LEGEND

1. Hunter Water supply
2. Potable water storage
3. Pump set
4. Potable water distribution
5. Cooranbong Development (new)
6. Top-up to recycled water storage
7. Chlorine dosing
8. Additional potable water storage
9. Additional Pump Set

QUALITY CONTROL POINTS (QCP) FOR WATER QUALITY

POTABLE WATER STORAGE (2)
- Free chlorine
- pH

POTABLE WATER DISTRIBUTION (3)
- Turbidity
- Pressure

CRITICAL CONTROL POINTS (CCP) FOR WATER QUALITY

HUNTER WATER SUPPLY (1)
- Turbidity
- Ph
- Free chlorine

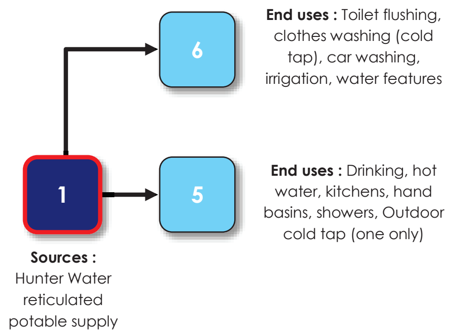
Location of QCP — Major flow

Location of CCP — Minor flow

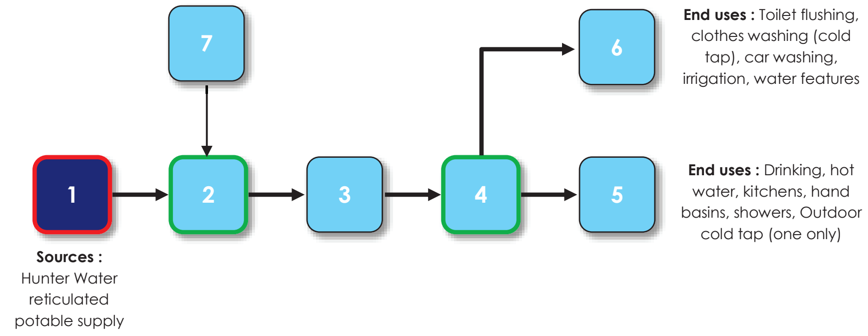
New infrastructure — Existing infrastructure

Phase 1a

Stage 1E-1H

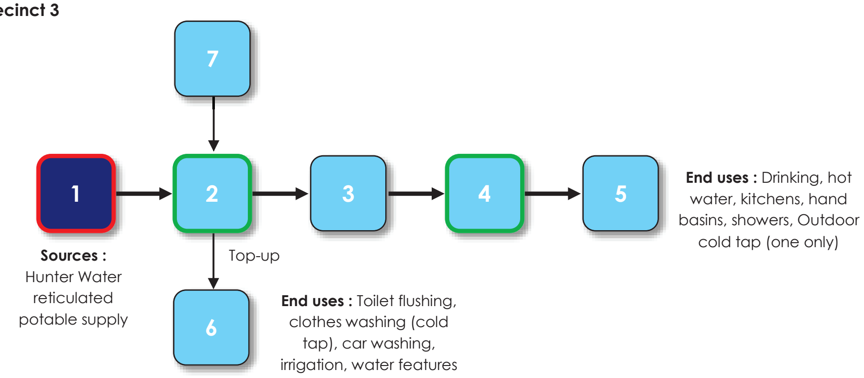


Phase 1b



Phase 2a

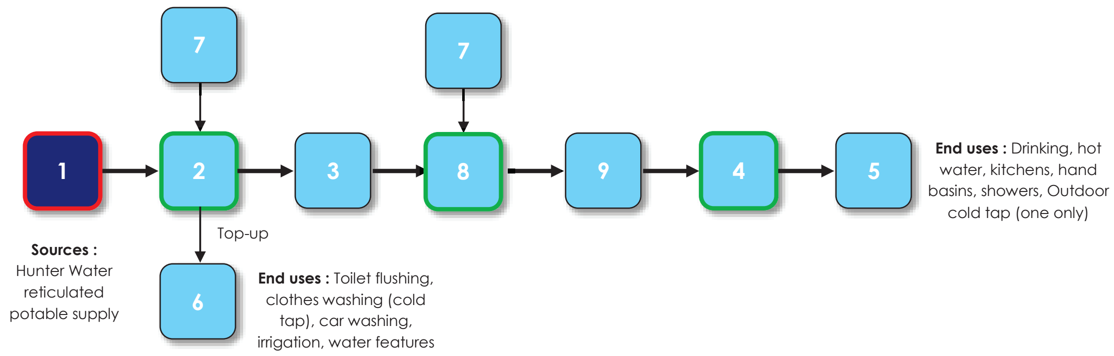
Up to Precinct 3



(Refer to 10 on C14107-201)

Phase 2b

All Stages



(Refer to 10 on C14107-201)

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B	260514	AJC			For information
A	160514	AJC			For information

CLIENT

flow systems

Name :	Cooranbong Water
Project :	Cooranbong Local Water Centre

Design	Date	Drafting	Date
AJC	030614		

Title : Potable Water Process Flow Diagram **Staged Facility Development**

Scale	Permeate Project #	Permeate Drawing #
NTS	C14107	C14107-202
Sheet	**Client Project #**	**Client Drawing #**
A3	TBA	TBA

North Cooranbong Development

Bulk Water Servicing Strategy

301020-06837 – WW-REP-0002

7 October 2015

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PROJECT 301020-06837 - NORTH COORANBONG DEVELOPMENT

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
0	Final submission	A.Ford	L.Russell	I.Waterman	4 June 14	N/A	
1	Issued for client review	L.Russell	D.Powell	D.Powell	6 Feb 15		N/A
2	Reissued for client review	L.Russell	D.Powell	D.Powell	4 Aug 15		N/A
3	Reissued for client review	L.Russell	D.Powell	D.Powell	2 Oct 15		N/A

CONTENTS

1 INTRODUCTION

WorleyParsons (WP) has been commissioned by Cooranbong Water (a wholly owned subsidiary of Flow Systems) to prepare a Bulk Water Servicing Strategy for the North Cooranbong development. The location of the development is shown on Figure 1.

Cooranbong Water has been engaged by Johnson Property Group as an independent operator to provide potable water, wastewater and recycled water services to most of the North Cooranbong development. Hunter Water Corporation (HWC) will not own or operate the water, wastewater or recycled water assets servicing the properties within Cooranbong Water's area of operations (refer Figure 2).

A Water Supply Servicing Strategy (HWA 2009) and Water Servicing Strategy (SMEC 2013) have previously been prepared for the North Cooranbong development. However, these studies were based on HWC's design criteria for water and wastewater systems. Cooranbong Water has advised that they anticipate lower overall demands from the North Cooranbong development than have been estimated using HWC criteria.

HWC have advised that as Johnson Property Group have elected to be serviced by a private network (i.e. Cooranbong Water) any previous approved servicing strategies or commitments made by HWC are no longer valid and this Bulk Water Servicing Strategy supersedes these previous HWC approved reports. This report has therefore been prepared assuming no prior servicing strategy is in place.

This Bulk Water Servicing Strategy has been prepared for provision of bulk potable water to Cooranbong Water's area of operations, based on design demands advised by Cooranbong Water.

1.1 Scope of Work

Tasks undertaken in preparation of this Bulk Water Servicing Strategy have included the following:

- Review existing servicing strategies (HWA 2009 and SMEC 2013).
- Obtain the existing HWC InfoWorks model of the water supply system in the North Cooranbong area.
- Run the existing InfoWorks model to check current operating pressures within HWC's water supply system.
- Update the InfoWorks model for each stage through to the ultimate development to include future HWC demands in the system. This will be used to determine a base case for any upgrades to the HWC network.
- Update the InfoWorks model for each stage through to the ultimate development to include future HWC demands and the demands from the North Cooranbong development.

- Determine the works required and staging options to service through to the ultimate development with potable water, while maintaining sufficient pressure within HWC's existing network.
- Develop strategies for provision of bulk water to the North Cooranbong development through to the ultimate development.

2 DESIGN CRITERIA

2.1 Land Use

Cooranbong Water's area of operations includes residential lots and medium density dwellings, a library and community centre, a retail zone, public plazas, a school and sports grounds.

Proposed land uses at ultimate development of the North Cooranbong development are included in Table 2-1.

Table 2-1 North Cooranbong Ultimate Land Use

Land Use	Count
Residential	1664 lots
Medium Density	440 dwellings
Library & Community Centre	0.11 Ha
Retail	0.54 Ha
Public Plazas	7.1 Ha
School	0.6 Ha
Sports Grounds	7.6 Ha

The portion of the North Cooranbong development that is located within Cooranbong Water's area of operations is divided into 18 stages (refer Figure 3).

As residential stages are developed, land will also be developed for retail, a library and community centre, public plazas, school and sports ground purposes.

Land uses associated with development of each residential stage are included in Table 2-2.

Table 2-2 North Cooranbong Stage Development

Stage	Cumulative Count						
	Residential (Lots)	Medium Density (Dwellings)	Library & Community Centre (Ha)	Retail (Ha)	Public Plazas (Ha)	School (Ha)	Sports Grounds (Ha.)
1E & 1F	40	0	0	0	0	0	0
1G & 1H	81	0	0	0	0	0	0
Precinct 2	376	0	0	0	0	0	0
Twine & Thomson	451	0	0	0	0	0	0
2A	482	0	0	0	3.5	0	3.8
2B	517	0	0	0.05	3.5	0	3.8
2C	556	0	0	0.11	3.5	0	3.8
2D	589	0	0	0.22	3.5	0	3.8
3	629	0	0	0.27	3.5	0	3.8
6	690	12	0.11	0.33	3.5	0.6	3.8
7A	806	12	0.11	0.38	3.5	0.6	3.8
7B	842	12	0.11	0.44	7.1	0.6	7.6
8	1030	12	0.11	0.49	7.1	0.6	7.6
8 – Medium Density	1030	440	0.11	0.54	7.1	0.6	7.6
9	1191	440	0.11	0.54	7.1	0.6	7.6
10	1343	440	0.11	0.54	7.1	0.6	7.6
11	1574	440	0.11	0.54	7.1	0.6	7.6
12	1664	440	0.11	0.54	7.1	0.6	7.6

2.2 Average Day Demand

All land use types within Cooranbong Water's area of operations will be provided with both potable and recycled water at ultimate development.

The total average day demand (potable water component only) for each land use within the North Cooranbong development is included in Table 2-3. The average day demand for HWC residential customers is also included in the first row for comparison.

Table 2-3 Average Day Demand

Land Use	Unit	Potable Water	Source
Residential (HWC)	L/day/ET	700	WSA 03-2002-2.3 (HWC Edition Version 1) Table HW 2.1
Residential (Huntlee Water)	L/day/lot	275	Flow Systems
Medium Density	L/day/lot	275	Flow Systems
Library & Community Centre	L/day/Ha	15000	Flow Systems- The area represents the net lettable floor space
Retail	L/day/Ha	14000	Flow Systems- The area represents the net lettable floor space
Public Plazas	L/day/Ha	0	Flow Systems- The public plazas only contain a recycled water demand
School	L/day/Ha	2000	Flow Systems
Sports Grounds	L/day/Ha	0	Flow Systems- The sports grounds only contain a recycled water demand
Recycled Water Top Up	L/day	388992 (Ultimate)	Flow Systems. The top up volume assumed 50% of the recycled water average day demand.
Unaccounted Water	15% of average day demand		WSA 03-2002-2.3 (HWC Version 1.0) Section 2.2.2.4 (Unaccounted Water)

2.3 Demand Factors

Demand categories and factors for each land use type were sourced from WSA 03-2002-2.3 (Hunter Water Corporation Version 1.0) Table 2.1 (Water Supply Design Demands). The adopted categories and factors are included in Table 2-4.

Table 2-4 Demand Categories and Factors

Land Use	HWC Demand Category	Peak Day Factor	Peak Hour Factor	Extreme Day Factor	95th %ile Factor
Residential	Residential House – Lake Macquarie LGA	2.25	2.02	1.15	1.8
Medium Density	Flats/Units	2.20	2.02	1.15	1.76
Library & Community Centre	Commercial	1.20	1.90	1.15	1.14
Retail	Commercial	1.20	1.90	1.15	1.14
Public Plazas	Parks and Rural	1.60	1.50	1.15	1.52
School	Schools/ Colleges	1.60	2.50	1.15	1.52
Sports Grounds	Parks and Rural	1.60	1.50	1.15	1.52
Unaccounted Water	Unaccounted Water	1.00	1.00	1.00	1.00

It should be noted that the demand factors presented above relate to single supply systems i.e. systems without a recycled water component. The introduction of recycled water may change the traditional demand factors as usage that may typically increase during peak periods such as external watering may be covered by the recycled water system.

2.4 Diurnal Demand Factors

Diurnal demand factors for each land use type were sourced from WSA 03-2002-2.3 (Hunter Water Corporation Version 1.0) Table 2.2 (Diurnal Demand Factors). The demand category adopted for each land use type is included in Table 2-5.

Table 2-5 Diurnal Demand Categories

Land Use	WSA Demand Category
Residential	Domestic Peak & Extreme Day
Medium Density	Domestic Peak & Extreme Day
Library & Community Centre	Commercial
Retail	Commercial
School	Schools / Colleges
Public Plazas	Parks / Gardens
Sports Grounds	Parks / Gardens
Unaccounted Water	Unaccounted

2.5 Service Pressure Limits

The service pressure limits from WSA 03-2002-2.3 (Hunter Water Corporation Version 1.0) Table 2.4 (Service Pressure (SP) Limits) were adopted for the North Cooranbong development and are summarized in Table 2-6.

Table 2-6 Adopted Service Pressure Limits

Service Pressure Limit	Demand	Pressure (m)
Maximum	All applications	60
Minimum	Peak hour flow on a peak day of a peak week	20/25*
	Peak hour flow on an extreme day of an extreme week	12
	Peak hour flow on a 95th percentile peak day plus firefighting flow (at location of fire flow)	15
	Peak hour flow on a 95th percentile peak day plus firefighting flow (other than location of a fire flow)	3

Notes: * Booster pump stations to be designed to deliver a minimum pressure of 25 m.

2.6 Reservoirs

The North Cooranbong potable water reservoirs have been sized based on the following:

- Storage does not fall below 20% capacity during an extreme week demand period.

3 NORTH COORANBONG POTABLE WATER DEMANDS

3.1 Ultimate Potable Water Demands

Average day, peak and extreme hour potable water demands for the ultimate North Cooranbong development have been calculated from the criteria included in Tables 2-1, 2-3 and 2-4 and are presented in Table 3-1.

Table 3-1 Potable Water Demands

Land Use	Average Day Demand (L/s)[1]	Peak Hour Demand (L/s)	Extreme Hour Demand (L/s)
Residential	5.30	24.07	27.68
Medium Density	1.40	6.22	7.16
Library & Community Centre	0.02	0.04	0.05
Retail	0.09	0.20	0.23
Public Plazas	0.00	0.00	0.00
School	0.01	0.06	0.06
Sports Grounds	0.00	0.00	0.00
Unaccounted Water	1.02	1.02	1.02
Recycled Water Top Up[3]	4.50	4.50	4.50
Total (Excluding Recycled Water Top Up)	**7.84**	**31.62**	**36.21**
Total (Including Recycled Water Top Up)	**12.34**	**36.12**	**40.71**

Notes: 1 The average day demand is represented as a constant flow over 24hrs. The actual flowrate will follow a diurnal pattern as indicated in Section 2.4.
2 The totals in Table 3-1 above assume that the peak demands for all land use types occur simultaneously. In reality, the peak demands for each land use type would occur at different times of the day.
3 Recycled water top up will be delivered from the potable water storage tank at the LWC and not the potable water reservoirs.

3.2 Development Staging

Based on the development staging included in Table 2-2, the cumulative average day, peak hour and extreme hour potable water demands associated with development of each stage has been calculated and is included in Table 3-2.

Cooranbong Water has advised that the Local Water Centre (LWC) for the development would not be operational until the first 156 lots have been developed, which would occur after the first 75 lots of Precinct 2 are developed (refer Table 2-2). Therefore, recycled water would not initially be available for properties within Stages 1E & 1F, 1G & 1H and Precinct 2 and the recycled water reticulation would be supplied with potable water until a supply of recycled water is available from the LWC.

The actual potable water demands for stages developed prior to commissioning of the LWC would therefore need to include provision for supplying the recycled water system with potable water. The demands for Stage 1E & 1F, Stage 1G & 1H and the first 75 lots of Precinct 2 in Table 3-2 include this allowance.

Table 3-2 Cumulative Potable Water Demands

Stage	North Cooranbong ADD (L/s)	North Cooranbong PHD (L/s)	North Cooranbong EHD (L/s)
1E & 1F	0.29[1]	1.20[1]	1.37[1]
1G & 1H	0.59[1]	2.42[1]	2.77[1]
Precinct 2 (first 75 lots)	1.14[1]	4.66[1]	5.34[1]
Precinct 2	1.38	5.62	6.43
Twine & Thomson	1.65	6.74	7.72
2A	1.76	7.20	8.25
2B	1.90	7.75	8.87
2C	2.06	8.35	9.56
2D	2.20	8.89	10.18
3	2.35	9.51	10.89
6	2.67	10.72	12.28
7A	3.10	12.47	14.28
7B	3.25	13.04	14.93
8	3.94	15.86	18.17

Stage	North Cooranbong ADD (L/s)	North Cooranbong PHD (L/s)	North Cooranbong EHD (L/s)
8 – Medium Density	5.52	22.14	25.36
9	6.11	24.55	28.11
10	6.67	26.82	30.71
11	7.51	30.27	34.67
12 (Excluding Recycled Water Top Up)	7.84	31.62	36.21
12 (Including Recycled Water Top Up)[2]	12.34	36.12	40.71

Notes: 1 Cumulative demands for the first 156 lots take into account servicing the recycled water system with potable water.
2 Recycled water top up will be delivered from the potable water storage tank at the LWC and not the potable water reservoirs.

4 DEVELOPMENT STAGING

4.1 HWC Growth Profile

HWC has supplied WorleyParsons with their predicted growth polygons for the North Cooranbong area. The cumulative growth profile at 3 separate load points (refer to Figure 4-1 below) was provided in HWC ET's until ultimate (beyond 2030).

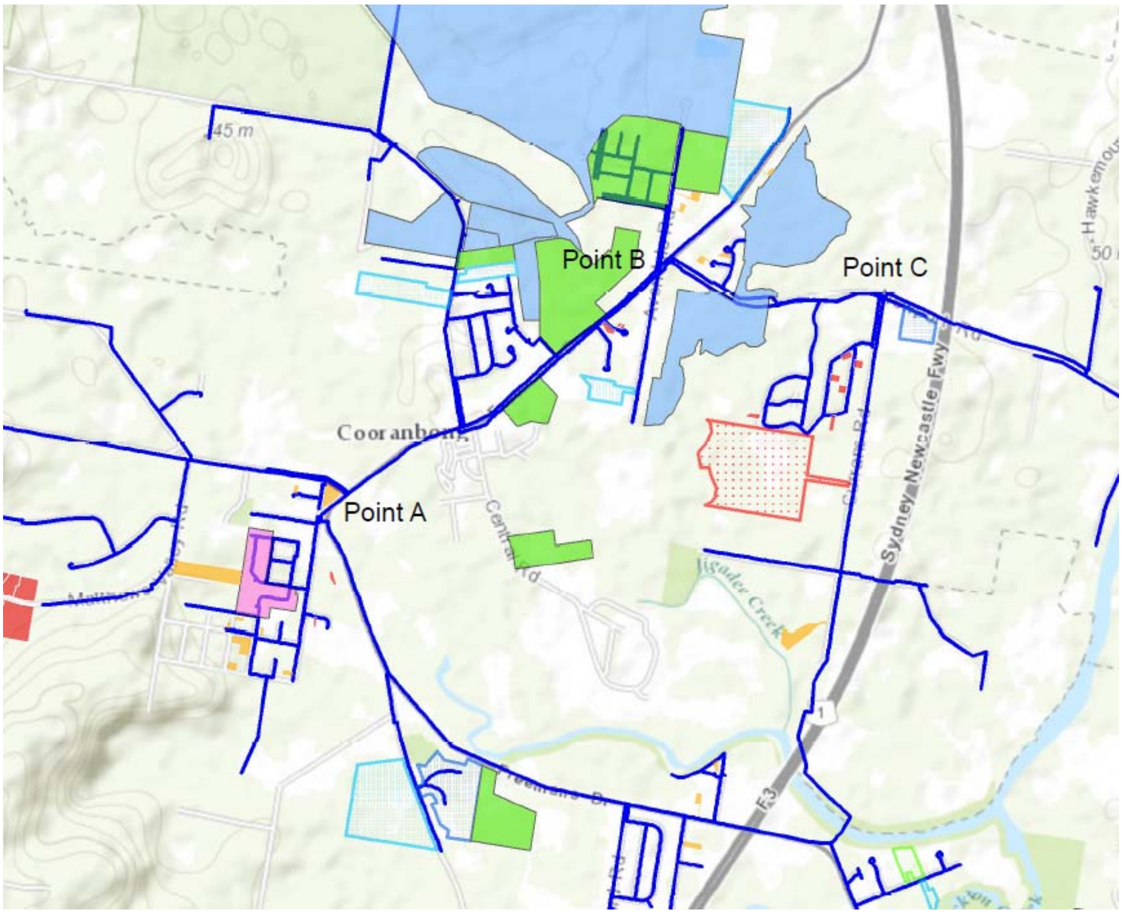

Figure 4-1 HWC predicted growth load points.

4.2 Combined Growth Profile

In order to combine the HWC growth with the North Cooranbong staging presented in Table 2.2 & Table 3.2, the timing of the stages has been aligned with the HWC development profile from 2016 through to the ultimate development. This combined growth profile is presented in Table 4-1.

Table 4.1 North Cooranbong and HWC Development Staging Plan

	HWC			North Cooranbong						
Year	HWC Point A (ET)	HWC Point B (ET)	HWC Point C (ET)	Residential Lots (No.)	Medium Density (No.)	Library & Community (Ha)	Retail (Ha)	Public Plaza (Ha)	School (No.)	Sports Grounds (Ha)
2016	80	80	10	200	0	0	0	0	0	0
2018	130	170	20	400	0	0	0	0	0	0
2022	250	350	110	640	160	0	0.16	3.5	0	3.8
2030	300	600	230	1160	440	0.11	0.54	7.1	0.6	7.6
Ultimate	350	700	230	1664	440	0.11	0.54	7.1	0.6	7.6

Based on the staging plan presented in Table 4-1, average day, peak hour and extreme hour potable water demand flowrates for the North Cooranbong and HWC development staging plan have been calculated from the criteria included in Tables 2-2, 2-3 and 2-4 and are presented in Table 4-2. The North Cooranbong demands presented in Table 4-2 represent the flowrates delivered from the North Cooranbong reservoirs and not the demand applied to the HWC network.

Table 4-2 Potable Water Demands (Flowrates)

Year	HWC[4] ADD (L/s)	HWC[4] PHD (L/s)	HWC[4] EHD (L/s)	North Cooranbong ADD (L/s)	North Cooranbong PHD (L/s)	North Cooranbong EHD (L/s)
2016	1.38	6.26	7.20	0.73	2.99	3.42
2018	2.59	11.78	13.55	1.46	5.98	6.85
2022	5.75	26.14	30.07	2.96	11.97	13.71
2030	9.16	41.61	47.85	6.00	24.09	27.58
Ultimate	10.37	47.13	54.20	7.84	31.62	36.21

Notes: 1. The results in Table 4-2 above assume that the peak demands for all land use types occur simultaneously. In reality, the peak demands for each land use type would occur at different times of the day.

2. The average day demand is represented as a constant flow over 24hrs. The actual flow rate will follow a diurnal pattern.

3. The results presented are for the drinking water system in isolation and does not consider the need for potable top up of the recycled water system.

4. The HWC flowrates in Table 4-2 only represent the demand from future growth and does not incorporate the potable water demand of any existing development in the area.

5 BULK WATER STRATEGY

5.1 Bulk Water Model

The bulk water servicing strategy has been developed by modelling HWC's existing water supply system in the vicinity of the North Cooranbong development using InfoWorks.

The HWC and North Cooranbong average day demand flowrates for each year of the development presented in Table 4-2 were progressively included in the model to determine the bulk water strategy for the North Cooranbong development including the staging of HWC upgrades.

Three separate scenarios were investigated:

- North Cooranbong Demands Only
- HWC Demands Only
- North Cooranbong & HWC Demands Combined

The servicing strategy for each option is detailed in Sections 6, 7 and 8.

5.2 Operational Assumptions

The following assumptions were made in relation to upgrade requirements and operation of the North Cooranbong water system:

- Upgrade works have been progressively inputted into the InfoWorks model to ensure that the North Cooranbong development is not creating new operational issues in the existing HWC system.
- It is assumed that the potable water balance tank located at the LWC would be filled from the HWC system between 11:30pm and 6:30am. A flow control valve would regulate this flow.
- Transfer rates from the HWC system to the North Cooranbong storage tank has been determined to ensure the storage tank and reservoirs do not fall below 20% capacity during an extreme week.
- The service pressure within the North Cooranbong reticulation would be constantly maintained by booster pumps.

6 NORTH COORANBONG DEMANDS ONLY

The base case used for modelling the impact of the North Cooranbong development was HWC's existing water supply network from the Wangi Wangi reservoir (HWC 2014).

This existing system is already at capacity with 29 connections currently experiencing minimum peak pressures ranging from 7.2m to 18.9m. These properties do not meet the HWC service pressure limits specified in Table 2-6. This indicates that any further peak loads added to this system is only going to decrease the service pressure at these properties and create further low pressure issues in the network.

Where a reference to a year is included against an upgrade this date refers to the upgrade being completed and capacity available at the start of that year.

6.1 Initial Potable Water Connection (2015)

The initial development (up until the end of Stage 1G & 1H) would be serviced via connection to the existing 300 mm diameter HWC potable water main in Wainman Drive.

As mentioned in Section 3.2, the LWC will not be operational until the first 156 lots have been developed. Therefore the recycled water reticulation for the initial stages would be supplied with potable water until a supply of recycled water is available from the LWC.

6.1.1 Stage 1E & 1F

The first stage of North Cooranbong to be developed within Cooranbong Water's area of operations would be Stage 1E & 1F (refer Table 2-2). This stage would be serviced via connection to the existing 300 mm diameter HWC potable water main in Wainman Drive (refer Figure 4). A bulk water meter and check valve would be located at this connection point.

The peak hour potable water demand for Stage 1E & 1F would be 1.20 L/s (refer Table 3-2), which could be serviced from the Wainman Drive main without the need for booster pumping or upgrades to the existing HWC potable water system.

Potable water would initially be used to supply both the potable water and recycled water reticulation systems within Stage 1E & 1F.

6.1.2 Stage 1G & 1H

The second stage to be developed within Cooranbong Water's area of operations would be Stage 1G & 1H. This stage would connect to the potable water reticulation supplying Stage 1E & 1F.

The total peak hour potable water demand from Stage 1E & 1F and Stage 1G & 1H would be 2.42 L/s (refer Table 3-2). Several properties within Stage 1G & 1H may experience low service pressures during a peak hour demand period when being serviced from the Wainman Drive water main. The minimum pressure ranges of the affected properties are highlighted in Figure 4. Note that these service pressure concerns would be temporary, until the potable water balance tank and pump station is constructed as part of Phase 1 (refer below).

Potable water would initially be used to supply both the potable water and recycled water reticulation systems within Stage 1G & 1H.

6.2 Phase 1 - Development until the end of Stage 7 (2016)

Precinct 2 would be the third stage of North Cooranbong to be developed within Cooranbong Water's area of operations. There is not the required head in HWC's system to service Precinct 2 directly from the Wainman Drive connection point. This stage would therefore be serviced by the LWC site.

A transfer main from the Wainman Drive connection point to the LWC site and reticulation between the LWC site and Precinct 2 would be constructed. The direct HWC connection into the Stage 1 reticulation would be shut off and the development would be serviced from a balance tank and a water pumping station (WPS) at the LWC site.

Once the first 156 lots of North Cooranbong have been developed, the LWC would be commissioned and recycled water would be provided to the development. Potable water would not be required to service the recycled water reticulation, with the exception of top up of the recycled water system when there is a deficit of recycled water.

All of the remaining stages up until the end of Stage 7 would be serviced from the potable water balance tank and WPS located at the LWC site. The balance tank would be topped up from the Wainman Drive connection point over a 7 hour period between the off peak times of 11:30pm to 6:30am. A flow control valve would regulate this flow up until a draw of approximately of 23 L/s, which is required by Stage 7. The flow control valve would be gradually adjusted to match the demand of the development ensuring that the balance tank does not drop below 20% capacity during an extreme week.

The following major works would need to be undertaken to service up to the end of Stage 7 (refer Figure 5):

- A 2.4 ML potable water balance tank (this could also be provided by 2 x 1.2ML tanks).
- Approximately 600m of PVC-M DN300 water main between the connection point and the potable water balance tank.
- A potable water pumping station at the LWC containing two jockey pumps (one duty and one standby) to cater for low flows and two centrifugal pumps (one duty and one standby), with a capacity of approximately 21 L/s at 50 metres head to cater for fire flows (10L/s fire + 11L/s 95%ile demand). This WPS will be required to deliver fire flows and hence sufficient redundancy will be required.

Applying a direct draw of 23L/s from the Wainman Drive connection point over a 7 hour period between the off peak times of 11:30am to 6:30pm did not create any further service pressure issues than those already present in the HWC base model.

Therefore no upgrade to the HWC network is required to service the Cooranbong Development until the end of Stage 7 due to the unique way that Cooranbong Water is proposing to take bulk water from the HWC network.

6.3 Phase 2 - Stage 8 until the end of Stage 9 (2024)

From Stage 8 onward, potable water reservoirs would be constructed on a site in the northern part of Stage 10 of the North Cooranbong development. This site would be used for both potable and recycled water reservoirs.

The existing WPS at the LWC site would be reconfigured to deliver flows to fill the potable water reservoir via a delivery main. The WPS would no longer pump directly to reticulation mains within the development area.

An additional potable water pumping station would be located at the reservoir site and would transfer water from the reservoir to the reticulation network within the North Cooranbong development, to ensure that minimum pressure requirements are met.

To service the additional demand from the Cooranbong development from Stage 8 through to the end of Stage 9 the flow control valve on the Wainman Drive connection will be reconfigured to increase the flow from 23L/s up to 37L/s. It is proposed that water would be taken from the HWC network over a 7 hour period between the off peak times of 11:30pm to 6:30am only, ensuring that the minimum impact on the HWC network is achieved.

The following additional works would need to be undertaken to service up to Stage 10 (refer Figure 6):

- 2 x 2.5 ML potable water reservoirs on a site in the northern part of Stage 10.
- A potable water pumping station at the reservoir site containing two jockey pumps (one duty and one standby) to cater for low flows and three centrifugal pumps in parallel configuration (two duty and one standby), with a combined capacity with two pumps operating of approximately 36 L/s at 30 metres head to cater for fire flows (10L/s fire + 26L/s 95%ile demand). This WPS will be required to deliver fire flows and hence sufficient redundancy will be required.
- An upgrade of the potable water pumping station at the LWC site to contain two centrifugal pumps (one duty and one standby), with a capacity of approximately 12 L/s at 45 metres head. Additional configurations for pump rate can be investigated to allow pumping to be done over a shorter delivery timeframe.

- Approximately 2460m of PVC-M DN200 water main between the LWC potable water pumping station and the potable water reservoirs. Note this may be partially constructed as part of works up to Stage 7.

The timing of the reservoirs could also be staged, with one 2.5 ML reservoir constructed initially and the second reservoir constructed to meet the peak hour demand. However, this option reduces the storage available in the event of a failure within the potable water system at the LWC.

Applying a direct draw of 37L/s from the Wainman Drive connection point over a 7 hour period between the off peak times of 11:30pm to 6:30am did not create any further service pressure issues than those already present in the HWC base model.

Therefore no upgrade to the HWC network is required to service the ultimate Cooranbong Development due to the unique way that Cooranbong Water is proposing to take bulk water from the HWC network.

6.4 Phase 3 - Stage 10 to Ultimate Development (2030)

To service the additional demand from the Cooranbong development from Stage 10 through to the Ultimate development the flow control valve on the Wainman Drive connection will be reconfigured to increase the flow from 37 L/s up to a maximum of 50 L/s. It is proposed that water would be taken from the HWC network over a 7 hour period between the off peak times of 11:30pm to 6:30am only, ensuring that the minimum impact on the HWC network is achieved.

The following additional works would need to be undertaken to service up to ultimate development (refer Figure 7):

- Approximately 1900 m of DICL DN150 water main along Newport Road between Macquarie Street and Hawkmount Road.

6.5 Impact on previously affected properties

29 connections of the existing HWC system currently experience peak pressures below the recommend service pressure limits for an average cumulative duration of 3hrs 49 minutes per day. Once North Cooranbong has reached ultimate development these 29 connections will be below the HWC recommended service pressure limits for an average cumulative duration of 3hrs 41 minutes per day.

This indicates that applying a direct draw of 50L/s from the Wainman Drive connection point over a 7 hour period between the off peak times of 11:30pm to 6:30am will not create any further service pressure issues than those already present in the existing HWC system.

6.6 Capital Works Summary

A summary of the required works is provided in Table 6-1.

Table 6-1 Capital Works Summary

Works	Demand from HWC System	Peak Hour Demand	New HWC Infrastructure Required	New North Cooranbong Infrastructure Required	Cumulative Infrastructure Required
Initial Connection	Average Demand of 0.59 L/s	2.42 L/s		• Connection to Wainman Drive	• Connection to Wainman Drive
Phase 1	Up to 23 L/s between 11:30pm and 6:30am	13.04L/s		• 2.4ML balance tank • 600m PVC-M DN300 water main between the connection point and the balance tank • LWC WPS (21 L/s @50m)	• Connection to Wainman Drive • 2.4ML balance tank • 600m PVC-M DN300 water main between the connection point and the balance tank • LWC WPS (21 L/s @50m)
Phase 2	Up to 37 L/s between 11:30pm and 6:30am	31.62 L/s		• 2 x 2.5 ML potable water reservoirs • Reservoir WPS (36 L/s @ 30m) • Upgrade to LWC WPS (12 L/s @ 45m) • 2460m of PVC-M DN200 water main between the LWC WPS and the potable water reservoirs	• Connection to Wainman Drive • 2.4ML balance tank • 600m PVC-M DN300 water main between the connection point and the balance tank • 2 x 2.5 ML potable water reservoirs • Reservoir WPS (36 L/s @ 30m)

Works	Demand from HWC System	Peak Hour Demand	New HWC Infrastructure Required	New North Cooranbong Infrastructure Required	Cumulative Infrastructure Required
					• Upgrade to LWC WPS (12 L/s @ 45m) • 2460m of PVC-M DN200 water main between the LWC WPS and the potable water reservoirs
Phase 3	Up to 50 L/s between 11:30pm and 6:30am		• 1900m of DICL DN150 water main along Newport Road.		• Connection to Wainman Drive • 2.4ML balance tank • 600m PVC-M DN300 water main between the connection point and the balance tank • 2 x 2.5 ML potable water reservoirs • Reservoir WPS (36 L/s @ 30m) • Upgrade to LWC WPS (12 L/s @ 45m) • 2460m of PVC-M DN200 water main between the LWC WPS and the potable water reservoirs

Works	Demand from HWC System	Peak Hour Demand	New HWC Infrastructure Required	New North Cooranbong Infrastructure Required	Cumulative Infrastructure Required
					• 1900m of DICL DN150 water main along Newport Road.

7 HWC DEMANDS ONLY

The base case used for the modelling was HWC's existing water supply network from the Wangi Wangi reservoir (HWC 2014).

This existing system is already at capacity with 29 connections currently experiencing minimum peak pressures ranging from 7.2m to 18.9m. These properties do not meet the HWC service pressure limits specified in Table 2-6. This indicates that any further peak loads added to this system is only going to decrease the service pressure at these properties and create further low pressure issues in the network.

The predicted HWC growth at Points A, B and C (refer to Figure 4-1 and Table 4-1) were progressively included in the model to determine what HWC upgrades to the Wangi Wangi system are required to ensure a minimum of 20m service pressure is maintained during peak hour flows. This modelling assumed zero demand from the North Cooranbong development.

Where a reference to a year is included against an upgrade this date refers to the upgrade being completed and capacity available at the start of that year.

7.1 Newport Road Upgrade (Must be implemented by the start of 2016)

After applying the predicted 2016 HWC growth from Table 4-1 to the model, the results were analyzed to determine what impact the additional load had on the existing HWC network. The model results calculated a pressure drop across the network of approximately 1-2m during a peak hour demand period. This would result in a further 25 properties (total now being 54 properties) receiving inadequate service pressure during a peak week event.

The major bottle neck that is restricting the distribution of flow throughout the network is the existing DN200 watermain that runs along Newport Road, between Macquarie Street and Hawkmount Road. This pipeline is the main link between the Wangi Wangi Reservoir and the network to the west and is undersized to be able to support any future growth within the catchment. Duplication of this main is the most efficient way of allowing more flow into the network and increasing the system pressure.

In order to meet the additional HWC predicted demand for 2016 whilst ensuring that adequate service pressure is maintained during a peak week event, the following additional works would need to be undertaken (refer Figure 8):

- Approximately 1900 m of DICL DN 250 water main along Newport Road between Macquarie Street and Hawkmount Road.

This upgrade addresses 42 of the 54 connections that experience inadequate service pressures during a peak week and will service additional HWC development through to the ultimate development. The 12 connections that experience peak pressures below the HWC minimum service limits are due to their high elevation in relation to the rest of the network and not due to excessive pipe friction losses. Note that with the proposed upgrade these properties would receive a 5m increase in ultimate peak service pressure on top of the current base case condition.

WorleyParsons investigated options for staging this initial 1900m of DN250 pipeline. Due to the seriousness of the bottleneck it was discovered that to service the existing system with the 2016 growth, approximately 1200m of DN250 pipeline was required. As this represents almost the full length of the required upgrade, and undertaking only 1200m of upgrade meant that inadequate service pressures were again evident by 2018 (only 2 years later) it was determined that the full upgrade should be undertaken initially

It should be noted that there are two options for cross connections that have been identified in the network that could be made to help reduce some of the head loss in the system. These cross connections are as follows;

1. A cross connection between the existing DN200 and DN300 pipelines along Newport Road (refer to Figure 8)
2. A cross connection between the existing DN100 and DN200 between Cooranbong Road and Newport Road (refer to Figure 8)

Modelling has been completed to determine the impact of undertaking these two cross connections. It has been determined that the net benefit realized from these solutions is minimal and does not delay the requirement to construct the 1900m DN250 pipeline. Specifically completing the two cross connections noted above at the same time gave the following results;

- Pressure increase in the system for the 2016 growth of approximately 0.5-1m during a peak week
- Reduction in number of properties that experienced below minimum service pressure during a peak week in 2016 from 54 properties to 35 properties

As it can be seen above, undertaking the identified cross connections results in a small overall increase in service pressures during a peak week. However since this pressure increase does not result in a significant reduction to the number of properties that experience below acceptable service pressure, undertaking the cross connections is not seen as a valid solution.

7.2 Ultimate Development

The HWC growth projections for the remaining years (2018, 2022, 2030 and Ultimate) have been checked with the addition of this new 1900m of DN250 pipeline proposed in section 7.1 and the results have indicated that at ultimate development there are just the 12 connections mentioned previously that experience peak pressures below the HWC minimum service limits. It should be noted again that with the proposed upgrade, these 12 properties would have a 5m increase in peak service pressure at ultimate development compared with the existing base case condition.

7.3 Implications of not undertaking upgrades

As mentioned previously HWC's existing network is at capacity and currently has properties that do not comply with minimum peak service pressure limits. The InfoWorks model was run without the proposed DN250 watermain upgrade and the number of nodes that experienced below minimum service pressures for greater than 30 minutes were recorded in Table 7-1 below.

Table 7-1 Number of nodes below minimum service pressure

Year	Total nodes affected[1]	Nodes (0-3m)	Nodes (3-12m)	Nodes (12-20m)
Current	7	0	1	6
2016	8	0	1	7
2018	11	0	3	8
2022	51	1	4	46
2030	146	2	15	129
Ultimate	175	2	31	142

Note: 1. Each node in the model has between1 and 9 properties connected to it.

8 NORTH COORANBONG & HWC DEMANDS COMBINED

The base case used for the modelling was HWC's existing water supply network from the Wangi Wangi reservoir (HWC 2014).

This existing system is already at capacity with 29 connections currently experiencing minimum peak pressures ranging from 7.2m to 18.9m. These properties do not meet the HWC service pressure limits specified in Table 2-6. This indicates that any further peak loads added to this system is only going to decrease the service pressure at these properties and create further low pressure issues in the network.

The predicted North Cooranbong and HWC potable water demands (refer to Table 4-2) were progressively included in the model to determine what upgrades are required to service the North Cooranbong development and ensure a minimum of 20m service pressure is maintained within the HWC network during peak hour flows.

Where a reference to a year is included against an upgrade this date refers to the upgrade being completed and capacity available at the start of that year.

8.1 Initial Potable Water Connection (2015)

The initial development (up until the end of Stage 1G & 1H) would be serviced via connection to the existing 300 mm diameter HWC potable water main in Wainman Drive.

As mentioned in Section 3.2, the LWC will not be operational until the first 156 lots have been developed. Therefore the recycled water reticulation for the initial stages would be supplied with potable water until a supply of recycled water is available from the LWC.

8.1.1 Stage 1E & 1F

The first stage of North Cooranbong to be developed within Cooranbong Water's area of operations would be Stage 1E & 1F (refer Table 2-2). This stage would be serviced via connection to the existing 300 mm diameter HWC potable water main in Wainman Drive (refer Figure 4). A bulk water meter and check valve would be located at this connection point.

The peak hour potable water demand for Stage 1E & 1F would be 1.20 L/s (refer Table 3-2), which could be serviced from the Wainman Drive main without the need for booster pumping or upgrades to the existing HWC potable water system.

Potable water would initially be used to supply both the potable water and recycled water reticulation systems within Stage 1E & 1F.

8.1.2 Stage 1G & 1H

The second stage to be developed within Cooranbong Water's area of operations would be Stage 1G & 1H. This stage would connect to the potable water reticulation supplying Stage 1E & 1F.

The total peak hour potable water demand from Stage 1E & 1F and Stage 1G & 1H would be 2.42 L/s (refer Table 3-2). Several properties within Stage 1G & 1H may experience low service pressures during a peak hour demand period when being serviced from the Wainman Drive water main. The minimum pressure ranges of the affected properties are highlighted in Figure 4. Note that these service pressure concerns would be temporary, until the potable water balance tank and pump station is constructed as part of Phase 1 (refer below).

Potable water would initially be used to supply both the potable water and recycled water reticulation systems within Stage 1G & 1H.

8.2 Phase 1 - Development until the end of Stage 7 (2016)

Precinct 2 would be the third stage of North Cooranbong to be developed within Cooranbong Water's area of operations. There is not the required head in HWC's system to service Precinct 2 directly from the Wainman Drive connection point. This stage would therefore be serviced by the LWC site.

A transfer main from the Wainman Drive connection point to the LWC site and reticulation between the LWC site and Precinct 2 would be constructed. The direct HWC connection into the Stage 1 reticulation would be shut off and the development would be serviced from a balance tank and a water pumping station (WPS) at the LWC site.

Once the first 156 lots of North Cooranbong have been developed, the LWC would be commissioned and recycled water would be provided to the development. Potable water would not be required to service the recycled water reticulation, with the exception of top up of the recycled water system when there is a deficit of recycled water.

All of the remaining stages up until the end of Stage 7 would be serviced from the potable water balance tank and WPS located at the LWC site. The balance tank would be topped up from the Wainman Drive connection point over a 7 hour period between the off peak times of 11:30pm to 6 am. A flow control valve would regulate this flow up until a draw of approximately of 23 L/s, which is required by Stage 7. The flow control valve would be gradually adjusted to match the demand of the development ensuring that the balance tank does not drop below 20% capacity during an extreme week.

After applying the predicted HWC 2016 demands from Table 4-2 to the model, the results were analyzed to determine what impact the additional load had on the existing HWC network. The model results calculated a pressure drop across the network of approximately 1-2m during a peak hour demand period. This would result in a further 25 properties (total now being 54 properties) receiving inadequate service pressure during a peak week event.

An initial direct draw of 4 L/s (required in 2016 to ensure the volume of the balance tank is greater than 20% in an extreme week) from the Wainman Drive connection point over a 7 hour period between the off peak times of 11:30pm to 6:30am did not create any further service pressure issues than those already present.

The major bottle neck that is restricting the distribution of flow throughout the network is the existing DN200 watermain that runs along Newport Road, between Macquarie Street and Hawkmount Road. This pipeline is the main link between the Wangi Wangi Reservoir and the network to the west and is undersized to be able to support any future growth within the catchment. Duplication of this main is the most efficient way of allowing more flow into the network and increasing the system pressure.

In order to meet the additional demand for 2016 whilst ensuring that adequate service pressure is maintained during a peak week event, the following works would need to be undertaken (refer Figure 9):

- Approximately 1900 m of DICL DN 250 water main along Newport Road between Macquarie Street and Hawkmount Road.

This upgrade addresses 42 of the 54 connections that experience inadequate service pressures during a peak week and will service additional development through to the ultimate development. The 12 connections that experience peak pressures below the HWC minimum service limits are due to their high elevation in relation to the rest of the network and not due to excessive pipe friction losses. Note that with the proposed upgrade these properties would receive a 5m increase in ultimate peak service pressure on top of the current base case condition.

The 2018 and 2022 demands were then checked with the addition of this new 1900m of DN250 pipeline as well as drawing up to 23 L/s by the end of Stage 7 from the Wainman Drive connection point between the off peak times of 11:30pm to 6:30am. The results determined that no additional upgrade to the HWC network was required.

The following additional major works would need to be undertaken by North Cooranbong to service up to the end of Stage 7 (refer Figure 9):

- A 2.4 ML potable water balance tank (this could also be provided by 2 x 1.2ML tanks).
- Approximately 600m of PVC-M DN300 water main between the connection point and the potable water balance tank.
- A potable water pumping station at the LWC containing two jockey pumps (one duty and one standby) to cater for low flows and two centrifugal pumps (one duty and one standby), with a capacity of approximately 21 L/s at 50 metres head to cater for fire flows (10L/s fire + 11L/s 95%ile demand). This WPS will be required to deliver fire flows and hence sufficient redundancy will be required.

8.3 Phase 2 - Stage 8 to Ultimate Development

From Stage 8 onward, potable water reservoirs would be constructed on a site in the northern part of Stage 10 of the North Cooranbong development. This site would be used for both potable and recycled water reservoirs.

The existing WPS at the LWC site would be reconfigured to deliver flows to fill the potable water reservoir via a delivery main. The WPS would no longer pump directly to reticulation mains within the development area.

An additional potable water pumping station would be located at the reservoir site and would transfer water from the reservoir to the reticulation network within the North Cooranbong development, to ensure that minimum pressure requirements are met.

To service the additional demand from the Cooranbong development from Stage 8 through to the Ultimate development the flow control valve on the Wainman Drive connection will be reconfigured to increase the flow from 23 L/s up to a maximum of 50 L/s. It is proposed that water would be taken from the HWC network over a 7 hour period between the off peak times of 11:30pm to 6:30am only, ensuring that the minimum impact on the HWC network is achieved.

The following additional works would need to be undertaken to service up to ultimate development (refer Figure 10):

- 2 x 2.5 ML potable water reservoirs on a site in the northern part of Stage 10.
- A potable water pumping station at the reservoir site containing two jockey pumps (one duty and one standby) to cater for low flows and three centrifugal pumps in parallel configuration (two duty and one standby), with a combined capacity with two pumps operating of approximately 36 L/s at 30 metres head to cater for fire flows (10L/s fire + 26L/s 95%ile demand). This WPS will be required to deliver fire flows and hence sufficient redundancy will be required.
- An upgrade of the potable water pumping station at the LWC site to contain two centrifugal pumps (one duty and one standby), with a capacity of approximately 12 L/s at 45 metres head. Additional configurations for pump rate can be investigated to allow pumping to be done over a shorter delivery timeframe.
- Approximately 2460m of PVC-M DN200 water main between the LWC potable water pumping station and the potable water reservoirs. Note this may be partially constructed as part of works up to Stage 7.

The timing of the reservoirs could also be staged, with one 2.5 ML reservoir constructed initially and the second reservoir constructed to meet the peak hour demand. However, this option reduces the storage available in the event of a failure within the potable water system at the LWC.

The HWC growth projections for the ultimate development including an ultimate North Cooranbong direct draw of 50L/s from the Wainman Drive connection point over a 7 hour period between the off peak times of 11:30pm to 6:30am have been modeled with the addition of the proposed 1900m DN250 pipeline. The results indicate that at ultimate development there are still the 12 connections mentioned in Section 7.1 that experience peak pressures below the HWC minimum service limits. It should be noted again that with the proposed upgrade, these 12 properties would have a 5m increase in peak service pressure at ultimate development compared with the existing base case condition.

8.4 Capital Works Summary

A summary of the required works is provided in Table 8-1.

Table 8-1 Capital Works Summary

Works	Demand from HWC System	Peak Hour Demand	New HWC Infrastructure Required	New North Cooranbong Infrastructure Required	Cumulative Infrastructure Required
Initial Connection	Average Demand of 0.59 L/s	2.42 L/s		• Connection to Wainman Drive	• Connection to Wainman Drive
Phase 1	Up to 23 L/s between 11:30pm and 6:30am	13.04L/s	• 1900m of DICL DN250 water main along Newport Road.	• 2.4ML balance tank • 600m PVC-M DN300 water main between the connection point and the balance tank • LWC WPS (21 L/s @50m)	• Connection to Wainman Drive • 2.4ML balance tank • 600m PVC-M DN300 water main between the connection point and the balance tank • LWC WPS (21 L/s @50m) • 1900m of DICL DN250 water main along Newport Road.
Phase 2	Up to 50 L/s between 11:30pm	31.62 L/s		• 2 x 2.5 ML potable water reservoirs • Reservoir WPS (36	• Connection to Wainman Drive • 2.4ML balance tank

Works	Demand from HWC System	Peak Hour Demand	New HWC Infrastructure Required	New North Cooranbong Infrastructure Required	Cumulative Infrastructure Required
	and 6:30am			L/s @ 30m) • Upgrade to LWC WPS (12 L/s @ 45m) • 2460m of PVC-M DN200 water main between the LWC WPS and the potable water reservoirs	• 600m PVC-M DN300 water main between the connection point and the balance tank • 1900m of DICL DN250 water main along Newport Road. • 2 x 2.5 ML potable water reservoirs • Reservoir WPS (36 L/s @ 30m) • Upgrade to LWC WPS (12 L/s @ 45m) • 2460m of PVC-M DN200 water main between the LWC WPS and the potable water reservoirs

9 SECURITY OF SUPPLY

The North Cooranbong development reservoirs consist of the following:

- 2.4ML at the LWC site
- 5 ML at the Reservoir site

Cooranbong Water may choose to utilize the storage within their internal reservoirs for security of supply in the event that HWC encounter a system interruption which temporarily prevents supply of water into the North Cooranbong development.

A scenario has been modelled in which the direct draw from HWC was taken offline for 1 day (7 hours between 11:30pm to 6:30am) during an extreme week. In this scenario the North Cooranbong reservoirs would not run out of water during the extreme week but may fall below 20% capacity. It is envisaged that losing supply for a full 24hr period would be the maximum foreseeable interruption possible.

If an event like this occurred the proposed North Cooranbong development would not run out of water, however as this would be considered an extreme/unlikely event it is envisaged that HWC would allow provision for Cooranbong Water to extract a percentage of the interrupted supply outside of their regular 7hr window to allow for the North Cooranbong reservoirs to recover. This may cause some short term impacts to the wider HWC network however this will be temporary in nature and only exist for that day.

Some other internal security of supply options for Cooranbong Water to consider include:

- Providing backup diesel pumps in case either of the water pump stations loses power.
- Providing a cross connection between the reservoirs so that supply can be maintained in case one reservoir needs to be taken offline.

10 COST ESTIMATE

A high level cost estimate has been prepared for the DN150 and DN250 water mains along Newport Road. Version 2.03 of the HWC Estimating Guidelines Tool has been used to estimate the capital cost of the proposed works (refer to Appendix A). To compile this cost estimate, the following assumptions have been made:

- No allowance has been made for acquiring easements.
- Pipe work is assumed to be DICL
- Area classification B1 has been used as per HWC Estimating Guidelines.
- Terrain classification A has been used as per HWC Estimating Guidelines.
- Road crossings have been included, as per HWC Estimating Guidelines.
- For the portions where the main will be installed using an open trench a cost for the restoration of the ground surface is included.
- An allowance for pipelines being constructed close to several other existing services has been included.
- An allowance for tree removal and trimming has been included for various sections of pipework.
- An allowance for traffic management during construction has been included.
- A default allowance for valves and fittings has been generated by the HWC Estimating Tool.
- The estimate excludes dewatering of the open cut excavation.
- The estimate excludes HWC Fees/Charges.
- The estimate assumes no excavation through rock.
- The estimate excludes relocation of any existing services.

11 MODEL ASSUMPTIONS

HWC supplied WorleyParsons with a section of their InfoWorks Wangi Wangi supply network model which extends from the DN200 watermain at the corner of Newport Road and Watt Street.

The model was edited and run using a range of scenarios to verify that adequate service pressure could be maintained and that the North Cooranbong reservoirs did not fall below 20% capacity during an extreme week demand period.

The following key assumptions were made when editing the model:

- For (2016, 2018 and 2022) the average potable water demands for North Cooranbong were allocated to a single node connected to the balance tank at the LWC. Demands were based on the staging plan presented in Table 4-1.
- For (2030 and ultimate) the average potable water demands for North Cooranbong were allocated to a single node connected to the North Cooranbong reservoir. Demands were based on the staging plan presented in Table 4-1.
- For (2016 – ultimate) the average potable water demands for HWC growth was allocated to the three nodes illustrated in Figure 4-1. Demands were based on the staging plan presented in Table 4-1.
- The demand factors in Table 2-4 were applied to the average daily demands entered at each node.
- The diurnal factors in Table 2-5 were entered into the model to simulate the distribution of demands over a peak week.
- All internal pipework inside of the North Cooranbong development area was modelled as PVC-M (PN16).
- All pipes outside of the North Cooranbong development area were modelled as DICL (PN35).
- The potable water balance tank located at the highest elevation in the LWC has been modelled as 2.4 ML. The bottom water level of this tank was modelled at RL 15 m, while the top water level was modelled at RL 20 m.
- The interim WPS at the LWC with a duty of approximately 21 L/s at 50 metres head was modelled to pump potable water from the balance tank at the LWC to the development catering for fire flows + 95%ile flows up to completion of Stage 7B. Note that 10 L/s was assumed for firefighting although 20 L/s may be required for properties that are zoned as commercial as per WSA 03-2002-2.3 Section HW 2.2.3.7
- The upgraded pump at the LWC was modelled to delivery water from the balance tank to the reservoirs at a duty of 12 L/s at 45 meters head.

- The North Cooranbong potable water reservoir has been modelled as 5 ML. The bottom of this reservoir was modelled at RL 40m, while the top water level was modelled at RL 45m.
- An ultimate WPS with a duty of approximately 36 L/s at 30 metres head was modelled to pump potable water from the reservoir catering for fire flows + 95%ile flows for the entire development. Note that 10 L/s was assumed for firefighting although 20 L/s may be required for properties that are zoned as commercial as per WSA 03-2002-2.3 Section HW 2.2.3.7
- A flow control valve has been modelled to limit the draw from the HWC system into the balance tank to 50 L/s from between 11:30pm and 6:30am.
- An allowance for regular potable water top up to the recycled water system has been made during average, peak and extreme demand periods.

12 REFERENCES

HWA (2008)

North Cooranbong Water Supply Servicing Strategy. Hunter Water Australia. Revision C. 15 May 2008.

SMEC (2013)

North Cooranbong Development Water Servicing Strategy. SMEC. Revision C. September 2013.

WP (2014)

North Cooranbong Development, Potable and Recycled Water Masterplan. WorleyParsons. May 2014.

HWC (2014)

Cooranbong System InfoWorks Model. Hunter Water Corporation. July 2014.

Figures

FIGURE 1

flow systems

Cooranbong Water

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NORTH COORANBONG
LOCALITY PLAN

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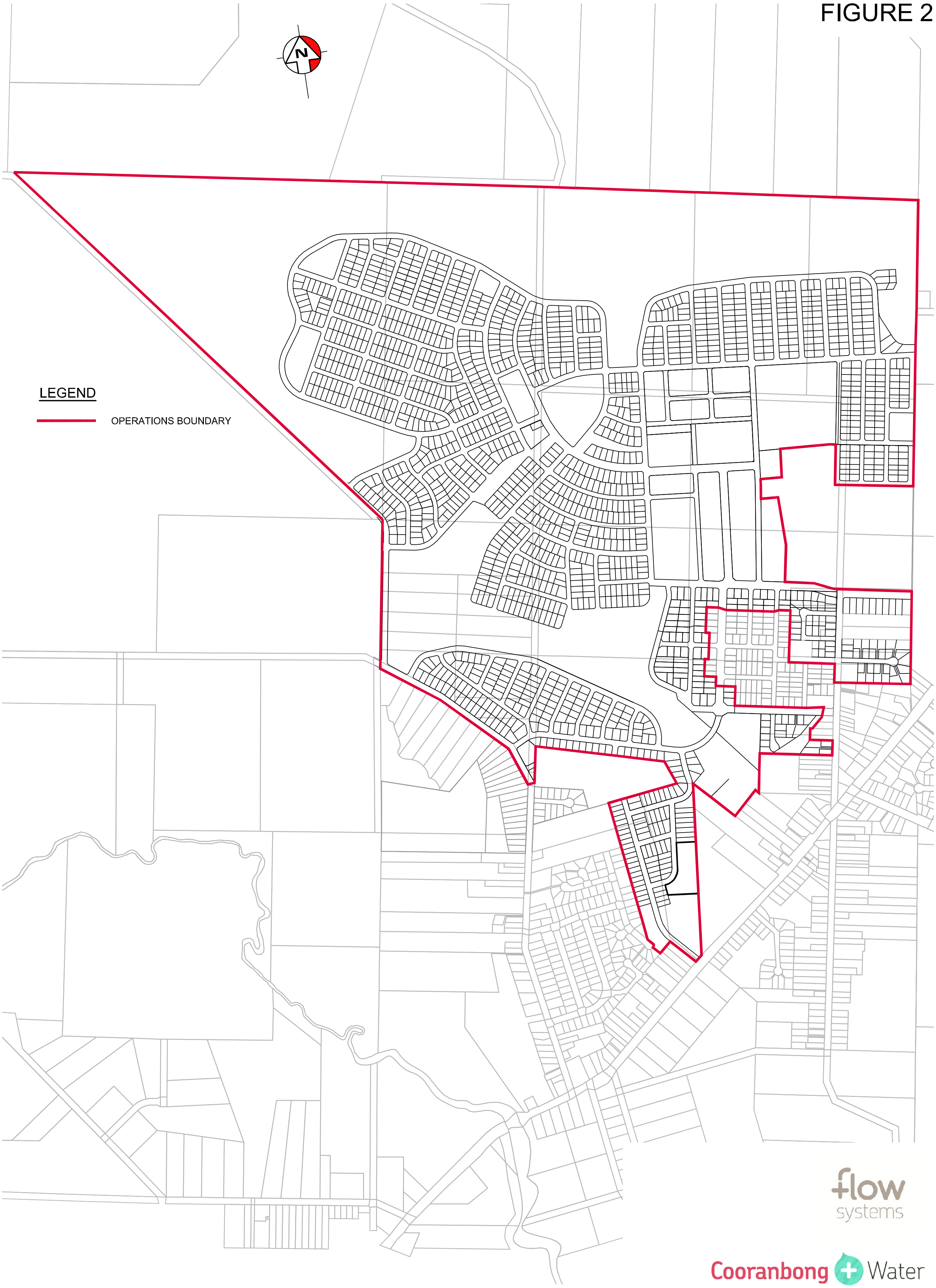
FIGURE 2



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COORANBONG WATER
AREA OF OPERATIONS

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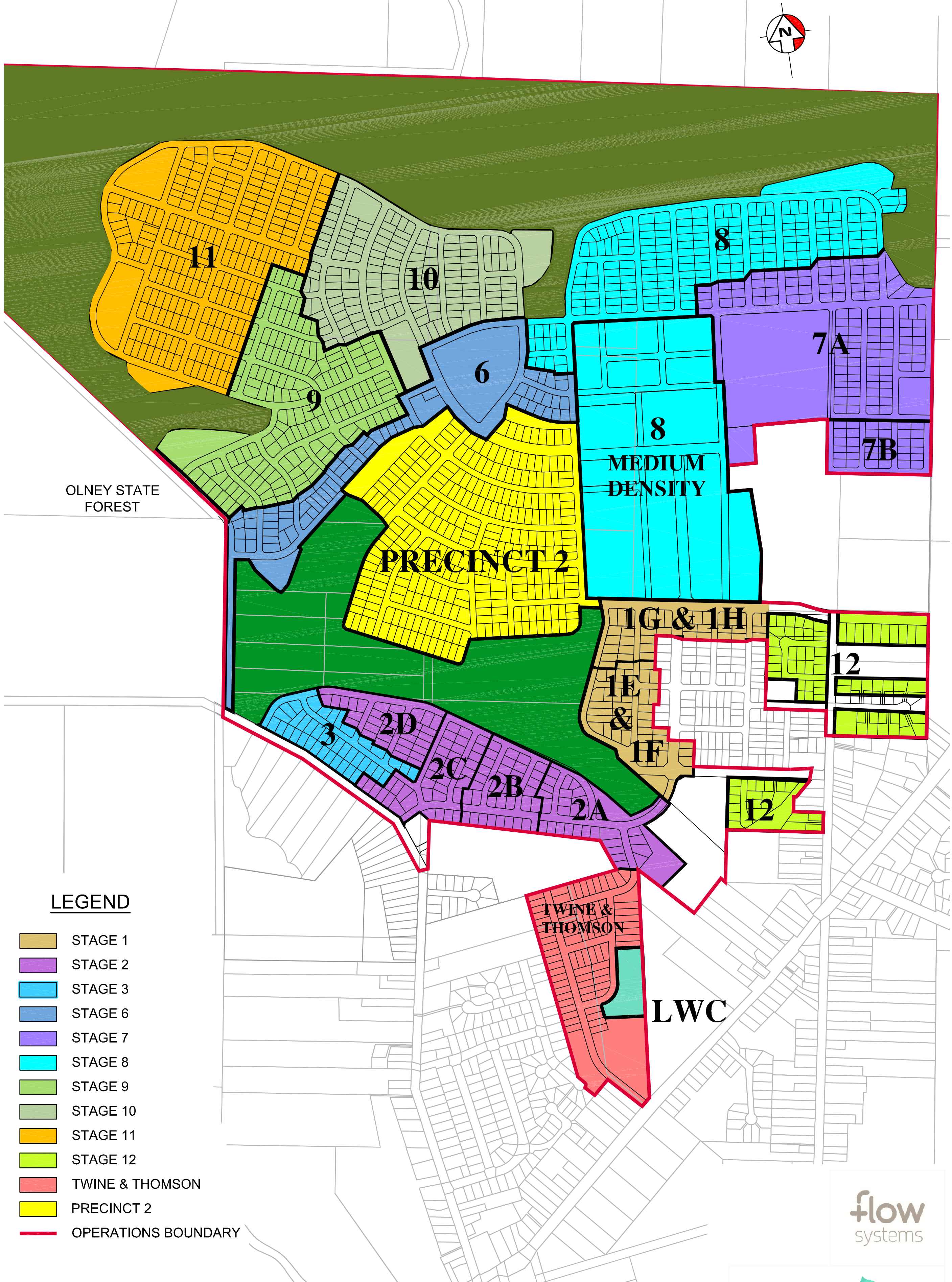
FIGURE 3



flow systems

Cooranbong Water

WorleyParsons
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NORTH COORANBONG
DEVELOPMENT STAGING

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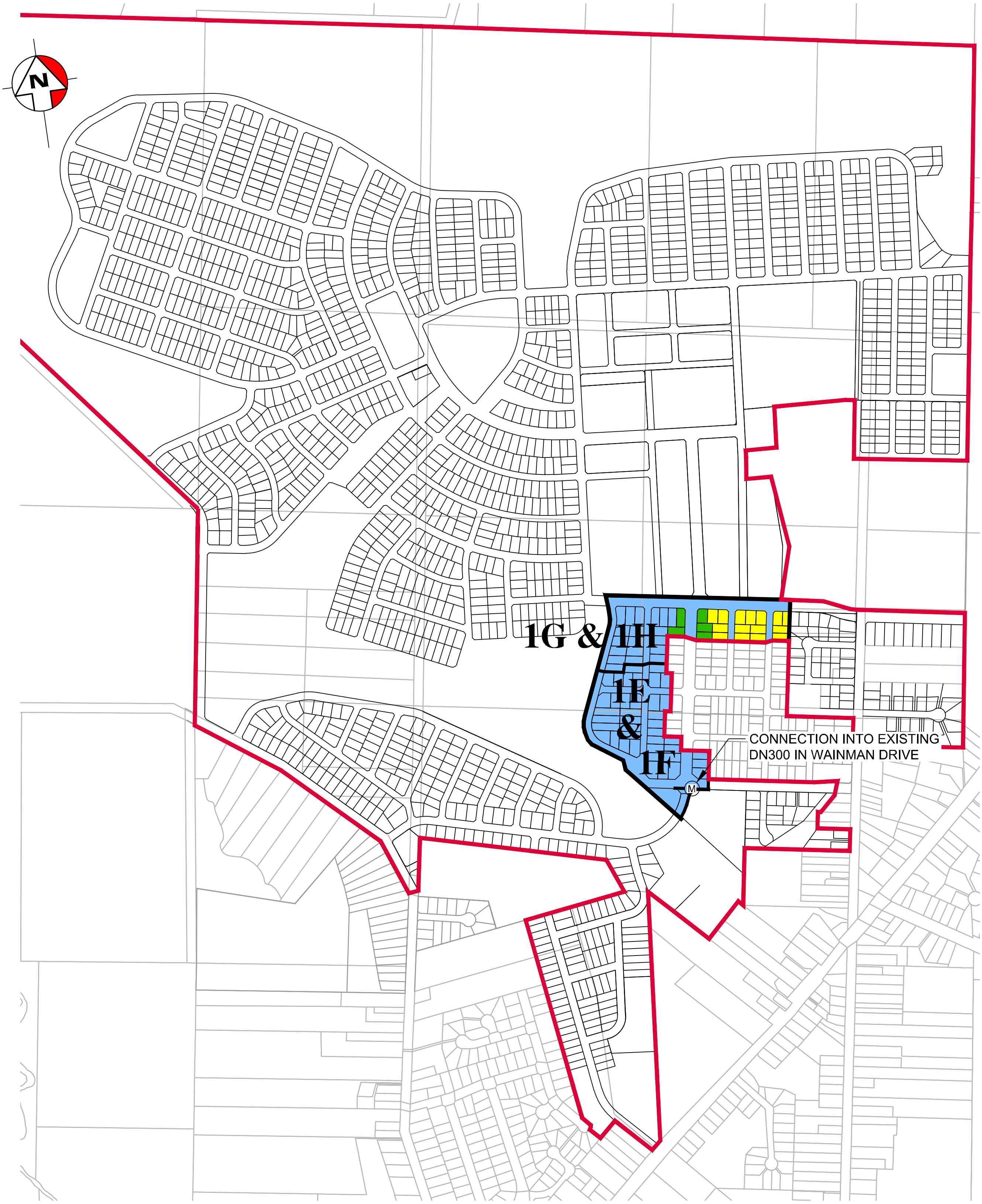

LEGEND

STAGES SERVICED

BULK WATER METER

OPERATIONS BOUNDARY

SERVICE PRESSURE DURING PEAK HOUR DEMAND

14 - 17m

17- 20m

flow systems

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NORTH COORANBONG
BULK WATER SERVICING STRATEGY
INITIAL CONNECTION

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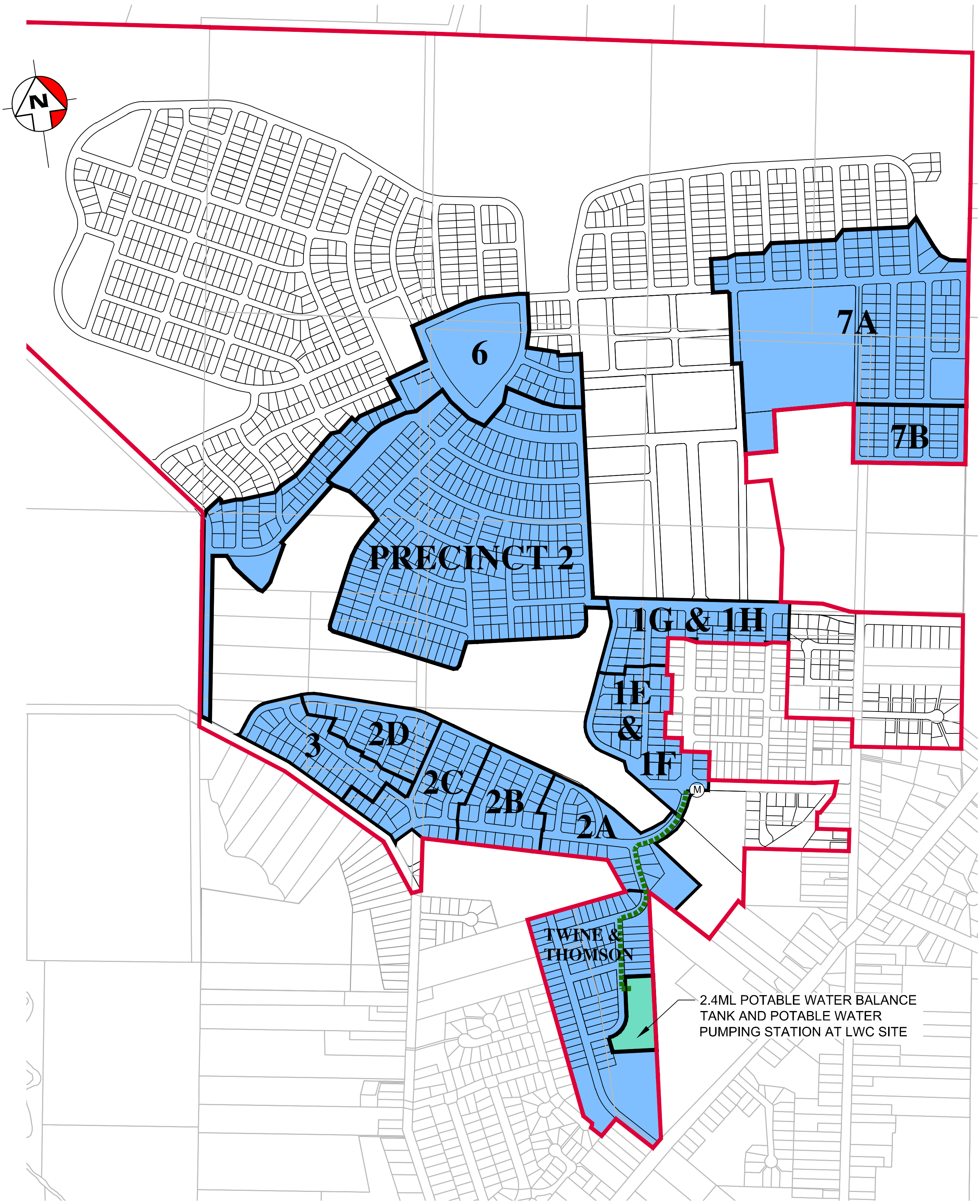
FIGURE 5



