with plans of the locations of their assets.

As per these plans, it is apparent that there are Telstra optic fibre cables present near the works and therefore would require further investigation to determine the full impact.

There are a number of Essential Energy poles located in or near the work area, which may require relocation during construction.

Further investigation will be undertaken to determine the full impact of all services and outline the extent of relocation works required.

## **4.7 Existing Levee**

The existing levee is to be removed within the Teridgerie Creek floodplain, over the extents shown on the detailed plans. Much of the existing levee embankment contains abundant organics and deleterious materials, and as such should not be reused as structural material.

The existing levee is to be demolished prior to construction of the new levee embankment.

## **4.8 Lowering the Teridgerie Creek Flood Plan**

The Teridgerie Creek floodplain is being lowered by approximately 250 mm between Walker Street and Lachlan Street. This includes lowering a section of Namoi Street by up to 500 mm where it crosses Teridgerie Creek.



# 5. Retaining Wall

## 5.1 Scope

The design includes construction of an 80 m long section of levee retaining wall immediately upstream of Namoi Street. This retaining wall will be comprised of a cantilevered reinforced concrete retaining wall system with a maximum soil retaining height of 2.15 m.

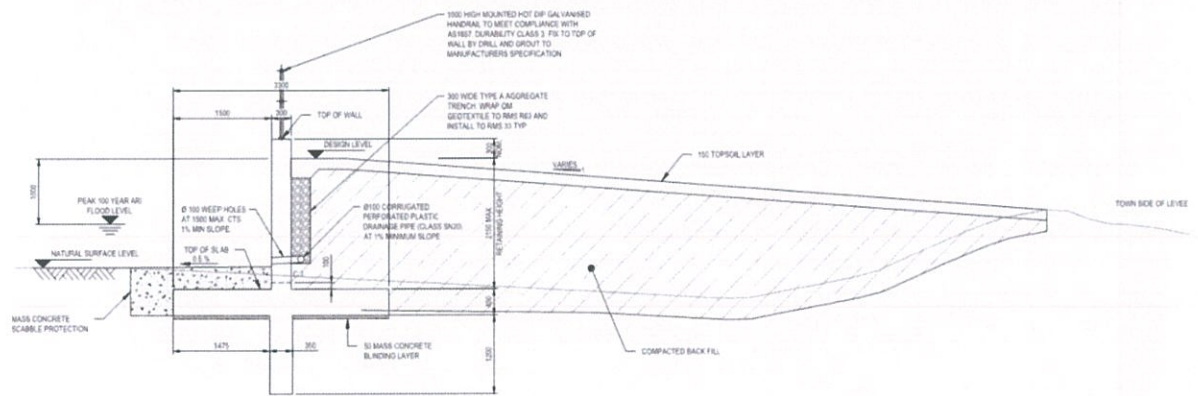
The retaining wall design was based on the geotechnical parameters and recommendations provided in the Geotechnical Investigation Report by GHD dated May 2018 and summarised in Table 5-1.

**Table 5-1 Preliminary geotechnical design parameters for retaining wall**

| Geotechnical parameter                                  | Select Fill for embankment |
|---|----------------------------|
| Active horizontal earth pressure coefficient, $k_a$     | 0.33                       |
| Passive horizontal earth pressure coefficient, $k_p$    | 1.0*                       |
| At rest horizontal earth pressure coefficient, $k_0$    | 0.5                        |
| Saturated unit weight $\gamma_s$ , (kN/m <sup>3</sup> ) | 20                         |
| Effective friction angle, $\phi$ (degrees)              | 30                         |
| Effective cohesion, $c'$ (kPa)                          | 5                          |

Within the basis of design, a subsoil drainage system and a footing scour protection will be also provided to the design system for an effective and durable retaining wall structure.

Figure 5-1 shows the typical cantilevered reinforced concrete retaining wall system designed for the levee application.



**Figure 5-1 Typical Retaining Wall Section**

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## 6. Road Design

### 6.1 Introduction

The scope of works includes raising sections of Ashby Road, Walker Street, Namoi Street, Lachlan Street and Worrigal Street. These raised sections of road ensure continuity of the levee and prevent floodwaters entering the urbanised parts of Baradine. The horizontal alignment of these roads will be maintained.

A review of the Concept Design Report completed by Lyall & Associates, June 2016, identified that extent of road works had been significantly underestimated. In order to comply with Austroads and Australian standards for vertical curves and sight distance the extent of road works has been adjusted. As a result there is a significant increase in the extent of road works and consequently there are a number of additional impacts that were not identified at concept design detailed below.

### 6.2 Basis of Design

#### 6.2.1 General

All of the roads throughout the project have been classified as rural roads, in accordance with Austroads Guide to Road Design. Road levels match levee levels to maintain continuity of the flood barrier. The select fill and compaction requirements under the road are the same as for the levee embankment (refer to the Geotechnical Report, GHD 2018).

#### 6.2.2 Ashby Road

##### *Existing Conditions*

Ashby Road is currently unsealed, with no formal drainage. There is no sign posted speed limit, therefore the speed limit adopted is 50 km/hr. Ashby Road runs East-West and provides access to GrainCorp properties, either side of the disused railway line.

##### *Ashby Road Upgrade*

The raised section of Ashby Road (raised approximately 1.4 m) is provided to prevent floodwaters from outflanking the town levee and flowing into town.

The total length of works is approximately 220 m, compared to 135 m in the concept design. In order to comply with Austroads standards for vertical change in grade, the intersection of Baradine Road and Ashby Road will also need to be lifted. The extent of work required along Baradine Road to tie in to the new grading is approximately 130 m.

#### 6.2.3 Walker Street

##### *Existing Conditions*

Walker Street will be raised to provide continuity of the Flood Levee. Walker Street is currently sealed, approximately 8 m wide for edge of bitumen to edge of bitumen. There is no kerb or formal drainage. There is no sign posted speed limit, therefore the speed limit adopted is 50 km/hr.

##### *Walker Street Upgrade*

At the highest point Walker Street is being raised approximately 1.2 m from existing surface. The extent of work is approximately 160 m in length, compared to 38 m assumed in the concept design.

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As a result of the increase work extent the intersection of Barwon Street, an unsealed road that runs North of Walker Street, will likely need to be adjusted.

Walker Street passes over Teridgerie Creek, to the east of the new Flood Levee. In this location the upgraded road will be approximately 900 mm higher than existing. This means these culverts will need to be extended, or replaced depending on their condition.

#### **6.2.4 Namoi Street**

##### ***Existing Conditions***

There is no kerb and drainage is provided via sheet flow runoff to a roadside grassed swale. There are overhead electricity poles along the western side of Namoi Street. There is no sign posted speed limit, therefore the speed limit adopted is 50 km/hr.

There is a lowered concrete causeway along Namoi Street where the Teridgerie Creek passes over the road. Just to the north of this crossing is the existing levee embankment.

##### ***Namoi Street Upgrade***

At the highest point Namoi Street is being raised approximately 1.5 m from existing surface. The extent of work is approximately 245 m in length, this includes raising a section to match the new flood levee and lowering a section to suit the channel improvement works.

The regrading works will impact the Queen Street and Wellington Street intersections.

Namoi Street cross Teridgerie Creek via a lowered concrete causeway. This will need to be demolished a reinstated to suit the channel improvement works and the new grading.

#### **6.2.5 Lachlan Street**

##### ***Existing Conditions***

Lachlan Street is sealed, with no kerb or formal drainage is provide. There is no sign posted speed limit, therefore the speed limit adopted is 50 km/hr. There is an existing low level concrete causeway across Lachlan Street. There are Essential Energy poles present at the intersection of Lachlan Street and Namoi Street.

