PUBLIC APPLICATION

Cooranbong Water

Appendix 4.1.1(a) Process Flow Diagram (Potable Water)

flow systems

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

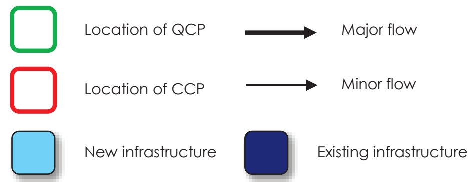
QUALITY CONTROL POINTS (QCP) FOR WATER QUALITY

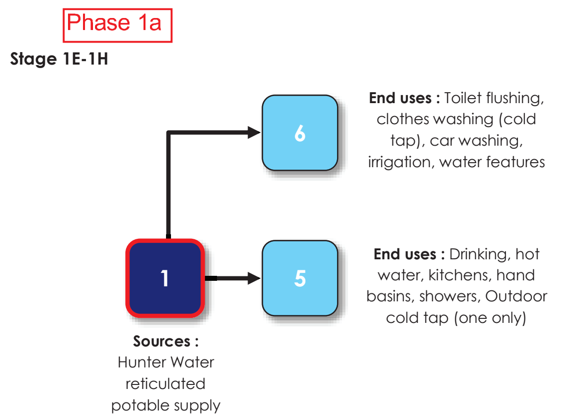
POTABLE WATER STORAGE (2)
- Free chlorine
- pH

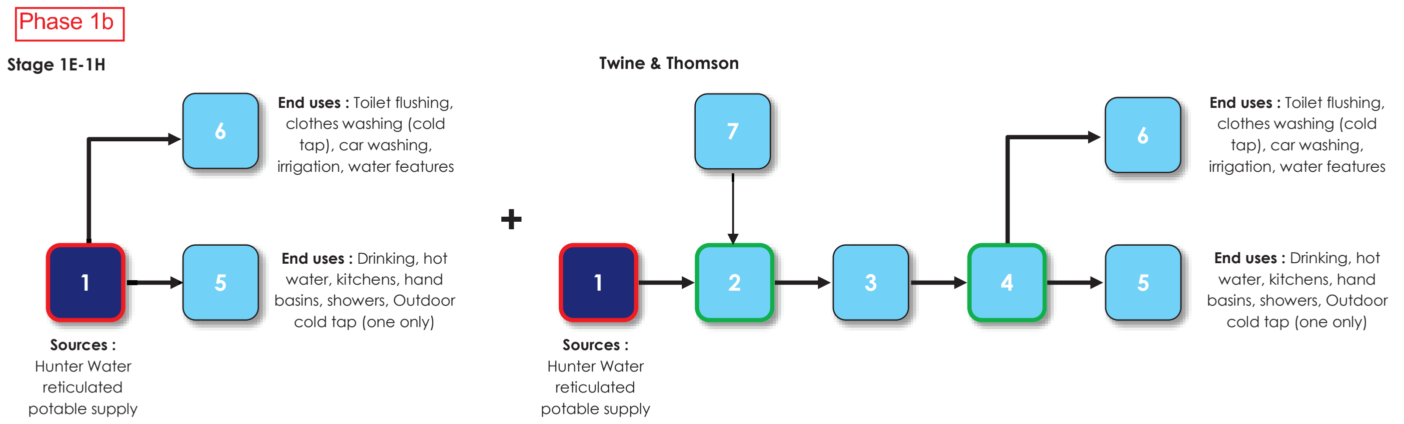
POTABLE WATER DISTRIBUTION (3)
- Turbidity
- Pressure

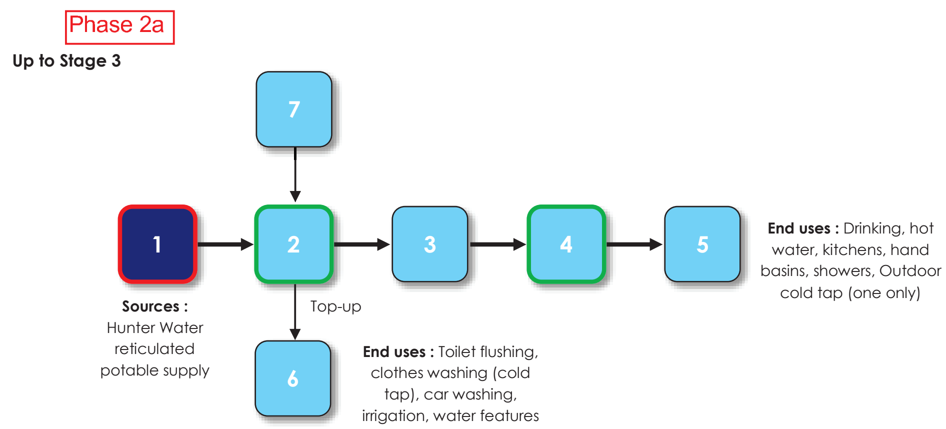
CRITICAL CONTROL POINTS (CCP) FOR WATER QUALITY

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

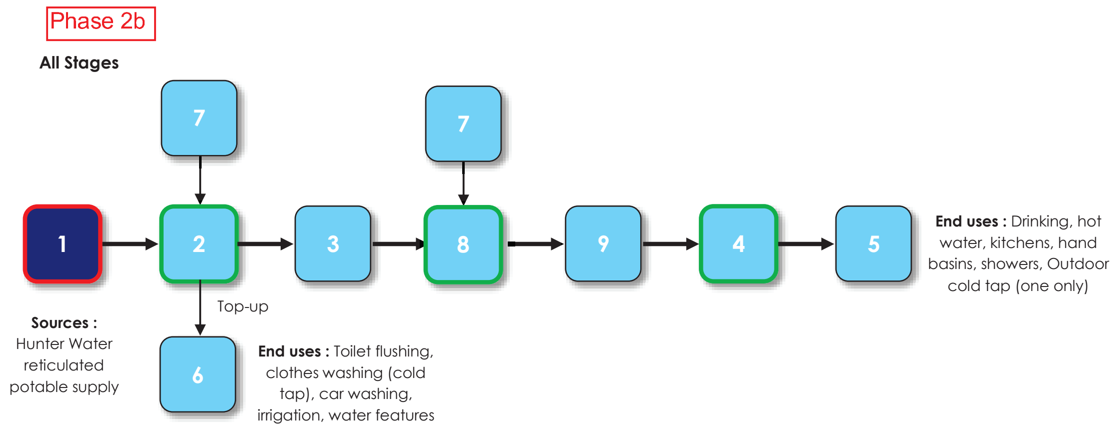








(Refer to 10 on C14107-201)



(Refer to 10 on C14107-201)

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No.	Date	Drafter	Design	Mgmt	Amendment
C	030614	AJC			For information
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 NTS	Permeate Project # C14107	Permeate Drawing # C14107-202
Sheet A3	Client Project # TBA	Client Drawing # TBA

PUBLIC APPLICATION

Cooranbong Water

Appendix 4.1.1(b) Letter of Support from Hunter Water

flow systems

Hunter Water Corporation
ABN 46 228 513 446

PO Box 5171
HRMC NSW 2310
36 Honeysuckle Drive
NEWCASTLE NSW 2300
1300 657 657
(02) 4979 9625 (F)
enquiries@hunterwater.com.au

5 June 2014

Our Ref: 2007-94/23/23.005

Flow Systems
Suite 201, Level 2
1 Alfred Street
SYDNEY NSW 2000

COORANBONG WATER - UTILITY SERVICES AGREEMENT
Letter of Support - Independent Pricing & Regulatory Tribunal Licence Application

Hunter Water is offering this letter of support to form part of the 'Cooranbong Water' licence application being made by Flow Systems to the Independent Pricing and Regulatory Tribunal under the Water Industry Competition Act (WICA). Hunter Water understands that Cooranbong Water will be a wholly owned subsidiary of Flow Systems. 'Cooranbong Water' is referred to from here on in this correspondence.

In this instance the predominant land developer in North Cooranbong is JPG, holding approximately 2,350 lots of the planned 2,500 lot potential in the release area. JPG has engaged Cooranbong Water to supply a range of water utility services to 'Watagan Park' estate, amongst other relatively minor nearby developments comprising the release area.

Hunter Water is continuing to negotiate with Cooranbong Water regarding the bulk supply of drinking water and an interim point of connection to sewer services. Progress has been made on a number of technical and commercial terms. An initial draft 'Utility Services Agreement' has been provided to Hunter Water for consideration, joint development and future negotiation.

