

STORMWATER MANAGEMENT STRATEGY

NUMURKAH
MAY 2024

PREPARED FOR MOIRA SHIRE COUNCIL

This report has been prepared by the office of Spiire
Level 2, 10 Moorabool Street PO Box 4032 **Geelong** Victoria 3220

Acknowledgements and Recognition

Paul Diffey – Moira Shire Council

Issue Date	Rev No	Authors	Checked	Approved
24/04/2024	01	M. DODGSHUN	A. DAVIDSON	A. BROWN
20/05/2024	02	M. DODGSHUN	A. DAVIDSON	A. BROWN

Spiire Job Number: 310429

Citation: Spiire 2024, STORMWATER MANAGEMENT STRATEGY Report for MOIRA SHIRE COUNCIL.
Authors: M Dodgshun Spiire Australia Pty Ltd. Project Number 310429

File Name: G:\31\310429\Water\Documents & Calculations\Reports\310429-REP-SW-04 - Numurkah Stormwater Management Strategy – FINAL.docx

© Spiire

The information contained in this document is intended solely for the use of the client named for the purpose for which it has been prepared and no representation is made or is to be implied as being made to any third party. Other than for the exclusive use of the named client, no part of this report may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, mechanical, photocopying or otherwise, without the prior written permission of Spiire.

TABLE OF CONTENTS

1. INTRODUCTION 4

1.1 SCOPE OF WORKS 4

2. EXISTING SITE CONDITIONS 6

2.1 SITE DRAINAGE 6

2.2 LAKE NUMURKAH 7

2.3 EXISTING FLOODING 7

2.4 GOULBURN MURRAY WATER IRRIGATION CHANNEL NO 6/6 8

3. PREVIOUS INVESTIGATIONS 10

3.1 OPPORTUNITIES AND CONSTRAINTS ASSESSMENT, NUMURKAH DRAINAGE STRATEGY (SPIIRE, 2022) 10

3.2 DEVELOPMENT PLAN 10

4. PROPOSED DEVELOPMENT 12

5. STORMWATER MANAGEMENT STRATEGY 15

6. HYDROLOGICAL ASSESSMENT 17

6.1 EXISTING CONDITIONS 17

6.2 DEVELOPED CONDITIONS 18

6.3 RESULTS 19

6.3.1 DEVELOPED CONDITIONS 19

7. HYDRAULIC ASSESSMENT 21

7.1 ESTATE DRAINAGE, ROAD GRADING AND FILL 21

7.2 PUMP STATION AND OUTFALL TO LAKE NUMURKAH 21

7.3 DRAINAGE RESERVE CONCEPT DESIGN 22

8. WATER QUALITY TREATMENT 25

8.1 WATER QUALITY OBJECTIVES 25

8.2 WSUD CONCEPT DESIGN 26

8.3 RESULTS 27

9. PERMIT 1 DEVELOPMENT 29

10. SUMMARY AND RECOMMENDATIONS 31

11. REFERENCES 33

APPENDIX A STRATEGY PLANS 34
APPENDIX B HYDROLOGICAL MODELLING REPORT 35
APPENDIX C URBAN DESIGN 36

1. INTRODUCTION

1.1 SCOPE OF WORKS

Spiire has been engaged by Moira Shire Council to complete a Stormwater Management Strategy (SMWS) for a parcel of land located north of Wattle Drive, Numurkah “The Growth Area”. This growth area is proposed for future residential development.

The scope of works which has been undertaken in the SWMS is:

- Prepare Concept Urban Design
- Develop Catchment Plans for existing and developed conditions
- Design flow estimation (using RORB software package)
- Hydraulic calculations to ensure flow conveyance capacities
- MUSIC modelling for water quality
- Concept Drainage Strategy plans

A SWMS was previously completed by Spiire in September 2023. That SWMS investigated a drainage solution that was consistent with the previous development plan and utilised a gravity drainage solution. Adopting a gravity drainage solution induced a considerable volume of fill onsite and was not preferred by council. This revised SWMS adopts a retarding basin and pumped outlet to minimise the required volume of fill onsite and provide a more practical solution to develop the site. Location

The growth area is located north of Wattle Drive in Numurkah as shown in Figure 1. The eastern boundary of the growth area is located adjacent to an existing Goulburn Murray Water (GMW) open irrigation channel. The western boundary of the growth area is located adjacent to existing residential development. Pine Street bounds the growth area to the north.

The growth area is proposed to be developed in 4 separate parcels:

- Permit 1, bounding Pine Street to the south.
- Permit 2, in the southwest of the site.
- Permit 3, in the southeast of the site.
- North of Pine Street (Future Growth Area)

The combination of the Permit 1, Permit 2 and Permit 3 development will hereby be referred to as “The subject site” or “The site” and has an area of 26.5 ha. The development of these parcels is described in detail in Section 0.

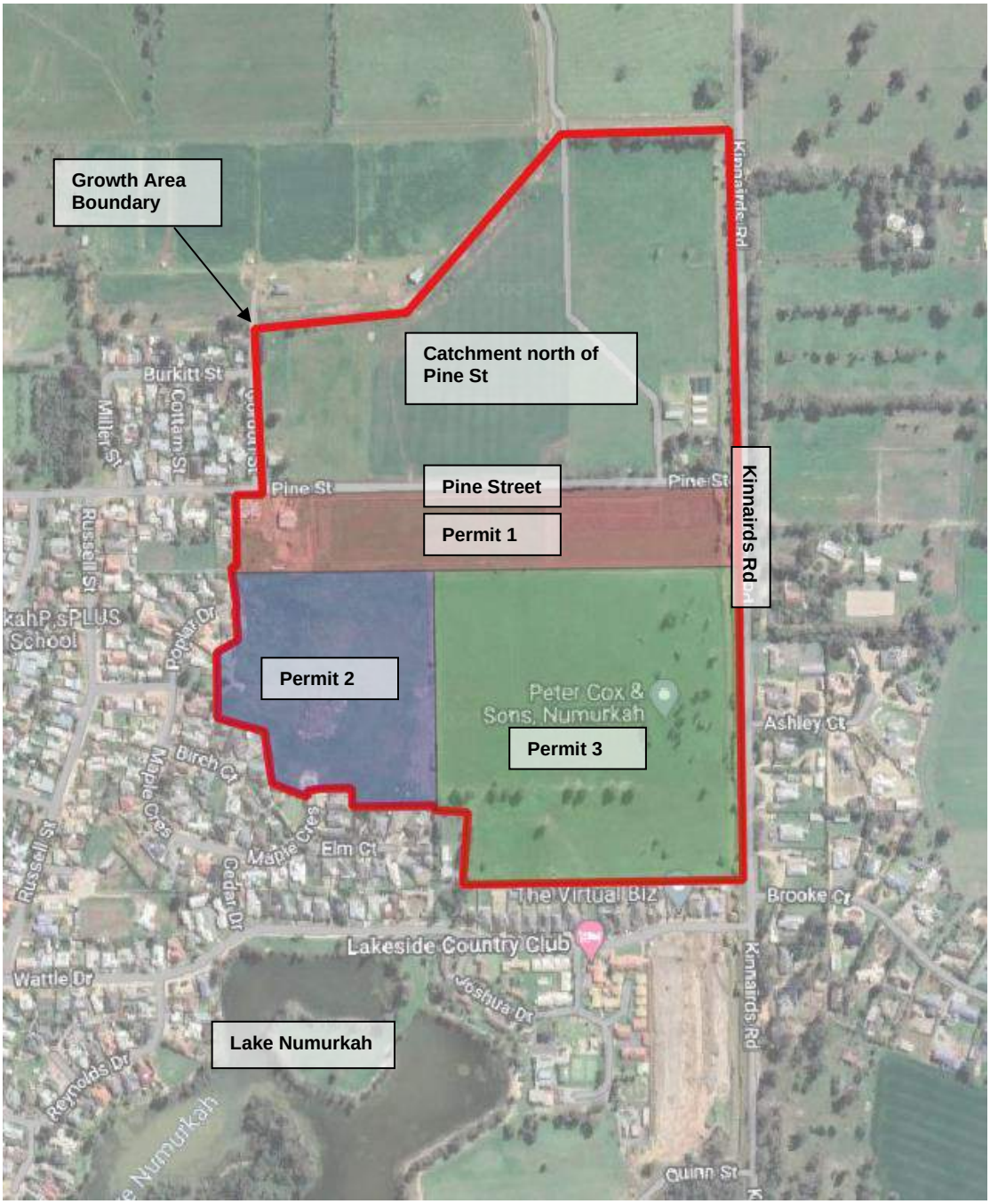


Figure 1: Growth Area Location

2. EXISTING SITE CONDITIONS

2.1 SITE DRAINAGE

The growth area is approximately 43.3 ha and has limited grade (around 1 in 1000) across the site to convey overland flows. The future growth area north of Pine Street (approximately 19 ha) drains south and south-east before overtopping Pine Street at an existing low point. Flows are then conveyed west along an existing swale that runs on the south of Pine Street, before turning south. Flows travel south from the site and go through the property at 52 Wattle Drive as shown in Figure 2. From here, flows continue southwards to discharge to Lake Numurkah.

The property in the south-east (Permit 3) drains south through an unmade road reserve between properties on Wattle Drive. Once flow is conveyed to Wattle Drive, underground pipes convey flow which outlets into the northern part of Lake Numurkah.

Refer to the existing conditions plan in Appendix A for more details.

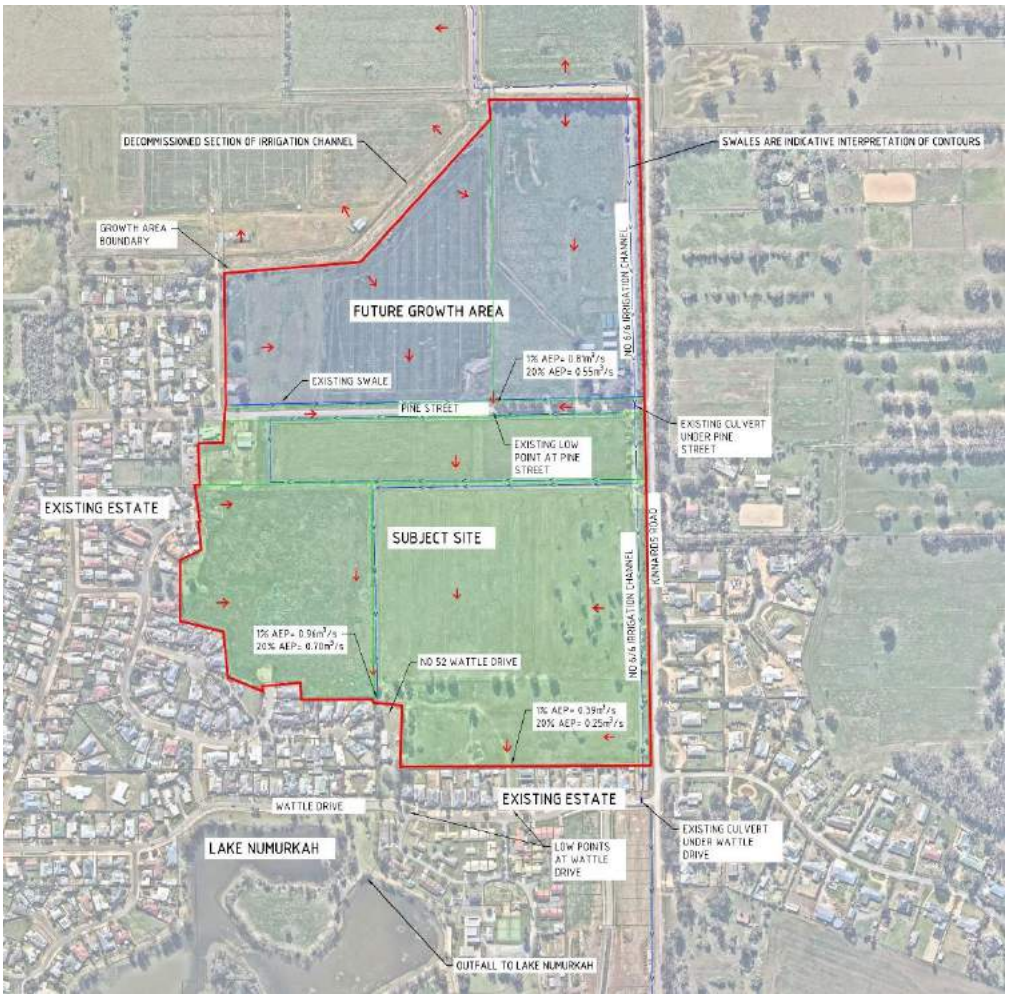


Figure 2: Existing Conditions Plan

2.2 LAKE NUMURKAH

Lake Numurkah is located south of the growth area. Lake Numurkah fills during periods of rainfall, however, being oversized in relation to the connecting catchment, dries out during summer months. During dry out periods water reduces to only a few permanent pools located in the low points of the lake.

The lake drains at the southwest corner to Broken Creek through box culverts. It is understood that during high rainfall events, Broken Creek can backwater through those culverts and fill Lake Numurkah. Penstocks are installed to the outlet culvert to prevent this backwatering occurring. It is also understood that 1% AEP overland flows from Broken Creek enter Lake Numurkah, with flood extents described below.

Spiire have recently completed community consultation for a landscape masterplan for Lake Numurkah (Spiire, 2022). The assessment of this masterplan included an investigation of possible modifications to the existing lake system based on water balance modelling to improve the lake's functionality and enhance the area from an aesthetic, water quality and environmental perspective.

For more information on Lake Numurkah, refer to *Lake Numurkah Analysis and Opportunities* (Spiire, 2022).

2.3 EXISTING FLOODING

The growth area is currently subjected to inundation from Broken Creek in a 1% Annual Exceedance Probability (AEP) flood event to depths up to approximately 0.5 – 1 metre (Water Technology, 2017). Water Technology has completed a flood plain management study to inform Moira Shire council and Goulburn Broken Catchment Management Authority (CMA) on existing 1% AEP flooding in Broken Creek – Figure 3.

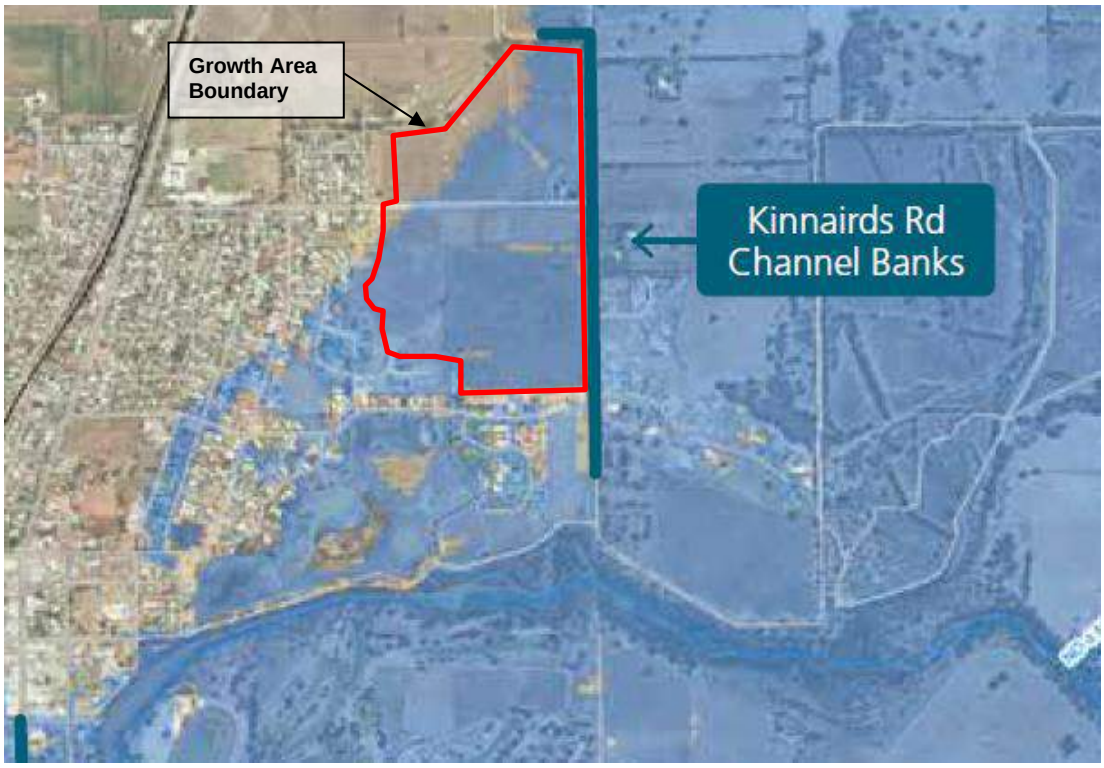


Figure 3: Existing conditions 1% AEP flooding conditions (extracted from Water Technology, 2017)

It is understood that Moira Shire are planning to implement recommendations from the Water Technology 2017 report, with regards to flood mitigation works. This will entail the construction of a flood levee running down the western side of Kinnairds Road, as shown in Figure 4. It is essential that the construction of this flood levee by Council will be completed to provide complete 1% AEP flood immunity for the subject site. This includes an appropriate outfall arrangement from Lake Numurkah to prevent Broken Creek from backwatering into Lake Numurkah.