##### ***Lachlan Street Upgrade***

Lachlan Street is being raised 1.5 m above existing surface level at the highest point. The total extent of work is approximately 170 m. Minor modifications are to intersection of Lachlan Street and Namoi Street

It is likely the design will impact Telstra assets. Further investigation required to confirm, however encasement, relocation or replacement might be required.

#### **6.2.6 Worrigal Street**

##### ***Existing Conditions***

Worrigal Street is sealed, with no kerb or formal drainage is provide. There is no sign posted speed limit, therefore the speed limit adopted is 50 km/hr. There are Essential Energy poles running along the southern side of the road. Within the road reserve there are a number of large trees.



### **Worrigal Street Upgrade**

Worrigal Street is being raised approximately 1.1 m, with works extending approximately 550 m. Raising Worrigal Street impacts 12 driveways/property accesses. A new table drain/swale will need to be graded along the road to drain road runoff. New pipes will need to be provided under raised driveways to create a flow path.

There are trees and vegetation along the northern side of Worrigal Street, located only a short distance from the edge of pavement. These will likely be impacted by the batters from the raised road level.

There are Essential Energy power poles that run along the southern side of Worrigal Street, over the length of the modification.

There are Telstra services present within the road corridor. Further investigation required, however encasement, relocation or replacement might be required.

### **Road Upgrade Summary**

The following table summarises the extent of road works involved in raising the nominated roads to suit the flood modelling levels. This includes a summary of identified constraints and impacts.

**Table 6-1 Road Upgrade Summary**

| Road          | Change in Level (max) | Extent of Work | Additional Comments  |
|---------------|-----------------------|----------------|--|
| Ashby Road    | 1.4 m                 | 220 m          | Impact to Baradine Road and Ashby and Baradine Road intersection.<br><br>Impact to Telstra services. Encasement or relocation may be required.<br><br>Four trees within 5 m of embankment interface which may be impacted during construction.   |
| Walker Street | 1.25 m                | 160 m          | Large culverts through Teridgerie Creek will need to be extended or replaced.<br><br>Impact to Barwon Street Intersection.<br><br>Impact to one driveway/property connection.<br><br>No apparent services shown in this location.<br><br>Impact on one tree within work area that will need to be removed. |
| Namoi Street  | 1.5 m                 | 245 m          | Impact to Queen Street and Wellington Street intersections.<br><br>Replace existing concrete causeway.<br><br>Impact to Telstra buried cables and Essential Energy poles and associated wires. Encasement, relocation or replacement may be required.  |



| Road            | Change in Level (max) | Extent of Work | Additional Comments   |
|-----------------|-----------------------|----------------|---|
| Lachlan Street  | 1.5 m                 | 170 m          | <p>Minor modifications to intersection of Lachlan Street and Namoi Street.</p> <p>Replacement of existing concrete causeway.</p> <p>Impact to Telstra assets. Further investigation required to confirm, however encasement, relocation or replacement might be required.</p> <p>Essential Energy poles present at the intersection of Lachlan Street and Namoi Street.</p> |
| Worrigal Street | 1.1 m                 | 550 m          | <p>12 driveways impacted.</p> <p>Additional table drains required.</p> <p>Telstra services present. Further investigation required, however encasement, relocation or replacement might be required.</p> <p>Essential Energy poles located in this area.</p> <p>Eight or more trees may require removal depending on total work area required during construction.</p>      |

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## 7. Risks and Opportunities

Through the development of preliminary design from the Lyall and Associates concept design a number of risks and opportunities have been identified. These should be reviewed by Council and confirmed during Detailed Design.

### 7.1 Project Footprint

The road design has been completed in accordance with Austroads standards. This has resulted in a significant increase to the overall footprint of the road works. The roads now extend outside the original scope of works boundary and as such no detailed survey is available for the tie in points.

This increased extent of works is likely to result in additional service relocation, driveway works, intersection works and drainage. The extent of this work cannot be quantified at this design stage.

### 7.2 Biodiversity and Vegetation Impacts

The Biodiversity Assessment (Report 2219321-REP-A-Biodiversity Assessment, GHD 2018), has noted the will remove about 28.4 hectares of vegetation across the levee alignment and compound and borrow pit sites. This comprises 4.9 hectares of Box Gum Woodland and 22.5 hectares of derived native grassland. This also includes removing 18 hollow-bearing trees.

The area provides potential habitat for ten ecological communities, 19 flora species, 32 bird species, eight migratory species, eight mammal species (five of which are bats), three reptile species, two amphibian species and one fish species listed under the BC Act and/or EPBC Act that are known or likely to occur in the study area. Of these, one ecological community, one flora species, 15 bird species and three bat species listed under the BC Act and/or the EPBC Act could potentially be impacted by the proposal.

The levee alignment could be amended to reduce the vegetation impacts. This will be reviewed during Detailed Design, in consultation with Council.

### 7.3 Land Acquisition and Easements

An easement of 3 m wide either side of the levee embankment has been allowed for at preliminary design. This allows for maintenance from either side of the embankment. This may be reduced depending on Council requirements.

### 7.4 Maintenance

At preliminary design it is unclear how WSC intend to maintain the levee. At this stage batter slopes of 1(V):4(H) have been provided on both sides of the levee, as this will allow for mowing. Depending how Council intend to maintain the levee these batter slopes could be made steeper, to 1(V):3(H), and therefore reduce the overall footprint of the levee.

### 7.5 Lowering the existing Teridgerie Creek

The concept design proposed lowering the existing Teridgerie Creek by approximately 250 mm. Preliminary flood modelling has shown this lowering may not be required. Additional investigations will be completed at Detailed Design, in consultation with Council, to confirm this scope item.

### 7.6 Impact to Existing Railway Line

In order to raise Ashby Road to the flood levee level the tie in extends over the existing railway line. This section of railway line should be removed in order to prevent a seepage/flow path through the road/levee embankment.

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## 7.7 Freeboard to spillway

The freeboard levels adopted are consistent with the concept design report. Additional flood modelling completed by GHD shows the height of the freeboard is such that in a 1 in 500 year event the spillways are not engaged. There is an opportunity to reduce the crest height and spillway height. This would result in a reduction of earthworks, construction footprint, easement, construction cost, and environmental impacts. This should be reviewed with reviewed in consultation with Warrumbungle Shire Council during Detailed Design.