While the technical and commercial terms are yet to be finalised, it is intended that Hunter Water and Cooranbong Water enter a 'Utility Services Agreement' that contemplates:

Bulk Water Supply:

1. Hunter Water supplying bulk drinking water to Cooranbong Water at North Cooranbong;
2. Augmentation of Hunter Water's water network is to be undertaken by the developer in accordance with the approved North Cooranbong Development Water Servicing Strategy (Version C, September 2013), as amended, and in consultation with Cooranbong Water;
3. The points of connection to Hunter Water's water network are shown diagrammatically in Appendix A.

Interim Sewer Servicing:

4. On a commercial basis Hunter Water is willing to consider an interim single sewer point of connection for Cooranbong Water in lieu of their commissioned local wastewater treatment facility. This is subject to reaching a satisfactory commercial arrangement that adequately addresses Hunter Water's operational and environmental risks in a range of operating scenarios including the potential delayed availability of the wastewater treatment plant or the treatment plant not being able to be established at all.
5. Cooranbong Water have advised that the local waste water treatment facility will be available by August 2016. Hunter Water requires that the interim sewer connection arrangement, therefore, must be abandoned by August 2016, or as soon as the treatment plant is available, whichever is the earlier;

6. The interim sewer servicing arrangement must be controlled to ensure that by accepting the interim sewer discharges, Hunter Water is able to remain compliant with its own regulatory and licencing obligations and maintain service standards to its existing customers;

7. Flow Systems have advised that up to a maximum of 156 lots may connect during the period to establish the local wastewater treatment plant generating a peak sewer discharge of 4.0L/sec from the pressure sewer network.

8. Hunter Water requires that the proposed pressure sewer network operated by Cooranbong Water be able to be remotely isolated from the Hunter Water sewer network during a number of abnormal operating events. The satisfactory operation of the interim sewer servicing arrangement relies on the provision of 24 hours emergency storage on each lot and the ability to cease discharge as required from time to time.

9. The interim sewer connection point will need to be setup to provide interoperability with Hunter Water downstream assets. Isolation during power outages, high well alarms or other as yet unspecified events will be required.

Discharge of excess untreated or treated effluent to Hunter Water

10. Cooranbong Water have indicated that from time to time the need may arise to discharge either excess treated wastewater or, in the event that their treatment plant is offline, discharge untreated sewerage to Hunter Water's network.

11. Depending on the circumstance presented at the time of the need arising, Hunter Water will work with Cooranbong Water to assist where possible. The operational status of Hunter Water infrastructure at the time of the request will influence the ability of Hunter Water in this regard. Direct discharge to the local network, road tankering of waste to Dora Creek WWTW, or to other downstream assets may be possible.

12. Each request will be considered on its merit giving consideration to the operational and environmental impacts that may ensue for both network operators.

13. Depending on the characteristics of the discharge requested, tariff costs may be incurred by Cooranbong Water.

14. Hunter Water is not able to offer a standing arrangement that can be called upon at will by Cooranbong Water to discharge excess treated or untreated sewerage.

Other matters

15. Cooranbong Water will be responsible for the provision of operation, maintenance and retail services to all customers upstream of the point of connection to the water and sewer network of Hunter Water.

16. Other interface requirements as needed.

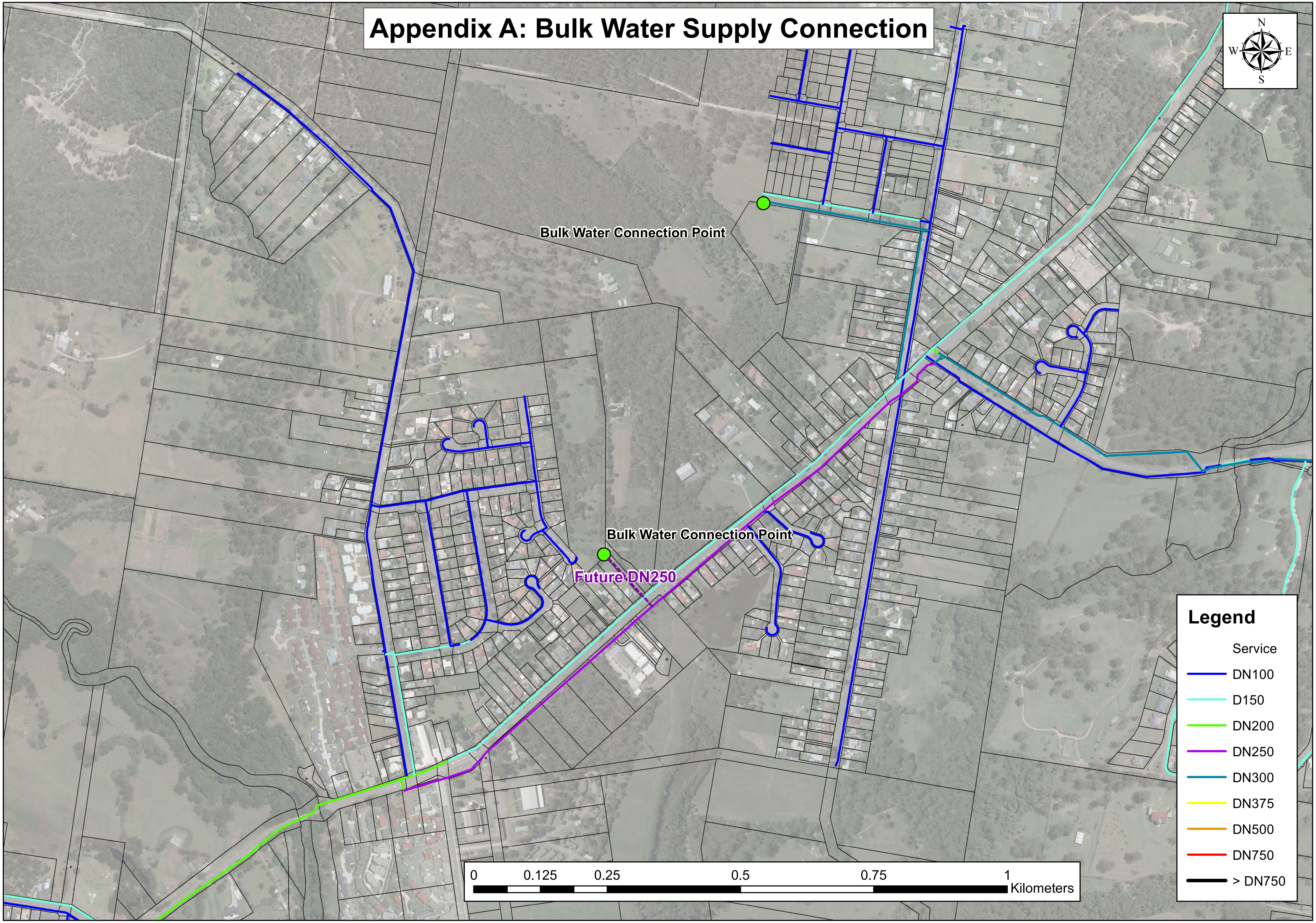
Hunter Water looks forward to establishing an ongoing commercial relationship with Cooranbong Water. Should you wish to discuss these matters further please contact me on (02) 4979-9495.