LEGEND

STAGES SERVICED

(M) BULK WATER METER

DN300 PVC-M DELIVERY MAIN TO BALANCE TANK (APPROX. 600m)

OPERATIONS BOUNDARY

flow systems

Cooranbong Water

WorleyParsons resources & energy

NORTH COORANBONG
BULK WATER SERVICING STRATEGY - PHASE 1
DEVELOPMENT UNTIL THE END OF STAGE 7

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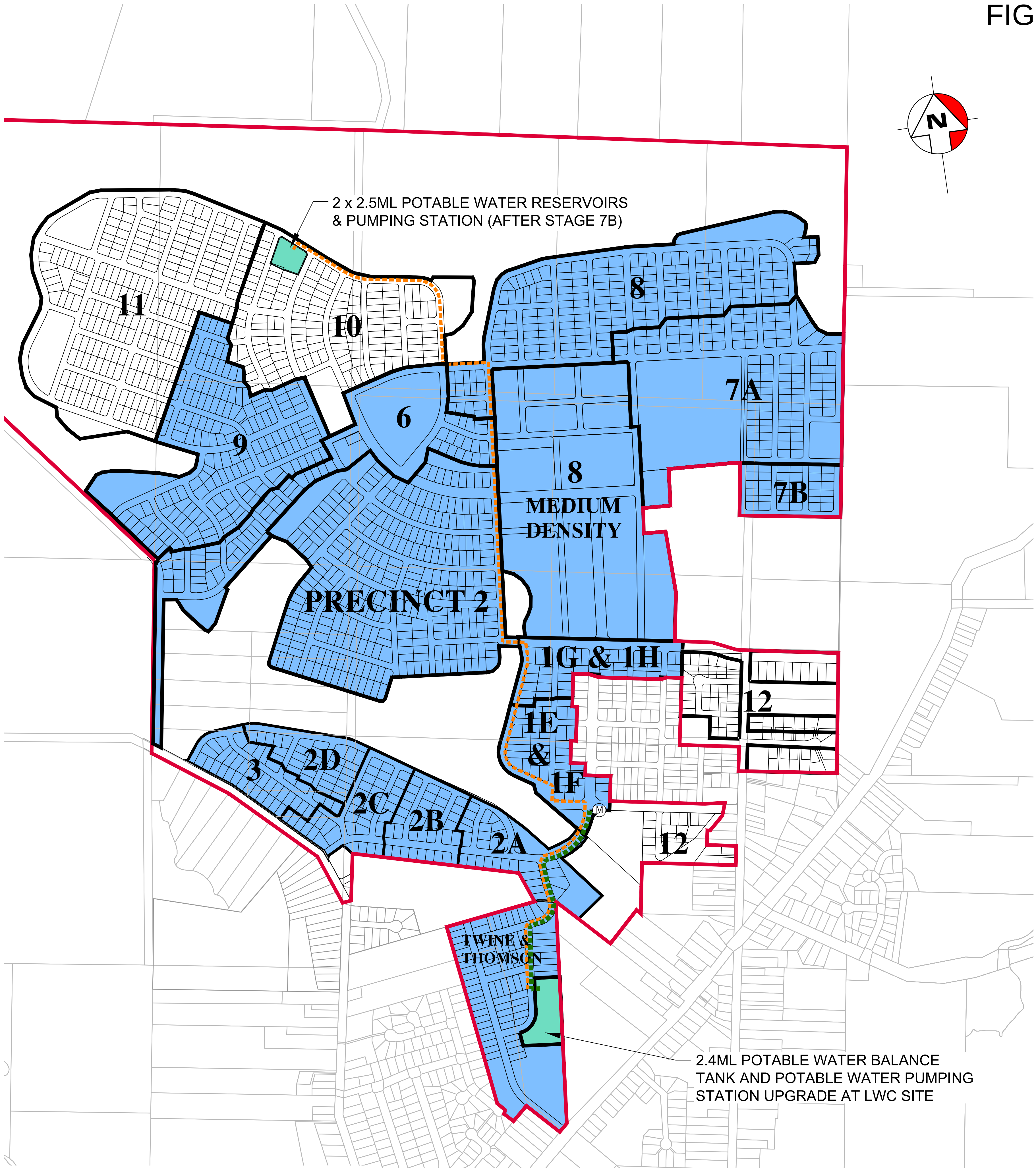
FIGURE 6



LEGEND

STAGES SERVICED

(M) BULK WATER METER

DN300 PVC-M DELIVERY MAIN TO BALANCE TANK (APPROX. 600m)

OPERATIONS BOUNDARY

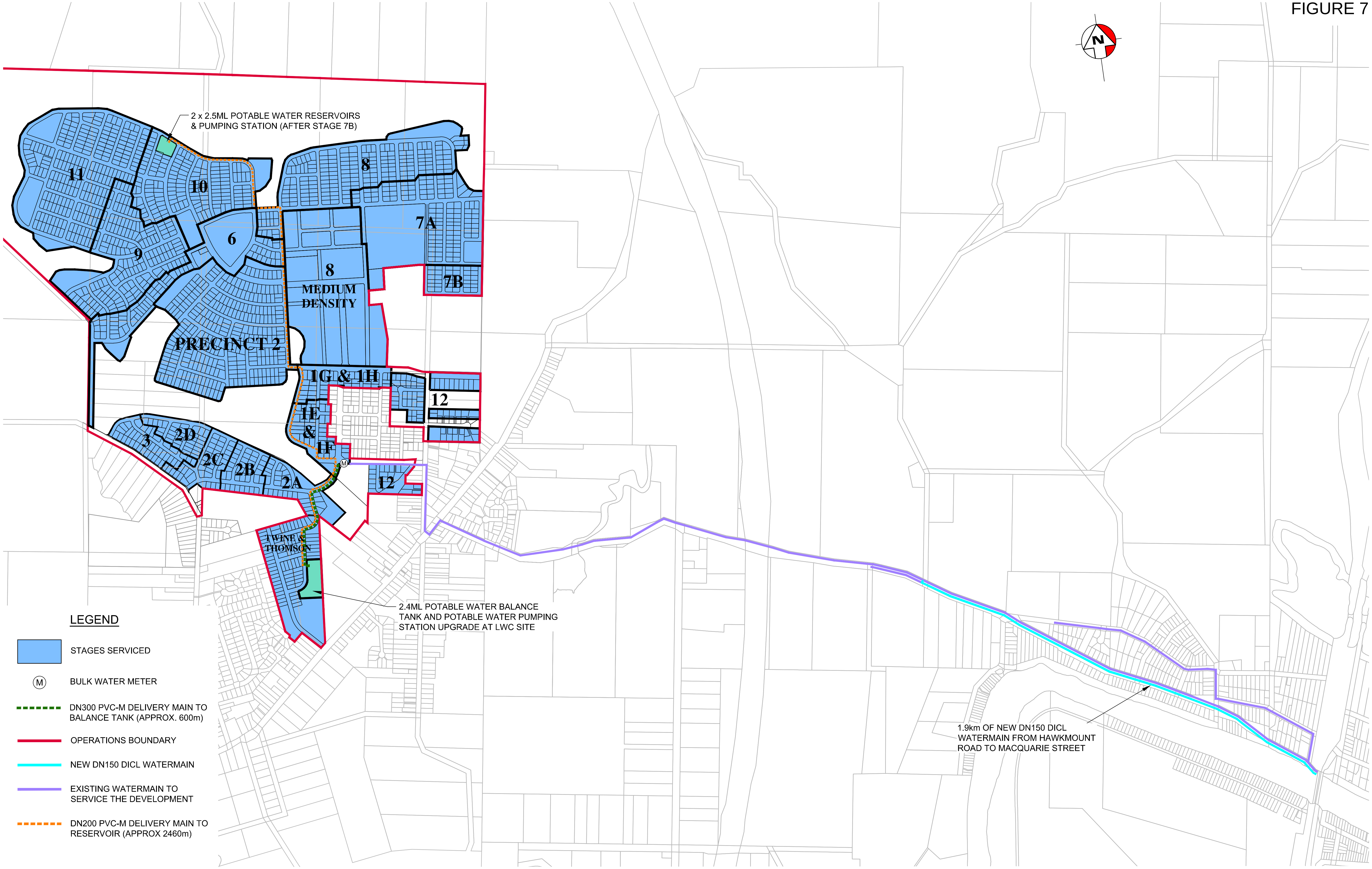
DN200 PVC-M DELIVERY MAIN TO RESERVOIR (APPROX 2460m)

Cooranbong Water

WorleyParsons
resources & energy

NORTH COORANBONG
BULK WATER SERVICING STRATEGY - PHASE 2
STAGE 8 UNTIL THE END OF STAGE 9

FIGURE 7



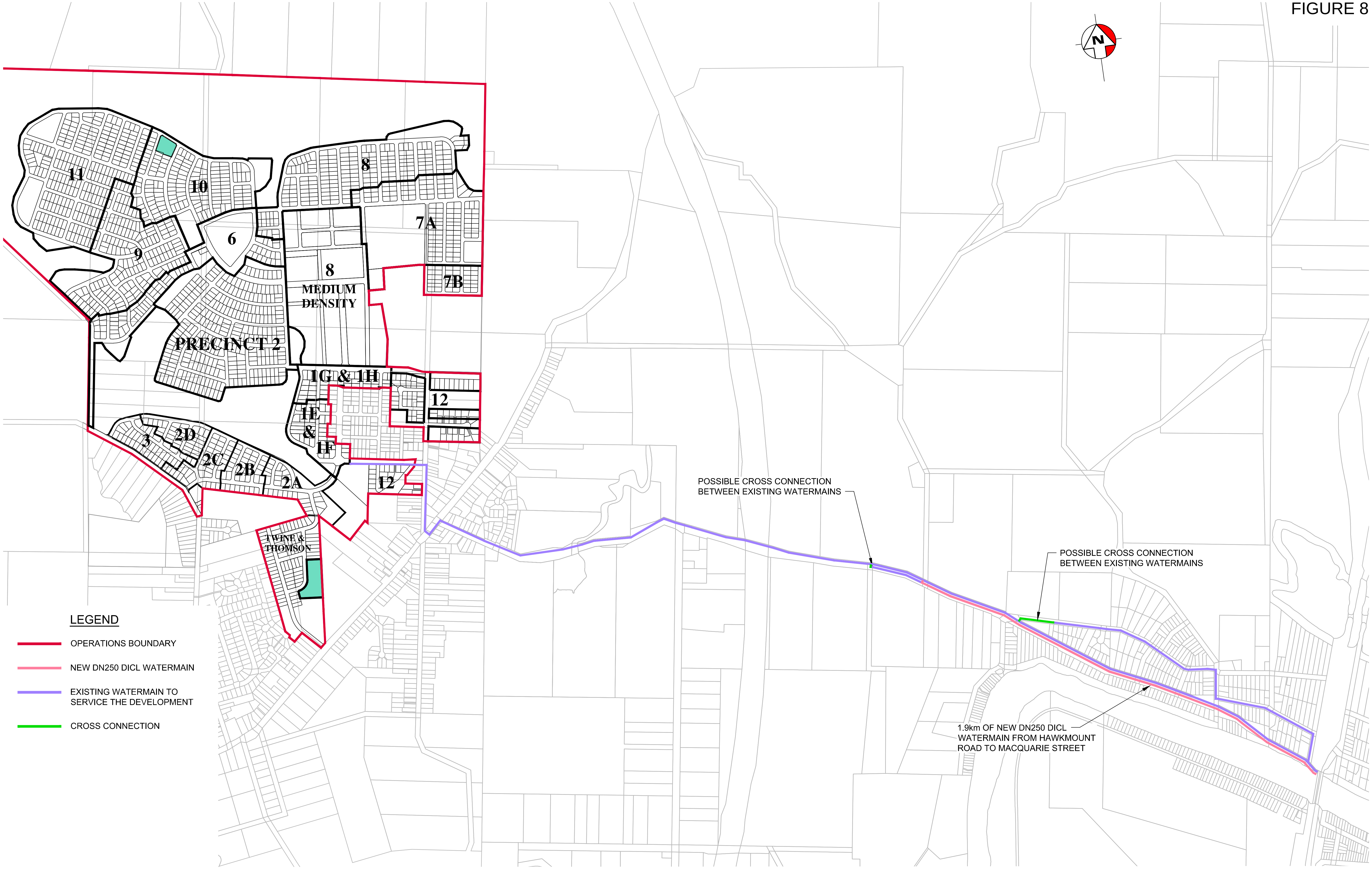
WorleyParsons resources & energy

Cooranbong Water

flow systems

NORTH COORANBONG
BULK WATER SERVICING STRATEGY - PHASE 3
STAGE 10 TO ULTIMATE DEVELOPMENT

FIGURE 8



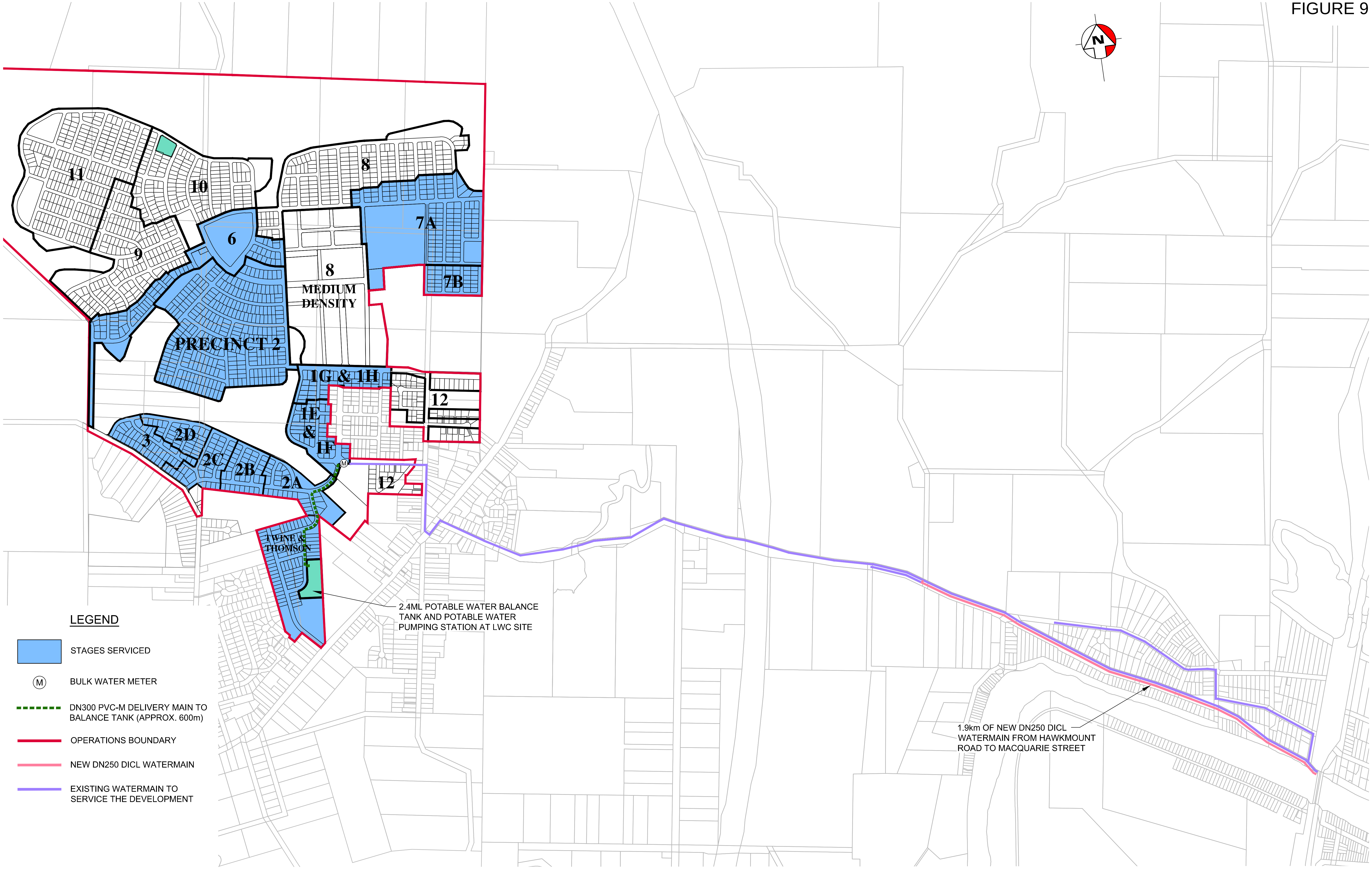
WorleyParsons resources & energy

Cooranbong Water

flow systems

NORTH COORANBONG
BULK WATER SERVICING STRATEGY
HWC DEMANDS ONLY - NEWPORT ROAD UPGRADE

FIGURE 9



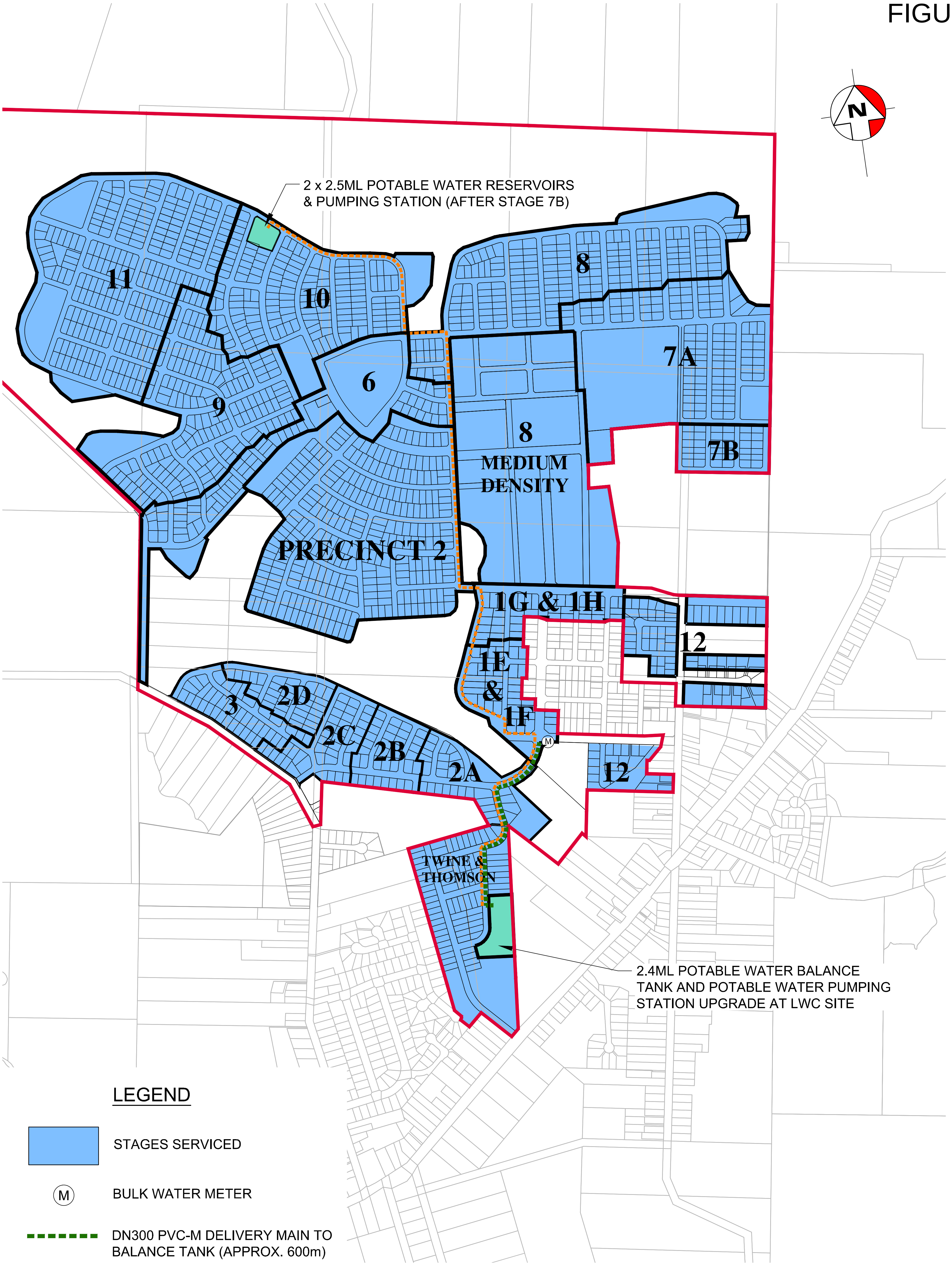
WorleyParsons
resources & energy

Cooranbong Water

flow systems

NORTH COORANBONG
BULK WATER SERVICING STRATEGY - PHASE 1
DEVELOPMENT UNTIL THE END OF STAGE 7

FIGURE 10



LEGEND

STAGES SERVICED

(M) BULK WATER METER

DN300 PVC-M DELIVERY MAIN TO BALANCE TANK (APPROX. 600m)

OPERATIONS BOUNDARY

DN200 PVC-M DELIVERY MAIN TO RESERVOIR (APPROX 2460m)

flow systems

Cooranbong Water

WorleyParsons
resources & energy

NORTH COORANBONG
BULK WATER SERVICING STRATEGY - PHASE 2
FROM STAGE 8 TO ULTIMATE DEVELOPMENT

Appendix A – Cost Estimate

ESTIMATING SHEET

PROJECT DESCRIPTION: DN150 water main along Newport Road

Item No.	Item Description	Qty	Unit	Rate $/Unit	Amount $
HW0001	All work not included elsewhere in this schedule	Item	Lump Sum	$ 10,357.00	$ 10,357
HW0002	Site Establishment	Item	Lump Sum	$ 15,000.00	$ 15,000
HW0003	Site Disestablishment	Item	Lump Sum	$ 15,000.00	$ 15,000
HW0004	Preparation and implementation of the Construction EMP	Item	Lump Sum	$ 4,000.00	$ 4,000
HW0005	Preparation and implementation of the Safety Management Plan.	Item	Lump Sum	$ 9,000.00	$ 9,000
HW0006	Preparation and implementation of the Traffic Control Plan.	Item	Lump Sum	$ 25,300.00	$ 25,300
HW0007	Preparation and Implementation of Quality Management Plan	Item	Lump Sum	$ 6,328.63	$ 6,329

Water Pipeline - Trunk - section will be present if one or more trunk watermains are specified

Item	Construction of Trunk Mains	Qty	Unit	Rate $/Unit	Amount $
HWT001	Service Location	Item	Lump Sum	$ 1,516.20	$ 1,516
HWT02.01	DN150 Valves / Flowmeters	Item	Lump Sum	$ 20,370.00	$ 20,370
HWT003	Supply all fittings	Item	Lump Sum		
HWT03.01	DN150 Fittings	Item	Lump Sum	$ 2,800.00	$ 2,800
HWT004	Supply all pipes materials, including detector tape, pipe protection wrapping, rubber rings and lubricant for following pipe sizes:				
31EDSS	Nominal DN150 DICL pipe	1900	m	$ 68.00	$ 129,200
HWT005	Clear, excavate, lay, join, bed, backfill & test reticulation pipelines (installation). Up to **1.5 m depth** to invert in OTR.				
31EDSS	Nominal DN150 DICL (Trench type B)	1900	m	$ 105.36	$ 200,177
HWT018	Road / creek crossings				
HWT018.01	Thrustbore 1	15	m	$ 603.00	$ 9,045
HWT018.02	Thrustbore 2	15	m	$ 603.00	$ 9,045
HWT018.03	Thrustbore 3	15	m	$ 603.00	$ 9,045
HWT018.04	Thrustbore 4	15	m	$ 603.00	$ 9,045
HWT018.05	Open Cut 1	40	m	$ 57.00	$ 2,280
HWT018.06	Open Cut 2	15	m	$ 57.00	$ 855
HWT027	Preparation of line sheets	1900	m	$ 1.16	$ 2,204
HWT000	***Sub Total***				$ 395,582

Item No.	Item Description	Qty	Unit		Amount $
HW0009	Restoration - Pipelines:				
HW0009.02	Concrete driveway	76.7	m2	$ 185.00	$ 14,190
HW0009.10	Turf	1280	m2	$ 11.00	$ 14,080
HW0009.11	Grass seeding	5600	m2	$ 7.00	$ 39,200
HW0012	Preconstruction record				
HW0012.01	Photographic	Item	Lump Sum	$ 1,311.00	$ 1,311
HW0013	Work as Constructed Information	Item	Lump Sum	$ 15,200.00	$ 15,200

A.	**TOTAL ESTIMATED CONTRACT AWARD SUM**	$ 564,549

B.	**PRE-CONSTRUCTION COST (Table 10)**	
HW0016	Design (15% of A)	$ 84,682
HW0017	Project Management of Design (20% of Design + $10,000)	$ 26,936
	Sub Total(B1)	$ 111,619
	Pre construction contingency (30% of B1)	$ 33,486
	TOTAL PRE-CONSTRUCTION COST (B)	$ 145,104

C.	**CONSTRUCTION COST**	
	Total Estimated Contract Award Sum (A)	$ 564,549
HW0023	Construction Management (22% of A)	$ 124,201
	Sub Total (C1)	$ 688,749
	Construction contingency (Table 12) (30% of C1) — Preliminary Estimate	$ 206,625
	TOTAL CONSTRUCTION COST (C)	$ 895,374

TOTAL PRELIMINARY PROJECT ESTIMATE (B+C) (Preliminary Estimate)	$ 1,040,478

Say **$1.04 Mil**

ESTIMATING SHEET

PROJECT DESCRIPTION: DN250 water main along Newport Road

Item No.	Item Description	Qty	Unit	Rate $/Unit	Amount $
HW0001	All work not included elsewhere in this schedule	Item	Lump Sum	$ 14,187.00	$ 14,187
HW0002	Site Establishment	Item	Lump Sum	$ 15,000.00	$ 15,000
HW0003	Site Disestablishment	Item	Lump Sum	$ 15,000.00	$ 15,000
HW0004	Preparation and implementation of the Construction EMP	Item	Lump Sum	$ 4,000.00	$ 4,000
HW0005	Preparation and implementation of the Safety Management Plan.	Item	Lump Sum	$ 9,000.00	$ 9,000
HW0006	Preparation and implementation of the Traffic Control Plan.	Item	Lump Sum	$ 25,300.00	$ 25,300
HW0007	Preparation and Implementation of Quality Management Plan	Item	Lump Sum	$ 8,243.71	$ 8,244

Water Pipeline - Trunk - section will be present if one or more trunk watermains are specified

Item	Construction of Trunk Mains	Qty	Unit	Rate $/Unit	Amount $
HWT001	Service Location	Item	Lump Sum	$ 2,394.00	$ 2,394
HWT02.01	DN250 Valves / Flowmeters	Item	Lump Sum	$ 24,450.00	$ 24,450
HWT003	Supply all fittings	Item	Lump Sum		
HWT03.01	DN250 Fittings	Item	Lump Sum	$ 7,000.00	$ 7,000
HWT004	Supply all pipes materials, including detector tape, pipe protection wrapping, rubber rings and lubricant for following pipe sizes:				
31EDSS	Nominal DN250 DICL pipe	1900	m	$ 118.00	$ 224,200
HWT005	Clear, excavate, lay, join, bed, backfill & test reticulation pipelines (installation). Up to **1.5 m depth** to invert in OTR.				
31EDSS	Nominal DN250 DICL (Trench type B)	1900	m	$ 138.36	$ 262,877
HWT018	Road / creek crossings				
HWT018.01	Thrustbore 1	15	m	$ 956.00	$ 14,340
HWT018.02	Thrustbore 2	15	m	$ 956.00	$ 14,340
HWT018.03	Thrustbore 3	15	m	$ 956.00	$ 14,340
HWT018.04	Thrustbore 4	15	m	$ 956.00	$ 14,340
HWT018.05	Open Cut 1	40	m	$ 72.00	$ 2,880
HWT018.06	Open Cut 2	15	m	$ 72.00	$ 1,080
HWT027	Preparation of line sheets	1900	m	$ 1.16	$ 2,204
HWT000	***Sub Total***				$ 584,445

Item No.	Item Description	Qty	Unit		Amount $
HW0009	Restoration - Pipelines:				
HW0009.02	Concrete driveway	91	m2	$ 185.00	$ 16,835
HW0009.10	Turf	1280	m2	$ 11.00	$ 14,080
HW0009.11	Grass seeding	5600	m2	$ 7.00	$ 39,200
HW0012	Preconstruction record				
HW0012.01	Photographic	Item	Lump Sum	$ 1,311.00	$ 1,311
HW0013	Work as Constructed Information	Item	Lump Sum	$ 15,200.00	$ 15,200

A.	TOTAL ESTIMATED CONTRACT AWARD SUM	$ 761,802

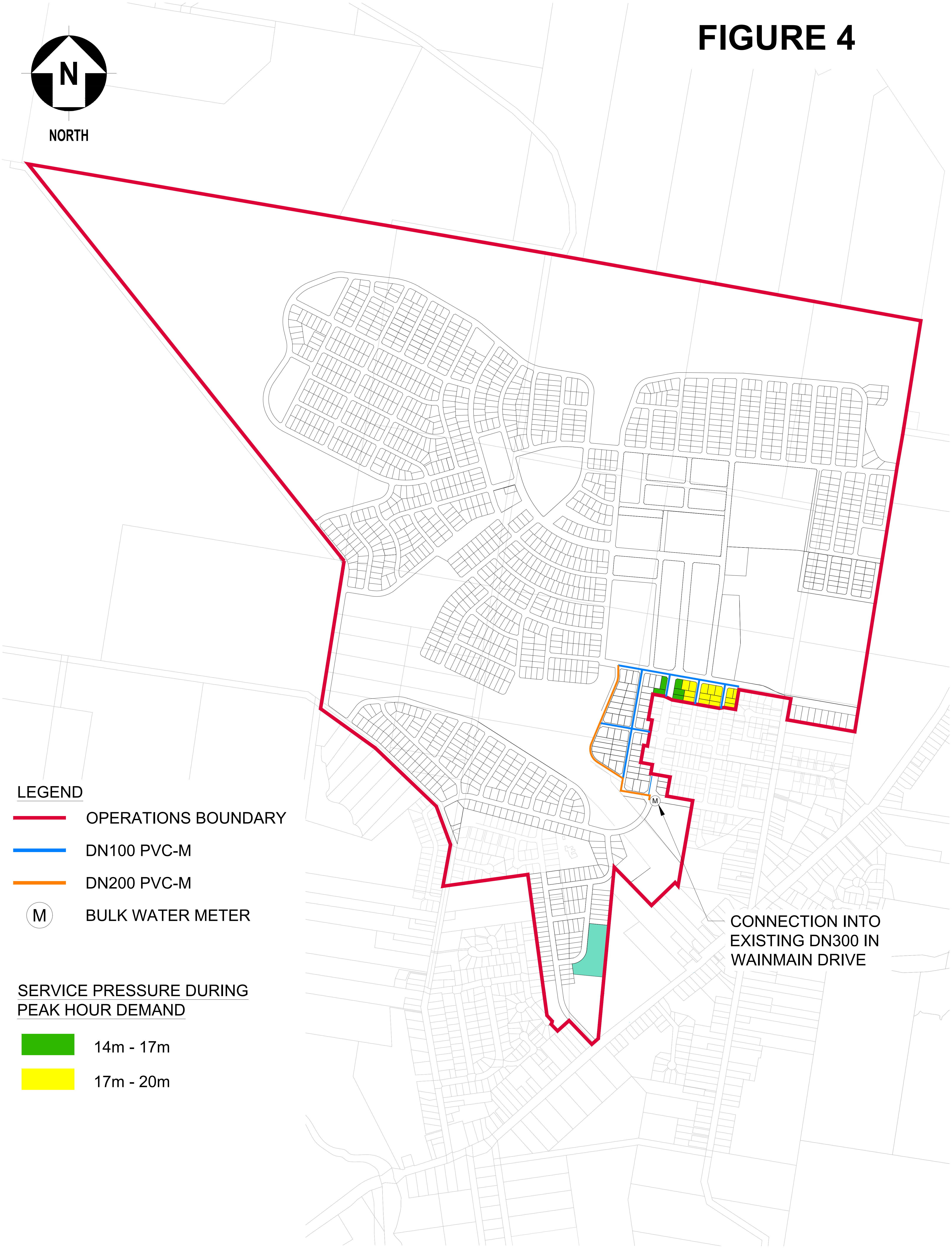
B.	**PRE-CONSTRUCTION COST (Table 10)**	
HW0016	Design (15% of A)	$ 114,270
HW0017	Project Management of Design (20% of Design + $10,000)	$ 32,854
	Sub Total(B1)	$ 147,124
	Pre construction contingency (30% of B1)	$ 44,137
	TOTAL PRE-CONSTRUCTION COST (B)	$ 191,262

C.	**CONSTRUCTION COST**		
	Total Estimated Contract Award Sum (A)		$ 761,802
HW0023	Construction Management (22% of A)		$ 167,596
	Sub Total (C1)		$ 929,398
	Construction contingency (Table 12) (30% of C1)	Preliminary Estimate	$ 278,820
	TOTAL CONSTRUCTION COST (C)		$ 1,208,218

TOTAL PRELIMINARY PROJECT ESTIMATE (B+C) (Preliminary Estimate)		$ 1,399,480

Say **$1.4 Mil**

FIGURE 4



Cooranbong Water

flow systems

NORTH COORANBONG
POTABLE WATER MASTER PLAN
INITIAL CONNECTION

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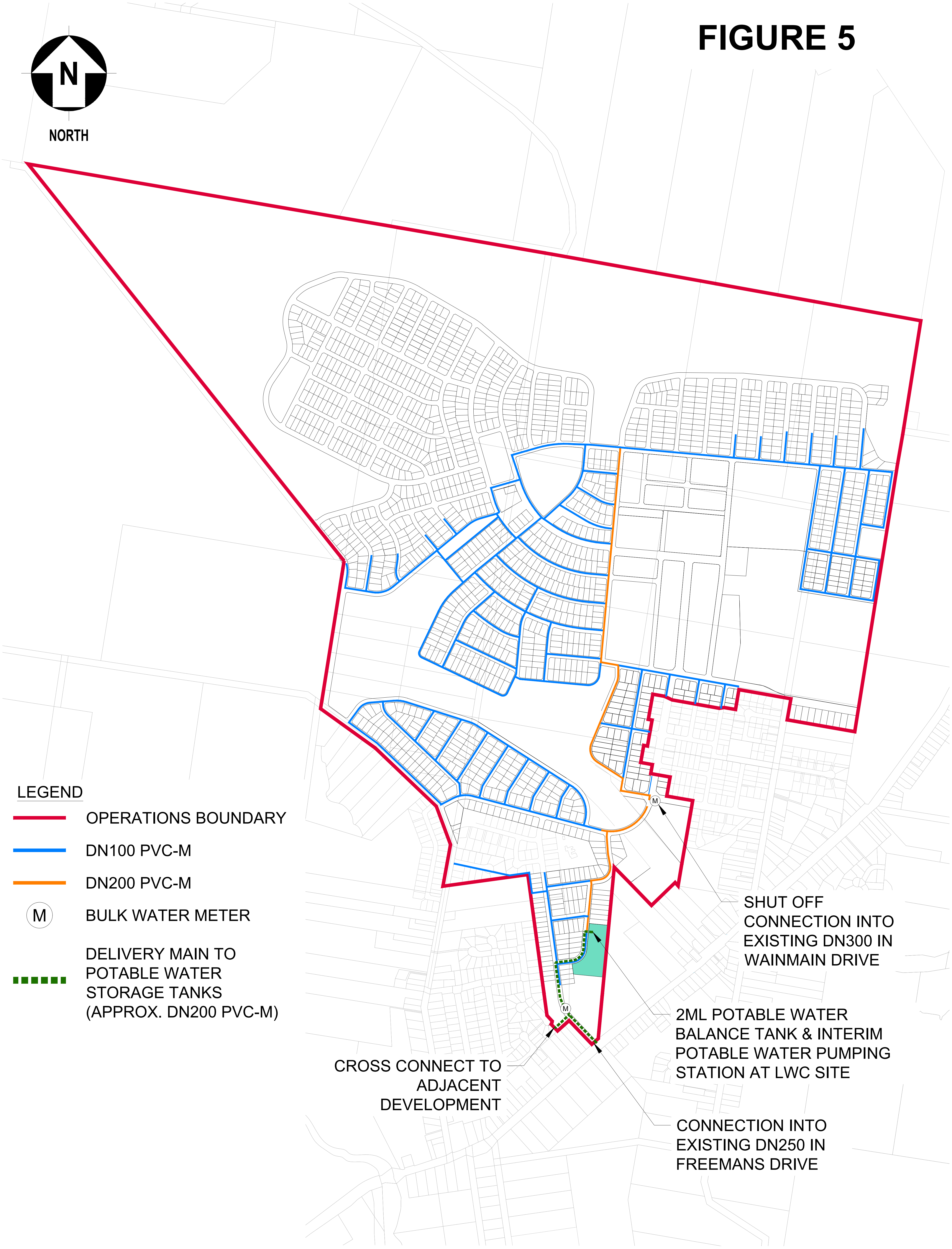
FIGURE 5



Cooranbong Water

flow systems

NORTH COORANBONG
POTABLE WATER MASTER PLAN
DEVELOPMENT TO END OF STAGE 7B

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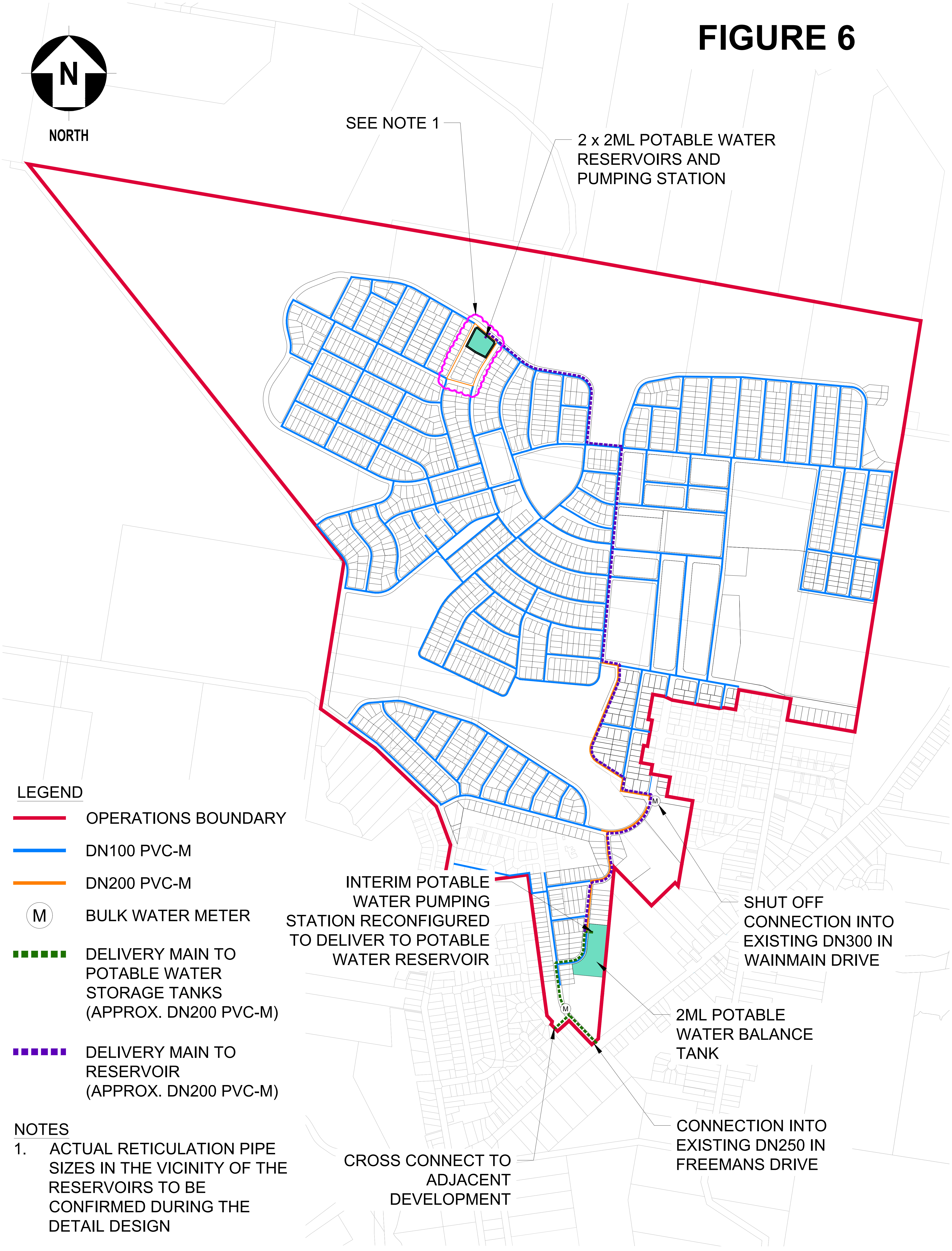
FIGURE 6



NORTH COORANBONG
POTABLE WATER MASTER PLAN
ULTIMATE DEVELOPMENT

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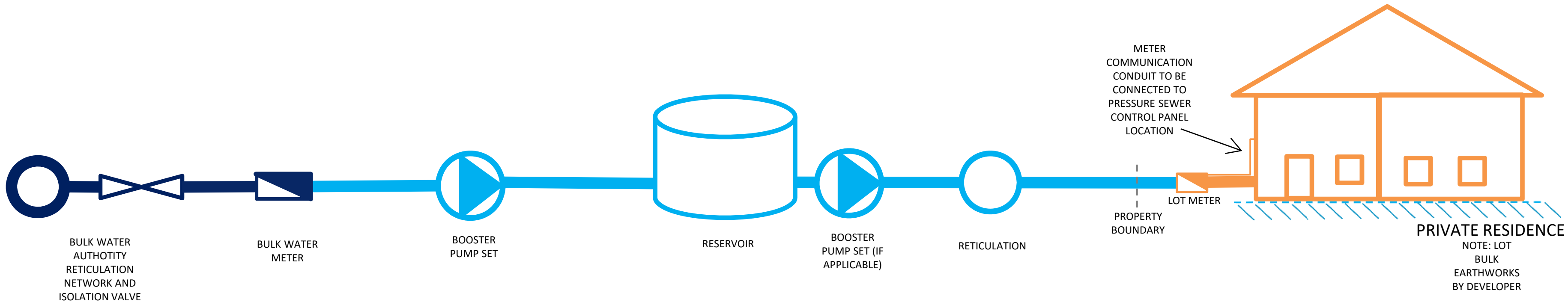
POTABLE WATER INFRASTRUCTURE – TYPICAL CONSTRUCTION RESPONSIBILITY SCHEMATIC



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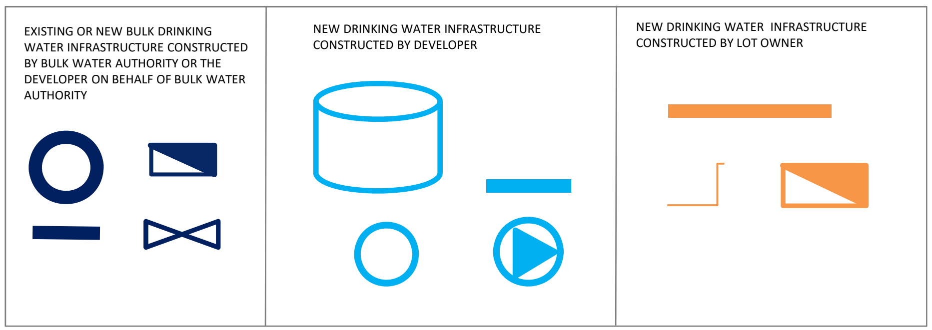
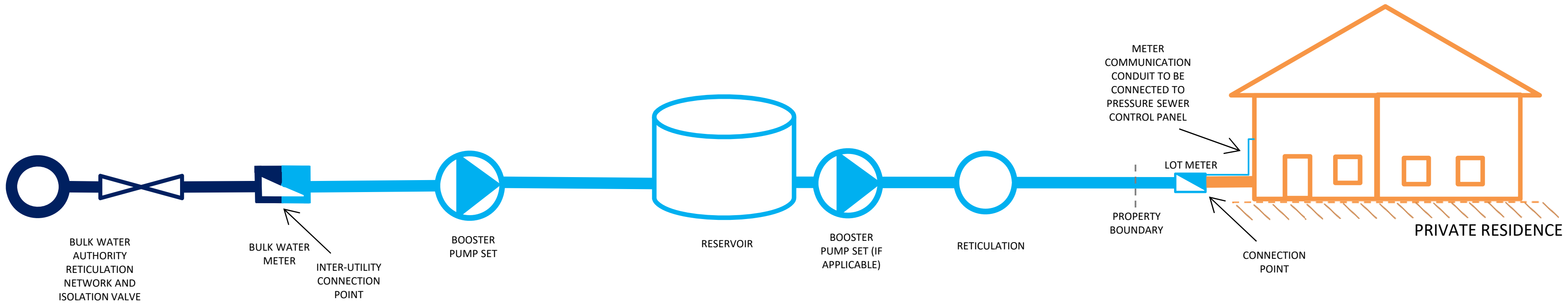


POTABLE WATER INFRASTRUCTURE – TYPICAL OWNERSHIP & O+M RESPONSIBILITY SCHEMATIC



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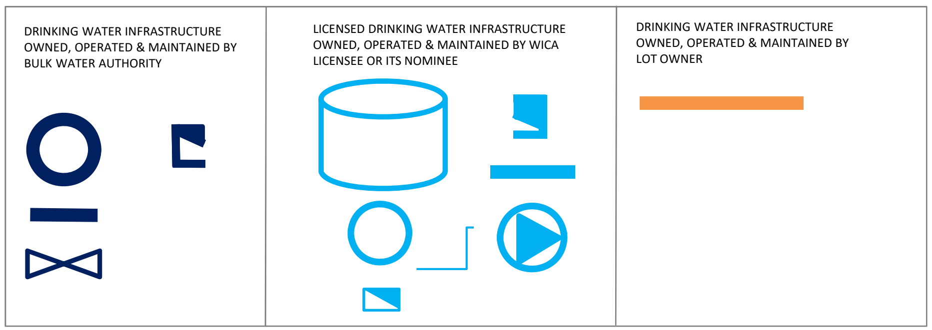

NORTH COORANBONG

WATER BALANCE SUMMARY

9 FEBRUARY 2016

V1.1

PREPARED BY KINESIS FOR FLOW SYSTEMS

Prepared by Kinesis
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Document Version
Final

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Note: This report is provided subject to some important assumptions and qualifications:

The results presented in this report are modelled estimates using mathematical calculations. The data, information and scenarios presented in this report have not been separately confirmed or verified. Accordingly, the results should be considered to be preliminary in nature and subject to such confirmation and verification.

Energy, water and greenhouse consumption estimates are based on local climate and utility data available to the consultant at the time of the report. These consumption demands are, where necessary, quantified in terms of primary energy and water consumptions using manufacturer's data and scientific principles.

Generic precinct-level cost estimates provided in this report are indicative only based on Kinesis's project experience and available data from published economic assessments. These have not been informed by specific building design or construction plans and should not be used for design and construct cost estimates.

The Kinesis software tool and results generated by it are not intended to be used as the sole or primary basis for making investment or financial decisions (including carbon credit trading decisions). Accordingly, the results set out in this report should not be relied on as the sole or primary source of information applicable to such decisions.

CONTENTS

EXECUTIVE SUMMARY

North Cooranbong is a proposed residential development between near Lake Macquarie. Construction will be completed in 2035 which will consist of 2,104 dwellings and a 6 ha town centre and 2.2 ha school.

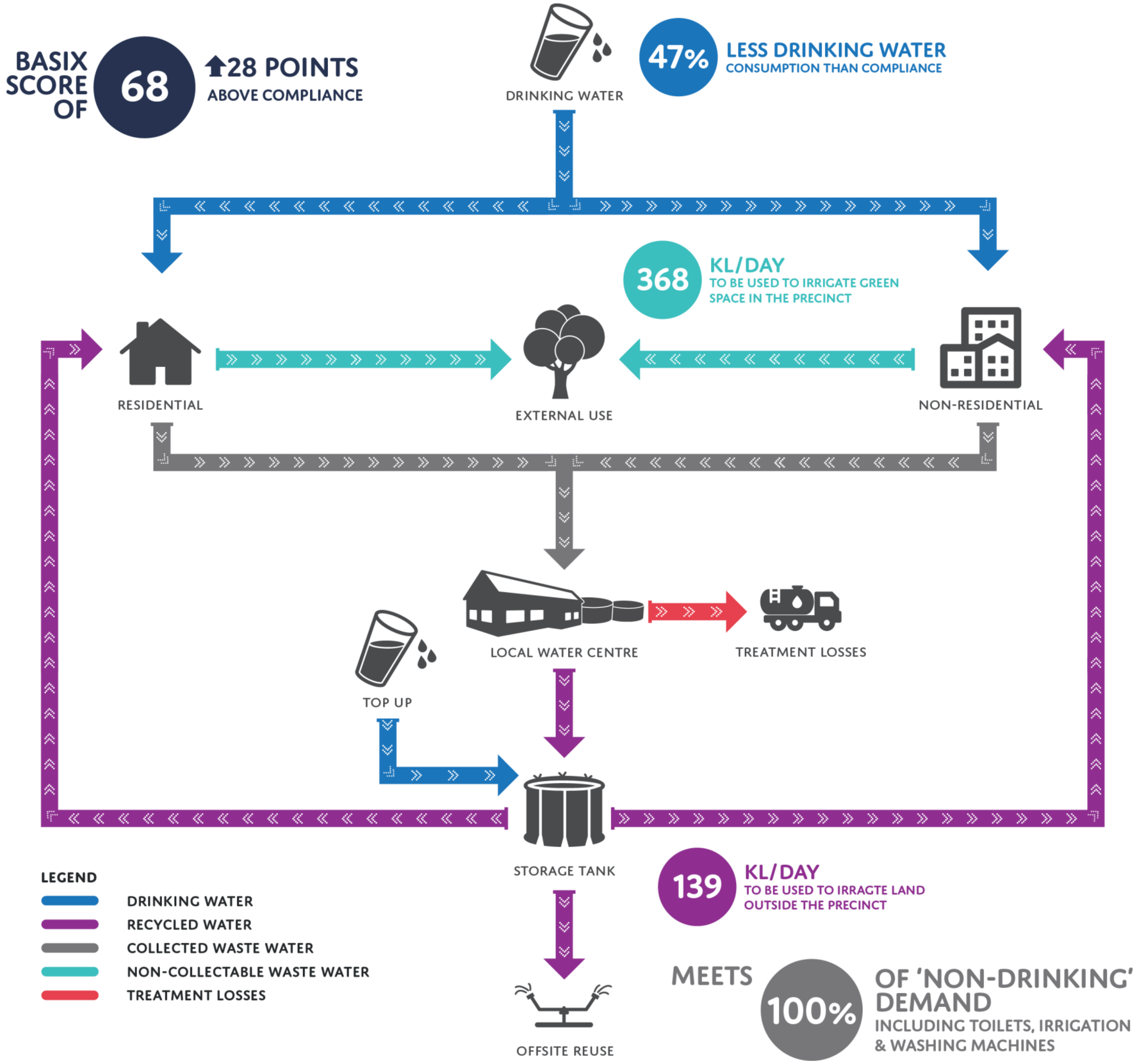
The proposed recycled water scheme is a combined membrane bioreactor and ultrafiltration system with 2 x 1.2 ML and 2 x 2.0 ML storage tanks for a total of 6.4 ML of storage at 2036. The system will take as inflows all grey and black waste water from both the residential and non-residential precincts and provide recycled water for:

- Residential use in
    - Toilets
    - Washing Machines (cold only)
    - External irrigation
- Non-residential use in
    - Toilets
    - Washing machines (cold only)
    - Irrigation
    - Washdown, and
    - Water features.

In the event that the storage tanks are empty and the recycled water system is unable to service recycled water demand then drinking water will be used for these end-uses. Additional sensitivity analysis under various climate conditions has been undertaken to further qualify this statement.

With the recycled water scheme dwellings in the precinct will, on average, achieve a BASIX water score of **68**. Furthermore, without the recycled water scheme dwellings at North Cooranbong would be required to install rainwater tanks connected to both toilet flushing and external use. To achieve a BASIX water score of 50, the rainwater tanks would need to be sized 3.5 kL, 2.5 kL and 0.5 kL per detached dwelling, attached dwelling and apartment respectively.

NORTH COORANBONG WATER SYSTEM



1. PROJECT DETAILS

This report documents the water balance analysis of the North Cooranbong development in order to inform the delivery of a recycled water scheme.

The North Cooranbong development will comprise 2,104 residential lots and 6 hectares of new town centre area. Analysis in this report outlines the results and performance outcomes for the total North Cooranbong development. This analysis is undertaken based on figures provided by Flow Systems (see **Figure 1** and **Table 1**) using Kinesis's C^{CAP} Precinct modelling tool. C^{CAP} Precinct is a land use and planning tool that models key environmental, economic, social and infrastructure implications and requirements for precinct-scale development projects.

The report is structured as follows:

- Water Demands
- Source Water Production
- Recycled Water System Performance
- Project Staging

Land Use	Area
Total Development Area	**340 ha**
Public Space	
Road area	70 ha
Playing fields	7.6 ha
Native Parklands/Reserves	119 ha
Public Plazas	7.1 ha
Total public space	**203.7 ha**
Non-Residential Land Use	**6.3 ha**
Retail	5,445 m^2
Primary Secondary Education	6,000 m^2
Library & Community	1,100 m^2
Total non-residential	**12,545 m^2**
Residential Dwellings	
Detached dwellings	1,664
Attached dwellings	440
Total dwellings	**2,104**

Table 1: Dwelling yield and floor space for the North Cooranbong development Precinct.

NORTH COORANBONG MASTER PLAN

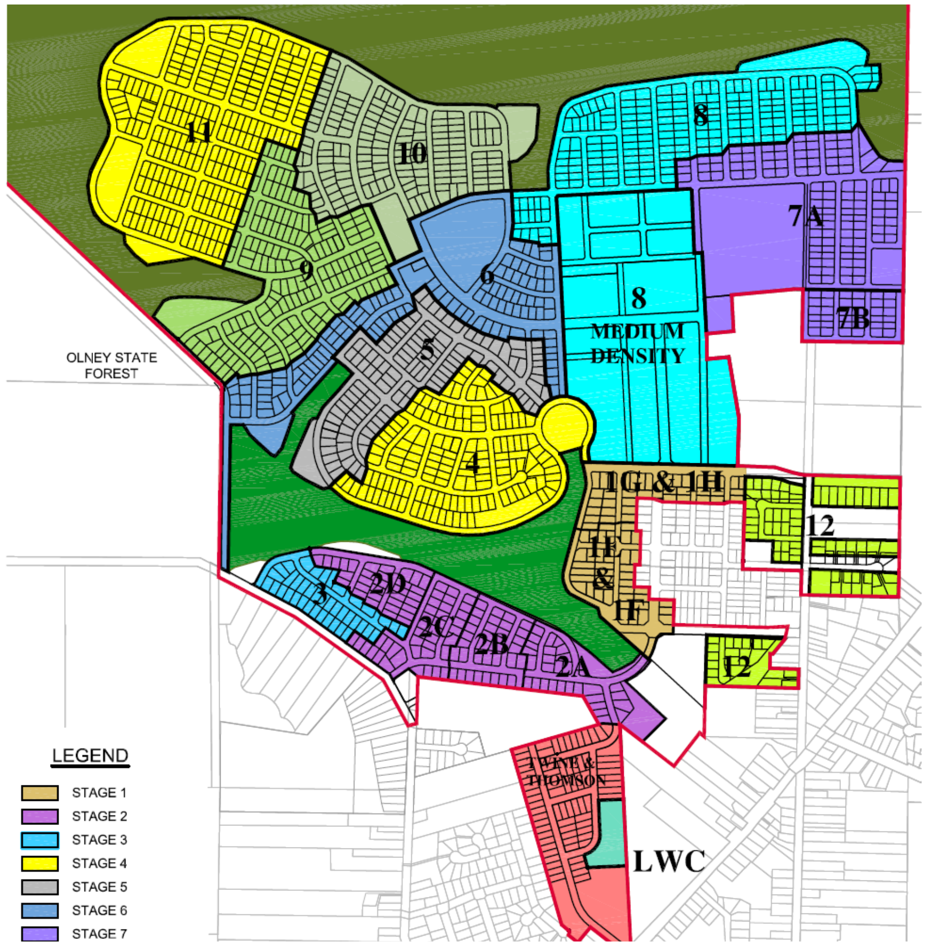


Figure 1: North Cooranbong development Master Plan

2. WATER DEMANDS

2.1 RESIDENTIAL WATER DEMANDS

Residential water demands were calculated based on the specific residential building types proposed for the North Cooranbong development. The details of the dwelling type configuration are outlined in **Tables 2 and 3**. Monthly total and daily average residential water demands by end use are outlined in **Figures 3 and 4**. Month to month variation is evident due to changes to irrigation water demands based on rainfall and evaporation profiles. Monthly internal total demands vary slightly due to differences in the number of days per month.

HOUSEHOLD DAILY WATER BALANCE

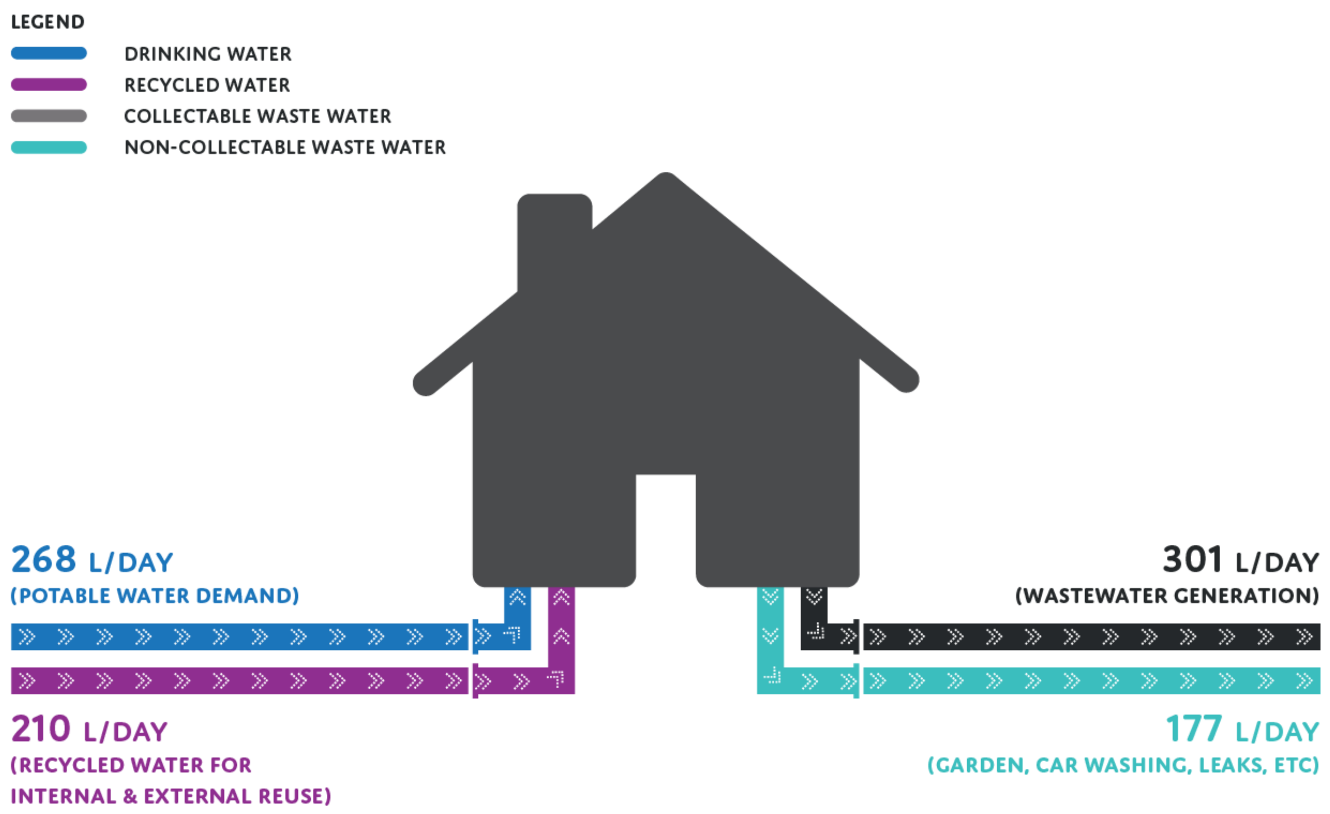


Figure 2: Schematic showing a household's expected daily drinking and recycled water consumption, sewage production and non-collectable water use.

NOTE: Wastewater is discussed further in Section 3 - Source Water Production.

RESIDENTIAL DWELLING SPECIFICATIONS

Dwelling type	Number	Lot area	Bedrooms	Occupancy	Irrigated area	EP
Detached dwellings	1,664	400 - 600 m2	4 to 5	3.44 - 4.04	75 - 120 m2	5,816
Attached dwellings	440	200 - 250 m2	2 to 3	1.86 - 2.6	85 - 95 m2	982
TOTAL	**2,104**	**-**	**-**	**-**	**-**	**6,798**
AVE. DWELLING		**440 m^2**	**3.8**	**3.23**	**103 m^2**	

Table 2: Residential dwelling specifications used in the analysis

RESIDENTIAL END USE SPECIFICATIONS AND AVERAGE DEMANDS

Water End Use	Technology	Per Person Demand L/day			Development Demand kL/day		
		DW	RW	Total	DW	RW	Total
Shower	3+ star WELS	28.4	-	28.4	193.1	-	193.1
Kitchen Sink	5 Star WELS	7	-	7	47.6	-	47.6
Bathroom Basin	5 Star WELS	1.4	-	1.4	9.5	-	9.5
Dishwasher	4 Star WELS	2.1	-	2.1	14.3	-	14.3
Laundry trough	-	5.0	-	5.0	34.0	-	34.0
Bath	-	8.7	-	8.7	59.1	-	59.1
Leaks	-	10	-	10	68.0	-	68.0
Pools/Spa	-	10.5	-	10.5	71.4	-	71.4
Toilet	4 star WELS	-	17.5	17.5	-	119.0	119.0
Washing Machine	4.5 star WELS	3.5	19.6	23.1	23.8	133.2	157.0
Garden Irrigation	-	-	27.8	27.8	-	189.0	189.0
Cooling Tower	-	-	-	-	-	-	-
Fire Test	-	-	-	-	-	-	-
Car Washing	-	6.4	-	6.4	43.5	-	43.5
TOTAL	**-**	**83.0**	**64.9**	**147.9**	**564.4**	**441.3**	**1005.5**
AVE. DWELLING		**268**	**210**	**478**			

Table 3: Residential dwelling end use specifications and average per person daily demands used in the analysis (DW = Drinking water demand, RW = Recycled water demand)

TOTAL RESIDENTIAL WATER DEMANDS

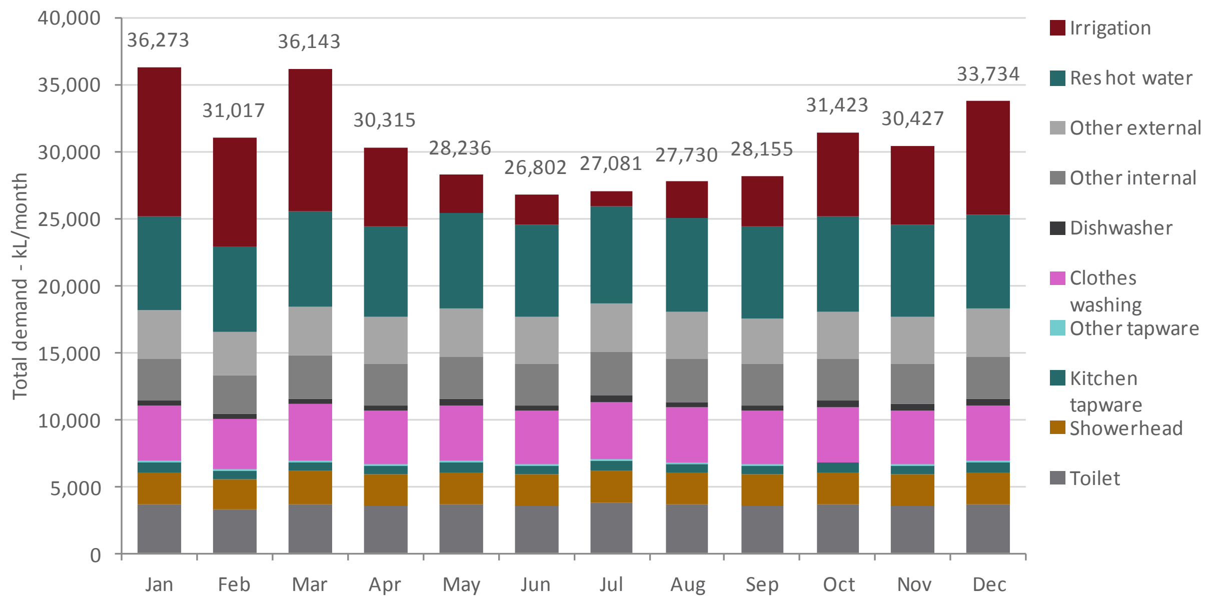


Figure 3: Total residential total water demands by end use, by month

AVERAGE DAILY RESIDENTIAL WATER DEMANDS

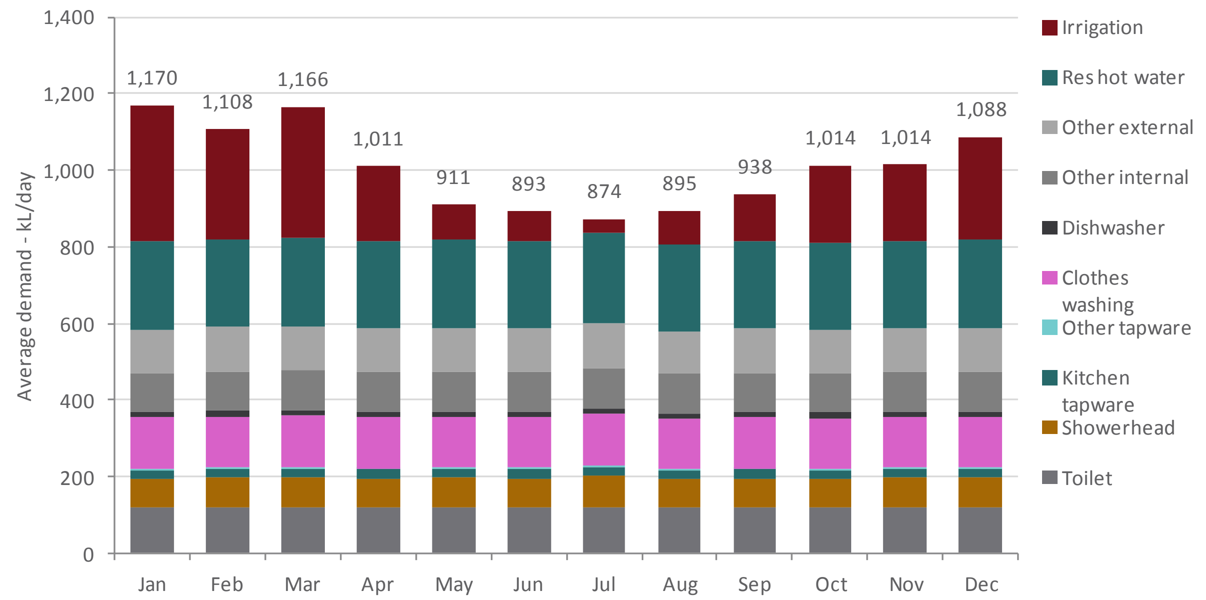


Figure 4: Average daily residential water demands by end use, by month

TEMPERATURE, RAINFALL AND EVAPORATION AT COORANBONG

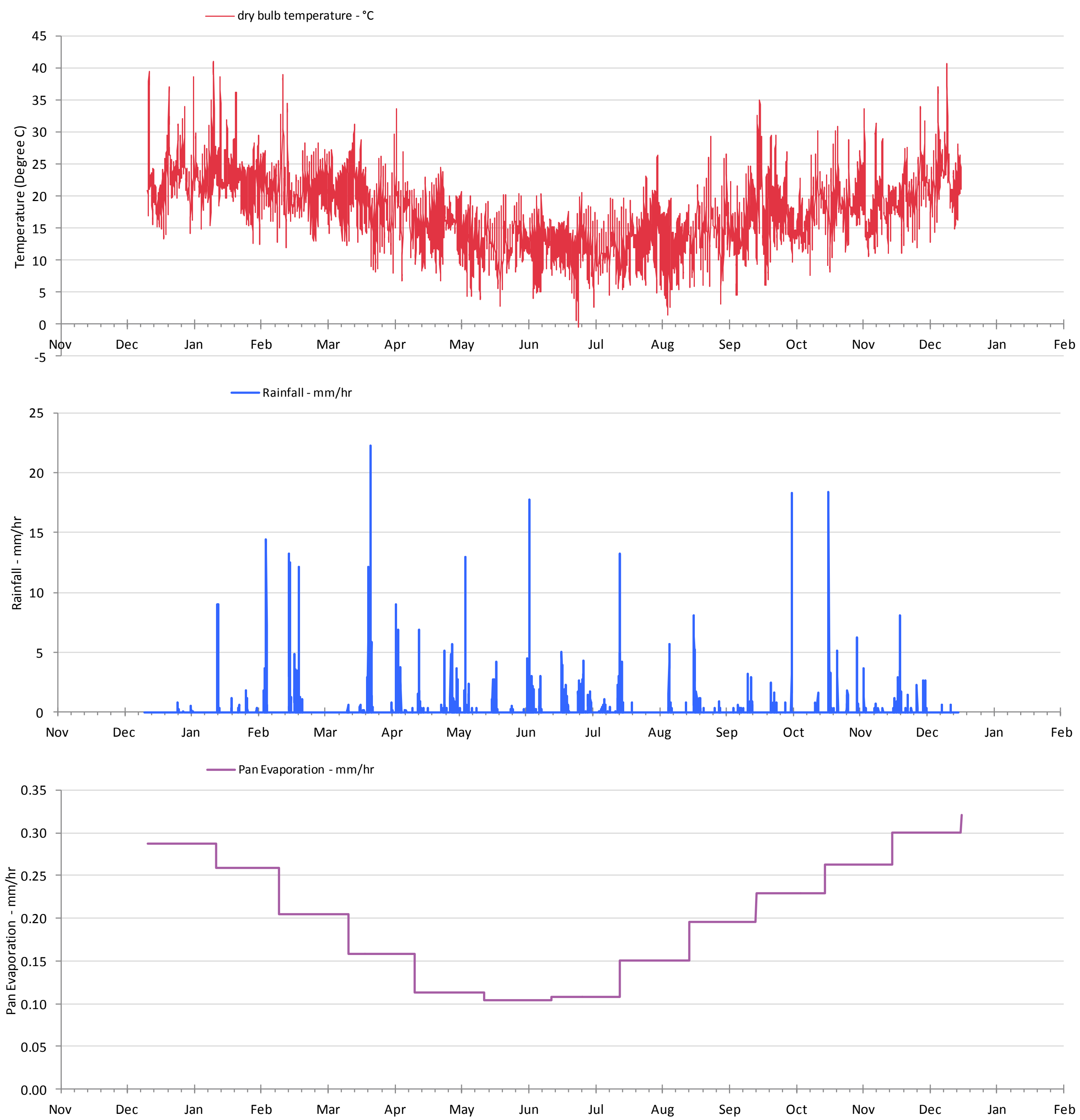


Figure 5: Dry bulb temperature, historic average rainfall and pan evaporation* for local climate zone.