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## Appendices

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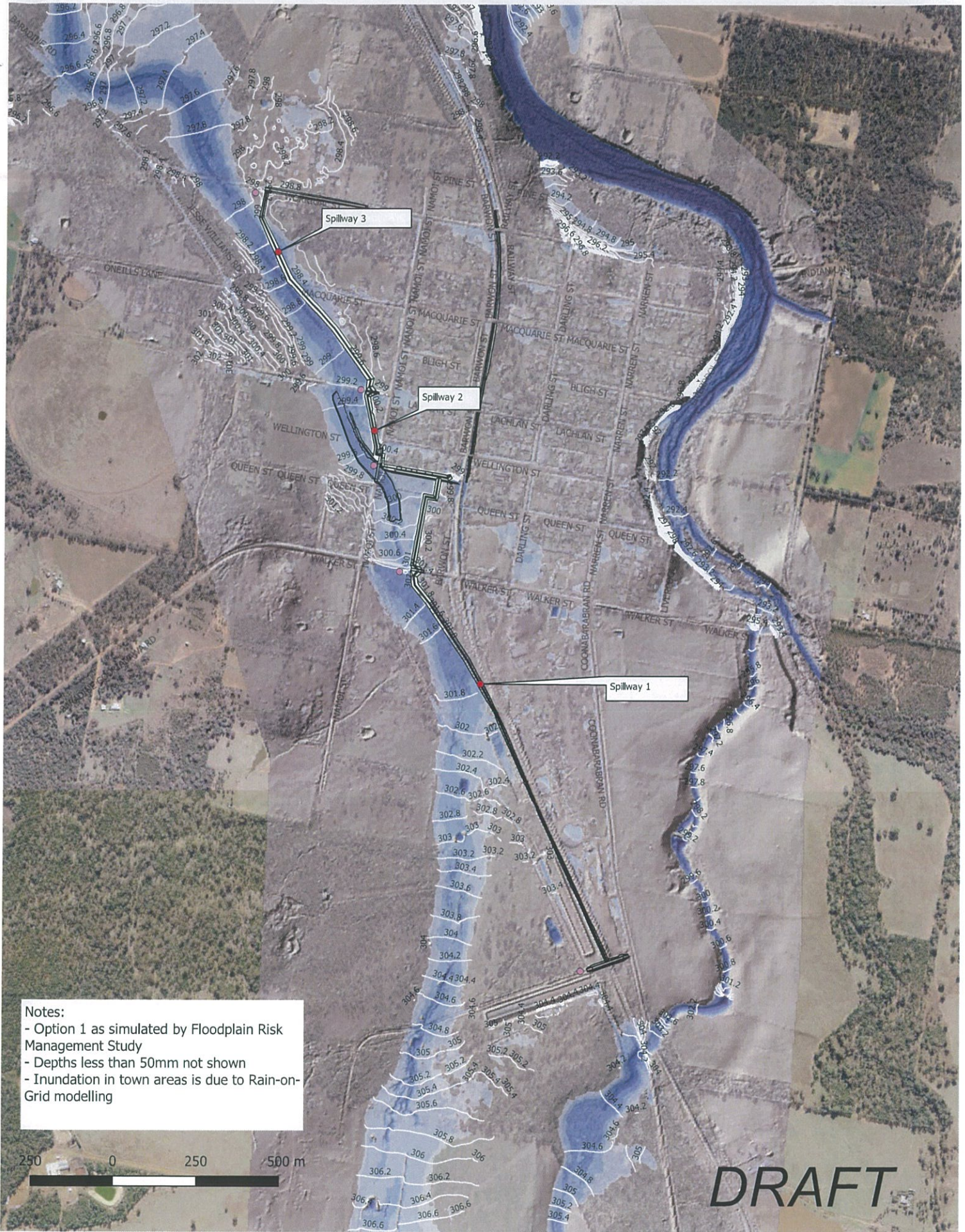


# Appendix A – Flood mapping figures

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Notes:  
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 - Inundation in town areas is due to Rain-on-Grid modelling

Scale 10000

Paper Size A3

Map projection: Transverse Mercator  
 Horizontal datum: GDA 1994  
 Grid: GDA 1994 MGA Zone 55



LEGEND

- Levee Alignment
- Level Contours (mAHd)
- Depth (m)
- 0.1
- 0.3
- 0.5
- 1
- 2
- >2



Warrumbungle Shire Council  
 Detailed design of Baradine Town Levee

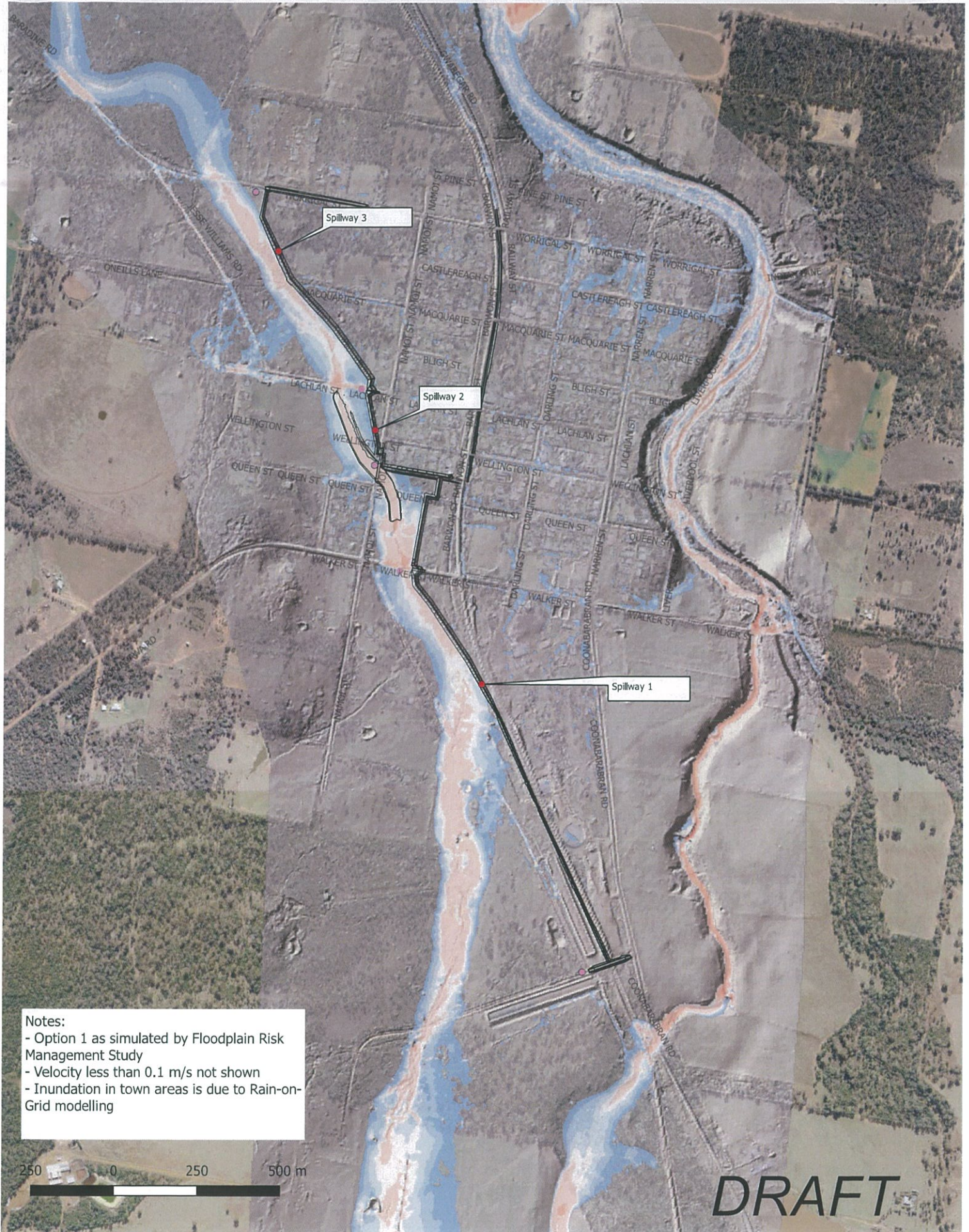
Flooding Assessments  
 Option 1 - 5-year ARI

Job Number | 2219321  
 Revision | A  
 Date | 2018/03/15

Figure 1

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Scale 10000

Paper Size A3

Map projection: Transverse Mercator  
 Horizontal datum: GDA 1994  
 Grid: GDA 1994 MGA Zone 55



LEGEND

|                   |         |         |
|-------------------|---------|---------|
| — Levee Alignment | 0.2-0.3 | 1.0-2.0 |
| v (m/s)           | 0.3-0.4 | 2.0-3.0 |
|                   | 0.4-0.5 | 3.0-5.0 |
|                   | 0.5-1.0 | >5.0    |
|                   | 0.1-0.2 |         |