Yours faithfully

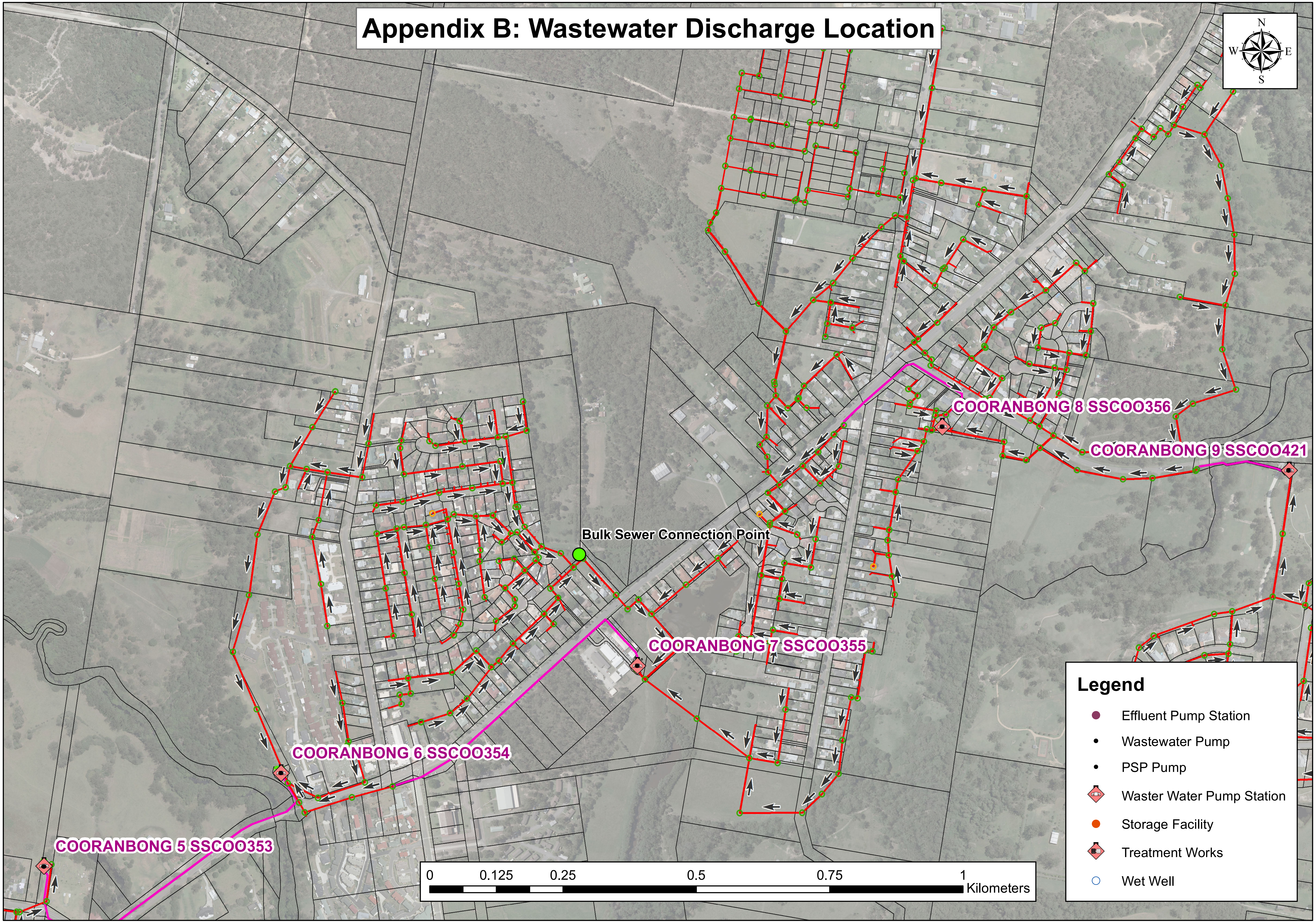
DEAN TAYLOR
Chief Customer Services Officer

Attached: **Appendix A – Water Connection Points**
Appendix B – Interim Sewer Connection Point

Appendix A: Bulk Water Supply Connection



Appendix B: Wastewater Discharge Location



Cooranbong Water

Appendix 4.1.1(c) Water Servicing Strategy (extract)

flow systems

North Cooranbong Development

Bulk Water Servicing Strategy

301020-06837 – WW-REP-0002

6 February 2015

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Newcastle, NSW 2304 Australia
PO Box 814 NEWCASTLE NSW 2300
Telephone: +61 2 4985 0000
Facsimile: +61 2 4985 0099
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ABN 61 001 279 812

Disclaimer

This report has been prepared on behalf of and for the exclusive use of Flow Systems / Cooranbong Water, and is subject to and issued in accordance with the agreement between Flow Systems / Cooranbong Water and WorleyParsons. WorleyParsons accepts no liability or responsibility whatsoever for it in respect of any use of or reliance upon this report by any third party.

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PROJECT 301020-06837 - NORTH COORANBONG DEVELOPMENT

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
C	Issued for internal review	A.Ford	L.Russell		27 May 14	N/A	
D	Issued for client approval	A.Ford	L.Russell	I.Waterman	28 May 14		N/A
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

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.

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:

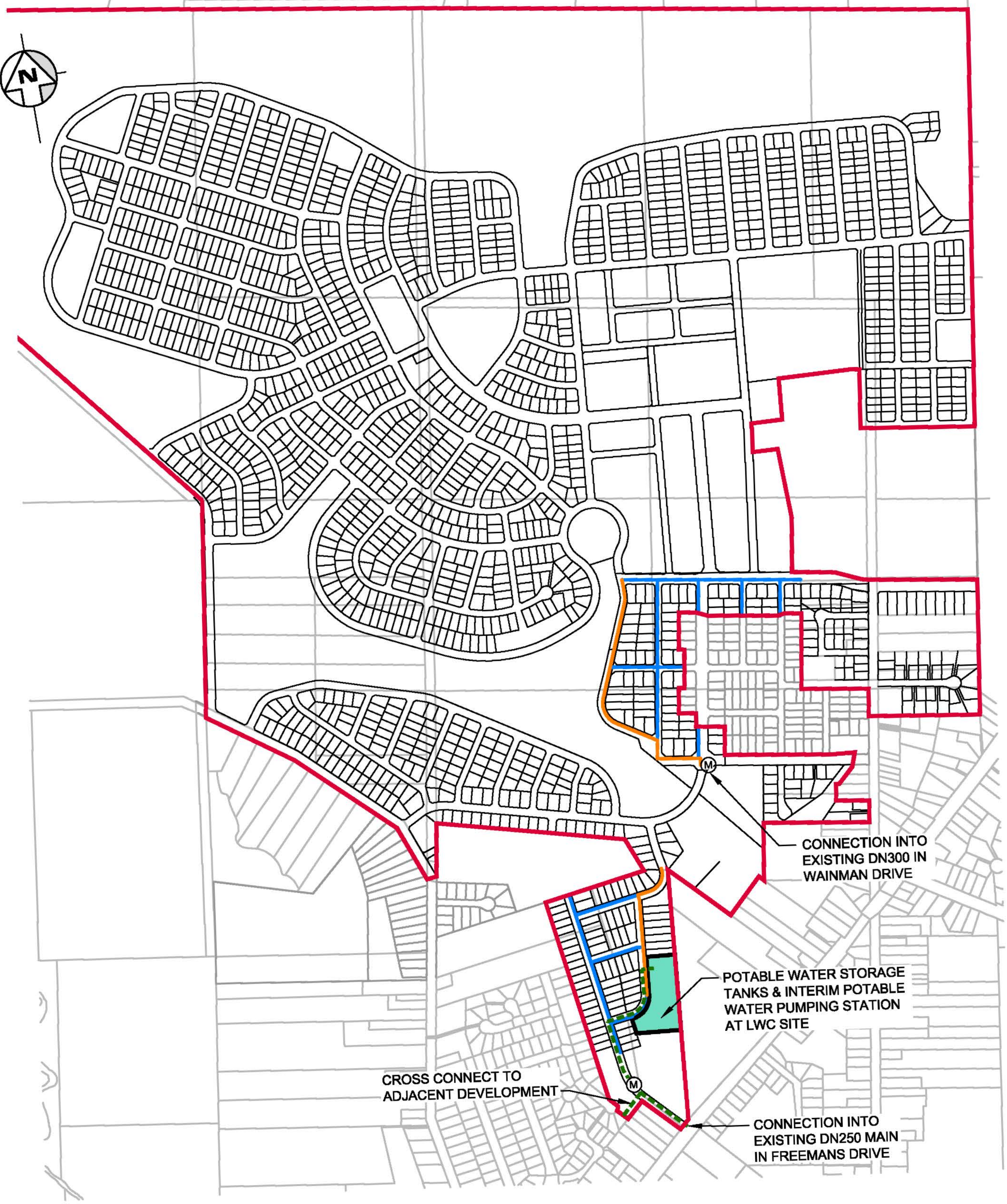
- Review existing servicing strategies (HWA 2009 and SMEC 2013).
- Obtain the existing HWC InfoWorks model of the water supply system in the North Cooranbong area.
- Run the existing InfoWorks model to check current operating pressures within HWC's water supply system.
- Update the InfoWorks model to include demands from the North Cooranbong development.
- Run the updated InfoWorks model.
- Determine the works required and staging options to service the 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.