For more details around the proposed flood mitigation works, refer to Water Technology 2017.



Figure 4: Original Mitigation Package Option (extracted from Water Technology 2017)

2.4 GOULBURN MURRAY WATER IRRIGATION CHANNEL NO 6/6

Irrigation channel No 6/6 is a GMW asset which distributes irrigation water from the Murray River (to the north) through the landscape. As shown in Figure 5, Irrigation channel No 6/6 extends from north of Pine Street before running west of and parallel to Kinnairds Road. Irrigation channel No 6/6 runs southwards along this alignment before discharging to Broken Creek, approximately 450m downstream of the subject site.

A decommissioned section of irrigation channel is shown in Figure 5. This previously conveyed water westwards, however it is no longer required due to this western area now being developed. It is understood that the irrigation system has been modified such that the decommissioned channel is no longer part of this system.

Council have advised that the reach of Irrigation Channel No 6/6 in the vicinity of the subject site will ultimately be piped, in the same location as the existing channel. A future easement will be created for this pipe, in favour of GMW.

A key assumption of this SWMS is that the future piping of Irrigation channel No 6/6 will negate any flood risk from the irrigation system to the future development, including backwatering from Broken Creek. It is outside the scope of this study to assess potential concept design options of the future pipe arrangement, together with associated flood risk. It

is critical that flood risk management to the future development from the future piped irrigation system is fully addressed during relevant future design phases, including consideration of any surcharge or emergency spillway considerations.

A number of relatively small irrigation channels run from Irrigation Channel 6/6 on the eastern site boundary through the site. These were previously used for agricultural purposes, are no longer required and will be decommissioned as part of the future development.

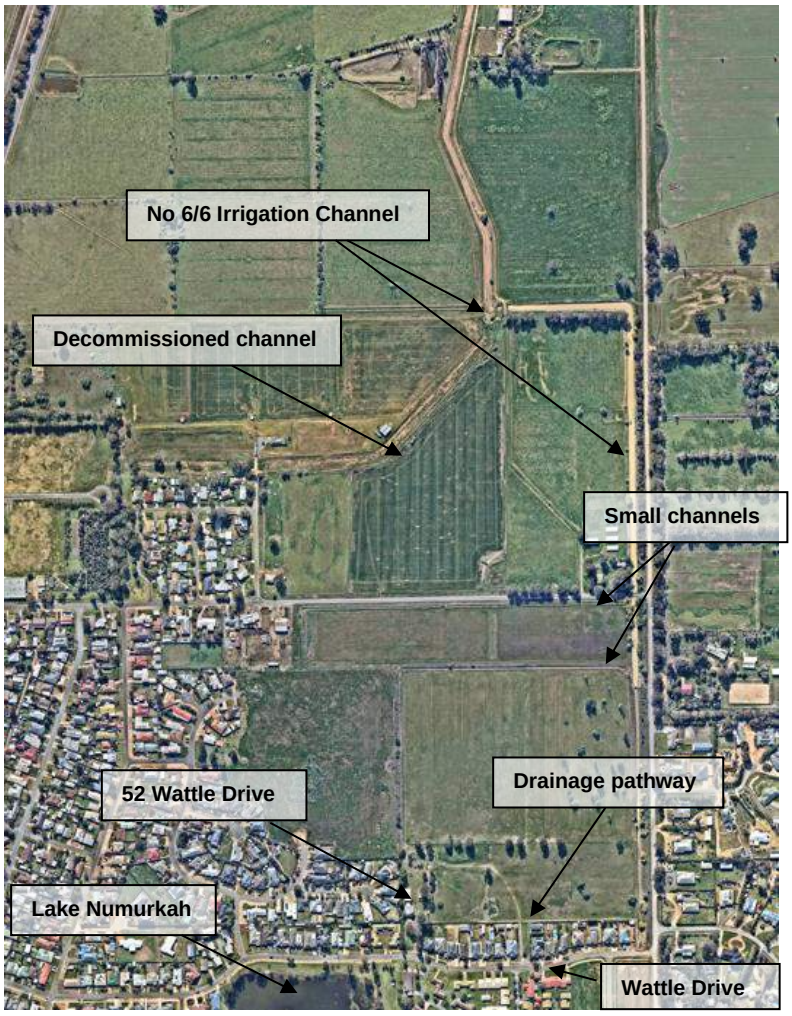


Figure 5. Existing irrigation channels (Nearmap, August 2023)

3. PREVIOUS INVESTIGATIONS

Previous investigations relevant to the site have been introduced in the existing conditions section above. Additional relevant investigations are discussed below.

3.1 OPPORTUNITIES AND CONSTRAINTS ASSESSMENT, NUMURKAH DRAINAGE STRATEGY (SPIIRE, 2022)

This assessment undertook a review of site existing conditions and presented four conceptual drainage strategy options for the site.

- ***Option 1*****:** Site drains via a pumped retarding basin/raingarden to existing GMW irrigation channel to the east of the site. Drains to Broken Creek crossing at Kinnard's Rd.
- ***Option 2*****:** Site drains via a pumped retarding basin/raingarden to Wattle Drive via new road between 68 and 70 Wattle Drive. Option requires approximately 440m of new underground stormwater pipe from the retarding basin.
- ***Option 3*****:** Site drains via a pumped retarding basin/raingarden to Wattle Drive via new drainage easement through 52 Wattle Drive. Option requires approximately 200m of stormwater pipe from the retarding basin.
- ***Option 4*****:** Site drains via a pumped retarding basin/raingarden to Maple Crescent with flows conveyed via 340m of pipe from the retarding basin to Lake Numurkah. 230m of this pipe is along Maple Crescent and Cedar Drive.

The assessment identified a preferred drainage option (Option 3) which is progressed as part of this SWMS.

3.2 DEVELOPMENT PLAN

A development plan was produced for the Numurkah site for the Moria Shire Council by EarthTech in 2006. The development plan gave a high level overview of the urban layout including road layout, drainage asset locations and open space, and lot layout as seen in Figure 6.



Figure 6: Numurkah Development Plan (Moira Shire Council / EarthTech, 2006)

4. PROPOSED DEVELOPMENT

The site is proposed to be developed in 4 separate parcels, as shown in Figure 1 (page 5). The four parcels are:

- Permit 1 (south of Pine Street)
- Permit 2 (south-west of the site)
- Permit 3 (south-east of the site)
- North of Pine Street (future growth area)

At the time of writing, the Permit 1 area has received planning approval which is contingent on an endorsed SWMS. In order to avoid fragmented assets which can result in poor outcomes, the Moira Shire Council has engaged Spiire to undertake an overarching SWMS (this report) that considers the Growth Area in entirety. This SMWS will be used to inform the development of future site specific SWMS.

Permit 1 is anticipated to be the first development to occur, therefore this SWMS considers two stages:

- Permit 1 only developed.
- Permit 1, 2 and 3 developed.

The future growth area to the north of Pine Street is anticipated to be developed at a later date, but given it contributes to the study area, has been considered as part of this SWMS. Permit areas 1, 2 and 3 have been rezoned to General Residential (GRZ1) and are the focus of this SWMS. The future growth area north of Pine Street is currently categorised as Farming Zone (FZ1) and while included in the SWMS, is considered in less detail.

At the request of the Moira Shire Council, Spiire have updated the development objectives from that outlined in the development plan (Figure 6). The new development objectives to be adopted in the updated urban design and SWMS are:

- Integration with the approved Permit 1 (refer Figure 7)
- Road connectivity to Poplar Drive, Cedar Drive and Wattle Drive through the road reserve between 68-70 Wattle Drive
- Green spine and shared used path (min 10m wide) running east-west through the development connecting the reserve on Poplar Drive, the proposed WSUD assets and Kinnairds Road.
- One central WSUD asset within a retarding basin evenly split between the Permit 2 and 3.
- Green open space surrounding the drainage reserve, split as 5% of the permit area for each of Permit 2 and Permit 3. The green open space should be above the 20% AEP.
  - Permit 2 green open space = 0.33 ha
  - Permit 3 green open space = 0.72 ha
- Permit 2 lot density of 465m^2 and Permit 3 lot density of 780m^2.

- Preferred batter slopes of 1 in 6 within the drainage reserve, with an absolute maximum of 1 in 4.

- Retention of the existing café on 52 Wattle Drive, however the property can be used for an outfall pipe and ancillary flow path (easement likely to be created to contain pipe and ancillary flow channel).

These development objectives have been incorporated into an urban design which is shown in Figure 8 and Appendix C and forms the basis of the SWMS.

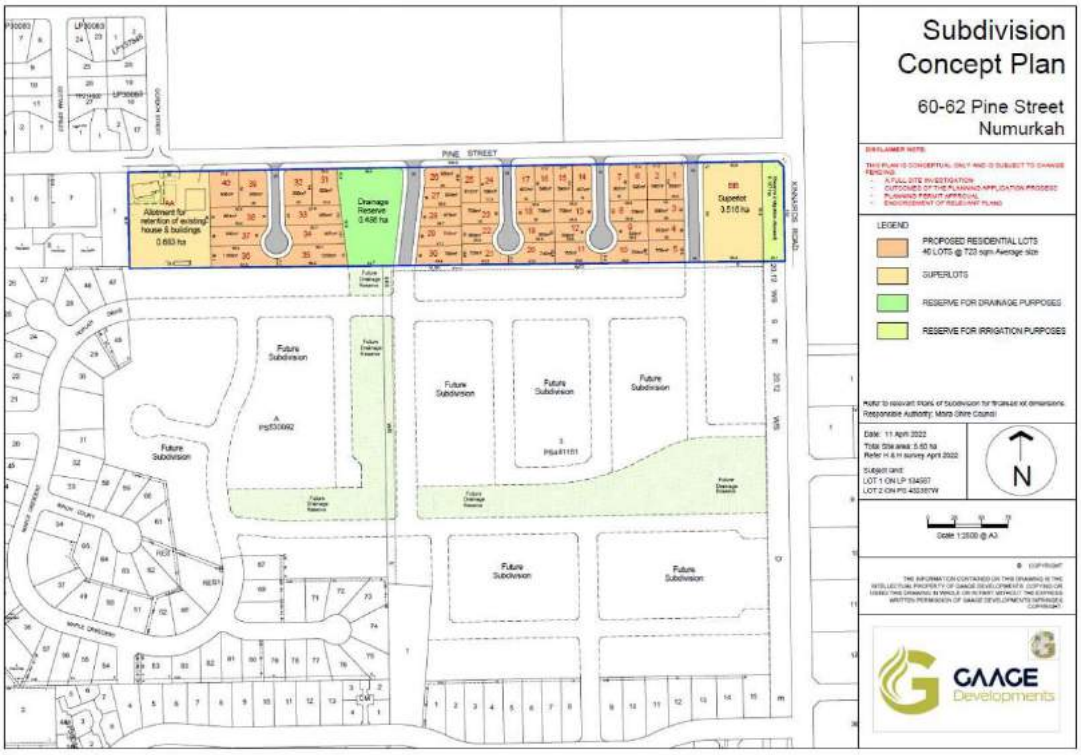


Figure 7: Permit 1 Concept Subdivision Plan (Gaage Developments, 2022)



Figure 8: Urban Design (Spiire, Feb 2024)

5. STORMWATER MANAGEMENT STRATEGY

The SWMS considers three main aspects:

- Flow conveyance through the site and downstream discharge.
- Water treatment using Water Sensitive Urban Design (WSUD).
- Flood management.

To meet the three main objectives listed above, the SWMS has been developed to manage stormwater using the following:

- Pipes to convey 20% AEP flows
- Roads to convey gap flows (between 1% AEP and 20% AEP)
- Centralised drainage reserve with co-located sediment basin, wetland and retarding basin
  - 800 m^2 Sediment Basin
  - 5,000 m^2 Wetland
  - 42,000 m^3 Retarding Basin
- 100 L/s Outlet Pump Station and rising main discharging to Lake Numurkah
- Ancillary flow path through 52 Wattle Drive to Lake Numurkah
- A future drainage reserve north of Pine Street to provide water quality and retardation for the future growth area. A gravity main drain will convey flows from the Pine Street retarding basin to the site retarding basin. This has been allowed for at a high level, to be considered in more detail as part of the future growth area SWMS.

The proposed SWMS layout is presented in the plans located in Appendix A, and also in Figure 9. Each aspect of the SWMS is described in more detail in subsequent sections of this report.



Figure 9: Ultimate Development SWMS concept design

6. HYDROLOGICAL ASSESSMENT

A hydrologic analysis using a RORB model has been undertaken to inform the SWMS. The purpose of the RORB model is to:

- Assess existing and developed conditions flows in the 1% and 20% AEP events
- Determine the retarding basin storage capacities in the 1% and 20% AEP events

This section outlines a summary of the results from the hydrological analysis. For further details of model build and assumptions see Appendix B.

6.1 EXISTING CONDITIONS

Flows have been calculated under existing conditions using a fraction impervious of 0.1 for all catchments. The RORB model catchment plan is shown in Figure 10.

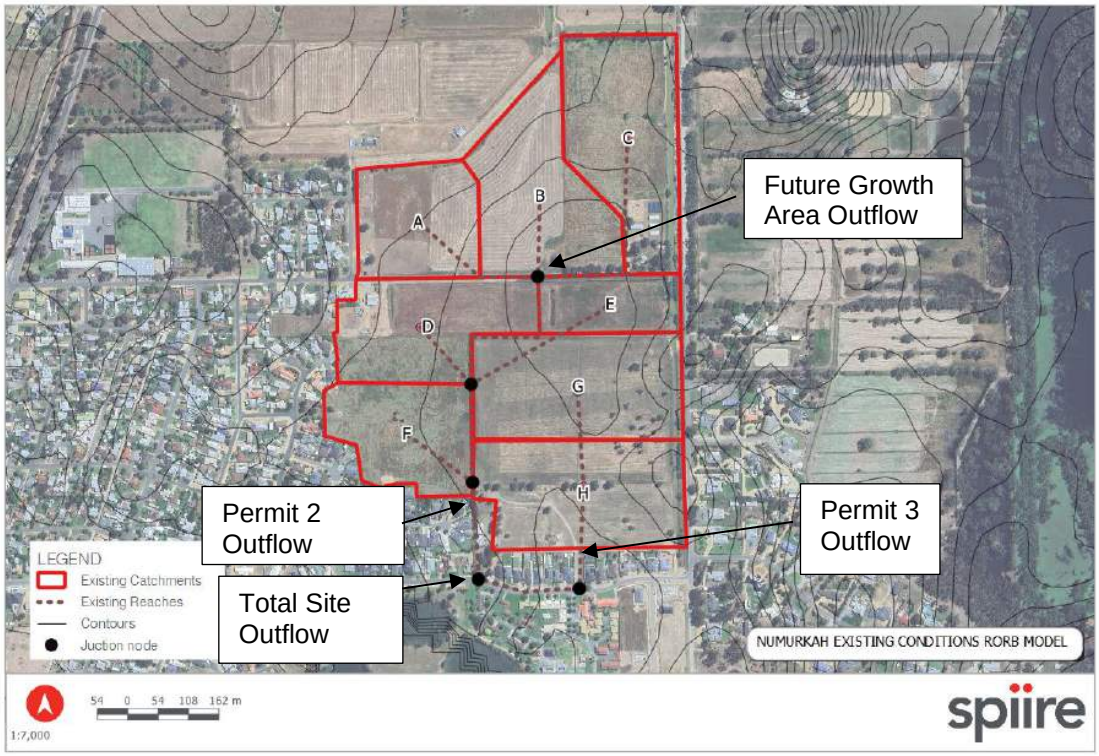


Figure 10: Existing Conditions RORB model

The 1% AEP storm event results at various critical locations for the existing conditions RORB Model is shown in Table 1. The flows in Table 1 are for the temporal pattern one above calculated median for the critical duration at the respective location.