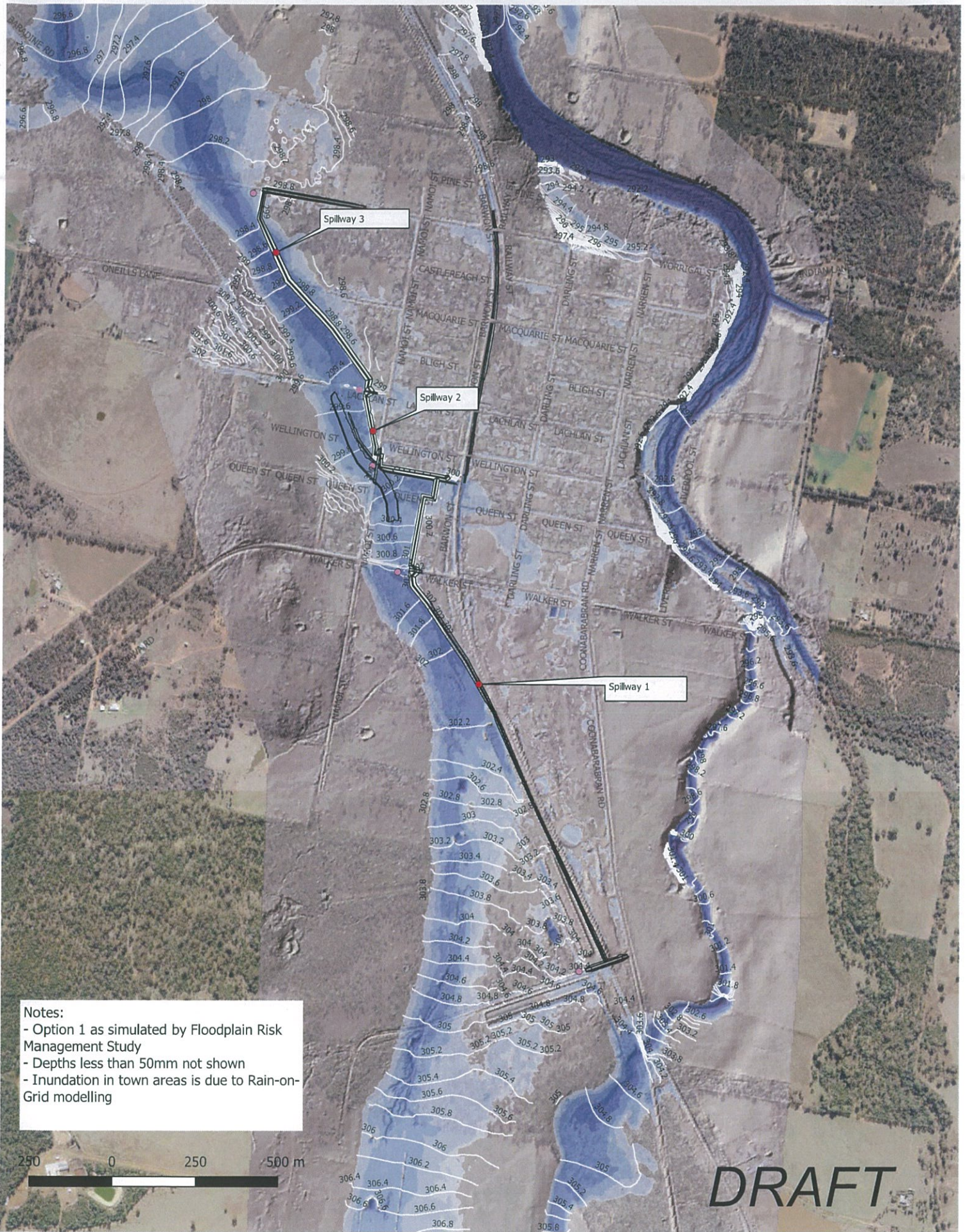
Warrumbungle Shire Council  
 Detailed design of Baradine Town Levee  
**Flooding Assessments**  
 Option 1 - 5-year ARI

Job Number | 2219321  
 Revision | A  
 Date | 2018/03/15

Figure 2

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Scale 10000

Paper Size A3

Map projection: Transverse Mercator  
Horizontal datum: GDA 1994  
Grid: GDA 1994 MGA Zone 55



**LEGEND**

- Levee Alignment
- Level Contours (mAHD)
- Depth (m)
- 0.1
- 0.3
- 0.5
- 1
- 2
- >2



Warrumbungle Shire Council  
Detailed design of Baradine Town Levee

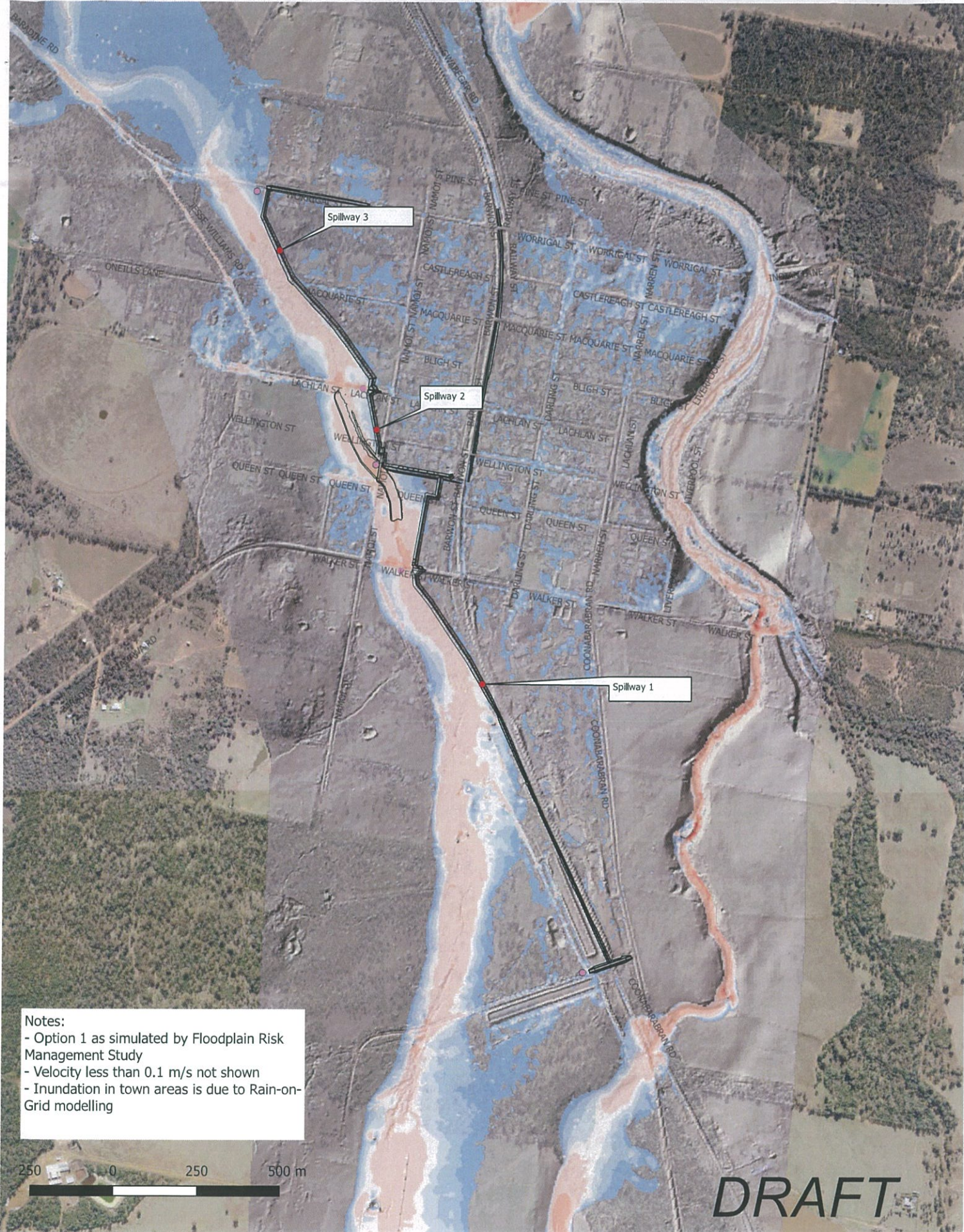
**Flooding Assessments**  
Option 1 - 20-year ARI