PUBLIC APPLICATION

Cooranbong Water

Appendix 4.1.1(d) Potable Water Reticulation Masterplan

flow systems



LEGEND

DN100 PVC - M

DN200 PVC - M

(M) BULK WATER METER

DELIVERY MAIN TO POTABLE WATER STORAGE TANKS (APPROX. DN200 PVC - M)

OPERATIONS BOUNDARY

flow systems

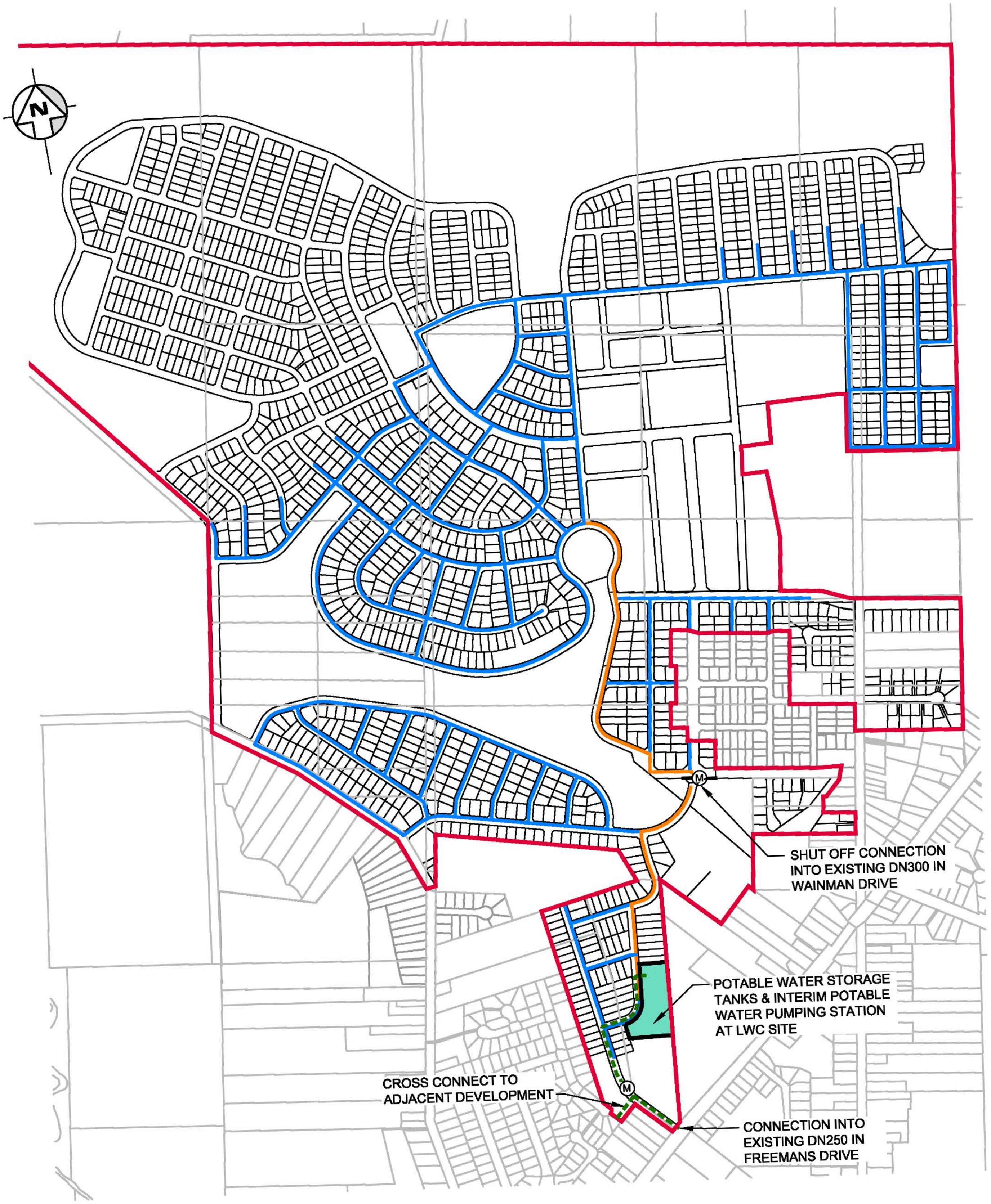
Cooranbong Water

NORTH COORANBONG POTABLE WATER MASTER PLAN FIRST 156 LOTS

WorleyParsons
resources & energy

O:\301020\06837 — Watagan Park Masterplan\12.0 Drawings\12.13 Water\FIGURES\301020-06837-FIG-04.dwg
28/05/2014

FIGURE 5



LEGEND

- DN100 PVC - M
- DN200 PVC - M
- (M) BULK WATER METER
- DELIVERY MAIN TO POTABLE WATER STORAGE TANKS (APPROX. DN200 PVC - M)
- OPERATIONS BOUNDARY

flow systems

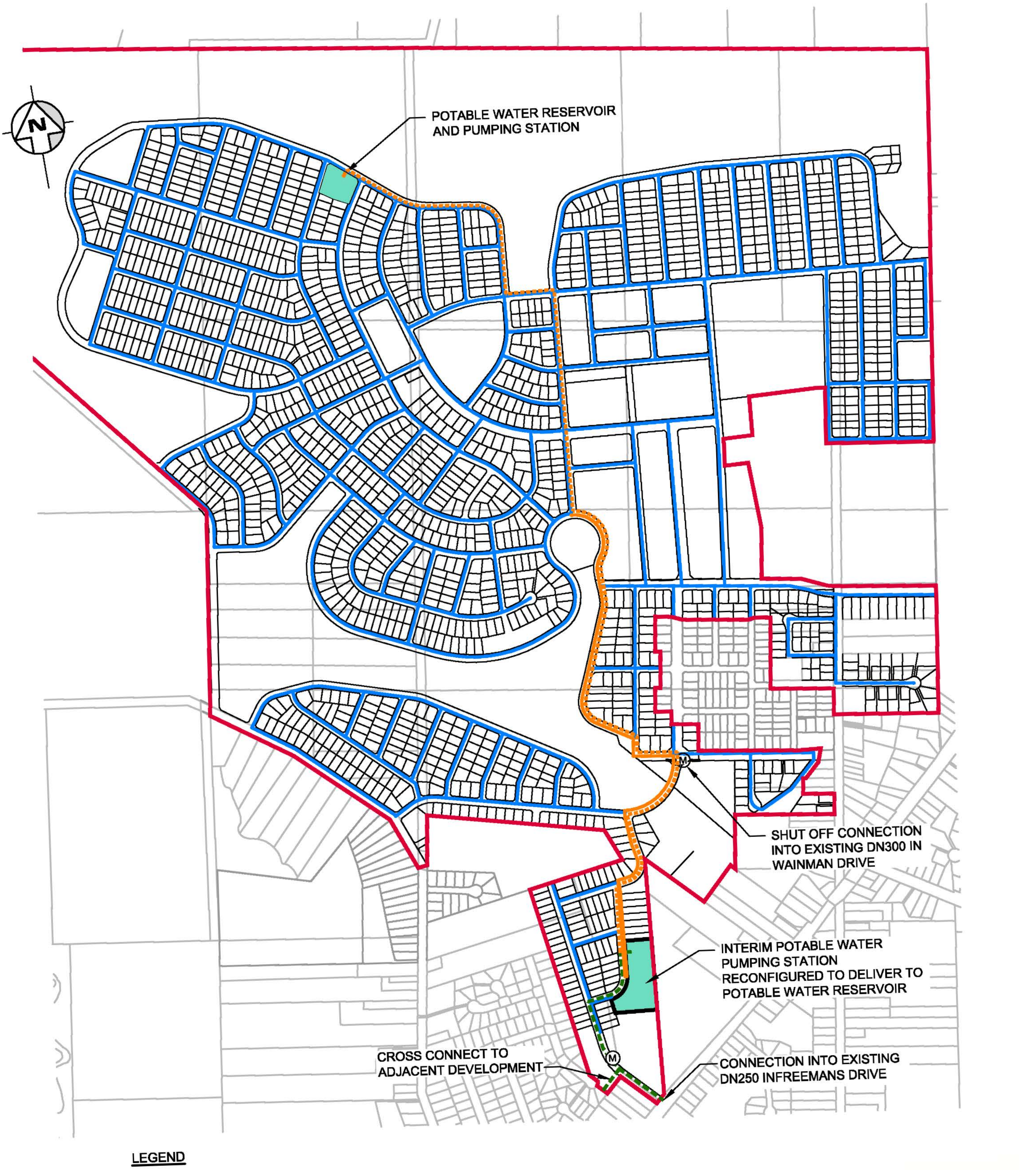
Cooranbong Water

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

WorleyParsons
resources & energy

O:\301020\06837 – Watagan Park Masterplan\12.0 Drawings\12.13 Water\FIGURES\301020–06837–FIG–05.dwg
28/05/2014