Table 1: Existing Conditions RORB Model Results

Location	1% AEP Flow (m^3/s)	20% AEP Flow (m^3/s)
Future Growth Area Outflow (Pine St)	1.0 1.5-hr TP22	0.3 3-hr TP8
Permit 2 Outflow	0.9 6-hr TP27	0.3 4.5-hr TP4
Permit 3 Outflow	0.7 1.5-hr TP22	0.2 3-hr TP6
Site Outfall (Total outflows combined)	1.6 3-hr TP29	0.4 4.5-hr TP4

6.2 DEVELOPED CONDITIONS

Spiire have noted that the future growth area north of Pine Street will eventually be developed. A key assumption of the strategy is, that development upstream of Pine Street will retard flows back to the existing conditions discharge rates and therefore contribute peak flows no greater than that derived under existing conditions. It should be noted that the assumption under this SWMS is that the Pine Street basin retards back to 1% AEP existing conditions peak flows (1,000 L/s). This is considered to be a conservative assumption, both from main drain sizing and also on site retarding basin sizing. While a levels assessment has shown that a gravity basin north of Pine Street is possible, should this basin be designed as a pumped system, sizing of both the main drain and on site retarding basin can be reduced. This will be assessed in more detail in future drainage studies for the development north of Pine Street.

RORB modelling has been completed using a fraction impervious of 0.75 for developed catchments and 0.1 for open space/drainage reserves. The developed conditions catchment plan is shown in Figure 11.

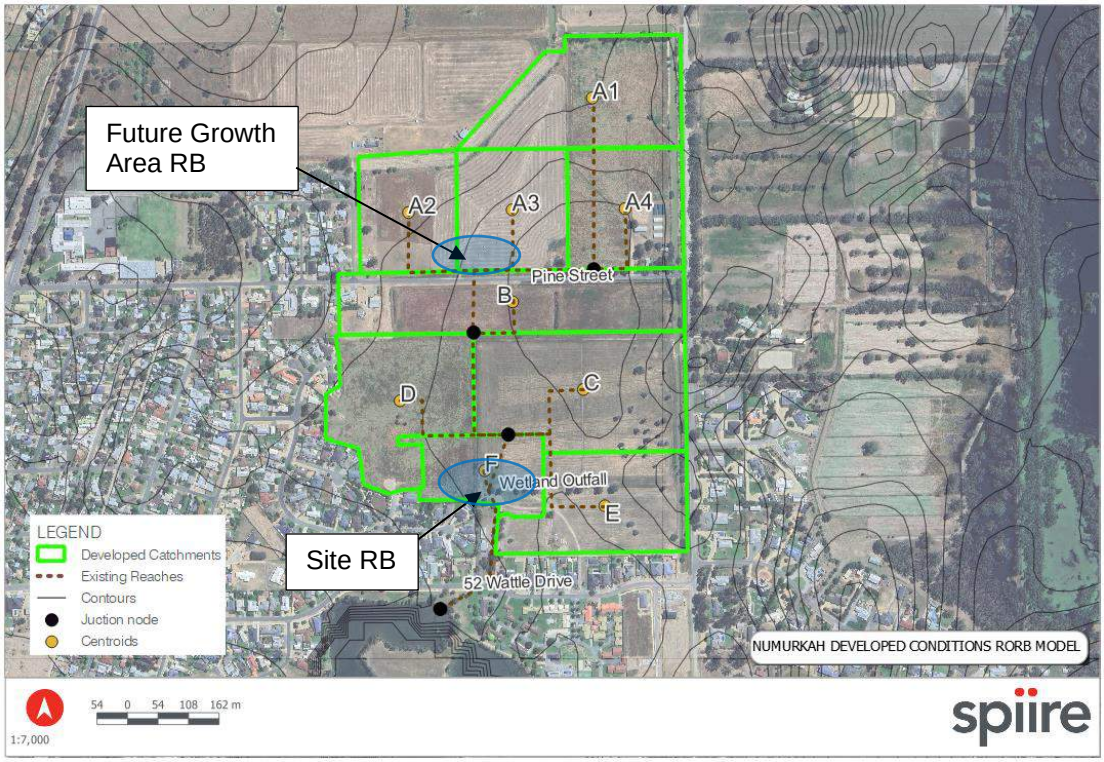


Figure 11: Developed Conditions RORB model

6.3 RESULTS

6.3.1 DEVELOPED CONDITIONS

The developed conditions RORB model has been run for the 1% and 20% AEP storm events at key locations and the results shown in Table 2.

Table 2: Developed Conditions RORB Model Results

Location	1% AEP Flow (m^3/s)	20% AEP Flow (m^3/s)
Future Growth Area RB Inflow	4.0 15-min TP24	2.0 30-min TP5
Future Growth Area RB Outflow	1.0 10-min TP21	1.0 10-min TP1
Site RB Inflow	7.3 25-min TP25	3.7 30-min TP1
Site RB Outflow	0.1 48-hr TP27	0.1 12-hr TP2
Total Site Outflow	0.1	0.1

	48-hr TP27	12-hr TP2

The required storage volume was calculated for the 1% and 20% representative event, with the 1% AEP volume derived from the 24-hour storm with no outfall condition (pump offline) as per clause 18.3 in the Infrastructure Design Manual (2022). The required storage volumes and corresponding peak levels are:

- 20% AEP – 12,000 m^3 (105.6m AHD)
- 1% AEP – 42,000 m^3 (107.0m AHD)

This design criteria is the controlling factor determining the retarding basin volume, and flexibility in this criteria would result in a smaller basin.

7. HYDRAULIC ASSESSMENT

The hydraulic assessment has been conducted inline with the broader strategy to:

- Drain the Pine Street basin via a main drain to the site centralised drainage reserve.
- Drain the site to a centralised drainage reserve with a pumped outfall to Lake Numurkah.

7.1 ESTATE DRAINAGE, ROAD GRADING AND FILL

The key design assumption and outcomes are;

- Lake Numurkah tailwater 106.6m AHD. This was advised by Council as representative of a high water level within the lake. Note that no specific flood frequency is applied to this level.
- 20% AEP flow conveyance in pipes
- 1% AEP flow conveyance in roadways
- 1 in 300 minimum pipe grade
- 1 in 300 minimum road grade

The subject site is low lying, flat topography as described in the existing conditions section of this report. However, given the SWMS has a pumped outlet, the basin level can be dropped to achieve the desired road and pipe grades, whilst negating or minimising the requirement for on-site filling. This is discussed in more detail below.

7.2 PUMP STATION AND OUTFALL TO LAKE NUMURKAH

The key design outcomes are;

- Pump Station controlling discharge from retarding basin, with Rising Main
  - 100 L/s Pump Station with 2m discharge head
  - 375mm Rising Main Outlet to Lake Numurkah (indicative size, subject to detailed design).
- Ancillary flow path through 52 Wattle Drive
  - Spillway from retarding basin to ancillary flow path channel set at RL 107.0.
  - Ancillary flow channel to convey spillway flows to Lake Numurkah. Indicative 1m base width and 1 in 4 batter slopes. The ancillary flow channel has not been designed to cater for a specific flow rate, but rather provide a pathway should the basin fill to above the 1% AEP event.
  - 1 in 300 longitudinal grade
  - Box culverts with an IL of 106.4m will be required to convey ancillary flows under Wattle Drive (road crest RL 108.4m AHD). These have been nominally sized at

1200mm (width) x 450mm (height). Note that underground services exist in Wattle Drive, including gas, water and sewer. Therefore, services proving is required to inform box culvert design.

  - The downstream ancillary flow path channel connecting the proposed Wattle Street box culverts to Lake Numurkah. This will convey flows through an existing Council reserve. The outlet to Lake Numurkah will connect in at IL 106.2m AHD. This IL is below the Lake Numurkah tail water level (106.6m AHD). This would result in water backwatering into the channel and into the culverts under Wattle Drive. The channel level can be adjusted in detailed design to minimise this backwatering.

- An appropriate drainage easement (approximately 10m wide – pending design flow rate and grade of channel) through 52 Wattle Drive will be required to accommodate the rising main and ancillary flow path.

A 100 L/s pumping rate has been selected as this would dewater the retarding basin in 5 days following a 24-hour event. Five days is considered to be an extended duration for the macrophtyes to be inundated – therefore a pump rate less than 100L/s (with a corresponding increase in inundation duration) is considered unacceptable. Given the extended inundation duration, appropriate macrophyte plant species selection is important for plant survival and sustainability.

As an alternative to constructing an outlet rising main to Lake Numurkah, a discharge directly to the upstream end of the ancillary channel through 52 Wattle Drive would be possible. This would avoid a large portion of rising main pipework. However, outlet velocities from the pump station would need to be properly controlled to mitigate channel erosion. This may require rock lining of the channel and may result in a larger easement being required. This can be investigated further at detailed design.

At the time of writing, it is understood that the café located within the 52 Wattle Drive property is proposed to remain. However, should plans change to remove the café as part of the overall development site, an opportunity would exist to design a larger ancillary flow and rising main outlet through the property, which would provide a more aesthetically pleasing outcome, to be integrated into the existing landscaping. This opportunity should be investigated further in the event that the café is removed from the ultimate plans.

7.3 DRAINAGE RESERVE CONCEPT DESIGN

The drainage reserve is proposed as a sediment basin and wetland treatment train, located within the base of a retarding basin, as follows:

The concept sediment basin has been designed as follows (Refer to Section 8 for key design criteria):

- Area = 800m^2
- NWL = 104.5m AHD
- EDD = 104.85m AHD

The concept constructed wetland has been designed as follows (Refer to Section 8 for key design criteria):

- Area = 5,000m^2

- NWL = 104.3m AHD
- EDD = 104.65m AHD
- A high flow bypass pipe has been allowed to protect the macrophte zone from scouring through high velocities. It should be noted that given this wetland is proposed in the base of a pumped outlet retarding basin, sufficient backwater effect may be present to negate high velocities. This should be investigated further at detailed design, and if appropriate, the need for a high flow bypass can be removed.

The concept retarding basin has been designed as follows:

- As outlined in Section 6, the RORB modelling determined the required retarding basin storage volume as:
  - 20% AEP – 12,000 m^3
  - 1% AEP – 42,000 m^3
- 20% AEP Level = 105.6m AHD (green open space/kick-about space set at the 20% AEP level)
- 1% AEP Level = 107.0m AHD
- Spillway Level = 107.0m AHD
- Minimum Road Level set at 107.3m AHD (300mm freeboard to 1% AEP level)
- Minimum Lot Level = 107.6m AHD (300mm freeboard to 1% AEP level), or 300mm above the local gap flow level within the road reserve, whichever is greater. Note this minimum lot level is below the surrounding estate lot levels and flow from surrounding catchments should be assessed to ensure that it does not enter the site.
- As advised by Moira Shire council, the basin was designed to have the green open space above 20% AEP. The green open space includes a 'kick-about space' and the batter slopes up to the road level (at the preferred 1 in 6 batter). The kick-about space has a flat grade and can be designed as a sporting area or playground in subsequent design phases.

The retarding basin spillway is located at the south of the drainage reserve adjacent to the outlet pump station. Once the retarding basin reaches the 1% AEP level, flows will overtop the spillway and enter the ancillary flow path channel to Lake Numurkah.

The retarding basin height-volume relationship is presented in Table 3, with a concept wetland/retarding basin cross section shown in Figure 12.

Table 3: Retarding Basin Height-Volume Relationship

Height (m)	Volume (m3)
104.5	0
105	5166
105.5	11033

106	20086
106.5	30652
107	42280

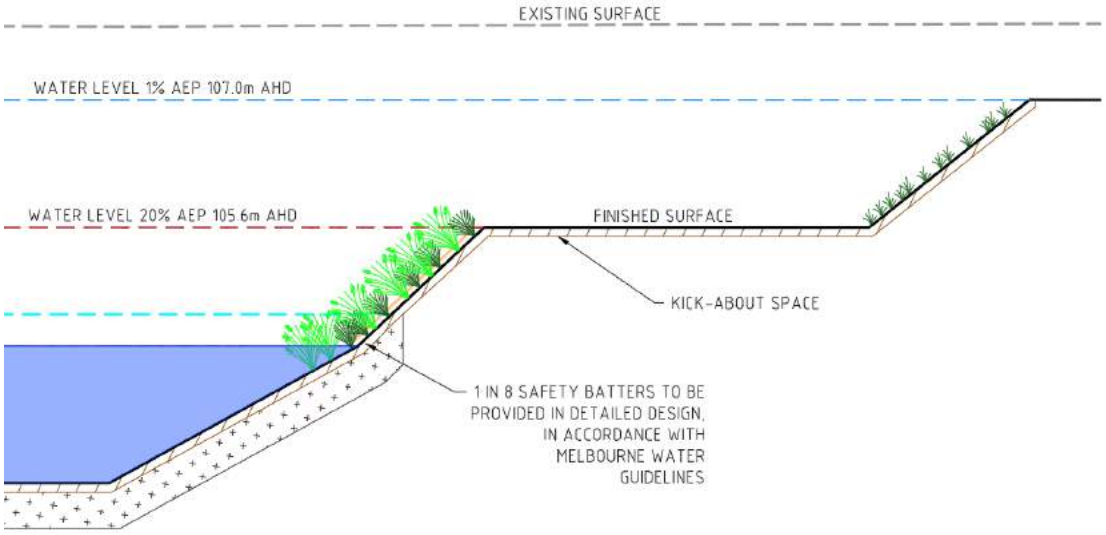


Figure 12: Drainage Reserve Detailed Section

8. WATER QUALITY TREATMENT

WSUD is an approach to integrating the urban water cycle into urban planning and design and mitigating the impacts of urbanisation on waterways. Key principles of WSUD as outlined by Victorian Stormwater Committee (1999) in the Best Practice Environmental Management Guidelines (BPEMG) are to:

- Protect and enhance natural water systems within urban environments.
- Integrate stormwater treatment into the landscape, maximising the visual and recreational amenity of developments.
- Improve the quality of water draining from urban developments into receiving environments.
- Reduce runoff and peak flows from urban developments by increasing local detention times and minimising impervious areas; and
- Minimise drainage infrastructure costs of development due to reduced runoff and peak flows.

8.1 WATER QUALITY OBJECTIVES

Guidelines for urban stormwater quality management in Victoria are contained in Urban Stormwater Best Practice Environmental Management Guidelines (BPEMG). These guidelines are included in all municipal planning schemes as State Policy. The guidelines seek to minimise the detrimental effects of urbanisation on receiving waterways. Table 4 lists the water quality objectives.