Job Number 2219321  
Revision A  
Date 2018/03/15

Figure 3

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Notes:  
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 - Velocity less than 0.1 m/s not shown  
 - Inundation in town areas is due to Rain-on-Grid modelling



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|  |  |         |         |         |         |         |         |         |         |      |         |      |  |   |  |
|--|--|---------|---------|---------|---------|---------|---------|---------|---------|------|---------|------|--|---|--|
| <p>Scale 10000</p> <p>Paper Size A3</p> <p>Map projection: Transverse Mercator<br/>         Horizontal datum: GDA 1994<br/>         Grid: GDA 1994 MGA Zone 55</p> | <p>LEGEND</p> <p>— Levee Alignment</p> <p>v (m/s)</p> <table border="1"> <tr> <td>0.1-0.2</td> <td>0.2-0.3</td> <td>1.0-2.0</td> </tr> <tr> <td>0.3-0.4</td> <td>2.0-3.0</td> <td>3.0-5.0</td> </tr> <tr> <td>0.4-0.5</td> <td>3.0-5.0</td> <td>&gt;5.0</td> </tr> <tr> <td>0.5-1.0</td> <td>&gt;5.0</td> <td></td> </tr> </table> | 0.1-0.2 | 0.2-0.3 | 1.0-2.0 | 0.3-0.4 | 2.0-3.0 | 3.0-5.0 | 0.4-0.5 | 3.0-5.0 | >5.0 | 0.5-1.0 | >5.0 |  | <p>Warrumbungle Shire Council<br/>         Detailed design of Baradine Town Levee</p> <p><b>GHD</b></p> <p>Flooding Assessments<br/>         Option 1 - 20-year ARI</p> | <p>Job Number   2219321<br/>         Revision   A<br/>         Date   2018/03/15</p> |
| 0.1-0.2  | 0.2-0.3  | 1.0-2.0 |         |         |         |         |         |         |         |      |         |      |  |   |  |
| 0.3-0.4  | 2.0-3.0  | 3.0-5.0 |         |         |         |         |         |         |         |      |         |      |  |   |  |
| 0.4-0.5  | 3.0-5.0  | >5.0    |         |         |         |         |         |         |         |      |         |      |  |   |  |
| 0.5-1.0  | >5.0   |         |         |         |         |         |         |         |         |      |         |      |  |   |  |

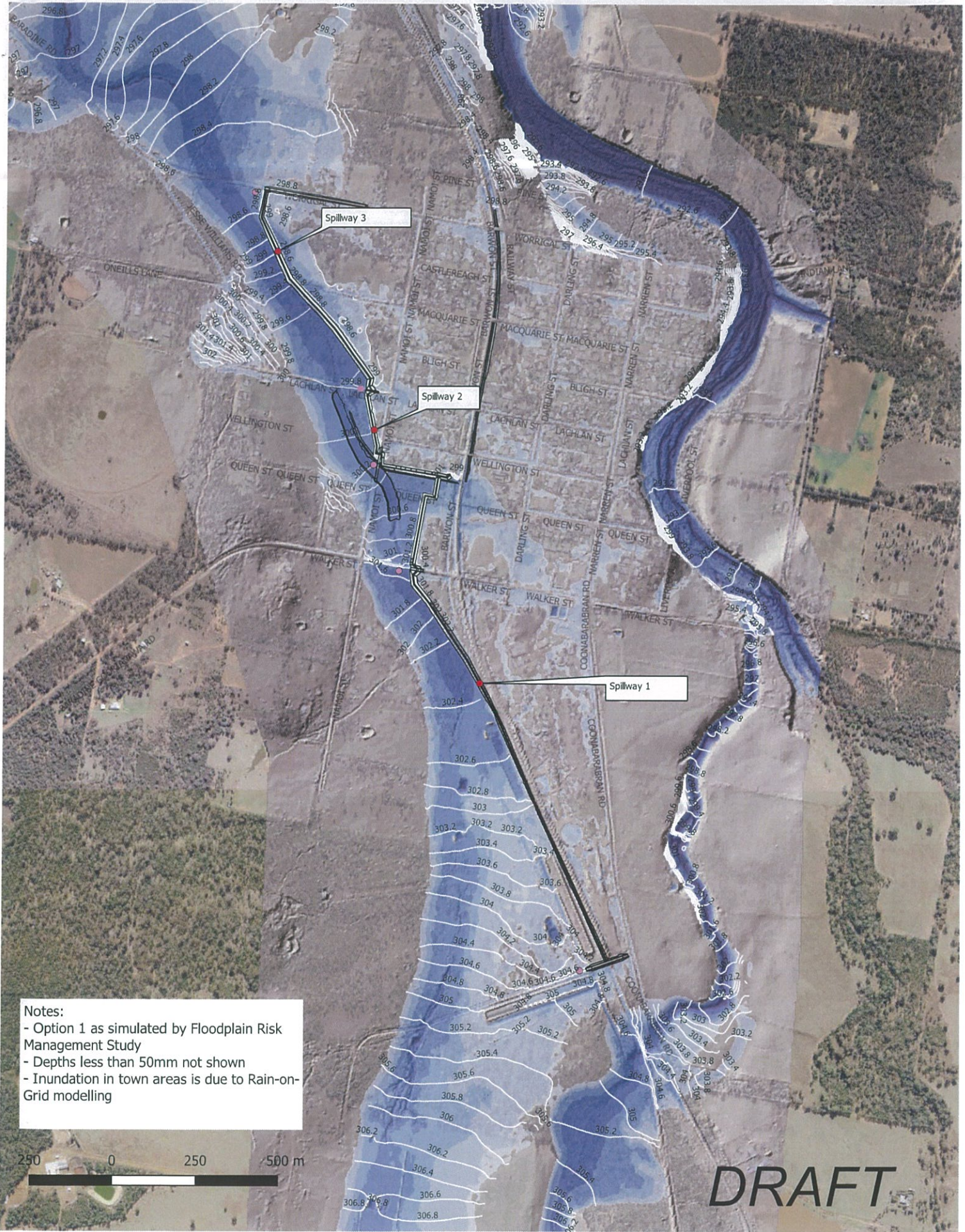
Figure 4

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Data Source: NSW LPI:DTDE & DCD, 2012; GHD Flood Mapping (2017) Created by RRB

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Notes:  
 - Option 1 as simulated by Floodplain Risk Management Study  
 - Depths less than 50mm not shown  
 - Inundation in town areas is due to Rain-on-Grid modelling

Scale 10000

Paper Size A3

Map projection: Transverse Mercator  
 Horizontal datum: GDA 1994  
 Grid: GDA 1994 MGA Zone 55



LEGEND

- Levee Alignment
- Level Contours (mAHd)
- Depth (m)
- 0.1
- 0.3
- 0.5
- 1
- 2
- >2