*As the storage tanks at North Cooranbong will be covered there are no modelling implications for pan evaporation. The inclusion of pan evaporation above is for completeness only.

2.2 NON-RESIDENTIAL WATER DEMANDS

Non-Residential water demands were calculated based on the specific commercial, retail, education, community and open space proposed for the North Cooranbong development.

Details of the building type configuration are outlined in **Table 4**. Median Practice is assumed to be current average practice and is derived from various sources, including Sydney Water Best Practice Guidelines for water conservation in commercial office buildings and shopping centres (see Appendix).

Monthly total and daily average non-residential water demands by end use are outlined in **Figures 6 and 7**. Monthly internal total demands vary due to differences in the number of days per month. Month to month variation is only evident in changes to irrigation water demands based on rainfall and evaporation profiles.

NON-RESIDENTIAL SPECIFICATIONS - TOTAL

Demand Hierarchy	Water End Use	Floor Area	Per m2 demand L/day			Development Demand kL/day		
			DW	RW	Total	DW	RW	Total
1	Retail	5,445 m^2	1.36	0.48	1.83	7.39	2.59	9.99
	Commercial Total	**5,445 m^2**				**7.39**	**2.59**	**9.99**
1	Education	6,000 m^2	0.22	2.34	2.56	1.32	14.06	15.38
1	Library & Community	1,100 m^2	1.42	0.50	1.92	1.56	0.55	2.11
	Community Total	**7,000 m^2**				**2.88**	**14.60**	**17.48**
2	Public Plaza irrigated	71,000 m2	0.00	0.09	0.09	-	6.27	6.27
3	Playing field irrigated	76,000 m^2	0.00	0.61	0.61	-	46.38	46.38
	Irrigation Total	147,000 m^2				**0.0**	**52.64**	**52.64**
n/a	Native Parklands	1,190,000 m^2	-	-	-	-	-	-
					TOTAL	**10.3**	**69.8**	**80.1**

Table 4: Non-Residential specifications and average annual demands used in the analysis
(DW = Drinking water demand, RW = Recycled water demand)

TOTAL NON-RESIDENTIAL WATER DEMANDS

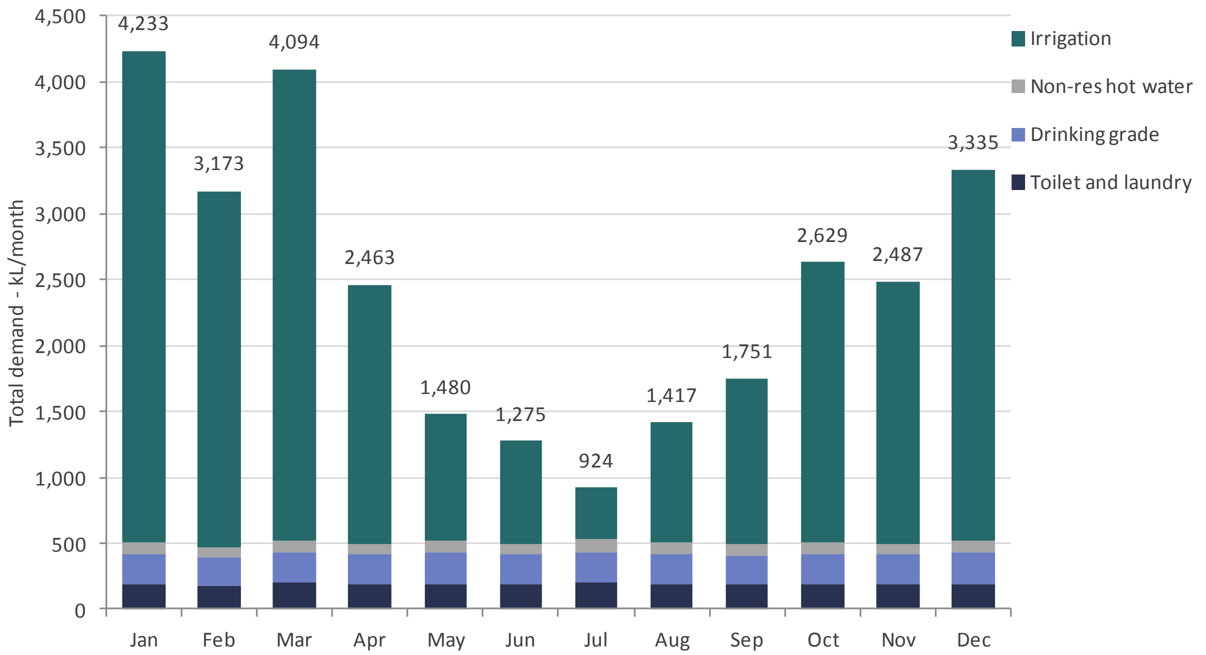


Figure 6: Non-Residential total water demands by end use, by month

AVERAGE DAILY NON-RESIDENTIAL WATER DEMANDS

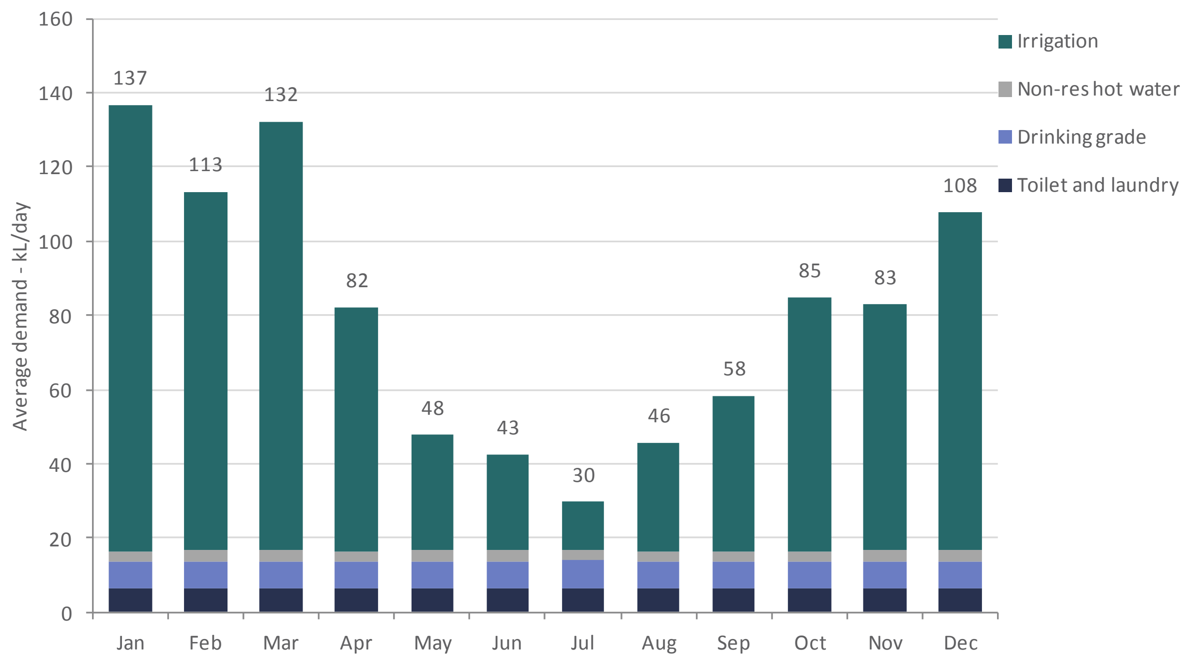


Figure 7: Average daily Non-Residential water demands by end use, by month

2.3 TOTAL AND PEAK WATER DEMANDS

Total water consumption, drinking water demand and recycled water demands are outlined in **Tables 5 to 7**, showing both total and peak demands for each use.

Total water demands are outlined in **Figures 8 to 10** (monthly totals) and **Figures 11 to 13** (daily average), summarising the results of the residential demands and non-residential demands for both drinking water demand and recycled water demands.

As with the individual residential and non-residential demands, month to month variation is predominantly due to changes in irrigation demands. The irrigation demand analysis takes into account hourly rainfall data and cumulative period since the last rain event and irrigation, to predict the time and water use of the next irrigation event. Predictions are also calibrated against real irrigation data for better alignment and accuracy (See Key Data Sources in Appendix A).

Peak water demand (kilolitres per hour) for each month is provided in **Figure 14**. Peak demands for drinking water and recycled water are also shown separately in **Figures 15 and 16**. The peak demand was determined based on the hourly maximum demand for each month, calculated based on the following variables:

- Hourly internal water demands based on a standard hourly internal water demand profile for each end use and building type.
- Hourly irrigation demands based on the irrigation area and local hourly rainfall and evaporation rates.

Due to the fact that internal water demand is relatively consistent over time, in all cases, outdoor irrigation demand is the key contributor towards peak water demands. It should also be noted that peak demands for drinking water and recycled water (**Figure 15** and **Figure 16**) do not necessarily add up to the total peak demand (**Figure 14**) as the individual peak demands may occur at different times.

TOTAL WATER DEMAND PROFILE

FACTOR	RESIDENTIAL	NON-RESIDENTIAL	TOTAL
Average Daily Demand - kL/d	1,006	80	1,087
Peak day - kL/d	1,837	245	2,082
Peak hour – kL/h	173	21	192

Table 5: Demand profile for the North Cooranbong development

DRINKING WATER DEMAND PROFILE

FACTOR	RESIDENTIAL	NON-RESIDENTIAL	TOTAL
Average Daily Demand - kL/d	565	10	575
Peak day - kL/d	814	15	829
Peak hour – kL/h	85	2	87

Table 6: Demand profile for the North Cooranbong development

RECYCLED WATER DEMAND PROFILE

FACTOR	RESIDENTIAL	NON-RESIDENTIAL	TOTAL
Average Daily Demand - kL/d	442	70	511
Peak day - kL/d	1,023	231	1,253
Peak hour – kL/h	90	20	110

Table 7: Demand profile for the North Cooranbong development

TOTAL WATER DEMAND

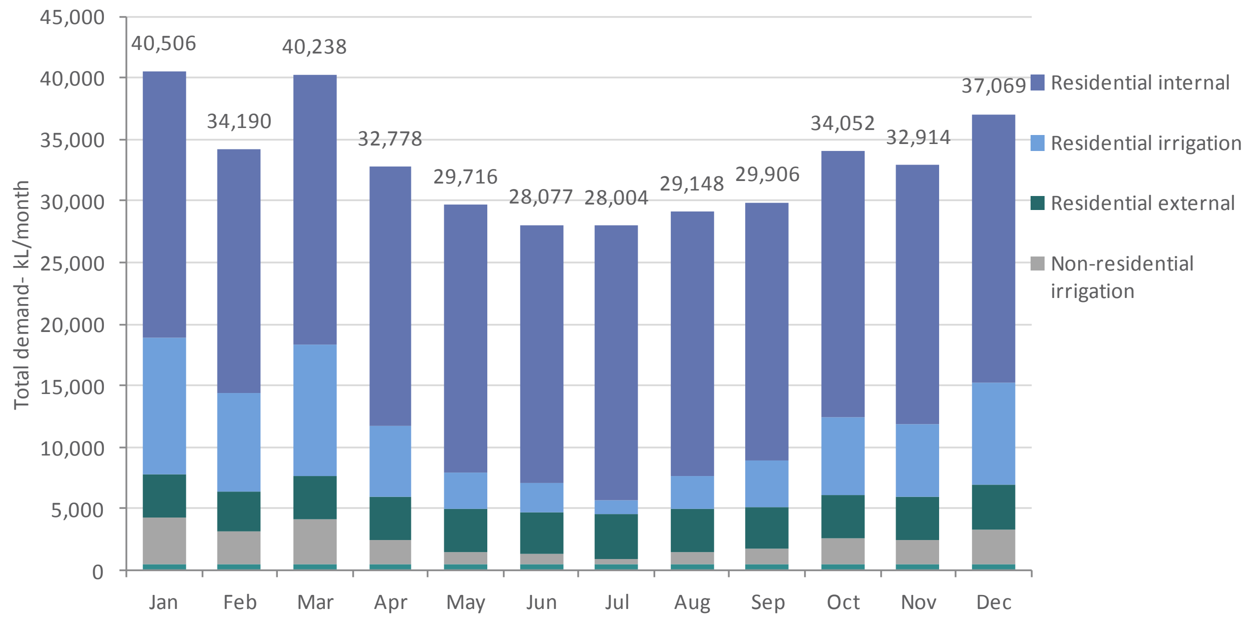


Figure 8: Total water demand by month

TOTAL DRINKING WATER DEMAND

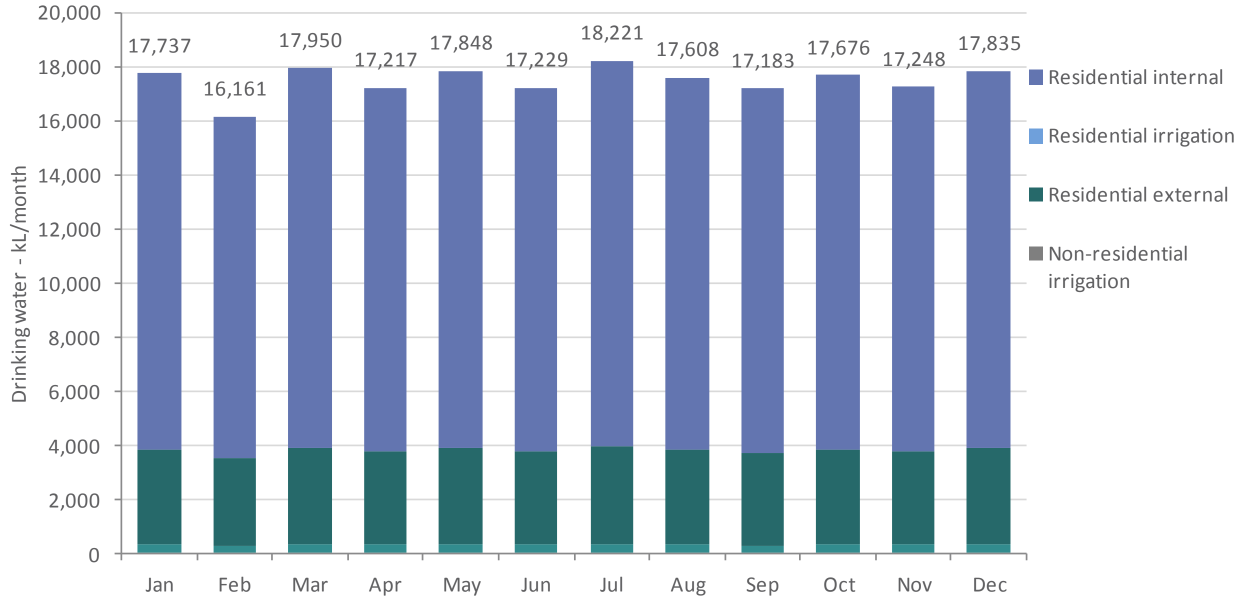


Figure 9: Total drinking water demand by month

DAILY AVERAGE WATER DEMAND

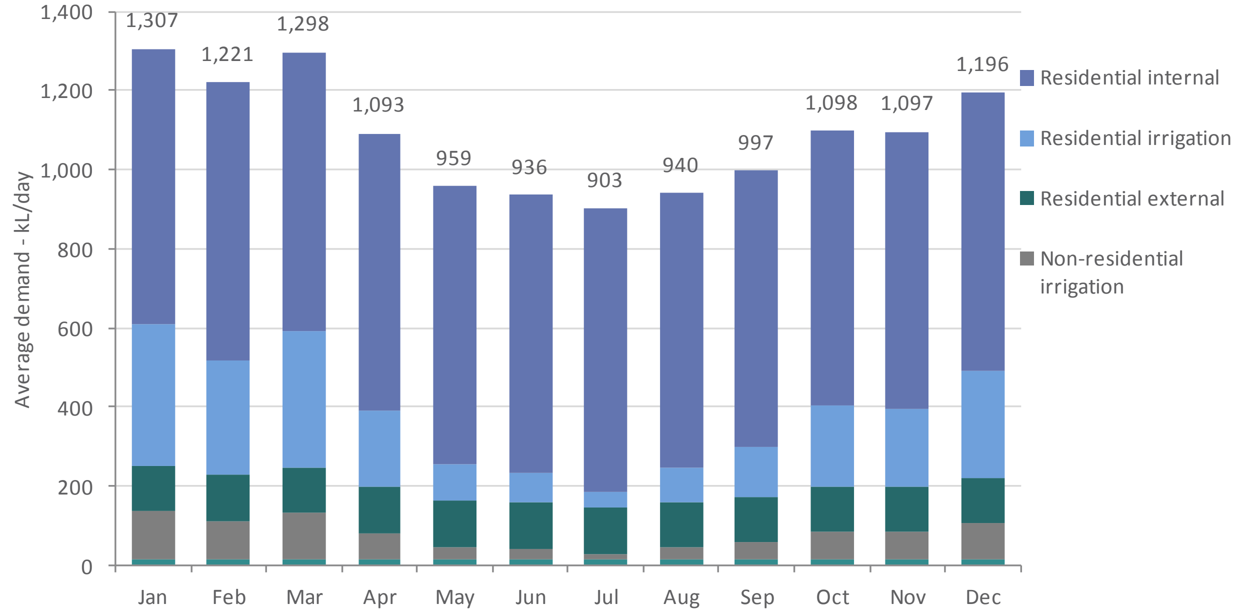


Figure 11: Daily average total water demands by month

TOTAL RECYCLED WATER DEMAND

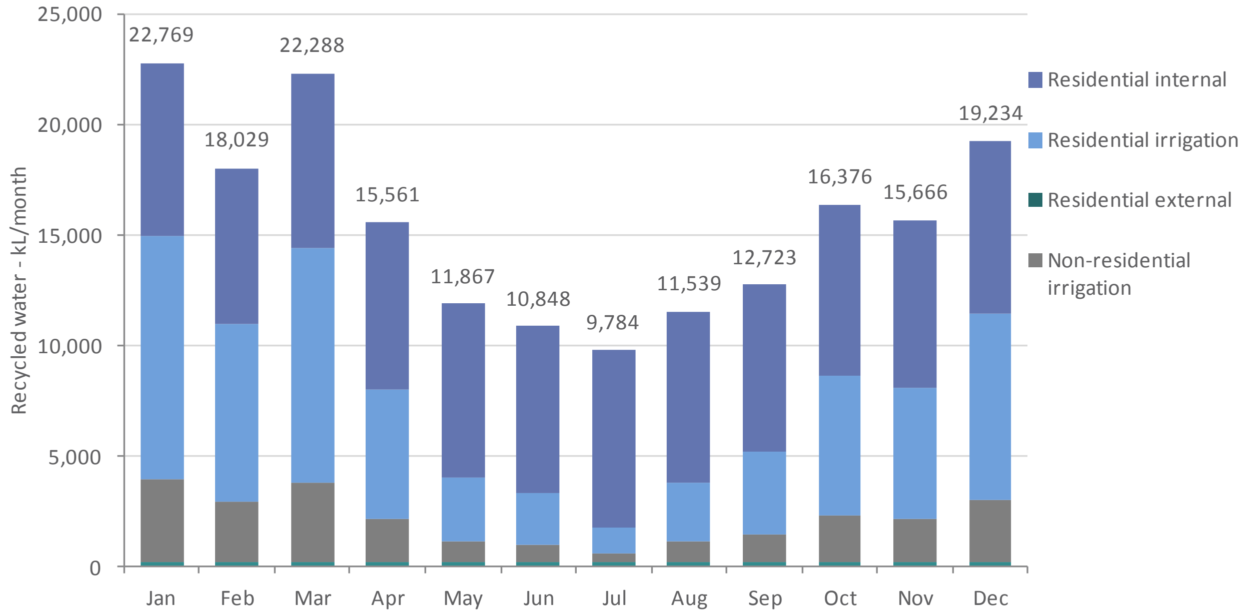


Figure 10: Total recycled water demands by month

DAILY AVERAGE DRINKING WATER DEMAND

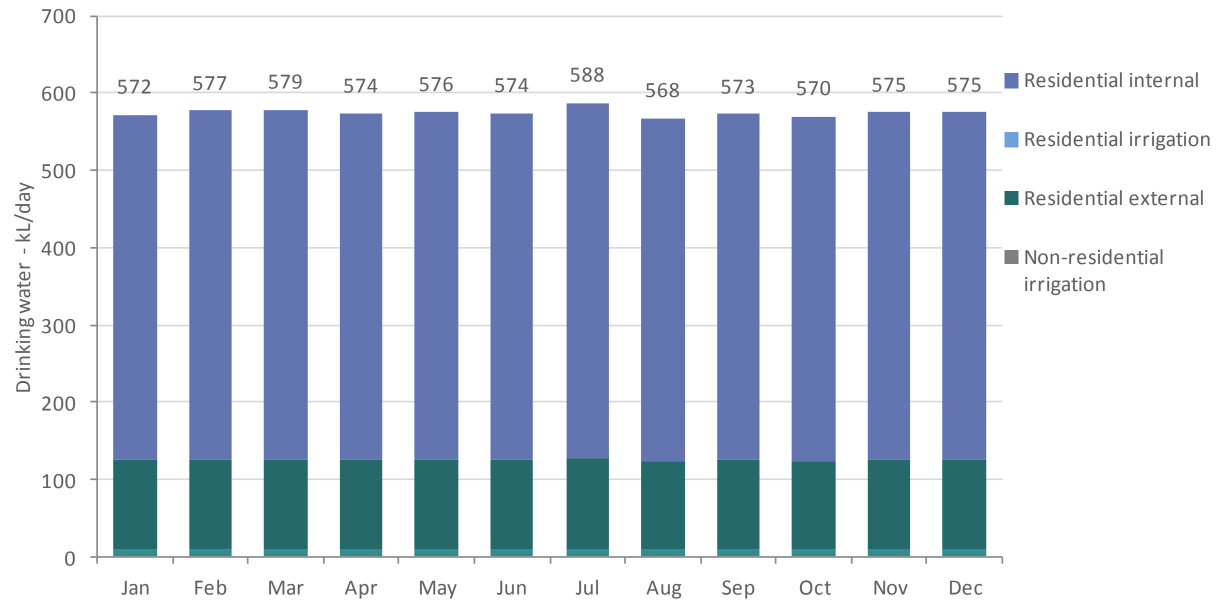


Figure 12: Daily average drinking water demand by month

DAILY AVERAGE RECYCLED WATER DEMANDS

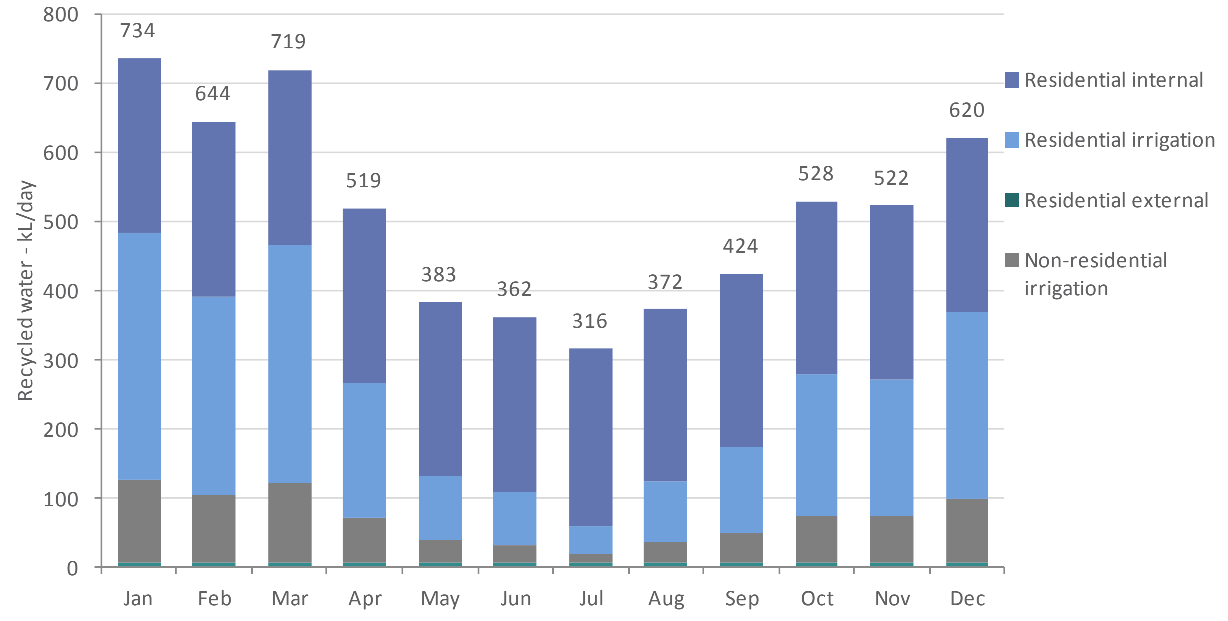


Figure 13: Daily average recycled water demand by month

PEAK RECYCLED WATER DEMANDS

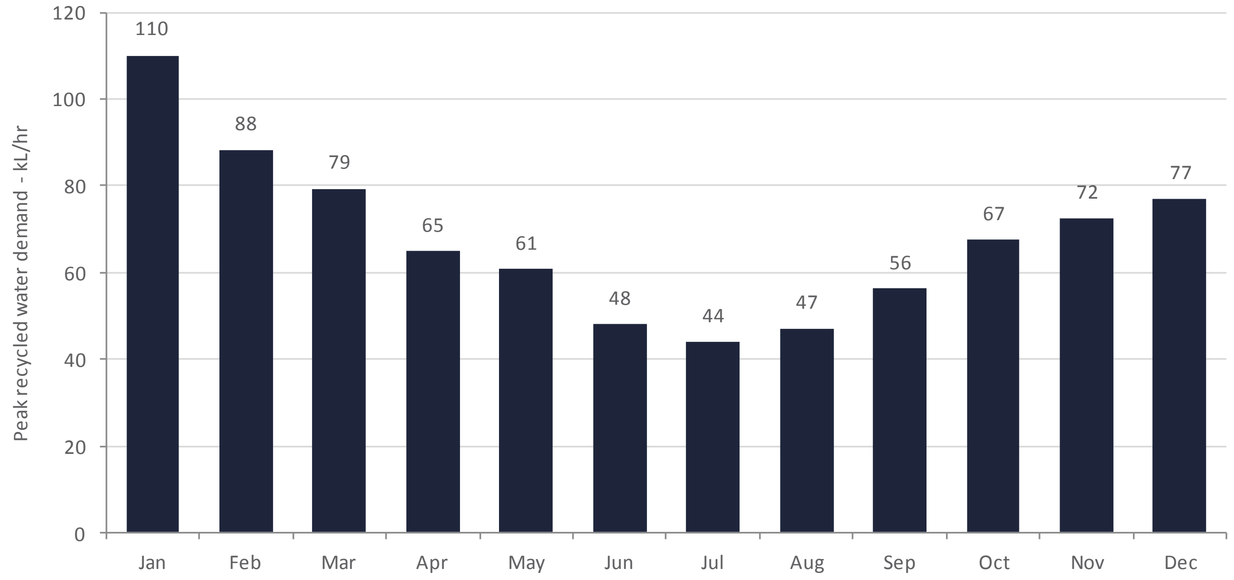


Figure 15: Peak recycled water demands by month

PEAK TOTAL WATER DEMANDS

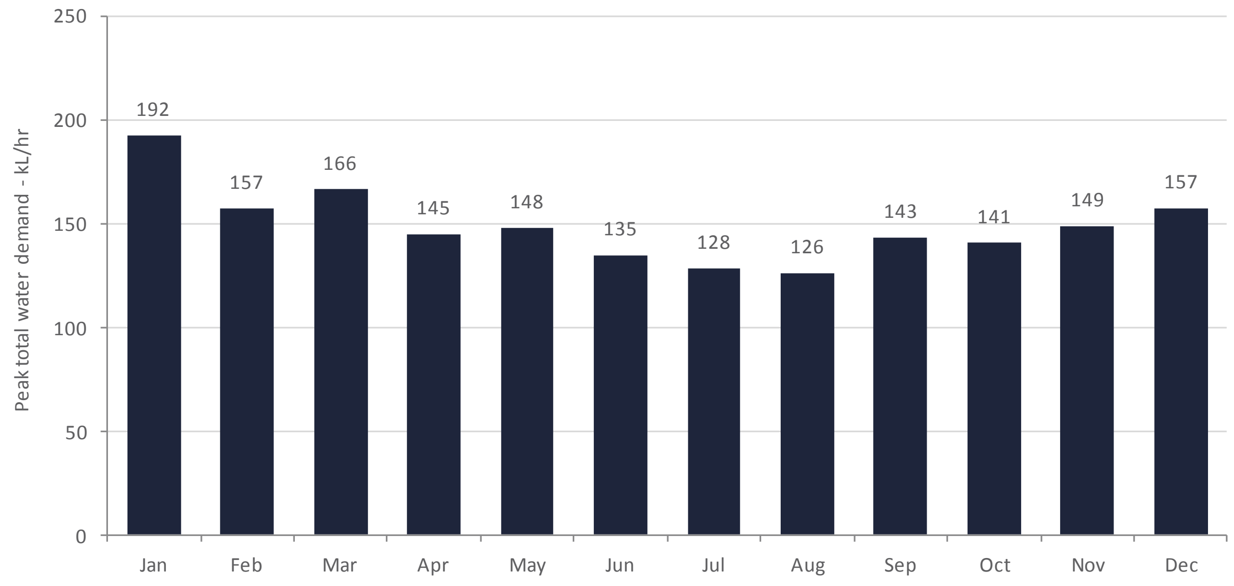


Figure 14: Peak total water demand by month

PEAK DRINKING WATER DEMANDS

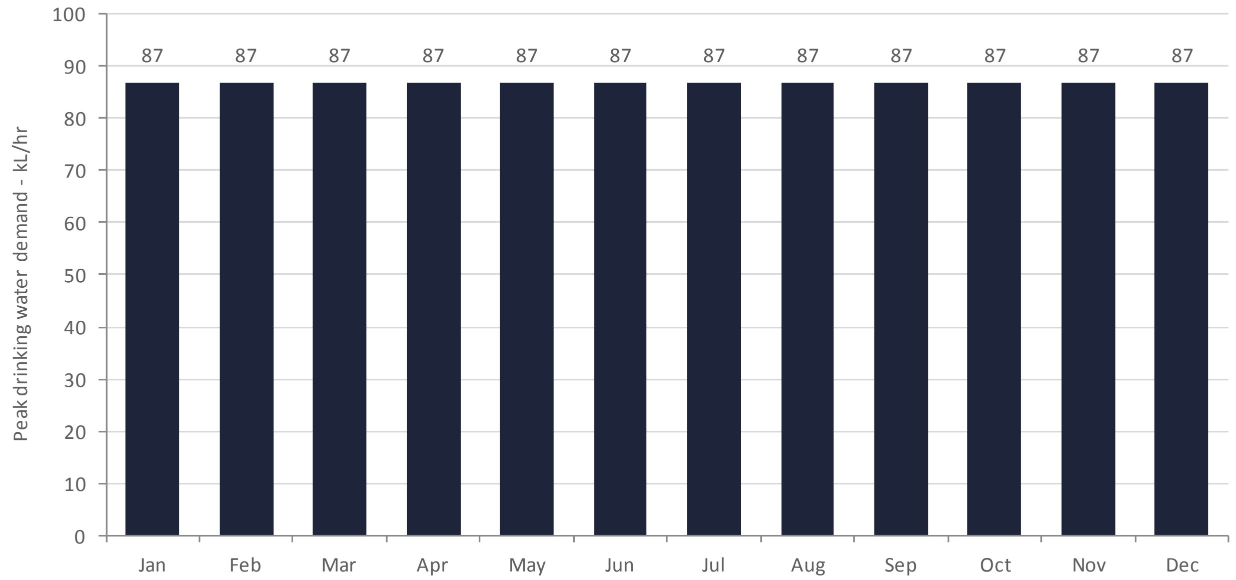


Figure 16: Peak drinking water demand by month

NOTE: Peak demands for drinking water and recycled water (Figures 15 and 16) do not necessarily add up to the total peak demand (Figure 14) as the individual peak demands may occur at different times.

3. SOURCE WATER PRODUCTION

3.1 SOURCE WATER PRODUCTION

Source water for the recycled water scheme is primarily sourced from sewage production. Residential and non-residential sewage production is calculated based on the specific building types proposed for the North Cooranbong development (as shown previously in **Tables 3 and 4**).

Table 9 outlines the average daily and peak sewer production for the residential and non-residential components of the development. Source water production from the residential and non-residential buildings is broken down further in **Tables 8 and 10**.

RESIDENTIAL SEWAGE PRODUCTION

Water End Use	Per Person Sewage Production L/day	Development Sewage Production kL/day
Shower	28.5	193.4
Kitchen Sink	7	47.8
Bathroom Basin	1.4	19.4
Dishwasher	2.1	14.3
Laundry trough	5.0	34.0
Bath	8.7	59.1
Leaks	0	0.0
Pools/Spa	0	0.0
Toilet	17.5	119.2
Washing Machine	23.1	156.7
Garden Irrigation	-	-
Cooling Tower	-	-
Fire Test	-	-
Car Washing	-	-
TOTAL	93.2	633.9
AVE. DWELLING	301.0 L/dwelling/day	

Table 8: Residential dwelling end use specifications and per person daily demands used in the analysis

PRODUCTION PROFILE

FACTOR	RESIDENTIAL	NON-RESIDENTIAL	TOTAL
Average Daily Production - kL/d	634	17	651
Peak day - kL/d	915	24	938
Peak hour – kL/h	96	2	98

Table 9: Source water production profile for the North Cooranbong development

NON-RESIDENTIAL SEWAGE PRODUCTION

Building Type	Per m2 Sewage Production L/day	Development Sewage Production kL/day
Retail	1.8	9.5
Commercial Total		**9.5**
Education	0.8	5.0
Library & Community	1.8	1.9
Community Total		**7.0**
Public Plaza irrigated	0.1	0.0
Playing field irrigated	0.3	0.0
Irrigation Total		**0.0**
Native Parklands	0	0.0
	TOTAL	16.5

Table 10: Non-Residential specifications and average annual demands used in the analysis

4. RECYCLED WATER SYSTEM PERFORMANCE

4.1 RECYCLED WATER SYSTEM CONFIGURATION

The recycled water system for North Cooranbong development was configured as follows:

- Connection to all dwellings for irrigation, toilet, washing machine (cold tap)
- Connection to all non-residential buildings for irrigation, toilet flushing and washdown
- Connection to all open space for irrigation
- Storage tank is sized at 6.4 ML (2 x 1.0 ML recycled water tanks at the local water centre and 2 x 2 ML header tanks)
- Accepted inflow volume is calculated as the sum of end-use demand and missing storage volumed, analysed on an hourly basis.
- A 2% volume loss is also considered for the MBR/UF treatment process.

4.2 WATER BALANCE

The average daily performance of the recycled water system at full build out of Corranbong is in **Figure 18** and the key water results are shown in **Table 11**.

Water Source	ML per year
Sewage Production	238 ML
Recycled Water Demand	187 ML
Recycled Water Demand Met	187 ML
Water Import for Recycled Water Use	0 ML
Drinking Water Demand	210 ML
New lot establishment irrigation or offsite use	52 ML

Table 11: Estimated development average water balance with recycled water system at full build out

Water Import for Recycled Water Use

The model shows that at full build out, stored recycled water will be sufficient to meet demand during summer when daily sewage production is less than daily recycled water demand. As per section 3.1 stormwater will be sourced as a secondary source of recycled water to provide both top up water as required during the staging of the development and to maintain full storage as a contingency measure.

New lot establishment irrigation or off-site use

New lot establishment irrigation or off-site use of recycled water only occurs when the treated volume is greater than the demand. Assuming a sustainable irrigation application rate of 3 mm per day based on Whitehead & Associates Land Capability Assessment for Recycled Water Management Scheme at Proposed North Cooranbong development (June 2014), the monthly average volume available for this end use varies from 0 kL/day to 349

ANNUAL AVERAGE DAILY FLOWS IN KL/DAY

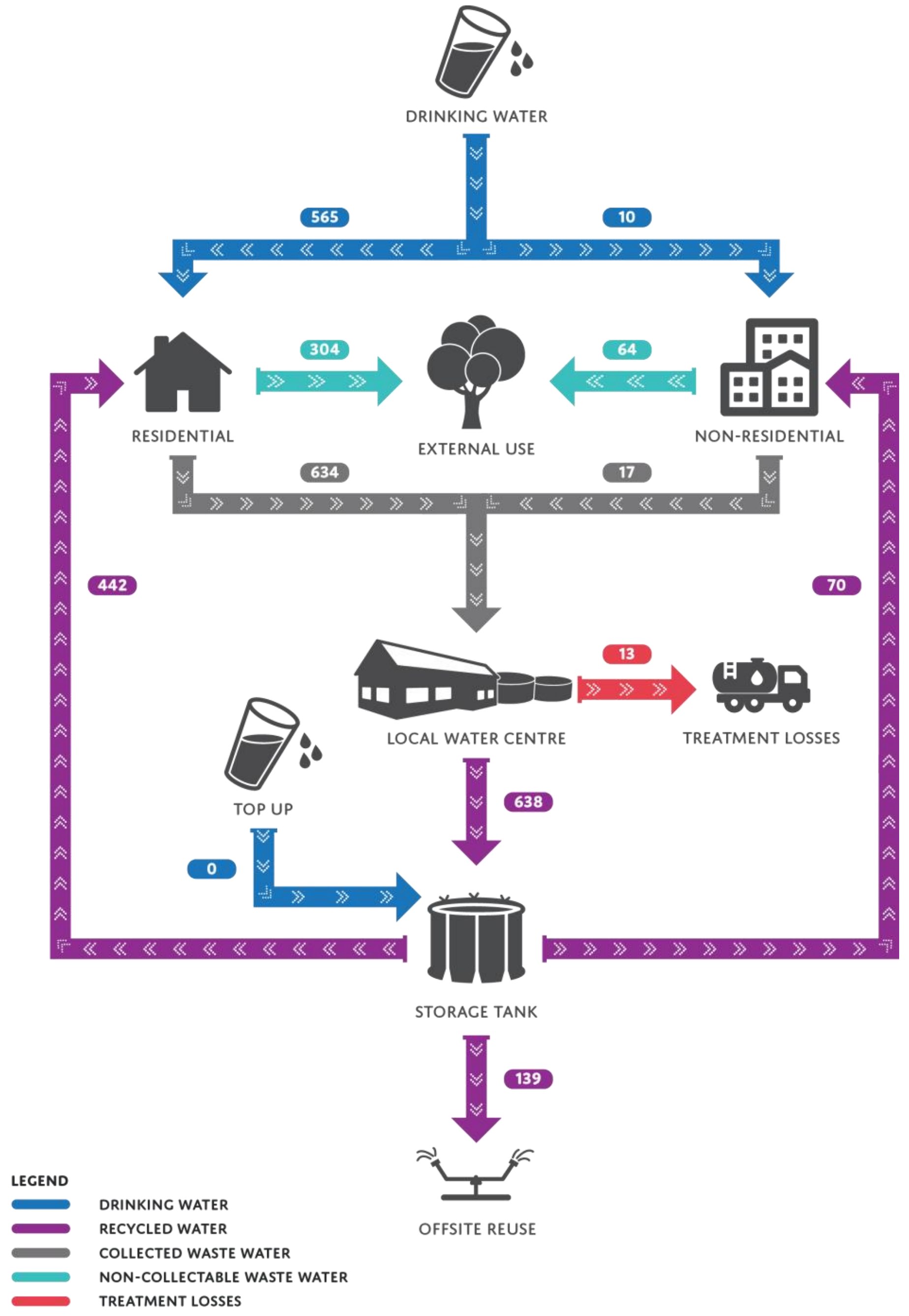


Figure 17: Schematic of the recycled water system showing annual average daily flows in kL/day.

Note - The sum of monthly recycled water use and new lot establishment irrigation does not always equal the total sewage production, due to the hourly analysis run by CCAP Precinct and the storage tank actively accepting and supplying water in order to minimize top-up and off-site use, e.g. sewage production excessive of the recycled water demand is kept in the recycled water storage tank, for periods where sewage production cannot meet the recycled water demand kL/day. The peak day volume is 496 kL, this equates to approximately 16.5 ha of irrigated land, however, as shown in **Figure 19**, 10.0 ha is sufficient for 80% of days.

RECYCLED WATER SYSTEM PERFORMANCE AT FULL BUILD OUT

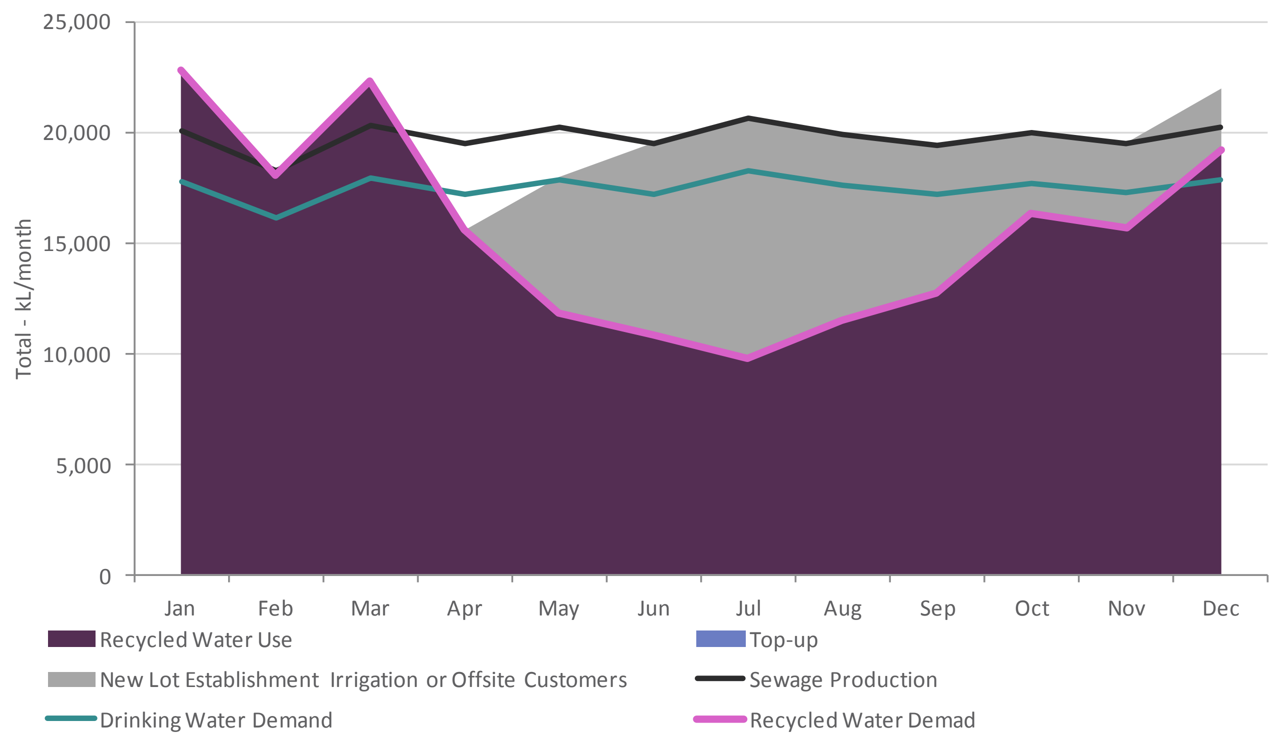


Figure 18: Recycled water system performance showing monthly recycled water use, demand and off-site use

Recycled Water System Stored Volume

Figure 20 outlines the daily average storage volume of recycled water over the year, highlighting the significant recycled water consumption for irrigation during summer and lower recycled water demands over the winter months. On average, the daily stored volume in the recycled water system tanks is 5,413 kL.

DISTRIBUTION OF OFF-SITE REUSE

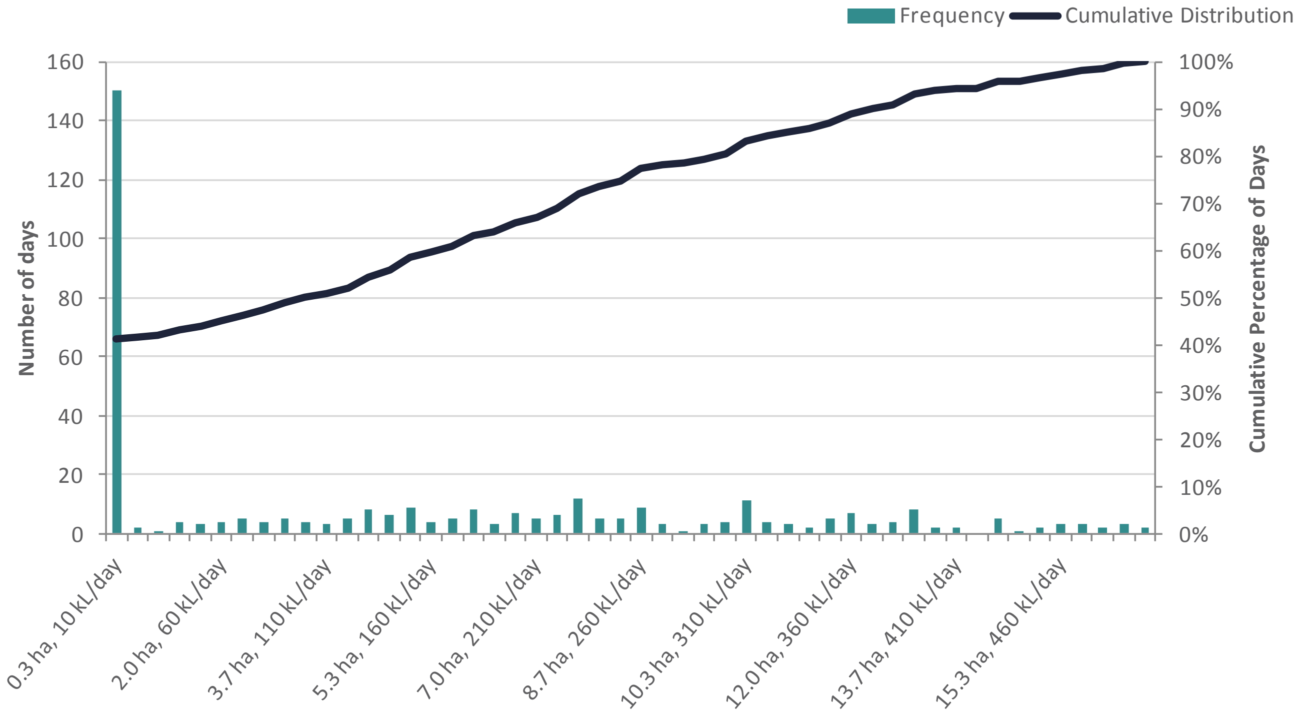


Figure 19: Frequency histogram and cumulative distribution of area required for new-lot irrigation

RECYCLED WATER STORED VOLUME

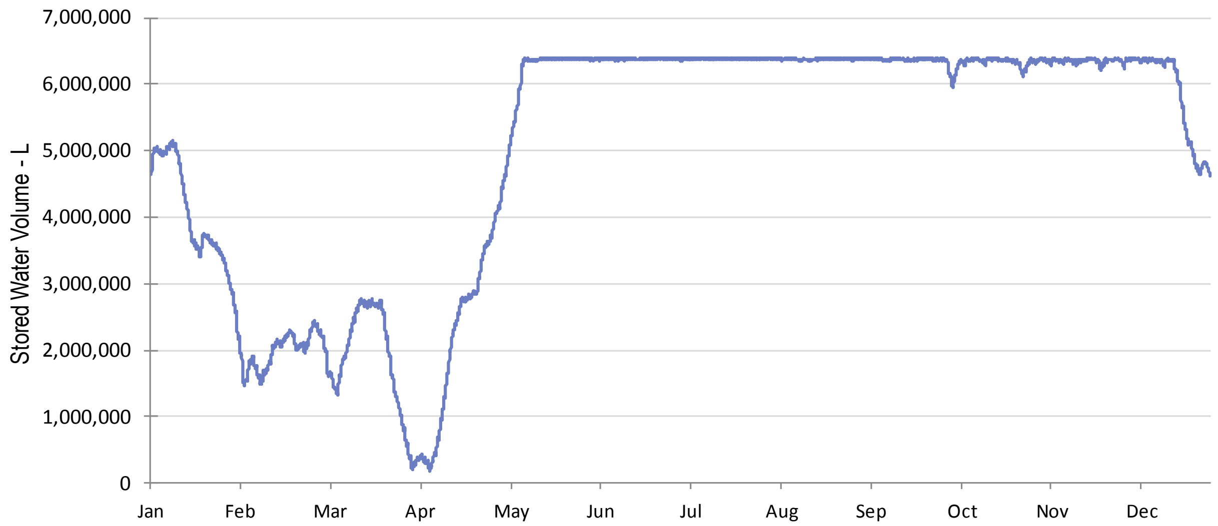


Figure 20: Hourly recycled water stored volume for the recycled water system

4.3 BASIX COMPLIANCE

With connection to the recycled water system, residential dwellings at North Cooranbong development are estimated to achieve an average **BASIX water score of approximately 68**.

Without connection to the recycled water system, dwellings at North Cooranbong development would be required to install rainwater tanks in all dwellings connected to both irrigation and toilet flushing. Rainwater tanks would need to be sized as follows:

Detached dwellings	3,500 L per dwelling
Attached dwellings	2,500 L per dwelling
Apartments	500 L per dwelling

This scenario would achieve an average BASIX water score of approximately 50 (modelled to reflect the new proposed BASIX targets).

APPENDIX

Date	Version No.	Change Summary
1/6/2015	1.0	
9/2/2016	1.1	Corrected inconsistencies between **Tables 3** and **4** and **Tables 5**, **6** and **7** • Car-washing moved to Drinking Water (**Table 3**) • Non-residential water irrigation demands were re-allocated to the correct land-uses (**Table 4**)

KEY DATA SOURCES

- ACADS-BSG Australian Climatic Data (Reference Meteorological Year, RMY) for hourly temperature, insulation and humidity.
- Bureau of Meteorology local rainfall and evaporation data (station 94776 – Williamtown AMO, 45 km from development, synthesized RMY):
- The selected year is the repentative weather station for the local climate zone (NatHERS zone 15)
- The RMY (Representative Meteorlogical Year) is synthesized from a composite of 12 typical meteorological months that best represent the historic average of the specified location using post-1986 data in addition to the earlier weather data for each of the 69 climate zones in Australia. The total rainfall and evaportation for this climate zone is:
- Annual rainfall (mm) – 1,050
- Annual evaporation (mm) – 1,728
- Bureau of Meteorology (2015) 10 year historic hourly rainfall, temperature and evaporation data (2005 to 2014), Kinesis data request.
- Department of Resources, Energy and Tourism, 2010, Energy in Australia – 2010, ABARE, Canberra
- Kinesis 2014, Additional water end use breakdowns derived from first principle analysis of residential and non-residential building types.
- National Water Commission, 2011, National performance report 2009-2010: urban water utilities, National Water Commission, Canberra
- NSW Department of Planning, BASIX Residential Water Consumption Data (2010)
- Sydney Water Best Practice Guidelines for water conservation in commercial office buildings and shopping centres (2007), http://www.sydneywater.com.au/web/groups/publicwebcontent/documents/document/zgrf/mdu0/~edisp/dd_054580.pdf
- Sydney Water Best Practice Guidelines for holistic open space turf management (2011), https://www.sydneywater.com.au/web/groups/publicwebcontent/documents/document/zgrf/mdq1/~edisp/dd_045253.pdf
- Water Corporation. (2014). Mapping water use at school. from https://www.watercorporation.com.au/home/teachers/lesson-plans-and-teaching-resources/lesson-plan-search/lesson-plan/?id=%7BD9516524-4A2C-4B98-A113-3891D59F1AAA%7D

Preliminary Risk Assessment Summary for Cooranbong

Purpose

The purpose of undertaking the preliminary risk assessment was to:

- Identify potential risks that may impact the safe and reliable operation of the facility (and associated components), specifically focused on risks associated with the following:
  - Potential impacts to public health and/or water quality
  - Environmental impacts including noise, odour and general environmental impacts
  - Operational reliability and process performance
  - Financial viability
  - Customer service
- Identify early, potential risk mitigation/control measures that can be incorporated into the design, construction and operation of the facility to sufficiently mitigate these risks
- Facilitate further dialogue with all key stakeholders to ensure all key risks associate with the project are identified and effectively controlled.

Methodology

A risk assessment was conducted for provision of the following services:

- Sewage
- Recycled water
- Drinking water

The assessment approach adopted for conducting the sewage and recycled water preliminary risk assessments was consistent with the recommendations in the Australian Guidelines for Water Recycling (AGWR). The assessment criteria are provided in Attachment A.

The assessment approach adopted for conducting the drinking water preliminary risk assessment was consistent with the recommendations in the Australian Drinking Water Guidelines (ADWG). The assessment criteria are provided in Attachment B.

Business risks, or risks leading to a loss of service or complaints, were assessed using the Flow assessment criteria provided in Attachment C.

The preliminary risk assessment process included the following activities:

- **Risk Identification** – The identification of a range of risks related to the project (what might happen?)
- **Risk Categorisation** – The categorization of the risks into various types to aid understanding and to provide context.
- **Risk Assessment** – Determination of the likelihood and consequence of the unmitigated/uncontrolled risk (what is the likelihood and impact/consequence?)
- **Managing the Risk/Risk Mitigation** – the identification of appropriate controls to be further developed and implemented as appropriate should the project be approved to process (what can be done to stop it happening?)
- **Post Mitigation Risk Assessment** – the reassessment of the risk following implementation of appropriate controls to ensure that the risk is sufficiently mitigate (how effective do we anticipate the controls to be?)

Controls

Controls modify the likelihood or the impact of the risk (i.e. both the likelihood and consequence of a risk).

- Preventive controls apply at the beginning of a risk's life, at or near the root causes(s). As a device, they often act as a barrier to "nip it (the risk) in the bud". They primarily reduce the likelihood of the risk occurring. Examples are system passwords, locked doors, machinery maintenance etc.
- Detective controls usually apply somewhere in the middle of the risk's life. Detective controls rely on the analysis of information in order to detect that a risk is "in motion". Detective controls that are "early" in the risk's life usually modify likelihood and those that are "late" in the life, usually modify impact. Examples are online monitoring, inspections, complaints and incident monitoring etc.
- Reactive controls (sometimes also called Responsive or Corrective), apply towards the end of a risk's life when the impact is imminent or being felt. They are focused on modifying impact. Examples are plant shutdown, drinking water top up, incident and emergency response processes.

Risk rating before and after controls

The risk rating after controls is a risk assessment with controls in place. As explained above, controls can modify both the likelihood and consequence of a risk.

The qualitative descriptions for consequence or impact contained in the recommendations of the AGWR and ADWG (refer to Attachments A and B), use a combination of the scale of the impact and the size of population or ecosystem affected. If the controls can reduce the scale of the impact or size of the population or ecosystem affected, then the overall risk rating can be reduced.

Examples include:
Drinking water - The risk of a low disinfection residual will lead to lower disinfection, but there will still be a level of disinfection, thereby reducing the scale of the impact and the size of the population affected.
Sewage – The risk of sewage overflow is mitigated by rapid response and isolation reducing the quantity of sewage released, and/or the flows to sensitive receiving environments being diverted, and therefore the scale and size of the ecosystems affected.
Recycled water - The risk of process failure is mitigated by a multi-barrier treatment approach and plant shutdown if critical control points are exceeded.

Outcomes

Sewage Risk Assessment

In undertaking the preliminary risk assessment, risks were identified across the following areas:

Area	Descriptions
The Catchment	Risks associated with the catchment area including consideration of items such as contamination, volume changes, public health incidents, storage requirements, illegal discharge to sewers etc.
The Sewer Network	Risks associate with the network itself including blockages, pipe or equipment failure, loss of power etc.
Management	General operation management issues risks that may impact operational reliability or supply surety.

Risks have been summarise at Attachment D as the detailed preliminary risk assessment contains information that is commercial in confidence.

Recycled Water Risk Assessment

In undertaking the preliminary risk assessment, risks were identified across the following areas:

Area	Descriptions
Local Water Centre	Consideration of the potential risk associated with the operation of the treatment facility including tank and/or equipment failure, odour, noise, process risks, capacity, power failure, telemetry, vandalism, operator error, flooding etc.
Recycled Water Reticulation and Use	Risks associated with the storage and distribution of recycled water to users and considered areas such as equipment failure, demand, unauthorized usage, water quality, security, power failure etc.
Management	General operation management issues risks that may impact operational reliability or supply surety.

Risks have been summarise at Attachment E as the detailed preliminary risk assessment contains information that is commercial in confidence.

Drinking Water Risk Assessment

In undertaking the preliminary risk assessment, risks were identified across the following areas:

Area	Descriptions

Supply	Consideration of the potential risk associated with the supply of drinking water from a public water authority
Potable Water Reticulation and Use	Risks associated with the storage and distribution of drinking water to users and considered areas such as equipment failure, demand, unauthorized usage, water quality, security, power failure etc.
Management	General operation management issues risks that may impact operational reliability or supply surety.

Risks have been summarise at Attachment F as the detailed preliminary risk assessment contains information that is commercial in confidence.

Attachment A Qualitative Risk Assessment Criteria as per the AGWR

Risk Matrix - Australian Guidelines for Water Recycling

Likelihood		Insignificant 1	Minor 2	Moderate 3	Major 4	Catastrophic 5
A	Almost certain	Low	Moderate	High	Very High	Very High
B	Likely	Low	Moderate	High	Very High	Very High
C	Possible	Low	Moderate	High	Very High	Very High
D	Unlikely	Low	Low	Moderate	High	Very High
E	Rare	Low	Low	Low	High	High

Consequence

Likelihood (qualitative measures)

Level	Descriptor	Example description
A	**Almost certain**	Is expected to occur, with probability of multiple occurrences within a year.
B	**Likely**	Will probably occur within a 1-5 year period.
C	**Possible**	Might occur or should be expected to occur within 5-10 year period.
D	**Unlikley**	Could occur within 20 years or in unusual circumstances.
E	**Rare**	May occur in exceptional circumstances; may occur once in 100 years.

Consequence or impact (qualitative measures)

Level	Descriptor	Example description
1	**Insignificant**	Insignificant impact or not detectable.
2	**Minor**	Health - minor impact for small population Environment - potentially harmful to local ecosystem with local impacts contained to site.
3	**Moderate**	Health - minor impact for large population Environment - potentially harmful to regional ecosystem with local impacts primarily contained on site.
4	**Major**	Health - major impact for small population Environment - potentially lethal to local ecosystem. Predominantly local, but potential for off-site impacts.
5	**Catastrophic**	Health - major impact for large population Environment - potentially lethal to regional ecosystem or threatened specias. Widespread on-site and off-site impacts.

Note:
1. The levels used for "Likelihood" have been changed to be the same as the ADWG i.e. A = Almost certain. In the AGWR A = Rare

Attachment B Qualitative Risk Assessment Criteria as per the ADWG

Risk Matrix - Australian Drinking Water Guidelines

Likelihood		Insignificant 1	Minor 2	Moderate 3	Major 4	Catastrophic 5
A	Almost certain	Moderate	High	Very High	Very High	Very High
B	Likely	Moderate	High	High	Very High	Very High
C	Possible	Low	Moderate	High	Very High	Very High
D	Unlikely	Low	Low	Moderate	High	Very High
E	Rare	Low	Low	Moderate	High	High
		Consequence				

Likelihood (qualitative measures)

Level	Descriptor	Example description
A	**Almost certain**	Is expected to occur in most circumstances.
B	**Likely**	Will probably occu in most circumstances.
C	**Possible**	Might occur or should occur at some time.
D	**Unlikley**	Could occur at some time.
E	**Rare**	May occur only in exceptional circumstances.

Consequence or impact (qualitative measures)

Level	Descriptor	Example description
1	**Insignificant**	Insignificant impact, little disruption to normal operation, low increase in normal operation costs.
2	**Minor**	Minor impact for small population, some maneagable operation design interuption, some increase in operating costs.
3	**Moderate**	Minor impact for large population, signicificant modificaiton to nornal operation but manageable, operation costs increased, increased monitoring.
4	**Major**	Major impact for small population, systems significantly compromised and abnormal operation if at all, high level of monitoring required.
5	**Catastrophic**	Major impact for large population, complete failure of system.

Attachment C Flow's Qualitative Risk Assessment Criteria

Risk Matrix – Flow Systems

Likelihood			1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophic
Likelihood	A	Almost certain	Low	Medium	High	Very High	Very High
Likelihood	B	Likely	Low	Medium	High	Very High	Very High
Likelihood	C	Possible	Minimal	Low	Medium	High	Very High
Likelihood	D	Unlikely	Minimal	Minimal	Low	Medium	High
Likelihood	E	Rare	Minimal	Minimal	Low	Medium	High

Consequence

Attachment C Flow's Qualitative Risk Assessment Criteria *cont.*

Likelihood (qualitative measures)

Level	Descriptor	Example description (Flow)
A	Almost certain	Expected to occur in most circumstances. Greater than 90% chance of occurrence. More than once per year.
B	Likely	Will probably occur in most circumstances. 65%-90% chance of occurrence Once in 1-2 years
C	Possible	Might occur or should occur at some time. 35%-65% chance of occurrence Once in 2-5 years
D	Unlikley	Could occur in unusual circumstances. 10%-35% chance of occurrence. Once in 5- 20 years.
E	Rare	May occur only in exceptional circumstances. Less than 10% chance of occurrence. Once in 20 years

Consequence or impact (qualitative measures)

Level	Descriptor	Example description
1	Insignificant	No material financial consequence to Flow Cost <$10k 1-2 customers impacted. Little disruption to normal operation, low increase in normal operation costs.
2	Minor	Some financial consequences to Flow Cost $10k-100k. 2-10 customers or a whole street impacted. May require notification but no other extraordinary activities. Some manageable operation disruption, some increase in operating costs.
3	Moderate	Considerable financial consequences to Flow. Cost $100k-$250k. Subdivision of community or whole development stage impacted. Significant negative consequences requiring additional actions to rectify. Negative client / customer reaction but temporary. Significant modification to normal operation but manageable, operation costs increased, increased monitoring.
4	Major	Material financial consequences to Flow Cost $250k-$1 million. Whole community impacted. High likelihood of adverse client/ customer reaction (e.g. lawsuits). May lose some clients / customers permanently. Systems significantly compromised and abnormal operation if at all, high level of monitoring required.
5	Catastrophic	Such significant financial consequences to Flow that its ability to operate is threatened. Cost > $1 million. More than one community impacted. Adverse client / customer reaction (e.g. lawsuits). Permanent loss of multiple clients / customers. Flow's key point of contact with IPART in the short term. Complete failure of systems.