FIGURE 6



LEGEND

- DN100 PVC - M
- DN200 PVC - M
- (M) BULK WATER METER
- DELIVERY MAIN TO LWC SITE (APPROX. DN200 PVC - M)
- OPERATIONS BOUNDARY
- DELIVERY MAIN TO RESERVOIR (AFTER STAGE 7B)

flow systems

Cooranbong Water

WorleyParsons
resources & energy

NORTH COORANBONG
POTABLE WATER MASTER PLAN
ULTIMATE DEVELOPMENT

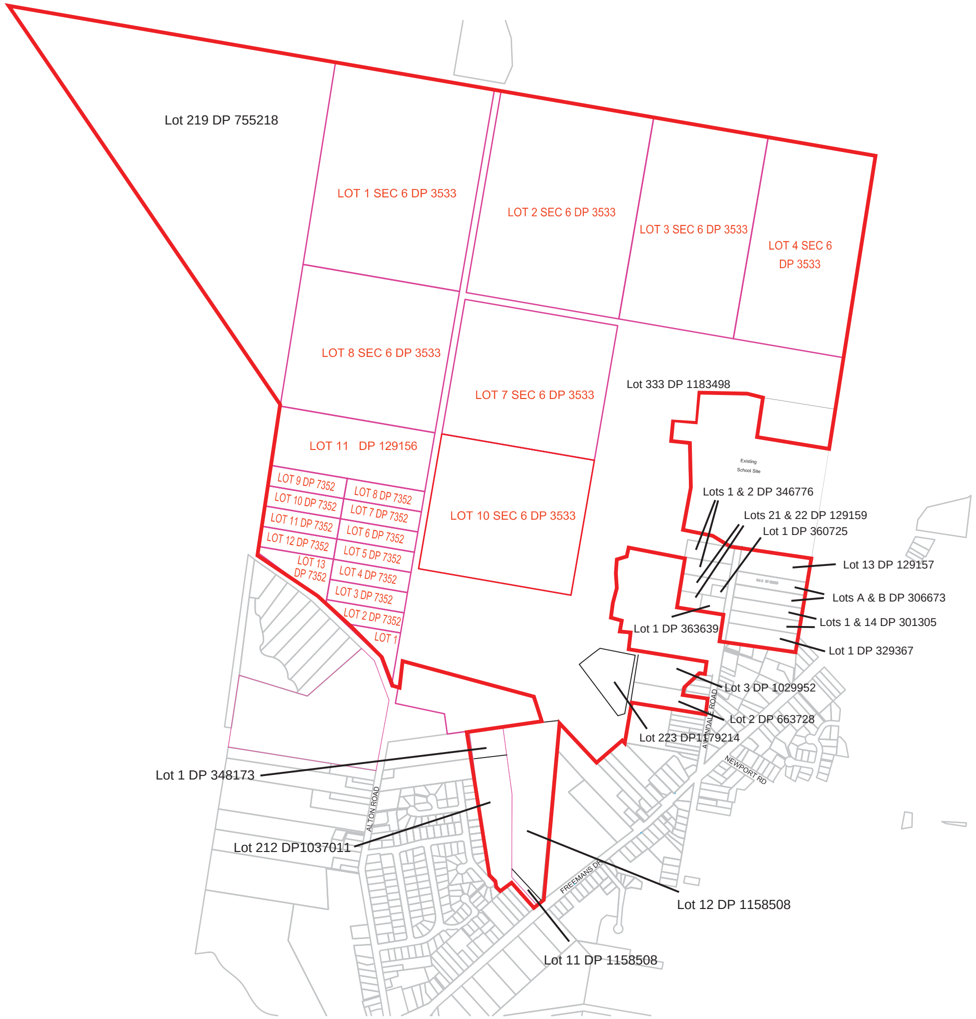
O:\301020\06837 – Watagan Park Masterplan\12.0 Drawings\12.13 Water\FIGURES\301020–06837–FIG–06.dwg
28/05/2014

PUBLIC APPLICATION

Cooranbong Water

Appendix 4.1.3 Scheme Lot and DP references

flow systems



NORTH COORANBONG SCHEME

LOT AND DEPOSITED PLAN REFERENCES

PUBLIC APPLICATION

Cooranbong Water

Appendix 4.1.9 Preliminary Risk Assessment Summary

flow systems

Preliminary Risk Assessment Overview

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 focussed 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 in the design, construction and operation of the facility in order to sufficiently mitigate these risks.
- Facilitate further dialogue with all key stakeholders to ensure all key risks associated with the project are identified and effectively controlled.

Methodology

The risk assessment approach adopted for conducting the preliminary risk assessment for the project was consistent with the recommendations in the Australian Guidelines for Recycled Water Management (AGRW). The process included the following activities:

- Risk Identification – The identification of a range of risk related to the Huntlee project *(what might happen?)*
- Risk Categorisation – The categorisation 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, see Attachment A for details of the assessment criteria *(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 proceed *(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 mitigated *(how effective do we anticipate the controls to be?)*

Outcomes

Identification

In undertaking the preliminary risk assessment a total of 67 key 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 associated with the network itself including blockages, pipe or equipment failure, loss of power etc.
Local Water Centre	Consideration of the potential risks 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 transfer of recycled water from the facility to the users and covered areas such as equipment failure, demand, unauthorised usage, water quality, power failure etc.
Potable Water Distribution	Risks associated with the storage and distribution of potable water to users and considered areas such as equipment failure, demand, unauthorised usage, water quality, security, power failure etc.
Management	General operations management issues risks that may impact operational reliability or supply surety.

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

ATTACHMENT A: RISK ASSESSMENT QUALITATIVE CRITERIA

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

QUALITATIVE MEASURES OF CONSEQUENCE		
Level	**Descriptor**	**Example description**
1	Insignificant	Insignificant impact or non-detectable.
2	Minor	Health - Minor impact for small population.
		Environment - Potentially harmful to local ecosystem with local impacts contained to site.
		Financial - Cost of event and / or rectification is less than $10K.
3	Moderate	Health - Minor impact for large population.
		Environment - Potentially harmful to regional ecosystem with local impacts primarily contained to site.
		Financial - Cost of event and / or rectification is greater than $10K but less than $100K.
4	Major	Health - Major impact for small population.
		Environment - Potentially lethal impact to local ecosystem, predominantly local, but potential for off-site impacts.
		Financial - Cost of event and / or rectification is greater than $100K but less than $1,000K.
5	Catastrophic	Health - Major impact for large population.
		Environment - Potentially lethal to regional ecosystem or threatened species; widespread on-site and off-site impacts.
		Financial - Cost of event and / or rectification is greater than $1,000K.

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

ATTACHMENT B: PRELIMINARY RISK ASSESSMENT SUMMARY

Item	Component	Potential Hazard	Pre-mitigation Risk	Controls	Post-mitigation (Residual) Risk
1	Catchment	Low flow in reticulation generates odour	Very High	– Regular flushing of reticulation – Interim, staged servicing strategy	Low
		Out of specification feed water for treatment process	High	– Testing and monitoring – Disinfection barriers – Education of customer base – Utility approval of new connections – Buffering tank	Low
2	Pressure sewer reticulation	Sewage overflow in community	Very High	– Monitoring – Ability to isolate reticulation built into design – Registration on DBYD – Allow adequate storage in collection tanks	Moderate
		Sewage overflow at household	High	– Installation of pumps by authorised personnel – Monitoring of network – Proactive maintenance regime – Plumbing checks for infiltration prior to occupancy	Moderate
		Odour	High	– Design to minimise air entrainment – Odour control on air valves – Regular replacement of cartridges	Low
3	Local Water Centre	Inability to treat water due to process unit failure	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 – Maintain Asset Protection Zones – Maintain access around LWC for fire fighting – Access to water for fire fighting – Located above 1 in 100 year flood level – Backup generator	Low
		Product water out of specification due to process failure	Very High	– Production shut down – Duty / standby of equipment – Inlet and product water buffer storage – Monitoring and controls – Proactive maintenance regime – Experienced operators	Low
		Noise and odour	High	– Odour and noise modelling at planning phase – Odour scrubbing – Noise mitigation in building design	Moderate
		Environmental spill from tank rupture	Very High	– Quality assurance processes in construction – Isolation from stormwater drainage – Experienced construction contractors and operators – Monitoring of tank levels	Moderate
4	Recycled water reticulation and use	Compromise of public health through consumption of recycled water	High	– Plumbing inspections prior to occupancy – High treatment quality – Education – Signage in public areas	Low
		Interruption to household recycled water supply due to breakage in reticulation	Moderate	– Monitoring – Ability to isolate reticulation built into design – Registration on DBYD	Low
		Recycled water supply exceeds demand	Moderate	– Buffer storage – System monitoring – Evaluation of offsite uses as the development progresses	Moderate
		Recycled water demand exceeds supply	Moderate	– Buffer storage – Top up with drinking water	Low
5	Drinking water storage and reticulation	Interruption to household drinking water supply due to breakage in reticulation	Moderate	– Monitoring – Ability to isolate reticulation built into design – Registration on DBYD	Low
		Compromise of public health due to poor water quality	Low	– Cooranbong Water is distributing drinking water provided by Hunter Water under a Utility Services Agreement – Monitoring in distribution network	Low
6	Management	Unable to provide services due to business failure	Moderate	– Ongoing auditing of the business in accordance with the network operator's licence – Internal governance regime – Water Industry Competition Act's Operator of Last Resort provisions and step in rights	Low