Warrumbungle Shire Council  
 Detailed design of Baradine Town Levee

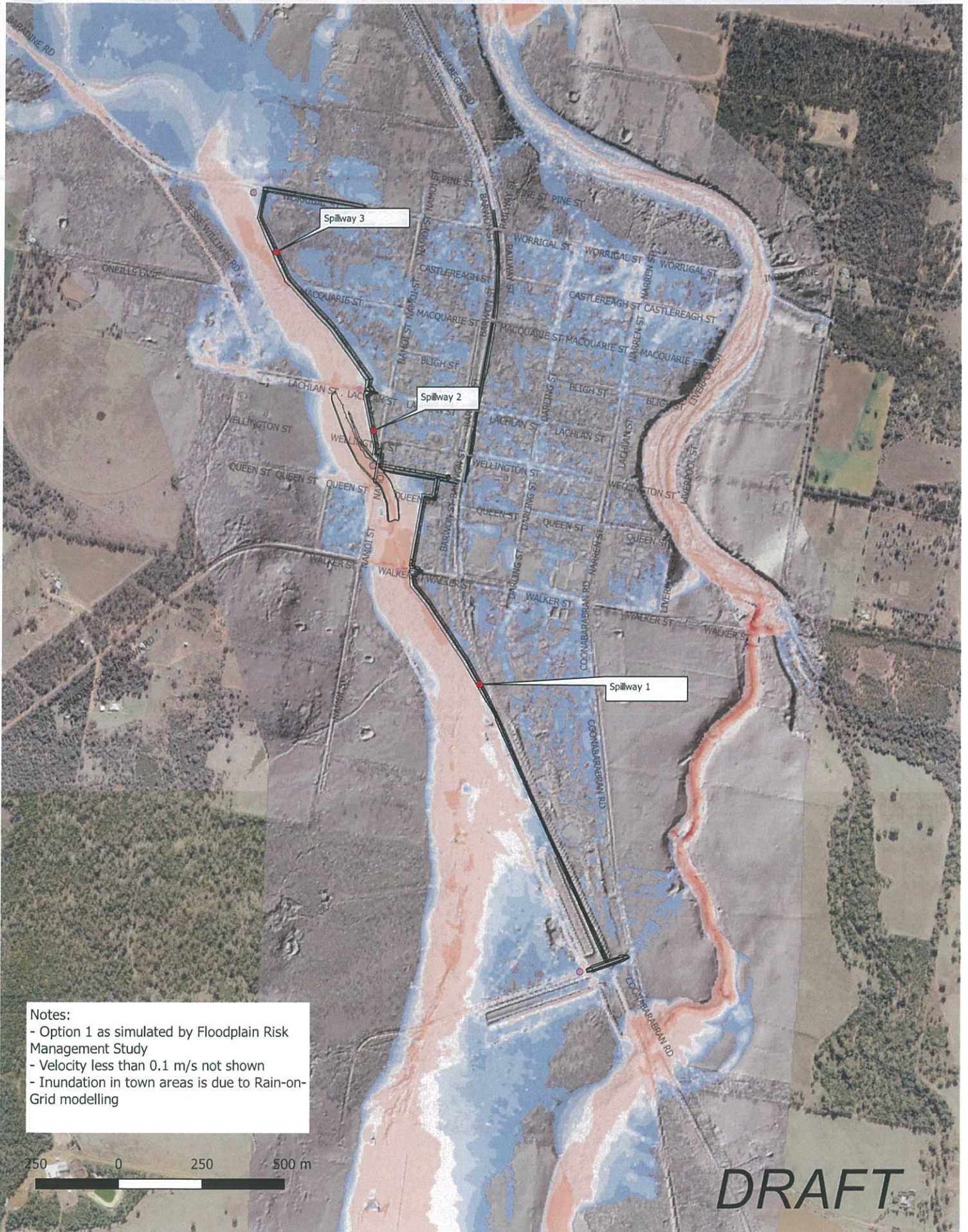
Flooding Assessments  
 Option 1 - 100-year ARI

Job Number 2219321  
 Revision A  
 Date 2018/03/15

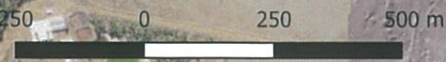
Figure 5

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Scale 10000

Paper Size A3

Map projection: Transverse Mercator  
 Horizontal datum: GDA 1994  
 Grid: GDA 1994 MGA Zone 55



LEGEND

|                   |         |         |
|-------------------|---------|---------|
| — Levee Alignment | 0.2-0.3 | 1.0-2.0 |
| v (m/s)           | 0.3-0.4 | 2.0-3.0 |
|                   | 0.4-0.5 | 3.0-5.0 |
|                   | 0.5-1.0 | >5.0    |
|                   | 0.1-0.2 |         |



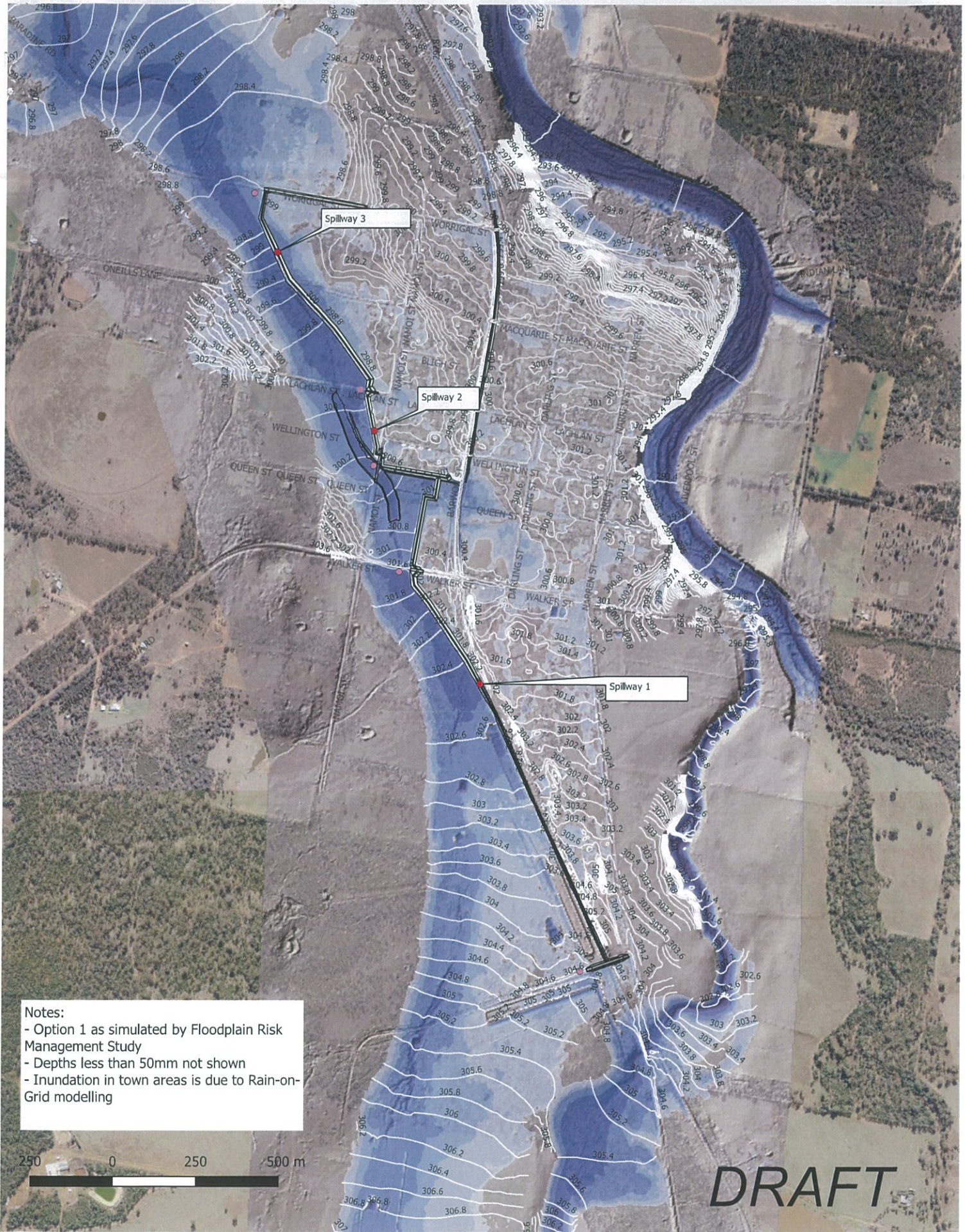
Warrumbungle Shire Council  
 Detailed design of Baradine Town Levee  
**Flooding Assessments**  
 Option 1 - 100-year ARI

Job Number | 2219321  
 Revision | A  
 Date | 2018/03/15

Figure 6

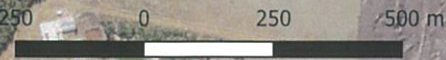
c2017. Whilst every care has been taken to prepare this map, GHD (and Warrumbungle Shire Council) make no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.