Attachment D – Preliminary Risk Assessment Summary - Sewage

Risk ID	Component	Potential Risk	Pre-mitigation Risk	Controls	Post-mitigation Risk (or residual risk)
SW 1.1	Whole of system	Failure of overarching sewer management plan	**High**	• Additional controls as listed for each individual risk below. • Preventive: • Business Management System (BMS) independently verified to the International Standards ISO 9001 for quality management, ISO 14001 for environmental management and ISO 45001 for safety management • Regular audits by auditors from the regulator's (IPART) independent panel of auditors. • Regular internal process and compliance audits are a component of the Flow BMS. • Review of resource requirements as part of Flow's business planning and budgeting process. • Annual review of BMS and water quality management plans. • Regulator oversight and enforcement action. • Skilled and trained operators. • Competency based training system. • Detective: • Consumer complaints • Operator inspections • Reactive: • Incident & Emergency Management Plan and associated processes to ensure a rapid and effective incident response and to prevent incident escalation. • Incident Notification Protocol with NSW Health to ensure risks to public health are controlled quickly • Qualified contractors engaged to provide rapid response to faults and emergencies including sewage overflows. • Pollution incident notification as per POEO Act requirements • Water Industry Competition Act's Operator of Last Resort provisions and step in rights	**Low**
SDW 1.1	Delivery of developer works	Delays in construction and delivery of infrastructure by developer	**Very High**	• Compliance Certificate only issued when developer completes works • If works delayed, developer pays bond to Flow and Flow will deliver infrastructure • ISO 9001 certified project management processes including project meetings, program updates, and reporting. • Generators if delay related to connection to power. • Other reactive contingency measures dependent on service i.e. : sewage tankering, drinking water tankering, deployment of extra pumps	**Low**
SDW 1.2	Delivery of Local Water Centre	Delays in construction and delivery of Local Water Centre by Flow	**Very High**	• ISO 9001 certified project management processes to ensure timely delivery of infrastructure • Early identification of contingency measures through modelling. • Sewage tankering • Provision of drinking water through recycled water network.	**Low**
SC 1.1 SC 1.2	Collection System (On-lot)	Overflow from on-lot infrastructure	**Very High**	• NSW Office of Fair Trading inspections during installation to mitigate illegal stormwater connections	**Low**

				• Monitoring of pump operation, sewage level and pumped volumes through telemetry. • Communication with home builders to ensure sewer connection prior to occupancy	
SC 1.1b	Collection system (On-lot)	Builders allow occupancy before contacting Cooranbong Water to connect sewer	**Very High**	• Builder workshops • Home owner education • Messaging with DA Plan review • Tag on tank • Social media reminders • Regular inspection of house building progress • Qualified contractors to manage wastewater spills	**Low**
SC 1.3 SC 1.4	Collection system (Sewer main)	Sewage escape from sewer main due to third party damage	**Very High**	• Dial Before You Dig (DBYD) • Pressure monitoring and alarms of network • Incident and Emergency Management Plan and associated processes to ensure rapid response and mitigation.	**Low**
SC 1.5	Collection system (Sewer main)	Odour from low flows at beginning (in initial stages of development)	**High**	• Regular flushing during early connection phase.	**Minimal**
SL 1.6 SL 1.10	Local Water Centre (Flow Balance Tank)	Overflow from tank	**High**	• Design, production, installation and testing by qualified contractors and quality assurance to AS3735 Water Retaining Structures. • Incident and Emergency Management Plan and associated processes to ensure rapid response and mitigation.	**Low**
SL 1.8 SL 1.9 SL 1.10	Local Water Centre (Flow Balance Tank)	Operational failure	**High**	• Flow Balance Tank in secure environment without public access • Standard equipment type so spares easily available on short lead times • Duty / standby of equipment • Inlet and product water buffer storage • Spares of critical equipment on site • Monitoring and controls • Proactive maintenance regime • Experienced operators • Incident and Emergency Management Plan and associated processes to ensure rapid response and mitigation. • Tankering company on emergency callout contract. • Generator back-up • Additional network storage in on-lot wastewater collection tanks	**Low**
SL 1.11	Local Water Centre	Inability to service customers	**Very High**	• Standard equipment type so spares easily available on short lead times • Duty / standby of equipment • Inlet and product water buffer storage • Spares of critical equipment on site • Monitoring and controls • Proactive maintenance regime • Experienced operators • Incident and Emergency Management Plan and associated processes to ensure rapid response and mitigation. • Tankering company on emergency callout contract • Generator back-up • Additional network storage in on-lot wastewater collection tanks	**Low**

Attachment E – Preliminary Risk Assessment Summary – Recycled Water

Risk ID	Component	Potential Risk	Pre-mitigation Risk (or	Controls	Post-mitigation Risk (or residual risk)
RW 1.1	Whole of system	Failure of overarching recycled water quality plan	**Very High**	• Additional controls as listed for each individual risk below. • Preventive: • Business Management System (BMS) independently verified to the International Standards ISO 9001 for quality management, ISO 14001 for environmental management and ISO 45001 for safety management • Regular audits by auditors from the regulator's (IPART) independent panel of auditors. • Regular internal process and compliance audits are a component of the Flow BMS. • Review of resource requirements as part of Flow's business planning and budgeting process. • Annual review of BMS and water quality management plans. • Regulator oversight and enforcement action. • Skilled and trained operators. • Competency based training system. • Detective: • Consumer complaints • Operator inspections • Reactive: • Incident & Emergency Management Plan and associated processes to ensure a rapid and effective incident response and to prevent incident escalation. • Incident Notification Protocol with NSW Health to ensure risks to public health are controlled quickly • Qualified contractors engaged to provide rapid response to faults and emergencies including sewage overflows. • Pollution incident notification as per POEO Act requirements • Water Industry Competition Act's Operator of Last Resort provisions and step in rights	**Low**
RDW 1.1	Delivery of developer works	Delays in construction and delivery of infrastructure by developer	**Very High**	• Compliance Certificate only issued when developer completes works • If works delayed, developer pays bond to Flow and Flow will deliver infrastructure • ISO 9001 certified project management processes including project meetings, program updates, and reporting. • Generators if delay related to connection to power. • Other reactive contingency measures dependent on service i.e. : sewage tankering, drinking water tankering, deployment of extra pumps	**Low**
RDW 1.2	Delivery of Local Water Centre	Delays in construction and delivery of Local Water Centre by Flow	**Very High**	• ISO 9001 certified project management processes to ensure timely delivery of infrastructure • Early identification of contingency measures through modelling. • Sewage tankering • Provision of drinking water through recycled water network.	**Low**
RC 1.1 RC 1.2	Collection System	Raw sewage characteristics are	**Very High**	• Design influent parameters based on industry guidelines for water efficient homes.	**Low**

RC 1.3		outside of design influent parameters		• Treatment process log reduction is greater than the minimum for required uses. • Community education i.e. new owner information packs, newsletters, school experience programmes etc. used to inform the public on what can be disposed of down the sewer. • Trade Waste Agreements with retail and commercial users • Multiple treatment barrier approach • Automatic plant shutdown when critical control points are breached. • Key process parameters are monitored and alarms generated should these indicate a toxic event.	
RL 1.1 RL 1.6 RL 1.8 RL 1.10 RL 1.13	Local Water Centre	Process equipment damage / failure	**Very High**	• Duty / standby of equipment • Inlet and product water buffer storage • Spares of critical equipment on site • Monitoring and controls • Proactive maintenance regime • Experienced operators • Incident and Emergency Management Plan and associated processes to ensure rapid response and mitigation. • Tankering company on emergency callout contract. • Site security	**Low**
RL 1.2 RL 1. 4 RL 1. 7 RL 1. 9 RL 1.12	Local Water Centre	Process performance outside operational parameters	**Very High**	• Duty / standby of equipment • Inlet and product water buffer storage • Spares of critical equipment on site • Monitoring and controls • Proactive maintenance regime • Experienced operators • Incident and Emergency Management Plan and associated processes to ensure rapid response and mitigation. • Tankering company on emergency callout contract.	**Low**
RL 1.3 RL 1.5	Local Water Centre	Tank failure	**Very High**	• Design, production, installation and testing by qualified contractors and quality assurance to AS3735 Water Retaining Structures. • Incident and Emergency Management Plan and associated processes to ensure rapid response and mitigation.	**Low**
RL 1.11 RL 1. 14	Local Water Centre	Supply of chemicals is exhausted or degraded/poor quality	**Very High**	• Tanks sized for adequate storage but with regular ordering of small volumes due to degradation over time • Recycled water production will cease if chemicals are not available. • Chemical supply contract with minimum and emergency supply provisions. • Skilled operators with documented operational procedure. • Chemical storage tanks are fitted with level devices to ensure levels are continuously monitored.	**Low**
RL 1.15	Local Water Centre	Chemical spill	**Very High**	• Chemicals stored within weatherproof, bunded area as per Australian standards • Chemical loading area within bunded area • Chemical delivery procedures • Trained and inducted delivery drivers • Spill response procedure • Tankering company on emergency callout contract • Incident and Emergency Management Plan and processes	**Low**
RL 1.16	Local Water Centre	Incorrect chemical delivery	**Very High**	• Colour coded and labelled intake nozzles for chemical tanks	**Low**

				• Chemical supply agreements and operational procedures • Chemical delivery procedures • Trained and inducted delivery drivers • Tankering company on emergency callout contract • Incident and Emergency Management Plan and processes	
RL 1.17 RL 1.18 RL 1.19 RL 1.20	Local Water Centre	Disaster Emergency such as fire, lightning, vandalism, theft, power failure	**Very High**	• In the event of power failure onsite back-up generator used to maintain key process units. • Regular maintenance of back up generator • Ability to source an offsite generator as a backup • UPS system installed to ensure control and access to the plant is still maintained. • Top-up with drinking water • Firefighting system for the LWC from both potable and recycled water system • Incident and Emergency Management Plan and processes	**Low**
RL 1.23 RL 1.24	Local Water Centre	Poor aesthetics / Noise	**Very High**	• Local Water Centre has been designed to blend in with the local environment whilst not hiding its core activity. • Building layout has been designed to facilitate scheduled visits from interested stakeholders. • All odour generating equipment has been fitted with covers and odour treatment as required. • Odour modelling has been undertaken to confirm that expected impact on surrounding stakeholders is negligible. • H_2S monitoring on odour control vent • All noise generating equipment has been fitted with acoustic covers. Further acoustic treatment has been provided on the Local Water Centre building. • Noise modelling has been used to confirm that expected impact on surrounding stakeholders is negligible.	**Low**
RL 1.25	Local Water Centre	PLC / SCADA failure	**Very High**	• Local Water Centre can continue operation in the event telemetry is lost. • Automatic LWC shutdown on PLC failure • Operating procedure to respond to PLC failure • Data capture will continue on the local SCADA and PLC. • Plant would shut down if parameters were out of specification. • Top up with drinking water • Software and hardware back up • Supply agreement with telemetry with emergency response provision	**Low**
RD 1.1 RD 1.2	Recycled Water Distribution	Tank overflow / failure	**Low**	• Design, production, installation and testing by qualified contractors and quality assurance • Incident and Emergency Management Plan and associated processes to ensure rapid response and mitigation • Tankering company on emergency callout contract	**Low**
RD 1.3 RD 1.4	Recycled Water Distribution	Cross connection	**Very High**	• Recycled water kept at lower pressure than drinking water thereby mitigating recycled water entering the system • Colour coded, different materials, labelled pipes and marker tape • QA inspections of house plumbing by NSW Office of Trading prior to handover / operation	**Low**

				• Plumbing inspections triggered by DA process • OFT inspection and Flow's cross-connection plumbing check pre-conditions to Flow's connection of sewerage • QA checks on reticulation installation prior to handover to Flow (and Flow's issue of Certificate of Compliance) • Home builder education (website, Builders Guide) • Customer education (website, home owners guide, including translated services) • Backflow prevention at each house connection • Telemetry monitoring of drinking and recycled water usage to identify anomalous use • High quality recycled water has low risk of health impact.	
RD 1.5	Recycled Water Distribution	Recycled water is used for unauthorized purposes	**Very High**	• Colour coded, different materials, labelled pipes and marker tape • Information packs will be supplied to householders on initial connection or with change of ownership. These information packs will clearly define the authorised uses for the recycled water. • Factsheets will be sent with billing information to householders reinforcing the authorised uses for the recycled water. • Community education on recycled water / website • Signage on recycled water taps • Telemetry monitoring of drinking and recycled water usage to identify anomalous use	**Low**
RD 1.6	Recycled Water Distribution	Process equipment damage / failure	**High**	• Pumps are installed duty / standby with automatic changeover. • Maintenance contractor to be engaged under standard protocols to investigate cause of pump failure. • Maintenance contractor to be engaged under emergency protocols to repair pump(s) or install temporary pump or repair leak. • Standard equipment type so spares easily available on short lead times • Spares of critical equipment on site • Where possible, recycled water storage located at high elevation to allow gravity feed • Preventive maintenance on pumps • Reticulation pipe work will be provided with a number of valves enabling isolation of parts of the network.	**Low**
RD 1.7	Recycled Water Distribution	Main break leading to discharge of recycled water	**Moderate**	• Reticulation pipe work will be provided with a number of valves enabling isolation of parts of the network. • Maintenance contractor to be engaged under emergency protocols to repair leak. • High quality recycled water • Dial Before You Dig (DBYD) • Automatic shut down on high flow* • Looped reticulation design and construction • Highlighting of single supply mains as high priority on DBYD where looping not possible • Pressure monitoring of the network for early alert of leaks	**Low**

				• Mechanical vehicle protection on storage tanks (height restrictions, bollards) • Detectable marker tape over all mains	
RD 1.9	Recycled Water Distribution	Demand exceeds supply	**Moderate**	• Recycled water storage sized at >5 days of average production. • Drinking water used to maintain supply if the recycled water storage tank drops below a minimum level. • Membrane tank over-sized to allow for the option of stormwater harvesting to supplement the source water supply.	**Low**
RD 1.10	Recycled Water Distribution	Health impact from exposure to water features	**Very High**	• Signage indicating use of recycled water in water features and proper use • High quality recycled water has low risk of health impact.	**Low**
RD 1.11	Recycled Water Distribution	Supply exceeds demand	**Very High**	• Implement Integrated Water Cycle Management (IWCM) Policy and regularly review scheme specific IWCM Plan. • Seek additional recycled water customers. • Detective: • Monitor volumes, demands and trends and adjust operations to suit • Identify properties with higher than average sewer consumers and target for illegal connection studies. • Tankering • Construct additional storage	**Low**
RI 1.1 RI 1.2 RI 1.3 RI 1.4 RI 1.5 RI 1.6 RI 1.10 RI 1.11	Recycled Water Irrigation (by Flow)	Irrigation affecting receiving environments (water, land)	**High**	• Flow operates to ISO 14001 certified Environmental Management System • Recycled Water Irrigation Management Plan (RWIMP), irrigation policies, procedures and systems implemented by trained and skilled staff • High quality recycled water treated for licensed end-use • Irrigation not applied to buffer area around waterways • Water quality and soil monitoring in accordance with Flow Monitoring and Sampling Plan/Program • Remote and in person monitoring of irrigation areas • Visual inspection of irrigation areas and irrigation infrastructure	**Low**
RI 1.7	Recycled Water Irrigation (by Flow)	Poor irrigation practices	**Moderate**	• Flow operates to ISO 14001 certified Environmental Management System • Recycled Water Irrigation Management Plan (RWIMP), irrigation policies, procedures and systems implemented by trained and skilled staff • Irrigation site selection criteria • Seasonal irrigation to meet water balance requirements • High quality recycled water treated for licensed end-use • Water quality and soil monitoring in accordance with Flow Monitoring and Sampling Plan/Program • Remote and in person monitoring of irrigation areas • Visual inspection of irrigation areas and irrigation infrastructure	**Low**
RI 1.8	Recycled Water Irrigation (by Flow)	Water not suitable for irrigation	**Moderate**	• Flow operates to ISO 14001 certified Environmental Management System • Recycled Water Irrigation Management Plan (RWIMP), irrigation policies, procedures and systems implemented by trained and skilled staff • High quality recycled water treated for licensed end-use	**Low**

				• Controls as listed above related to performance • Water quality monitoring	
RI 1.9	Recycled Water Irrigation (by Flow)	Salinity increase in soils, groundwater and surface water	**High**	• Flow operates to ISO 14001 certified Environmental Management System • Recycled Water Irrigation Management Plan (RWIMP), irrigation policies, procedures and systems implemented by trained and skilled staff • Water quality and soil monitoring in accordance with Flow Monitoring and Sampling Plan/Program • High quality recycled water treated for licensed end-use • Controls as listed above related to performance • Appropriate site selection • Vegetation selection and maintenance • Receiving environment monitoring - water and soil quality • Gypsum application	**Low**

Attachment F – Preliminary Risk Assessment Summary – Drinking Water

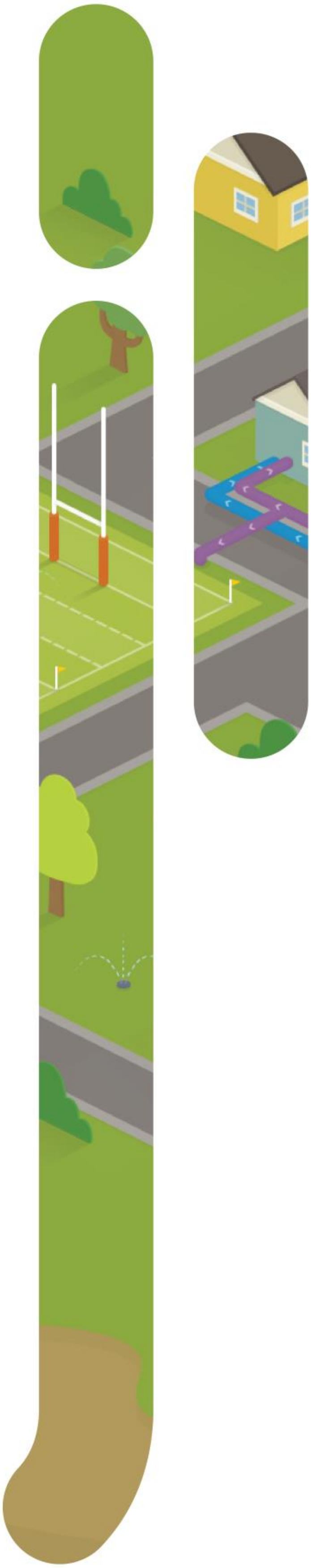
Risk ID	Component	Potential Risk	Pre-mitigation Risk (or	Controls	Post-mitigation Risk (or residual risk)
DW 1.1	Whole of system	Failure of overarching drinking water quality plan	**Very High**	• Additional controls as listed for each individual risk below. • Preventive: • Business Management System (BMS) independently verified to the International Standards ISO 9001 for quality management, ISO 14001 for environmental management and ISO 45001 for safety management • Regular audits by auditors from the regulator's (IPART) independent panel of auditors. • Regular internal process and compliance audits are a component of the Flow BMS. • Review of resource requirements as part of Flow's business planning and budgeting process. • Annual review of BMS and water quality management plans. • Regulator oversight and enforcement action. • Skilled and trained operators. • Competency based training system. • Detective: • Consumer complaints • Operator inspections • Reactive: • Incident & Emergency Management Plan and associated processes to ensure a rapid and effective incident response and to prevent incident escalation. • Incident Notification Protocol with NSW Health to ensure risks to public health are controlled quickly • Qualified contractors engaged to provide rapid response to faults and emergencies including sewage overflows. • Pollution incident notification as per POEO Act requirements • Water Industry Competition Act's Operator of Last Resort provisions and step in rights	**Low**
DDW 1.1	Delivery of developer works	Delays in construction and delivery of infrastructure by developer	**Very High**	• Compliance Certificate only issued when developer completes works • If works delayed, developer pays bond to Flow and Flow will deliver infrastructure • ISO 9001 certified project management processes including project meetings, program updates, and reporting. • Generators if delay related to connection to power. • Other reactive contingency measures dependent on service i.e. : sewage tankering, drinking water tankering, deployment of extra pumps	**Low**
DC 1.1 DC 1.2	Catchment (Connection to Public Water Utility)	Out of specification drinking water quality supplied by Public Water Utility	**Very High**	• Utility Services Agreement with supplying water authority obliging the need to meet ADWG in supply water • Agreed communications protocols between local water utility and supplying water authority forming part of the USA • Accredited laboratory water quality testing by Flow Systems (quarterly grab samples and upon incident notification) • Incident and Emergency Management Plan and processes • Incident notification protocols with Public Health Unit and determine appropriate public health response	**Low**

DC 1.3	Catchment (Connection to Public Water Utility)	Interruption to supply	**Moderate**	• Utility Services Agreement between local water utility and supplying water authority • Agreed communications protocols between local water utility supplying water authority forming part of the USA • Pressure monitoring at or near the bulk supply points • Provide tankered / bottled water • Incident and Emergency Management Plan and processes	**Low**
DD 1.1 DD 1.2	Drinking Water Distribution	Main break	**Very High**	• Dial Before You Dig (DBYD) • Mechanical vehicle protection on storage tanks (height restrictions, bollards) • Detectable marker tape over all mains • Spare repair fittings kept on site • As recycled water is supplied for up to 60% of home water demand, the consequence is already mitigated • Isolation valves on reticulation to allow isolation of sections	**Low**
DD 1.3 DD 1.4	Drinking Water Distribution	Recycled water cross connection	**Very High**	• Recycled water kept at lower pressure than drinking water thereby mitigating recycled water entering the system • Colour coded, different materials, labelled pipes and marker tape • QA inspections of house plumbing by NSW Office of Trading prior to handover / operation • Plumbing inspections triggered by DA process • OFT inspection and Flow's cross-connection plumbing check pre-conditions to Flow's connection of sewerage • QA checks on reticulation installation prior to handover to Flow (and Flow's issue of Certificate of Compliance) • Home builder education (website, Builders Guide) • Customer education (website, home owners guide, including translated services) • Backflow prevention at each house connection • Telemetry monitoring of drinking and recycled water usage to identify anomalous use	**Low**
DD 1.5	Drinking Water Distribution	Loss of supply / pressure	**High**	• Pump provide in duty / standby • Supply recycled water to non-potable use (reduced impact on potable use) • Tankered / bottled water • Continuous pressure monitoring	**Low**
DD 1.6 DD 1.7	Drinking Water Distribution	Chemical leaching into supply	**Very High**	• New system, new materials, PVC pipework • Pipework designed to Australian Standards AS4020:2005 • Commissioning testing • Asset management and 6 monthly maintenance inspections • Accredited laboratory water quality testing by Flow Systems (grab samples and upon incident notification)	**Low**
DS 1.1	Drinking Water Storage	Contamination of drinking water storage	**Very High**	• Enclosed storage to ADWG standard • Security including fencing, CCTV, anti-climb measures, locked tank hatches and telemetry notification immediately • Routine inspection of storage • Water quality monitoring • Online analysing and automatic top up of chlorine residual	**Low**

DS 1.2 DS 1.3	Drinking Water Storage	Chlorine dosing duty and standby pump fail and chlorine for residual can not be dosed	**Very High**	• Chlorine dosing for disinfection pumps are installed duty / standby. If duty pump fails then standby pump will automatically start. • Key spare parts kept on site to facilitate local / rapid repair. • Manually dose until pumps repaired • Online monitoring of chlorine residual	**Low**
DS 1.4 DS 1.5	Drinking Water Storage	Supply of chemicals is exhausted or degraded/poor quality	**Very High**	• Tanks sized for adequate storage but with regular ordering of small volumes due to degradation over time • Chemical supply contract with minimum and emergency supply provisions. • Skilled operators with documented operational procedure. • Chemical storage tanks are fitted with level devices to ensure levels are continuously monitored.	**Low**
DS 1.6	Drinking Water Storage	Incorrect chemical delivery	**Very High**	• Colour coded and labelled intake nozzles for chemical tanks • Chemical supply agreements and operational procedures • Chemical delivery procedures • Trained and inducted delivery drivers • Tankering company on emergency callout contract • Incident and Emergency Management Plan and processes	**Low**

Drinking Water Quality Plan

(DWQP)



Document Issue Record

Issue Date	Revision	Issue	Issued To	Prepared By	Approved By
24/10/14	1	First revision	Flow	Kirsten Evans	Andrew Horton
30/1/15	2	Added AMP to: Figure 1 Table 1	Flow	Kirsten Evans	Andrew Horton
11/02/15	3	Added Acronyms Table	Flow	Laura Dixon	Andrew Horton
8/09/15	4	Amended to include interim drinking water supply system	Flow	Kirsten Evans	Andrew Horton
22/11/16	5	Annual review	Flow	Laura Dixon	Andrew Horton
31/08/17	6	Removed Public Health (General) Regulation 2002 (NSW) reference and updated Flow logos	Flow	Laura Dixon	Andrew Horton
22/01/18	7	Annual review	Flow	Laura Dixon	Andrew Horton
3/07/18	8	BMS document map updated	Flow	Michael Northcott	Andrew Horton
10/09/18	9	Updated cover page	Flow	Kirsten Evans	Andrew Horton

Contents

flow

Cooranbong Scheme Management Plan (Scheme MP)

Cooranbong Water

Document Issue Record

Rev	Issue Date	Change	Prepared By	Approved By
1	06/02/15	First revision	Darren Wharton	
2	22/09/15	Second revision Renumbered and issued Inserted section 5 and section 7	Darren Wharton	
3	24/11/15	Revision of generic content and addition of OEMP section	Kirsten Evans	Darren Wharton
4	25/10/16	Updated figures 4 and 5 and updated tables 2, 3, 4 and 6	Laura Dixon	Andrew Horton
5	2/11/16	Updated section 7.2.2.1	Laura Dixon	Andrew Horton
6	22/01/18	Annual review	Laura Dixon and Andrew Horton	Andrew Horton
7	21/09/18	Addition of section 3.2.2 on extension area Update to all subsections of Section 7 Recycled Water Irrigation including: - Water balance figures, number and extent of DIZs, miscellaneous irrigation risks, irrigation quality control point	CWT/Michael Northcott	Darren Wharton

1 Executive Summary

1.1 Purpose of the Scheme Management Plan

This document is the Cooranbong scheme-specific Scheme Management Plan (Scheme MP) which outlines the scheme-specific details referenced by the Flow Recycled Water Quality Plan, Drinking Water Quality Plan, Sewage Management Plan and others. It therefore forms part of Flow's conformance to the requirements of the Water Industry Competition Regulations 2008 (WICR) Schedule 1 clauses 7, 13 and 14 and forms part of Flow's:

- commitment to compliance with the Water Industry Competition Act 2006 (WICA)
- Overall management plan framework for the provision of sewage, drinking and recycled water services.

The purpose of this document is to supplement the following Flow management plans with scheme specific information:

- Recycled Water Quality Plan
- Drinking Water Quality Plan
- Recycled Water Irrigation Management Plan
- Sewage Management Plan
- Infrastructure Operating Plan
- Asset Management Plan
- Incident Management Plan
- Operations Environmental Management Plan.

1.2 Scheme summary

Table 1: Scheme Summary Details

Scheme Summary Details		
Location:	**Region**	**State**
Cooranbong	Hunter	NSW
Ultimate Residential	**Ultimate size**	
2,100		
Development Type:	**Development Precinct**	**Development Marketing Name**
Housing Supply	North Cooranbong	Watagan Park
Utility Name	**Network Operator**	**Retailer**
Cooranbong Water	Cooranbong Water P/L	Flow Systems P/L
WICA NOL No.	**WICA RSL No.**	
15_033	13_001R	
Recycled water		
Source	Sewage from residential dwellings and retail connections	
Treatment	Screening, Biological Reactor, UV Disinfection, Chlorination	
Further Treatment	Chemical storage and dosing, WAS Dewatering, Odour Scrubbing	
End Uses	Toilet flushing, washing machines, general purpose washdown, carwash use, irrigation, treatment plant service water	

Drinking Water	
Source	Hunter Water Drinking Water Network
Treatment	Treated by Hunter Water
Further treatment	Residual disinfection only

1.3 Critical Control Points

Table 2: Process Critical Control Points

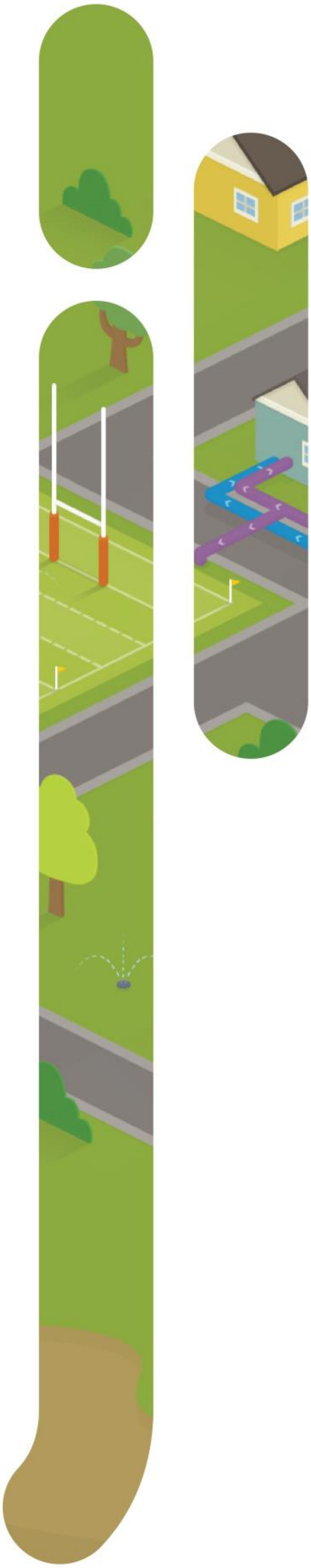
Critical Control Point	Treatment Process	Parameter	Target
1	Membrane Bioreactor	Turbidity (NTU)	<0.2NTU
2	Ultraviolet (UV) Disinfection	UV transmissivity (mJ/cm^2)	>5 W/cm^{2}UVI, >55% UVT
3	Chlorination	Free chlorine (mg/L)	
		Chlorine contact time (mg.min/L)	>19 mg.min/L
		pH	6.5<pH<7.5

1.4 High Level Program

The high-level program shows the approximate staging of infrastructure development over the life of the Cooranbong development. Refer to the documents listed in section 2.1.4.

Contents

Infrastructure Operating Plan (IOP)



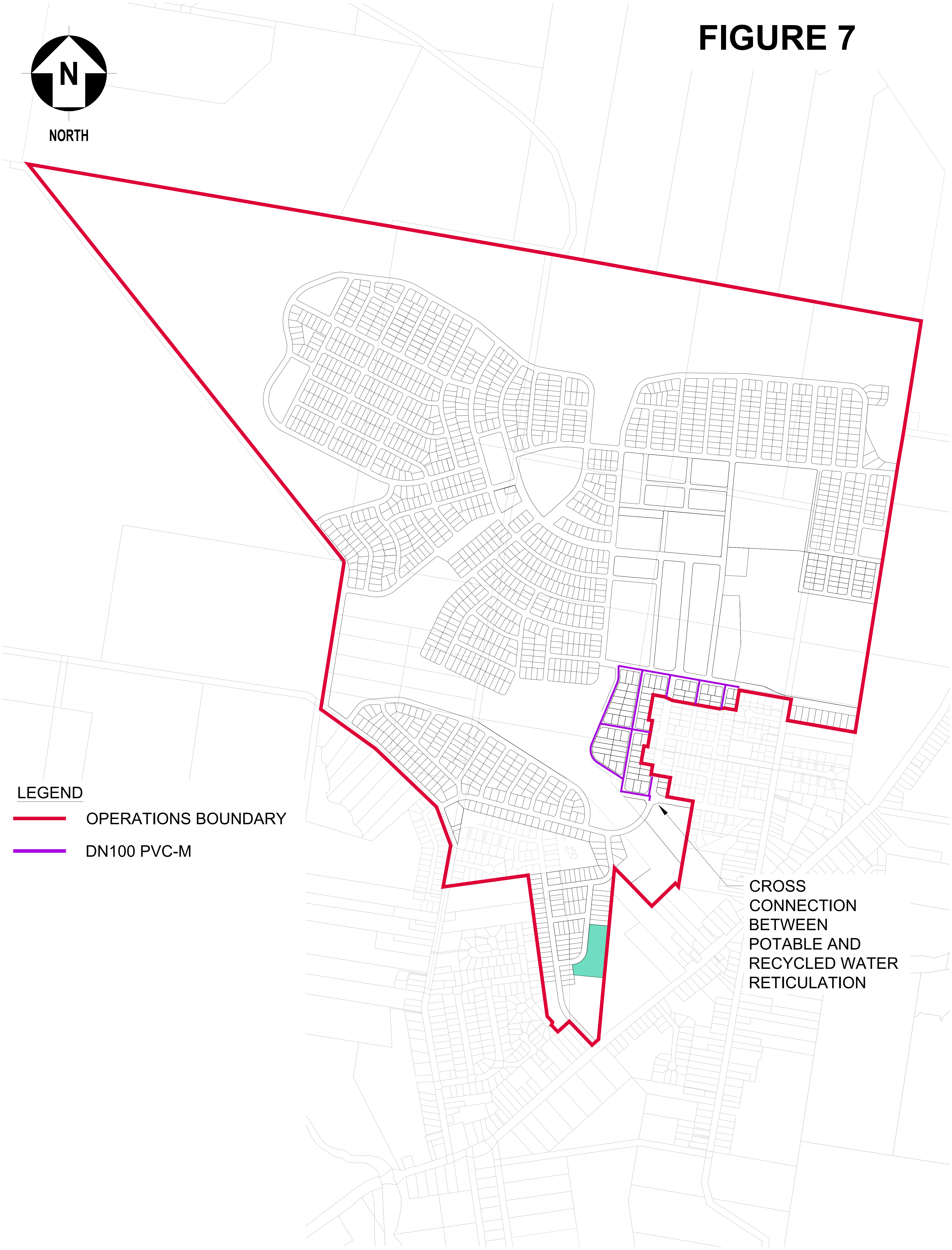
Document Issue Record

Issue Date	Revision	Issue	Issued To	Prepared By	Approved By
24/10/14	1	First revision	Flow	Kirsten Evans	Andrew Horton
12/12/14	2	Minor formatting corrections	Flow	Kirsten Evans	Andrew Horton
30/1/15	3	Added AMP to: Figure 1 Table 1 Added: Section 3.4	Flow	Kirsten Evans	Andrew Horton
22/5/15	4	Added reference to AMP in Section 7 Added information regarding water meters to 2.5.1	Flow	Kirsten Evans	Andrew Horton
8/9/15	5	Amended to include interim drinking water supply system	Flow	Kirsten Evans	Andrew Horton
25/5/16	6	Reviewed plan and updated Figures 1, 2, 3, 5 and 6	Flow	Laura Dixon	Andrew Horton
21/10/16	7	Updated NSW COP Plumbing & Drainage to Plumbing Code of Australia	Flow	Laura Dixon	Andrew Horton
21/12/16	8	Changed Hunter Water to PWU	Flow	Laura Dixon	Andrew Horton

		(Public Water Utility) in section 4.1.1.1			
22/01/18	9	Annual review	Flow	Laura Dixon	Andrew Horton
3/7/18	10	Updated BMS document map	Flow	Michael Northcott	Andrew Horton
10/9/18	11	Changed cover page to new format	Flow	Kirsten Evans	Andrew Horton

Contents

FIGURE 7



NORTH COORANBONG
RECYCLED WATER MASTER PLAN
INITIAL DEVELOPMENT

Cooranbong Water

flow systems

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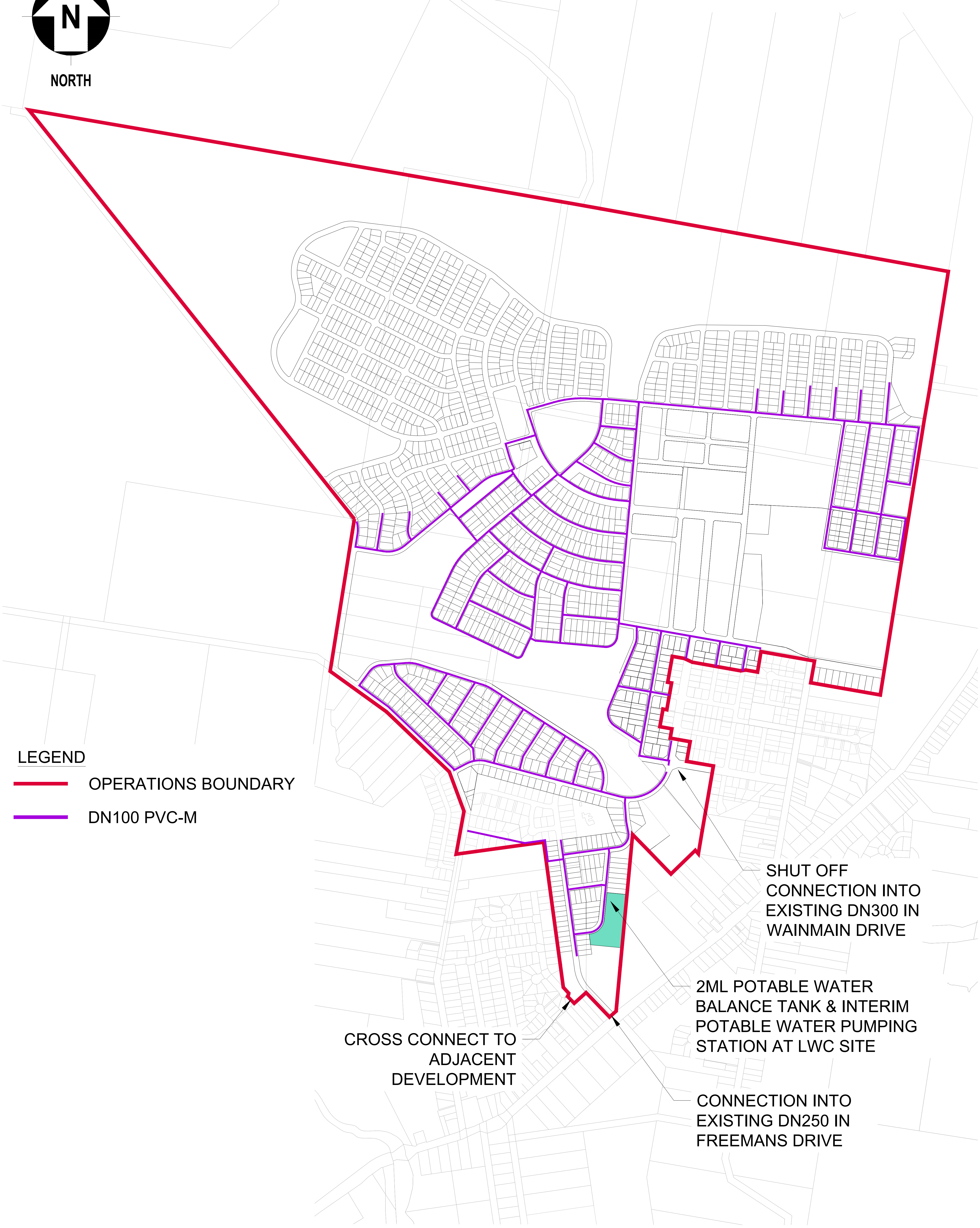
FIGURE 8



NORTH COORANBONG

RECYCLED WATER MASTER PLAN

DEVELOPMENT TO END OF STAGE 7B

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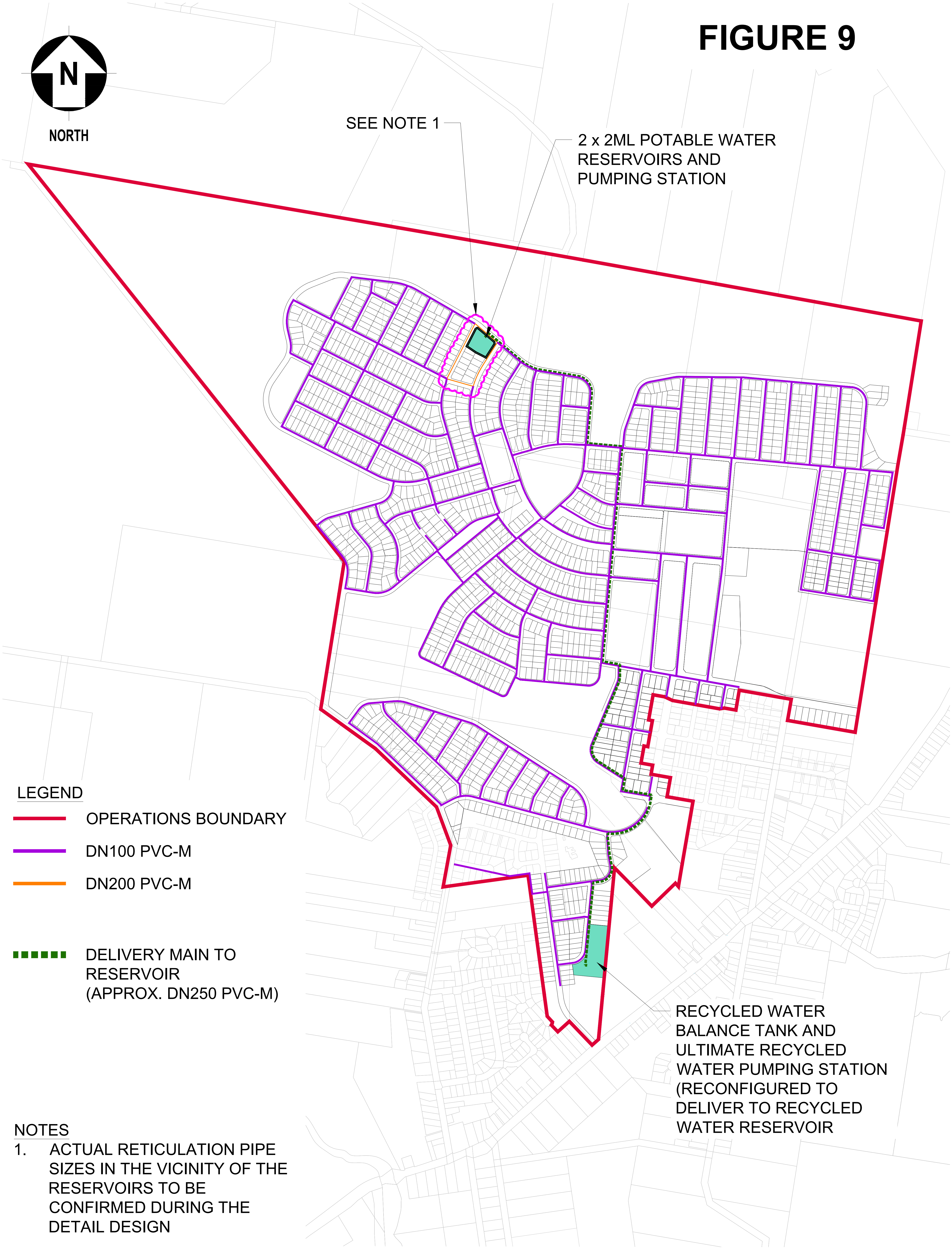
FIGURE 9



NOTES

1. ACTUAL RETICULATION PIPE SIZES IN THE VICINITY OF THE RESERVOIRS TO BE CONFIRMED DURING THE DETAIL DESIGN

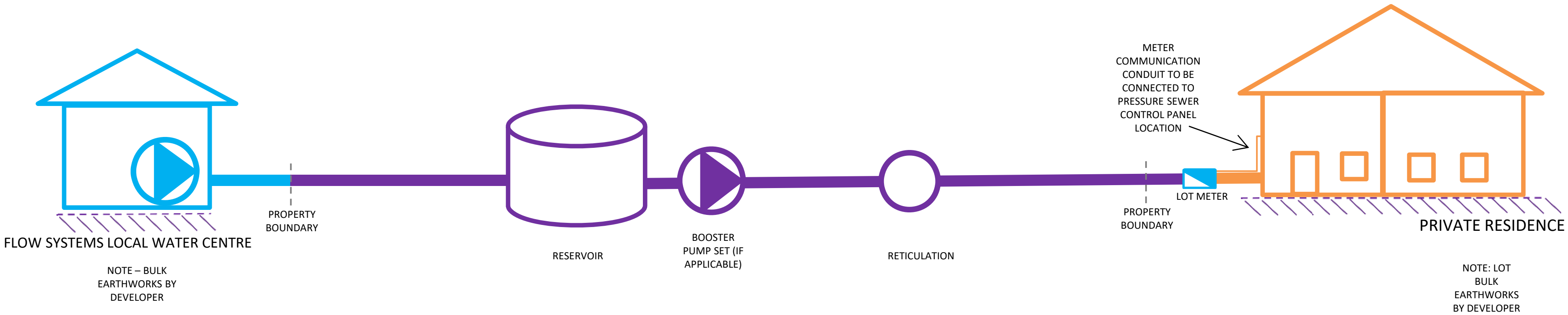
Cooranbong Water

flow systems

NORTH COORANBONG
RECYCLED WATER MASTER PLAN
ULTIMATE DEVELOPMENT

F:\PARETO\02 PROJECTS\18.09.18 – Cooranbong\CAD\18.09.19.02 – Cooranbong.dwg 19/09/2018

RECYCLED WATER INFRASTRUCTURE – TYPICAL CONSTRUCTION RESPONSIBILITY SCHEMATIC



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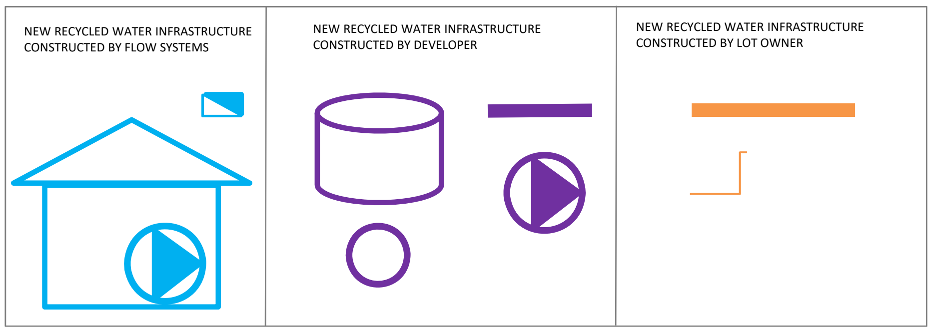
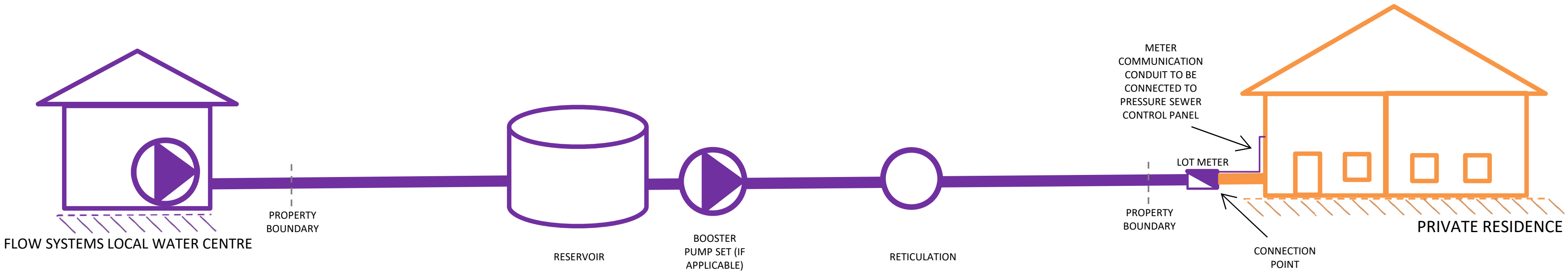


RECYCLED WATER INFRASTRUCTURE – TYPICAL OWNERSHIP, OPERATION & MAINTENANCE RESPONSIBILITY SCHEMATIC



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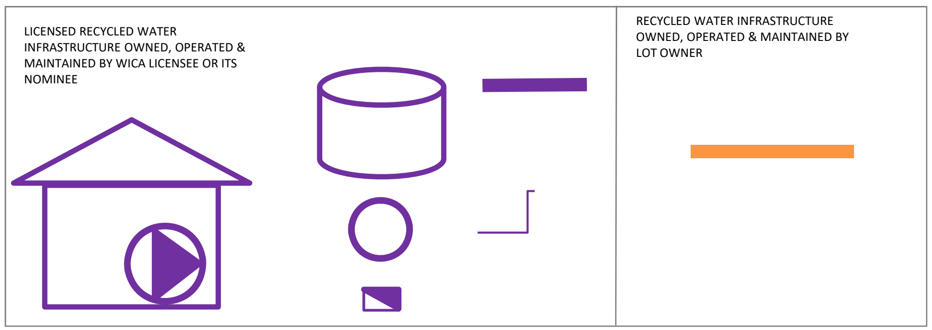

File: RW infrastructure ownership & O+M responsibility schematic_Land and Housing Schemes

RPS

Table 1 Lands within area of operations (activity area)

Lot	Section	Deposited Plan	Lot	Section	Deposited Plan	Lot	Section	Deposited Plan
25	2	3533	21		3534	172		566271
26	2	3533	20		3534	2		949586
200		1145829	16		3534	221		597525
19	1	3533	17		3534	222		597525
18	1	3533	9		3534	1		107903
28	2	3533	19	2	3533	1		176217
17	1	3533	25	1	3533	1		362702
31	2	3533	27	1	3533	1		1049393
29	2	3533	3	1	3533	4		3534
30	2	3533	12	1	3533	6		3534
24	2	3533	26	1	3533	5		3534
8	3	3533	11	1	3533	7		3534
11		3534	16	1	3533	27	2	3533
12		3534	21	3	3533	10	2	3533
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19		3534	24	1	3533	16		129155
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30	1	3533	17	3	3533	1	7	3533
6	1	3533	2	1	3533	7	7	3533
2	2	3533	22	3	3533	2	7	3533

RPS

Lot	Section	Deposited Plan	Lot	Section	Deposited Plan	Lot	Section	Deposited Plan
5	3	3533	20	2	3533	8	7	3533
1	3	3533	3	2	3533	6	7	3533
4		1117517	4	2	3533	10	7	3533
100		1135959	22	1	3533	9	7	3533
20	1	3533	28	3	3533	19		129134
10	1	3533	4	1	3533	1	1	3533
9	1	3533	21	2	3533	2		1198484
184		1141376	28	1	3533	211		859820
183		1141376	14	1	3533	33		736908
181		1141376	2	3	3533	212		859820
182		1141376	3	3	3533	1231		561165
2		1049393	2		626662	1		806401
1		263276	201		1059478	910		1055697
17		129155	1		626662	B		417719
4		263276	1		949585	B		338440
2		263276	171		566271	81		551865
122		788148	92		1007441	1		263276
2		806401	4	1	3533			SP 57931
		SP 958896						

The proposed activity will be connected to the Cooranbong LWC and is predominately located south of Freemans Drive, Cooranbong within the confines of the existing village. The existing land parcels within the proposed activity includes road side reserve of Freemans Drive and Central Road, Cooranbong as well as land associated with the Avondale Technical College which is predominately cleared.

To allow for the potential for lots adjacent to the proposed recycled water mains to experience the benefits of a recycled water connection, residential and commercial sized lots are also to be listed in the proposed licence area variation application. The environmental impact assessment of property service connections from the proposed recycled water main to each lot is taken to be included in the assessment of the impact of the recycled water mains.

flow

RW Irrigation Management Plan (RWIMP)

Document Issue Record

Issue Date	Rev	Issue	Issued To	Prepared By	Approved By
4/6/2018	1	First	Flow	CWT	MN/KE

Contents

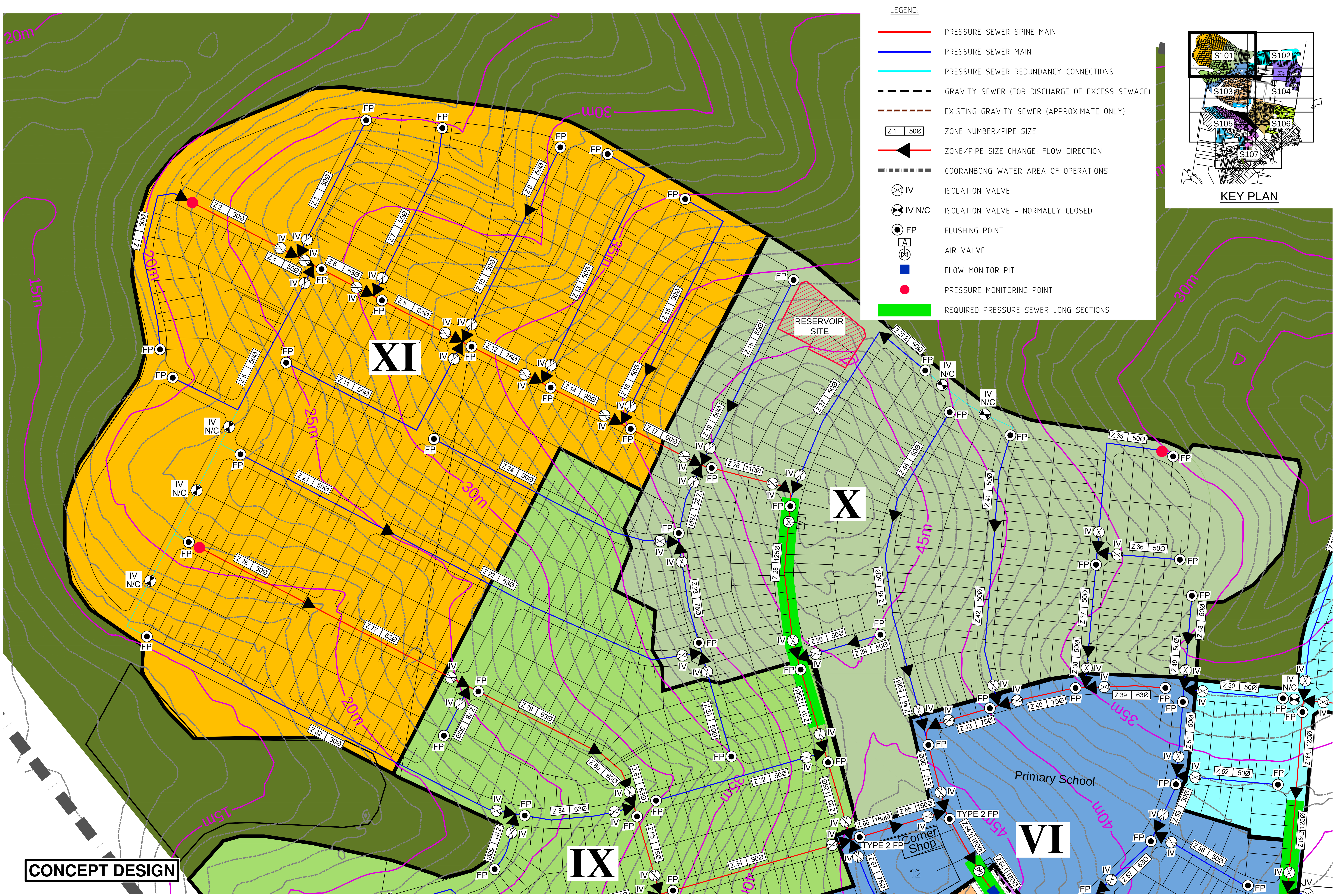
Recycled Water Quality Plan (RWQP)

Document Issue Record

Issue Date	Revision	Changes	Issued To	Prepared By	Approved By
24/10/14	1	First revision	Flow	Kirsten Evans	Andrew Horton
12/12/14	2	Minor formatting corrections	Flow	Kirsten Evans	Andrew Horton
30/1/15	3	Added AMP to: Figure 1 Table 1	Flow	Kirsten Evans	Andrew Horton
05/05/15	4	Added TDS figures for HR & LH to: Table 6	Flow	Marcelo Sales	Andrew Horton
25/05/16	5	Reviewed plan, updated Figure 1, changed magnesium hydroxide to sodium hydroxide	Flow	Laura Dixon	Andrew Horton
21/10/16	6	Updated NSW COP Plumbing & Drainage to Plumbing Code of Australia	Flow	Laura Dixon	Andrew Horton
25/07/17	7	Updated sections 7.3 and 9.1 based on NSW Health's comments in their email dated 25/07/17	Flow	Laura Dixon	Andrew Horton
31/08/17	8	Updated section 7.1.2 and	Flow	Laura Dixon	Andrew Horton

		removed the reference to Public Health (General) Regulation 2002 (NSW)			
15/12/17	9	Amended Office of Water and DPI Water references to Crown Lands and Water	Flow	Laura Dixon	Andrew Horton
3/7/18	10	Updated BMS Document Map Chapter 1		Michael Northcott	Andrew Horton
10/09/18	11	Updated cover page to new format		Kirsten Evans	Andrew Horton

Contents



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D	UPDATE WITH UPDATED PRECINCT 2 CADASTRE	LC	30/04/15
C	UPDATE WITH REVISED MASTERPLAN (REV I)	LC	26/03/15
B	UPDATE WITH DW COMMENTS	LC	27/05/14
A	CONCEPT DESIGN	SW	07/05/14

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SCALE 1:1500 AT A1

CLIENT: flow systems
PROJECT: Cooranbong Water

TITLE: PRESSURE SEWERAGE LAYOUT PLAN SHEET 1 OF 7

DRG No. 140310-S101
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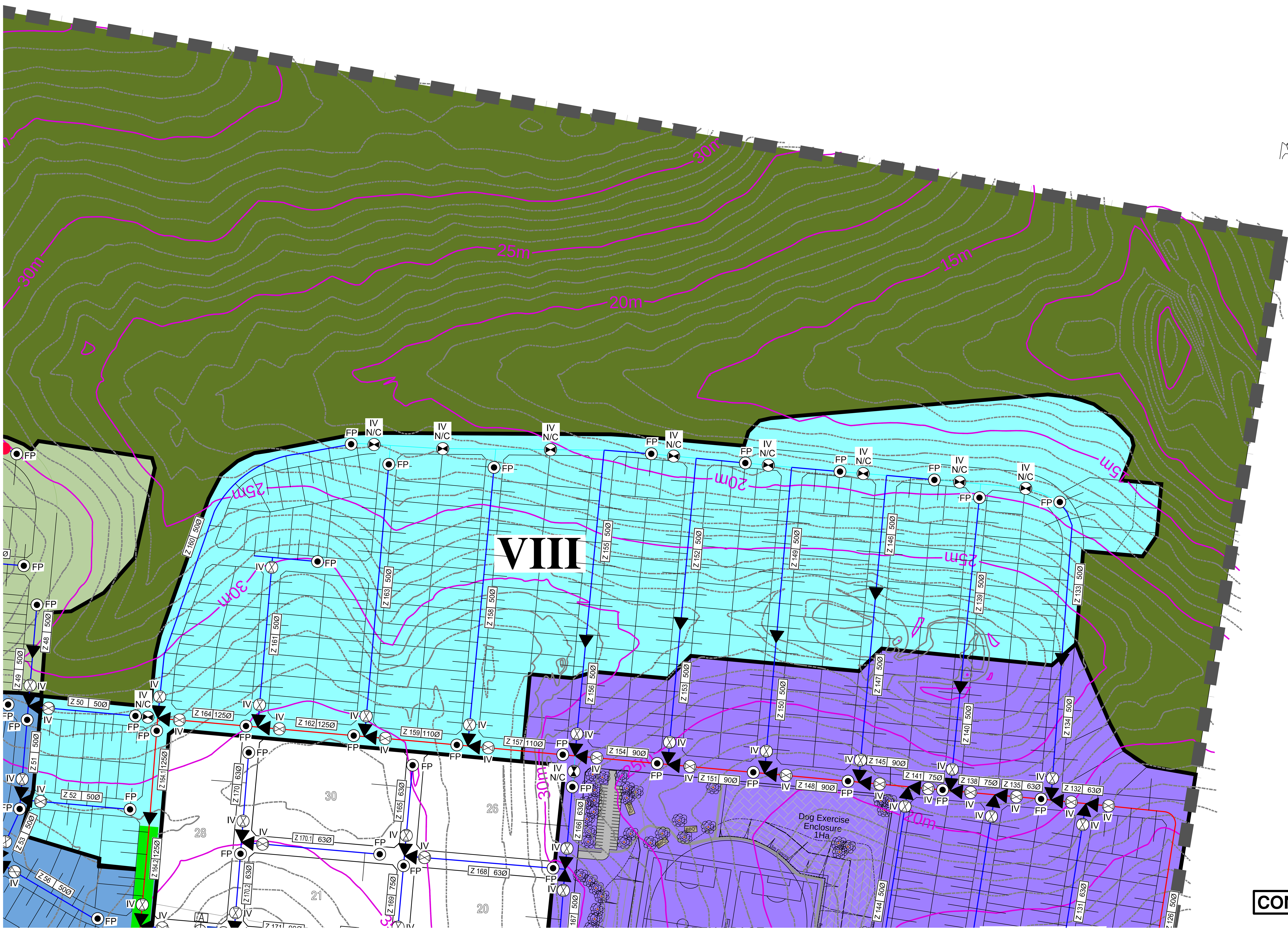

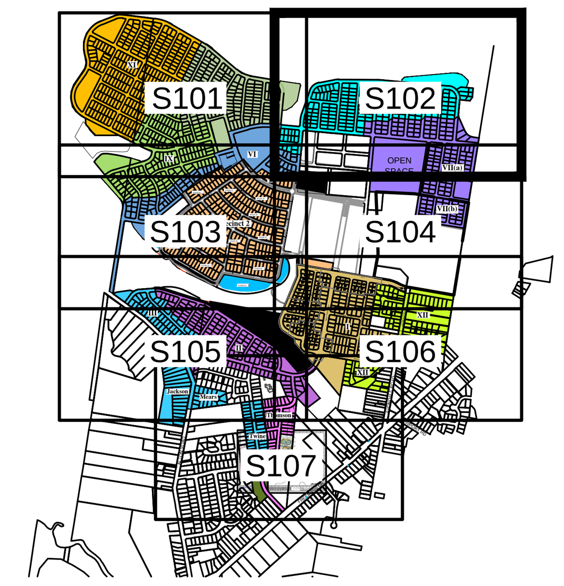

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CLIENT: flow systems

PROJECT: Cooranbong Water

TITLE: PRESSURE SEWERAGE LAYOUT PLAN SHEET 2 OF 7

DRG No. 140310-S102

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CLIENT: flow systems

PROJECT: Cooranbong Water

TITLE: PRESSURE SEWERAGE LAYOUT PLAN SHEET 3 OF 7

DRG No. 140310-S103

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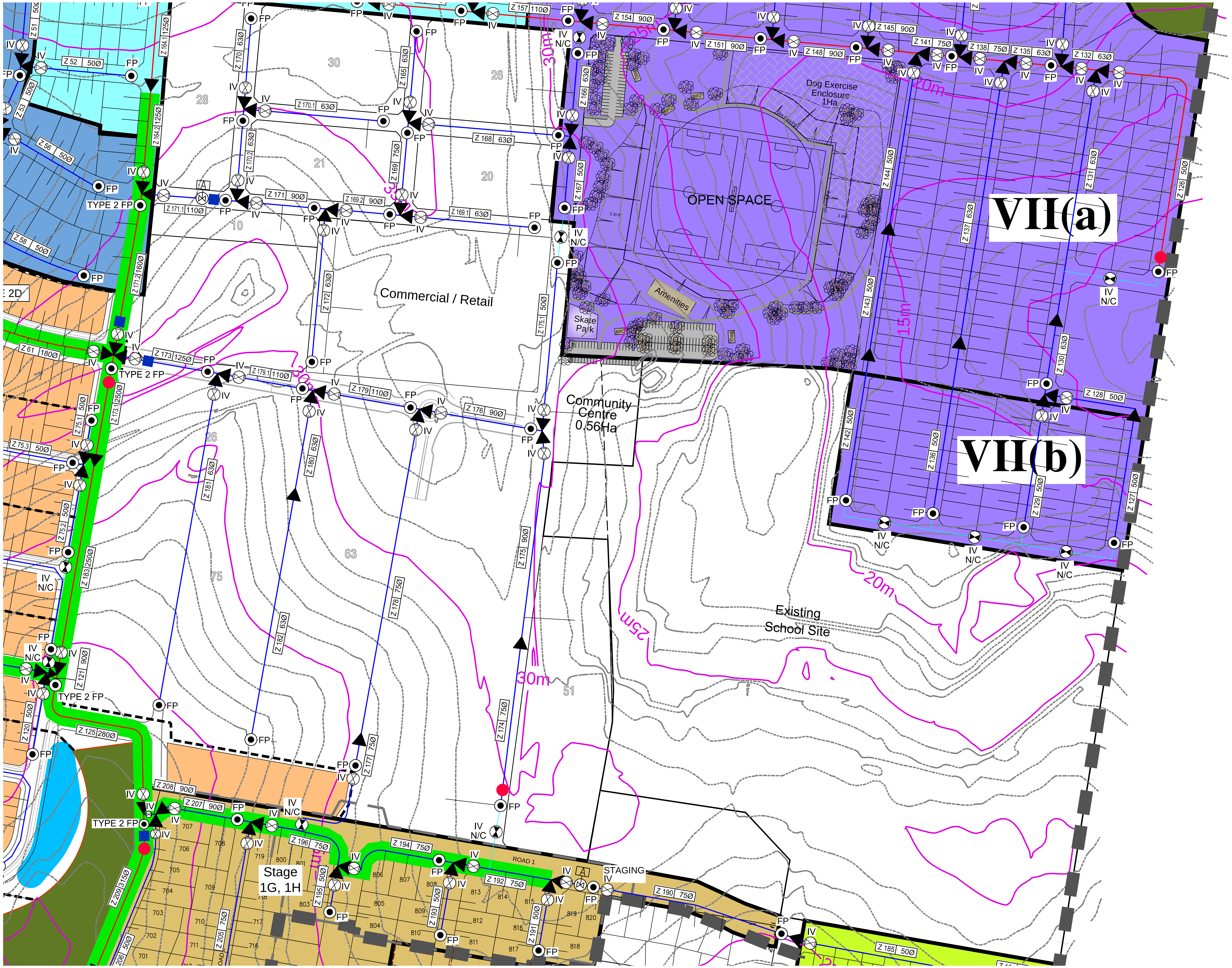

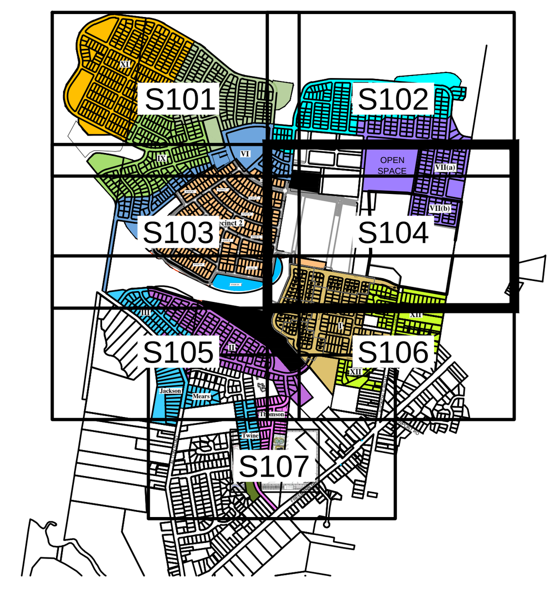

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APPROVED	SW	DATE	19/09/18

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CLIENT: flow systems

PROJECT: Cooranbong Water

TITLE: PRESSURE SEWERAGE LAYOUT PLAN SHEET 4 OF 7

DRG No. 140310-S104

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CLIENT: flow systems

PROJECT: Cooranbong Water

TITLE: PRESSURE SEWERAGE LAYOUT PLAN SHEET 5 OF 7

DRG No. 140310-S105

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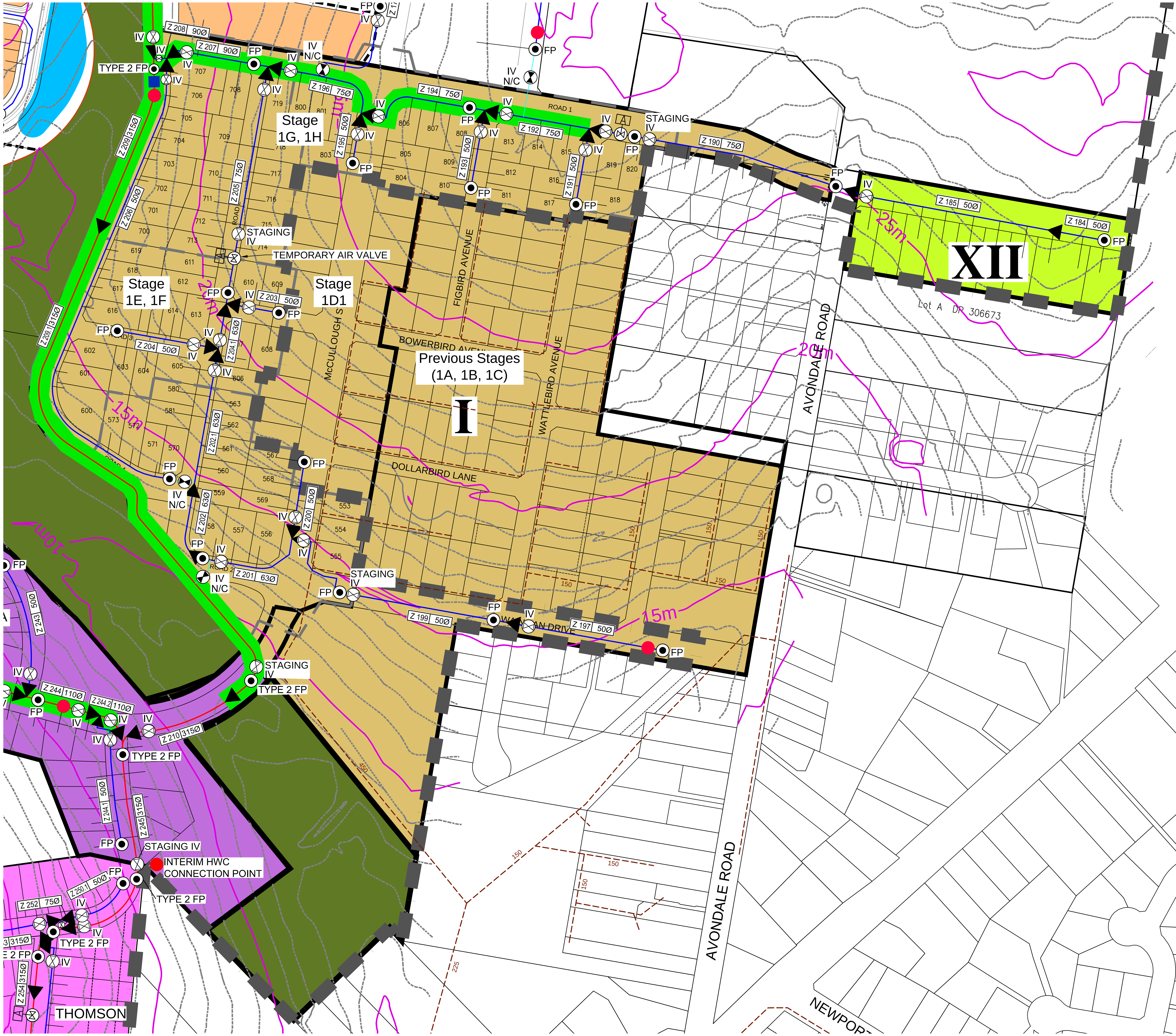

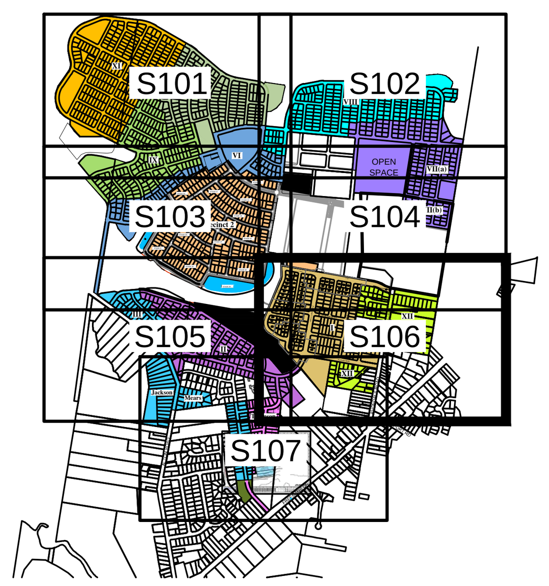

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CLIENT: flow systems

PROJECT: Cooranbong Water

TITLE: PRESSURE SEWERAGE LAYOUT PLAN SHEET 6 OF 7

DRG No. 140310-S106

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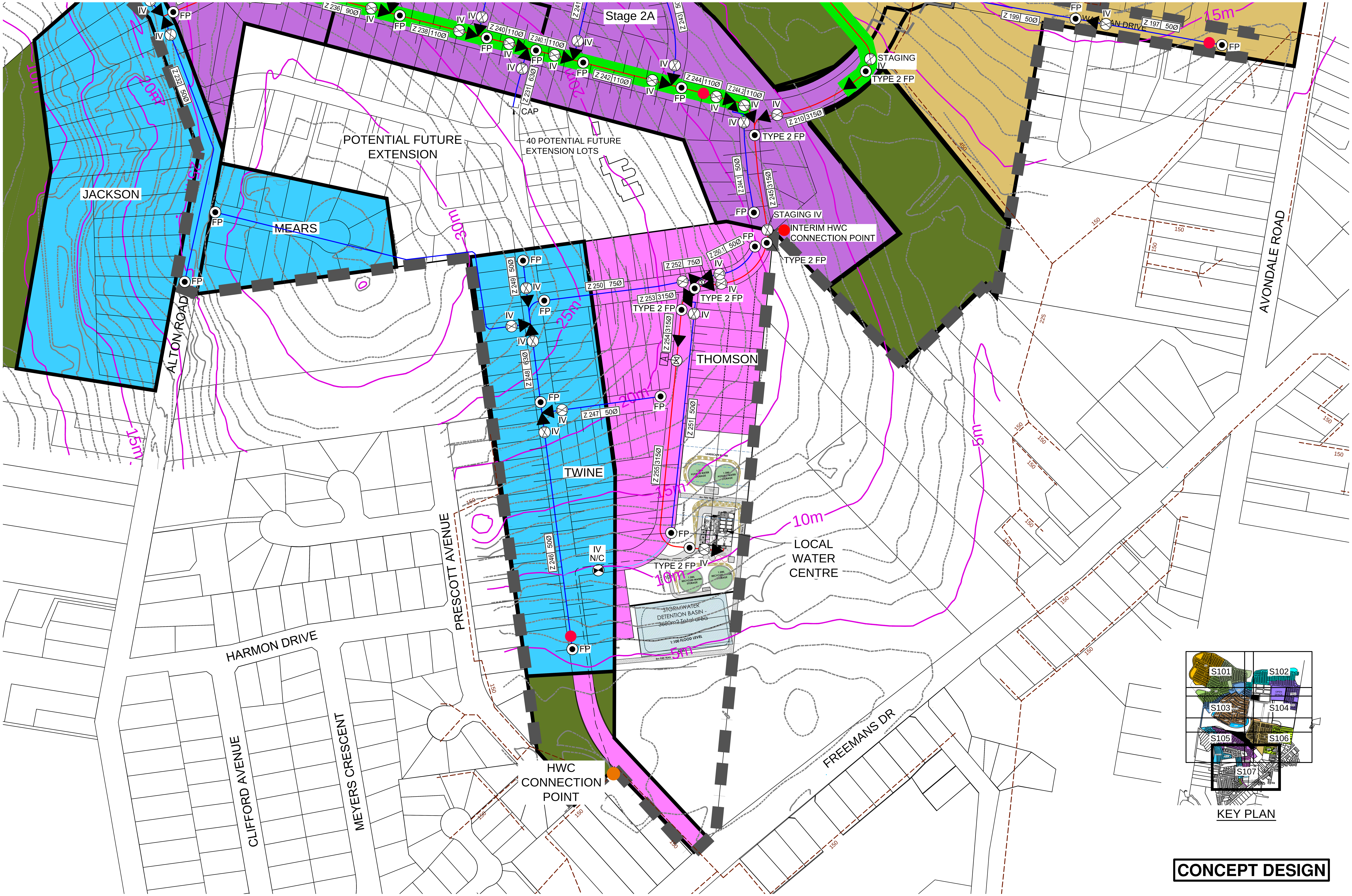