Table 4: Best Practice Stormwater Management Objectives

Pollutant	Water Quality Objectives
Total Suspended Solids (TSS)	80% retention of the typical urban load
Total Phosphorus (TP)	45% retention of the typical urban load
Total Nitrogen (TN)	45% retention of the typical urban load
Litter[1]/Gross Pollutants (GP)	70% retention of the typical urban load

Note 1 – Litter is defined as anthropogenic material larger than five millimetres (Source: Victorian Stormwater Committee, 1999)

Model for Urban Stormwater Improvement Conceptualisation v6.2.1 (MUSIC) has been used to determine the indicative size of treatment infrastructure required to ensure the stormwater runoff from the proposed development is treated to the appropriate standard defined in BPEMG targets.

The closest rainfall station to the site is Cobram. Therefore, Cobram rainfall data for the reference period from 1957-2010 (53 years) with a 6-minute time step has been input into MUSIC, with other parameters adopted in accordance with Melbourne Water MUSIC Guidelines (Melbourne Water, 2018). The average annual rainfall using this template is 422mm.

8.2 WSUD CONCEPT DESIGN

The proposed water quality treatment strategy is to provide a centralised drainage reserve, with a sediment basin and wetland. The sediment basin is designed to remove suspended solids, while the wetland is designed to remove nitrogen and phosphorus. The treatment train was modelled in MUSIC as shown in Figure 13. Proposed sediment basin and wetland treatment sizes are presented in Table 5 and Table 6.

Flows greater than the 4EY event are designed to bypass around the sediment basin and wetland. Bypass pipework will convey flows to the pump station outlet and other surcharge pits which will surcharge flows into the wetland at strategic locations to minimise the impact of high flows on the wetland macrophyte plant species. We recommend that the high flow bypass should be reviewed in detailed design to assess how the velocities through the wetland can be managed.

The concept is designed to have a baffle pit and sidewinding penstock which controls the outlet flow rate from the wetland. This sidewinding penstock should be adjusted to achieve the desired 72-hour residence time in the wetland. To achieve the 72-hour residence time, the opening size of the penstock may be too small and pose a blockage risk. A compromise might need to be struck between residence time and opening size of the outlet. This can be assessed at the detailed design stage.

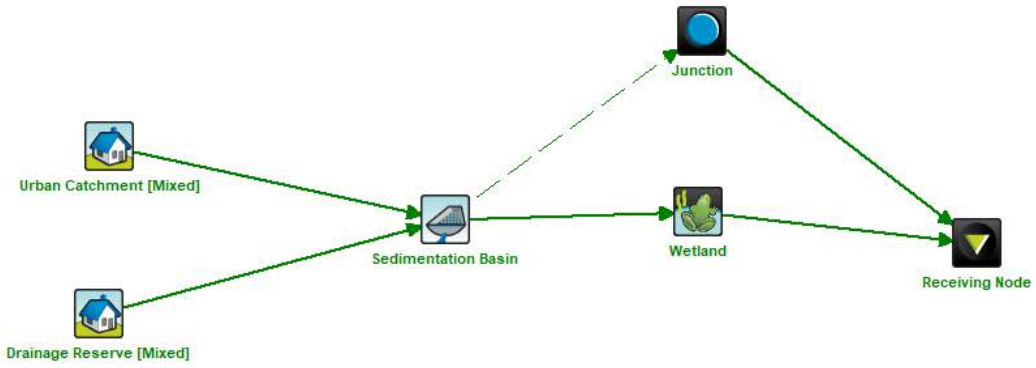


Figure 13: MUSIC model configuration

Table 5: Sediment Basin Specifications

Catchment Area (ha)	Treatment Area (m^2)	Minimum Width (m)	Length (m)	Extended Detention Depth (m)	Permanent Pool Volume (m^3)	Dry-Out Area (m^2)	Clean Out Frequency
26.5	800	20	40	0.35	551	488	5 years

Table 6: Wetland Specifications

Catchment Area (ha)	Treatment Area (m^2)	Minimum Width (m)	Length (m)	Extended Detention Depth (m)
26.5	5,000	43	140	0.35

The maximum velocities in the wetland and sediment basin have been checked against Melbourne Water design guidelines as shown in Table 7 and are deemed to comply.

Table 7: Velocity Checks

Asset	4EY Flow (m^3/s)	Actual Width (m)	EDD (m)	Velocity (m/s)	Velocity Threshold (m^2/s)	Check
Sediment Basin	0.76	20	0.35	0.1	0.5	Okay
Wetland	0.76	43	0.35	0.05	0.05	Okay

It is recognised that due to small catchment areas, there is risk of wetlands drying out, particularly during the summer months. Therefore, appropriate macrophyte plant species selection will be critical, to ensure the planting is sustainable in both periods of dry and extended inundation (refer Section 7.2). It is also imperative to ensure species are surviving during establishment and irrigation may be required to accommodate this. A spells analysis should be completed in subsequent design phases to ensure appropriate water levels in the wetland and inform plant selection.

8.3 RESULTS

The results at the 'Receiving Node' of the MUSIC model are shown in Table 8. The 'Receiving Node' corresponds to the pump station outlet to Lake Numurkah.

Table 8: MUSIC Treatment Train Performance Results

	Sources (kg/yr)	Residual Load (kg/yr)	% Reduction
Total Suspended Solids	13,100	2,510	80.9
Total Phosphorus	27.1	8.24	69.6
Total Nitrogen	189	100	47.1
Gross Pollutants	2,610	128	95.1

The results show that the proposed layout will meet BPEMG water quality objectives. The Melbourne Water Auditor tool was applied and shows in Figure 14 that the effective water level (50% of time exceeded) is within 50mm of normal water level and is therefore deemed to comply, with 72-hour residence time has been achieved.

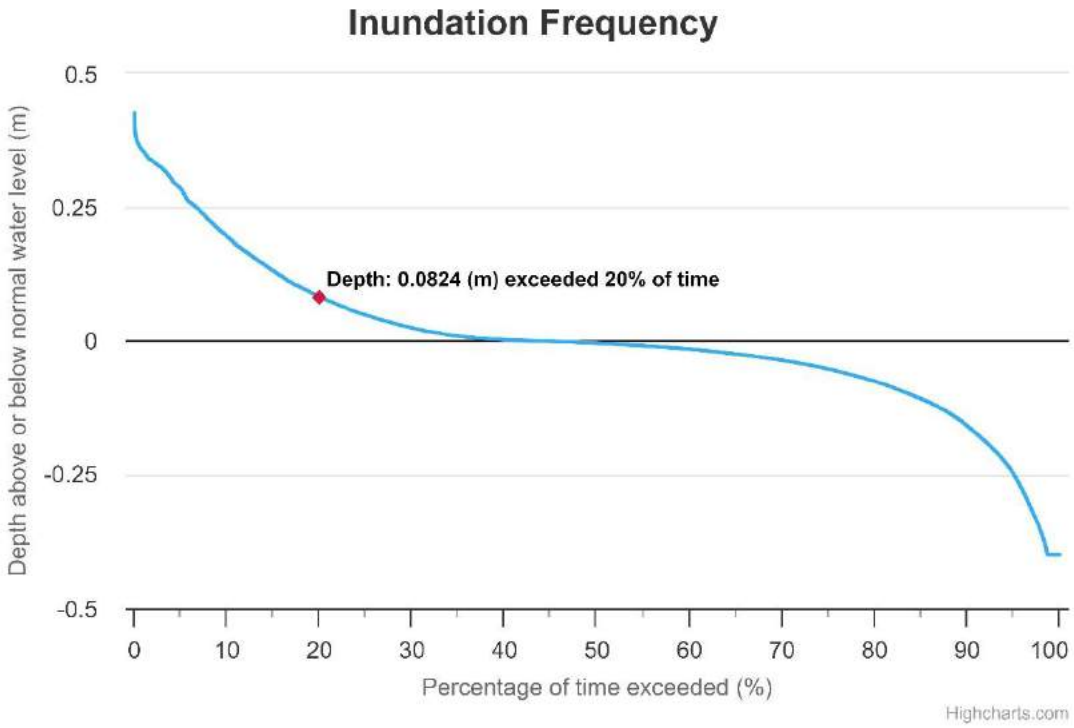


Figure 14: Melbourne Water Wetland Inundation Frequency

9. PERMIT 1 DEVELOPMENT

The permit 1 development is likely to occur prior to the permit 2 and 3 development. Therefore, a staged stormwater management approach is proposed to allow early development of this parcel. The Permit 1 SWMS concept is shown in Figure 15 and Appendix A. The key features of the Permit 1 SWMS are:

- Bulk earthworks of the ultimate retarding basin, down to Normal Water Level (NWL) of 104.3m AHD. This will provide temporary sedimentation. No requirement for clay liner or planting until the ultimate basin is constructed.
- Retarding basin to be excavated in-line with the ultimate design to provide the ultimate retardation volume. However, there will be opportunity for the Permit 1 SWMS to refine (reduce) the retardation volume to satisfy Permit 1 only, thus reducing the Permit 1 temporary basin size. This can be considered as part of the detailed design phase, to the satisfaction of Council.
- Ultimate 20% AEP main drain which discharges to a temporary open channel which conveys flows to the temporary basin.
- Ultimate pump station, rising main and outlet configuration to Lake Numurkah.
- Ultimate ancillary flow channel through the property at 52 Wattle Drive, proposed culverts under Wattle Drive and ancillary flow channel on south side of Wattle Drive.

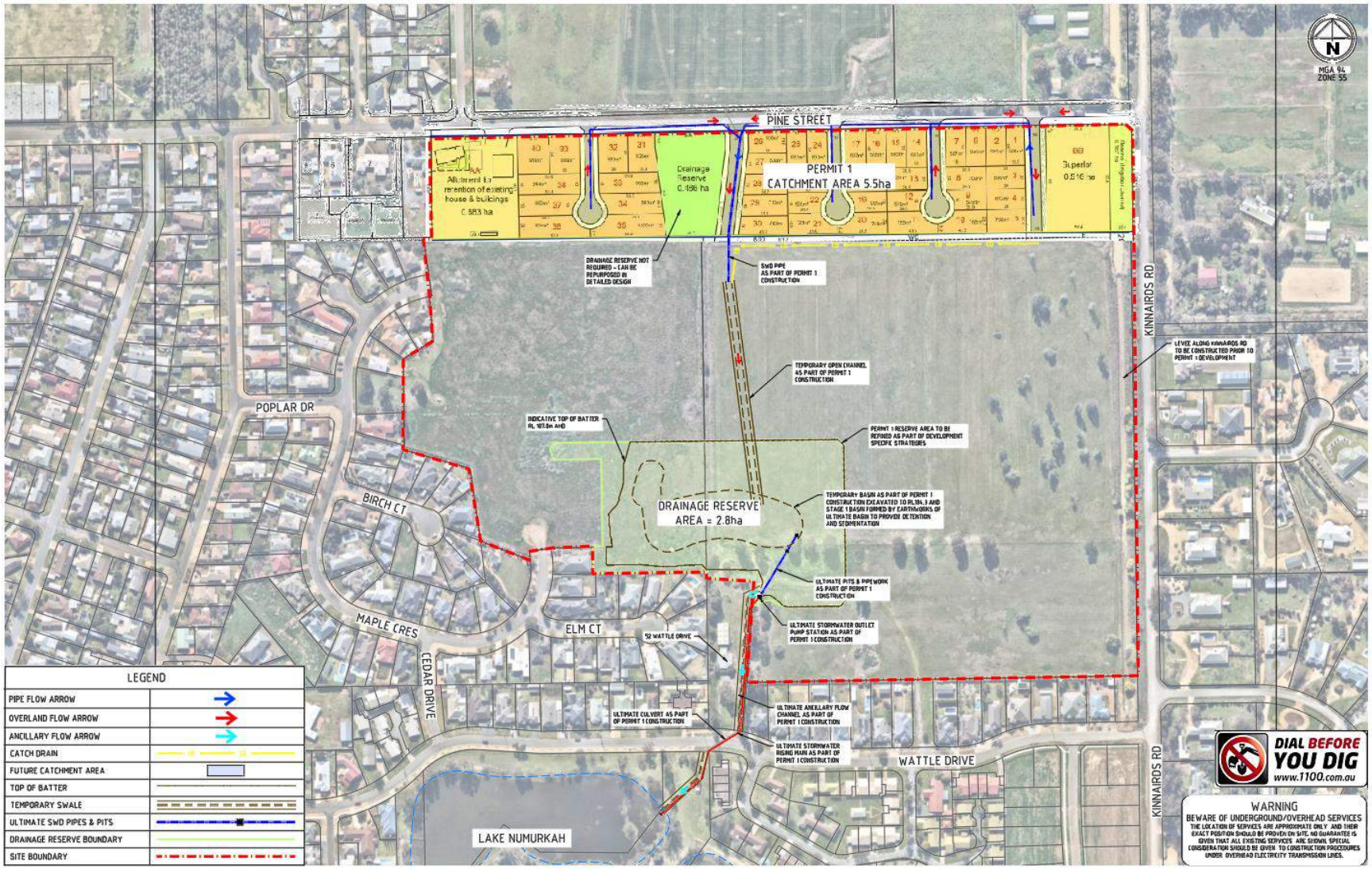


Figure 15: Permit 1 SWMS concept design

10. SUMMARY AND RECOMMENDATIONS

A SWMS has been prepared for the proposed development north of Wattle Drive, Numurkah. In summary:

- Internal pipes convey the 20% AEP flows, with flows up to the 1% AEP conveyed in the roadway.
- 1050mm main drain from future growth area basin to drainage reserve.
- The ultimate design has one centralised drainage reserve, containing:
  - Sediment Basin = 800 m^2
  - Wetland = 5,000 m^2
  - Retarding Basin = 42,200 m^3
- A 100 L/s outlet pump station is required to discharge water to Lake Numurkah.
- Ancillary flow path from basin to Lake Numurkah, in the form of a channel.
- Box culverts under Wattle Drive indicatively sized as 1200mm x 450mm.
- Open space within basin above the 20% AEP level (105.6m AHD).
- 1% AEP level in the basin at 107.0m AHD.
- Retarding Basin in future growth area to retard flows to 1% AEP existing conditions flow (1,000 L/s).

The SWMS identifies the following recommendations for further works during the detailed design phase:

- It is essential that the future levee (understood to be planned for construction by Council) is constructed along Kinnairds Road and northern bank of Broken Creek to provide appropriate flood mitigation for the site. This is critical for the site given it sits within the existing 1% AEP floodplain.
- Finished surface of estate should interface to existing surface level of surrounding lots/roads.
- Size temporary sediment basin and retarding basin for Permit 1, to the satisfaction of Council.
- Ensure appropriate macrophyte plant selection which can withstand dry periods and consider irrigation requirements during establishment phase. The macrophyte plants should also be of suitable species to tolerate durations of extended duration when the retarding basin is engaged.
- Undertake services proving of Wattle Drive to inform design of proposed culverts, required to facilitate an ancillary flow path from the basin to Lake Numurkah.

- The future growth area north of Pine Street is assumed to retard flows to the existing 1% AEP peak flow rate. There is an opportunity to refine this basin outflow in detailed design.
- Regrading of Pine St is required to create low point for emergency overflow for the basin in the future growth area.
- No CHMP, biodiversity assessment, geotechnical nor groundwater investigations have been conducted onsite and therefore has not been considered in the design. These assessments should be undertaken to confirm the proposed stormwater management solution is viable.
- It is understood that the Irrigation Channel No 6/6 will be piped and located in a future easement, under future works. It must be ensured that these future works and designed to provide flood immunity to the future development area, including backwater/surcharge from Broken Creek.
- The design solution uses the property at 52 Wattle Drive as a drainage easement for the rising main and ancillary flow path. This is subject to detailed design.
- The proposed channel that runs from 52 Wattle Drive to Lake Numurkah with proposed box culvert under Wattle Drive has been conceptually designed to convey ancillary flows. Detailed design must consider interface with existing assets, potential service clashes, level constraints and the outfall design to Lake Numurkah.
- During detailed design the outlet location of the rising main can be investigated further. There is an alternative option is to discharge directly into the ancillary channel through 52 Wattle Drive instead of constructing the rising main to Lake Numurkah.