PUBLIC APPLICATION

Cooranbong Water

Appendix 4.1.10(a) Flow Systems Drinking Water Quality Plan

(Table of Contents)

flow systems

Drinking Water Quality Plan (*DWQP*)

October 2014

flow systems

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

Contents

PUBLIC APPLICATION

Cooranbong Water

Appendix 4.1.10(b) Draft CW Scheme Management Plan

(Table of Contents)

flow systems

Cooranbong Water

Scheme Management Plan (Scheme MP)

Document Issue Record

Issue Date	Revision	Issue	Issued To	Prepared By	Approved By
06/02/15	1	First revision	Flow	Darren Wharton	

Contents

PUBLIC APPLICATION

Cooranbong Water

Appendix 4.1.12 Flow Systems Infrastructure Operating Plan

(Table of Contents)

flow systems

Infrastructure Operating Plan (IOP)

December 2014

flow
systems

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

Contents

PUBLIC APPLICATION

Cooranbong Water

Appendix 4.2.1(a) Process Flow Diagram (Sewerage and Recycled Water – Interim Facility)

flow systems

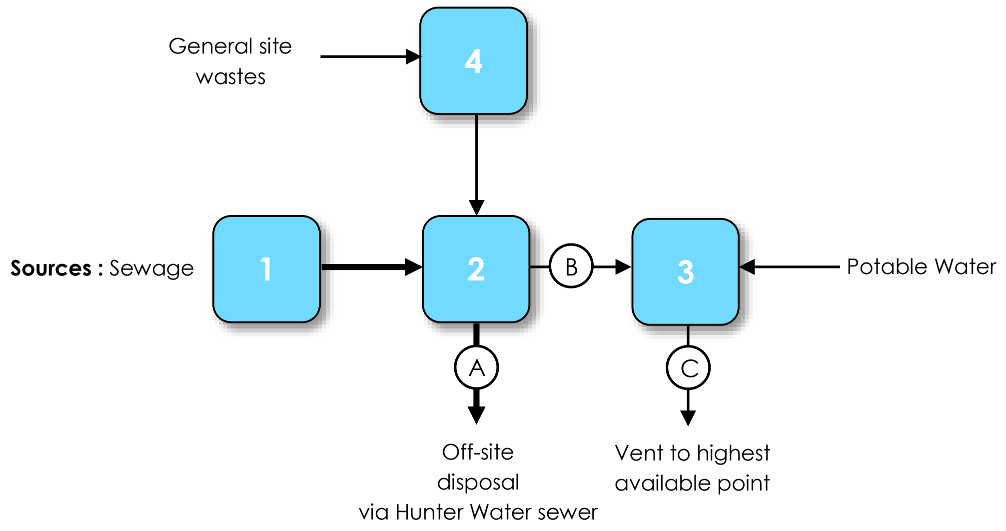
LEGEND

1. Pressure sewerage network
2. Interim flow balance tank (if required)
3. Odour scrubbing
4. General site sump

A. Raw sewage
B. Foul air (untreated)
C. Foul air (treated)

QUALITY CONTROL POINTS (QCP) FOR WATER QUALITY

Location of QCP — Major flow — Minor flow — New infrastructure — Existing infrastructure



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No.	Date	Drafter	Design	Mgmt	Amendment
C	030614	AJC			For information
B	260514	AJC			For information
A	160514	AJC			For information

CLIENT

Name :	Cooranbong Water
Project :	Cooranbong Local Water Centre

Design	Date	Drafting	Date
AJC	030614		

Title : Sewerage Process Flow Diagram **Interim Facility**

Scale	Permeate Project #	Permeate Drawing #
NTS	C14107	C14107-200
Sheet	Client Project #	Client Drawing #
A3	TBA	TBA

PUBLIC APPLICATION

Cooranbong Water

Appendix 4.2.1(b) Process Flow Diagram (Sewerage and Recycled Water – Permanent Facility)

flow systems

LEGEND

1. Pressure sewerage network
2. Inlet screen
3. Flow balance tank
4. Pre-Anoxic zone
5. Aerobic zone
6. Post-Anoxic zone
7. Membrane filtration
8. UV Disinfection
9. Chlorine contact tank
10. Recycled water storage
11. Recycled water distribution pumps
12. Residential non-potable uses
13. Odour scrubbing
14. Alum dosing
15. Carbon dosing
16. Citric acid dosing
17. Caustic dosing
18. Chlorine dosing
19. General site sump
20. Belt press
21. Polymer dosing

A. Screenings and grit
B. Foul air (untreated)
C. Foul air (treated)
D. Internal recycle
E. Return Activated Sludge (RAS)
F. Dewatered Waste Activated Sludge (WAS)
G. Chlorine for membrane cleaning
H. Chlorine for disinfection
I. Chlorine for residual dosing

QUALITY CONTROL POINTS (QCP) FOR WATER QUALITY

BIOREACTOR (4, 5 & 6)
- pH
- Dissolved oxygen
- Temperature
- Flow

CHLORINE RESIDUAL (10)
- Chlorine residual

CRITICAL CONTROL POINTS (CCP) FOR WATER QUALITY

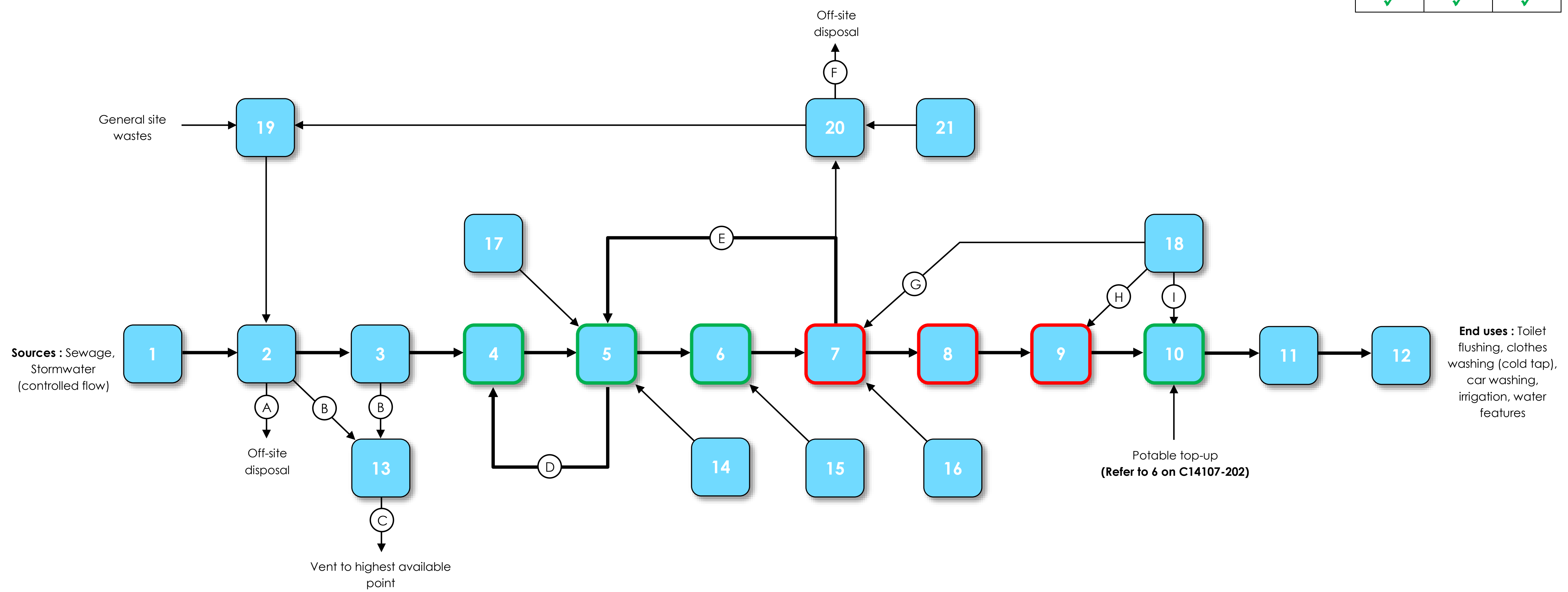
MEMBRANES (7)
- Permeate turbidity

UV (8)
- UV Transmissivity
- UV Intensity
- Flow

CHLORINE CONTACT (9)
- Chlorine residual
- Flow

Location of QCP — Major flow
Location of CCP — Minor flow
New infrastructure — Existing infrastructure