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CLIENT: flow systems
PROJECT: Cooranbong Water

TITLE: PRESSURE SEWERAGE LAYOUT PLAN SHEET 7 OF 7

DRG No. 140310-S107

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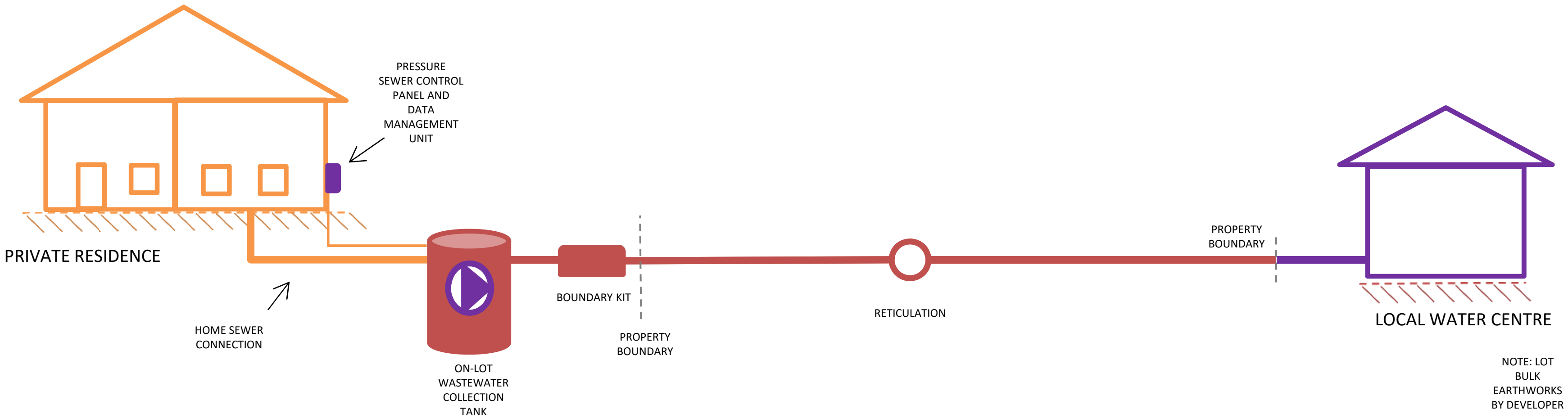
SEWERAGE INFRASTRUCTURE (PRESSURE SEWER) – TYPICAL CONSTRUCTION RESPONSIBILITY SCHEMATIC



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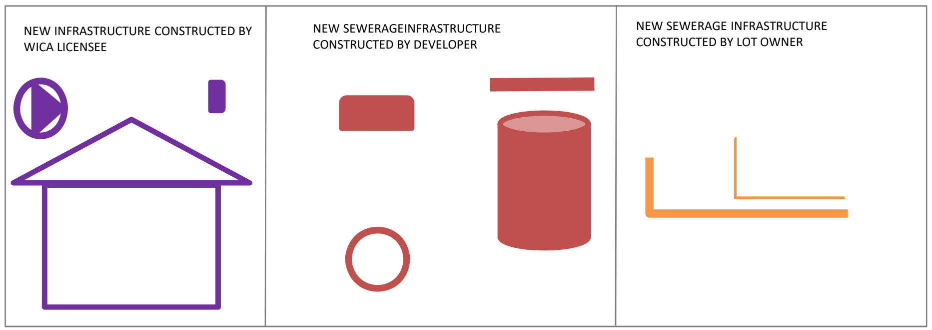
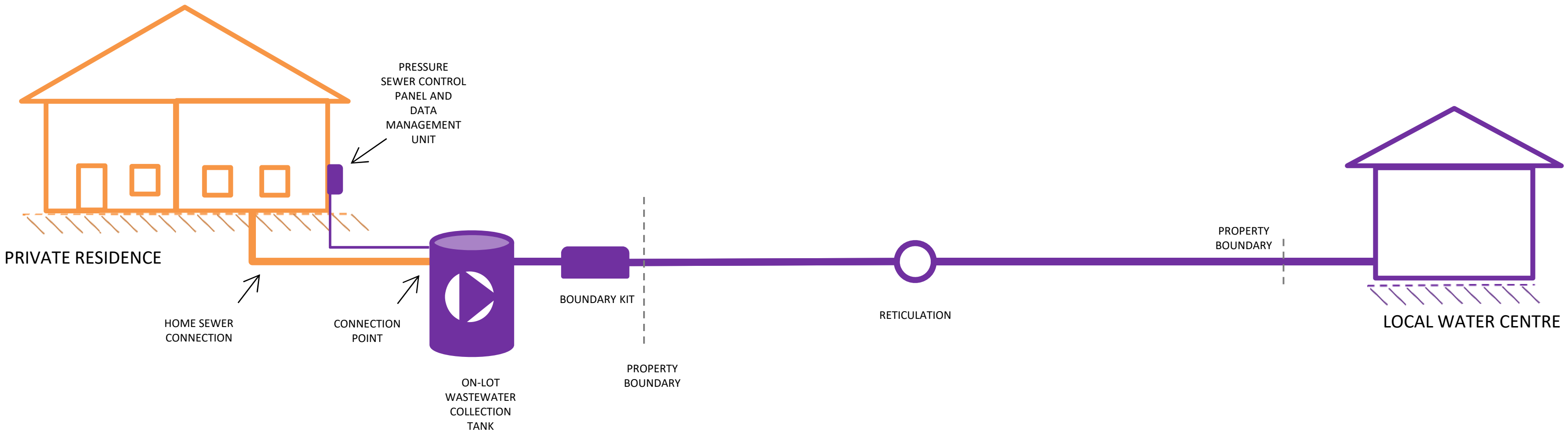


SEWERAGE INFRASTRUCTURE (PRESSURE SEWER) – TYPICAL <u>OWNERSHIP, OPERATION & MAINTENANCE</u> RESPONSIBILITY SCHEMATIC



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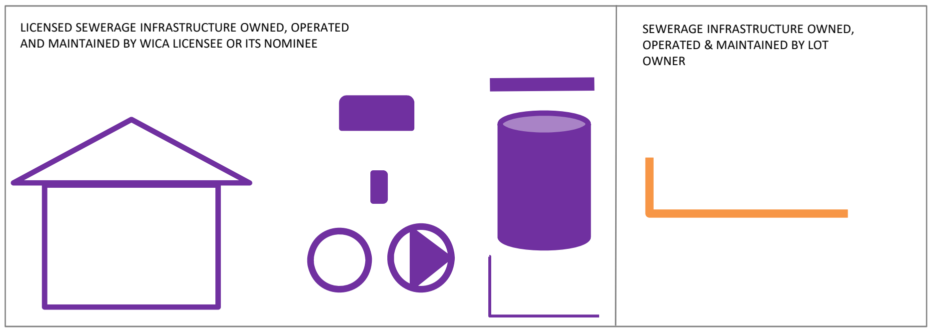

Sewage Management Plan

Document Issue Record

Revision	Issue Date	Change	Prepared By	Approved By
1	24/10/14	First revision	Kirsten Evans	Andrew Horton
2	30/1/15	Added AMP to Table 1	Kirsten Evans	Andrew Horton
3	23/2/16	General review	Andrew Horton	Andrew Horton
4	18/5/17	General review – no changes	Laura Dixon	Andrew Horton
5	4/7/18	BMS document map updated	Michael Northcott	Andrew Horton
6	31/07/18	• General review • Changed cover page • Reviewed references to legislation • Minor body document edits	Kirsten Evans/Michael Northcott	Andrew Horton

Contents

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Land Capability Assessment for Recycled Water Management Scheme at Proposed 'North Cooranbong' Master Plan Development, Cooranbong, NSW

Prepared for RPS Australia

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Document Control Sheet

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<tr><td>Author:</td><td colspan="5">Zoe Rogers</td></tr>
<tr><td>Project Manager:</td><td colspan="5">Mark Saunders</td></tr>
<tr><td>Date of Issue:</td><td colspan="5">21/05/14</td></tr>
<tr><td>Job Reference:</td><td colspan="5">Report_01242_LCA_002</td></tr>
<tr><td>Synopsis:</td><td colspan="5">This preliminary report provides the results of our investigations regarding Land Capability Assessment for the proposed North Cooranbong Master Plan Development, Cooranbong.</td></tr>
<tr><th colspan="6">Client Details</th></tr>
<tr><td>Client:</td><td colspan="5">RPS Australia</td></tr>
<tr><td>Primary Contact:</td><td colspan="5">Mr Stuart Greville (RPS Australia)</td></tr>
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</table>

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The information contained in this report is based on independent research undertaken by Zoe Rogers of Whitehead & Associates Environmental Consultants Pty Ltd (W&A). To our knowledge, it does not contain any false, misleading or incomplete information. Recommendations are based on an appraisal of the site conditions subject to the limited scope and resources available for this project, and follow relevant industry standards. The work performed by W&A included a desktop review and limited soil sampling only, and the conclusions made in this report are based on the information gained and the assumptions as outlined. Under no circumstances, can it be considered that these results represent the actual state of the site at all points as subsurface conditions are inherently variable. Concentrations of contaminants may also change with time, and the conclusions in this report have a limited lifespan.

Copyright Note

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1 Introduction

Whitehead & Associates Environmental Consultants Pty Ltd ("W&A") were engaged by RPS Australia Pty Ltd ("the Client") on behalf of Cooranbong Water to undertake a Land Capability Assessment (LCA) for recycled water management for the proposed staged subdivision named North Cooranbong ("the Site"). The Site is located to the north of Freemans Drive at the northern end of the existing township of Cooranbong, as shown in Figure 1, Appendix A.

This LCA focuses on the Site's capacity to sustainably accommodate 'excess' recycled water generated by a proposed Local Water Centre (LWC) at North Cooranbong (owned and operated by Cooranbong Water, once the LWC is commissioned and operational. We understand that the initial Stages of the subdivision that have been, or are currently being developed, have or will be connected to existing reticulated sewerage provided by Hunter Water Corporation (HWC).

The Site is located entirely within the Lake Macquarie City Council ("Council") local government area (LGA). Field investigations were undertaken by Nicholas Banbrook and Jasmin Kable of W&A on the 14th April 2014. This LCA report provides the results of our investigations and provides input into a subsequent Staging Plan and report for the preferred Recycled Water Irrigation Zones (RWIZs) that will be developed to manage excess recycled water once the Cooranbong LWC recycled water network is operational.

2 Overview of Proposed Development

The Site is proposed to contain a combination of commercial and residential development, including twelve (12) residential sub-stages of approximately 2,300 residential lots in total; and eight (8) Commercial and Community Centre stages. The development area covers approximately 200ha (the entire Site is approximately 300ha, including public open space, environmental buffers and other improvements including roads and infrastructure). The entire build out of the Site is expected to be implemented over at least ten years.

Cooranbong Water is assisting the developer, Johnston Property Group (JPG) in delivering sewerage, recycled water and drinking water infrastructure to the North Cooranbong development. The Cooranbong LWC will treat wastewater generated by the proposed residential and commercial developments (separate trade waste agreements may be required for certain types of commercial uses). The LWC facility is intended to operate 24 hours, 7 days per week, housed in a low-scale, single level building within an open space setting. The proposed LWC will incorporate a dual reticulation ('third pipe') system to distribute recycled water to households for non-potable water reuse such as toilet flushing, washing machine supply, irrigation and car washing, thus reducing potable water demand. At this stage in development planning, it is intended that the remaining excess recycled water will be irrigated in the undeveloped land associated with later development stages, in the proposed RWIZs.

3 Site Description

The Site is dominated by areas of Eucalyptus woodland and cleared land that has been used for low-density/rural residential development, the existing Avondale School and low-level stock grazing. In addition, there is a large airstrip located in the central and eastern sections of the Site, which is cleared and predominantly un-paved, except for a bitumen runway running north-south in the eastern section of the Site. There is an existing water storage dam located in the north-eastern section of the existing Avondale School (located within the Site boundaries), which will be retained. A Site Plan is provided in Figure 1, Appendix A. Section 4 below provides the results of the land capability assessment (LCA) investigations undertaken for the development with respect to recycled water management.

4 Site & Soil Assessment

4.1 Site Physical Characteristics

A Site and Soil Assessment was undertaken on the 14th of April 2014 by Nicholas Banbrook and Jasmin Kable of W&A. A description of the Site physical conditions and the degree of limitation they pose to recycled water management is provided in Table 1 below. Reference is made to the rating scales described in NSW DEC (2004) and NSW DLG (1998).

Table 1 Site Physical Conditions & Constraints

Parameter	Constraint
Climate: Mean monthly rainfall data was sourced from the BoM for Cooranbong (Avondale) Station 61012 for 1903-2013. Mean monthly evaporation data was sourced from the BoM 'Data Drill' climate data service for the nearby locality of Wyee in 2010. Mean annual rainfall for the Site is 1,137mm; ranging from an average of 59mm in September to an average of 134mm in February. Mean annual pan evaporation is 1,468mm, ranging from an average of 58mm in June to an average of 191mm in December. On average, there is a net evaporation deficit (soil moisture surplus) from April to July, which is typical for temperate regions.	Minor
Aspect and Exposure: Site aspects vary depending on position on the undulating slopes, but generally have good solar and wind exposure in the proposed RWIZs and elsewhere on the property.	Minor
Vegetation: The Site covers areas of previously cleared native bushland which has been used as open pasture for stock grazing, as well as existing stands of native open forest (Murphy, 1993). The proposed RWIZs will be vegetated, either with the existing cover or with new areas of pasture or turf (if bushland is cleared). It is possible (although more difficult) to irrigate open forest with recycled water, due to the low density of the understorey which is mainly comprised of native grasses and small shrubs.	Moderate
Landform and Slope: The Site contains undulating and rolling low-hills, with moderate slopes typically ranging between 3% and 8%. Recycled water irrigation using moveable or fixed pipes with spray or sprinkler heads is feasible on slopes up to 12%; however, use of a travelling irrigator is constrained to more gentle slopes. We consider that the 8% slopes will be appropriate for travelling irrigators, with appropriate management.	Moderate
Rocks and Rock Outcrops: Rock outcrops were encountered at ground surface on the ridgeline crests in various places throughout the Site. These areas are expected to account for less than 5% of the total Site area.	Minor

Parameter	Constraint
Bedrock was encountered at a minimum depth of 900mm, during test pit excavations. A maximum of 30% coarse fragments were observed in some soil test pits, typically in the lower horizons. Gravel size varies, but is typically less than 10mm in diameter.	
Fill: There was some evidence of small amounts of imported fill (natural gravel and rock) in areas on and around the existing airstrip on the Site. Generally, natural soil profiles were observed in test pits excavated, with small amounts of fill observed near the surface of test pits excavated near the airstrip. This extent of fill is not expected to impact on recycled water management by irrigation.	Minor
Erosion Potential: At present the Site is generally stable with minor existing erosion, which is limited to cleared areas (access tracks and the airstrip). However, the native soils are highly susceptible to erosion if they are not vegetated or otherwise appropriately covered. The erosion hazard is manageable, provided that: 1) an adequate groundcover (grass) is retained or re-established; 2) stormwater is effectively diverted around any disturbed areas; and 3) good soil conservation practices are applied during construction.	Moderate
Groundwater and Site Drainage: A search of the NSW Office of Water's groundwater bores, maps and records indicated that there are no registered groundwater bores within 250m of the Site. Surface drainage is considered to be generally good throughout the Site; however, ponded surface water was observed during rainfall conditions at the time of the Site assessment. This was more prevalent on cleared areas (such as access tracks and the airstrip). Mottling and hardsetting characteristics of some of the excavated subsoils indicate relatively poor subsurface drainage conditions (discussed in Table 2).	Moderate
Proximity to Surface Waters: The Site contains unnamed tributaries to Felled Timber Creek (to the west of the Site) and Jigadee Creek (to the east of the Site). In addition there are various intermittent or permanent watercourses and drainage lines (shown as 'blue lines' on NSW government maps of the area). According to the advice of consulting engineers, contained in the NSW Planning Director-General's Environmental Assessment Report (2008), "the site is located on undulating terrain and has several subcatchments draining in various directions, several of which contain watercourses. Approximately half of the main development area drains via a main creekline to the southeast, toward Freemans Drive. The remainder of the site is divided into smaller subcatchments which drain generally to the north and east." We understand from the Site plans that minor intermittent drainage lines will be included in a reticulated stormwater network, while the existing creeks will be buffered from development. We have included a 40m buffer from all 'blue lines' in our LCA Plan, as recycled water will be irrigated on undeveloped stages prior to the construction of the reticulated stormwater system.	Moderate
Flood Potential We understand that the flood studies undertaken by consulting engineers indicated that the 100 year annual return interval (ARI) flood levels would be "incorporated into the retained riparian corridors or into the drainage system	Minor

Parameter	Constraint
upstream of the corridors" (NSW Planning Director General's Environmental Assessment Report, 2008). On this advice, we consider that flooding is not expected to be a constraint for recycled water irrigation, as this will occur outside the 40m riparian buffer of the creeks where flood levels were identified.	

4.2 Soil Landscape

We reviewed the Soil Landscapes of the Gosford-Lake Macquarie 1:100,000 Sheet (Murphy, 1993) which indicates that Site soils belong entirely to the Doyalson (**do**) soil landscape. The descriptions below are taken from Murphy (1993); soil characteristics as surveyed by W&A are provided in Section 4.3.

The landform of the 'do' soil landscape is located on gently undulating rises with slope gradients <10% and local relief to 30m. Topography is characterised by broad crests and ridges and long, gently inclined slopes. The underlying geological formation is Munmorah Conglomerate, including conglomerate, pebbly sandstone, siltstone and claystone. Soils on conglomerate and sandstone parent material are typically characterised by dark brown loamy sand to loam (10cm) with weak structure (**do1**); overlying hardsetting, bleached yellowish brown clayey sand (10-30cm) with weak to massive structure (**do2**); overlying yellowish brown sandy clay loam to sandy clay (30-60cm) with moderate structure (**do3**), occasionally overlying up to 50cm of massive pale grey clay (**do4**).

The exceptions to the above are where lenses of fine-grained substrate material (such as siltstone or mudstone) occur, or in drainage lines and footslopes; both of which were observed in several areas of the Site during the Site assessment.

Soils on siltstone or mudstone parent material are characterised by up to 10cm of **do1** overlying up to 30cm of **do2** and more than 100cm of strongly pedal, yellow to red clay (**do5**). Total soil depth is 75-200cm and the boundaries between soil horizons are usually sharp.

Soils in drainage lines and footslopes are characterised by up to 20cm of **do1**, overlying up to 30cm of **do2**, overlying >100cm of **do4.**

Sections 4.3 and 4.4 below describe the soil physical characteristics as surveyed by W&A on 14^{th} April, 2014.

4.3 Soil Survey & Physical Characteristics

Site soils were observed and examined by excavating fifteen (15) test pits (TPs) using either a hand auger or mechanical auger (on an excavator). Soil characteristics varied with parent material (conglomerate or fine-grained sedimentary rocks) as well as position on the slope. The soil survey had two principal aims – to verify regional soil landscape mapping information and to assess local soil conditions and variability in areas where recycled water irrigation might occur.

Generally, topsoils throughout the Site are composed of dark brown, sandy loam material ranging from 50-200mm depth. The subsoils also varied depending on the parent material; however, there was less contrast between subsoils from different parent materials than suggested by the Soil Landscape map and report, with sandy clay to silty clay subsoils dominating most test pits. Based on subsoil characteristics, it is likely that fine-grained parent material (siltstone or mudstone) is present in the area around and including Test Pits 7 and 10, in the middle of the northern edge of the proposed subdivision. Drainage conditions were apparent in Test Pits 1 and 4; however, the parent material may differ between these two sites.

Soil depth was at least 800mm and horizon boundaries varied from well-defined to gradual. Subsoils are typically mottled and/or gleyed (all parent materials), indicating intermittent (seasonal) saturated conditions; and this increases with depth.

Regardless of the parent material, sandy clay, silty clay and light clay were found to be the dominant subsoil types across the area surveyed. Medium clay was observed below 1.3m in Test Pit 1; this was the heaviest-textured soil observed in any of the fifteen test pits throughout the Site. There is no guarantee that medium or heavy clays are not present at shallower depths; however, the soil survey undertaken by W&A and the soil landscape descriptions indicate that these conditions are not likely to be common.

Table 2 summarises the key soil physical and chemical constraints and the degree of limitation they pose to recycled water management is provided in Table 1 below. Reference is made to the rating scales described in NSW DEC (2004) and NSW DLG (1998). Appendix B provides soil borelog summaries for each test pit.

4.4 Soil Chemical Characteristics

Samples of all discrete soil horizons were collected for subsequent laboratory analysis. Fifteen (15) samples from five (5) representative test pits were analysed in-house for pH, Electrical Conductivity (ECe) and Emerson Aggregate Class. Ten (10) composite samples from ten (10) representative test pits were analysed by an independent, NATA accredited soil testing laboratory for Sodicity (Exchangeable Sodium Percentage or ESP), Cation Exchange Capacity (CEC) and Phosphorous Sorption Capacity (P-sorption).

Table 2 provides a summary of the results and discussion of the soil chemistry with respect to soil constraints for recycled water irrigation. Reference is made to the rating scales described in NSW DEC (2004) and NSW DLG (1998). Raw data and interpretation is presented in Appendix C.

Table 2 Soil Physical & Chemical Characteristics & Constraints

Parameter	Constraint
Soil Depth: Bedrock was encountered in three (3) of the TPs during the Site investigations. The minimum refusal depth was at 0.9m in TP9.	Minor to Moderate
Depth to water table: The depth of the vadose zone (i.e. non-saturated soil material above water table) is >0.8m (minimum depth of test pits). All soil horizons were either slightly moist or dry, with no saturated conditions observed during the Site assessment. However, based on soil gleying and mottling characteristics, the depth to seasonal groundwater can be quite shallow and potentially within the zone of influence regarding recycled water management. This will mitigated by appropriately conservative loading rates for recycled water irrigation.	Moderate
Coarse Fragments (%): Coarse fragments may impede plant growth by reducing soil water holding capacity, nutrient retention capacity and overall fertility because of the reduced fine earth fraction and increased permeability. The surface soils typically contained <10% coarse fragments, while subsoils contained up to 50% coarse fragments (typically less than 30mm in diameter). Based on the proposed land application method (irrigation), coarse fragments	Minor

Parameter	Constraint
are expected to present a minor limitation to recycled water management.	
Soil Permeability and Design Loading Rates: Soil permeability was not directly measured but can be inferred from observed soil properties. AS/NZS 1547:2012 describes conservative Design Irrigation Rates (DIRs) for irrigation systems (Table 5.2), depending on two important soil properties – texture and structure. Soil depth, colour, mottling and drainage characteristics are also important to consider and guide selection of appropriate loading rates. The observed sandy loam to sandy clay loam topsoils were too shallow to be used to determine the DIR (50-200mm). The observed subsoils were dominated by sandy clays and silty clays, with some areas of clayey sand or sandy clay loam subsoils (TP3 and TP4, respectively). Sandy and silty clays are classified as 'light' clays, or Category 5 soils, with an indicative permeability (K_{sat}) ranging from **<0.06m/day** (2.5mm/hr) to **0.5m/day** (21mm/hr). Based upon slope and soil characteristics, the following DIR is recommended for sizing all of the required RWIZs: • **3mm/day** (surface spray irrigation)	Moderate to Severe
pH: The pH of 1:5 soil/water suspensions were measured in-house using a *Hanna*™ hand held pH / EC meter. The measured pH of the soil samples (topsoils and subsoils) ranged from 4.9 to 6.2. Soils range from very strongly acidic to moderately acidic; however, plant growth did not appear to be affected by soil acidity and this is not expected to pose a significant constraint to recycled water management.	Moderate
Electrical Conductivity (EC_e): Electrical conductivity of the saturated extract (EC_e) was calculated by first measuring the electrical conductivity of 1:5 soil in water suspensions and using appropriate multiplier factors (based on soil texture) to convert the 1:5 suspension EC to EC_e. Soil samples were found to range from non-saline to moderately saline, having EC_e values of 0.00 – 0.49dS/m. Soil salinity is not considered to pose a constraint for recycled water management.	Minor
Emerson Aggregate Class: The modified Emerson Aggregate Test (EAT) is a measure of soil dispersibility and susceptibility to erosion and structural degradation. It assesses the physical changes that occur in a single air-dried ped (naturally forming aggregate) of soil when immersed in water; specifically whether the soil slakes and falls apart or disperses and clouds the water. The test was performed on samples collected from each horizon of all test pits (TP1 – 15), which yielded Emerson Aggregate Classes of 2(2) (for all subsoils and some topsoils) or 8 (some topsoils). EAT Class 2 indicates high levels of slaking with moderate dispersion. This poses a moderate constraint for recycled water management (as well as erosion control), though is mitigated by an appropriately low DIR of 3mm/day, in accordance with best-practice irrigation procedure.	Moderate
Sodicity (Exchangeable Sodium Percentage- ESP) (%): The Exchangeable Sodium Percentage (ESP) is the proportion of sodium on	Moderate

Parameter	Constraint
the cation exchange sites reported as percentage of exchangeable cations and is an important indicator of sodicity, which affects soil structural stability and susceptibility to dispersion. The ESP is a measure of how readily the soils allow sodium from recycled water to be substituted in the soil lattice for other cations. Once accepted, the weak sodium bonds allow increased structural degradation of the soil, increasing erosion risk. It is calculated as [% Na / CEC] x 100. Hazelton & Murphy (2007) suggest: • ESP values less than 6 are rated as non-sodic; • ESP values between 6 and 15 are rated as sodic; • ESP values between 15 and 25 are rated as strongly sodic; and • ESP values greater than 25 are rated as very strongly sodic. Ten (10) composite soil samples were analysed for ESP. Six (6) yielded values <6 (non-sodic), while the remaining four (4) samples yielded values of 6-9 (marginally sodic). The presence of sodic soils presents a moderate limitation for recycled water management; however, it can be managed through conservative soil loading rates, soil amendment and pasture management practices. Further discussion on proposed mitigation measures is provided in Section 8.	
Cation Exchange Capacity (cmol/kg): The Cation Exchange Capacity (CEC) is the capacity of the soil to hold and exchange cations [aluminium, calcium, magnesium, potassium and sodium]. It is a major controlling agent for soil structural stability, nutrient availability for plants and the soils' reaction to fertilisers and other ameliorants (Hazelton & Murphy, 2007). Like ESP, the CEC is a measure of how easily the soils accept excess cations from the recycled water. These cations are used by plants as a nutrient source; so the higher the CEC the more likely plant growth will be aided by the application of recycled water. The CEC of the ten (10) composite soil samples analysed, was measured between 2.4 and 10.2cmol/kg. The samples ranged from a very low to low CEC rating. The low CEC values indicate that plant growth may be inhibited by a lack of trace nutrients such as calcium, and the application of gypsum may be beneficial. This presents a moderate constraint for recycled water management and can be managed through appropriate pasture management practices. Further discussion on proposed mitigation measures is provided in Section 8.	Moderate
Phosphorus Sorption Capacity (kg/ha): The Phosphorous Sorption Capacity (P-sorption) is used to calculate the potential immobilisation rate of phosphorous by the soil. The P-sorption capacity of a soil is an important feature that relates to the potential for a soil to bind any phosphorus that may not be utilised by the plants within an available RWIZ. Phosphorous is required only to a limited extent by plants as a trace nutrient, but if there is an excess of phosphorous in environments where other limiting factors are not present (such as waterways), excess phosphorous can result in very high plant growth. Typically, on land, excess phosphorous is taken up by soil adsorption, or is flushed out of the soil into groundwater or surface water bodies. In many instances, P-sorption will be the dominant phosphorus removal mechanism when applying recycled water to the land. P-sorption analysis was undertaken on the ten soil samples by Lanfax laboratories, Armidale. For the laboratory sample a five point isotherm of P-	Minor

Parameter	Constraint
sorption capacity was generated. The methodology is described further in Patterson (2001). For the analysed soils, a nominal threshold P-sorption value (in mg/kg) is selected as the value that equates to roughly 70% of complete sorption. The P-sorption of the ten (10) composite samples tested ranged from 140 to 780mg/kg. The average of the samples is 446mg/kg and the median is 390mg/kg. For modelling purposes, we have adopted the lowest value of 140mg/kg. In a phosphorus-limiting system, this would be a major limitation; however, the low permeability and relatively low DIR recommended will likely result in a hydraulically-limited irrigation design and therefore the impact is considered minor.	

5 Buffers

Buffer distances from irrigation areas are recommended to minimise risk to public health, maintain public amenity and protect sensitive environments. The AGWR (2006) guideline recommends that spray irrigation buffer zones are generally not required for high-quality recycled water suitable for domestic non-drinking water use, as is the case with the proposed LWC/RWI schemes at the Site. However, buffer zones are recommended as they provide a form of mitigation against unidentified hazards and reduce potential pathways of human and environmental exposure.

W&A recommend the following environmental buffers for surface spray irrigation based on NSW DEC (2004) guidelines;

- 250 metres from domestic groundwater bores;
- 50-100 metres from permanent watercourses;
- 40 metres from intermittent watercourses and dams; and
- 50 metres from houses, schools, playing fields, roads and public open space[1].

It should be noted that once development commences, relevant setbacks, in accordance with AGWR (2006), from dwellings will need to be applied. Recommendations to prevent off-lot discharge include the use of low-throw sprinklers, 180º inward-throwing sprinklers and/or tree or shrub screens.

6 Mitigation Measures

6.1 Vegetation Establishment and Management

Vegetation should be established within the proposed RWIZs. A complete vegetation cover is important to reduce the erosion hazard and optimise water and nutrient uptake. A good cover of managed pasture (lucerne, ryegrass etc.) will be suitable for surface irrigation as suggested in this report. Achieving a nutrient balance within an irrigation area relies on nutrients being taken up by vegetation and then exported with the cut vegetation (e.g. baled or rolled). This balance can only be maintained by removing the cut material from the area.

If the currently forested areas are to be cleared for irrigation, they should be deep-ripped and at least 200mm of organic topsoil and/or compost should be ploughed into the upper profile prior to being revegetated with turf or similar cover. Gypsum can be added prior to revegetation, as described below.

[1] Assumes spray irrigation. If sub-surface irrigation techniques are used, these buffers may be relaxed for some public open space uses.

6.2 Soil Improvement

Sodic soils are soils with an excess of sodium compared with calcium and magnesium on the soils' cation exchange sites. Generally, sodic soils can be highly susceptible to dispersion, erosion, structural decline and surface crusting, and can have very low infiltration capacities, low hydraulic conductivity and high shrink/swell properties on wetting and drying. These properties can reduce the soils' capacity to sustainably manage recycled water.

Soil sodicity is variable at the Site, with some topsoil and subsoil samples returning ESP results greater than 6%, the threshold at which soil is considered to be sodic. While soils do not appear to be currently experiencing any significant drainage problems, erosion or structural decline; prolonged application of elevated-sodium recycled water could exacerbate the situation. Application of gypsum is a recognised way of reducing the effects of soil sodicity. It does this by supplying calcium to the affected soil and thereby elevating calcium concentrations with respect to sodium. It is recommended that gypsum be applied to soils in the RWIZs to reduce the potential for soil structural degradation and dispersion.

Gypsum is only slowly soluble in water so simply broadcasting it at the surface can be relatively difficult as it can take a long time for the calcium to penetrate the soil and reach the deeper soil layers. Therefore, it is necessary to incorporate gypsum into the limiting soil horizon at the time of application. One way to achieve this is to dose the irrigation water with a pre-mixed gypsum solution during the irrigation cycle. At scheme commencement, this practice should be undertaken for each irrigation area at an application rate of approximately 0.5kg/m^2 of gypsum.

In the long term, soil sodicity within the RWIZs can be managed by the annual surface application of gypsum at a rate not less than 0.2kg/m^2.

7 Conclusions and Recommendations

This report provides the results and recommendations of our preliminary investigations, including detailed site and soil investigations and constraints to recycled water management.

The LCA shows that the Site is diverse in terms of its physical characteristics such as topography, soil depth and characteristics, drainage and the presence of intermittent watercourses; all of which influence the design and proposed location of the RWIZs for surface irrigation of recycled water. However, all required buffers are achievable with regard to the location of the proposed RWIZs.

Having undertaken a land capability assessment of the Site at Freemans Drive, Cooranbong, W&A consider that on-site surface irrigation is generally appropriate on identified land throughout the Site.

8 References (Cited and Used)

Department of Local Government et al. (1998). Environment & Health Protection Guidelines: On-site Sewage Management for Single Households.

Crites, R. W. & Tchobanoglous, G., (1998) Small and Decentralised Wastewater Management Systems, McGraw Hill, USA.

Hazelton, P. & Murphy, B. (2007) Interpreting Soil Test Results, What to all the numbers mean? CSIRO Publishing, Victoria.

Murphy, C.L. (1995). Soil Landscapes of the Gosford-Lake Macquarie 1:100,000 Sheet. Soil Conservation Service of NSW, Sydney.

NSW DEC (2004). Environmental Guidelines – Use of Effluent by Irrigation. NSW Department of Environment and Conservation, Sydney.

Patterson, R.A. (2002). 'Workshop 2 – Calculations for Nutrient Balances.' In Evaluating Site and Soil Assessment Reports for On-site Wastewater Systems. A one-day training course held in Fairfield, Sydney. Centre for Environment Training, Cardiff Heights NSW. March 2002.

Patterson, R.A. (2003). Nitrogen in Wastewater and its Role in Constraining On-Site Planning. In Patterson & Jones (Eds.) Proceedings of On-site '03 Conference: Future Directions for On-site Systems: Best Management Practice. Lanfax Laboratories, Armidale.

Standards Australia / Standards New Zealand (2012). AS/NZS 1547:2012 On-site Domestic-wastewater Management.

Appendix A

Figures & Site Plans

Figure 1: Site Plan Showing Test Pit Locations

Watagan Park Master Plan - LCA

N

Whitehead & Associates
Environmental Consultants

0 300 600 900 1200 m

(Approx Scale)

Revision	2
Drawn	NB
Approved	MS

Appendix B

Soil Borelogs

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Key to Soil Borelogs

Symbols

W	Watertable depth	●	Sample collected
X	Depth of refusal		

Moisture condition

D	Dry
SM	Slightly moist
M	Moist
VM	Very moist
W	Wet / saturated

Graphic Log and Textures

S - Sand
LS - Loamy sand
CS - Clayey sand

CL - Clay loam
SCL - Sandy clay loam
SiCL - Silty clay loam

Gravel (G)

SL - Sandy loam

LC - Light clay
SC - Sandy clay
SiC - Silty clay

Parent material (stiff)

L - Loam
LFS - Loam fine sandy
SiL - Silty loam

MC - Medium clay
HC - Heavy clay

Parent material (weathered)

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	RPS	**Test Pit No:**	**TP1**
Site:	Watagan Park, Cooranbong	Excavated/logged by:	Nicholas Banbrook
Date:	14 April 2014	Excavation type:	Mechanical Auger/Excavator
Notes:	see Site Plan for test pit locations. Topography: artificial planar, linear slope - mound off runway. Some surface fill material (small rocks) present. Slope ~ 4%. Surface drainage poor on fill surface (ponded water present, during rainfall).		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
		TP 1/1	O	SL	Friable/apedal	dark brown	nil	nil	SM	
0.1		TP 1/2	A	SC to SiC	weak pedality (SC)	grey	30% pink/red	nil	SM	
0.2										
0.3										
0.4										
0.5										
0.6		TP 1/3	B1	LC	weak pedality to massive	orange-brown	nil	nil	SM	includes remnant organic layer @ 550-750mm
0.7										
0.8										
0.9										
1.0										
1.1										
1.2										
1.3		TP 1/4	B2	MC	blocky, pedal	orange-pink	50% red	nil	SM	
1.4										
1.5										
1.6										
1.7										pit terminated at 1,700mm
1.8										
1.9										
2.0										

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	RPS	**Test Pit No:**	**TP2**
Site:	Watagan Park, Cooranbong	Excavated/logged by:	Nicholas Banbrook
Date:	14 April 2014	Excavation type:	Mechanical Auger/Excavator
Notes:	see Site Plan for test pit locations. Slope ~ 3-4%. Some erosion on cleared areas (access track and airport runway). Surface drainage moderate to poor.		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1–0.2		TP 2/1	A	SL	weak pedality to single grained	light brown	nil	nil	SM	gradual boundary to B1 horizon
0.3–0.5		TP 2/2	B1	LC	pedal	orange-brown	nil	nil	SM	sharp boundary to B2 horizon
0.6–1.5		TP 2/3	B2	SC	pedal	orange-brown	>50% red + gleying	nil	D	sand fraction is coarse hardsetting when dry pit terminated at 1,500mm
1.6										
1.7										
1.8										
1.9										
2.0										

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	RPS	**Test Pit No:**	**TP3**
Site:	Watagan Park, Cooranbong	Excavated/logged by:	Nicholas Banbrook
Date:	14 April 2014	Excavation type:	Mechanical Auger/Excavator
Notes:	see Site Plan for test pit locations. Located on crest with 0% slopes at peak, 30% slopes down to adjacent drainage line. Surface drainage moderate.		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 3/1	A	SCL	pedal	dark brown	nil	nil	SM	high organic content
0.2		TP 3/2	B1	CS + gravel	weak pedality to massive	yellow brown	nil	30%	D	gravel <10mm diameter large rocks present as fill
0.3										
0.4										
0.5										
0.6										
0.7		TP 3/3	B2	CS + gravel	weak pedality to massive	yellow brown	<20% gley	50%	D	gravel size varies weathered conglomerate rock present at depth
0.8										
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										
1.6										pit terminated at 1,600mm
1.7										
1.8										
1.9										
2.0										

Soil Bore Log

Whitehead & Associates
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Client:	RPS	**Test Pit No:**	**TP4**
Site:	Watagan Park, Cooranbong	Excavated/logged by:	Nicholas Banbrook
Date:	14 April 2014	Excavation type:	Hand Auger
Notes:	see Site Plan for test pit locations. Topography: waxing divergent slopes 4-8%. On side of drainage channel with standing water at base. Drainage is moderate.		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 4/1	A1	SL	weak pedality to single grained	dark grey brown	nil	nil	SM	
0.2										
0.3		TP 4/2	A2	SCL	weak pedality	yellow-grey	nil	<10%	SM	gravel size varies
0.4										
0.5										
0.6										
0.7		TP 4/3	B1	SCL	weak pedality	orange-grey brown	nil	30%	SM	gravel size varies
0.8										pit terminated at 800mm
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										
1.6										
1.7										
1.8										
1.9										
2.0										

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	RPS	**Test Pit No:**	**TP5**
Site:	Watagan Park, Cooranbong	Excavated/logged by:	Nicholas Banbrook
Date:	14 April 2014	Excavation type:	Mechanical Auger/Excavator
Notes:	see Site Plan for test pit locations. Topography: planar linear, at end of runway. Slopes 7%, drainage is good.		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 5/1	A	SL	weak pedality	dark brown	nil	<5%	SM	
0.2		TP 5/2	B1	SC - SiC	weak pedality	light yellow-grey	30% gley	<20%	D	gravel <10mm diameter
0.3										
0.4										
0.5										
0.6										
0.7										
0.8		TP 5/3	B2	SC - SiC	weak pedality	light yellow-grey brown	50% pink/red	<20%	SM	gravel <10mm diameter
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										pit terminated at 1,500mm
1.6										
1.7										
1.8										
1.9										
2.0										

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	RPS	**Test Pit No:**	**TP6**
Site:	Watagan Park, Cooranbong	Excavated/logged by:	Nicholas Banbrook
Date:	14 April 2014	Excavation type:	Mechanical Auger/Excavator
Notes:	see Site Plan for test pit locations. Topography: generally flat, drainage is poor (ponded water on surface), surface soils very susceptible to water erosion.		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 6/1	A	SCL	weak pedality	dark brown	nil	<10%	SM	gravel <10mm diameter
0.2–0.4		TP 6/2	B1	SiC	pedal	light yellow-grey brown	nil	nil	SM	
0.5–1.2		TP 6/3	B2	SC- SiC	pedal	grey-pink -orange	60% red + gley	nil	SM	refusal on bedrock @1,200mm
1.3										
1.4										
1.5										
1.6										
1.7										
1.8										
1.9										
2.0										

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	RPS	**Test Pit No:**	**TP7**
Site:	Watagan Park, Cooranbong	Excavated/logged by:	Nicholas Banbrook
Date:	14 April 2014	Excavation type:	Mechanical Auger/Excavator
Notes:	see Site Plan for test pit locations. Topography: divergent concave slopes 3-7%, towards top of ridge. Drainage is poor. Weathered sandstone outcrops. Water erosion present along access track.		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 7/1	A	SL	weak pedality	brown	nil	<10%	SM	gravel <10mm diameter
0.2		TP 7/2	B1	SiC	pedal	light yellow-brown	nil	nil	SM	hardsetting when dry
0.3										
0.4										
0.5										
0.6										
0.7		TP 7/3	B2	SiC	weak pedality to massive	pale grey	60% red + gley	nil	SM	
0.8										
0.9										
1.0										refusal on bedrock @1,000mm
1.1										
1.2										
1.3										
1.4										
1.5										
1.6										
1.7										
1.8										
1.9										
2.0										

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	RPS	**Test Pit No:**	**TP8**
Site:	Watagan Park, Cooranbong	Excavated/logged by:	Nicholas Banbrook
Date:	14 April 2014	Excavation type:	Hand auger
Notes:	see Site Plan for test pit locations. Topography: waxing divergent slopes 7%. Drainage is good.		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 8/1	A1	SL	weak pedality	dark brown	nil	nil	SM	high organic content
0.2		TP 8/2	A2	SL	weak pedality	dark brown	nil	nil	SM	sand fraction is coarse
0.3										
0.4										
0.5		TP 8/3	B1	SC - SiC	weak pedality to massive	light grey-brown	50% gley + red	<10%	SM	gravel size varies
0.6										
0.7										
0.8										pit terminated at 800mm
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										
1.6										
1.7										
1.8										
1.9										
2.0										

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	RPS	**Test Pit No:**	**TP9**
Site:	Watagan Park, Cooranbong	Excavated/logged by:	Nicholas Banbrook
Date:	14 April 2014	Excavation type:	Mechanical Auger/Excavator
Notes:	see Site Plan for test pit locations. Topography: concave convergent slopes 4-5%. Drainage is good.		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
		TP 9/1	A	SL	weak pedality	dark brown	nil	<2%	SM	high organic content
0.1		TP 9/2	B	LC	pedal	yellow-grey -brown	nil	<10%	SM	gravel size varies
0.2										
0.3										
0.4										
0.5										
0.6										
0.7		TP 9/3	C	LS	weak pedality to masive	yellow-brown	30% gley + red	<10%	SM	gravel size varies sand fraction is coarse
0.8										
0.9										refusal on bedrock @900mm
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										
1.6										
1.7										
1.8										
1.9										
2.0										

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	RPS	**Test Pit No:**	**TP10**
Site:	Watagan Park, Cooranbong	Excavated/logged by:	Nicholas Banbrook
Date:	14 April 2014	Excavation type:	Mechanical Auger/Excavator
Notes:	see Site Plan for test pit locations. Topography: undulating crest along powerline easement, slopes 3%. Drainage is moderate.		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 10/1	A1	SL	weak pedality	dark grey brown	nil	nil	SM	
0.2										
0.3		TP 10/2	B1	SiC	pedal, blocky	bright yellow-brown	gleying common	nil	SM	
0.4										
0.5										
0.6										
0.7										
0.8		TP 10/3	B2	SiC	pedal, blocky	grey	30% red	nil	SM	
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										pit terminated at 1,400mm
1.5										
1.6										
1.7										
1.8										
1.9										
2.0										

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	RPS	**Test Pit No:**	**TP11**
Site:	Watagan Park, Cooranbong	Excavated/logged by:	Nicholas Banbrook
Date:	14 April 2014	Excavation type:	Hand auger
Notes:	see Site Plan for test pit locations. Topography: top of crest, slope 0-2%.		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 11/1	A	SL	single grained	dark grey brown	nil	<10%	SM	gravel size varies
0.2		TP 11/2	B1	SC	pedal - blocky	orange-brown	nil	nil	D	
0.3										
0.4										
0.5										
0.6		TP 11/3	B2	LC	pedal	brownish pink	~50% gley + pink mottles	nil	SM	
0.7										
0.8										pit terminated at 800mm
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										
1.6										
1.7										
1.8										
1.9										
2.0										

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	RPS	**Test Pit No:**	**TP12**
Site:	Watagan Park, Cooranbong	Excavated/logged by:	Nicholas Banbrook
Date:	14 April 2014	Excavation type:	Mechanical Auger/Excavator
Notes:	see Site Plan for test pit locations. Topography: concave convergent midslope of crest, slope 5%.		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 12/1	A	SL	weak pedality	dark brown	nil	nil	SM	
0.2		TP 12/2	B1	LC	weak pedality	light yellow-brown	nil	nil	SM	
0.3										
0.4										
0.5										
0.6		TP 12/3	B2	SC	pedal	light orange-brown	~50% gley + red mottles	nil	SM	
0.7										
0.8										
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										pit terminated at 1,400mm
1.5										
1.6										
1.7										
1.8										
1.9										
2.0										

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	RPS	**Test Pit No:**	**TP13**
Site:	Watagan Park, Cooranbong	Excavated/logged by:	Nicholas Banbrook
Date:	14 April 2014	Excavation type:	Mechanical Auger/Excavator
Notes:	see Site Plan for test pit locations. Topography: waxing divergent midslope, slope 4%. Some minor erosion in cleared areas		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 13/1	A	SL	weak pedality	light yellow-grey-brown	nil	nil	SM	
0.2		TP 13/2	B1	LC	pedal	light yellow-brown	nil	nil	SM	
0.3										
0.4										
0.5										
0.6		TP 13/3	B2	SC	weak pedality	light yellow-brown	20% orange	nil	SM	
0.7										
0.8										pit terminated at 800mm
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										
1.6										
1.7										
1.8										
1.9										
2.0										

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	RPS	**Test Pit No:**	**TP14**
Site:	Watagan Park, Cooranbong	Excavated/logged by:	Nicholas Banbrook
Date:	14 April 2014	Excavation type:	Mechanical Auger/Excavator
Notes:	see Site Plan for test pit locations. Topography: waxing divergent midslope, slope 4%.		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1–0.2		TP 14/1	A1	SL	weak pedality	dark grey brown	nil	nil	SM	
0.3–0.6		TP 14/2	B1	SC	weak pedality	bright yellow-brown	nil	20%	D	gravel size varies
0.7–1.2		TP 14/3	B2	SC	weak pedality	yellow-grey brown	40% gleying + red/pink mottles	20%	SM	gravel size varies
1.3–1.5		TP 14/4	B3	SC	weak pedality	light orange brown	~50% gley + red mottles	nil	SM	pit terminated at 1,500mm
1.6										
1.7										
1.8										
1.9										
2.0										

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	RPS	**Test Pit No:**	**TP15**
Site:	Watagan Park, Cooranbong	Excavated/logged by:	Nicholas Banbrook
Date:	14 April 2014	Excavation type:	Mechanical Auger/Excavator
Notes:	see Site Plan for test pit locations.		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 15/1	A1	SL	weak pedality to massive	dark grey brown	nil	nil	D	
0.2										
0.3		TP 15/2	B1	LS	weak pedality	light yellow-brown	20% gley	<10%	SM	gravel size varies
0.4										
0.5										
0.6										
0.7										
0.8										
0.9		TP 15/3	B2	SC - SiC	weak pedality	grey	40% red/pink	<10%	SM	gravel size varies
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										pit terminated at 1,500mm
1.6										
1.7										
1.8										
1.9										
2.0										

Appendix C

Raw Soil Data and Analytical Results

Sheet 1 - Soil Sampling Schedule and Results of pH, EC and Emerson Aggregate Test Analysis

Test Pit/ Horizon	Sample Name	Sample Depth (mm)	Texture Class	EAT [1]	Rating [2]	pH f [3]	pH 1:5 [4]	Rating	EC 1:5 (µS/cm)	ECe (dS/m) [5]	Rating	Other analysis [6]
TP2 - A	2/1	100	SL	2(2)	Mod	n/a	6.1	Slightly acid	25	0.28	Non-saline	
TP2 - B1	2/2	300	LC	2(2)	Mod	n/a	6.2	Slightly acid	12	0.10	Non-saline	
TP2 - B2	2/3	600	LC	2(2)	Mod	n/a	6.2	Slightly acid	11	0.09	Non-saline	see external results
TP5 - A	5/1	50	SL	8	Low	n/a	5.1	Strongly acid	4	0.04	Non-saline	
TP5 - B1	5/2	200	MC	2(2)	Mod	n/a	4.9	Very strongly acid	12	0.08	Non-saline	
TP5 - B2	5/3	800	LC	2(2)	Mod	n/a	5.1	Strongly acid	43	0.34	Non-saline	see external results
TP7 - A	7/1	50	SL	8	Low	n/a	5.6	Moderately acid	6	0.07	Non-saline	
TP7 - B1	7/2	200	HC	2(2)	Mod	n/a	5.7	Moderately acid	34	0.20	Non-saline	
TP7 - B2	7/3	700	HC	2(2)	Mod	n/a	5.2	Strongly acid	52	0.31	Non-saline	n/a
TP11 - A	11/1	50	SL	8	Low	n/a	5.7	Moderately acid	8	0.09	Non-saline	
TP11 - B1	11/2	200	LC	2(2)	Mod	n/a	5.9	Moderately acid	11	0.09	Non-saline	
TP11 - B2	11/3	600	LC	2(2)	Mod	n/a	5.9	Moderately acid	9	0.07	Non-saline	see external results
TP15 - A	10/1	100	SL	8	Low	n/a	5.5	Strongly acid	3	0.03	Non-saline	
TP15 - B1	10/3	300	LS	2(2)	Mod	n/a	5.7	Moderately acid	4	0.00	Non-saline	
TP15 - B2	10/4	900	HC	2(2)	Mod	n/a	4.8	Very strongly acid	82	0.49	Non-saline	see external results

Notes:- (also refer Interpretation Sheet 1)

[1] The modified Emerson Aggregate Test (EAT) provides an indication of soil susceptibility to dispersion.

[2] Ratings describe the likely hazard associated with land application of treated wastewater.

[3] pH measured in the field using Raupac Indicator.

[4] pH measured on 1:5 soil:water suspensions using a *Hanna Combo* hand-held pH/EC/temp meter.

[5] Electrical conductivity of the saturated extract (ECe) = $EC_{1:5}$(µS/cm) x MF / 1000. Units are dS/m. MF is a soil texture multiplication factor.

[6] External laboratories used for the following analyses, if indicated:

- CEC (Cation exchange capacity)
- Psorb (Phosphorus sorption capacity)
- Bray Phosphorus
- Organic carbon
- Total nitrogen

Interpretation Sheet 1 - pH, EC & Emerson Aggregate Class

Interpretation of Soil pH (1:5 Soil:Water)
(rating based on Hazelton & Murphy (2007))

pH			Rating	
0.00	to	4.50	Extremely acid	
4.51	to	5.00	Very strongly acid	
5.01	to	5.50	Strongly acid	preferred range (5.01 – 7.80)
5.51	to	6.00	Moderately acid	
6.01	to	6.50	Slightly acid	
6.51	to	7.30	Neutral	
7.31	to	7.80	Mildly alkaline	
7.81	to	8.40	Moderately alkaline	
8.41	to	9.00	Strongly alkaline	
9.01	to	14.00	Very strongly alkaline	

Multiplier Factors for Calculating ECe
(taken from Hazelton & Murphy (2007))

Texture Class	Applicable Soil Textures	MF
S	Sand, loamy sand, clayey sand	17
SL	sandy loam, fine sandy loam	11
L	loam, loam fine sandy, silty loam	10
CL	clay loam, sandy clay loam	9
LC	light clay, sandy clay	8
MC	medium clay	7
HC	heavy clay	6

Interpretation of ECe (1:5 Soil:Water)
(rating based on Hazelton & Murphy (2007))

Ece (dS/m)			Rating	
0.00	to	2.00	Non-saline	increasing hazard ↓
2.01	to	4.00	Slightly saline	
4.01	to	8.00	Moderately saline	
8.01	to	16.00	Highly saline	
16.00	up		Extremely saline	

Interpretation of Emerson Aggregate Class
(rating describes likelihood of dispersion)

EAT Class	Rating
1	High
2(1)	Mod
2(2)	Mod
2(3)	High
2(4)	High
3(1)	Low
3(2)	Low
3(3)	Mod
3(4)	Mod
4	Low
5	Low
6	Low
7	Low
8	Low

Sheet 2 - Results of External Laboratory Analysis

Site	Name	CEC (me/100g)	Rating	Ca (mg/kg)	Rating	Mg (mg/kg)	Rating	Na (mg/kg)	Rating	K (mg/kg)	Rating	ESP (%)	Rating	P-sorp. (mg/kg)	Rating
TP2	TP 2 composite (all horizons)	7.3	L	9	VL	285	M	34	L	23	VL	2.0	NS	580	H
TP3	TP 3 composite (all horizons)	4.4	VL	173	VL	233	M	87	M	30	VL	8.7	S	140	M
TP4	TP 4 composite (all horizons)	2.4	VL	23	VL	82	L	15	VL	17	VL	2.6	NS	290	MH
TP5	TP 5 composite (all horizons)	7.7	L	9	VL	90	L	15	VL	32	VL	0.9	NS	355	MH
TP6	TP 6 composite (all horizons)	10.2	L	3	VL	193	M	46	L	38	VL	1.9	NS	780	VH
TP8	TP 8 composite (all horizons)	6.1	L	16	VL	262	M	84	M	80	L	6.0	NS	560	H
TP9	TP 9 composite (all horizons)	7.1	L	7	VL	220	M	103	M	82	L	6.3	S	390	MH
TP11	TP 11 composite (all horizons)	6.4	L	57	VL	214	M	18	VL	57	VL	1.2	NS	735	VH
TP14	TP 14 composite (all horizons)	6.0	VL	52	VL	126	M	18	VL	24	VL	1.3	NS	390	MH
TP15	TP 15 composite (all horizons)	4.9	VL	24	VL	105	L	88	M	22	VL	7.8	S	300	MH

Interpretation Sheet 2 - CEC, P-Sorption, Bray P, Organic carbon, Total nitrogen

Interpretation of CEC

(rating based on Hazelton & Murphy (2007))

Rating	CEC (me/100g)			Ca (mg/kg)			Mg (mg/kg)			Na (mg/kg)			K (mg/kg)		
VL	0.00	to	6.00	0.00	to	400.00	0.00	to	36.50	0.00	to	23.00	0.00	to	78.20
L	6.01	to	12.00	400.01	to	1000.00	36.51	to	121.50	23.01	to	69.00	78.21	to	117.00
M	12.01	to	25.00	1000.01	to	2000.00	121.51	to	365.00	69.01	to	161.00	117.01	to	274.00
H	25.01	to	40.00	2000.01	to	4000.00	365.01	to	972.00	161.01	to	460.00	274.01	to	782.00
VH	40.01	up		4000.01	up		972.01	up		460.01	up		782.01	up	

VL=very low, L=low, M=medium, H=high, VH=very high

Interpretation of ESP

(rating based on Hazelton & Murphy (2007))

Rating	ESP (%)			Description
NS	0.00	to	6.00	Non-sodic
S	6.01	to	15.00	Sodic
SS	15.01	to	25.00	Strongly sodic
VSS	25.01	up		Very strongly sodic

increasing hazard

Interpretation of Phosphorus Sorption Capacity

(rating based on Hazelton & Murphy (2007))

Rating	P-sorption (mg/kg)			Description
L	0.00	to	125.00	Low
M	125.01	to	250.00	Medium
MH	250.01	to	400.00	Medium-High
H	400.01	to	600.00	High
VH	600.01	up		Very high

increasing hazard

Interpretation of Bray Phosphorus

(rating based on Hazelton & Murphy (2007))

Rating	Bray P (mg/kg)			Description
VL	0.00	to	5.00	Very Low
L	5.01	to	10.00	Low
M	10.01	to	17.00	Moderate
H	17.01	to	25.00	High
VH	25.01	up		Very high

Interpretation of Soil Nitrogen (TN)

(rating based on Hazelton & Murphy (2007))

Rating	TN (%)			Description
VL	0.000	to	0.050	Very Low
L	0.051	to	0.150	Low
M	0.151	to	0.250	Medium
H	0.251	to	0.500	High
VH	0.501	up		Very high

Interpretation of Soil Organic Carbon (OC)

(rating based on Hazelton & Murphy (2007))

Rating	OC (%)			Description
VL	0.00	to	1.50	Very Low
L	1.51	to	2.00	Low
M	2.01	to	3.00	Medium
H	3.01	to	5.00	High
VH	5.01	up		Very high

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Soil Scientists and Environmental Engineers

Lanfax Laboratories
ABN 72 212 385 096
Proficiency tested by Aust. Soil & Plant Analysis Council Inc.
ASPAC

24th April 2014

Whitehead & Associates
197 Main Road
Cardiff NSW 2285

Soil Report: Project 1242, 10 samples
Samples received 22nd April 2014
Samples dried to 50°C, crushed and sieved to minus 2 mm prior to analysis

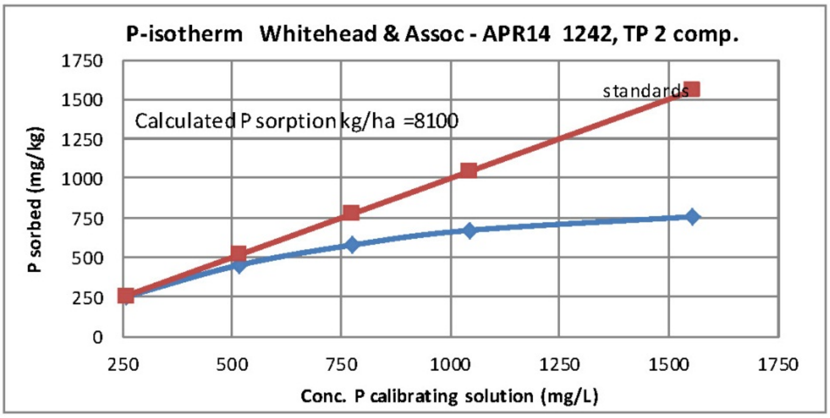
Whitehead & Assoc. Project 1242 APR14

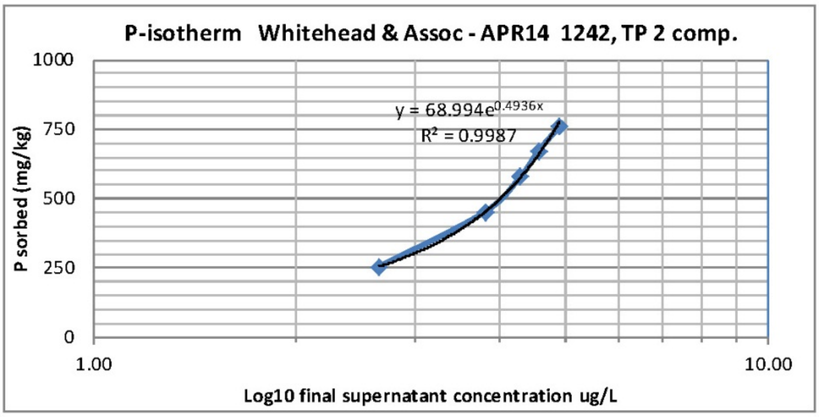
Exc.Al+H	Ca		K		Mg		Na		Base Sat.	ESP	CEC	Ca/Mg	Site Location
cmol+/kg	mg/kg	cmol+/kg	mg/kg	cmol+/kg	mg/kg	cmol+/kg	mg/kg	cmol+/kg	%	%	cmol+/kg	ratio	Sample ID
4.72	9	0.04	23	0.06	285	2.35	34	0.15	35.5	2.0	7.3	0.0	1242, TP 2 comp.
1.12	173	0.86	30	0.08	233	1.92	87	0.38	74.3	8.7	4.4	0.4	1242, TP 3 comp.
1.52	23	0.12	17	0.04	82	0.67	15	0.06	37.1	2.6	2.4	0.2	1242, TP 4 comp.
6.72	9	0.04	32	0.08	90	0.74	15	0.07	12.2	0.9	7.7	0.1	1242, TP 5 comp.
8.32	3	0.02	38	0.10	193	1.59	46	0.20	18.6	1.9	10.2	0.0	1242, TP 6 comp.
3.28	16	0.08	80	0.20	262	2.16	84	0.37	46.1	6.0	6.1	0.0	1242, TP 8 comp.
4.64	7	0.04	82	0.21	220	1.81	103	0.45	35.0	6.3	7.1	0.0	1242, TP 9 comp.
4.16	57	0.29	57	0.15	214	1.76	18	0.08	35.3	1.2	6.4	0.2	1242, TP 11 comp.
4.56	52	0.26	24	0.06	126	1.04	18	0.08	23.9	1.3	6.0	0.2	1242, TP 14 comp.
3.52	24	0.12	22	0.05	105	0.86	88	0.38	28.8	7.8	4.9	0.1	1242, TP 15 comp.