11. REFERENCES

- Wattle Drive Numurkah, VIC 3630 - *Site Plan*.
- EarthTech. (2006, August). *Development Plan*, Numurkah, Moira Shire Council.
- EPA Victoria. (2021). *Urban Stormwater Management Guidance.*
- Local Government Infrastructure Design Association . (2020). *Infrastructure Design Manual.*
- Melbourne Water. (2018). *MUSIC Modelling Guidelines*.
- Melbourne Water. (2020). *Wetland Design Manual.*
- Sinclair Knight Merz. (1998, July). *Urban Drainage Strategy, Township of Numurkah*.
- Spiire. (2022, March 2). *Lake Numurkah Analysis and Opportunities - Community Consultation.*
- Spiire. (2023, September). *Numurkah Stormwater Management Strategy*
- Stormy Water Solutions. (2020). *Drainage Analysis Numurkah.*
- Water Technology. (2017). *Numurkah Floodplain Management Study and Plan - Study Report.*

APPENDIX A

STRATEGY PLANS



LEGEND	
PROPERTY BOUNDARY	
OVERLAND FLOW ARROW	
SUBJECT SITE	
FUTURE GROWTH AREA	
EXISTING SWALE	
CATCHMENT BOUNDARY	
EXISTING STORMWATER CULVERT	

DIAL BEFORE YOU DIG www.1100.com.au

WARNING

BEWARE OF UNDERGROUND/OVERHEAD SERVICES

THE LOCATION OF SERVICES ARE APPROXIMATE ONLY AND THEIR EXACT POSITION SHOULD BE PROVEN ON SITE. NO GUARANTEE IS GIVEN THAT ALL EXISTING SERVICES ARE SHOWN. SPECIAL CONSIDERATION SHOULD BE GIVEN TO CONSTRUCTION PROCEDURES UNDER OVERHEAD ELECTRICITY TRANSMISSION LINES.

Rev	Amendments	Approved	Date
B	ISSUED TO CLIENT	AB	13/05/24
A	ISSUED TO CLIENT	AB	24/04/24

Scale
H 1:2500
SCALE @ A1
0 25 50 75 100 125

dtcs ISO 9001 certified ISO 45001 certified ISO 14001 certified
System Certified

© Spiire Australia Pty Ltd All Rights Reserved
This document is produced by Spiire Australia Pty Ltd solely for the benefit of and use by the client in accordance with the terms of the retainer. Spiire Australia Pty Ltd does not and shall not assume any responsibility or liability whatsoever to any third party arising out of any use or reliance by third party on the content of this document.

spiire
10 MOORABOOL STREET GEELONG
VICTORIA 3220 AUSTRALIA T 61 3 5249 6888
spiire.com.au ABN 55 050 029 635

moira SHIRE

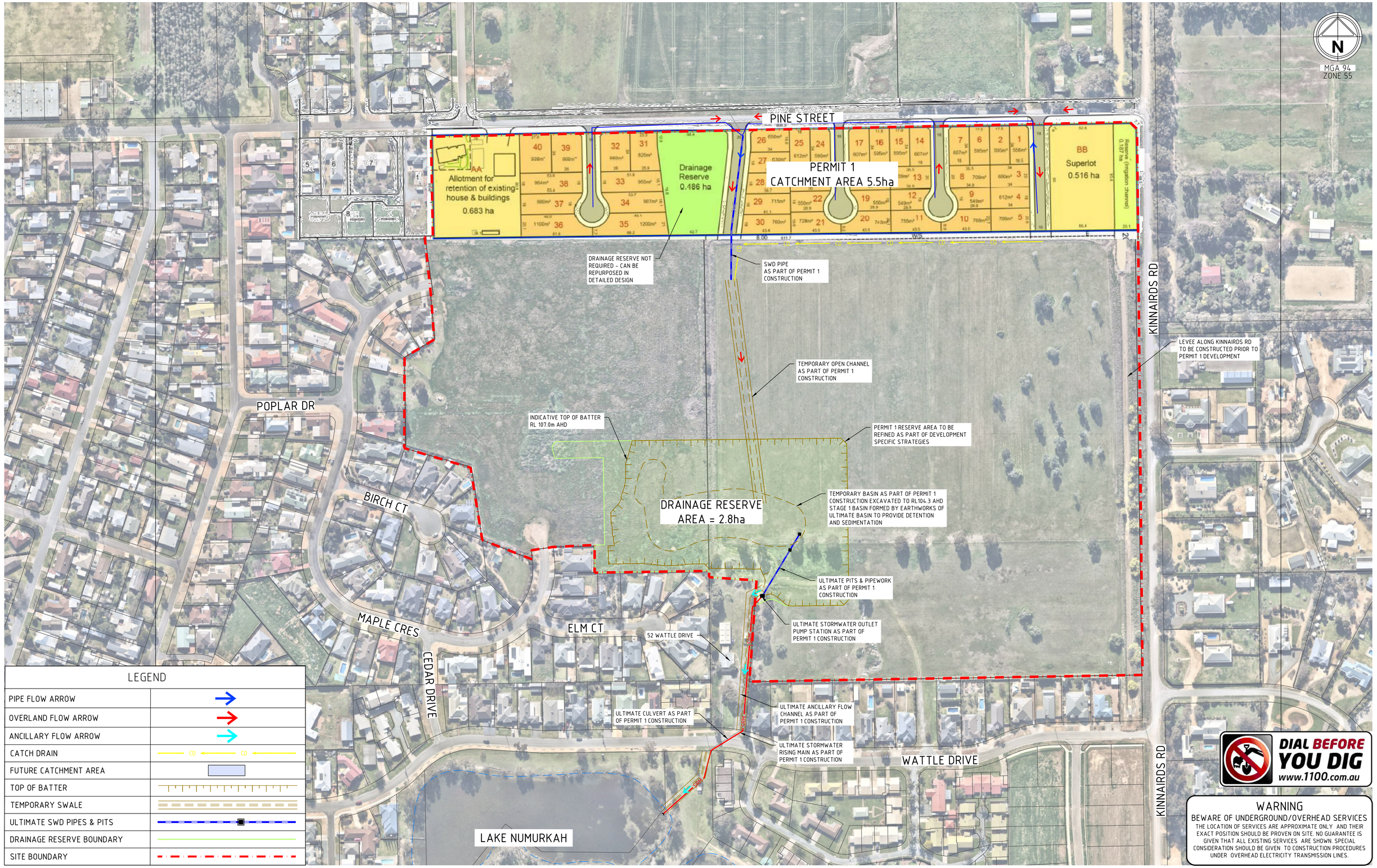
Designed M. DODGSHUN
Checked A. DAVIDSON
Authorised A. BROWN
Date 13/05/24

NUMURKAH DRAINAGE STRATEGY
PINE STREET TO WATTLE DRIVE
CONCEPT DESIGN
LAYOUTS & CATCHMENT PLANS - EXISTING CONDITIONS

MOIRA SHIRE COUNCIL

PRELIMINARY Drg No 310429WC200 Rev B

file name 310429WC200.dwg layout name WC200 plotted by Mark Dodgshun
file location G:\31\310429\Water\CAD plot date 10/05/2024 9:05 AM Sheet 2 of 8 Sheets



LEGEND

PIPE FLOW ARROW	
OVERLAND FLOW ARROW	
ANCILLARY FLOW ARROW	
CATCH DRAIN	CD
FUTURE CATCHMENT AREA	
TOP OF BATTER	
TEMPORARY SWALE	
ULTIMATE SWD PIPES & PITS	
DRAINAGE RESERVE BOUNDARY	
SITE BOUNDARY	

Rev	Amendments	Approved	Date
B	ISSUED TO CLIENT	AB	13/05/24
A	ISSUED TO CLIENT	AB	24/04/24

Scale
H 1:1500 0 15 30 45 60 75
SCALE @ A1

dtcs ISO 9001 certified ISO 45001 certified ISO 14001 certified
System Certified

© Spiire Australia Pty Ltd All Rights Reserved
This document is produced by Spiire Australia Pty Ltd solely for the benefit of and use by the client in accordance with the terms of the retainer. Spiire Australia Pty Ltd does not and shall not assume any responsibility or liability whatsoever to any third party arising out of any use or reliance by third party on the content of this document.

spiire
10 MOORABOOL STREET GEELONG
VICTORIA 3220 AUSTRALIA T 61 3 5249 6888
spiire.com.au ABN 55 050 029 635

moira SHIRE

Designed	Checked
M. DODGSHUN	A. DAVIDSON
Authorised	Date
A. BROWN	13/05/24

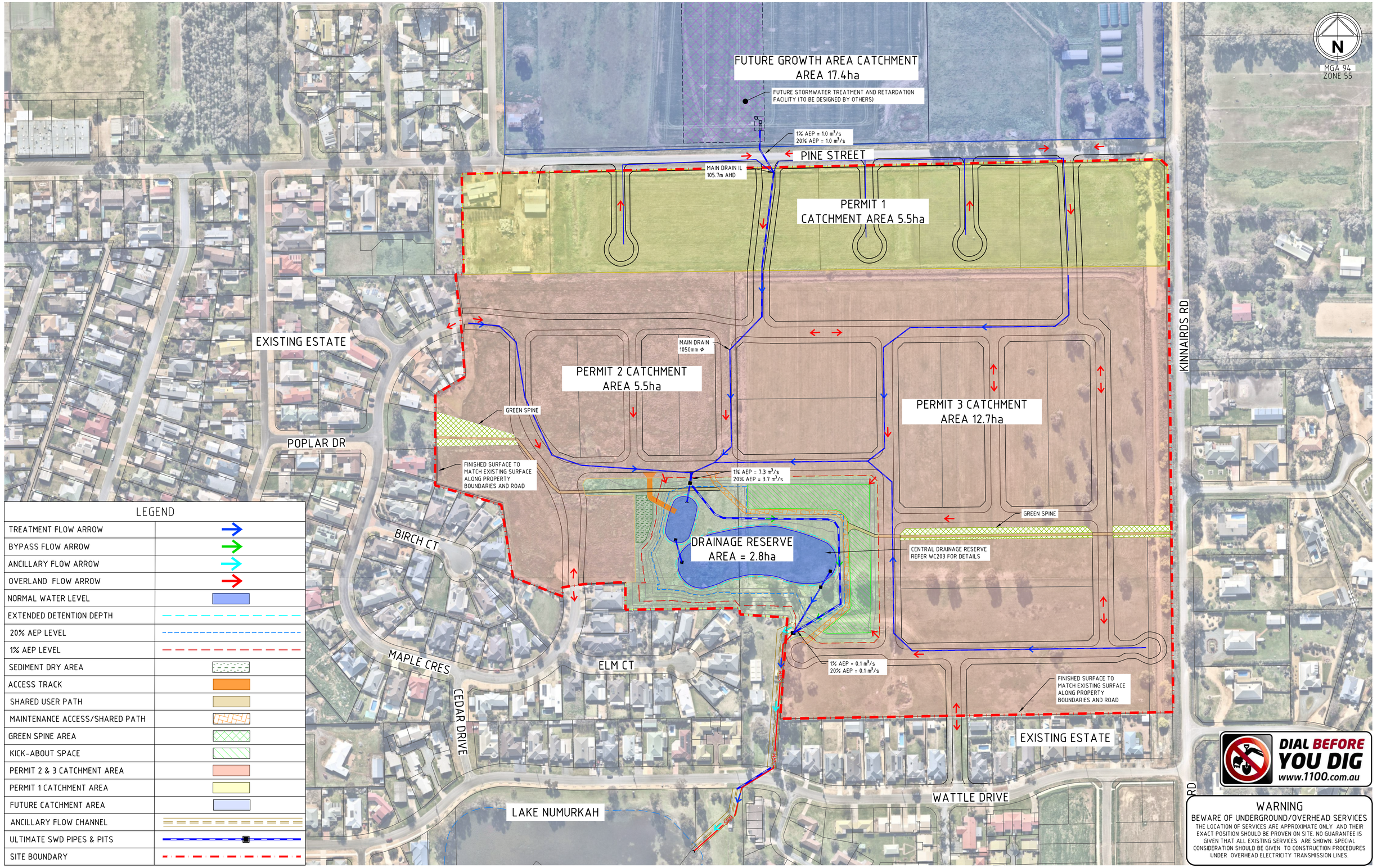
NUMURKAH DRAINAGE STRATEGY
PINE STREET TO WATTLE DRIVE
CONCEPT DESIGN
LAYOUTS & CATCHMENT PLANS - PERMIT 1 INTERIM

MOIRA SHIRE COUNCIL

PRELIMINARY

Drg No 310429WC201 Rev B

file name:310429WC200.dwg Layout name:WC201 plotted by:Mark Dodgshun
file location:G:\311\310429\Water\CAD plot date:10/05/2024 10:31 AM Sheet 3 of 8 Sheets



LEGEND	
TREATMENT FLOW ARROW	
BYPASS FLOW ARROW	
ANCILLARY FLOW ARROW	
OVERLAND FLOW ARROW	
NORMAL WATER LEVEL	
EXTENDED DETENTION DEPTH	
20% AEP LEVEL	
1% AEP LEVEL	
SEDIMENT DRY AREA	
ACCESS TRACK	
SHARED USER PATH	
MAINTENANCE ACCESS/SHARED PATH	
GREEN SPINE AREA	
KICK-ABOUT SPACE	
PERMIT 2 & 3 CATCHMENT AREA	
PERMIT 1 CATCHMENT AREA	
FUTURE CATCHMENT AREA	
ANCILLARY FLOW CHANNEL	
ULTIMATE SWD PIPES & PITS	
SITE BOUNDARY	

DIAL BEFORE YOU DIG www.1100.com.au

WARNING

BEWARE OF UNDERGROUND/OVERHEAD SERVICES

THE LOCATION OF SERVICES ARE APPROXIMATE ONLY AND THEIR EXACT POSITION SHOULD BE PROVEN ON SITE. NO GUARANTEE IS GIVEN THAT ALL EXISTING SERVICES ARE SHOWN. SPECIAL CONSIDERATION SHOULD BE GIVEN TO CONSTRUCTION PROCEDURES UNDER OVERHEAD ELECTRICITY TRANSMISSION LINES.