	Log removal		
Unit operation	Virus	Protozoa	Bacteria
MBR	≥2.5	≥4.0	≥4.0
UV	≥1.0	≥1.5	≥3.0
Chlorine	≥3.0	-	≥4.0
Design	**≥6.5**	**≥5.5**	**≥11.0**
Required	**≥6.5**	**≥5.0**	**≥5.0**
	✓	✓	✓



PERMEATE PARTNERS

E : info@permeate.com.au P : 1300 799 155 | W : www.permeate.com.au F : 1300 799 005

No.	Date	Drafter	Design	Mgmt	Amendment
C	030614	AJC			For information
B	260514	AJC			For information
A	160514	AJC			Early Draft For information

CLIENT

flow systems

Name : Cooranbong Water
Project : Cooranbong Local Water Centre

Design	Date	Drafting	Date
AJC	030614		

Title : Sewerage and Recycled Water Process Flow Diagram **Permanent Facility**

Scale NTS	Permeate Project # C14107	Permeate Drawing # C14107-201
Sheet A3	Client Project # TBA	Client Drawing # TBA

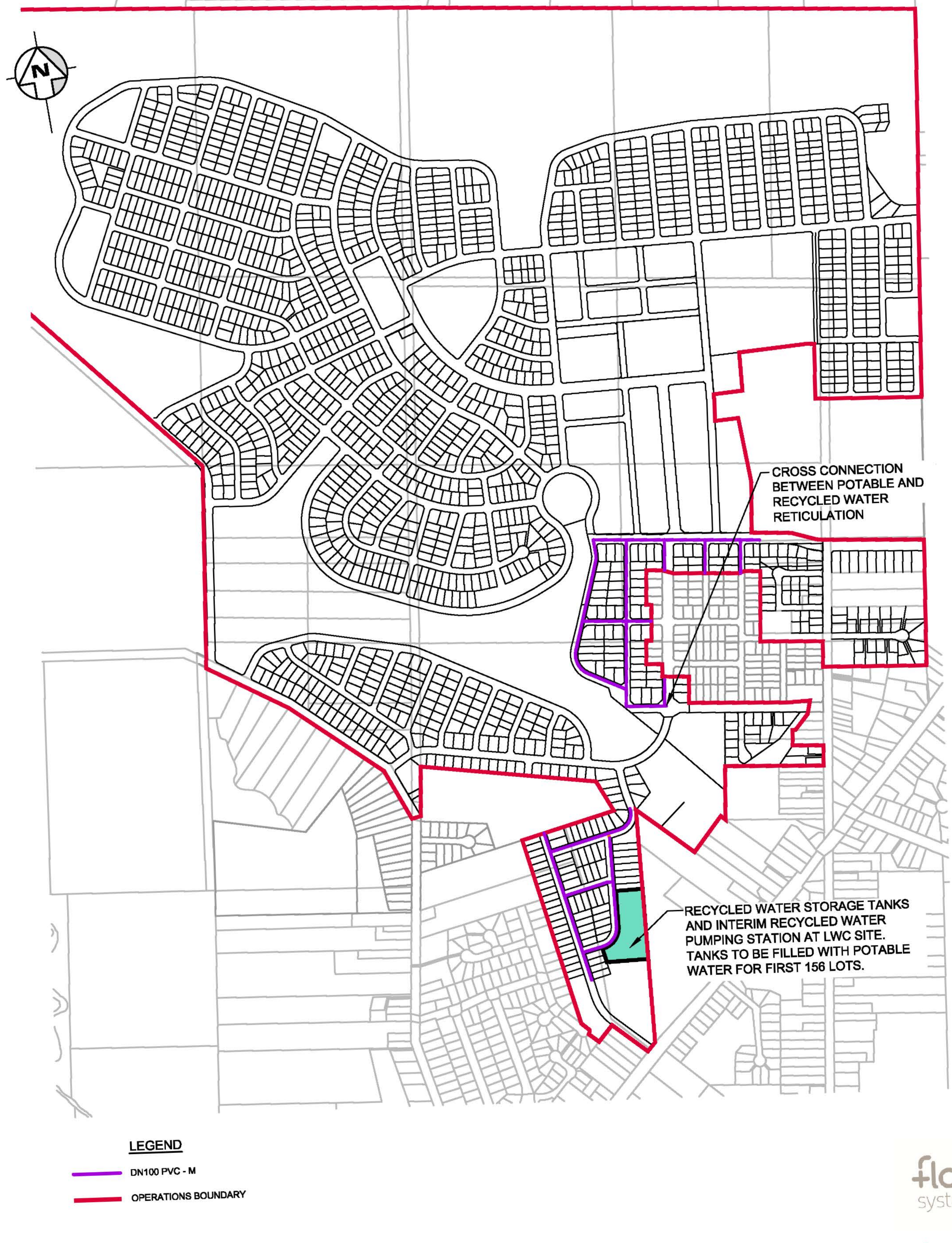
PUBLIC APPLICATION

Cooranbong Water

Appendix 4.2.1(c) Recycled Water Reticulation Masterplan

flow systems

FIGURE 7



flow systems

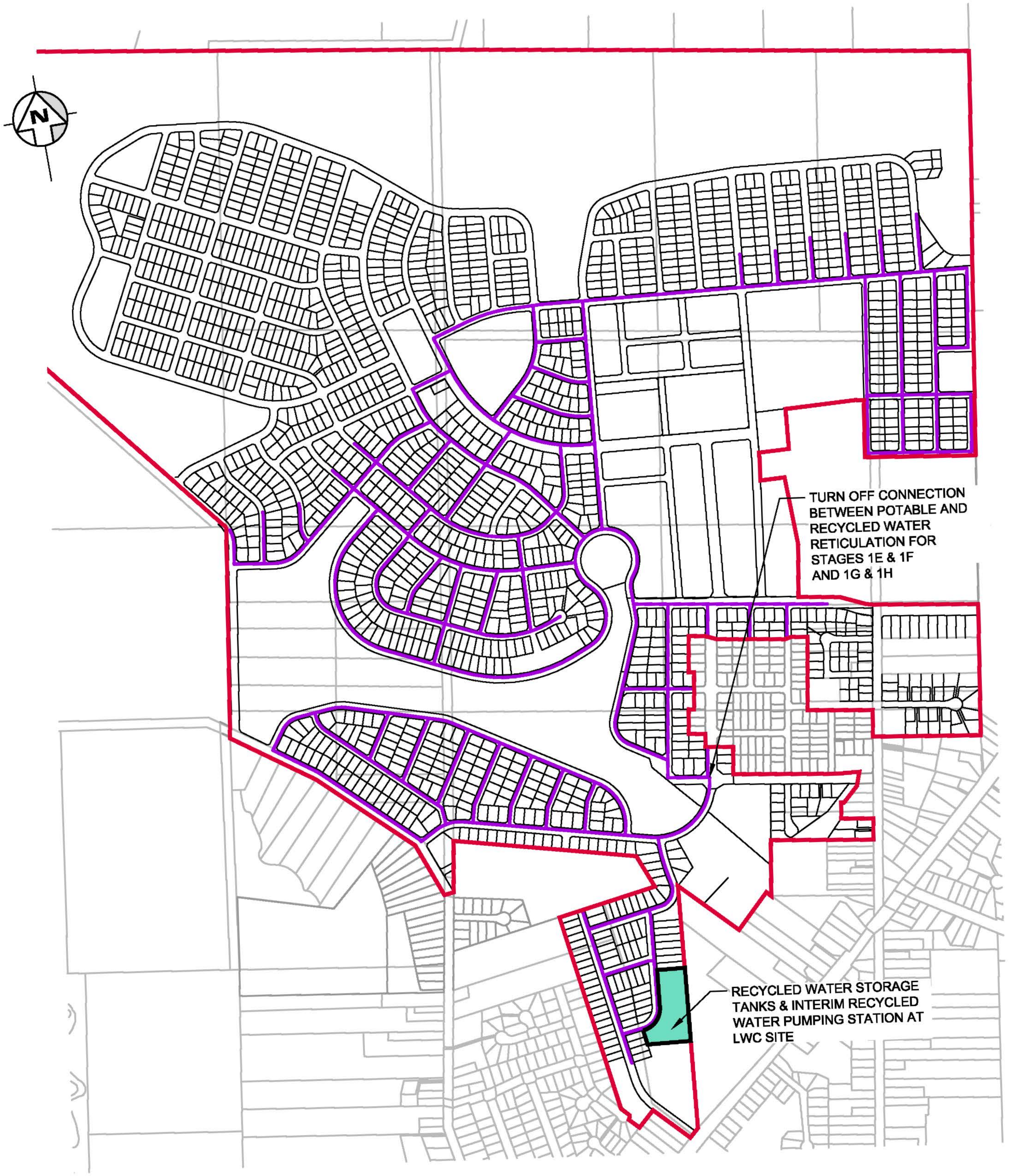
Cooranbong Water

NORTH COORANBONG
RECYCLED WATER MASTER PLAN
FIRST 156 LOTS

WorleyParsons
resources & energy

O:\301020\06837 – Watagan Park Masterplan\12.0 Drawings\12.13 Water\FIGURES\301020–06837–FIG–07.dwg
28/05/2014

FIGURE 8



LEGEND

DN100 PVC - M

OPERATIONS BOUNDARY

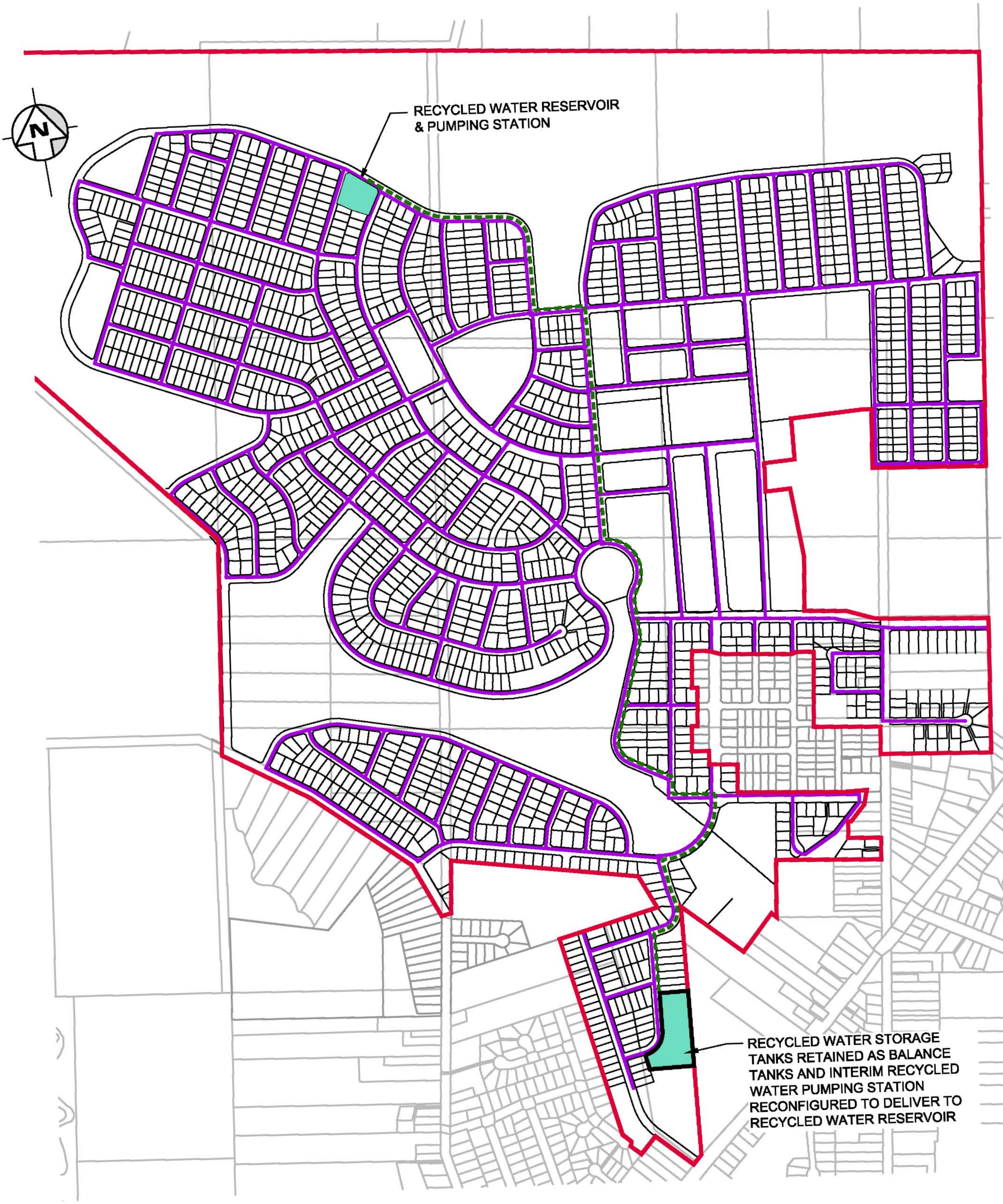
flow systems

Cooranbong Water

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

WorleyParsons
resources & energy

O:\301020\06837 — Watagan Park Masterplan\12.0 Drawings\12.13 Water\FIGURES\301020—06837—FIG—08.dwg
28/05/2014



LEGEND

- DN100 PVC - M
- DELIVERY MAIN TO RESERVOIR (APPROX. DN250 PVC - M)
- OPERATIONS BOUNDARY

flow systems

Cooranbong Water

NORTH COORANBONG RECYCLED WATER MASTER PLAN ULTIMATE DEVELOPMENT