Methods: Rayment & Lyons 2011
P sorption modified method 9J1 - elevated equilibrating solutions, ICP determination of P

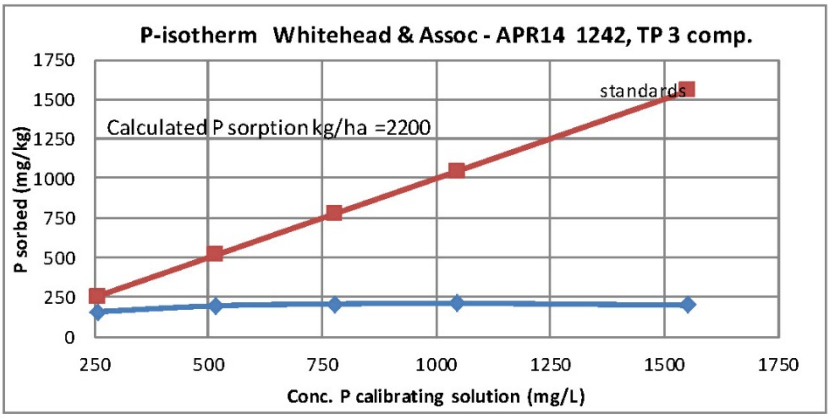
Dr Robert Patterson

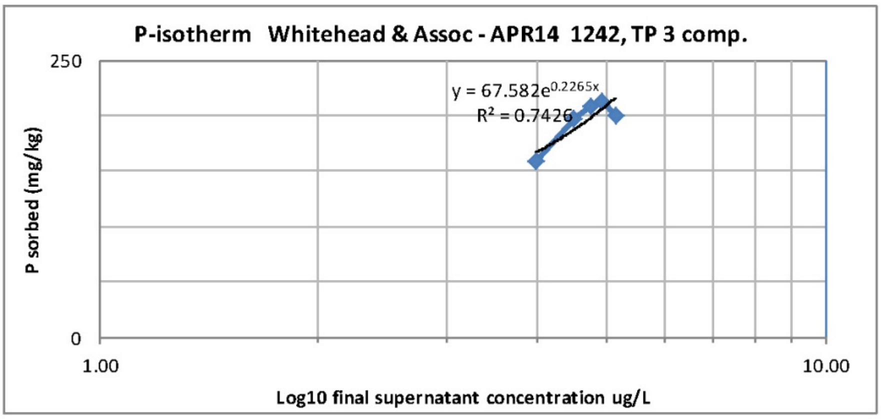
Commercial and research laboratory for soil, water and plant analysis.
Soil survey and analytical assessments, landscape analysis and plant nutrient relationships,
Wastewater and effluent reuse specialists - on-site and decentralised





Percent sorbed is the proportion of the initial P sorbed during equilibration						P-isotherm Whitehead & Assoc - APR14 1:			
Initial P	filtrate	sorbed P	Sample	Percent		Std line	filtrate	Y axis	X axis
mgP/L	P	mg/kg	I.D.	sorbed			C	Log C	
	mg/L			(%)			ugP/L	Y axis	X axis
25.8	0.45	253.9	Whitehead & Assoc - APR14	98.3		258	447	2.65	253.9
51.6	6.41	452.0	1242, TP 2 comp.	87.6		516	6407	3.81	452.0
77.7	19.74	579.2		74.6		777	19740	4.30	579.2
104.5	37.29	672.1		64.3		1045	37290	4.57	672.1
155.3	79.53	757.7		48.8		1553	79530	4.90	757.7
Calculated P sorption kg/ha =			8100						



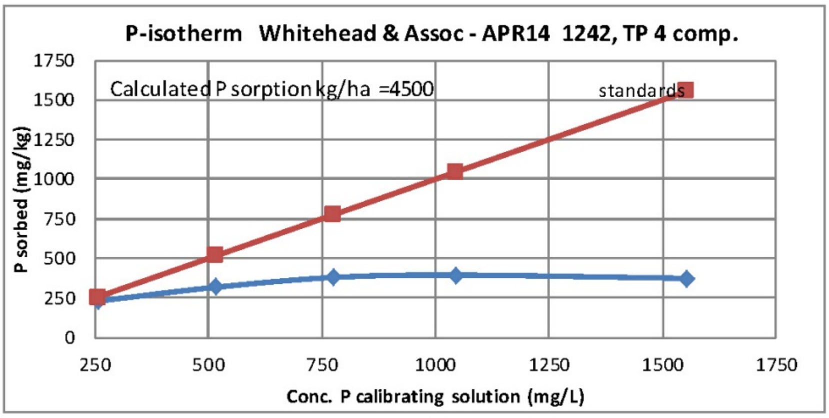


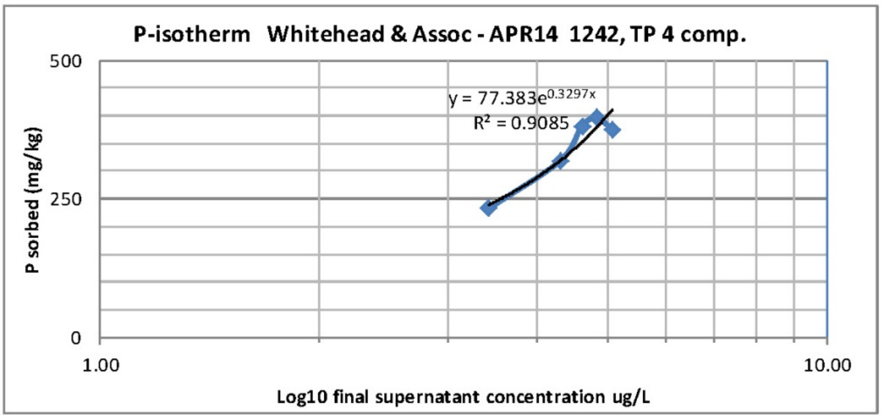
Percent sorbed is the proportion of the initial P sorbed during equilibration

Initial P mgP/L	filtrate P mg/L	sorbed P mg/kg	Sample I.D.	Percent sorbed (%)	Std line	filtrate C ugP/L	Y axis Log C	X axis
25.8	9.91	159.3	Whitehead & Assoc - APR14	61.7	258	9906	4.00	159.3
51.6	31.96	196.5	1242, TP 3 comp.	38.1	516	31960	4.50	196.5
77.7	56.85	208.1		26.8	777	56850	4.75	208.1
104.5	83.28	212.2		20.3	1045	83280	4.92	212.2
155.3	135.30	200.0		12.9	1553	135300	5.13	200.0

P-isotherm Whitehead & Assoc - APR14 1:

Calculated P sorption kg/ha = 2200

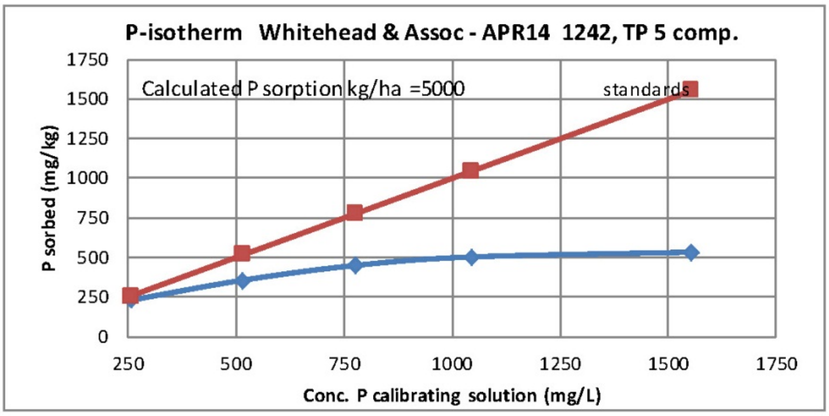


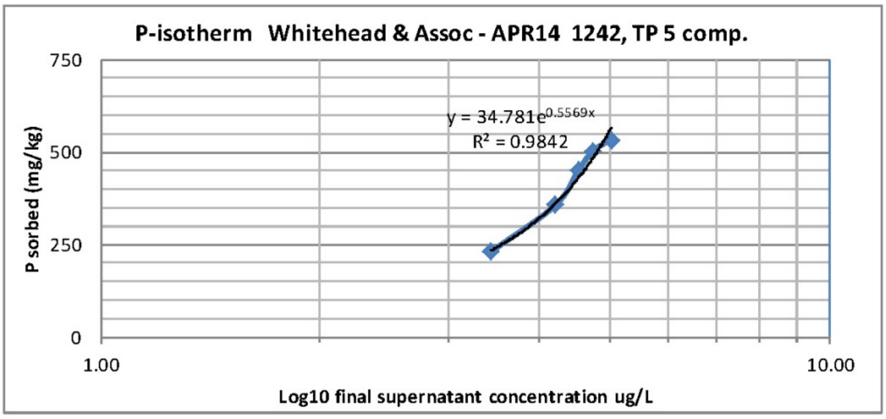


Percent sorbed is the proportion of the initial P sorbed during equilibration

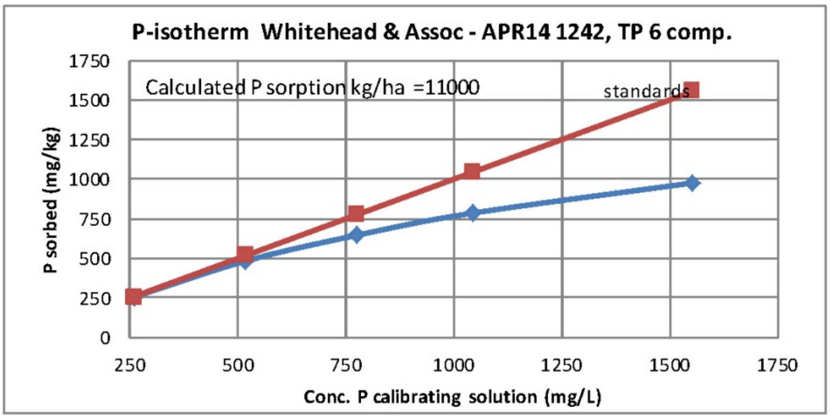
Initial P	filtrate	sorbed P	Sample	Percent		P-isotherm Whitehead & Assoc - APR14 1:			
mgP/L	P	mg/kg	I.D.	sorbed		Std line	filtrate	Y axis	X axis
	mg/L			(%)			C	Log C	
							ugP/L		
25.8	2.63	232.1	Whitehead & Assoc - APR14	89.8		258	2630	3.42	232.1
51.6	19.74	318.7	1242, TP 4 comp.	61.8		516	19740	4.30	318.7
77.7	39.59	380.7		49.0		777	39590	4.60	380.7
104.5	64.90	396.0		37.9		1045	64900	4.81	396.0
155.3	117.80	375.0		24.1		1553	117800	5.07	375.0

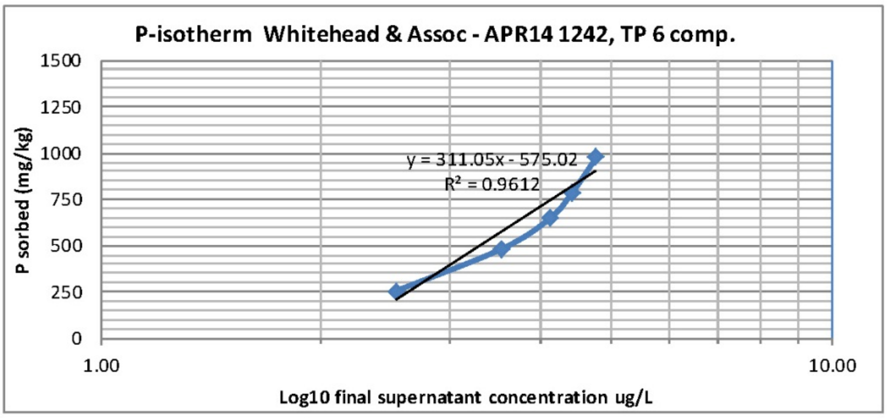
Calculated P sorption kg/ha = 4500





Percent sorbed is the proportion of the initial P sorbed during equilibration						P-isotherm Whitehead & Assoc - APR14 1:			
Initial P	filtrate	sorbed P	Sample	Percent		Std line	filtrate	Y axis	X axis
mgP/L	P	mg/kg	I.D.	sorbed			C	Log C	
	mg/L			(%)			ugP/L		
25.8	2.70	231.4	Whitehead & Assoc - APR14	89.6		258	2698	3.43	231.4
51.6	15.92	356.9	1242, TP 5 comp.	69.2		516	15920	4.20	356.9
77.7	32.63	450.3		58.0		777	32630	4.51	450.3
104.5	54.13	503.7		48.2		1045	54130	4.73	503.7
155.3	101.90	534.0		34.4		1553	101900	5.01	534.0
Calculated P sorption kg/ha =			5000						



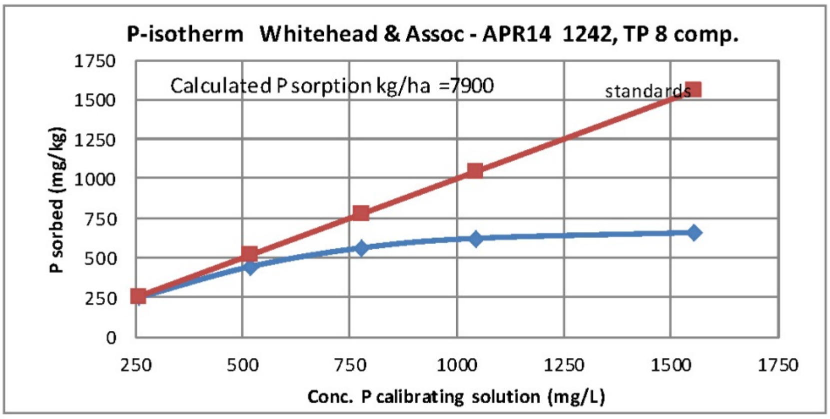


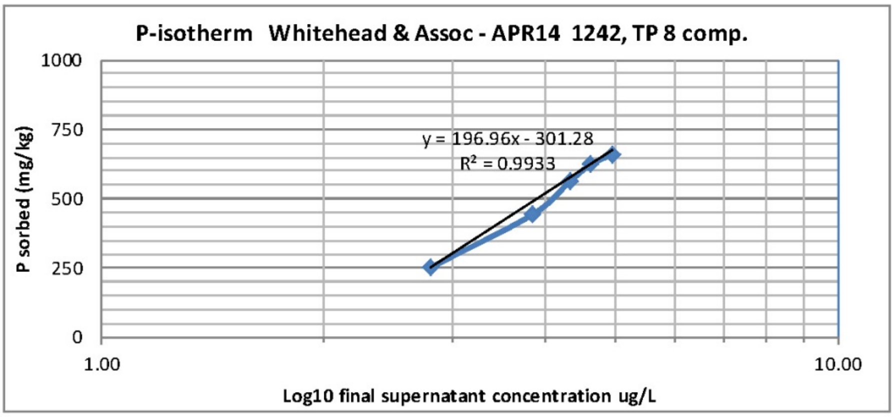
Percent sorbed is the proportion of the initial P sorbed during equilibration

Initial P mgP/L	filtrate P mg/L	sorbed P mg/kg	Sample I.D.	Percent sorbed (%)	Std line	filtrate C ugP/L	Y axis Log C	X axis
25.8	0.34	255.0	Whitehead & Assoc - APR14	98.7	258	342	2.53	255.0
51.6	3.41	482.0	1242, TP 6 comp.	93.4	516	3414	3.53	482.0
77.7	13.00	646.6		83.3	777	13000	4.11	646.6
104.5	25.90	786.0		75.2	1045	25900	4.41	786.0
155.3	57.71	975.9		62.8	1553	57710	4.76	975.9

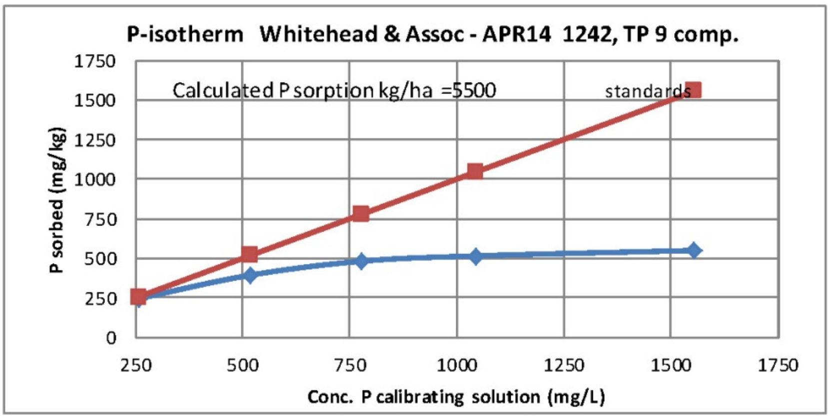
P-isotherm Whitehead & Assoc - APR14 12

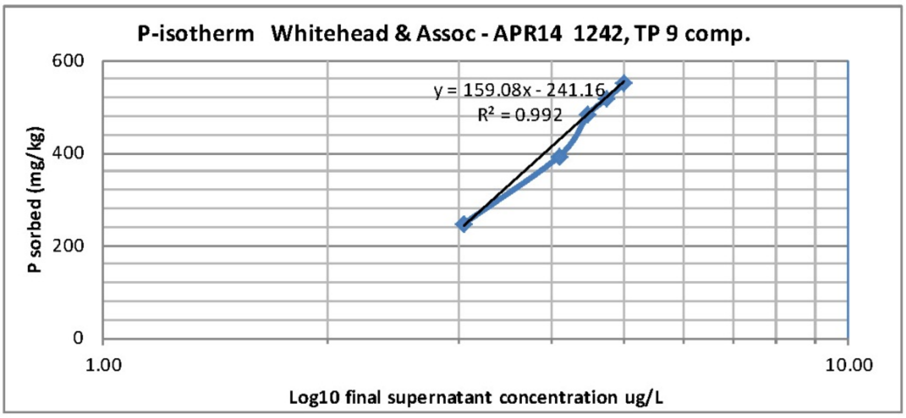
Calculated P sorption kg/ha = 11000





Percent sorbed is the proportion of the initial P sorbed during equilibration						P-isotherm Whitehead & Assoc - APR14 1:			
Initial P	filtrate	sorbed P	Sample	Percent		Std line	filtrate	Y axis	X axis
mgP/L	P	mg/kg	I.D.	sorbed			C	Log C	
	mg/L			(%)			ugP/L		
25.8	0.63	252.1	Whitehead & Assoc - APR14	97.6		258	632	2.80	252.1
51.6	7.20	444.1	1242, TP 8 comp.	86.0		516	7203	3.86	444.1
77.7	21.35	563.1		72.5		777	21350	4.33	563.1
104.5	42.11	623.9		59.7		1045	42110	4.62	623.9
155.3	89.26	660.4		42.5		1553	89260	4.95	660.4
Calculated P sorption kg/ha =			7900						

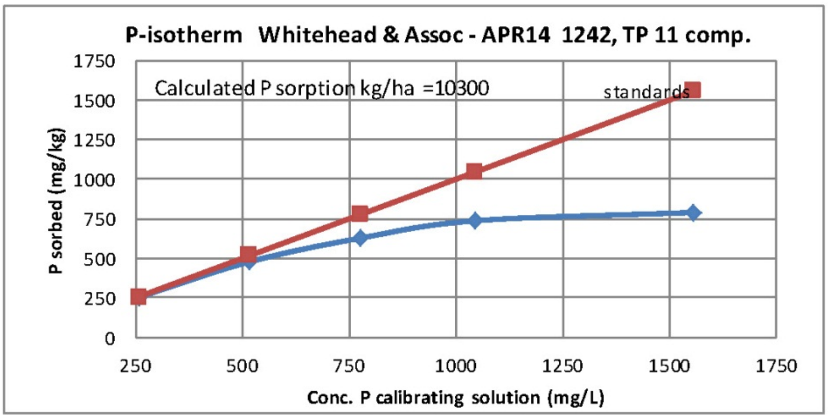


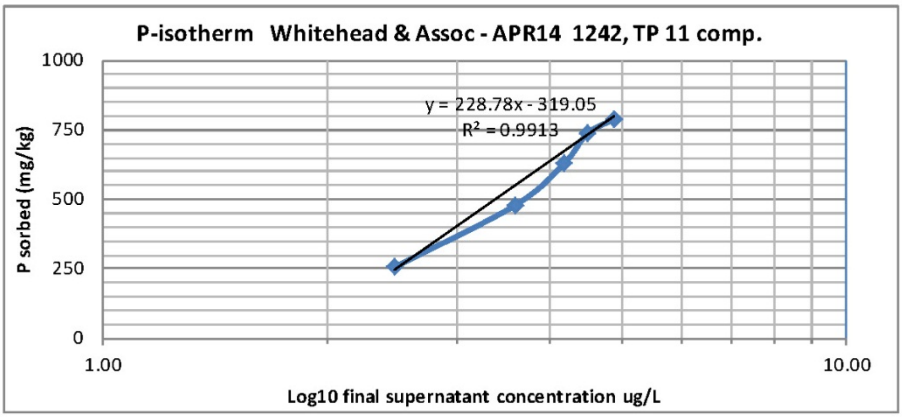


Percent sorbed is the proportion of the initial P sorbed during equilibration

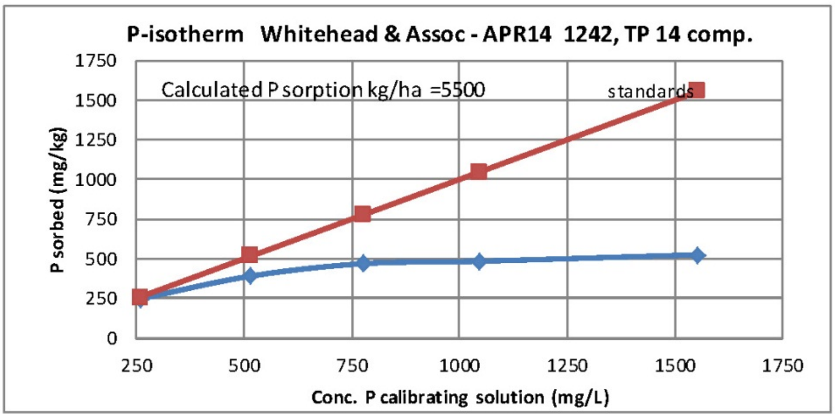
Initial P mgP/L	filtrate P mg/L	sorbed P mg/kg	Sample I.D.	Percent sorbed (%)		Std line	filtrate C ugP/L	Y axis Log C	X axis
25.8	1.12	247.3	Whitehead & Assoc - APR14	95.7		258	1115	3.05	247.3
51.6	12.30	393.1	1242, TP 9 comp.	76.2		516	12300	4.09	393.1
77.7	29.49	481.7		62.0		777	29490	4.47	481.7
104.5	52.94	515.6		49.3		1045	52940	4.72	515.6
155.3	100.30	550.0		35.4		1553	100300	5.00	550.0
Calculated P sorption kg/ha =			5500						

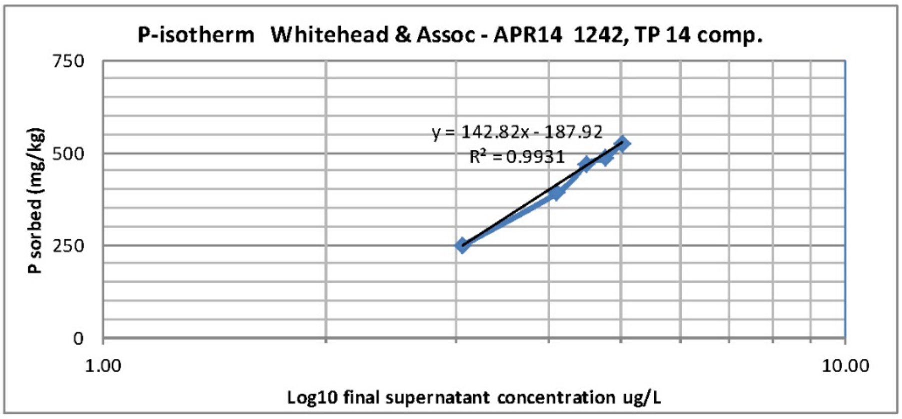
P-isotherm Whitehead & Assoc - APR14 1:





Percent sorbed is the proportion of the initial P sorbed during equilibration						P-isotherm Whitehead & Assoc - APR14 1			
Initial P mgP/L	filtrate P mg/L	sorbed P mg/kg	Sample I.D.	Percent sorbed (%)		Std line	filtrate C ugP/L	Y axis Log C	X axis
25.8	0.29	255.5	Whitehead & Assoc - APR14	98.9		258	294	2.47	255.5
51.6	3.83	477.8	1242, TP 11 comp.	92.6		516	3829	3.58	477.8
77.7	14.86	628.0		80.9		777	14860	4.17	628.0
104.5	30.78	737.2		70.5		1045	30780	4.49	737.2
155.3	76.38	789.2		50.8		1553	76380	4.88	789.2
Calculated P sorption kg/ha =			10300						

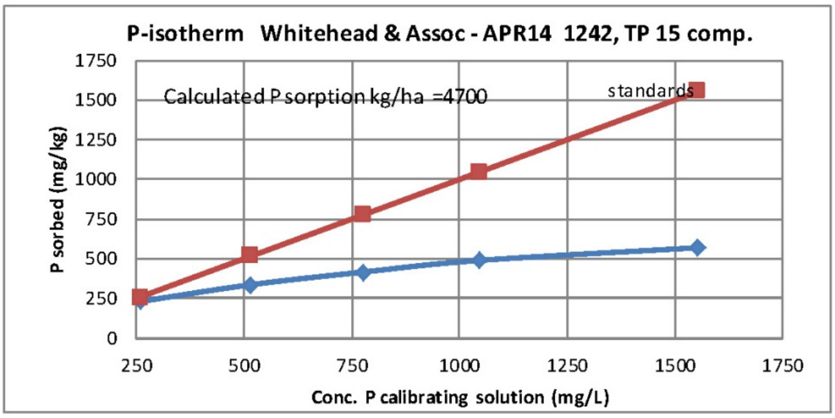


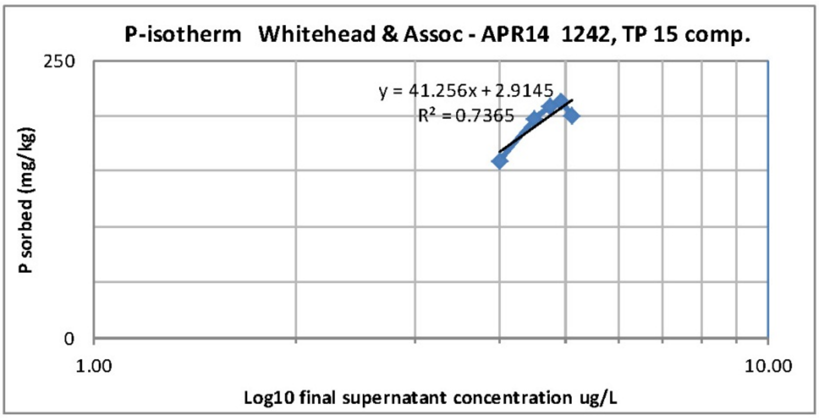


Percent sorbed is the proportion of the initial P sorbed during equilibration

Initial P mgP/L	filtrate P mg/L	sorbed P mg/kg	Sample I.D.	Percent sorbed (%)		Std line	filtrate C ugP/L	Y axis Log C	X axis
25.8	1.12	247.2	Whitehead & Assoc - APR14	95.7		258	1120	3.05	247.2
51.6	12.53	390.8	1242, TP 14 comp.	75.7		516	12530	4.10	390.8
77.7	30.78	468.8		60.4		777	30780	4.49	468.8
104.5	56.07	484.3		46.3		1045	56070	4.75	484.3
155.3	102.80	525.0		33.8		1553	102800	5.01	525.0
Calculated P sorption kg/ha =			5500						

P-isotherm Whitehead & Assoc - APR14 1





Percent sorbed is the proportion of the initial P sorbed during equilibration

Initial P mgP/L	filtrate P mg/L	sorbed P mg/kg	Sample I.D.	Percent sorbed (%)
25.8	2.79	230.5	Whitehead & Assoc - APR14	89.2
51.6	17.97	336.4	1242, TP 15 comp.	65.2
77.7	36.04	416.2		53.6
104.5	55.58	489.2		46.8
155.3	98.34	569.6		36.7
Calculated P sorption kg/ha =			4700	

P-isotherm Whitehead & Assoc - APR14 1

Std line	filtrate C ugP/L	Y axis Log C	X axis
258	2791	3.45	230.5
516	17970	4.25	336.4
777	36040	4.56	416.2
1045	55580	4.74	489.2
1553	98340	4.99	569.6

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Staging Assessment for Recycled Water Management Scheme at Proposed 'North Cooranbong' Development, Cooranbong, NSW

Prepared for	RPS Australia
Prepared by	Zoe Rogers, Jasmin Kable & Mark Saunders Whitehead & Associates Environmental Consultants Pty Ltd 197 Main Road CARDIFF NSW 2285

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Document Control Sheet

Document and Project Details	
Document Title:	Staging Assessment for recycled water management scheme at proposed North Cooranbong Development, Cooranbong, NSW
Author:	Zoe Rogers and Jasmin Kable
Project Manager:	Mark Saunders
Date of Issue:	03/06/14
Job Reference:	Report_01242_Staging_003
Synopsis:	This report provides the results of our investigations regarding the Staging Assessment for the proposed North Cooranbong Development, Cooranbong. This report should be read in conjunction with the LCA report prepared for the project (Report_01242_LCA_002).
Client Details	
Client:	RPS Australia
Primary Contact:	Mr Stuart Greville (RPS Australia)

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02	03/06/14	Final	1e	-	-
03	04/06/14	Revised FINAL	1e	-	-

Document Verification

Checked by: Mark Saunders	***Issued by:*** Zoe Rogers

Disclaimer

The information contained in this report is based on independent research undertaken by Zoe Rogers and Jasmin Kable of Whitehead & Associates Environmental Consultants Pty Ltd (W&A). To our knowledge, it does not contain any false, misleading or incomplete information. Recommendations are based on an appraisal of the site conditions subject to the limited scope and resources available for this project, and follow relevant industry standards. The work performed by W&A included a desktop review and limited soil sampling only, and the conclusions made in this report are based on the information gained and the assumptions as outlined. Under no circumstances, can it be considered that these results represent the actual state of the site at all points as subsurface conditions are inherently variable. Concentrations of contaminants may also change with time, and the conclusions in this report have a limited lifespan.

Copyright Note

Executive Summary

Whitehead & Associates were engaged by RPS Australia Pty Ltd to undertake a Land Capability Assessment and Staging Assessment for a Recycled Water Scheme at the proposed North Cooranbong Development, located to the northwest of Freemans Drive, Cooranbong. The LCA report has been provided to the Client. Based on plans provided by the developer, Johnson Property Group, it is proposed to subdivide the existing, approximately 300ha Site in multiple release stages for primarily residential development, comprising approximately 2,250 residential lots and an area designated for commercial/retail development.

It is proposed to develop a water supply and recycling scheme for the entire development (except for the 132 lots already developed or being developed). The recycled water would be produced at the proposed Cooranbong Local Water Centre. The proposed LWC would supply the subdivision with a reticulated recycled water supply (i.e. 'third pipe'). As the development progresses, any unused recycled water (i.e. that not being reused internally or externally on individual residential properties) will be irrigated on managed pasture in the land set aside for the subsequent development stages of the subdivision. Permanent irrigation areas will be established on community or/and privately owned lands (e.g. parks, sporting fields) for any unused recycled water prior to Stage 8 of the subdivision being finalised.

A site and soil assessment was conducted on the 14th April 2014, in accordance with the Australian Guidelines for Water Recycling (2006) under the requirements of the Water Industry Competition Act (WICA, 2006), to determine the limitations (if any) for the irrigation of the Site. Overall, the Site constraints for Recycled Water Irrigation (RWI) were generally moderate, due to the presence of clay subsoils across much of the Site, and localised areas of poor subsoil drainage and a high seasonal watertable (particularly adjacent to existing drainage lines).

Design household (ET) water demands and wastewater generation rates were determined in accordance with the Building Sustainability (BASIX) and Water Efficiency Labelling Scheme (WELS) requirements. The household water demands have been estimated as 741L/ET/day based on the determined occupancy data and 'pre BASIX' benchmark home condition. Each design household has a potential to offset approximately 40% of the total potable water demand using recycled water, on an annual basis.

Monthly water and nutrient balances as well as a daily-timestep model have been undertaken to determine sustainable irrigation rates for community land in the subdivision and ultimate irrigation capacity to determine the maximum development potential of the subdivision before an alternative end-use must be found for the recycled water.

The assessment demonstrates that the hydraulic load is limiting across the Site and an off-site recycled water reuse option would be required once maximum subdivision development potential has been reached. If the four currently partially-forested stages are not used for recycled water irrigation, then the maximum capacity of the Site to sustain irrigation of recycled water would be reached once stage 8 is built out. This assumes that stages will be developed in approximately the order in which they are listed in this Report and on the Site plans.

The results of the DSM modelling simulations indicates that nutrient loads in surface surcharge and deep drainage of recycled water represent <1% increase on the background nutrient loads in runoff from the Site. This figure is considered to be relatively insignificant. It is assumed that the attenuation rates for nutrients in soil (94% phosphorous and 93% nitrogen) are more than sufficient to capture these minor nutrient contributions. It is anticipated that the nutrient loads in the recycled water will have no appreciable impact on environmental and/or public health.

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List of Tables

1 Introduction

Whitehead & Associates Environmental Consultants Pty Ltd ("W&A") were engaged by RPS Australia Pty Ltd ("the Client") on behalf of Cooranbong Water to undertake a Land Capability and Staging Assessment for recycled water management for the proposed staged subdivision to be known as North Cooranbong ("the Site"). The Site is located to the north of Freemans Drive at the northern end of the existing township of Cooranbong, as shown in Figure 1, Appendix A.

This Staging Assessment report focuses on the Site's capacity to sustainably accommodate recycled water that is not reused internally or externally by residential developments, once the proposed Local Water Centre (LWC) at North Cooranbong is commissioned and operational. The LWC will be owned and operated by Cooranbong Water. The proportion of recycled water that is reused by households will fluctuate throughout the year (and can be as high as 100% in warmer months); however this report deals with averages for simplicity. We understand that the initial stages of the subdivision that have been, or are currently being developed, have or will be connected to existing reticulated sewerage provided by Hunter Water Corporation (HWC). A separate LCA report has been provided to the Client.

The Site is located entirely within the Lake Macquarie City Council ("Council") local government area (LGA). Field investigations were undertaken by Nicholas Banbrook and Jasmin Kable of W&A on the 14th April 2014. This report provides the results of our investigations and recommendations for Recycled Water Irrigation Zones (RWIZs) proposed to be developed to manage unused recycled water once the Cooranbong LWC recycled water scheme is operational. It should be read in conjunction with the Land Capability Assessment (LCA) Report prepared for the project (Report_01242_LCA_002).

2 Overview of Proposed Development

The Site is proposed to contain a combination of predominantly residential as well as commercial development, including twelve (12) residential stages of approximately 2,250 lots in total; and a commercial/retail/community precinct to service and support the residential development. The development area covers approximately 200ha (the entire Site is approximately 300ha, including public open space, environmental buffers and other improvements including roads and infrastructure). The entire build out of the Site is expected to be implemented over at least 10-15 years.

Cooranbong Water is assisting the developer, Johnston Property Group (JPG) in delivering sewerage, recycled water and drinking water infrastructure to the North Cooranbong development. The Cooranbong LWC will treat wastewater generated by the proposed residential and commercial developments (separate trade waste agreements may be required for certain types of commercial uses). The LWC facility is intended to operate 24 hours, 7 days per week, housed in a low-scale, single level building within an open space setting. The proposed LWC will incorporate a dual reticulation ('third pipe') system to distribute recycled water to households for non-potable water reuse such as toilet flushing, washing machine supply, irrigation and car washing, thus reducing potable water demand. At this stage in development planning, it is intended that any remaining unused recycled water will be irrigated in the undeveloped land associated with later development stages, in proposed RWIZs.

3 Regulatory Requirements and Guidelines

The Independent Pricing and Regulatory Tribunal (IPART, NSW) regulate the licensing of private water schemes under the *Water Industry Competition Act (WICA) 2006*. Under the Act, a corporation must obtain a licence to construct, maintain or operate any water industry infrastructure (network operators' licence), or to supply potable or non-potable water, or provide sewerage services by means of any water industry infrastructure (retail suppliers licence). Both the network operators' and retail suppliers' licences are applicable for the development of the LWC at the Site.

Under the *Water Industry Competition (General) Regulation (WICR) 2008*, network operator licensees for sewerage schemes are required to produce a Sewage Management Plan (SMP) and subsequent audit reports on the SMP before commercial operation of the scheme. The sustainability assessment is an audit of relevant components of the SMP, with the aim of helping to determine whether the proposed infrastructure will provide sewerage services which are sustainable and do not present a risk to the environment.

This report, along with the LCA report provide, will address the 'sustainability assessment' requirements set out by *WICR (2008)*, that deal with the application of recycled water to land, including water balance calculations for the scheme. The sustainable rate of application of the recycled water will be determined; and general storage capacity requirements will also be outlined for the recycled water scheme based on the water balance calculations. The remaining sections of the sustainability assessment will be completed by the licensee. The outstanding SMP audit components can be completed after commencement of construction.

The Australian Guidelines for Water Recycling: Managing health and environmental risks (Phase 1) (AGWR, 2006), were developed to provide guidance on the supply, use and regulation of recycled water schemes. The guidelines use a risk management framework comprising of twelve (12) elements with multiple barriers to control hazards. The framework is summarised by four (4) main categories: commitment to responsible use and management of recycled water; system analysis and management; supporting requirements; and review.

The principles of sustainable use of recycled water are based on three main principles:

- protection of public and environmental health is of paramount importance and should never be compromised;
- protection of public and environmental health depends on implementing a preventative risk management approach; and
- application of preventative measures and requirements for water quality should be commensurate with the source of recycled water and the intended uses.

In regards to public health, relatively few restrictions need to be placed on non-drinking water uses of tertiary treated and disinfected recycled water. End use controls and onsite constraints can also be used to minimise both human exposure to hazards and the impact on receiving environments; such as signage, use of buffer zones, and control of plumbing and distribution systems.

The licensed network operator must submit to IPART an Infrastructure Operating Plan and a Water Quality Plan which is consistent with the AGWR (2006) and addressing the Framework for Management of Recycled Water Quality and Use.

4 Recycled Water Analysis

4.1 Local Water Centre

It is our understanding that Cooranbong Water will supply the LWC, which will incorporate membrane bioreactor (MBR) technology for the treatment of wastewater from the North Cooranbong development. MBR systems effectively combine two proven wastewater treatment processes (i.e. microbial digestion and membrane separation) into a single process where suspended solids and microorganisms responsible for biodegradation are separated from the treated water by an ultra-filtration (UF) system.

We understand that the proposed LWC will be designed to accommodate the maximum daily load from North Cooranbong at build out, with required provisions for peak flow management (flow-balancing) and emergency storage.

4.2 Recycled Water Generation

Wastewater generation for the proposed development will include domestic sources (stages I to XII) as well as commercial and community sources within the designated precinct, as described below.

Generally, wastewater from each future lot will be generated from the entire (combined) wastewater stream including blackwater (toilet flushing and kitchen wastes), and greywater (laundry and shower/bath/handbasin wastes). The exception to this may include particular types of trade waste generated in commercial premises, which may require separate collection and disposal. At this stage, the exact types of commercial premises to occupy the Commercial Centre are not known. However, most (if not all) of them are expected to generate wastes that are appropriate for treatment in the LWC (such as supermarkets, retail, takeaway food, etc.). Flow Systems has provided estimations of the equivalent tenement (ET) for the proposed retail and community developments, which have been used in our analysis.

It is proposed to provide dual reticulation to distribute recycled water to households and public open space, whilst any unused recycled water will be irrigated in the undeveloped land associated with later development stages (and ultimately to other permanent uses once build-out is complete).

4.3 Recycled Water Quality

The recycled water produced by the LWC will be of tertiary quality; that is, it is expected to meet, or exceed, the following criteria:

- Total Nitrogen: ≤15mg/L;
- Total Phosphorus: 2-5mg/L;
- BOD_5: ≤10mg/L;
- Suspended Solids: ≤10mg/L;
- Faecal Coliforms: ≤10cfu/100mL;
- Total Dissolved Solids: 700mg/L; and
- EC: ~1,000µS/cm.

RWIZs will likely be accessible to the public and residents either through direct exposure or inadvertent/secondary contact. Appropriate signage must be employed to identify the use of recycled water for irrigation. The proposed LWC will treat recycled water to a quality which would be considered low risk for direct human contact (DWE, 2008). The proposed recycled water quality will enable urban irrigation of community areas with unrestricted access.

4.4 Recycled Water Quantity

The Building & Sustainability Index (BASIX), implemented under the NSW State Environmental Planning Policy Sustainability Index 2004 (BASIX SEPP), mandates water and energy saving targets for all new residential construction in NSW. BASIX requires fixtures, fittings and appliances to have minimum ratings in accordance with AS/NZS 6400:2005 (Water Efficient Products) under the Water Efficiency Labelling and Standards (WELS) scheme.

For BASIX approval a new residential development is required to demonstrate up to 40% less potable water usage than the average 'pre BASIX' benchmark home of 90.34kL/person/year or 247L/person/day. The 'pre BASIX' benchmark home was determined from data collated by the then NSW Department of Water and Energy (DWE) and included regional data reflecting both demographic and climate considerations. The whole of the Lake Macquarie Local Government Area is located within a 40% reduction target zone. The BASIX reduction targets were determined from data provided by state and federal water and energy utilities as well as long-term climate data obtained from the Bureau of Meteorology. It is noted that the reduction targets are currently under review, with a proposal to increase the target to 50% in areas currently prescribed with a 40% reduction target.

BASIX encourages reductions in the consumption of potable water through any of the following strategies: landscape uses, fixtures, alternative water sources, pools and spas, and central systems. The Site will utilise an alternative water source through the reticulation of recycled water, for garden and lawns, toilets and laundry (cold water only) use, to meet the BASIX reduction targets. Additional listed strategies, i.e. fixtures, may also need to be used in addition to the alternative water source to meet the target.

4.4.1 Residential Development

Design Household

An ET occupancy value (capita per new residence) was determined based on population density information collated by W&A from the most recent ABS Census of Population and Housing (2011). An ET of three (3) persons per new residence was adopted, which is somewhat higher than the average of 2.6 persons currently residing in the Cooranbong area. We consider that this is an appropriate figure to adopt for design purposes for the proposed North Cooranbong development.

Household Water Usage

Subsequently, household water (usage) demand has been estimated for each new residence as 741L/ET/day (3 persons x 247L/person/day). Assuming a minimum requirement to meet the 40% BASIX reduction target, a reduction of 297L/ET/day is required from the total household water demand for each new residence. Figure 4 illustrates the proportional breakdown of the water use within a residential household based on BASIX targets and WELS scheme criteria.

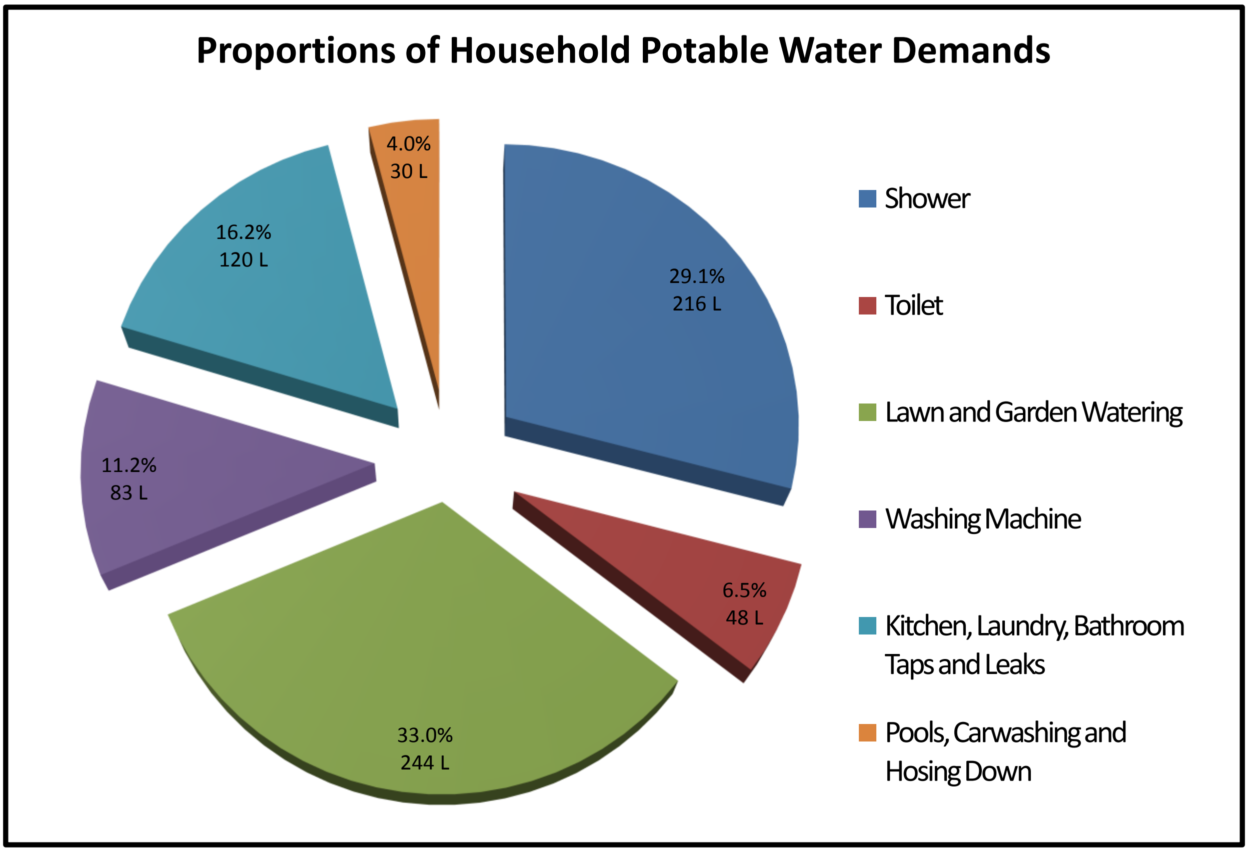

Figure 4 Proportional water usage within a residential household (internal and external water use)

The calculations and assumptions used by BASIX and WELS to proportion expected household usage are further described below.

Toilets

Based on the installation of retrofitted flush valves for single flush toilets only, 5.5L/full flush is the maximum WELS scheme registered water consumption for toilets. The maximum water consumption for dual flush toilets, which will likely be installed, is 4L/flush (6L full flush / 3L half flush). We have assumed an average of 4 flushes/person/day (13 per weekend and 3 per weekday, averaged over the week). Therefore, the total water demand for toilets would be 48L/ET/day. This equates to approximately 6.5% of the total household water demand.

Showers

The minimum NSW requirement, as per the Building Code Australia, for showerheads in new developments is a 3-star rating with a water consumption ranging between 4.5-9L/min. As per BASIX calculations, for an assumed shower duration of 8 minutes (one shower a day), with a maximum allowable showerhead flow rate of 9L/min, the total water consumption for showers would be 216L/ET/day. This equates to approximately 29.1% of the total household water demand.

Washing Machines

BASIX requires the following WELS scheme (star) ratings to be met for washing machines: a load capacity greater than 5kg requires a greater than 3-star rating and for capacities less than 5kg a rating greater than 2.5-star is required. The maximum consumption per load for a 2.5-star and a 3-star washing machine is an average of 76 and 97L/load, respectively. We have assumed the larger machine would be installed in each new residence and also that a ‘typical’ 3-person household would do six (6) loads per week. Based on this, we estimate that, at 97L/load, the total household water consumption for washing machines would be 83L/ET/day. This equates to approximately 11.2% of the total household water demand. Approximately one-third of washing machine water usage is assumed to be hot water (28L/ET/day) with the remaining two-thirds being cold water (55L/ET/day).

Kitchen, Laundry, Bathroom Taps and Leaks

The minimum BASIX requirements for taps are 3-star outlet tap sets with a maximum water consumption of 9.5L/min and an average of 8.4L/min. Assuming a ‘typical’ resident uses the taps for approximately 4min/day at 8.4L/min, then the estimated water consumption for taps is approximately 101L/ET/day. This equates to approximately 13.5% of the total household water demand.

The water consumption of a dishwasher as a proportion of the total ‘kitchen, laundry, bathroom taps and leaks’ component was also determined. The minimum WELS scheme rating for dishwashers is 1.5-star, with a maximum water consumption of 18.6L/wash. We have assumed a typical 3-person household does at least one wash per day. Therefore, the total water consumption for dishwashers is 18.6L/ET/day. This equates to approximately 2.5% of the total household water demand. When combined with expected tap uses, this results in an estimated 16.2% total household water demand for ‘kitchen, laundry, bathroom taps and leaks’.

The estimate of 16.2% for this particular household demand is validated by Sydney Water (2008) and Brisbane Water (QLD Department of Housing and Public Works, 2006) figures.

Pool, Car washing and Hosing Down

An approximate demand of 4% was adopted for (non-garden) external uses such as pool, car washing and hosing down. This equates to approximately 30L/ET/day of the total household water demand. This was based on figures adopted by both Sydney Water (2008) and Brisbane Water (QLD Department of Housing and Public Works, 2006). (Note that we have not assumed any reuse of recycled water for this purpose at this stage).

Lawn and Garden Watering

As lawn and garden watering can include seasonal variability, it was the most difficult type of water demand to estimate. By adopting the aforementioned proportions, the remaining 33% of on-lot usage is assigned for lawn and garden watering, which equates to approximately 244L/ET/day. This value compares to an (approximate) average of other published values from Brisbane Water 42% (QLD Department of Housing and Public Works, 2006) and Sydney Water 24% (2008), respectively.

Household Wastewater Generation

For the purposes of this report, the expected wastewater generation from the design household (ET) with a reticulated water supply is 467L/ET/day, which is approximately 63% of the total potable water demand of 741L/ET/day. The breakdown of the wastewater generating components of household fixtures is shown in Figure 5. The values are based on the BASIX and WELS scheme requirements and applied in the relative proportions as discussed in the previous section. It should be noted that the external household uses, lawn and garden watering and pools, car washing, and hosing down, do not contribute to the wastewater load.

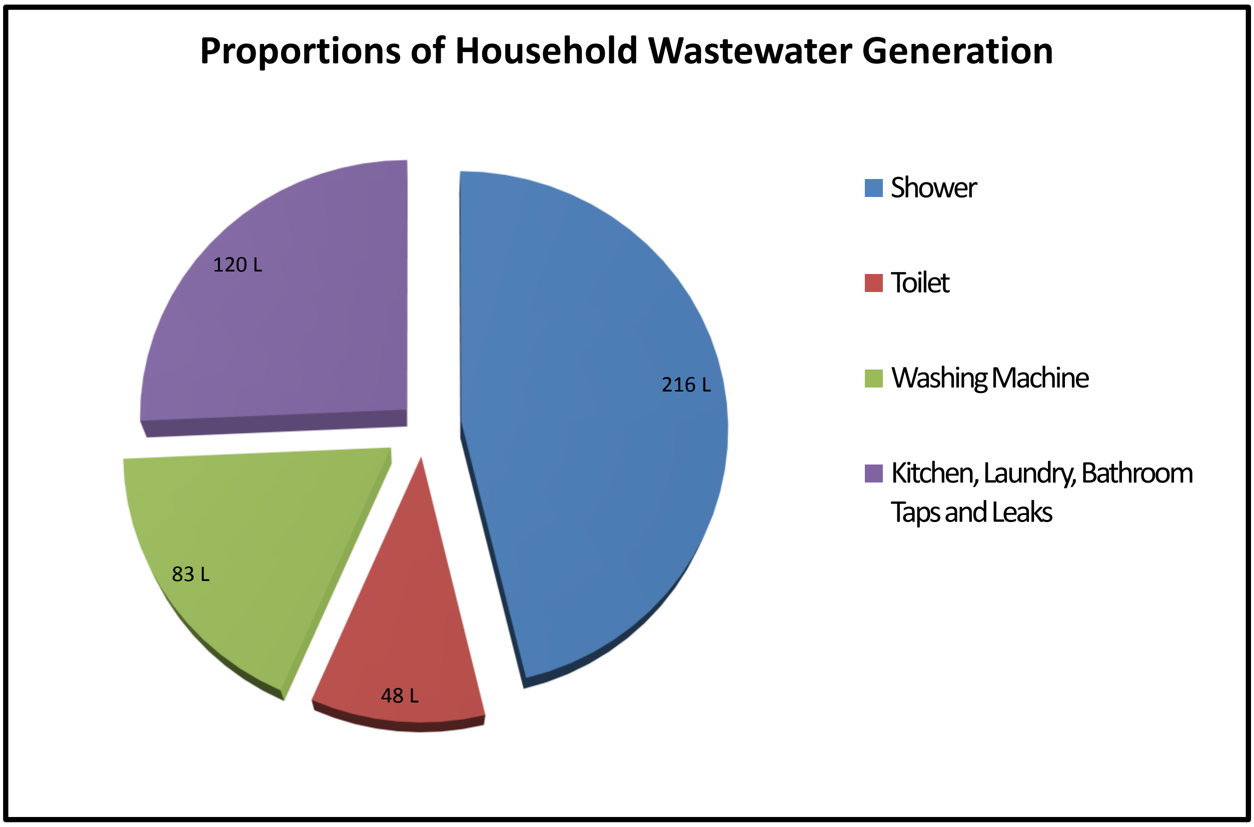

Figure 5 Proportional wastewater generation within a residential household

To determine the potential demand for recycled water returned to the dwellings in a dual-reticulation (third pipe) scenario, we investigated three different reuse scenarios representing annual seasonality (peak, shoulder and low). The 'shoulder' season (autumn and spring outdoor use) has been adopted as an appropriate figure for approximating year-round reuse rates. Table 1 below shows the breakdown of wastewater generation and recycled water reuse for proposed residential development. This includes the reuse of recycled water to replace potable water demand for the following uses: toilet (6.5%), lawn and garden watering (25% in shoulder seasons) and cold water washing machine only (7.5%).

Table 1 Household (ET) Potable / Recycled Water Demand scenarios

Water Use	Potable Water Use (L/ET/day)	Wastewater Generation (L/ET/day)	Shoulder[1] (Autumn/Spring) recycled Water Reuse Potential
Shower/Bath	216	216	0
Toilet	48	48	48
Lawn & Garden Watering	244	0	183
Washing Machine*	83	83	55
Kitchen, Laundry, Bathroom Taps & Leaks	120	120	0
Pools, Car-washing and hosing down	30	0	0
TOTAL	741	467	286
Recycled Water Requiring Irrigation (L/ET/day)			181
Potable Water Demand After Reuse of Recycled Water (L/ET/day)			455

[1]75% of external uses (annual average, including 50% in winter and 100% in summer);

*Washing machine reuse is for cold water supply only; therefore reuse potential is estimated as 2/3 of total demand for washing machine

The total reuse potential (indoor and outdoor) based on the shoulder ('average') scenario is 286L/ET/day with the remaining 181L/ET/day unused recycled water requiring irrigation within an undeveloped stage elsewhere in North Cooranbong (and ultimately elsewhere as North Cooranbong is progressively built out).

Based on our assessment, each household has a potential to off-set approximately 40% of the total potable water demand through the use of an alternative water (recycled water) source, on an annual basis.

Therefore, the BASIX target of a 40% reduction in the total household water demand is achievable under the shoulder scenario. However, other methods, such as the installation of higher WELS scheme star rated fixtures, may need to be implemented in order to ensure that the BASIX target criteria is met for the entire year.

5 Buffers

A risk based approach was followed and buffer zones from irrigation areas are recommended as they provide a form of mitigation against unidentified hazards and minimise risk to public health, maintain public amenity and protect sensitive environments. The AGWR (2006) guideline recommends restricted access and 25-30m (Table 3.5 & 3.8) buffer zones from the land application area to the nearest point of public access for spray irrigation of high-quality recycled water suitable for domestic non-drinking water use, as is the case with the proposed LWC/RWI schemes at the Site. The application of the recommended buffer zones will provide a minimum 1-log (equivalent) reduction in pathogen loads from the RWIZs. Recommendations to prevent off-lot discharge also include the use of low-throw sprinklers, part-circle (180º inward-throwing) sprinklers and/or tree or shrub screens.

W&A also recommends the following environmental buffers for surface spray irrigation based on NSW DEC (2004) guidelines;

- 250 metres from domestic groundwater bores;
- 50-100 metres from permanent watercourses; and
- 40 metres from intermittent watercourses and dams.

This recommendation is principally due to limitations identified in the site and soil assessment, including periodically waterlogged soils and potential flood inundation of low-lying areas.

It should be noted that once development commences, relevant setbacks from dwellings, in accordance with AGWR (2006), will need to be applied.

The areas comprising EECs, stormwater detention basins, the LWC, water reservoir site and conservation areas proposed in the development, as well as the buffer zones, were excluded from the determination of the available RWIZs.

6 Recycled Water Management

6.1 Recommended Recycled Water Irrigation Zones

As discussed, all recycled water that is not used on residential lots via dual reticulation is to be irrigated at sustainable loading rates on undeveloped (future) stages of the proposed North Cooranbong development. Due to the nature of the development, which is to proceed in stages over a number of years, the (preliminary) recycled water irrigation scheme has been developed in a manner compatible with the proposed development staging plan.

Each stage has been delineated as a potential discrete RWIZ, using the same numbering system (as shown on Figure 2 in Appendix A). Each stage includes areas earmarked for residential development and areas for public open space and public facilities (such as the proposed primary school), which vary in size between stages. The (approximate) total area of each stage was calculated using GIS and is provided in Table 2 below. The total area includes areas which are considered unsuitable for recycled water irrigation due to physical constraints such as rock outcrops and setback buffers from intermittent drainage lines or stage boundaries. The recommended setback buffers were applied from water courses and drainage lines, and stage/development boundaries using GIS. The residual areas considered 'usable' for recycled water irrigation on each stage were then calculated using GIS and are also provided in Table 4. Note that 'usable area' includes land contained within entirely and partially forested stages, which are problematic for irrigation (but would be suitable if cleared and returfed prior).

Table 2 Lot Staging and Usable Area Analysis

Stage	No. of Lots	No. of Dwellings/ET	Total Area (m^2)	Approx. Total Useable Area (m^2)[1]
1E/1F	40	40	46,125	- [2]
1G/1H	41	41	45,152	-
2A	31	31	45,660	23,588
2B	35	35	32,658	24,553
2C	39	39	40,478	26,122
2D	33	33	28,010	13,404
Twine & Thomson	75	75	97,083	-
3[3]	40	40	69,143	36,811
4	146	146	158,066	110,638
5	113	113	109,884	57,811
6	119	119	129,452	50,910
6 – primary school	1	28	27,862	-
6 – retail	1	5	4,510	-
7A	116	116	117,155	56,119
7A – community centre	1	2	5,188	-
7A – sports ground	1	2	63,841	-
7B	36	36	29,842	8,405
8	616	616	176,584	101,023
9	161	161	153,134	78,343
10	152	152	156,064	105,932
11	231	231	228,799	139,916
12	90	90	81,828	23,556

[1] Less setback buffers from development and stage boundaries, drainage lines and watercourses
[2] '-' indicates that the stage is either connected to the sewer in an earlier stage of development or it was assumed that it won't be utilised as an RWIZ.
[3] Excluding Jackson and Mears precincts.

6.2 Water and Nutrient Balance for Irrigation Area Sizing

The capacity of the RWIZs to manage the predicted hydraulic loads under seasonal variation has been assessed to determine the sustainability of the proposed recycled water irrigation scheme at the Site. Both water and nutrient balances have been undertaken to determine sustainable irrigation rates for ‘usable area’ in the subdivision and the ultimate irrigation capacity to determine the maximum development potential of the subdivision before an alternative end-use must be found for the recycled water. The key assumptions of the water and nutrient balance modelling are as follows:

- Average total recycled water reuse of ~40% for residential development demand (Section 4.4);
- Zero recycled water reuse for commercial and community development (including proposed primary school);
- Average Design Recycled Water Irrigation load (ET_{IRR}) of 181L/ET/day; and
- ‘Worst-case’ soil characteristics (including profile depth and chemistry) throughout the Site.

For preliminary design analysis, the water balance used is a ‘lumped’ monthly model adapted from the “Nominated Area Method” described in DLG (1998). These calculations determine minimum irrigation area requirements for given recycled water loads for each month of the year. The water balance can be expressed by the following equation:

Precipitation + Recycled Water Applied = Evapotranspiration + Percolation + Storage

Ideally, irrigation areas are calculated to achieve no net excess of water (recycled water and percolated rainfall) and hence zero wet weather storage for all months. A Design Irrigation Rate (DIR) of 3mm/day was adopted for the Site based on the most limiting site and soil characteristics as described in the associated LCA report.

Conservative nutrient balances (annual mass balance) were also undertaken to calculate the minimum area requirements to enable nutrients to be assimilated by the Site soils and vegetation. The nutrient balance used is based on the DLG (1998) methodology, but improves on this by more accurately accounting for natural nutrient cycles and processes. It acknowledges that a proportion of nitrogen will be retained in the soil through processes such as ammonification (the conversion of organic nitrogen to ammonia) and that a certain amount will be lost by denitrification, microbial digestion and volatilisation (Patterson, 2003). Patterson (2002) estimates that these processes may account for up to 40% loss of total nitrogen. We have adopted a more conservative estimate of 15% for the nitrogen losses due to soil processes. Tables 3 and 4 below provide details of the inputs for the preliminary water and nutrient balances for the RWI systems.

Table 3 Data Inputs for Monthly Water Balance

Data Parameter	Units	Value	Comments
Design Recycled Water Irrigation load (ET_{IRR})	L/ET/day	181	Average figure on annual basis (including low reuse in winter, high reuse in summer and average reuse in spring and autumn)
Precipitation	mm/month	Mean rainfall	From BoM monitoring station (Cooranbong #61412) precipitation data (110 years)
Pan Evaporation	mm/month	Mean pan evaporation	From BoM Data Drill for nearby location (Wyee) evaporation data (40 years)
Retained Rainfall	unitless	0.8	Proportion of rainfall that falls on the RWIZs and infiltrates the soil (80%), allowing for up to 20% runoff from a well pastured gently sloping site
Crop Factor	unitless	0.7-0.8	Expected annual range based on good ground cover and exposure
Design Irrigation Rate (DIR)	mm/day	3	Category 5 soils from AS1547:2012, for most constrained conditions in proposed RWIZs

Table 4 Data Inputs for Annual Nutrient Balance

Data Parameter	Units	Value	Comments
Recycled Water total nitrogen (TN)	mg/L	15	Minimum target recycled water quality from tertiary treatment system
Nitrogen lost to soil processes (denitrification and volatilisation)	annual percentage	15	Maximum expected, per Patterson (2002). Very conservative
Recycled Water total phosphorus (TP)	mg/L	5 (expected 2–5)	Minimum target recycled water quality from tertiary treatment system
Soil phosphorus sorption capacity	mg/kg	140	Conservative 'worst-case' i.e. lowest P-sorb result (range 140-780mg/kg)
Nitrogen uptake rate by plants	kg/Ha/yr	250	Less than half that expected of irrigated pasture grass (DECCW, 2004 Table 4.2)
Phosphorus uptake rate by plants	kg/Ha/yr	25	Less than half that expected of irrigated pasture grass (DECCW, 2004 Table 4.2)

The model results show that the hydraulic load is limiting across the Site. The nitrogen and phosphorus balances require less area for sustainable assimilation, and therefore are not considered limiting. Table 5 summarises the results of the monthly water balances for the unused recycled water to be irrigated, assuming the average value of 181L/day.

Table 5 Results of Water Balance for North Cooranbong

Stage	Daily Irrigation Load (L)	Irrigation Area Required (m^2)[4]	Remaining available area (m^2) once stage is developed
1E/1F	18,680	4,433	852,698
1G/1H	19,147	4,543	848,155
2A	14,477	3,435	821,132
2B	16,345	3,879	792,700
2C	18,213	4,322	778,546
2D	15,411	3,657	745,195
Twine & Thomson	35,025	8,311	736,884
3[5]	18,680	3,324	696,749
4	68,182	16,179	569,932
5	52,771	12,522	499,599
6	55,573	13,187	435,502
6 – primary school	20,748	7,622	427,880
6 – retail	3,705	2,268	425,612
7A	54,172	12,855	356,638
7A – community centre	1,482	907	355,731
7A – sports ground	1,482	907	354,824
7B	16,812	3,989	342,430
8	287,672	68,263	173,144
9	75,187	17,841	**76,960**
10	70,984	17,398	-46,370
11	107,877	25,599	-211,885
12	42,030	9,973	-245,414
Total	**718,577**	**245,414**	n/a

[4] Based on a 3mm/day loading rate; the hydraulic load is limiting, therefore the results for nutrient balances are not included.

[5] Excluding Jackson and Mears precincts.

Based on the results of the monthly water balance model, it is predicted that the maximum capacity of the North Cooranbong development to sustain irrigation of unused recycled water would be reached once stage 9 is built out. This assumes that stages are developed in approximately the order in which they are listed in Table 5 above. However, the use of the average irrigation volume during winter months, when outdoor reuse of recycled water is typically reduced and rainfall tends to exceed evaporation, may differ from the results of the daily timestep model in the Decentralised Sewage Model (below). A copy of the monthly water balance for the complete build out of the development is provided in Appendix B.

6.3 Decentralised Sewage Model

6.3.1 Overview of the DSM

The DSM is a GIS-based tool that was developed jointly by W&A and BMT WBM for the purpose of providing a rapid-assessment tool to predict the performance of on-site and decentralised wastewater management systems under varying environmental conditions. It has the ability to assess long-term environmental and human health performance of wastewater treatment and land application systems. Background information and general methodology of the DSM is provided in the DSM User Manual (BMT WBM, 2011).

The inputs to, and results of, the preliminary water and nutrient balances were used as inputs to the DSM. The DSM has five modules which are able to be used in isolation or collectively, depending on the needs of a project. For this project, the following modules were used:

- On-lot Performance Model (OLPM);
- Particle Tracking Model (PTM); and
- Node-Link Model (NLM).

The DSM does not predict the minimum area required to achieve zero surface runoff or deep drainage, instead, like the nominated area approach of the monthly water balance, the model predicts the surface and subsurface discharges based on a set of nominated conditions such as receiving node sensitivity, soil, slope, weather, recycled water input and land application area. The model developed for this study simulates a minimum 84-year time period and is designed to provide conservative estimates of the performance of the proposed recycled water irrigation scheme over that timeframe.

For this project, the model was used primarily to confirm the ‘carrying capacity’ of the Site and individual stages to sustainably accommodate unused recycled water, as well as the minimum irrigation area required following complete build out of the Site. These modelling scenarios take into consideration the available storage to be provided by the proposed recycled water storage tanks. The model has capacity to use a fluctuating application rate, depending on soil moisture (measured by in-ground sensors); however, we have maintained a nominal 3mm/day application rate due to the limiting soil chemical constraints, namely sodicity. The recycled water will contain sodium and other compounds which can be problematic for sodic soils at higher loading rates. Options for soil amelioration are discussed in the LCA report.

A summary of the model inputs is provided in Table 6 below.

Table 6 DSM Inputs and Results Summary

Input Parameter	Unit	Onsite Scenario
Unused Recycled Water for Irrigation	L/day	As per Table 5 (for modelled stage)
Recycled Water Total Nitrogen Concentration	mg/L	15
Recycled Water Total Phosphorus Concentration	mg/L	5
Recycled Water Virus Concentration[1]	MPN/100ml	<10
Daily Rainfall (1930-2013)	mm	From SILO Data Drill, North Cooranbong
Daily Pan Evaporation (1930-2013)	mm	From SILO Data Drill, North Cooranbong
Average Air Temperature (in lieu of ground temperature) (1930-2013)	ºC	From SILO Data Drill, North Cooranbong
Crop Factor[2]	unitless	0.7-0.8
Buffer From Waterways	m	≥40
Buffer From Property Boundaries	m	25
Buffer From Driveways	m	n/a
Slope	%	Digital Elevation Model
Required Recycled Water Irrigation Area	m^2	Various
Available Recycled Water Irrigation Area	m^2	Various
Soil Phosphorus Adsorption (P-sorb) Capacity	mg/kg	140
Soil Depth for P-sorb (assumed)	m	0.8
Crop Nitrogen Uptake	kg/ha/year	250
Crop Phosphorus Uptake	kg/ha/year	25
Total Recycled Water Storage Capacity	ML	2.4
Attenuation Rate for Total Phosphorus[3]	%	94
Attenuation Rate for Total Nitrogen[3]	%	93
Attenuation Rate for Viruses[3]	%	97
Attenuation for Surface Flow[3]	%	60

Notes
[1] Most Probable Number.
[2] Crop Factor as per W&A Water Balance for each month.
[3] Assumed nutrient attenuation in soils; i.e. proportion of residual nutrient concentration in recycled water predicted to be assimilated within surrounding (RWIZ) soils (assumes recommended buffer achievable).

6.3.2 DSM Results

The DSM was run iteratively, using input values corresponding to the sequential development of each stage and the associated reduction in available RWIZs. From this, the minimum required RWIZ sizing and corresponding development stage was calculated to determine the maximum capacity of the Site to sustainably irrigate unused recycled water. A summary of the various DSM inputs are provided in Appendix C.

In addition, to estimate the future irrigation requirements for the completed build out of the Site, the minimum required RWIZ size was also determined. The monthly water balance showed that the maximum carrying capacity of the North Cooranbong development for sustainable irrigation of unused recycled water would be reached once stage 9 is built out. Therefore, stage 9 provided the basis for the preliminary DSM modelling. The results of the iterative modelling scenarios are included in Tables 7 and 8, below.

Nutrient Loading

A summary of the nutrient export results of the DSM is provided in Table 7 below (full results are provided in Appendix C). The simulation was run for a period of 53 years (1950-2013).

Table 7 Average Annual Nutrient Concentrations

Nutrient Concentration	Parameter	Preliminary (Stage 9)	Optimisation (Stage 8)	Build Out (Stage 12) [1]
TP (kg/year)	**DSM Surface Surcharge + Deep Drainage Outputs**	0.14	0.08	0.10
TN (kg/year)	**DSM Surface Surcharge + Deep Drainage Outputs**	0.40	0.03	0.04

Notes
[1] Build out assumes utilisation of a RWIZ of 24.5ha (as determined from the monthly water and nutrient balances), sourced from suitable land elsewhere.

The combined average annual nutrient load for (combined) surface surcharge and deep drainage from onsite irrigation of recycled water equates to <1kg/year, with the development of stage 8, stage 9 and entire build out. Deep drainage is predicted to be the main route for nutrient export, as surface surcharge of recycled water is expected to be negligible, as discussed below.

Hydraulic Loading: Deep Drainage and Surface Surcharge

A summary of the deep drainage and surface surcharge results of the DSM is provided in Table 8 below (full results are provided in Appendix C). The simulation was run for a period of 53 years (1950-2013).

Table 8 Average Annual and Daily Hydraulic Export Results

Parameter	Preliminary (Stage 9)	Optimisation (Stage 8)	Build Out (Stage 12) [1]
Annual Surface Runoff (m^3) **Daily Surface Runoff (mm/day)**	0.09	0.04	0.04
Annual Deep Drainage (m^3) **Daily Deep Drainage (mm/day)**	1.03	0.56	0.54

Notes
[1] Build out assumes utilisation of a RWIZ of 24.5ha (as determined from the monthly water and nutrient balances), sourced from suitable land elsewhere.

6.3.3 Interpretation

Nutrient Loading

The DSM nutrient concentration results were compared to predicted 'background' nutrient loads from the rainwater/stormwater runoff of the Site as it is sequentially developed. The background values were derived from Figures 2.19 and 2.20 in Fletcher et. al. (2004), with adjustments made to land-uses, proportion of impervious to pervious surface areas, and mean annual rainfall to reflect ongoing development of the Site.

Based on the complete (Site) build out scenario, the annual background nitrogen load is estimated at 634kg/year and the annual background phosphorus load is estimated at 63kg/year (earlier stages of development have proportionally lower background nutrient loads).

The combined nutrient loads in surface surcharge and deep drainage of recycled water from each of the above DSM simulations represents <1% increase on the background nutrient loads in runoff. This figure is considered to be relatively insignificant. It was assumed that the attenuation rates[6] for nutrients in soil are as follows: 94% phosphorous and 93% nitrogen. Therefore, it is anticipated that the nutrient loads in the recycled water will have no appreciable impact on environmental and/or public health.

Hydraulic Loading: Deep Drainage and Surface Surcharge

The results from the DSM hydraulic modelling indicate that deep drainage is the main contributor to hydraulic export for the RWIZs. In consideration of the likely recycled water quality, as well the Site and soil constraints, we have adopted a conservative deep drainage acceptance limit of ≤1mm/day (less than a third of the adopted DIR) for our DSM simulations.

The average annual deep drainage volume from irrigation within the Site is approximately 0.54mm/day for the complete build out scenario. Simply, based on modelling, it is estimated that less than 18% of the recycled water applied to the RWIZs on a daily basis will be lost to deep infiltration (drainage), with the remaining majority of the daily hydraulic load utilised via evapotranspiration and soil moisture management. This acceptance limit was used iteratively in subsequent DSM simulations to estimate the necessary RWIZ sizing for the complete build out of the Site. Based on these modelling calculations, the approximate RWIZ area requirement is estimated at approximately 24.5ha, with a deep infiltration (drainage) rate of 0.54mm/day (≤18% of the adopted DIR).

6.3.4 DSM Stage Optimisation

Although the monthly water balance showed that the maximum carrying capacity of the North Cooranbong development to sustain irrigation of unused recycled water would be reached once stage 9 is built out, the DSM simulation showed that this stage could not be reached as the monthly balance didn't account for storage balancing in the wetter months. DSM modelling of stage 9 resulted in overflow, exceeding the current 2.4ML (recycled water) storage onsite.

An optimisation of this simulation was run to determine whether an additional 1.2ML of storage would be sufficient to prevent overflow. However; it was found that 3.6ML of storage was still insufficient to achieve completion of stage 9. Table 8 also shows that the average annual and daily hydraulic exports for stage 9 exceed the acceptance limits.

Due to the inability to sustainably complete stage 9, an additional DSM scenario was simulated for stage 8. This confirmed that the carrying capacity of the North Cooranbong development

[6] Attenuation rates derived from Port Stephens Technical Document (2012) Table 10.4.

would be reached once stage 8 is built out; as both the storage requirements were met and the hydraulic and nutrient exports were comparative to the complete build out scenario condition.

Cooranbong Water has advised that further (additional) storage may become available during the development of the recycled water scheme, allowing for extension of the development staging prior to sourcing off-site irrigation area.

Regardless, additional measures will need to be put in place in advance of the build out of stage 8 to ensure that there is available irrigation area to meet the potential increases in the recycled water loads generated with further development. Potential additional irrigation areas that could be investigated include: purchase of additional surrounding land, utilisation of open space/sports ground areas in the nearby college, landscape areas within the North Cooranbong development and within the designated conservation area between stages five and 2 within the development. Additional options to be investigated, include an increase in potential reuse once monitoring data has been collated and reviewed.

6.4 Pathogen Transport Modelling

6.4.1 Overview

We have modelled the fate of viral pathogens in the environment to assess the performance of the proposed recycled water irrigation systems at the Site and to assess any potential impact (if any) on receiving waters. The modelling is based on the viral die-off method developed by Beavers and Gardner (1993) and refined by Cromer et al. (2001). Details of the methodology can be found in Cromer et al. (2001).

The model generally applies to recycled water moving in saturated soils, i.e. in shallow groundwater beneath a land application area. These conditions are considered most conducive to pathogen transport. In unsaturated (vadose zone) soils the travel distance will be substantially less. As such, the method is very conservative when applied to areas with well drained soils and deep groundwater tables, such as the Site. Surface transport in rainfall/stormwater runoff is another obvious transport pathway for pathogens; however, irrigation of recycled water will cease during rainfall and while the soil is saturated.

6.4.2 Assumptions and Inputs

Some key assumptions used in the modelling are provided below:

- Bacteria have lesser die-off times than viruses and can therefore be assumed to be eliminated within a shorter distance than viruses (Cromer *et al*., 2001);
- Viral reduction has been set at one order of magnitude, due to the high quality of the recycled water with disinfection (resulting in very low pathogen levels prior to reuse and irrigation);
- The average groundwater temperature is conservatively estimated as 11°C, based on the average air temperature recorded at the nearby BOM station at Cooranbong (#61412). Cooler temperatures allow viruses to reside longer in the soil, hence provide potentially greater travel distances. Groundwater temperatures are significantly less variable than air temperatures and are rarely less than 13°C in temperate areas, therefore the adoption of this figure is considered to be conservative;
- We have used the expected hydraulic conductivity (K_{sat}) of the dominant soil materials, sandy clay to light clay (depths ranging from ~200mm), based on Table 5.2 of AS/NZS 1547:2012, as there was no evidence of shallow groundwater movement in the higher-permeability topsoils; and

- Depth to groundwater is conservatively assumed to be 0.5m, as mottling was present at depths of at least 500mm (generally at deeper depths), indicating seasonally perched watertables or saturated soil conditions.