Rev	Amendments	Approved	Date
B	ISSUED TO CLIENT	AB	13/05/24
A	ISSUED TO CLIENT	AB	24/04/24

Scale: H 1:1500 (0 15 30 45 60 75) SCALE @ A1

dlca ISO 9001 certified ISO 45001 certified ISO 14001 certified
System Certified

© Spiire Australia Pty Ltd All Rights Reserved
This document is produced by Spiire Australia Pty Ltd solely for the benefit of and use by the client in accordance with the terms of the retainer. Spiire Australia Pty Ltd does not and shall not assume any responsibility or liability whatsoever to any third party arising out of any use or reliance by third party on the content of this document.

spiire
10 MOORABOOL STREET GEELONG
VICTORIA 3220 AUSTRALIA T 61 3 5249 6888
spiire.com.au ABN 55 050 029 635

moira SHIRE

Designed: M. DODGSHUN
Checked: A. DAVIDSON
Authorised: A. BROWN
Date: 13/05/24

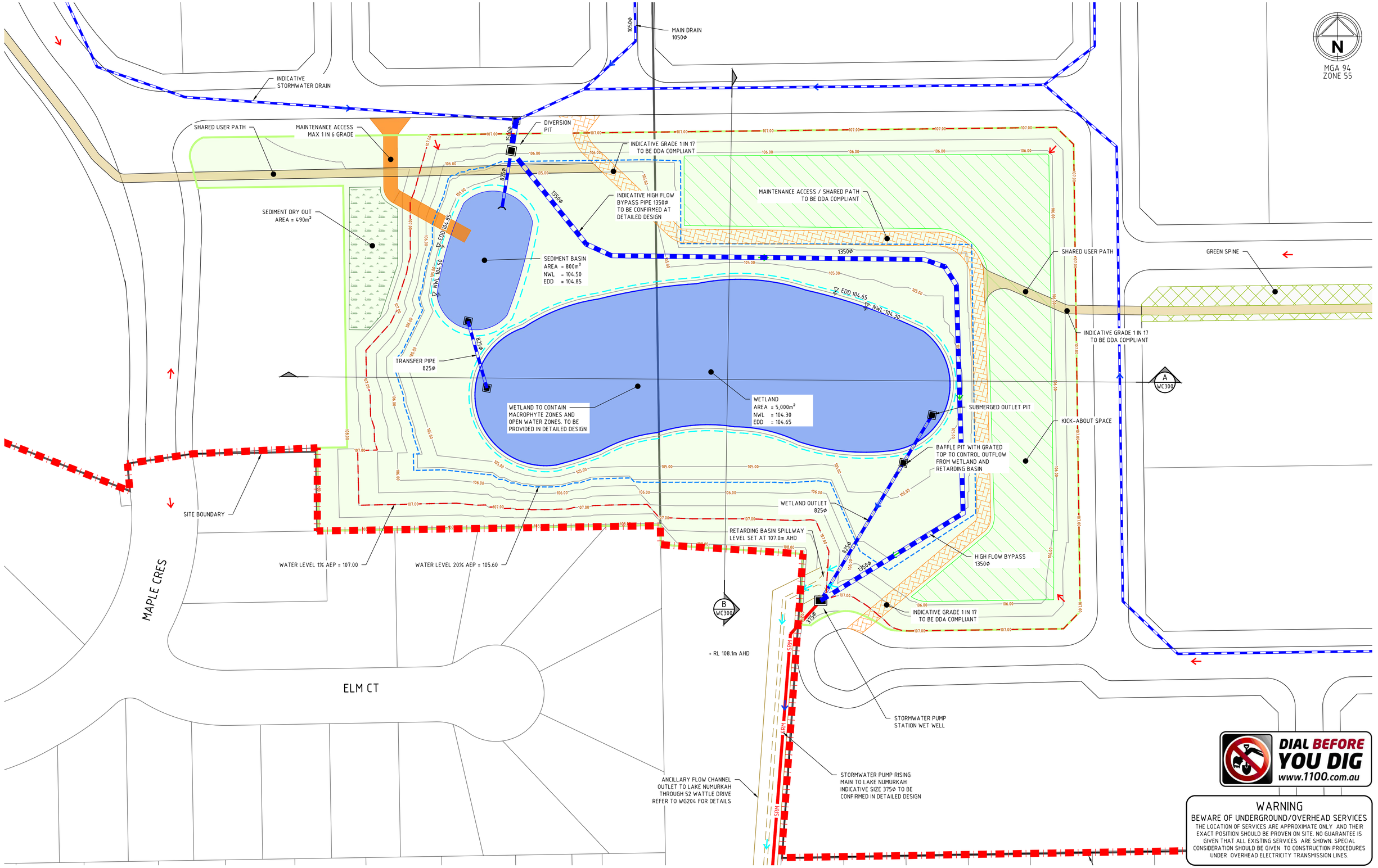
NUMURKAH DRAINAGE STRATEGY
PINE STREET TO WATTLE DRIVE
CONCEPT DESIGN
LAYOUTS & CATCHMENT PLANS - ULTIMATE

MOIRA SHIRE COUNCIL

PRELIMINARY

Drg No: 310429WC202
Rev: B

file name:310429WC200.dwg layout name:WC202 plotted by:Mark.Dodgshun
file location:G:\31\31042\9\Waters\ACAD\ plot date:10/05/2024 9:06 AM Sheet 4 of 8 Sheets



DIAL BEFORE YOU DIG
www.1100.com.au

WARNING

BEWARE OF UNDERGROUND/OVERHEAD SERVICES
THE LOCATION OF SERVICES ARE APPROXIMATE ONLY AND THEIR EXACT POSITION SHOULD BE PROVEN ON SITE. NO GUARANTEE IS GIVEN THAT ALL EXISTING SERVICES ARE SHOWN. SPECIAL CONSIDERATION SHOULD BE GIVEN TO CONSTRUCTION PROCEDURES UNDER OVERHEAD ELECTRICITY TRANSMISSION LINES.

Rev	Amendments	Approved	Date
B	ISSUED TO CLIENT	AB	13/05/24
A	ISSUED TO CLIENT	AB	24/04/24

Scale
H 1:500
SCALE @ A1
0 5 10 15 20 25

dlcs ISO 9001 certified ISO 45001 certified ISO 14001 certified
System Certified

© Spiire Australia Pty Ltd All Rights Reserved
This document is produced by Spiire Australia Pty Ltd solely for the benefit of and use by the client in accordance with the terms of the retainer. Spiire Australia Pty Ltd does not and shall not assume any responsibility or liability whatsoever to any third party arising out of any use or reliance by third party on the content of this document.

spiire
10 MOORABOOL STREET GEELONG
VICTORIA 3220 AUSTRALIA T 61 3 5249 6888
spiire.com.au ABN 55 050 029 635

moira SHIRE

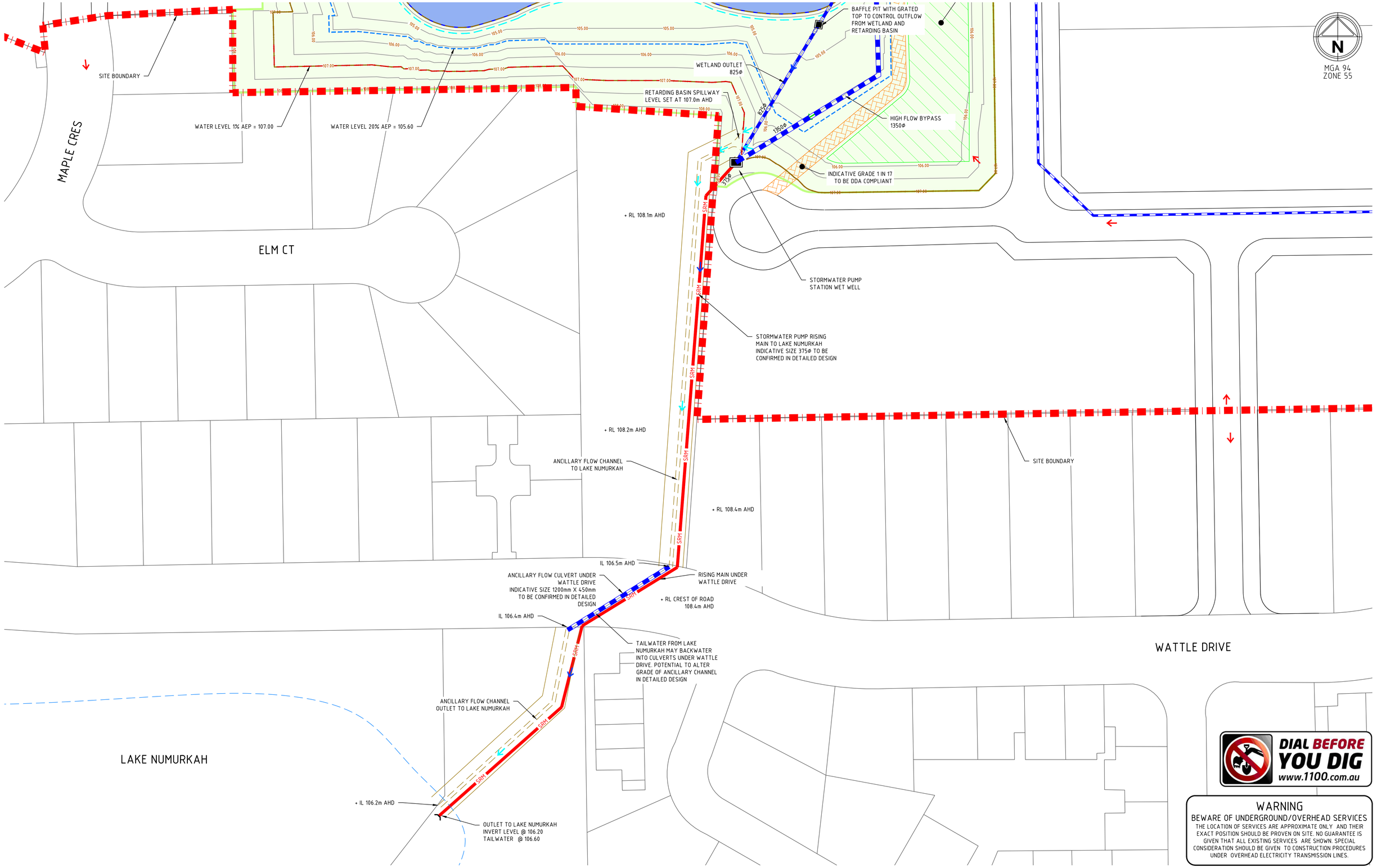
Designed	Checked
M. DODGSHUN	A. DAVIDSON
Authorised	Date
A. BROWN	13/05/24

NUMURKAH DRAINAGE STRATEGY
PINE STREET TO WATTLE DRIVE
CONCEPT DESIGN
LAYOUTS & CATCHMENT PLANS - DRAINAGE RESERVE

MOIRA SHIRE COUNCIL

PRELIMINARY Drg No 310429WC203 Rev B

file name 310429WC200.dwg layout name WC203 plotted by Mark Dodgshun
file location G:\310429\Water\CAD plot date 10/05/2024 9:06 AM Sheet 5 of 8 Sheets



DIAL BEFORE YOU DIG www.1100.com.au

WARNING

BEWARE OF UNDERGROUND/OVERHEAD SERVICES

THE LOCATION OF SERVICES ARE APPROXIMATE ONLY AND THEIR EXACT POSITION SHOULD BE PROVEN ON SITE. NO GUARANTEE IS GIVEN THAT ALL EXISTING SERVICES ARE SHOWN. SPECIAL CONSIDERATION SHOULD BE GIVEN TO CONSTRUCTION PROCEDURES UNDER OVERHEAD ELECTRICITY TRANSMISSION LINES.

Rev	Amendments	Approved	Date
B	ISSUED TO CLIENT	AB	13/05/24
A	ISSUED TO CLIENT	AB	24/04/24

Scale

H 1:500
SCALE @ A1
0 5 10 15 20 25

System Certified

© Spiire Australia Pty Ltd All Rights Reserved
This document is produced by Spiire Australia Pty Ltd solely for the benefit of and use by the client in accordance with the terms of the retainer. Spiire Australia Pty Ltd does not and shall not assume any responsibility or liability whatsoever to any third party arising out of any use or reliance by third party on the content of this document.

spiire
10 MOORABOOL STREET GEELONG
VICTORIA 3220 AUSTRALIA T 61 3 5249 6888
spiire.com.au ABN 55 050 029 635

moira SHIRE

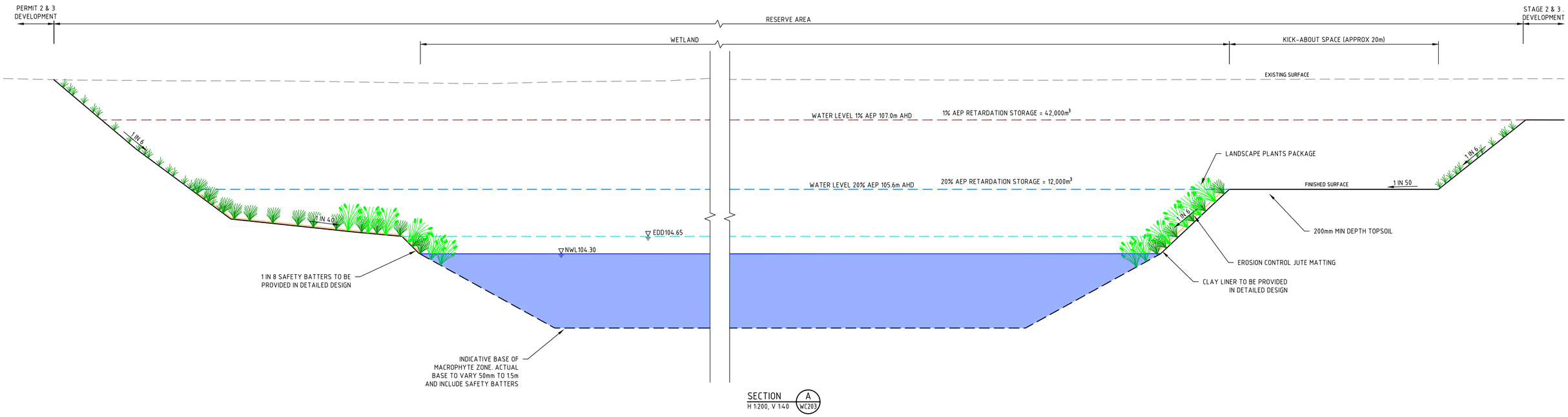
Designed M. DODGSHUN
Checked A. DAVIDSON
Authorised A. BROWN
Date 13/05/24

NUMURKAH DRAINAGE STRATEGY
PINE STREET TO WATTLE DRIVE
CONCEPT DESIGN
LAYOUTS & CATCHMENT PLANS - DRAINAGE OUTLET

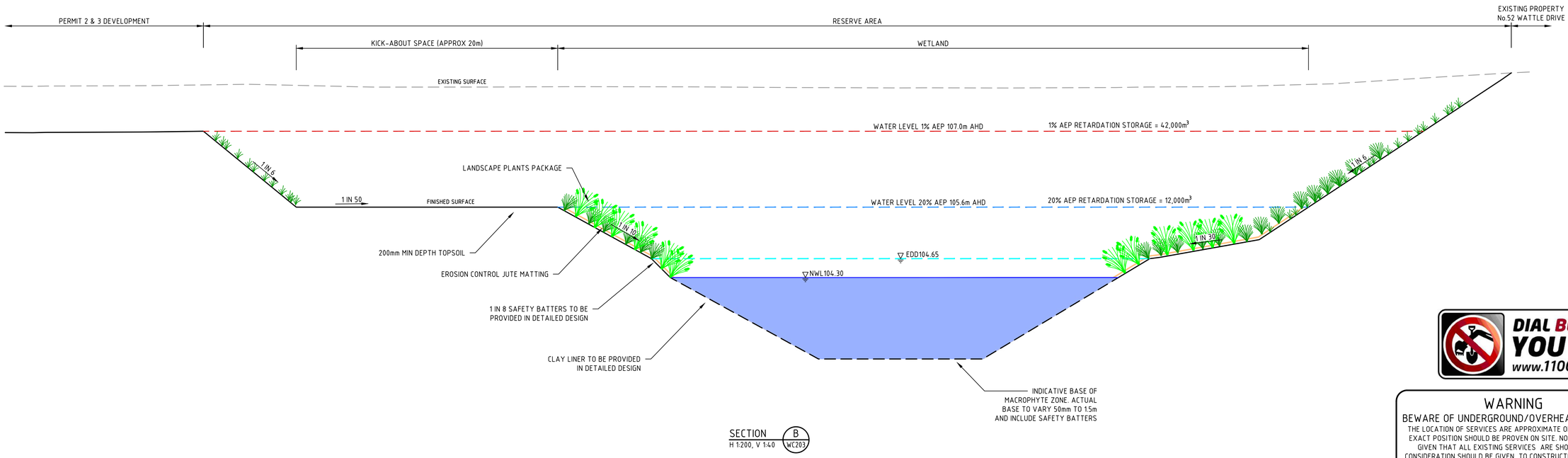
MOIRA SHIRE COUNCIL

PRELIMINARY Drg No 310429WC204 Rev B

file name 310429WC200.dwg layout name WC204 plotted by Mark Dodgshun
file location G:\31\310429\Water\CAD plot date 10/05/2024 9:06 AM Sheet 6 of 8 Sheets



SECTION A
H 1:200, V 1:40 WC203



SECTION B
H 1:200, V 1:40 WC203

DIAL BEFORE YOU DIG www.1100.com.au

WARNING
BEWARE OF UNDERGROUND/OVERHEAD SERVICES
THE LOCATION OF SERVICES ARE APPROXIMATE ONLY AND THEIR EXACT POSITION SHOULD BE PROVEN ON SITE. NO GUARANTEE IS GIVEN THAT ALL EXISTING SERVICES ARE SHOWN. SPECIAL CONSIDERATION SHOULD BE GIVEN TO CONSTRUCTION PROCEDURES UNDER OVERHEAD ELECTRICITY TRANSMISSION LINES.