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Scale 10000

Paper Size A3

Map projection: Transverse Mercator  
Horizontal datum: GDA 1994  
Grid: GDA 1994 MGA Zone 55



LEGEND

- Levee Alignment
- Level Contours (mAH)
- Depth (m)
- 0.1
- 0.3
- 0.5
- 1
- 2
- >2



Warrumbungle Shire Council  
Detailed design of Baradine Town Levee

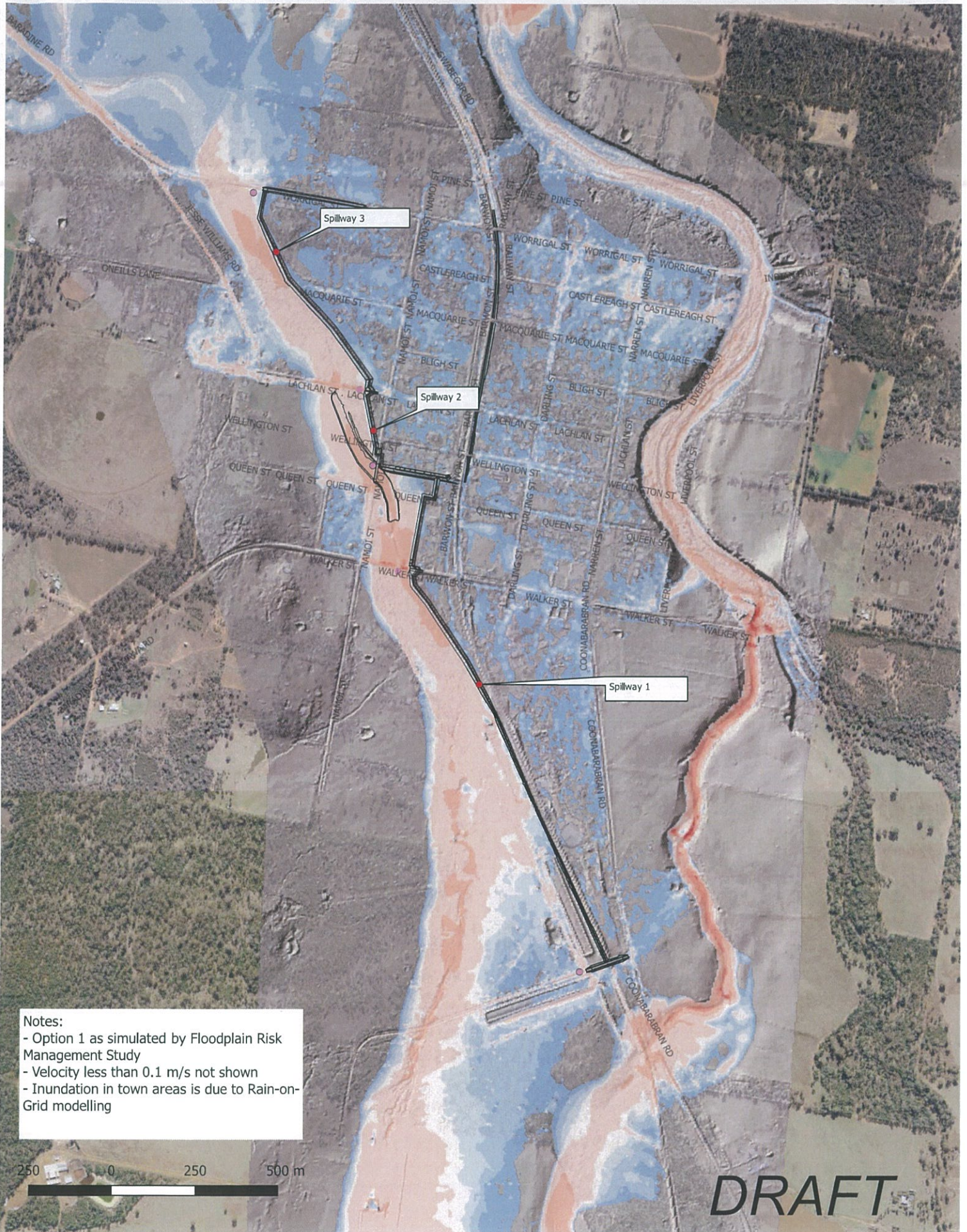
Flooding Assessments  
Option 1 - 200-year ARI

Job Number 2219321  
Revision A  
Date 2018/03/15

Figure 7

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Scale 10000

Paper Size A3

Map projection: Transverse Mercator  
 Horizontal datum: GDA 1994  
 Grid: GDA 1994 MGAZone 55



LEGEND

|                   |         |         |
|-------------------|---------|---------|
| — Levee Alignment | 0.2-0.3 | 1.0-2.0 |
| v (m/s)           | 0.3-0.4 | 2.0-3.0 |
|                   | 0.4-0.5 | 3.0-5.0 |
|                   | 0.5-1.0 | >5.0    |
|                   | 0.1-0.2 |         |



Warrumbungle Shire Council  
 Detailed design of Baradine Town Levee

Flooding Assessments  
 Option 1 - 200-year ARI

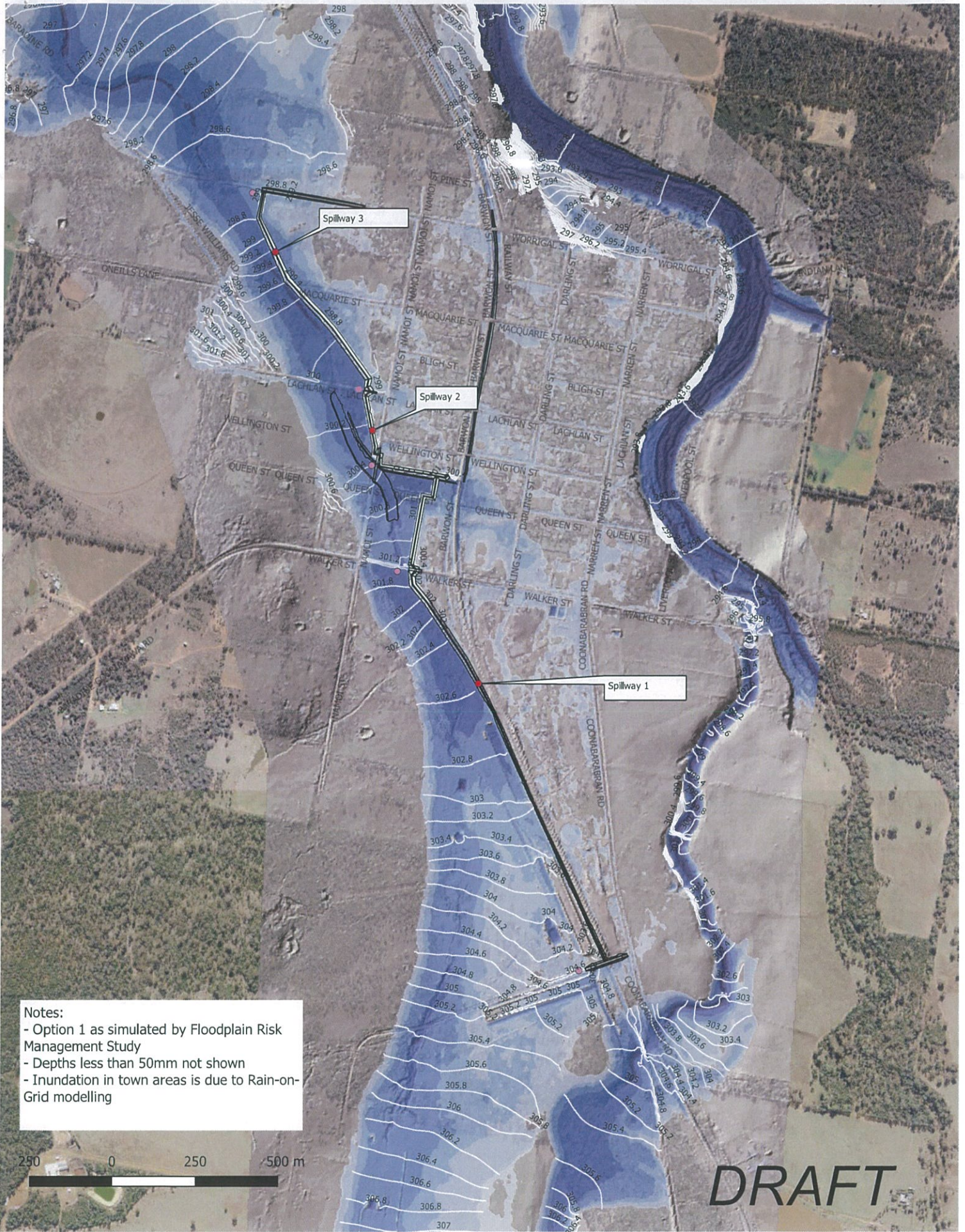
Job Number | 2219321  
 Revision | A  
 Date | 2018/03/15