The assumptions used in the pathogen transport modelling and predicted maximum viral transport distances are provided in Table 9 below. Appendix F provides full results of the modelling.

Table 9 Assumptions and Results of Pathogen Transport Modelling

Model Input Parameter	Value
Groundwater temperature (^{o}C)	11
Porosity of soil (decimal)	0.40 (40%)
Saturated Hydraulic Conductivity (K_{sat}) (m/day)	0.5
Groundwater gradient (%)	0.1
Depth to groundwater (m)	0.5
Horizontal distance travelled in groundwater to achieve a log 1 reduction in viral numbers (m)	2.4

* based on highest rate for soil category 5, from *AS/NZS 1547:2012*.

6.4.3 Interpretation of Results

The pathogen transport and die-off modelling demonstrates that log 1 reduction of pathogens is expected to occur within 2.4m horizontal distance, under saturated (worst-case) soil conditions. We note that shallow groundwater (i.e. saturated soil) was not encountered within 1m of the ground surface anywhere on the Site during our investigations (although mottling indicates that this occurs on a seasonal basis).

These results are supported by several studies into pathogen transport from standard septic tanks with soil absorption; that is, primary-treated effluent which has very high pathogen concentrations. The monitoring of eight standard septic tank with absorption / evapotranspiration bed systems in Florida indicated that 0.6m of sand effectively removed viruses (USEPA, 2002).

At North Cooranbong, the proposed recycled water plant will produce high quality and disinfected recycled water with greater than 6.5 log removal of viruses, 5.5 log removal of protozoa and complete bacterial elimination, thus providing an even higher level of security. Ziebell et al. in USEPA (2002) describe the widely acknowledged principle that by lowering hydraulic loading rates and ensuring unsaturated flows through the soil, better in-soil removal of bacteria and other pathogens can be achieved.

7 Conclusions and Recommendations

This report provides the results and recommendations of our preliminary investigations, including detailed site and soil investigations and constraints to recycled water management.

Having undertaken a Land Capability Assessment (previous report) and Staging Assessment of the Site at Freemans Drive, Cooranbong, W&A consider that on-site surface irrigation is generally appropriate on identified land throughout the Site. The site and soil investigation in the LCA report shows that the Site is diverse in terms of its physical characteristics such as topography, soil depth and characteristics, drainage and the presence of intermittent watercourses; all of which influence the design and proposed location of the RWIZs for surface irrigation of recycled water. However, all required buffers are achievable with regard to the location of the proposed RWIZs.

This report provides the results and recommendations of our investigations, including assessment of the likely recycled water volumes from various stages of the the Site subdivision; and recommendations for staging of the RWIZs as development progresses. Our DSM modelling predicts that on-site surface irrigation should be achievable up to, and including, the completion of stage 8 if internal and external reuse of recycled water is provided to each new property (via dual-reticulation). This is based on the assumption that designated conservation areas (forested areas) will not be used for recycled water irrigation. A plan for the sustainable and permanent usage of recycled water generated by stages 9-12 must be finalised prior to the build-out of stage 8 and prior to the construction of stages 9-12.

8 References (Cited and Used)

Beavers P D and Gardner E A (1993). Prediction of Virus Transport through Soils. Australian Water and Wastewater Association Technical Papers of the 15th Federal Convention, Gold Coast, Australia, 18-23 April 1993 (Volume 2 pp 530-535).Cromer et al. (2001)

BMT WBM (2011) *Decentralised Sewage Model User Manual*

Cromer W C (2001). Treating Domestic Wastewater in a Shallow Coastal Aquifer near Hobart, from Patterson & Jones (Eds.) Proceedings of On-site ’01 Conference: Advancing On-site Wastewater Systems. Lanfax Laboratories, Armidale, 25-27 September 2001.

Cromer W C, Gardner E A and Beavers P D (2001). An Improved Viral Die-off Method for Estimating Setback Distances, from Patterson & Jones (Eds.) Proceedings of On-site ’01 Conference: Advancing On-site Wastewater Systems. Lanfax Laboratories, Armidale, 25-27 September 2001.

Department of Local Government et al. (1998). Environment & Health Protection Guidelines: On-site Sewage Management for Single Households.

Crites, R. W. & Tchobanoglous, G., (1998) Small and Decentralised Wastewater Management Systems, McGraw Hill, USA.

eWater (2013) MUSIC v5 User Manual

Fletcher, T., Duncan, H., Poelsma, P. & Lloyd, S. Stormwater Flow and Quality, and the effectiveness of non-proprietary stormwater treatment measures – a review and gap analysis Technical Report 04/8 December 2004, Cooperative Research Centre for Catchment Hydrology.

Hazelton, P. & Murphy, B. (2007) Interpreting Soil Test Results, What to all the numbers mean? CSIRO Publishing, Victoria.

Landcom (2004). Managing Urban Stormwater: Soils and Construction (4th Edition). NSW Government, 2004.

Murphy, C.L. (1995). Soil Landscapes of the Gosford-Lake Macquarie 1:100,000 Sheet. Soil Conservation Service of NSW, Sydney.

NRMMC, EPHC & AHMC (2006). Australian Guidelines for Water Recycling: Managing health and environmental risks (phase 1).

NSW DEC (2004). Environmental Guidelines – Use of Effluent by Irrigation. NSW Department of Environment and Conservation, Sydney.

NSW Agriculture (1997). The New South Wales Feedlot Manual. NSW Inter-departmental Committee on Intensive Animal Industries (Feedlot Section).

NSW Department of Local Government et al. (1998). Environment & Health Protection Guidelines: On-site Sewage Management for Single Households.

NSW HD (2001): NSW Health Department, Septic Tank and Collection Well Accreditation Guideline-December 2001

Patterson, R.A. (2002). ‘Workshop 2 – Calculations for Nutrient Balances.’ In Evaluating Site and Soil Assessment Reports for On-site Wastewater Systems. A one-day training course held in Fairfield, Sydney. Centre for Environment Training, Cardiff Heights NSW. March 2002.

Patterson, R.A. (2003). Nitrogen in Wastewater and its Role in Constraining On-Site Planning. In Patterson & Jones (Eds.) Proceedings of On-site ‘03 Conference: Future Directions for On-site Systems: Best Management Practice. Lanfax Laboratories, Armidale.

Standards Australia / Standards New Zealand (2000). AS/NZS 1547:2000 On-site Domestic-wastewater Management.

Standards Australia / Standards New Zealand (2012). AS/NZS 1547:2012 On-site Domestic-wastewater Management.

USEPA (2002). Onsite Wastewater Treatment Systems Manual. United States Environmental Protection Agency.

Appendix A

Figures & Site Plans

Figure 1: Site Locality

LCA for Recycled Water Management Scheme at Proposed 'North Cooranbong' Development

Whitehead & Associates
Environmental Consultants

Revision	1
Drawn	JK
Approved	ZR

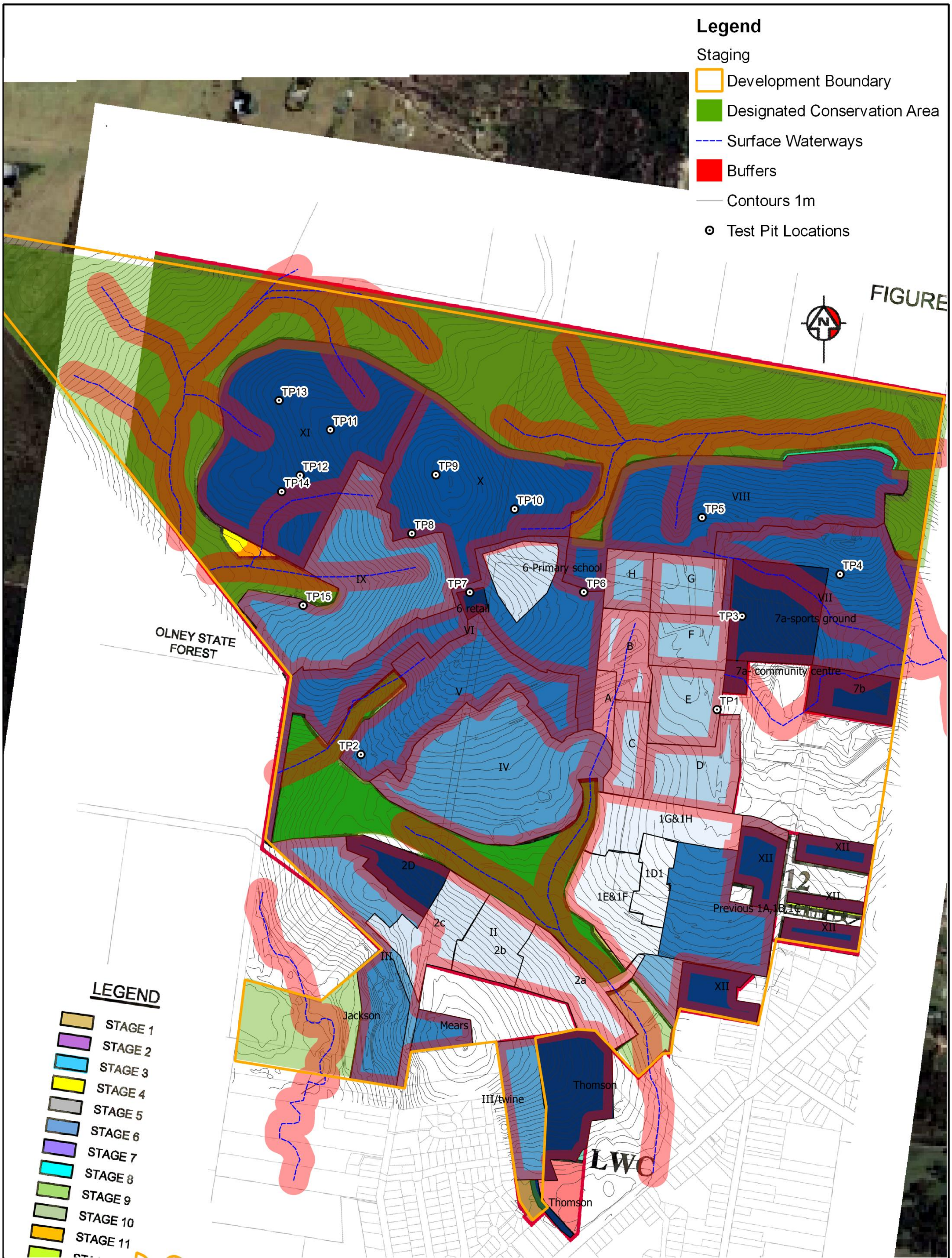

Figure 2: Site Plan

LCA for Recycled Water Management Scheme at Proposed 'North Cooranbong' Development

N

Whitehead & Associates
Environmental Consultants

0 250 500 750 1000 1250 m

(Approx Scale)

Revision	2
Drawn	JK
Approved	ZR

Appendix B

Water & Nutrient Balance Modelling

Nominated Area Water Balance & Storage Calculations

Site Address: North Cooranbong - Build out scenario

INPUT DATA

Design Wastewater Flow	Q	394,000	L/day	Daily load 'excess' recycled water for all development (average)
Design Percolation Rate	DIPR	21	mm/week	Weekly Design Infiltration Percolation Rate (DIPR)
Daily DPR		3.0	mm/day	Litres per sq.m. per day - based on Table M1 AS/NZS 1547:2012 for secondary effluent
Nominated Land Application Area	L	250,000	m sq	Estimates evapotranspiration as a fraction of pan evaporation; varies with season and crop type
Crop Factor	C	0.7-0.8	unitless	Proportion of rainfall that remains onsite and infiltrates; function of slope/cover, allowing for any runoff
Runoff Coefficient		0.8	untiless	Proportion of rainfall that percolates into soil profile (remainder runs off)
Rainfall Data	Cooranbong (Avondale)			Mean Monthly Data (1903 - 2013)
Evaporation Data	Data Drill Wyee 2010			Mean Monthly Data (1970 - 2009)

Flow Allowance		L/p/d
No. of bedrooms		
Occup Rate		

Parameter	Symbol	Formula	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Days in month	D	\	days	31	28	31	30	31	30	31	31	30	31	30	31	**365**
Rainfall	R	\	mm/month	108.1	133.9	126.2	119.8	97.7	102.0	69.1	59.1	58.6	67.4	81.4	98.2	**1137.0**
Evaporation	E	\	mm/month	182	146	131	98	71	58	67	93	119	151	161	191	**1468**
Daily Evaporation				5.9	5.2	4.2	3.3	2.3	1.9	2.2	3.0	4.0	4.9	5.4	6.2	
Crop Factor	C			0.80	0.80	0.80	0.70	0.70	0.70	0.70	0.70	0.70	0.80	0.80	0.80	
OUTPUTS																
Evapotranspiration	ET	ExC	mm/month	146	117	105	69	50	41	47	65	83	121	129	153	**1123.8**
Percolation	B	(DPR/7)xD	mm/month	93.0	84	93.0	90.0	93.0	90.0	93.0	93.0	90.0	93.0	90.0	93.0	**1095.0**
Outputs		ET+B	mm/month	238.6	200.8	197.8	158.6	142.7	130.6	139.9	158.1	173.3	213.8	218.8	245.8	**2218.8**
INPUTS																
Retained Rainfall	RR	R*runoff coef	mm/month	86.48	107.12	100.96	95.84	78.16	81.6	55.28	47.28	46.88	53.92	65.12	78.56	**897.2**
Effluent Irrigation	W	(QxD)/L	mm/month	48.9	44.1	48.9	47.3	48.9	47.3	48.9	48.9	47.3	48.9	47.3	48.9	**575.2**
Inputs		RR+W	mm/month	135.3	151.2	149.8	143.1	127.0	128.9	104.1	96.1	94.2	102.8	112.4	127.4	**1472.4**
STORAGE CALCULATION																
Storage remaining from previous month			mm/month	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Storage for the month	S	(RR+W)-(ET+B)	mm/month	-103.3	-49.6	-48.0	-15.5	-15.7	-1.7	-35.8	-62.0	-79.1	-111.0	-106.4	-118.4	**-228.1**
Cumulative Storage	M		mm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Maximum Storage for Nominated Area	N		mm	**0.00**												
	V	NxL	L	**0**												
LAND AREA REQUIRED FOR ZERO STORAGE			m^2	80292	117763	126126	188337	189247	241224	144339	110215	93498	76395	76913	73033	

MINIMUM AREA REQUIRED FOR ZERO STORAGE: **241,224** m^2

Nutrient Balance

Site Address: North Cooranbong - Build out scenario

Please read the attached notes before using this spreadsheet.

SUMMARY - LAA AREA REQUIRED BASED ON THE MOST LIMITING BALANCE = 176,758 m^2

INPUT DATA [1]

Wastewater Loading			Nutrient Crop Uptake					
Hydraulic Load	394,000	L/Day	Crop N Uptake	250	kg/ha/yr	which equals	68	$mg/m^2/day$
Effluent N Concentration	15	mg/L	Crop P Uptake	25	kg/ha/yr	which equals	7	$mg/m^2/day$
% Lost to Soil Processes (Geary & Gardner 1996)	0.15	Decimal	**Phosphorus Sorption**					
Total N Loss to Soil	886,500	mg/day	P-sorption result	140	mg/kg	which equals	1,568	kg/ha
Remaining N Load after soil loss	5,023,500	mg/day	Bulk Density	1.4	g/cm^3		or	
Effluent P Concentration	5	mg/L	Depth of Soil	0.8	m		15600	kg/ha
Design Life of System	50	yrs	% of Predicted P-sorp. [2]	0.5	Decimal	which equals	1392.857143	mg/kg

METHOD 1: NUTRIENT BALANCE BASED ON ANNUAL CROP UPTAKE RATES

Minimum Area required with zero buffer		
Nitrogen	73,343	m^2
Phosphorus	176,758	m^2

Determination of Buffer Zone Size for a Nominated Land Application Area (LAA)		
Nominated LAA Size	250,000	m^2
Predicted N Export from LAA	-4,416.42	kg/year
Predicted P Export from LAA	-297.95	kg/year
Phosphorus Longevity for LAA	208	Years
Minimum Buffer Required for excess nutrient	0	m^2

PHOSPHORUS BALANCE
STEP 1: Using the nominated LAA Size

Nominated LAA Size	**250000**	m^2				
Daily P Load	1.97	kg/day	→	Phosphorus generated over life of system	35952.5	kg
Daily Uptake	1.7123288	kg/day	→	Phosphorus vegetative uptake for life of system	0.125	kg/m^2
Measured p-sorption capacity	0.1568	kg/m^2				
Assumed p-sorption capacity	0.078	kg/m^2	→	Phosphorus adsorbed in 50 years	0.078	kg/m^2
Site P-sorption capacity	19600.00	kg	→	Desired Annual P Application Rate	1017.000	kg/year
				which equals	2.78630	kg/day
P-load to be sorbed	94.05	kg/year				

NOTES

[1]. Model sensitivity to input parameters will affect the accuracy of the result obtained. Where possible site specific data should be used. Otherwise data should be obtained from a reliable source such as,

- *Environment and Health Protection Guidelines: Onsite Sewage Management for Single Households*
- *Appropriate Peer Reviewed Papers*
- *EPA Guidelines for Effluent Irrigation*
- *USEPA Onsite Systems Manual.*

[2]. Conservative estimate based on work by Geary & Gardner (1996) and Patterson (2002).

[3]. A multiplier, normally between 0.25 and 0.75, is used to estimate actual P-sorption under field conditions which is assumed to be less than laboratory estimates.

Appendix C

DSM Output Results

Input Parameter	Unit	On-site Scenario		
		Stage 9	**Stage 8**	**Build Out (Stage 12)**
Average Wastewater Flow	L/day (m^3/day)	316,139	286,998	394,512
EMA Type	-	Surface Irrigation		
EMA	m^2	76,960	173,144	245,414
Application Type	-	Storage – 2.4ML		
Storage Type	-	Closed		
Effluent Total Nitrogen Concentration	mg/L	15		
Effluent Total Phosphorus Concentration	mg/L	5		
Effluent Virus Concentration[1]	MPN/100mL	10		
Average Annual Rainfall	mm	1137		
Average Annual Evaporation	mm	1468		
Crop Factor [2]	unitless	0.7-0.8 grass		
Buffer From Dam/Intermittent Waterway	m	40		
Buffer From Property Boundaries	m	25		
Soil Phosphorus Adsorption (P-sorb) Capacity	mg/kg	140 (min.)		
Soil Depth for P-sorb	mm	900		
Fixed Application Depth	mm/day	3		
Crop Nitrogen Uptake [3]	kg/ha/year	250		
Crop Phosphorus Uptake [3]	kg/ha/year	25		
Attenuation Rate for Total Phosphorus [4]	%	94		
Attenuation Rate for Total Nitrogen [4]	%	93		
Attenuation Rate for Viruses [4]	%	97		
Attenuation for Surface Flow	%	60		

Notes

[1] Most Probable Number.
[2] Crop Factor as per W&A Water Balance for each month.
[3] Assumes less than half that expected of irrigated pasture grass (DECCW, 2004 Table 4.2).
[4] Assumed nutrient attenuation in soils; i.e. proportion of residual nutrient concentration in recycled water predicted to be assimilated within surrounding soils (assumes recommended buffer achievable).

Soil Landscape Inputs

Soil_ID	SAT_mm	FC_mm	PWP_mm	SHC_mmd	SDP_mm	BD_kgm3	DS_mm	INF_mmd	EXP1_	A1_	B1_	B2_	old definition	applicable new soil types
do	380	240	16	40	900	1500	6	120	1	133.267	0.09847	0.049235		SC

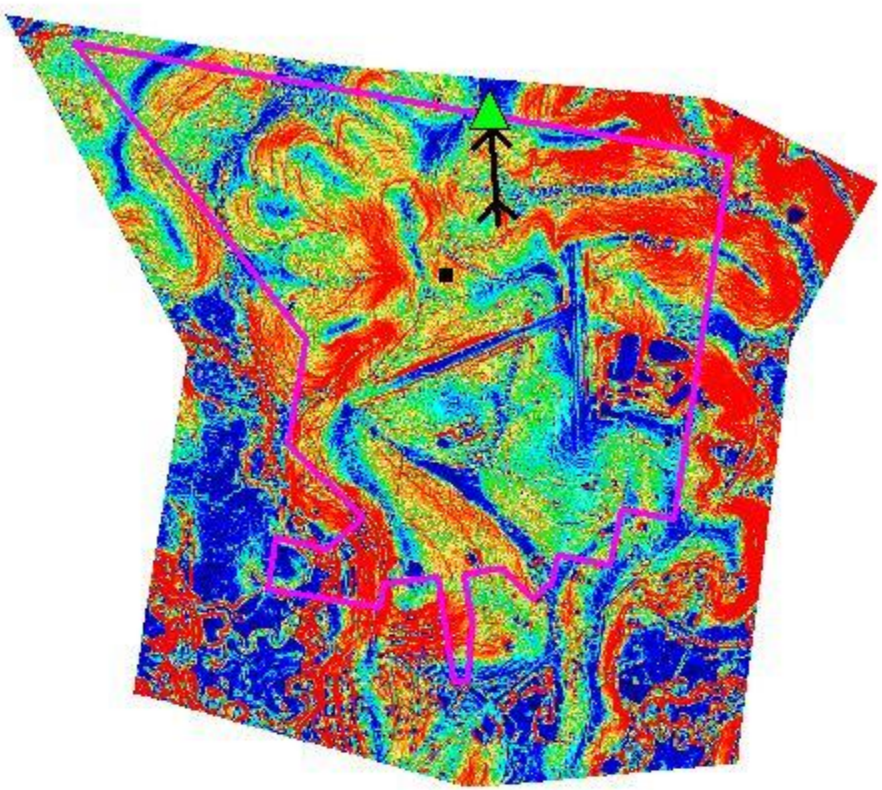

Figure: DSM Output screenshot

NUTRIENT SUMMARY TABLE	Build Out		Stage 9		Stage 8	
	TP kg/yr	TN kg/yr	TP kg/yr	TN kg/yr	TP kg/yr	TN kg/yr
Background Pollutant Export Loads (Fletcher, 2004)	63.36	633.60	63.36	633.60	63.36	633.60
Proposed Built Conditions Export Loads (Fletcher, 2004)	880.00	6336.00	880.00	6336.00	880.00	6336.00
DSM Deep Drainage Outputs - Nutrients	0.09	0.04	0.13	0.37	0.07	0.03
% increase from background levels - DD	0.01	0.00	0.02	0.01	0.01	0.00
DSM Surface Surcharge Outputs - Nutrients	0.01	0.00	0.01	0.03	0.01	0.00
% increase from background levels - S	0.00	0.00	0.00	0.00	0.00	0.00

HYDRAULIC AREAL LOADINGS TABLE	Build Out	Stage 9	Stage 8
Size of LAA (m2)	245414	76960	173144
Number of Lots within the Development	1	1	1
Total (combined) LAA of Site (m2)	245,414	76,960	173,144
Mean Surface Surcharge for Site (mm/day) (L/m2/day)	0.039	0.090	0.040
Mean Deep Drainage for Site (mm/day) (L/m2/day)	0.54	1.03	0.56

TOTAL ANNUAL LOADS - Total	RECEIVING NODE	CONVERSION	UNITS	CONVERSION	UNITS
Mean Annual Surface Runoff (m3) =	3,457.35	3,457,350.00	L/yr	3.46	ML/yr
Mean Annual Surface N (g) =	2.99	0.00	kg/yr		
Mean Annual Surface P (g) =	6.59	0.01	kg/yr		
Mean Annual Surface V (MPN) =	11,636.38	0.00	cfu/100ml		
Mean Annual Deep Drainage (m3) =	48,775.08	48,775,080.00	L/yr	48.78	ML/yr
Mean Annual Deep Drainage N (g) =	39.61	0.04	kg/year		
Mean Annual Deep Drainage P (g) =	90.63	0.09	kg/year		
Mean Annual Deep Drainage V (MPN) =	393,224.19	0.00	cfu/100ml		

Background POLLUTANT CALCULATIONS (Fletcher, 2004)	BACKGROUND - Build out	PROPOSED BUILT -Build out	BACKGROUND -Stage 9	PROPOSED BUILT -Stage 9	BACKGROUND - Stage 8	PROPOSED BUILT - Stage 8
Mean Annual Rainfall (mm)	1137	1137	1137	1137	1137	1137
Land Use Type	Forest	Urban	Forest	Urban	Forest	Urban
Impervious Percentage (%)	0	60	0	60	0	60
Background N (kg/ha/yr)	1.8	18	1.8	18	1.8	18
Background P (kg/ha/yr)	0.18	2.5	0.18	2.5	0.18	2.5
Site Area (ha)	352	352	352	352	352	352
Total Background N (kg/yr)	633.6	6336	633.6	6336	633.6	6336
Total Background P (kg/yr)	63.36	880	63.36	880	63.36	880

TOTAL ANNUAL LOADS Stage 9	RECEIVING NODE	CONVERSION	UNITS	CONVERSION	UNITS
Mean Annual Surface Runoff (m3) =	2,540.83	2,540,830.00	L/yr	2.54	ML/yr
Mean Annual Surface N (g) =	33.48	0.03	kg/yr		
Mean Annual Surface P (g) =	11.13	0.01	kg/yr		
Mean Annual Surface V (MPN) =	14,122.43	0.00	cfu/100ml		
Mean Annual Deep Drainage (m3) =	28,964.25	28,964,250.00	L/yr	28.96	ML/yr
Mean Annual Deep Drainage N (g) =	373.16	0.37	kg/year		
Mean Annual Deep Drainage P (g) =	133.41	0.13	kg/year		
Mean Annual Deep Drainage V (MPN) =	419,157.00	0.00	cfu/100ml		

TOTAL ANNUAL LOADS - Stage 8	RECEIVING NODE	CONVERSION	UNITS	CONVERSION	UNITS
Mean Annual Surface Runoff (m3) =	2,533.07	2,533,070.00	L/yr	2.53	ML/yr
Mean Annual Surface N (g) =	2.65	0.00	kg/yr		
Mean Annual Surface P (g) =	5.06	0.01	kg/yr		
Mean Annual Surface V (MPN) =	8,745.46	0.00	cfu/100ml		
Mean Annual Deep Drainage (m3) =	35,483.78	35,483,780.00	L/yr	35.48	ML/yr
Mean Annual Deep Drainage N (g) =	33.95	0.03	kg/year		
Mean Annual Deep Drainage P (g) =	69.40	0.07	kg/year		
Mean Annual Deep Drainage V (MPN) =	295,248.56	0.00	cfu/100ml		

Appendix D

Viral Die-Off Modelling

Beavers, Cromer, Gardner Viral Dieoff Model (refer Cromer *et al.* , 2001)

Site: **North Cooranbong**

Step 1	Use Figure 1 in Cromer *et al.* (2001) (reproduced below) to determine days travel time using groundwater temperature* and a selected order of magnitude reduction.	
	* If mean groundwater temperature is unavailable, mean daily air temperature can be used in most cases.	
Groundwater Temperature (^{o}C)	11	
Order of magnitude reduction	1	* Tertiary treated effluent
Days required for viral reduction	**20**	(from Figure 1, below)

Step 2

Calculate the predicted travel distance using Equation 4 from Cromer *et al.* (2001).
Dg = (t-d_v.P/K)/(P/K.I)

Time in days	t =	20	days
Effective porosity of soil (fraction)	P =	0.4	
Saturated hydraulic conductivity	K =	0.5	m/day
Groundwater gradient (fraction)	I =	0.1	
Vertical drainage before entering groundwater	d_v =	0.6	m

Setback Distance	**Distance travelled in groundwater**	**d_g =**	**2.4**	**m**

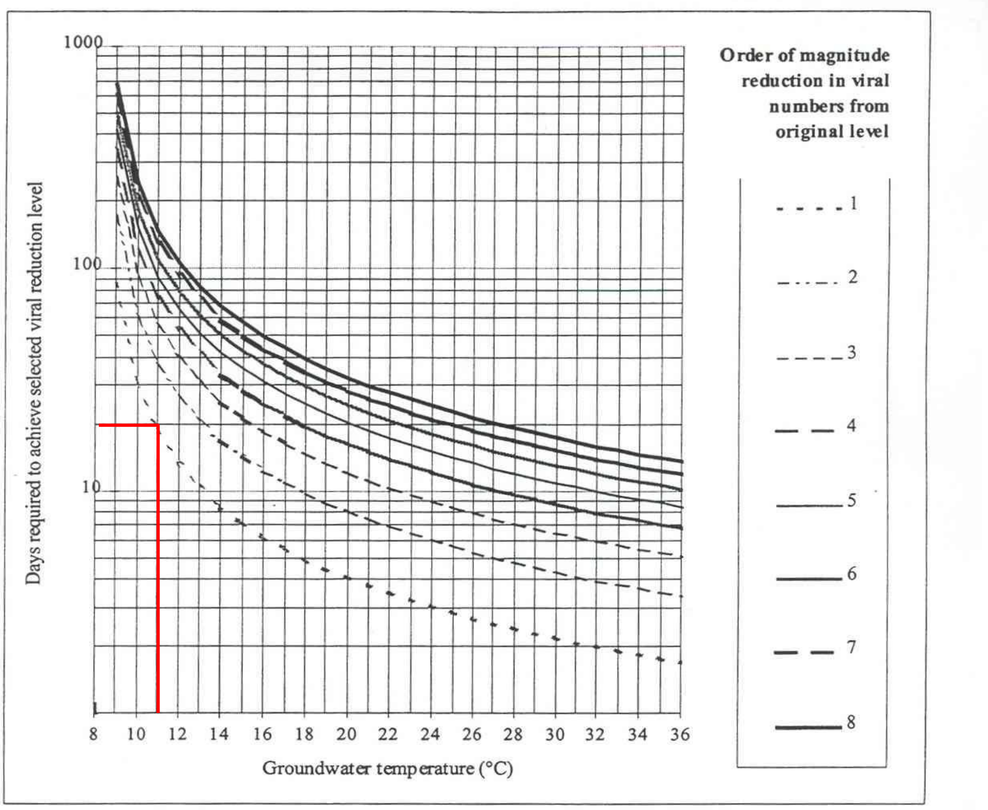

Figure 1. Relationship between Groundwater Temperature and Viral Die-Off Time for Various Order-of-Magnitude Reductions in Viral Numbers

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Land Capability and Recycled Water Irrigation Plan North Cooranbong, NSW

(Extension to Cooranbong Water NOL#15_033)

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Disclaimer

The information contained in this report is based on independent research undertaken by Nicholas Banbrook of Whitehead & Associates Environmental Consultants Pty Ltd (W&A). To our knowledge, it does not contain any false, misleading or incomplete information. Recommendations are based on an appraisal of the site conditions subject to the limited scope and resources available for this project, and follow relevant industry standards. The work performed by W&A included a desktop review and limited soil sampling only, and the conclusions made in this report are based on the information gained and the assumptions as outlined. Under no circumstances, can it be considered that these results represent the actual state of the site at all points, as subsurface conditions are inherently variable. Concentrations of contaminants may also change with time, and the conclusions in this report have a limited lifespan.

Copyright Note

Table of Contents

1 Introduction

Whitehead & Associates Environmental Consultants Pty Ltd ('W&A') were engaged by RPS Australia Pty Ltd (“the Client”) to prepare a Land Capability Assessment (LCA) for recycled water irrigation to enable expansion of the water recycling scheme at the North Cooranbong masterplan residential development known as 'North Cooranbong' (licence no. 15_033) North Cooranbong.

This LCA focuses on additional parcels of land located to the east of Freemans Drive (the 'Site') and the capacity of the land to accommodate irrigation with recycled water generated by the Local Water Centre (LWC) operated by 'Cooranbong Water' Pty Ltd, the network operator and subsidiary of the Client.

The report has been undertaken in reference to the assessment and design principles of:

- AS/NZS 1547:2012 *On-site Domestic Wastewater Management* (Standards Australia / Standards New Zealand, 2012);
- Environment & Health Protection Guidelines: *On-site Sewage Management for Single Households* (Department of Local Government, 1998);
- National Water Quality Management Strategy (2006), *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1)*; and
- NSW Department of Environment and Conservation (2004), *Environmental Guidelines for the Use of Effluent by Irrigation*.

2 Scope of Works

This document comprises Phase 1 and Phase 2 of our works including a land capability assessment and an irrigation capacity assessment, as determined necessary. As part of the study methodology, we completed the following:

- a review of a range of background information relevant to the project, including the development/design plans and any other relevant information from previous studies in the area.
- visited the Site to undertake a detailed site investigation to:
    - assess a range of site constraints including landform, slope, aspect, drainage, flooding and proximity to sensitive environments;
    - conducted a preliminary soil survey which involved the excavation of soil test pits (boreholes) within the available irrigation area(s), including the excavation of thirteen (13) soil test pits and five (5) boreholes to assess soil physical characteristics such as texture, structure, depth, colour, drainage and presence of water tables;
    - undertook in-house laboratory analysis of pH, electrical conductivity and Emerson Aggregate Class;
    - conducted in-situ (soil) permeability testing to confirm saturated hydraulic conductivity (K_{sat}) of site soils (both surface and subsurface soil horizons). Field measurements were undertaken using a constant-head permeameter following the Talsma-Hallam method described in AS/NZS 1547:2012;
    - provided (6) representative soil samples for independent lab analysis of phosphorus sorption and cation exchange capacity (nutrient modelling) and exchangeable sodium percentage (soil dispersion potential);

  - identified an appropriate location and configuration for the Designated Irrigation Zones (DIZs) including all recommended/required setbacks (buffers); and
  - identified any land improvement works or mitigation measures recommended to address particular site constraints (e.g. soil importation, vegetation improvement, landscaping, stormwater diversion).
- undertaken a daily soil water, nutrient and pathogen modelling to determine the land area and storage volume required. This has been undertaken with reference to NRMMC, EPHC, AHMC (2006) Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1), NSW DPI Office of Water (2015) NSW Guidelines for Recycled Water Management Systems and any provisions/requirements of the Water Industry Competition Act (WICA) (2006);
- conducted a sensitivity analysis using the daily modelling tool (DSM) to more accurately reflect the likely Site water and nutrient balance, allowing for diurnal and seasonal variation in both climate impacts and water quality variables; and
- provision of this report, including Site plan, describing the results and recommendations from our Phase 1 and Phase 2 investigations.

3 Site Description

The Site is located to the south east of Freemans Drive, and the North Cooranbong masterplan development and the LWC that services the development. The Site investigation area covers approximately 88.5ha and includes numerous adjacent land parcels located on either side of Central Road and is shown on the Site plan presented as Figure 1 in Appendix A.

4 Site & Soil Assessment

A site and soil assessment was undertaken on the 23rd of April 2018 by Nicholas Banbrook and Elise Powning of Whitehead & Associates. A follow up assessment was undertaken on the 5th of July 2018 to determine the suitability of additional areas located northwest of Freemans Drive and east of Avondale College.

4.1 Site Physical Characteristics

A description of the Site physical conditions and the degree of limitation they pose to recycled water irrigation is provided in Table 1 below. Where applicable, descriptions have been separated into sub areas denoted as Designated Irrigation Zones (DIZs) due to the broad scale of the Site.

It should be noted that whilst the land capability of DIZ 3 was assessed, it is not been included as a DIZ for the purposes of the licence extension. This area (~2.1ha) includes a narrow trip of of cleared grazing paddock, located within proximity of Test Pit 13 (TP13).

The DIZs are shown in Figure 2, Appendix A. Reference is made to the rating scale in Table 2.1 of DEC (2004) and, where appropriate, NSW DLG (1998) and the AS/NZS 1547:2012.

Table 1 Site Physical Conditions & Constraints

Parameter	Constraint
Climate: For the purpose of this LCA, climate data was sourced from local weather stations, namely; Cooranbong - Avondale (61012) and Peats Ridge – Waratah (61351).	Moderate

Parameter	Constraint
The Site experiences a temperate climate, typical of south-eastern Australia. Potential evapotranspiration exceeds rainfall for 4 months of the year at the Site. The soil moisture surplus is expected to be most limiting during the autumn/winter period. This presents a moderate limitation to Recycled Water Irrigation (RWI).	
Aspect and Exposure: The investigation area is dissected by Central Road, which roughly follows a broad low ridgeline tapering toward the south to southeast. DIZ 1, 3 and 5 – Aspects on the north eastern side of Central Road are predominantly north to easterly. DIZ 2 and 4 – Aspects to the southwest side of Central Road are south easterly to south-south westerly. DIZ 6, 7a and 7b – Aspects are predominantly easterly, through a large portion of these areas are relatively flat, as indicated in Figure 2. DIZ 8a and 8b – Aspect is relatively flat, with peripheral areas sloping toward adjacent waterways. Good solar and wind exposure was observed within the proposed DIZs. This presents a minor limitation to RWI.	Minor

Parameter	Constraint
Vegetation: DIZ 1 and 2 – Well cleared and vegetated by managed pasture. DIZ 3 (see TP13 in Figure 2) – Contains managed pasture. At the time of inspection, healthy ground cover was observed, though historic aerial imagery suggests pasture dieback has occurred in the past due to periodic flood inundation, stormwater run-on from the residential area upslope and localised poor drainage. DIZ 4 – Predominantly managed pasture, with mature trees located along paddock fence lines. Pasture dieback was observed in low lying plain areas surrounding agricultural drainage lines due to periodic saturation. The paddock adjacent to the southwest could not be accessed, and as such was not investigated during our site inspection. DIZ 5 – As per DIZ 4, with some pasture dieback observed in the northeast portion, down slope of a small farm dam, due to poor surface drainage. DIZ 6 – Contains a sports field with well managed lawn. DIZ 7a and 7b – Predominantly managed pasture, with some weeds and areas of clover, particularly in DIZ 7b. Mature trees (predominantly casuarinas and eucalyptus) are located along paddock fence lines and waterways. DIZ 8a and 8b – Managed pasture and weeds (primarily flatweed and blackberry), with mature eucalyptus trees along paddock fence lines and waterways.	Slight to Moderate
Landform and Slope: The Site exhibits slopes of up to 9% on convergent upper mid-slopes, though generally gradient ranges between 1% and 6% on planar to divergent mid-slope to low slope positions within the identified DIZs. Landform and gradient presents a slight to moderate limitation to RWI.	Slight to Moderate
Rocks and Rock Outcrops: Bedrock or rock outcrops were not encountered at the Site, either through direct observation or soil sampling. This presents no limitation to RWI.	Nil
Fill: Evidence of imported fill was observed within a raised recreational area in DIZ 6 (sports field) on the eastern side of Avondale College. No other fill material was identified at the Site on historical air photographs or observed during the site and soil investigations. The material appears to be uniform sandy clay, sourced locally, and presents only a minor limitation to RWI.	Minor
Erosion Potential: The ground surface is generally stable throughout the Site, with no erosion observed at the time of inspection. This presents no limitation to RWI.	Nil
Groundwater and Site Drainage: A search of the NSW Office of Water's groundwater bores, maps and records indicated that there are no registered groundwater bores within 250m of the Site	Slight to Severe

Parameter	Constraint
investigation area. Surface drainage is generally good throughout the Site, though some limitations were identified within individual DIZs: DIZ 1 and 2 – Located in an elevated position near the crest of a broad ridgeline. Thus, no limitation was identified. DIZ 3 (see TP13 in Figure 2) – Subject to run-on and periodic back creek flooding. Stormwater diversion infrastructure would need to be installed upslope of this area before being considered for use. Drainage is poor and presents a moderate limitation to RWI. DIZ 4 – Drainage is considered moderate within proximity of the TP locations. Groundwater seepage was encountered in TP8 at approximately 1.0m depth within anoxic clay subsoils, while the topsoil was observed to be relatively dry. Although the standing groundwater level at this location is outside the zone of influence for irrigation (>0.6m depth), the seasonal variation in the groundwater level may be significant. Poor surface drainage was observed in most areas below 1.0m AHD. This is confirmed by the presence of constructed agricultural drainage channels and presents a moderate to severe limitation to RWI. DIZ 5 – This area is predominantly well drained, except for the north eastern portion below 2.5m AHD, which is subject to periodic surface pooling and run-on from the dam immediately upslope to the northwest. This presents a slight to severe limitation to RWI. DIZ 6, 7a, 7b, 8a and 8b – Standing groundwater was recorded at approximately 0.9m depth within most augered boreholes (BHs). BH4 in DIZ 8a exhibited perched groundwater, also at 0.9m depth, due to an isolated depression restricting surface drainage.	
Flood Potential and Proximity to Surface Waters: There are two dams located within the investigation area on the Site. These dams are offline and elevated from natural surface drainage alignments. The Site is bordered by Dora Creek to the southwest and Jigadee Creek to the northeast. During our site inspection, the property manager indicated that most of the northern portion of the Site, identified as DIZ 3, is subject to periodic inundation from flooding "every several years". Review of WMA Water's 'Dora Creek Flood Study' (2015) indicates the 1 in 5-year Annual Exceedance Probability (20% AEP) flood level for the Cooranbong Gauge is 5.1m AHD. Based on this, flood potential in DIZ 1 and 2 is Slight, while DIZ 3, 4, 5, 6, 7a, 7b and 8a, 8b is moderate to severe.	Slight to Severe
Available Recycled Water Irrigation (RWI) Area: The key factors that determine availability of RWI area include the constraints imposed by the extent of existing development and nominated buffer distances to property boundaries and other sensitive receptors. As shown in Figure 2, approximately **61.8ha** of suitable RWI area has been	Nil

Parameter	Constraint
identified at the Site. A breakdown of the individual DIZ's is as follows; • DIZ 1 – 7.40ha; • DIZ 2 – 9.90ha; • DIZ 4 – 22.08ha; • DIZ 5 – 1.48ha; • DIZ 6 – 3.11ha; • DIZ 7a – 6.79ha; • DIZ 7b – 7.81ha; • DIZ 8a – 2.01ha; and • DIZ 8b – 1.21ha. Use of areas on the lower fringes of the identified DIZs (along drainage features) may be suitable for irrigation during dry periods, provided adequate monitoring and control measures can be implemented. The availability of RWI area does not present a limitation.	

4.2 Soil Landscape

Review of the 1:100,000 Gosford – Lake Macquarie Soil Landscape Map and Handbook (Murphy, 1993) indicates that Site soils belong to three (3) soil landscapes, namely; the Yarramalong (ya), Doyalson (do) and the Wyong (wy). Summary descriptions of these soil landscapes are provided below.

The Yarramalong (ya) soil landscape is confined to gently undulating alluvial plain on Quaternary sediments. Slopes are generally <5% with <10m local relief. Soils comprise red earths along levee banks, while deep yellow and brown podzolics dominate the back plains. The typical soil profile consists of dark brown to black sandy loam to sandy to silty clay loam (A); overlying strong brown medium clay with block structure and smooth fabric (B).

The landform of the Doyalson (do) soil landscape is located on gently undulating rises with slope gradients <10% and local relief to 30m. Topography is characterised by broad crests and ridges and long, gently inclined slopes. The underlying geological formation is Munmorah Conglomerate, including conglomerate, pebbly sandstone, siltstone and claystone. Soils are typically characterised by dark brown loamy sand to loam (10cm) with weak structure (A1); overlying hardsetting, bleached yellowish brown clayey sand (10-30cm) with weak to massive structure (A2); overlying yellowish brown sandy clay loam to sandy clay (30-60cm) with moderate structure (B1), occasionally overlying up to 50cm of massive pale grey clay (B2).

The Wyong (wy) soil landscape is dominated by poorly drained deltaic floodplains and alluvial flats of Quaternary sediments on the Central Coast Lowlands. Slope gradients are <3% with <10m local relief. Soils typically comprise moderately deep Yellow and Brown Podzolics. The typical soil profile consists of brownish black pedal loam to silty clay loam (A); overlying mottled grey plastic silty to heavy clay with massive structure (B).

4.3 Soil Survey & Physical Characteristics

The soil survey had two principal aims – to verify regional soil landscape mapping information and to assess local soil conditions in areas considered suitable for RW irrigation. Site soils were assessed by excavating thirteen (13) soil TPs using an excavator and drilling five (5) boreholes using a hand auger. Soils were generally consistent across the Site with topsoils composed of sandy loam to clay loam material between 100 – 700mm depth, with moderate structure and varying amounts of coarse material; overlying light to medium clay subsoil. DIZ 7 was the exception to this, exhibiting sandy loam topsoil over estuarine sand. Horizon boundaries were generally well defined. Mottling of clay subsoil was observed in the lower portion of the soil profiles. The descriptions generally conform to the available soil landscape information. Soil profile summaries are presented in Appendix B.

4.4 Soil Chemical Characteristics

Samples of discrete soil horizons were collected for subsequent laboratory analysis. Samples were taken from each horizon and were analysed in-house for pH, Electrical Conductivity (ECe) and Emerson Aggregate Class. Six (6) composite soil samples were taken for independent laboratory analysis for exchangeable sodium (ESP), cation exchange (CEC) and phosphorus sorption capacity (P-sorp).

Table 2 provides a summary of the results and discussion of the soil chemistry with respect to soil constraints for recycled water management. Where applicable, the descriptions have been separated into sub areas denoted as DIZs due to the broad scale of the Site. Reference is made to the rating scale described in Table 2.2 of DEC (2004). Raw data and interpretation is presented in Appendix C.

Table 2 Soil Physical & Chemical Characteristics & Constraints

Parameter	Constraint
Soil Depth: Bedrock was not encountered during the Site investigations. Soil depths were observed to be >1.5m. This presents no limitation to RWI.	Nil
Depth to water table: The depth of the vadose zone (i.e. non-saturated soil material above water table) is generally >1.5m, except for DIZ 4, 6, 7 and 8, which exhibited groundwater at 0.9-1.0m depth. Based on surface application of recycled water at conservative irrigation rates, the identified (seasonal) groundwater level is expected remain beyond the zone of influence (>0.6m depth) regarding RWI. This presents a moderate limitation to RWI.	Moderate
Coarse Fragments (%): Coarse fragments may impede plant growth by reducing soil water holding capacity, nutrient retention capacity and overall fertility because of the reduced fine earth fraction and increased permeability. Coarse fragments were observed in varying amounts between 0-5% within the excavated TPs. Based on the depth and concentration within the soil profile; coarse fragments present no limitation to RWI.	Nil
Soil Permeability and Design Loading Rates: Soil permeability was measured at five (5) separate locations throughout the Site using a constant head (Talsma-Hallam) permeameter. The test locations (P1-P5) are shown in Figure 2 of Appendix A. The field tests were conducted in accordance with the test procedure outlined in Appendix G of AS/NZS 1547:2012 and the saturated hydraulic conductivity (K_{sat}) was calculated using Equation G1, therein. Test boreholes were augered to 400-500mm depth.	Moderate to Severe

Parameter	Constraint
The permeameter test results and hydraulic conductivity calculations are presented in Appendix D. In summary, the K_{sat} calculations yielded the following values from the permeameter test locations; • P1 - 7mm/day for shallow Category 4 topsoil (300mm depth) overlying Category 6 subsoil; • P2 and P4 - 21mm/day for moderately deep Category 4 topsoil (500-600mm) overlying Category 6 subsoil; • P3 - 161mm/day for deep Category 4 topsoil (800mm) overlying Category 6 subsoil; • P5 - 66mm/day for moderately deep Category 2 topsoil (500mm) overlying Category 6 subsoil; • P6 – Permeameter malfunction / insufficient data obtained; • P7 – 21mm/day for Category 2 topsoil (700mm depth) overlying Category 1 subsoil; and • P8 - Permeameter malfunction / insufficient data obtained. The Saturated Hydraulic Conductivity (SHC) for the DIZs is broadly estimated between 60-160mm/day. This is considered a moderate limitation for RWI. Table M1 of AS/NZS 1547:2012 provides indicative permeability for various soil categories based on soil texture and structure. For a well structured medium clay (Category 6) soil, K_{sat} values ranging from 60mm/day to 500mm/day apply. The calculated K_{sat} values broadly concur with the indicative values provided in the standard, with the exception of P1, which may have been impacted by smearing of clay during augering of the test hole. Based on this information, a conservative design **K_{sat} of 60mm/day** has been adopted for modelling purposes. Soil permeability presents a moderate to severe constraint to RWI that will be mitigated through soil amelioration and best practice irrigation management, as described in Section 6.2.	
pH: The pH of 1:5 soil/water suspensions were measured in-house using a *Hanna*™ hand held pH / EC meter. The measured pH of the soil samples (topsoils and subsoils) ranged from 4.15 to 6.10. Soils range from slightly acidic to extremely acidic; however, plant growth did not appear to be affected by soil acidity at the time of inspection. Soil pH presents a slight to moderate limitation for RWI at the Site, which can be managed through long term monitoring of soil and groundcover health.	Slight to Moderate

Parameter	Constraint
Electrical Conductivity (EC_e): Electrical conductivity of the saturated extract (EC_e) was calculated by first measuring the electrical conductivity of 1:5 soil in water suspensions and using appropriate multiplier factors (based on soil texture) to convert the 1:5 suspension EC to EC_e. Soil samples were found to range from non-saline to slightly saline, having EC_e values of 0.0 dS/m (topsoil) - 2.29 dS/m (subsoil). Soil salinity presents no limitation for RWI.	Nil
Modified Emerson Aggregate Class: The Modified Emerson Aggregate Test (EAT) is a measure of soil dispersibility and susceptibility to erosion and structural degradation. It assesses the physical changes that occur in a single air-dried ped (naturally forming aggregate) of soil when immersed in water; specifically whether the soil slakes and falls apart or disperses and clouds the water. The test was performed on all samples collected, which yielded Emerson Aggregate (EAT) classes of 6 - 8 in topsoils and 5 – 6 in subsoils, with the exception of subsoils in TP1, TP10 and TP13. These subsoils exhibited an EAT class of 2(2). The EAT classifications indicate high levels of slaking with some dispersion within class 2(2) subsoil horizons. Given that this limiting EAT class occurs within subsoils overlain with permeable topsoil, the associated dispersion risk can be effectively managed through soil improvement measures described in Section 6.2. This presents a nil to slight limitation for RWI.	Nil to Slight
Sodicity (Exchangeable Sodium Percentage - ESP) (%): Exchangeable Sodium Percentage (ESP) is the proportion of sodium on the cation exchange sites reported as percentage of exchangeable cations and is an important indicator of sodicity, which affects soil structural stability and susceptibility to dispersion. The ESP is a measure of how readily the soils allow sodium from recycled water to be substituted in the soil lattice for other cations. Once accepted, the weak sodium bonds allow increased structural degradation of the soil, increasing erosion risk. It is calculated as [% Na / CEC] x 100. Hazelton & Murphy (2007) suggest: • ESP values less than 6 are rated as non-sodic; • ESP values between 6 and 15 are rated as sodic; • ESP values between 15 and 25 are rated as strongly sodic; and • ESP values greater than 25 are rated as very strongly sodic. Six (6) composite soil samples were analysed for ESP, giving recorded values for subsoils ranging from 4.2 - 9.8 for upslope areas of DIZs 1 - 3 and low lying areas of DIZ 4, which presents a moderate limitation to RWI. However, upslope areas of DIZs 4 and 5 exhibited ESP values of 22.3 and 28.2 respectively. These values are strongly to very strongly sodic and present a severe limitation to RWI that can be addressed through soil amelioration (see section 6.2) and monitoring.	Moderate to Severe

Parameter	Constraint
Cation Exchange Capacity (cmol/kg): The Cation Exchange Capacity (CEC) is the capacity of the soil to hold and exchange cations [aluminium, calcium, magnesium, potassium and sodium]. It is a major controlling agent for soil structural stability, nutrient availability for plants and the soils' reaction to fertilisers and other ameliorants (Hazelton & Murphy, 2007). Like ESP, the CEC is a measure of how easily the soils accept excess cations from the wastewater. The CEC of the composite soil samples analysed were measured at 5.2 - 12.4cmol/kg. The CEC ratings for the samples range from very low to moderate, indicating that plant growth may be inhibited by a lack of trace nutrients such as calcium, and the application of gypsum (or lime where soil pH is <5.5) may be beneficial for consideration in preparing DIZs. The calcium/magnesium ratios of the analysed samples were found to range from 0.3 - 0.6, with the exception of low the lying portion of DIZ 4 (TP8) which had a ratio of 9.6. It is generally accepted that the Ca/Mg ratio should be near 2.0 to improve fertility and lower the risk of dispersion. The CEC presents a slight to moderate limitation for RWI and can be improved through pasture management practices. Further discussion on proposed mitigation measures is provided in Section 6.2.	Slight to Moderate
Phosphorus Sorption Capacity (kg/ha): Phosphorus Sorption capacity (P-sorption) is used to calculate the potential immobilisation rate of phosphorus by the soil. The P-sorption capacity of a soil is an important feature that relates to the potential for a soil to bind any phosphorus that may not be utilised by the plants. Phosphorus is required only to a limited extent by plants as a trace nutrient, but if there is an excess of phosphorus in environments where other limiting factors are not present (such as waterways), excess phosphorus can result in very high plant growth. Typically, on land, excess phosphorus is taken up by soil adsorption, or is flushed out of the soil into groundwater or surface water bodies. In many instances, P-sorption will be the dominant phosphorus removal mechanism when applying recycled water to the land. P-sorption analysis was undertaken on the composite soil samples by Lanfax Laboratories, Armidale. For each laboratory sample a five point isotherm of P-sorption capacity was generated. The methodology is described further in Patterson (2001). For the analysed soils, a nominal threshold P-sorption value (in mg/kg) is selected as the value that equates to roughly 70% of complete sorption or the point on the sorption curve where the predicted P-sorption value departs from the theoretical line. The soil profile's P-sorption capacity can be estimated by adding the contribution from each discrete horizon to achieve a total P-sorption capacity or (weighted average). A bulk density of 1.5g/cm^3 was assumed and the relevant soil profile depth was used for the soil profile P-sorption calculation. Based upon this, the design P-sorption capacity of the Site soils is estimated as 210 - 1,290mg/kg. Given the low total phosphorus concentrations expected in	Slight

Parameter	Constraint
the recycled water, soil P-sorption capacity is considered to be significant limitation for RWI.	

5 Buffers

Buffer distances from LAAs are recommended to minimise risk to public health, maintain public amenity and protect sensitive environments. Buffer or setback distances are typically recommended to provide a form of mitigation against unidentified hazards and reduce potential pathways of human and environmental exposure.

The Australian Guidelines for Water Recycling (AGWR, 2006) and NSW Recycled Water Management System guidelines (DPI, 2015) both provide recommendation for 'non-treatment' barriers (i.e. buffers) to exposure for RWI. However, the basis for application is an assumption that 'Log Reduction Values' (LRVs) for treatment processes are limited to ≤6.5.

The North Cooranbong NOL (15_033) includes sufficient plant process (LWC) to achieve LRVs of 7.0 (enteric virus), 6.5 (enteric protozoa) and 10.5 (enteric bacteria) in the recycled water stream, suitable for unrestricted dual (residential) supply. Therefore, typical environmental setbacks are not considered relevant or applicable.

5.1 Other Boundary Controls

To further assist in maintaining appropriate environmental and public health offsets from proposed DIZs, it is recommended that:

- a nominal 5m buffer from surface waters be implemented to ensure direct discharge of RW does not occur;
- 180 degree (inward facing) spray heads are utilised along all DIZ boundaries;
- spray heads are of large-droplet type to reduce creation of aerosols and prevent spray drift; and
- throw (plume) height is limited to <1.5m near DIZ boundaries.

Consideration should also be given to the provision of screening (shrub planting or similar) along DIZs sharing a common boundary with residential areas.

6 Mitigation Measures

6.1 Stormwater Management

The performance of DIZs can be adversely affected if stormwater is allowed to flow overland onto these areas. This water should be diverted around the DIZs through construction of upslope diversion drains or stormwater infrastructure. Typical construction details are presented in Figure 3 of Appendix A.

Any earth banks and drains should be stabilised as soon as possible to prevent erosion using vegetation or a suitable alternative. The outlet must be stabilised and must discharge water in a safe location where it will not create an erosion hazard or impact on structures or neighbouring properties. Any stormwater captured from roofs should be disposed of outside RWI areas.

6.2 Soil Improvement

The majority of the soils within the DIZs exhibit a calcium deficiency, as well as moderate to extreme acidity and sodicity within subsoils. This is typical of many east Australian soils, although our Site investigations did not identify any significant related impact to vegetative growth.

Long-term recycled water irrigation can result in increases in soil sodicity, particularly where recycled water supplies are higher in sodium. However, active steps are taken at the North Cooranbong LWC to reduce sodium in recycled water by using magnesium-based neutralising solution and membrane filtration process steps.

Strong soil sodicity was encountered within upslope areas of DIZs 4 and 5. This can be managed by annual surface application of gypsum at a rate of 0.2kg/m².

7 Recycled Water Supply

The recycled water stream includes excess treated water generated by the Local Water Centre (LWC) at the build out stage of the North Cooranbong development. This RWI volume comprises all recycled water not reused in the reticulated 'third pipe' system (i.e. toilet flushing, washing machine supply, yard irrigation and car washing) or stored to meet seasonal demand requirements.

The proposed non-potable system includes a 6.4ML recycled water storage (tanks or reservoir) which, while primarily used to meet latent demand requirements, can also be utilised for short-term (wet weather) storage should the need arise.

7.1 Recycled Water Quantity

Based on the 'Kinesis' water balance summary data (dated 9 February 2016) provided by Flow Systems, an average recycled water volume of **140,000L/day** is expected to be achievable at subdivision buildout. It is most likely that this recycled water volume will be largest during the cooler months (May-August). This recycled water is proposed to be irrigated on suitable land external to the development precinct.

This value has been adopted for use in the irrigation staging assessment, included in Section 8.

7.2 Recycled Water Quality

The recycled water produced by the LWC is of 'tertiary quality'; which is disinfected and contains low concentrations of nutrients and suspended solids.

Information submitted with the WICA license application, and subsequently confirmed through external (IPART) auditing, confirms that recycled water produced from the LWC will have upper concentration limits (UCLs) equivalent to:

- Total Nitrogen: ≤15mg/L;
- Total Phosphorus: 2-5mg/L;
- BOD_5: ≤10mg/L;
- Suspended Solids: ≤10mg/L;
- Faecal Coliforms: ≤1cfu/100mL;
- Total Dissolved Solids: ≤700mg/L; and
- EC: ~1,000µS/cm.

The LWC produces treated recycled water of a quality that is of low risk for direct human contact (DWE, 2008) and is suitable for unrestricted urban irrigation. Therefore, surface irrigation of the recycled water within the licensed area and particularly in the DIZs is considered suitable.

8 Irrigation Capacity Assessment

Daily water and nutrient modelling was undertaken using the Decentralised Sewer Model (DSM) to determine the sustainability of the proposed additional RWI areas to assimilate the excess recycled water generated from the LWC following complete build out of the North Cooranbong development.

For this project, the irrigation area requirement was calculated iteratively for each nominated DIZ using the model and assessed against best practice human and environmental health protection targets.

A summary of the model processes, inputs and results is provided below.

8.1 DSM Overview

The DSM is a proprietary geographic information system (GIS) based platform that was developed jointly by W&A and BMT WBM to provide a rapid-assessment tool to predict the performance of on-site and decentralised wastewater management systems under varying environmental conditions. The DSM can assess long-term environmental and human health performance of wastewater systems. Background information and general methodology of the DSM is provided in the DSM User Manual (BMT WBM, 2011).

The DSM requires input of a range of bio-physical parameters. The resulting data from the monthly water balance, Digital Elevation Model (DEM) and soil grid created in MapInfo™ (v.10), and interpolated data from the SILO service Data Drill were used as inputs to the DSM to determine whether the proposed irrigation of the Site would be sustainable.

The model simulates the movement of pollutants (nitrogen, phosphorus and pathogens) within recycled water as it travels from the point source (individual DIZs) down the catchment as surface or subsurface flows. The DSM does not predict the minimum area required to achieve zero surface runoff or deep drainage, instead, the model predicts the surface and subsurface discharges based on a set of nominated conditions such as receiving node type/condition, soil, slope, weather, wastewater input and application area.

The DSM has five modules, with only two being used to assess the cumulative impact of the proposed subdivision of the Site. The on-lot performance module (OLPM) was used to derive the average annual hydraulic and pollutant loads to surface and subsurface export routes. The node link module (NLM) was used to simulate the movement of hydraulic, nutrient and pathogen loads from individual DIZs to sensitive receptors. However, it is important to note that the OLPM makes the conservative assumption that the entire, non-attenuated pollutant load is discharged from the DIZs.

8.2 DSM Input Parameters

The simulation was run for a data period of 64 years (1950-2014) and represents a conservative estimate of the long-term performance based on available information and a set of assumptions as detailed within this report. The key model input data are provided in Table 3. DSM inputs provide a detailed estimation of the soils ability to receive, store and transmit water by estimating parameters such as effective saturation, field capacity, and the infiltration exponent.

Soil input data specific to each modelled DIZ were used to account for the identified variations in soil texture and depth of (moderately permeable) topsoil over the relatively slowly permeable subsoils. For reference, the modelled variation in soil conditions is delineated as 'soil facets' in Figure 2 of Appendix A.

Evapotranspiration is a function of both climatic factors and the type of vegetation planted in the DIZs. The values adopted were those provided in the SILO Data Drill information acquired as part of this project, whereby the SILO data set uses the (FAO56) Penman-Monteith methodology to estimate reference evapotranspiration (ET_0). The P-sorption uptake capacity of the soil has been conservatively based on the most limiting laboratory result (TP10), which provides design contingency for aggregate application.

Table 3: DSM Site and Soil Inputs

Data Input	Code	Unit	Value	Source
Total Irrigation Area	DIZ	m^2	611,977	Combined DIZs
Limiting Soil Horizon	-	-	DIZ 1-5, 6, 7a – MC DIZ 7b – SL DIZ 8a, 8b – LC	DIZ dependant
Total Phosphorus	TP	mg/L	5	See Section 7.2
Total Nitrogen	TN	mg/L	15	See Section 7.2
Virus	V	MPN/100ml	10	See Section 7.2
Crop P Uptake		kg/ha/year	30	Table 4.2 in DECCW (2004) for grass (September-March)
Crop N Uptake		kg/ha/year	260	Table 4.2 in DECCW (2004) for grass (September-March)
Crop Factors		unitless	Pasture	Table 4.1 in DECCW (2004)
Soil Water at Effective Saturation	SAT	mm/m	DIZ 1, 2, 5 and 7 – 338 DIZ 4 – 350 DIZ 6 – 300 DIZ 8 – 380	Table 2.65 and 2.6 Hazelton & Murphy (2007), Charman & Murphy Chapter 10 (1991) and Table(s) 6.2 and 6.3 Connellan (2013)
Field Capacity	FC	mm/m	DIZ 1, 2, 5 and 7 – 322 DIZ 4 – 310 DIZ 6 – 190 DIZ 8 – 350	
Permanent Wilting Point	PWP	mm/m	DIZ 1, 2, 5 and 7 – 216 DIZ 4 – 200 DIZ 6 – 90 DIZ 8 – 230	
Saturated Hydraulic Conductivity	SHC	mm/day	60	See Table 2
Soil depth for Phosphorus Sorption	SDP	mm	DIZ 1, 2, 5, 7 and 8 – 300 DIZ 4 – 500 DIZ 6 – 700	Based on maximum rooting depth and depth to limiting soil layer
Soil Phosphorus Sorption Capacity	P-sorb	mg/kg	210	Most limiting laboratory result

Data Input	Code	Unit	Value	Source
Bulk Density	BD	kg/m^3	1,430 - 1,700	Average value based on soil texture/depth
Initial Depression Storage	DS	mm	6	Initial loss before infiltration: from landscape characteristics
Dry Soil Infiltration Rate	INF	mm/day	DIZ 1, 2, 5 and 7 – 189 DIZ 4 – 235 DIZ 6 – 150 DIZ 8 – 210	Published data for soil texture/structure (Macleod 2008)
Infiltration Exponent	EXP1	dimensionless	1	Exponent 1: how slowly infiltration decreases once soil gets wet (Macleod 2008)
Freundlich Adsorption Coefficient	A1	g/L	128.62	A1, B1 and B2 are related to phosphorus isotherm Laboratory analysis. A1 is exp10 of intercept of isotherm with y axis; B1 is slope of log normal line; B2 is half of B1
Freundlich Adsorption Exponent	B1	dimensionless	0.2980029	
Freundlich Desorption Exponent	B2	dimensionless	0.1490014	
Attenuation Rate for Hydraulic		%	60	Derived from PSC Technical Manual (2015)
Attenuation Rate for Nitrogen		%	93	
Attenuation Rate for Phosphorus		%	94	
Attenuation Rate for Viruses		%	97	

8.3 Background Condition

Background pollutant export loads for the existing Site condition were estimated for hydraulic and nutrient loads associated with rainwater/stormwater runoff.

These values have been used to establish a 'baseline condition' for comparison to the DSM results. This provides a basis for assessing the predicted performance of the proposed DIZs.

To quantify the ‘rainfall’ driven deep drainage and surface runoff for the total RWI area, the DSM was run without an irrigation component. The predicted total deep drainage from the combined DIZs is 78,220m^3/year and the combined surface runoff is 20,156m^3/year for background (rainfall only) conditions.

For data comparison the total ‘background’ deep drainage and runoff was proportioned between several distinctly separate sub-catchments, as shown in Table 4.

Table 4: Background Condition

Sub-Catchment	Mean Annual Surface Runoff (m^3/year)	Mean Annual Deep Drainage (m^3/year)
Jigadee Creek DIZ 1 and DIZ 5	5,546	13,904
Dora Creek DIZ 2 and DIZ 4	10,416	34,752
Jigadee Creek DIZ 6 and DIZ 7b	1,549	16,709
Jigadee Creek DIZ 7a	1,716	9,435
Jigadee Creek DIZ 8a and DIZ 8b	930	3,420

Background nutrient values were derived from Figures 2.19 and 2.20 in Fletcher *et al*. (2004), with adjustment made for the corresponding land-use (i.e. 'agricultural use'), proportion of impervious to pervious surface areas, and mean annual rainfall.

The annual background nitrogen load is estimated at 485.32kg/year and the annual background phosphorus load is estimated at 92.64kg/year.

8.4 Modelling Results

Hydraulic and nutrient loads are divided into surplus loads discharged to the ground surface as 'surface runoff' or draining below the root zone with subsequent (eventual) groundwater flow to surface water bodies or aquifers as 'deep drainage'.

To ensure that natural soil hydrology is not significantly altered, potentially resulting in groundcover die-back and excessive irrigation runoff or deep drainage to adjacent sensitive receptors, the following irrigation performance targets have been adopted:

- irrigation rates to all DIZs ensure that irrigation runoff only occurs when rainfall exceeds 30mm/day within the previous 24 hour period; and
- deep drainage does not exceed 0.56mm/day.

These target values were set out in W&A's 'Staging Assessment for Recycled Water Management Scheme at Proposed 'North Cooranbong' Development, Cooranbong, NSW' (dated 4 June 2014), which forms the basis for the current licence agreement.

The DSM results are presented in Table 5 (below). The reported values represent the 'net' increase of the DSM results above the adopted values for the 'background' condition.

Table 5: Modelling Results

Parameter	DSM Result
DIZ 1	
Maximum Daily RWI Volume (m^3/day)	**30**
Design Irrigation Rate (mm/day)	**0.39**
Mean Annual Surface Runoff (m^3/year)	771
Mean Annual Deep Drainage (m^3/year)	1,552
Mean Daily Deep Drainage (mm/day)	0.06
Total Nitrogen Export (kg/year)	0.00
Total Phosphorus Export (kg/year)	0.06
DIZ 2	
Maximum Daily RWI Volume (m^3/day)	**40**
Design Irrigation Rate (mm/day)	**0.40**
Mean Annual Surface Runoff (m^3/year)	1,024
Mean Annual Deep Drainage (m^3/year)	2,069
Mean Daily Deep Drainage (mm/day)	0.06
Total Nitrogen Export (kg/year)	0.35
Total Phosphorus Export (kg/year)	0.00
DIZ 4	
Maximum Daily RWI Volume (m^3/day)	**445**
Design Irrigation Rate (mm/day)	**2.02**
Mean Annual Surface Runoff (m^3/year)	4,662
Mean Annual Deep Drainage (m^3/year)	42,483
Mean Daily Deep Drainage (mm/day)	0.53
Total Nitrogen Export (kg/year)	0.45
Total Phosphorus Export (kg/year)	15.69
DIZ 5	
Maximum Daily RWI Volume (m^3/day)	**12**
Design Irrigation Rate (mm/day)	**0.81**
Mean Annual Surface Runoff (m^3/year)	345
Mean Annual Deep Drainage (m^3/year)	2,769
Mean Daily Deep Drainage (mm/day)	0.51
Total Nitrogen Export (kg/year)	0.00
Total Phosphorus Export (kg/year)	0.00
DIZ 6	
Maximum Daily RWI Volume (m^3/day)	**35**
Design Irrigation Rate (mm/day)	**1.12**
Mean Annual Surface Runoff (m^3/year)	976
Mean Annual Deep Drainage (m^3/year)	12,195

Parameter	DSM Result
Mean Daily Deep Drainage (mm/day)	0.25
Total Nitrogen Export (kg/year)	0.00
Total Phosphorus Export (kg/year)	0.01
DIZ 7a	
Maximum Daily RWI Volume (m^3/day)	**100**
Design Irrigation Rate (mm/day)	**1.28**
Mean Annual Surface Runoff (m^3/year)	1,031
Mean Annual Deep Drainage (m^3/year)	8,408
Mean Daily Deep Drainage (mm/day)	0.56
Total Nitrogen Export (kg/year)	0.01
Total Phosphorus Export (kg/year)	1.35
DIZ 7b	
Maximum Daily RWI Volume (m^3/day)	**50**
Design Irrigation Rate (mm/day)	**1.22**
Mean Annual Surface Runoff (m^3/year)	574
Mean Annual Deep Drainage (m^3/year)	4,642
Mean Daily Deep Drainage (mm/day)	0.31
Total Nitrogen Export (kg/year)	0.01
Total Phosphorus Export (kg/year)	0.11
DIZ 8a/8b	
Maximum Daily RWI Volume (m^3/day)	**15**
Design Irrigation Rate (mm/day)	**0.47**
Mean Annual Surface Runoff (m^3/year)	186
Mean Annual Deep Drainage (m^3/year)	1,036
Mean Daily Deep Drainage (mm/day)	0.10
Total Nitrogen Export (kg/year)	0.00
Total Phosphorus Export (kg/year)	0.00

8.5 Discussion

The results indicate that nutrient export rates under the modelled scenario are expected to have a negligible increase on the existing background condition, as all DIZs are hydraulically constrained. Therefore, the identified DIZs are of an appropriate size to assimilate the expected nutrient loads through vegetation uptake and in-soil processes.