Rev	Amendments	Approved	Date
B	ISSUED TO CLIENT	AB	13/05/24
A	ISSUED TO CLIENT	AB	24/04/24

Scale
H 1:200 SCALE @ A1 V 1:40
0 2 4 6 8 10
0 0.4 0.8 1.2 1.6 2.0

dlca ISO 9001 certified ISO 45001 certified ISO 14001 certified
System Certified

© Spiire Australia Pty Ltd All Rights Reserved
This document is produced by Spiire Australia Pty Ltd solely for the benefit of and use by the client in accordance with the terms of the retainer. Spiire Australia Pty Ltd does not and shall not assume any responsibility or liability whatsoever to any third party arising out of any use or reliance by third party on the content of this document.

spiire
10 MOORABOOL STREET GEELONG
VICTORIA 3220 AUSTRALIA T 61 3 5249 6888
spiire.com.au ABN 55 050 029 635

moira SHIRE

Designed	Checked
M. DODGSHUN	A. DAVIDSON
Authorised	Date
A. BROWN	13/05/24

NUMURKAH DRAINAGE STRATEGY
PINE STREET TO WATTLE DRIVE
CONCEPT DESIGN
TYPICAL SECTIONS & DETAILS - SHEET 1

MOIRA SHIRE COUNCIL

DRAFT | Drg No 310429WC300 | Rev B

file name 310429WC300.dwg Layout name WC300 plotted by Mark Dodgshun
file location G:\310\429\Water\LA\CAD\ plot date 10/05/2024 10:12 AM Sheet 7 of 8 Sheets

APPENDIX B

HYDROLOGICAL MODELLING REPORT

1. INTRODUCTION

As a part of Numurkah Stormwater Management Strategy, a hydrologic analysis has been completed to inform the strategy. Figure 1 below shows the site context, with the subject site located to the north of Wattle Drive and south of Pine Street. There is also a future growth area north of Pine Street which is considered to be developed in the developed conditions model.

RORB modelling has been undertaken in order to:

- Assess existing and developed conditions flows in the 1% and 20% AEP events
- Determine the required retarding basin storage capacities in the 1% and 20% AEP events

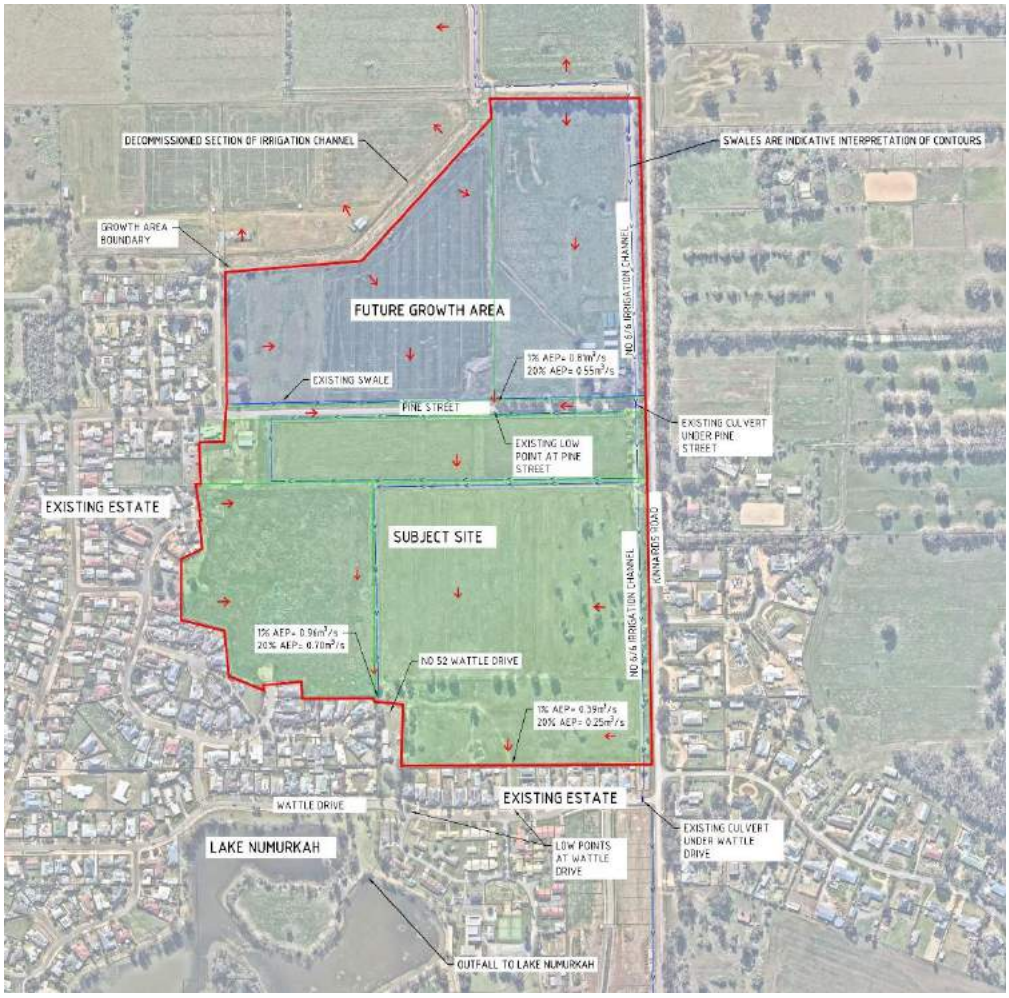


Figure 1: Site Context

2. HYDROLOGY

2.1 MODELLING INPUTS

2.1.1 LIDAR

LIDAR data was provided by Moira Shire Council April 2023 as a 20m x 20m grid in raster format.

2.1.2 RAINFALL DEPTH

Rainfall depths have been adopted from information available via the Bureau of Meteorology (Bureau of Meteorology, 2023). Rainfall depths for a range of AEP's are shown in Table 1.

Table 1: Rainfall Depths

	Annual Exceedance Probability					
Duration	50%	20%	10%	5%	2%	1%
10 min	8.46	12	14.5	16.9	20.3	23
15 min	10.3	14.7	17.7	20.8	24.9	28.2
20 min	11.7	16.6	20.1	23.5	28.2	32
25 min	12.8	18.2	21.9	25.7	30.8	34.9
30 min	13.7	19.4	23.4	27.4	32.9	37.2
45 min	15.7	22.1	26.7	31.2	37.4	42.3
1 hour	17.2	24.1	29	33.9	40.5	45.8
1.5 hour	19.3	26.9	32.3	37.7	45	50.8
2 hour	20.9	29.1	34.8	40.5	48.3	54.5
3 hour	23.5	32.3	38.6	44.9	53.4	60.2
4.5 hour	26.4	36.1	43	49.9	59.4	66.9
6 hour	28.7	39.2	46.6	54.1	64.3	72.4
9 hour	32.4	44.2	52.5	61	72.6	81.8
12 hour	35.3	48.2	57.4	66.7	79.6	89.8
18 hour	39.9	54.7	65.3	76.1	91.1	103
24 hour	43.3	59.8	71.6	83.6	100	114
30 hour	46.1	63.9	76.8	89.9	108	123
36 hour	48.3	67.4	81.1	95.2	115	131
48 hour	51.7	72.8	88	104	126	144
72 hour	56.1	79.7	97	115	140	161

2.1.3 LOSSES

An initial and continuing loss has been adopted from the Australian Rainfall and Runoff 2019 Data (J, Ball; Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, 2019).

- Initial Loss (IL) = 23 mm
- Continuing Loss (CL) = 2.6 mm

2.1.4 PRE-BURST DEPTHS

Median pre-burst depths were adopted from the Australian Rainfall and Runoff Data Hub. The initial loss was adjusted to account for pre-burst for each storm duration. For durations where a median pre-burst depth was not available a depth was interpolated from the previously shorter and next longer durations. For all durations less than 60 minutes the median pre-burst depth for the 60-minute duration was adopted. The median-pre-burst depths and corresponding adjusted initial losses are shown in Table 2.

Table 2: 1% and 20% AEP median pre-burst depths and adjusted initial losses

	1% AEP			20% AEP		
Duration (hrs)	**Median Pre-burst depth (mm)**	**Adjusted Initial Loss (mm)**	**Loss Factor**	**Median Pre-burst depth (mm)**	**Adjusted Initial Loss (mm)**	**Loss Factor**
1	1.0	22.0	0.96	2.7	20.3	0.88
1.5	1.1	21.9	0.95	0.8	22.2	0.97
2	0.4	22.6	0.98	1.5	21.5	0.93
3	1.0	22.0	0.96	3.4	19.6	0.85
4.5	2.1	20.9	0.91	2.7	20.4	0.88
6	3.2	19.8	0.86	1.9	21.1	0.92
9	2.7	20.4	0.88	1.2	21.8	0.95
12	2.1	20.9	0.91	0.5	22.5	0.98
18	1.7	21.3	0.93	0.1	22.9	1.00
24	0.2	22.8	0.99	0.1	22.9	1.00
30.00	0.1	22.9	1.00	0.0	23.0	1.00
36.00	0.0	23.0	1.00	0.0	23.0	1.00
48.00	0.0	23.0	1.00	0.0	23.0	1.00
72.00	0.0	23.0	1.00	0.0	23.0	1.00

2.1.5 TEMPORAL PATTERNS

Temporal patterns were adopted from the Australian Rainfall and Runoff 2019 Data Hub (J, Ball; Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, 2019). The catchment is in the Southern Slopes Mainland temporal pattern region.

2.1.6 AREAL REDUCTION FACTORS

Areal reduction factors (ARF) were adopted from the Australian Rainfall and Runoff 2019 Data Hub (J, Ball; Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, 2019). ARF parameters were adopted for the Southern semi-arid zone. The parameters adopted in RORB are shown in Table 3.

Table 3: ARF factors CHECK data

a	0.254
b	0.247
c	0.403
d	0.351
e	0.0013
f	0.302
g	0.058
h	0
i	0

2.2 EXISTING CONDITIONS MODEL

2.2.1 SUB CATCHMENTS AND REACHES

The RORB sub-catchments have been delineated using available LIDAR data. Since the catchment has largely undefined flow paths, the natural reach type was selected in RORB. The existing conditions RORB model layout is shown in Figure 2.

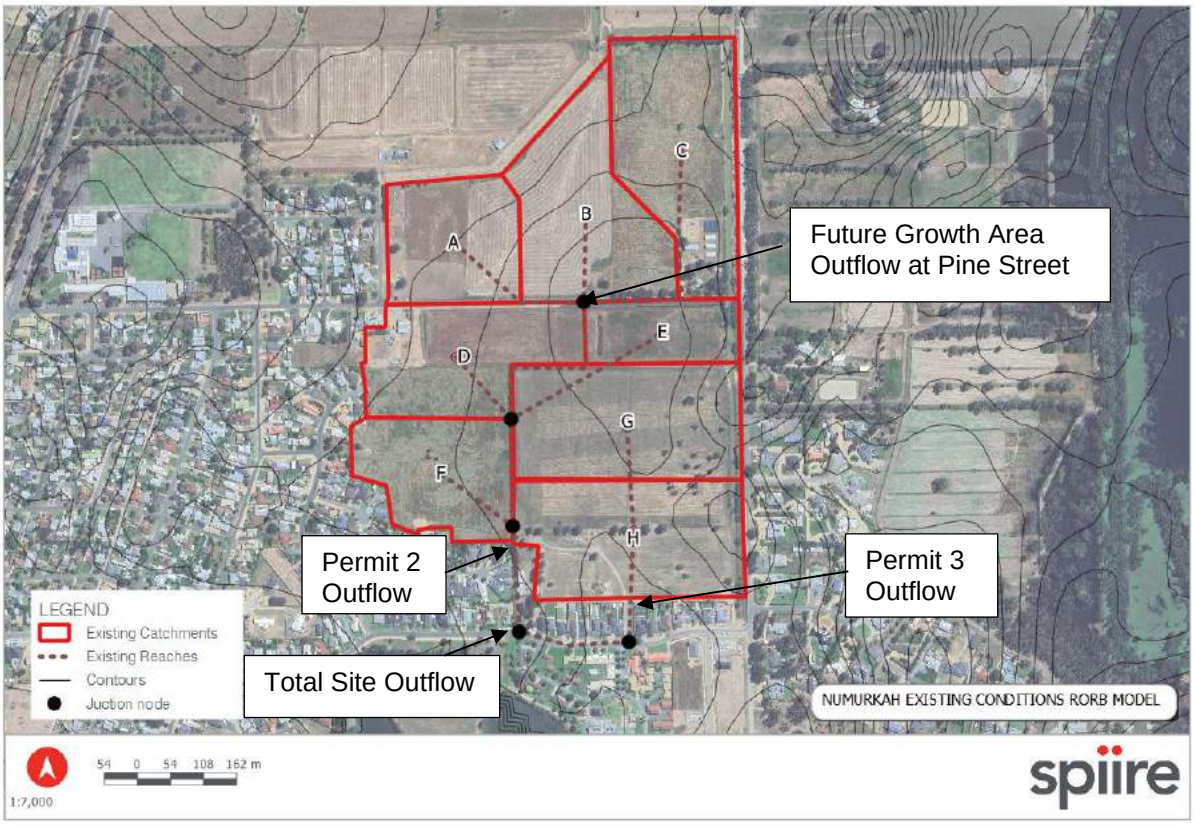


Figure 2: Existing Conditions RORB Model

2.2.2 FRACTION IMPERVIOUS

The fraction impervious for each sub-catchment has been determined based Melbourne Water MUSIC Modelling Guideline (October 2023). An aerial interrogation of the catchment shows that the entire catchment is a farming zone with no buildings except for a small section on the corner of Pine Street and Kinniards Road. The also a Pine Street which runs east-west through the catchment. Given the roads and buildings contribute less than 1% of the total catchment, there impact would be negligible on the runoff in the catchment and therefore the whole catchment has been denoted as a farming zone with a 0.1 fraction impervious.

Table 4: Sub-Catchment Parameters

Sub-Catchment	Sub-Catchment Area (ha)	FI
A	4.4	0.1
B	6.6	0.1
C	7.1	0.1
D	5.6	0.1

Sub-Catchment	Sub-Catchment Area (ha)	FI
E	2.6	0.1
F	4.4	0.1
G	7.0	0.1
H	6.9	0.1
TOTAL	44.6	0.1

2.2.3 VALIDATION

Flow estimates have been determined through the Regional Flood Frequency Estimation (RFFE) and rational calculations as shown in Table 5. These flow estimates have been compared to the RORB model using various Kc estimates in order to determine an appropriate Kc for the model.