Figure 8

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Scale 10000

Paper Size A3

Map projection: Transverse Mercator  
 Horizontal datum: GDA 1994  
 Grid: GDA 1994 MGA Zone 55



LEGEND

- Levee Alignment
- Level Contours (mAH)
- Depth (m)
  - 0.1
  - 0.3
  - 0.5
  - 1
  - 2
  - >2



Warrumbungle Shire Council  
 Detailed design of Baradine Town Levee

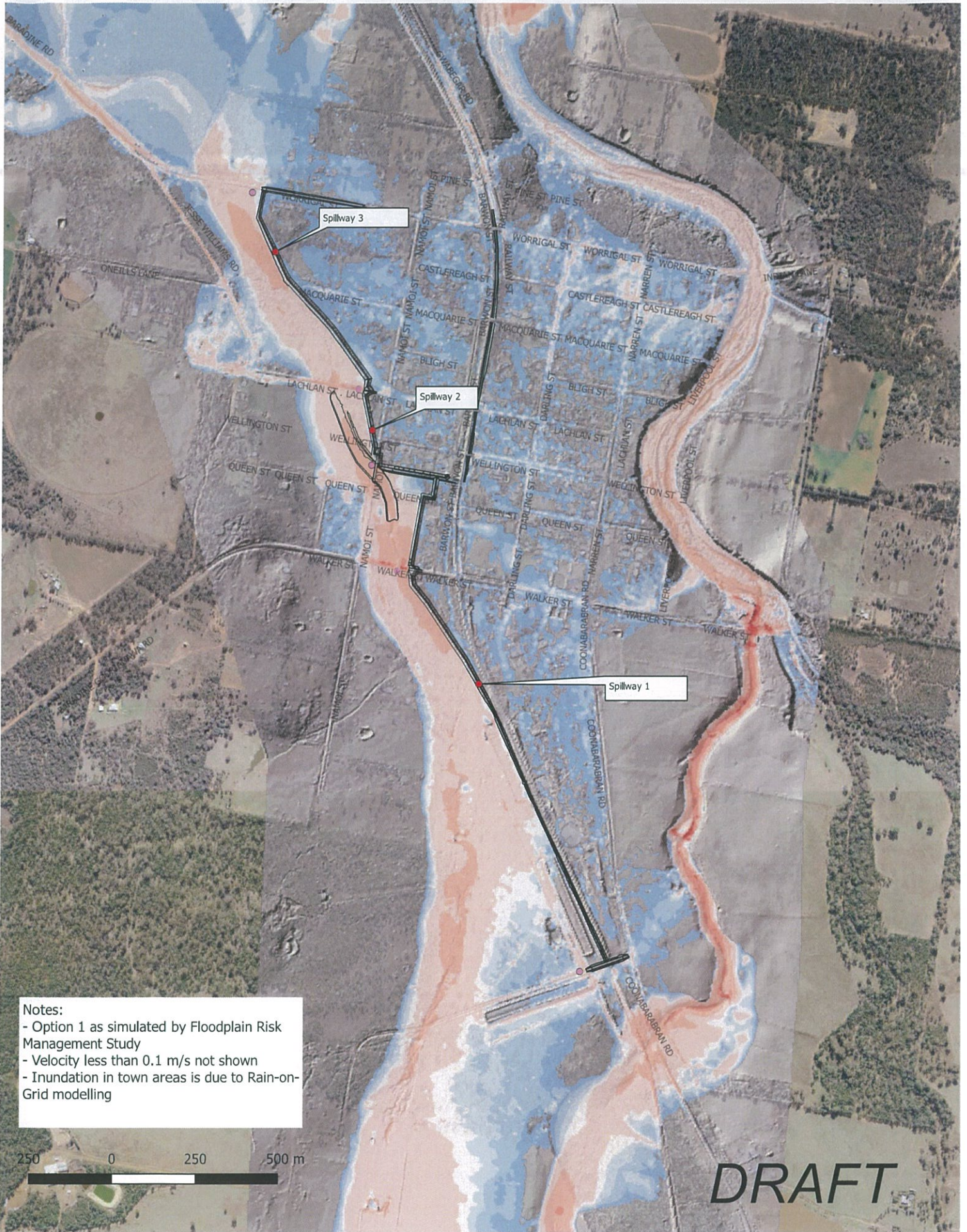
Flooding Assessments  
 Option 1 - 500-year ARI

Job Number | 2219321  
 Revision | A  
 Date | 2018/03/15

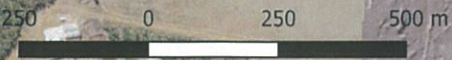
Figure 9

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Scale 10000

Paper Size A3

Map projection: Transverse Mercator  
 Horizontal datum: GDA 1994  
 Grid: GDA 1994 MGA Zone 55



LEGEND

|                   |         |         |
|-------------------|---------|---------|
| — Levee Alignment | 0.2-0.3 | 1.0-2.0 |
| v (m/s)           | 0.3-0.4 | 2.0-3.0 |
|                   | 0.4-0.5 | 3.0-5.0 |
|                   | 0.5-1.0 | >5.0    |
|                   | 0.1-0.2 |         |



Warrumbungle Shire Council  
 Detailed design of Baradine Town Levee  
**Flooding Assessments**  
 Option 1 - 500-year ARI

Job Number 2219321  
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Figure 10

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GHDDocId/https://projects.ghd.com/OC/Newcastle/wscbaradinelevee/Delivery/Documents/2219321-REP-Design Basis Report.docx

Document Status

| Revision | Author     | Reviewer  |           | Approved for Issue |           |            |
|----------|------------|-----------|-----------|--------------------|-----------|------------|
|          |            | Name      | Signature | Name               | Signature | Date       |
| A        | H. Gilbert | G. Morton |           | J. McPherson       |           | 28/05/2018 |
|          |            |           |           |                    |           |            |
|          |            |           |           |                    |           |            |

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