Based on adopted capacity assessment criteria, the daily hydraulic modelling indicates that an approximate (maximum) irrigation volume of 727kL/day can be sustainably irrigated within the identified DIZs. Therefore, the DIZs provide ample capacity to assimilate the anticipated average RWI volume of 140kL/day.

Surface surcharge or runoff of irrigated recycled water would be expected to occur during heavy rainfall days (>30mm rainfall) but can be effectively avoided through appropriate irrigation scheduling and management (see following section), as well as use of an automated rain gauge irrigation controller and Cooranbong Water's existing recycled water storage facilities.

9 Irrigation Scheduling and Management

For RWI schemes of this scale there should be established procedures and some automated means of preventing irrigation when conditions do not suit. Proper monitoring and operation of the 6.4ML of recycled water storage (LWC and header tanks) and integration with the irrigation scheduling program will be the key to its effectiveness.

It is recommended that a rain gauge sensor that connects electronically with the irrigation pump controls, suspending irrigation when a nominal rainfall volume is recorded (i.e. >30mm within 24 hours). Irrigation operations should ensure that all recycled water is assimilated within the area of application, avoiding both surface runoff and excessive deep infiltration. RWI should be undertaken on a suitable soil moisture deficit basis, i.e. the soil is always allowed to partially dry out before applying a controlled amount of recycled water to increase soil moisture levels to field capacity.

To avoid over irrigation of low lying poorly drained areas, soil moisture monitoring is recommended through the use of soil moisture probes and regular operator inspection of the DIZs. It is anticipated that irrigation control timers will be installed to ensure the design irrigation rates for each zone are not exceeded. Irrigation cycles will be interrupted by the aforementioned rain gauge controller.

As a guide, some simple rules for sustainable RWI management are provided below:

- Do not irrigate while it is raining, or if more than 30mm of rainfall has been recorded in the previous 24 hours;
- Do not irrigate if ponding water is observed in the irrigation area or if runoff is evident;
- Do not irrigate if soils are waterlogged;
- Do ensure that soil moisture conditions are kept within a range that is suitable for plant growth;
- Ensure regular, intermittent dosing of each separate DIZ at application rates sufficient to wet the ground but not cause ponding or runoff;
- For effective utilisation of water on hot days only irrigate early in the morning or late in the afternoon;
- Monitor soils;
- Record irrigation volumes (using a flow meter), and approximate area of the corresponding DIZ each day;
- Test soils occasionally to ensure they are not becoming over-irrigated and assess soil health and the need for fertilising or soil amelioration (e.g. with lime or gypsum); and
- Ensure groundcover health is maintained within each DIZ through appropriate land management practices.

10 Conclusions and Recommendations

This report provides the results and recommendations of our preliminary investigations, including detailed Site and soil investigations and constraints to recycled water management.

The LCA component of the report shows that the Site is varied in terms of its physical characteristics such as topography, drainage and the presence of watercourses; all of which influence the design and proposed location of the designated irrigation zones, although, all buffer distances have been met and recycled water quality is such that it poses a low risk to human health and the environment.

Having undertaken detailed daily hydraulic and nutrient modelling using conservative input data obtained from the LCA, W&A consider that surface irrigation of recycled water is generally appropriate on identified land throughout the Site and the anticipated recycled water volumes from the LWC can be sustainably assimilated.

Ongoing monitoring of irrigation should be undertaken and the performance of the irrigation zones managed using current best practices. This will assist in optimising irrigation operations, while minimising the chance of negative consequences impacting on the environment. We advise that the analysis we have undertaken is conservative and in line with current standard practice.

11 References (Cited and Used)

BMT WBM (2011) *Decentralised Sewage Model User Manual.*

Department of Water and Energy (2008) *Interim NSW Guidelines for Management of Private Recycled Water Schemes.*

Hazelton, P. & Murphy, B. (2007) *Interpreting Soil Test Results, What to all the numbers mean?* CSIRO Publishing, Victoria.

Murphy, C.L. (1993) *Soil Landscapes of the Gosford – Lake Macquarie 1:100,000 Sheet*. Department of Land & water Conservation.

NRMMC, EPHC & AHMC (2006). *Australian Guidelines for Water Recycling: Managing health and environmental risks (phase 1)*.

NSW DEC (2004). *Environmental Guidelines – Use of Effluent by Irrigation*. NSW Department of Environment and Conservation, Sydney.

NSW Department of Local Government et al. (1998). *Environment & Health Protection Guidelines: On-site Sewage Management for Single Households*.

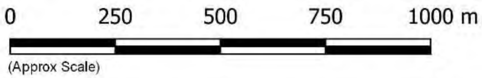
Standards Australia / Standards New Zealand (2012). AS/NZS 1547:2012 *On-site Domestic-wastewater Management*.

Appendix A

Figures & Site Plans

Figure 1: Site Location Plan

2117: Land Capability Assessment and Recycled Water Irrigation Plan - North Cooranbong



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Revision	3
Drawn	NB
Approved	MS

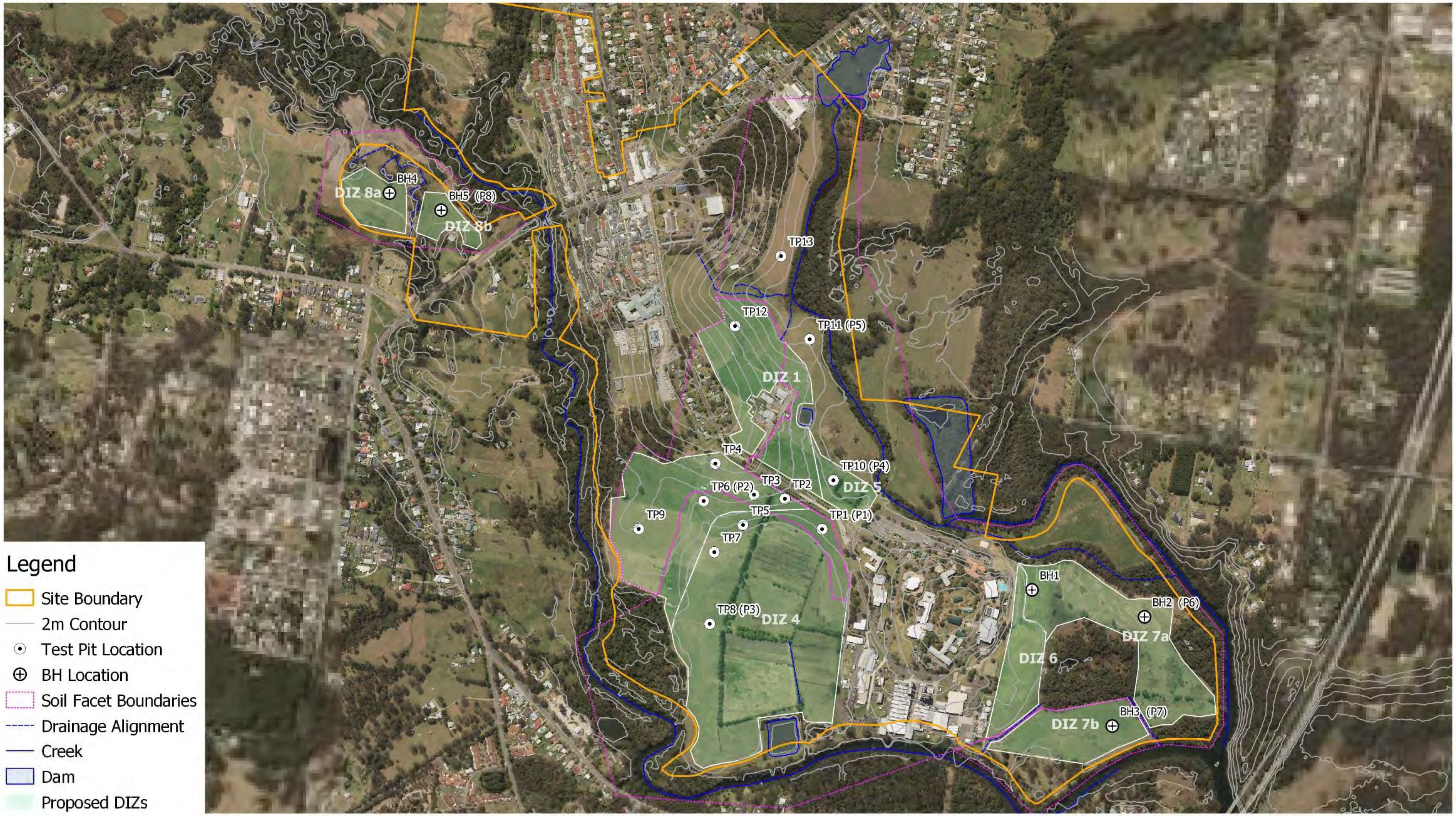

Figure 2: Site Plan Showing Designated Irrigation Zones (DIZs)

2117: Land Capability Assessment and Recycled Water Irrigation Plan - North Cooranbong

N

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0 250 500 750 1000 1250 1500 m

(Approx Scale)

Revision	7
Drawn	NB
Approved	MS

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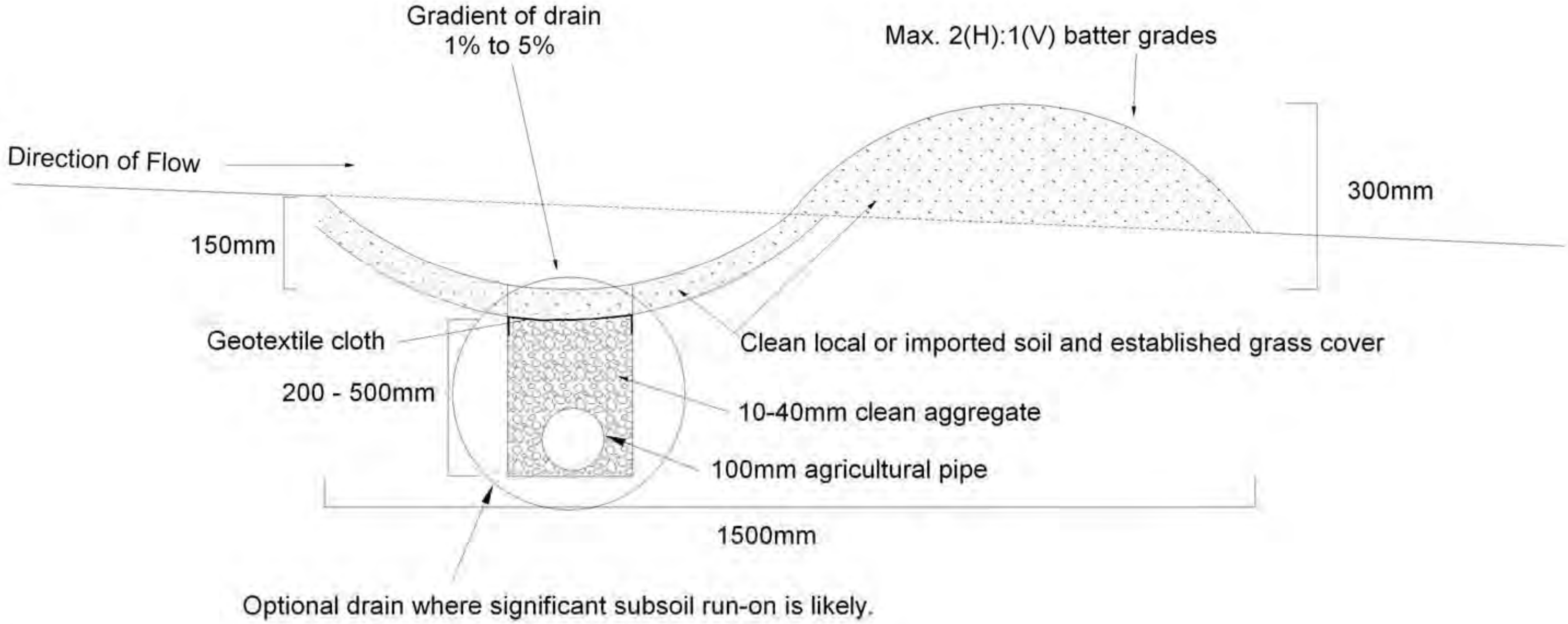
Cross Section: Upslope Diversion Drain



Whitehead & Associates Environmental Consultants	Figure 3: Upslope Diversion Drain	Project: 2117 Scale: NTS Drawn: NB For visualisation purposes only, not for construction use

Appendix B

Soil Borelogs

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Key to Soil Borelogs

Symbols

W	Watertable depth	●	Sample collected
X	Depth of refusal		

Moisture condition

D	Dry
SM	Slightly moist
M	Moist
VM	Very moist
W	Wet / saturated

Graphic Log and Textures

S - Sand
LS - Loamy sand
CS - Clayey sand

CL - Clay loam
SCL - Sandy clay loam
SiCL - Silty clay loam

Gravel (G)

SL - Sandy loam

LC - Light clay
SC - Sandy clay
SiC - Silty clay

Parent material (stiff)

L - Loam
LFS - Loam fine sandy
SiL - Silty loam

MC - Medium clay
HC - Heavy clay

Parent material (weathered)

SOIL BORE LOG

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Client:	RPS Australia	**Borehole No:**	**TP1**
Site:	Central Road, Cooranbong	Excavated/logged by:	N Banbrook
Date:	23 April 2018	Excavation type:	Excavator
Notes:			

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 1/1	A	CL	moderate rough earthy peds	7.5YR 3/1 very dark grey	nil	nil	SM	
0.2										
0.3										
0.4		TP 1/2	B1	MC	subrounded blocky to massive	7.5YR 6/2 pinkish grey	red orange	nil	SM	
0.5										
0.6										
0.7										
0.8										
0.9										
1.0										
1.1		TP 1/3	B2	MC	massive	7.5YR 6/1 grey	maroon orange	nil	SM	
1.2										
1.3										
1.4										
1.5										
1.6		Test pit terminated at 1.5m depth								
1.7										

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	RPS Australia	**Borehole No:**	**TP2**
Site:	Central Road, Cooranbong	Excavated/logged by:	N Banbrook
Date:	23 April 2018	Excavation type:	Excavator
Notes:			

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 2/1	A	fine SCL	moderate rough earthy peds	7.5YR 3/1 very dark grey	nil	nil	SM	
0.2										
0.3										
0.4		TP 2/2	B1	MC	subrounded blocky	7.5YR 5/8 strong brown	red orange	nil	SM	
0.5										
0.6										
0.7										
0.8		TP 2/3	B2	CS	subrounded to rough earthy peds	10YR 6/8 brownish yellow	pale orange	nil	D	
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										
1.6		Test pit terminated at 1.5m depth								
1.7										

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	RPS Australia	**Borehole No:**	**TP3**
Site:	Central Road, Cooranbong	Excavated/logged by:	N Banbrook
Date:	23 April 2018	Excavation type:	Excavator
Notes:			

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 3/1	A	fine SCL	moderate rough earthy peds	7.5YR 3/1 very dark grey	nil	nil	SM	
0.2										
0.3										
0.4		TP 3/2	B1	MC	subrounded blocky	10YR 5/4 yellowish brown	orange	nil	SM	
0.5										
0.6										
0.7		TP 3/3	B2	SC	subrounded to rough earthy peds	10YR 7/3 very pale brown	maroon orange	nil	D	
0.8										
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										
1.6		Test pit terminated at 1.5m depth								
1.7										

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	RPS Australia	**Borehole No:**	**TP4**
Site:	Central Road, Cooranbong	Excavated/logged by:	N Banbrook
Date:	23 April 2018	Excavation type:	Excavator
Notes:			

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 4/1	A	SiCL	weak rough earthy peds	7.5YR 3/1 very dark grey	nil	nil	SM	
0.2										
0.3										
0.4		TP 4/2	B1	MC	massive	10YR 5/2 brown	pale orange	nil	SM	
0.5										
0.6										
0.7										
0.8										
0.9		TP 4/3	B2	MC	massive	10YR 7/1 light grey	red orange	<5% angular cobbles	SM	
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										
1.6		Test pit terminated at 1.5m depth								
1.7										

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	RPS Australia	**Borehole No:**	**TP5**
Site:	Central Road, Cooranbong	Excavated/logged by:	N Banbrook
Date:	23 April 2018	Excavation type:	Excavator
Notes:			

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 5/1	A	SL	weak earthy peds	10YR 4/1 dark grey	nil	nil	SM	
0.2										
0.3										
0.4										
0.5										
0.6										
0.7		TP 5/2	B1	MC	massive	7.5YR 6/2 pinkish grey	pale orange red	nil	SM	
0.8										
0.9										
1.0										
1.1										
1.2		TP 5/3	B2	HC	massive	7.5YR 6/1 grey	nil	nil	SM	
1.3										
1.4										
1.5										
1.6		Test pit terminated at 1.5m depth								
1.7										

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	RPS Australia	**Borehole No:**	**TP6**
Site:	Central Road, Cooranbong	Excavated/logged by:	N Banbrook
Date:	23 April 2018	Excavation type:	Excavator
Notes:			

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 6/1	A	SL	weak to moderate rough peds	7.5YR 3/1 very dark grey	nil	nil	SM	
0.2										
0.3										
0.4										
0.5										
0.6										
0.7		TP 6/2	B1	SC	moderate subrounded blocky	10YR 4/3 brown	pale orange	nil	SM	
0.8										
0.9										
1.0		TP 6/3	B2	MC	subangular blocky	7.5YR 5/8 strong brown	red orange grey	nil	SM	
1.1										
1.2										
1.3										
1.4										
1.5										
1.6		Test pit terminated at 1.5m depth								
1.7										

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	RPS Australia	**Borehole No:**	**TP7**
Site:	Central Road, Cooranbong	Excavated/logged by:	N Banbrook
Date:	23 April 2018	Excavation type:	Excavator
Notes:			

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 7/1	A	CL	weak to moderate rough peds	10YR 2/1 black	nil	nil	SM	
0.2										
0.3										
0.4										
0.5										
0.6		TP 7/2	B1	MC	moderate subrounded blocky to massive	10YR 4/3 brown	orange	nil	SM	
0.7										
0.8										
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										
1.6		Test pit terminated at 1.5m depth								
1.7										

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	RPS Australia	**Borehole No:**	**TP8**
Site:	Central Road, Cooranbong	Excavated/logged by:	N Banbrook
Date:	23 April 2018	Excavation type:	Excavator
Notes:			

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 8/1	A	CL	moderate rough peds	10YR 2/1 black	nil	nil	SM	
0.2										
0.3										
0.4										
0.5										
0.6										
0.7										
0.8										
0.9		TP 8/2	B3	MC	massive	7.5YR 3/1 very dark grey	nil	nil	VM to W	Groundwater seepage at 1.0m depth
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										
1.6		Test pit terminated at 1.5m depth								
1.7										

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	RPS Australia	**Borehole No:**	**TP9**
Site:	Central Road, Cooranbong	Excavated/logged by:	N Banbrook
Date:	23 April 2018	Excavation type:	Excavator
Notes:			

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 9/1	A	fine SCL	weak to moderate rough peds	7.5YR 3/1 very dark grey	nil	nil	SM	
0.2										
0.3										
0.4		TP 9/2	B1	MC	massive	10YR 4/1 dark grey	orange	nil	SM	
0.5										
0.6										
0.7		TP 9/3	B2	HC	massive	10YR 4/3 brown	pale orange	nil	SM	
0.8										
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										
1.6		Test pit terminated at 1.5m depth								
1.7										

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	RPS Australia	**Borehole No:**	**TP10**
Site:	Central Road, Cooranbong	Excavated/logged by:	N Banbrook
Date:	23 April 2018	Excavation type:	Excavator
Notes:			

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 10/1	A	fine SCL	weak to moderate rough peds	10YR 4/2 dark grey brown	nil	nil	SM	
0.2										
0.3										
0.4										
0.5										
0.6										
0.7		TP 10/2	B1	MC	moderate subrounded blocky	10YR 4/1 dark grey	pale orange	nil	SM	
0.8										
0.9										
1.0										
1.1										
1.2										
1.3										
1.4		TP 10/3	B1	CS	moderate	10YR 4/1	orange red	nil	SM	
1.5										
1.6		Test pit terminated at 1.5m depth								
1.7										

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	RPS Australia	**Borehole No:**	**TP11**
Site:	Central Road, Cooranbong	Excavated/logged by:	N Banbrook
Date:	23 April 2018	Excavation type:	Excavator
Notes:			

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1–0.5		TP 11/1	A	fine SL	weak rough peds	10YR 4/2 dark grey brown	nil	nil	SM	
0.6–0.7		TP 11/2	B1	MC	moderate subrounded blocky	10YR 5/4 yellowish brown	orange	nil	SM	
0.8–1.5		TP 11/3	B2	HC	moderate	10YR 6/1 grey	red	nil	SM	
1.6–1.7		Test pit terminated at 1.5m depth								

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	RPS Australia	**Borehole No:**	**TP12**
Site:	Central Road, Cooranbong	Excavated/logged by:	N Banbrook
Date:	23 April 2018	Excavation type:	Excavator
Notes:			

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 12/1	A	SL	weak to moderate rough peds	10YR 4/2 dark grey brown	nil	nil	SM	
0.2										
0.3										
0.4		TP 12/2	B1	MC	moderate subrounded peds	10YR 4/1 dark grey	pale orange	nil	SM	
0.5										
0.6										
0.7										
0.8										
0.9										
1.0		TP 12/3	B4	CS	weak subrounded peds to massive	10YR 5/8 yellowish brown	orange red	nil	SM	
1.1										
1.2										
1.3										
1.4										
1.5										
1.6		Test pit terminated at 1.5m depth								
1.7										

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	RPS Australia	**Borehole No:**	**TP13**
Site:	Central Road, Cooranbong	Excavated/logged by:	N Banbrook
Date:	23 April 2018	Excavation type:	Excavator
Notes:			

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 13/1	A	SL	weak rough peds	7.5YR 3/1 very dark grey	nil	nil	SM	
0.2		TP 13/2	B4	CS	single grained	10YR 5/6 yellowish brown	nil	nil	VM	
0.3										
0.4										
0.5										
0.6		TP 13/3	B1	MC	massive	10YR 6/4 light yellowish brown	grey orange	nil	SM	
0.7										
0.8										
0.9										
1.0		TP 13/4	B2	MC	massive	10YR 4/2 dark grey brown	orange red grey	nil	SM	
1.1										
1.2										
1.3										
1.4										
1.5										
1.6		Test pit terminated at 1.5m depth								
1.7										

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants

Client:	RPS Australia	**Borehole No:**	**BH1**
Site:	Central Road, Cooranbong	Excavated/logged by:	N Banbrook
Date:	5 July 2018	Excavation type:	Hand Auger
Notes:			

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1–0.5		BH 1/1	XX	SC	moderate rough to subrounded peds	10YR 6/3 pale brown	orange grey	10%	SM	Imported fill
0.6–0.8		BH 1/2	A	CL	moderate rough faced earthy peds	10YR 2/1 black	nil	nil	VM	
0.9–1.1		BH 1/3	B1	MC	massive	10YR 3/1 very dark grey	nil	nil	W	
1.2		BH 1/4	B2	MC	massive	10YR 4/2 dark grey brown	nil	2 - 5%	W	
1.3		Borehole terminated at 1.2m depth								
1.4										
1.5										
1.6										
1.7										

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants

Client:	RPS Australia	**Borehole No:**	**BH2**
Site:	Central Road, Cooranbong	Excavated/logged by:	N Banbrook
Date:	5 July 2018	Excavation type:	Hand Auger
Notes:			

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		BH 2/1	A1	SL	weak rough faced peds	10YR 2/1 black	nil	<5%	SM	
0.2										
0.3										
0.4		BH 2/2	B1	MC	moderate rough to subrounded blocky peds	10YR 4/6 dark yellowish brown	orange grey	nil	SM	
0.5										
0.6										
0.7										
0.8		BH 2/3	B1	MC	massive	10YR 4/1 dark grey	orange grey	nil	W	Standing water at 0.9m
0.9										
1.0										
1.1		Borehole terminated at 1.0m depth								
1.2										
1.3										
1.4										
1.5										
1.6										
1.7										

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants

Client:	RPS Australia	**Borehole No:**	**BH3**
Site:	Central Road, Cooranbong	Excavated/logged by:	N Banbrook
Date:	5 July 2018	Excavation type:	Hand Auger
Notes:			

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1–0.7		BH 2/1	A1	SL	weak rough faced peds	10YR 2/1 black		<5%	SM	
0.8–1.0		BH 2/2	A2	S	single grained	10YR 3/1 very dark grey	nil	nil	W	
1.1–1.7		Borehole terminated at 1.0m depth								

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants

Client:	RPS Australia	**Borehole No:**	**BH4**
Site:	Central Road, Cooranbong	Excavated/logged by:	N Banbrook
Date:	5 July 2018	Excavation type:	Hand Auger
Notes:			

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1–0.4		BH 4/1	A1	SiCL	moderate subrounded peds	10YR 4/3 brown	nil	nil	SM	
0.5–1.2		BH 4/2	B1	LC	weak subrounded peds	7.5YR 4/4 brown	grey	nil	SM	
1.3–1.7		Borehole terminated at 1.2m depth								

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants

Client:	RPS Australia	**Borehole No:**	**BH5**
Site:	Central Road, Cooranbong	Excavated/logged by:	N Banbrook
Date:	5 July 2018	Excavation type:	Hand Auger
Notes:			

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		BH 5/1	A1	SiCL	moderate subrounded peds	10YR 4/3 brown	nil	nil	SM	
0.2										
0.3										
0.4		BH 5/2	B1	LC	weak subrounded peds	7.5YR 4/4 brown	orange grey	nil	SM	
0.5										
0.6										
0.7										
0.8										
0.9										
1.0										
1.1										
1.2										
1.3		Borehole terminated at 1.2m depth								
1.4										
1.5										
1.6										
1.7										

Appendix C

Raw Soil Data and Analytical Results

Sample ID	Depth (mm)	CEC (me/100g)	[redacted]	Ca (mg/kg)	[redacted]	Mg (mg/kg)	[redacted]	Na (mg/kg)	[redacted]	K (mg/kg)	[redacted]	ESP (%)	[redacted]	P-sorp. (mg/kg)	[redacted]
TP2 - Composite	1500	10.9	L	514	L	560	H	560	VH	72	VL	22.3	SS	340	MH
TP8 - Composite	1500	7.8	L	534	L	33	VL	75	M	29	VL	4.2	NS	1290	VH
TP9 - Composite	1500	12.4	M	258	VL	389	H	188	H	56	VL	6.6	S	720	VH
TP10 - Composite	1500	11.4	L	521	L	567	H	739	VH	113	L	28.2	VSS	200	M
TP12 - Composite	1500	9.2	L	244	VL	478	H	206	H	129	M	9.8	S	510	H
TP13 - Composite	1500	5.2	VL	209	VL	212	M	106	M	25	VL	8.8	S	210	M

2117 - Soil Sampling Schedule and Results of pH, EC and Emerson Aggregate Test Analysis

Site	Sample Name	Sample Depth (mm)	Texture Class	EAT [1]	Rating [2]	pH_f [3]	$pH_{1:5}$ [4]	Rating	$EC_{1:5}$ (µS/cm)	ECe (dS/m) [5]	Rating	Other analysis [6]
TP1	TP1/1	300	CL	6	Low	-	6.00	Moderately acid	33	0.30	Non-saline	
	TP1/2	1000	MC	2	High	-	5.01	Strongly acid	120	0.84	Non-saline	
	TP1/3	1500	MC	2	High	-	4.91	Very strongly acid	157	1.10	Non-saline	
TP2	TP2/1	400	CL	6	Low	-	5.65	Moderately acid	31	0.28	Non-saline	
	TP2/2	700	MC	5	Low	-	4.83	Very strongly acid	70	0.49	Non-saline	
	TP2/3	1500	CS	6	Low	-	4.40	Extremely acid	157	0.00	Non-saline	
TP3	TP3/1	300	CL	6	Low	-	5.10	Strongly acid	17	0.15	Non-saline	
	TP3/2	600	MC	6	Low	-	5.02	Strongly acid	13	0.09	Non-saline	
	TP3/3	800	CS	6	Low	-	4.21	Extremely acid	225	0.00	Non-saline	
TP4	TP4/1	300	CL	6	Low	-	4.80	Very strongly acid	33	0.30	Non-saline	
	TP4/2	800	MC	8	Low	-	4.17	Extremely acid	291	2.04	Slightly saline	
	TP4/3	1500	MC	8	Low	-	4.15	Extremely acid	270	1.89	Non-saline	
TP5	TP5/1	600	SL	6	Low	-	4.92	Very strongly acid	21	0.23	Non-saline	
	TP5/2	1100	MC	8	Low	-	4.85	Very strongly acid	16	0.11	Non-saline	
	TP5/3	1500	HC	8	Low	-	4.30	Extremely acid	133	0.80	Non-saline	
TP6	TP6/1	650	SL	6	Low	-	5.48	Strongly acid	15	0.17	Non-saline	
	TP6/2	900	SC	6	Low	-	5.15	Strongly acid	50	0.00	Non-saline	
	TP6/3	1500	MC	8	Low	-	4.75	Very strongly acid	62	0.43	Non-saline	
TP7	TP7/1	500	CL	6	Low	-	6.10	Slightly acid	254	2.29	Slightly saline	
	TP7/3	1500	MC	6	Low	-	4.31	Extremely acid	295	2.07	Slightly saline	
TP8	TP8/1	800	CL	6	Low	-	5.66	Moderately acid	251	2.26	Slightly saline	
	TP8/2	1500	MC	6	Low	-	5.25	Strongly acid	41	0.29	Non-saline	
TP9	TP9/1	100	CL	8	Low	-	4.71	Very strongly acid	45	0.41	Non-saline	
	TP9/2	600	LC	5	Low	-	5.10	Strongly acid	34	0.27	Non-saline	
	TP9/3	800	MC	5	Low	-	5.25	Strongly acid	217	1.52	Non-saline	
TP10	TP10/1	600	CL	6	Low	-	5.21	Strongly acid	18	0.16	Non-saline	
	TP10/2	1300	MC	2	High	-	4.59	Very strongly acid	36	0.25	Non-saline	
	TP10/3	1500	CS	2	High	-	4.34	Extremely acid	57	0.00	Non-saline	
TP11	TP11/1	500	SL	6	Low	-	5.18	Strongly acid	25	0.28	Non-saline	
	TP11/2	750	MC	6	Low	-	4.68	Very strongly acid	87	0.61	Non-saline	
	TP11/3	1500	HC	6	Low	-	4.46	Extremely acid	95	0.57	Non-saline	
TP12	TP12/1	300	SL	8	Low	-	5.00	Very strongly acid	155	1.71	Non-saline	
	TP12/2	950	MC	6	Low	-	4.32	Extremely acid	78	0.55	Non-saline	
	TP12/3	1500	CS	6	Low	-	4.20	Extremely acid	238	0.00	Non-saline	
TP13	TP13/1	150	SL	6	Low	-	5.16	Strongly acid	15	0.17	Non-saline	
	TP13/2	500	CS	2	High	-	5.13	Strongly acid	10	0.00	Non-saline	
	TP13/3	900	MC	2	High	-	4.85	Very strongly acid	17	0.12	Non-saline	
	TP13/4	1500	MC	5	Low	-	4.50	Extremely acid	69	0.48	Non-saline	
BH1	BH1/1	500	LC	6	Low	-	5.85	Moderately acid	32	0.26	Non-saline	
	BH1/2	800	CL	6	Low	-	5.89	Moderately acid	46	0.41	Non-saline	
	BH1/3	1100	MC	6	Low	-	5.11	Strongly acid	50	0.35	Non-saline	
	BH1/4	1200	MC	6	Low	-	5.24	Strongly acid	32	0.22	Non-saline	
BH2	BH2/1	300	CL	6	Low	-	5.06	Strongly acid	174	1.57	Non-saline	
	BH2/2	700	MC	6	Low	-	4.56	Very strongly acid	144	1.01	Non-saline	
	BH2/3	1000	MC	5	Low	-	4.47	Extremely acid	148	1.04	Non-saline	
BH3	BH3/1	700	SL	6	Low	-	5.88	Moderately acid	165	1.82	Non-saline	
	BH3/2	1000	S	6	Low	-	5.83	Moderately acid	146	2.48	Slightly saline	
BH4	BH4/1	400	CL	6	Low	-	5.20	Strongly acid	165	1.49	Non-saline	
	BH4/2	1200	LC	6	Low	-	5.03	Strongly acid	146	1.17	Non-saline	
BH5	BH5/1	300	CL	8	Low	-	4.76	Very strongly acid	158	1.42	Non-saline	
	BH5/2	1000	LC	6	Low	-	4.53	Very strongly acid	149	1.19	Non-saline	

Notes:- (also refer Interpretation Sheet 1)

[1] The modified Emerson Aggregate Test (EAT) provides an indication of soil susceptibility to dispersion.

[2] Ratings describe the likely hazard associated with land application of treated wastewater.

[3] pH measured in the field using Raupac Indicator.

[4] pH measured on 1:5 soil:water suspensions using a *Hanna Combo* hand-held pH/EC/temp meter.

[5] Electrical conductivity of the saturated extract (ECe) = $EC_{1:5}$(µS/cm) x MF / 1000. Units are dS/m. MF is a soil texture multiplication factor.

[6] External laboratories used for the following analyses, if indicated:

- CEC (Cation exchange capacity)
- Psorb (Phosphorus sorption capacity)
- Bray Phosphorus
- Organic carbon
- Total nitrogen

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Director: Dr Robert Patterson FIEAust, CPSS, CPAg
Soil Scientists and Environmental Engineers

Lanfax Laboratories
ABN 72 212 385 096
Quality Assurance and Quality Control by Approved Methods

30th April 2018

Whitehead & Associates
197 Main Road
Cardiff NSW 2285

Soil Report: Job No. 2117,
Received 26th April 2018, sample date not stated
Samples dried to 50ºC, crushed and sieved to minus 2 mm prior to analysis

Whitehead & Assoc. - APR18													
Site Location	Exc.Al+H	Ca		K		Mg		Na		Base Sat.	ESP	CEC	Ca/Mg
Sample ID	cmol+/kg	mg/kg	cmol+/kg	mg/kg	cmol+/kg	mg/kg	cmol+/kg	mg/kg	cmol+/kg	%	%	cmol+/kg	ratio
Whitehead&Assoc. 2117, TP2	1.1	514	2.57	72	0.18	560	4.61	560	2.44	89.7	22.3	10.9	0.6
Whitehead&Assoc. 2117, TP8	4.5	534	2.66	29	0.07	33	0.27	75	0.33	42.7	4.2	7.8	9.6
Whitehead&Assoc. 2117, TP9	7.0	258	1.29	56	0.14	389	3.20	188	0.82	43.9	6.6	12.4	0.4
Whitehead&Assoc. 2117, TP10	0.6	521	2.60	113	0.29	567	4.66	739	3.22	94.4	28.2	11.4	0.6
Whitehead&Assoc. 2117, TP12	2.8	244	1.22	129	0.33	478	3.93	206	0.90	69.5	9.8	9.2	0.3
Whitehead&Assoc. 2117, TP13	1.9	209	1.04	25	0.06	212	1.74	106	0.46	63.3	8.8	5.2	0.6

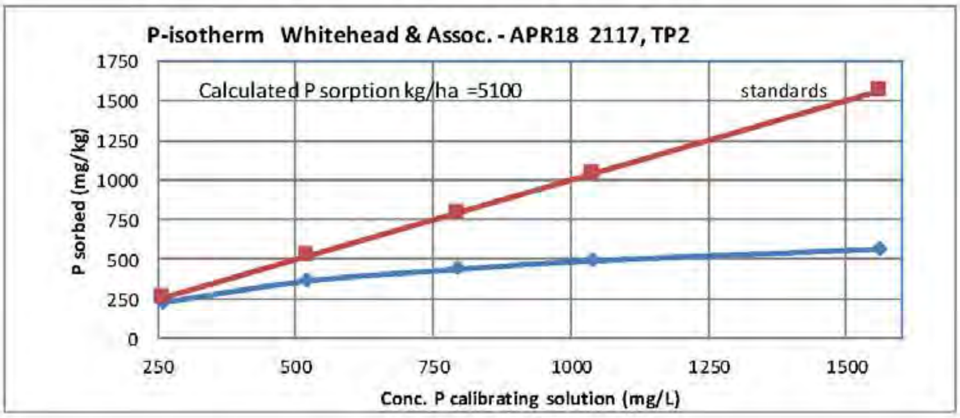
Methods: Rayment & Lyons 2011
P sorption modified method 9J1 - elevated equilibrating solutions, ICP determination of P
Cations: Method 15D3, no pretreatment
Exchangeable Acidity: Method 15G1

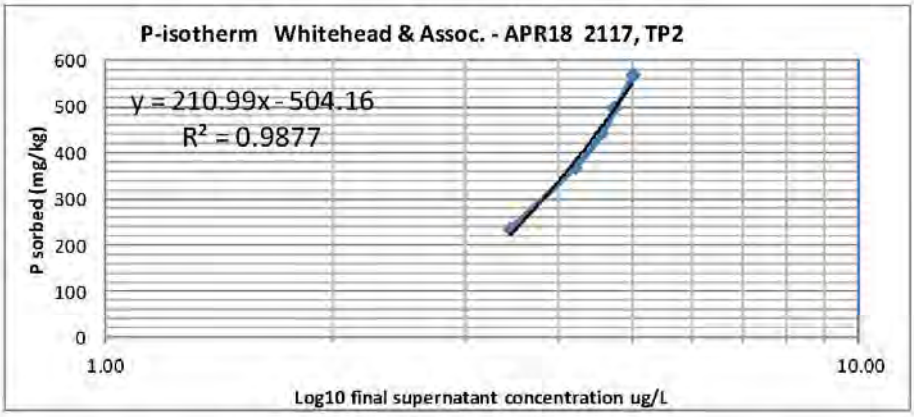
Yours faithfully,

RPatterson

Dr Robert Patterson FIEAust, CPSS(3), CPAg
Soil Scientist and Environmental Engineer

Commercial and research laboratory for soil, water and plant analysis.
Soil survey and analytical assessments, landscape analysis and plant nutrient relationships.
Wastewater and effluent reuse specialists - on-site and decentralised



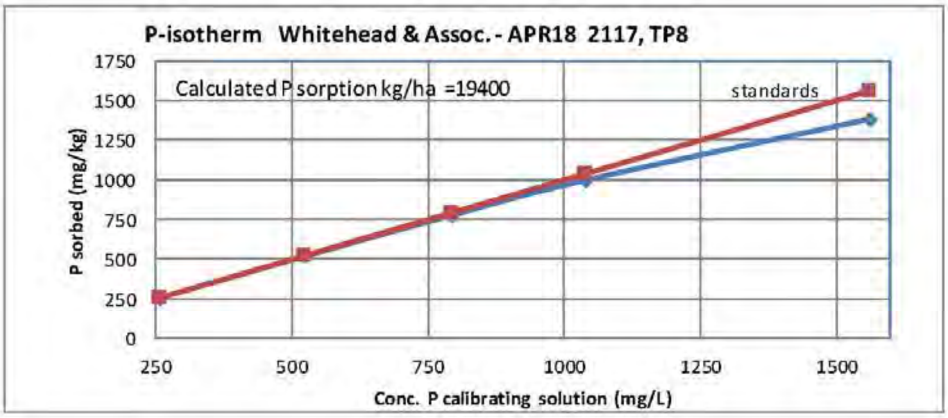


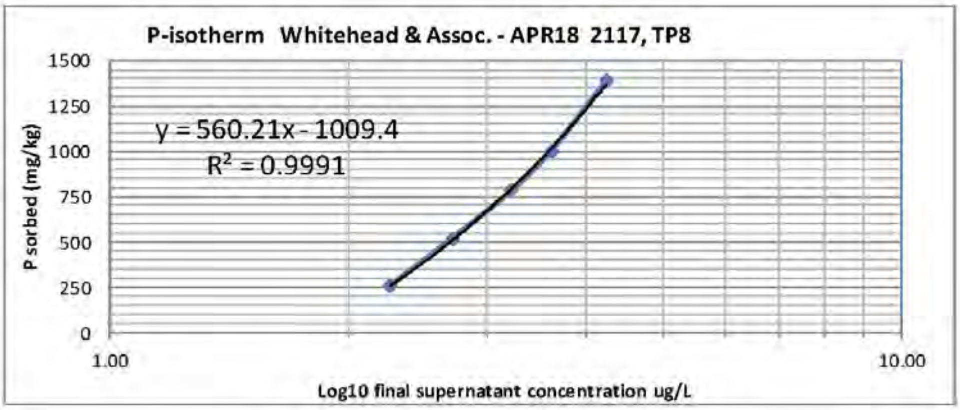
Percent sorbed is the proportion of the initial P sorbed during equilibration

P-isotherm Whitehead & Assoc. - APR18 2

Initial P	filtrate	sorbed P	Sample	Percent		Std line	filtrate	X-axis	Y-axis
mgP/L	P	mg/kg	I.D.	sorbed			C	Log C	
	mg/L			(%)			ugP/L		
26.0	2.75	232.3	Whitehead & Assoc. - APR18	89.4		260	2747	3.44	232.3
52.3	15.50	367.7	2117, TP2	70.3		523	15497	4.19	367.7
79.4	35.38	440.5		55.5		794	35377	4.55	440.5
104.0	54.55	494.3		47.5		1040	54550	4.74	494.3
156.1	99.37	567.8		36.4		1561	99371	5.00	567.8

Calculated P sorption kg/ha = 5100



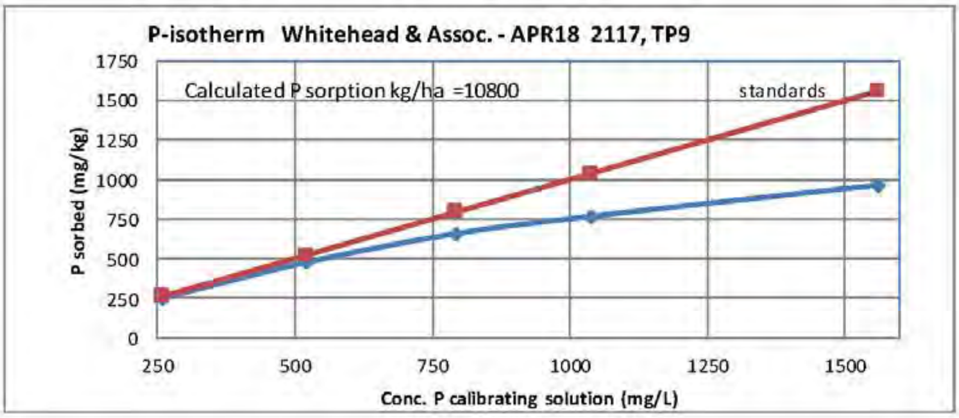


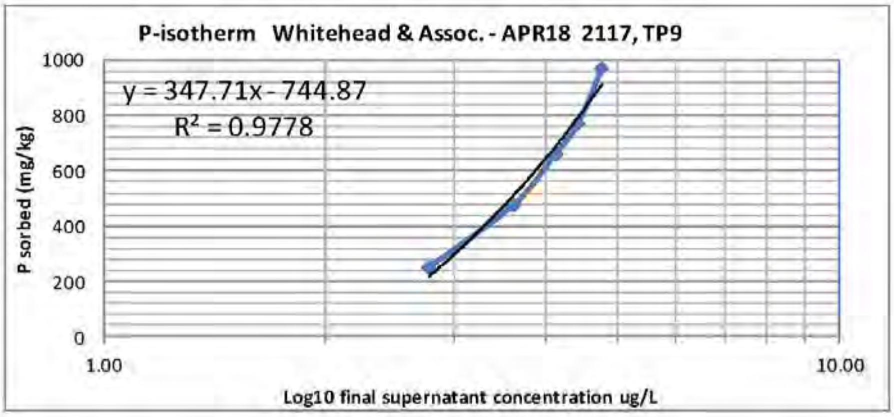
Percent sorbed is the proportion of the initial P sorbed during equilibration

P-isotherm Whitehead & Assoc. - APR18 2

Initial P mgP/L	filtrate P mg/L	sorbed P mg/kg	Sample I.D.	Percent sorbed (%)	Std line	filtrate C ugP/L	X-axis Log C	Y-axis
26.0	0.18	258.0	Whitehead & Assoc. - APR18	99.3	260	181	2.26	258.0
52.3	0.51	517.5	2117, TP8	99.0	523	509	2.71	517.5
79.4	1.63	778.0		98.0	794	1627	3.21	778.0
104.0	4.09	998.9		96.1	1040	4086	3.61	998.9
156.1	17.74	1384.1		88.6	1561	17737	4.25	1384.1

Calculated P sorption kg/ha = 19400



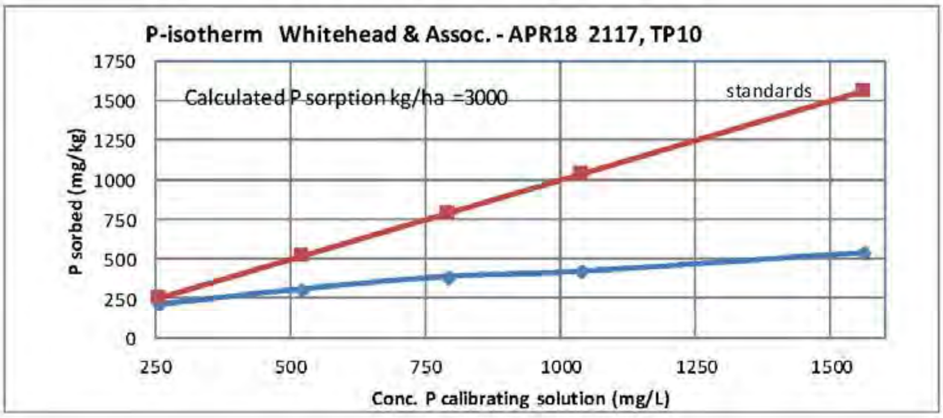


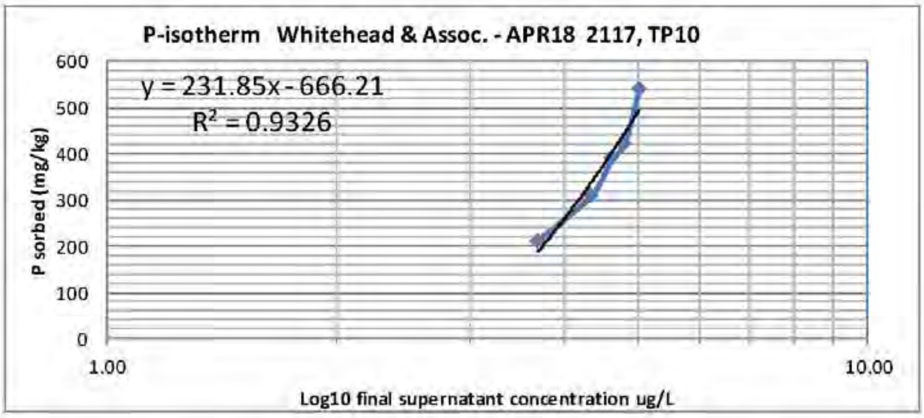
Percent sorbed is the proportion of the initial P sorbed during equilibration

P-isotherm Whitehead & Assoc. - APR18 2

Initial P mgP/L	filtrate P mg/L	sorbed P mg/kg	Sample I.D.	Percent sorbed (%)	Std line	filtrate C ugP/L	X-axis Log C	Y-axis
26.0	0.60	253.8	Whitehead & Assoc. - APR18	97.7	260	597	2.78	253.8
52.3	4.22	480.4	2117, TP9	91.9	523	4219	3.63	480.4
79.4	13.29	661.4		83.3	794	13285	4.12	661.4
104.0	26.91	770.7		74.1	1040	26907	4.43	770.7
156.1	59.27	968.7		62.0	1561	59274	4.77	968.7

Calculated P sorption kg/ha = 10800

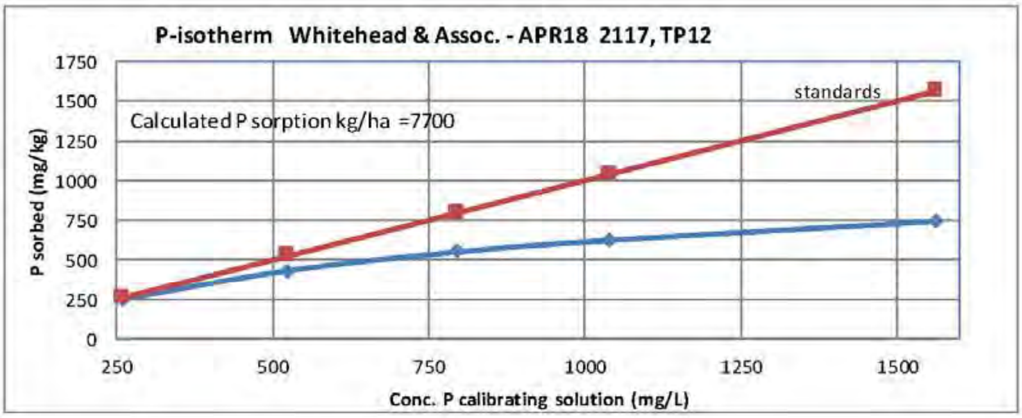


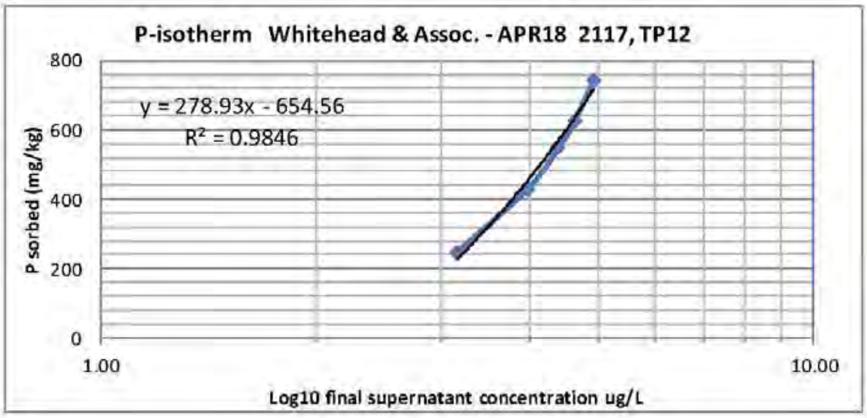


Percent sorbed is the proportion of the initial P sorbed during equilibration — P-isotherm Whitehead & Assoc. - APR18 2

Initial P mgP/L	filtrate P mg/L	sorbed P mg/kg	Sample I.D.	Percent sorbed (%)		Std line	filtrate C ugP/L	X-axis Log C	Y-axis
26.0	4.85	211.3	Whitehead & Assoc. - APR18	81.3		260	4848	3.69	211.3
52.3	21.39	308.8	2117, TP10	59.1		523	21385	4.33	308.8
79.4	40.58	388.4		48.9		794	40579	4.61	388.4
104.0	61.92	420.6		40.4		1040	61919	4.79	420.6
156.1	102.23	539.2		34.5		1561	102231	5.01	539.2

Calculated P sorption kg/ha = 3000



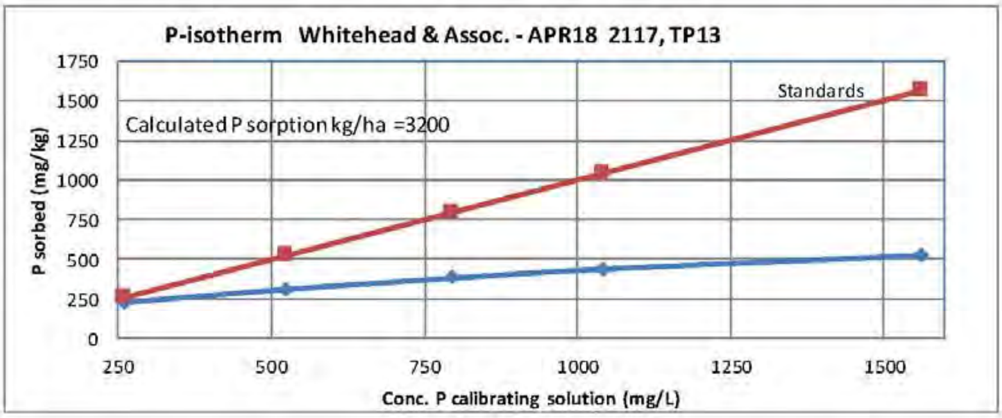


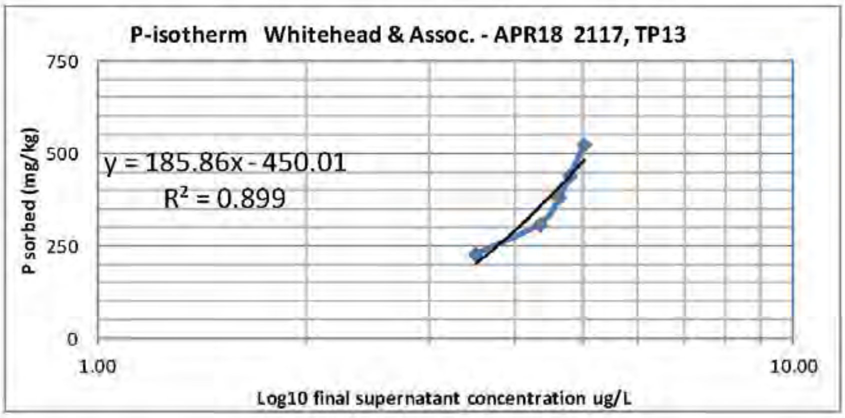
Percent sorbed is the proportion of the initial P sorbed during equilibration

P-isotherm Whitehead & Assoc. - APR18 2

Initial P	filtrate	sorbed P	Sample	Percent		Std line	filtrate	X-axis	Y-axis
mgP/L	P	mg/kg	I.D.	sorbed			C	Log C	
	mg/L			(%)			ugP/L		
26.0	1.44	245.4	Whitehead & Assoc. - APR18	94.5		260	1437	3.16	245.4
52.3	9.29	429.7	2117, TP12	82.2		523	9291	3.97	429.7
79.4	24.41	550.1		69.3		794	24413	4.39	550.1
104.0	41.45	625.3		60.1		1040	41453	4.62	625.3
156.1	81.54	746.1		47.8		1561	81537	4.91	746.1

Calculated P sorption kg/ha = 7700





Percent sorbed is the proportion of the initial P sorbed during equilibration

P-isotherm Whitehead & Assoc. - APR18 2

Initial P mgP/L	filtrate P mg/L	sorbed P mg/kg	Sample I.D.	Percent sorbed (%)	Std line	filtrate C ugP/L	X-axis Log C	Y-axis
26.0	3.18	228.0	Whitehead & Assoc. - APR18	87.8	260	3176	3.50	228.0
52.3	21.27	310.0	2117, TP13	59.3	523	21266	4.33	310.0
79.4	41.30	381.3		48.0	794	41295	4.62	381.3
104.0	60.12	438.6		42.2	1040	60116	4.78	438.6
156.1	103.58	525.7		33.7	1561	103579	5.02	525.7

Calculated P sorption kg/ha = 3200

Appendix D

Permeameter Test Results

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Test # P1 - Adjacent to TP1

Time	Time after start	Level in Tube	Drop of Level	Rate of Water Level Drop
(hr:min:sec)	(min)	(cm)	(cm)	(cm/min)
9:22	0	120.5		
9:27	5	120.5	0.0	0.0
9:32	10	120.3	0.2	0.0
9:37	15	120.2	0.1	0.0
9:42	20	120.1	0.1	0.0
9:47	25	120.0	0.1	0.0
9:52	30	119.7	0.3	0.1
9:57	35	119.5	0.2	0.0
10:02	40	119.5	0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
Selected Steady Rate of Water Level Drop			(cm/min)	0.1
Rate of Loss of Water from Reservoir			(cm^3/min)	0.7

Parameter	**Symbol**	**Value**
Depth of Water in Test Hole (cm)	H	25
Radius of Test Hole (cm)	r	3.75
Inner Tube External Diameter (cm)	D_i	0.9
Outer Tube Internal Diameter (cm)	D_o	3.2
Rate of Water Level Drop (cm/min)	L	0.1
Inner Tube Cross Sectional Area (cm^2)	A_i	0.64
Outer Tube Cross Sectional Area (cm^2)	A_o	8.04
Flowrate (cm^3/min)	Q	0.74
Saturated Hydraulic Conductivity (cm/min)	K_{sat}	0.000487
Saturated Hydraulic Conductivity (m/day)	K_{sat}	0.007020
Saturated Hydraulic Conductivity (mm/day)	K_{sat}	7.019645

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Test #	P2 - Adjacent to TP6

Time (hr:min:sec)	Time after start (min)	Level in Tube (cm)	Drop of Level (cm)	Rate of Water Level Drop (cm/min)
11:05	0	72.8		
11:10	5	72.1	0.7	0.1
11:15	10	70.8	1.3	0.3
11:20	15	70.3	0.5	0.1
11:25	20	69.6	0.7	0.1
11:30	25	67.7	1.9	0.4
11:35	30	65.5	2.2	0.4
11:40	35	63.2	2.3	0.5
11:45	40	61.7	1.5	0.3
11:50	45	60.4	1.3	0.3
11:55	50	59.5	0.9	0.2
12:00	55	57.8	1.7	0.3
12:05	60	56.2	1.6	0.3
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
Selected Steady Rate of Water Level Drop			(cm/min)	0.3
Rate of Loss of Water from Reservoir			(cm^3/min)	2.2

Parameter	**Symbol**	**Value**
Depth of Water in Test Hole (cm)	H	25
Radius of Test Hole (cm)	r	3.75
Inner Tube External Diameter (cm)	D_i	0.9
Outer Tube Internal Diameter (cm)	D_o	3.2
Rate of Water Level Drop (cm/min)	L	0.3
Inner Tube Cross Sectional Area (cm^2)	A_i	0.64
Outer Tube Cross Sectional Area (cm^2)	A_o	8.04
Flowrate (cm^3/min)	Q	2.22
Saturated Hydraulic Conductivity (cm/min)	K_{sat}	0.001462
Saturated Hydraulic Conductivity (m/day)	K_{sat}	0.021059
Saturated Hydraulic Conductivity (mm/day)	K_{sat}	21.058934

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Test # P3 - Adjacent to TP8

Time (hr:min:sec)	Time after start (min)	Level in Tube (cm)	Drop of Level (cm)	Rate of Water Level Drop (cm/min)
12:30	0	86.0		
12:35	5	81.0	5.0	1.0
12:37	7	76.0	5.0	2.5
12:39	9	71.3	4.7	2.4
12:41	11	66.1	5.2	2.6
12:43	13	61.5	4.6	2.3
12:45	15	56.5	5.0	2.5
12:47	17	51.9	4.6	2.3
12:49	19	47.0	4.9	2.5
12:51	21	42.5	4.5	2.3
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
Selected Steady Rate of Water Level Drop			(cm/min)	2.3
Rate of Loss of Water from Reservoir			(cm^3/min)	17.0

Parameter	Symbol	Value
Depth of Water in Test Hole (cm)	H	25
Radius of Test Hole (cm)	r	3.75
Inner Tube External Diameter (cm)	D_i	0.9
Outer Tube Internal Diameter (cm)	D_o	3.2
Rate of Water Level Drop (cm/min)	L	2.3
Inner Tube Cross Sectional Area (cm^2)	A_i	0.64
Outer Tube Cross Sectional Area (cm^2)	A_o	8.04
Flowrate (cm^3/min)	Q	17.03
Saturated Hydraulic Conductivity (cm/min)	K_{sat}	0.011212
Saturated Hydraulic Conductivity (m/day)	K_{sat}	0.161452
Saturated Hydraulic Conductivity (mm/day)	K_{sat}	161.451828

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Test #	P4 - Adjacent to TP10

Time	Time after start	Level in Tube	Drop of Level	Rate of Water Level Drop
(hr:min:sec)	(min)	(cm)	(cm)	(cm/min)
13:56	0	115.8		
15:30	34	108.6	7.2	0.2
16:01	65	100.8	7.8	0.3
16:03	67	100.3	0.5	0.3
16:05	69	99.7	0.6	0.3
16:07	71	99.1	0.6	0.3
16:09	73	98.6	0.5	0.3
16:11	75	97.6	1.0	0.5
16:13	77	97.0	0.6	0.3
16:15	79	96.1	0.9	0.5
16:17	81	95.5	0.6	0.3
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
Selected Steady Rate of Water Level Drop			(cm/min)	0.3
Rate of Loss of Water from Reservoir			(cm^3/min)	2.2

Parameter	**Symbol**	**Value**
Depth of Water in Test Hole (cm)	H	25
Radius of Test Hole (cm)	r	3.75
Inner Tube External Diameter (cm)	D_i	0.9
Outer Tube Internal Diameter (cm)	D_o	3.2
Rate of Water Level Drop (cm/min)	L	0.3
Inner Tube Cross Sectional Area (cm^2)	A_i	0.64
Outer Tube Cross Sectional Area (cm^2)	A_o	8.04
Flowrate (cm^3/min)	Q	2.22
Saturated Hydraulic Conductivity (cm/min)	K_{sat}	0.001462
Saturated Hydraulic Conductivity (m/day)	K_{sat}	0.021059
Saturated Hydraulic Conductivity (mm/day)	K_{sat}	21.058934

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Test #	P5 - Adjacent to TP11

Time	Time after start	Level in Tube	Drop of Level	Rate of Water Level Drop
(hr:min:sec)	(min)	(cm)	(cm)	(cm/min)
14:17	0	127.2		
15:15	58	105.9	21.3	0.4
15:38	81	92.2	13.7	0.6
15:40	83	90.9	1.3	0.6
15:42	85	89.5	1.4	0.7
15:44	87	88.3	1.2	0.6
15:46	89	87.1	1.2	0.6
15:48	91	85.5	1.6	0.8
15:50	93	84.1	1.4	0.7
15:52	95	82.7	1.4	0.7
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
Selected Steady Rate of Water Level Drop			(cm/min)	0.7
Rate of Loss of Water from Reservoir			(cm^3/min)	5.2

Parameter	**Symbol**	**Value**
Depth of Water in Test Hole (cm)	H	20
Radius of Test Hole (cm)	r	3.75
Inner Tube External Diameter (cm)	D_i	0.9
Outer Tube Internal Diameter (cm)	D_o	3.2
Rate of Water Level Drop (cm/min)	L	0.7
Inner Tube Cross Sectional Area (cm^2)	A_i	0.64
Outer Tube Cross Sectional Area (cm^2)	A_o	8.04
Flowrate (cm^3/min)	Q	5.18
Saturated Hydraulic Conductivity (cm/min)	K_{sat}	0.004604
Saturated Hydraulic Conductivity (m/day)	K_{sat}	0.066292
Saturated Hydraulic Conductivity (mm/day)	K_{sat}	66.291655

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Test # P6 - Adjacent to BH2

Time	Time after start	Level in Tube	Drop of Level	Rate of Water Level Drop
(hr:min:sec)	(min)	(cm)	(cm)	(cm/min)
11:11:00	0	114.1		
13:30:00	139	113.5	0.6	0.00432
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
Selected Steady Rate of Water Level Drop			(cm/min)	0.0
Rate of Loss of Water from Reservoir			(cm^3/min)	0.0

Parameter	**Symbol**	**Value**
Depth of Water in Test Hole (cm)	H	25
Radius of Test Hole (cm)	r	3.75
Inner Tube External Diameter (cm)	D_i	0.9
Outer Tube Internal Diameter (cm)	D_o	3.2
Rate of Water Level Drop (cm/min)	L	0.0
Inner Tube Cross Sectional Area (cm^2)	A_i	0.64
Outer Tube Cross Sectional Area (cm^2)	A_o	8.04
Flowrate (cm^3/min)	Q	0.03
Saturated Hydraulic Conductivity (cm/min)	K_{sat}	0.000019
Saturated Hydraulic Conductivity (m/day)	K_{sat}	0.000281
Saturated Hydraulic Conductivity (mm/day)	K_{sat}	0.280786

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Test # P7 - Adjacent to BH3

Time	Time after start	Level in Tube	Drop of Level	Rate of Water Level Drop
(hr:min:sec)	(min)	(cm)	(cm)	(cm/min)
13:40:00	0	83.3		
15:22:00	102	69.1	14.2	0.13922
15:28:00	108	66.5	2.6	0.4
15:32:00	112	65.6	0.9	0.2
15:36:00	116	64.4	1.2	0.3
15:46:00	126	61.3	3.1	0.3
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
Selected Steady Rate of Water Level Drop			(cm/min)	0.3
Rate of Loss of Water from Reservoir			(cm^3/min)	2.2

Parameter	Symbol	Value
Depth of Water in Test Hole (cm)	H	25
Radius of Test Hole (cm)	r	3.75
Inner Tube External Diameter (cm)	D_i	0.9
Outer Tube Internal Diameter (cm)	D_o	3.2
Rate of Water Level Drop (cm/min)	L	0.3
Inner Tube Cross Sectional Area (cm^2)	A_i	0.64
Outer Tube Cross Sectional Area (cm^2)	A_o	8.04
Flowrate (cm^3/min)	Q	2.22
Saturated Hydraulic Conductivity (cm/min)	K_{sat}	0.001462
Saturated Hydraulic Conductivity (m/day)	K_{sat}	0.021059
Saturated Hydraulic Conductivity (mm/day)	K_{sat}	21.058934

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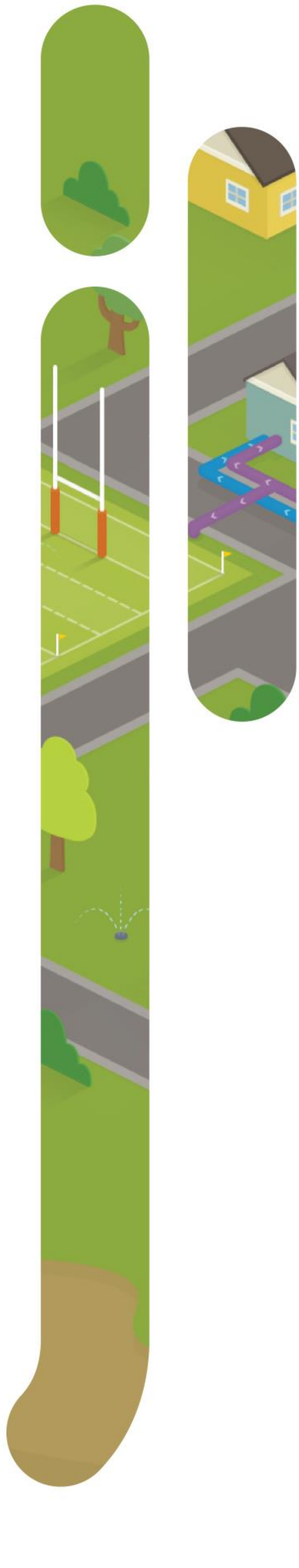
Test # P8 - Adjacent to BH5

Time (hr:min:sec)	Time after start (min)	Level in Tube (cm)	Drop of Level (cm)	Rate of Water Level Drop (cm/min)
12:40:00	0	122.5		
14:17:00	97	119.1	3.4	0.03505
14:56:00	136	119.0	0.1	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
Selected Steady Rate of Water Level Drop			(cm/min)	0.0
Rate of Loss of Water from Reservoir			(cm^3/min)	0.3

Parameter	Symbol	Value
Depth of Water in Test Hole (cm)	H	25
Radius of Test Hole (cm)	r	3.75
Inner Tube External Diameter (cm)	D_i	0.9
Outer Tube Internal Diameter (cm)	D_o	3.2
Rate of Water Level Drop (cm/min)	L	0.0
Inner Tube Cross Sectional Area (cm^2)	A_i	0.64
Outer Tube Cross Sectional Area (cm^2)	A_o	8.04
Flowrate (cm^3/min)	Q	0.26
Saturated Hydraulic Conductivity (cm/min)	K_{sat}	0.000171
Saturated Hydraulic Conductivity (m/day)	K_{sat}	0.002457
Saturated Hydraulic Conductivity (mm/day)	K_{sat}	2.456876

flow

Monitoring and Sampling Plan (MSP)



Document Issue Record

Issue Date	Rev	Change	Issued To	Prepared By	Approved By
24/10/14	1	First revision	Flow	Kirsten Evans	Andrew Horton
12/12/14	2	Minor formatting corrections	Flow	Kirsten Evans	Andrew Horton
30/1/15	3	Added AMP to Table 1	Flow	Kirsten Evans	Andrew Horton
22/5/14	4	Amended Table 10 to require 12 validation samples (instead of 10 samples)	Flow	Kirsten Evans	Andrew Horton
8/9/15	5	Amended to add interim drinking water supply	Flow	Kirsten Evans	Andrew Horton
22/11/16	6	Annual review and update	Flow	Laura Dixon	Andrew Horton
22/01/18	7	Annual review	Flow	Laura Dixon	Andrew Horton
8/06/18	8	Amended to include monitoring as required by the Recycled Water Irrigation Management Plan (RWIMP) Inserted Section 7 Monitoring of Designated Irrigation Zones	Flow	CWT / Michael Northcott	Andrew Horton

Contents MSP