Table 5: Existing Conditions Model Validation

Location	RFFE and Rational Flow Estimate (m^3/s)			RORB Flow Estimate (m^3/s)				
	[1]Regional Flood Frequency Estimation (RFFE)	Strict Method with Adams Tc (Rational Rural Calculation)	Strict Rational Method with Bransby Williams Tc	Default Kc = 1.47	Vic MAR < 800mm Kc = 0.29	Vic Data Pearse et al, 2002 Kc = 0.82	Aus Wide Dyer, 1994 Kc = 0.75	Aus Wide Yu, 1989 Kc = 0.63
Numurkah Outfall	2.6	0.6	0.4	1.6	4.7	3.0	3.1	3.5

The default Kc was determined the most representative for the model as this produced a flow rate that was close to the mid-point of the RFFE and rational calculation flow estimates. Therefore, the catchment parameters that have been adopted for the existing conditions RORB model are:

- m = 0.8
- Kc = 1.47

2.2.4 EXISTING CONDITIONS RESULTS

The existing conditions RORB model has been run for the 1% and 20% AEP storm events at key locations and the results shown in Table 6. The flows in Table 6 are for the temporal pattern one above calculated median for the critical duration at the respective location.

[1] Regional Flood Frequency Estimation (Dr. Ataur Rahman, 2019)

Table 6: Existing Conditions RORB Model Results

Location	1% AEP Flow (m^3/s)	20% AEP Flow (m^3/s)
Future Growth Area Outflow at Pine Street	1.0 1.5-hr TP22	0.3 3-hr TP8
Permit 2 Outflow	0.9 6-hr TP27	0.3 4.5-hr TP4
Permit 3 Outflow	0.7 1.5-hr TP22	0.2 3-hr TP6
Total Site Outfall	1.6 3-hr TP29	0.4 4.5-hr TP4

2.3 DEVELOPED CONDITIONS MODEL

2.3.1 SUB CATCHMENTS AND REACHES

The RORB sub-catchments have been delineated based on the Urban Design (Spiire, Feb 2024) as seen in Figure 3. Reach types have been selected as “lined channel or pipe” with an assumed grade of 1 in 300 and reach lengths follow the road alignments. The developed conditions RORB model layout is shown in Figure 4.



Figure 3: Urban Design (Spiire, Feb 2024)

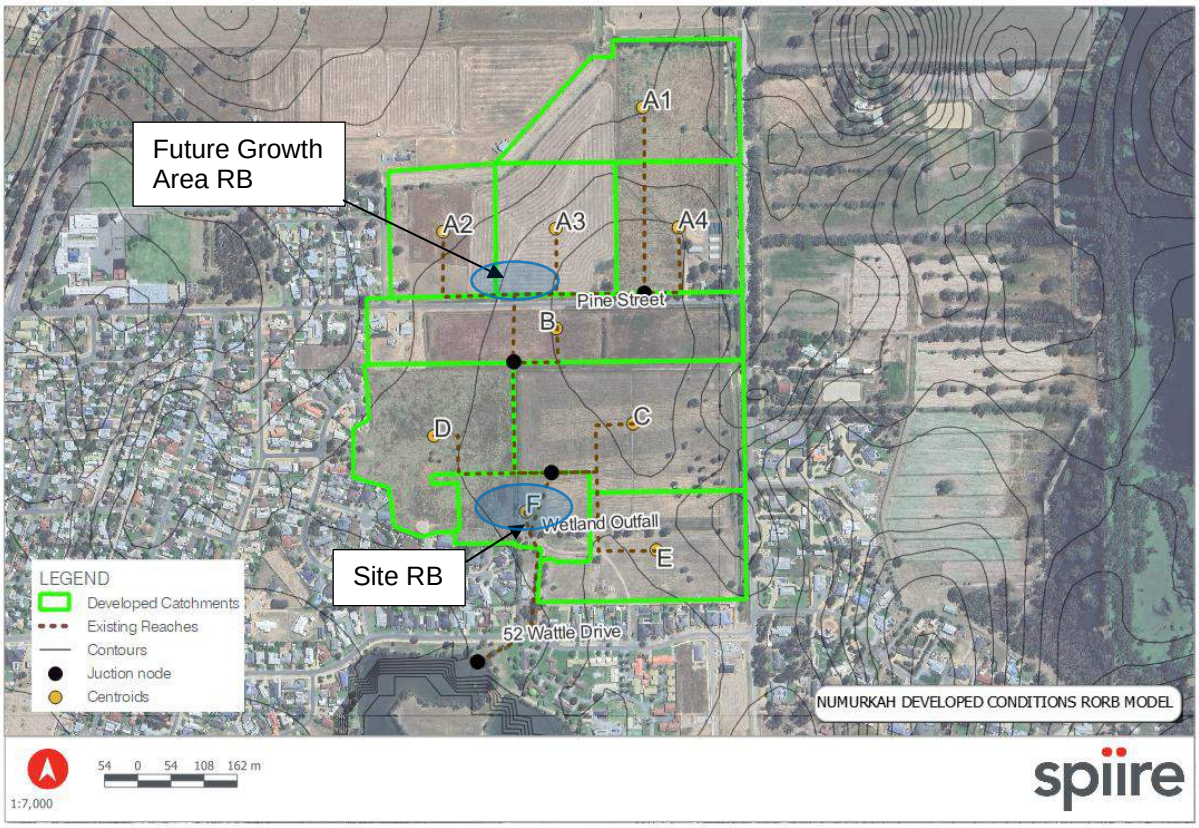


Figure 4: Developed Conditions RORB Model

2.3.2 FRACTION IMPERVIOUS

The fraction impervious for each sub-catchment has been determined based Melbourne Water MUSIC Modelling Guideline (October 2023). Council advised that the assumed lot densities for the development should be 465m^2 for Permit 2 (western portion of site) and 780m^2 for Permit 3 (eastern portion of site). To be conservative a fraction impervious of 0.75 which corresponds to a lot density between 300m^2 to 600m^2 was adopted for the entire development.

Table 7: Sub-Catchment Parameters

Sub-Catchment	Sub-Catchment Area (ha)	FI
A1	6.01	0.75
A2	3.64	0.75
A3	4.21	0.75
A4	4.34	0.75

Sub-Catchment	Sub-Catchment Area (ha)	FI
B	6.71	0.75
C	7.58	0.75
D	5.53	0.75
E	5.05	0.75
F	2.80	0.1
TOTAL	45.9	0.71

2.3.3 Future Growth Area

For modelling purposes. The retarding basin servicing the future growth area north of Pine St is assumed to retard flows back to the 1% AEP existing condition flow (1.0m^3/s) under gravity. This assumption is considered conservative for sizing of the main drain (which conveys flows from the Pine Street basin to the basin on site) and also the on site retarding basin.

Through development of a site specific SWMS for the future growth area, should the requirement for a pumped outfall be identified for the Pine Street basin, this would result in a lower basin peak discharge than the assumed 1,000L/s, due to limited pumping capacities. In this instance, the size of the main drain, together with required capacity of the site retarding basin can be reduced, subject to Council approvals.

2.3.4 VALIDATION

The Kc for the developed conditions has been adjusted by the average reach length and the formula:

$$\frac{\mathrm{k}_c\ (developed)}{d_{av}\ (developed)} = \frac{\mathrm{k}_c\ (existing)}{d_{av}\ (existing)}$$

Inputting the known parameters produces a Kc value as:

$$\frac{\mathrm{k}_c\ (developed)}{0.79} = \frac{1.47}{0.66}$$

$$\mathrm{k}_c\ (developed) = 1.76$$

Therefore, the developed case Kc value was adjusted to 1.76.

3. RESULTS

3.1 Run Log

A run log has been provided in Table 8 which outlines the modelling assumptions for each run. The model was run to determine the basin volume and key flow rates under 1% and 20% AEP events. Sensitivity runs were also undertaken to verify the results.

Table 8: Developed conditions RORB run log

Run	Purpose	Modelling Assumption	Run Duration
1	1% AEP Basin maximum volume, simulating pump failure	▸ Site RB pump offline ▸ Future growth area outlet at 1,000 L/s	24-hours
2	20% AEP Basin volume and flow rates	▸ Site RB pump at 100 L/s ▸ Future growth area outlet at 1,000 L/s	All durations
3	1% AEP flow rates and basin volume under normal pumping operation	▸ Site RB pump at 100 L/s ▸ Future growth area outlet at 1,000 L/s	All durations

3.2 Retarding Basin Design

The required storage volume was calculated for the 1% AEP and 20% AEP representative event. With the 1% AEP volume derived from the 24-hour storm with no outfall condition (pump offline) as per clause 18.3 in the Infrastructure Design Manual (2022) – refer Run 1 in Table 8 above.

The required storage volumes are:

- 20% AEP – 12,000 m^3 (~105.6m AHD) – based on Run 2 (Table 8)
- 1% AEP – 42,000 m^3 (~107.0m AHD) – based on Run 1 (Table 8)
- 1% AEP – 36,200 m^3 (~106.7 AHD) – based on Run 3 (Table 8)

The retarding basin spillway is designed to have a crest level of 107.0m AHD and will therefore be engaged when the basin reaches the 1% AEP level. The retarding basin height-volume relationship as derived from 3D modelling is shown in Table 9, and is based on the concept design presented in this SWMS. Note that basin has been designed to provide slightly more storage volumes for the 20% and 1% AEP required volumes shown above and is subject to refinement through design progression.

Table 9: Retarding Basin Height-Volume Relationship

Height (m)	Volume (m3)
104.5	0
105.0	5166
105.5	11033
105.6 (20% AEP level)	12360
106.0	20086
106.5	30652
107.0 (1% AEP level)	42280

The retarding basin for the future growth area was input into the model with a dummy storage volume. This volume is arbitrary so long as the model contains the 1% AEP flows within that retarding basin – which would be the design criteria for the future growth area.

3.3 Developed Conditions RORB Results

The developed conditions RORB model has been run for the 1% and 20% AEP storm events at key locations and the results shown in Table 10. The pump station for the site with 100 L/s capacity was input into the model to determine the key flow rates.

Table 10: Developed Conditions RORB Model Results

Location	1% AEP Flow (m^3/s)	20% AEP Flow (m^3/s)
Future Growth Area RB Inflow	4.0 15-min TP24	2.0 30-min TP5
Future Growth Area RB Outflow	1.0 10-min TP21	1.0 10-min TP1
Site RB Inflow	7.3 25-min TP25	3.7 30-min TP1
Site RB Outflow	0.1 48-hr TP27	0.1 12-hr TP2
Total site outflow	0.1 48-hr TP27	0.1 12-hr TP2

4. REFERENCES

Bureau of Meteorology. (2023). Retrieved from http://www.bom.gov.au

Dr. Ataur Rahman, D. K. (2019). *Regional Flood Frequency Estimation (RFFE)*, 4. Retrieved from Australian Rainfall and Runoff.

J, Ball; Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I. (2019). *Australian Rainfall and Runoff Data Hub.*

Melbourne Water. (2021). *AM STA 6200 Flood Mapping Projects Specification.* Melbourne Water.

R.B. Grayson, R. A. (2006). Hydrological Recipes.

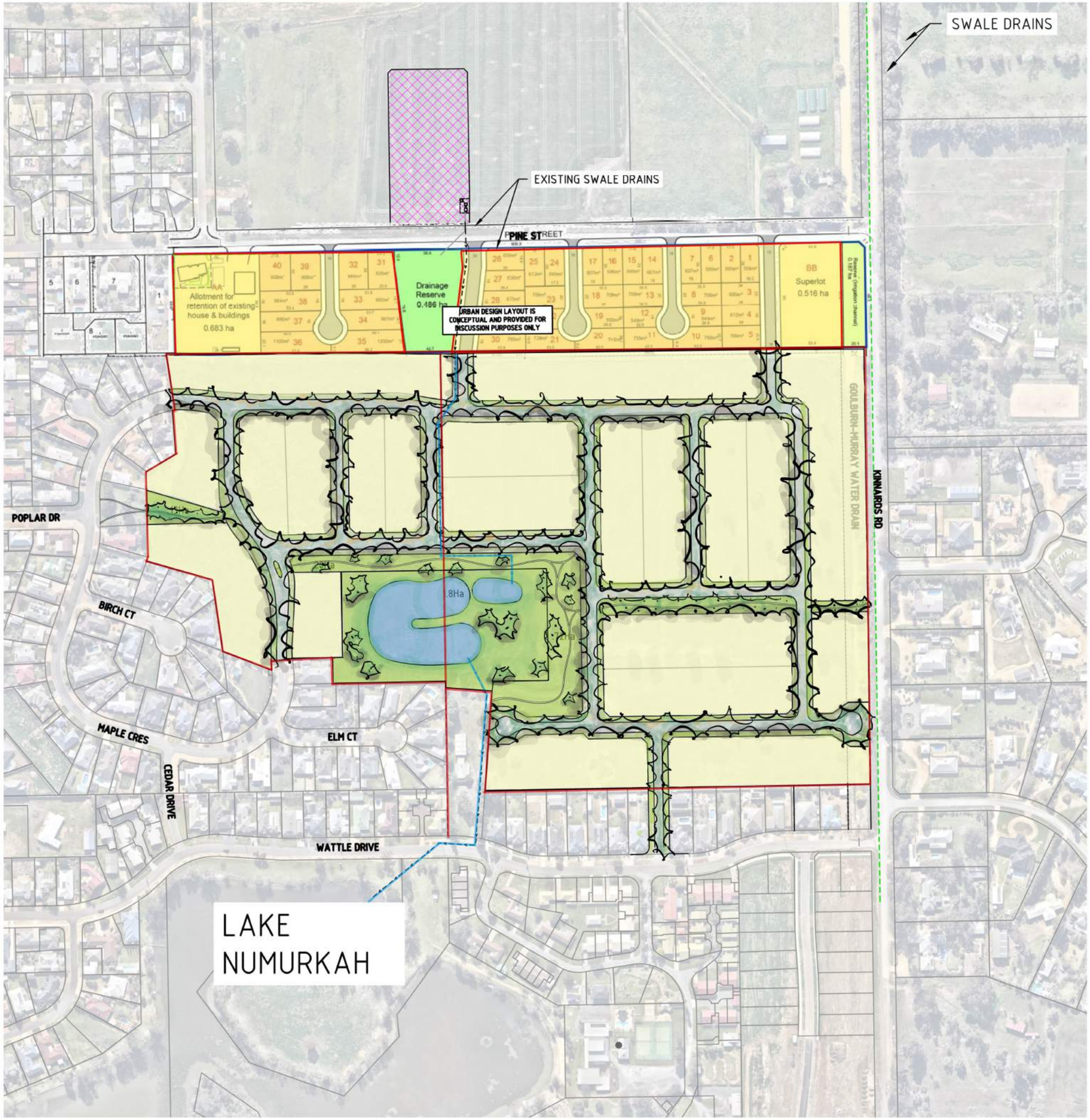
APPENDIX C

URBAN DESIGN

NUMURKAH DEVELOPMENT ANALYSIS:	AREA (Ha)	% GD Area
SITE AREA (permit areas 2 & 3 combined)	**21.23**	
Gross Developable Area	21.23	
OPEN SPACE		
Public Open Space (unencumbered)	1.05	4.95
Open Space for drainage and water treatment (encumbered)	1.8	8.48
NET DEVELOPABLE AREA		
roads	5.62	26.48
net residential area	12.76	60.09

NUMURKAH DEVELOPMENT ANALYSIS:	AREA (Ha)	% GD Area
SITE AREA (permit area 2)	**6.73**	
Gross Developable Area	6.73	
OPEN SPACE		
Public Open Space (unencumbered)	0.33	4.90
Open Space for drainage and water treatment (encumbered)	0.9	13.37
NET DEVELOPABLE AREA		
roads	1.74	25.80
net residential area	3.76	55.92

NUMURKAH DEVELOPMENT ANALYSIS:	AREA (Ha)	% GD Area
SITE AREA (permit area 3)	**14.5**	
Gross Developable Area	14.5	
OPEN SPACE		
Public Open Space (unencumbered)	0.72	4.97
Open Space for drainage and water treatment (encumbered)	0.9	6.21
NET DEVELOPABLE AREA		
roads	3.89	26.80
net residential area	8.99	62.03



Numurkah drainage and urban design concept