WorleyParsons
resources & energy

O:\301020\06837 – Watagan Park Masterplan\12.0 Drawings\12.13 Water\FIGURES\301020-06837-FIG-09.dwg
28/05/2014

PUBLIC APPLICATION

Appendix 4.2.11 Flow Systems Recycled Water Quality Plan

(Table of Contents)

Recycled Water Quality Plan (RWQP)

December 2014

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

Contents

PUBLIC APPLICATION

Cooranbong Water

Appendix 4.3.3 Pressure Sewer Reticulation Masterplan

flow systems

Stage	Loadings (ET)
Stage 1E & 1F (I)	40
Stage 1G & 1H (I)	41
Stage 2A (II)	31
Stage 2B (II)	35
Stage 2C (II)	39
Stage 2D (II)	33
Twine & Thomson (III)	75
III (excluding Jackson & Mears)	40
IV	146
V	113
VI	107 +Primary School (28) +Corner Shop (5) +Medium Density Residential (12)
VII(a)	116 +Open Space including Amenities (2)
VII(b)	36
VIII	188
IX	161
X	152
XI	231
XII	90
Medium Density Residential	428
Commercial / Retail	58
Community Centre	2
Potential Future Extension	40
Overall Total	2249

Date: 27/05/2014

Rev: C

Drawing No: SK02

Scale: 0 50 100 150m SCALE 1:3000 AT A0

NORTH COORANBONG MASTERPLAN

Cooranbong Water

flow systems

Pressure System Solutions Pty Ltd

Saved: 27.05.2014, By: kgao
J:\700-Projects\702-Current projects\140310 Watagan Park\720-Design\721-Drawings\730-Street mains\Watagan Park_SK02.dwg

PUBLIC APPLICATION

Cooranbong Water

Appendix 4.3.10 Flow Systems Sewage Management Plan

(Table of Contents)

flow systems

Sewage Management Plan
(Sewage MP)

January 2015

flow systems

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 Table 1	Flow	Kirsten Evans	Andrew Horton

Contents

PUBLIC APPLICATION

Cooranbong Water

Appendix 4.3.13 Cooranbong Land Capability Assessment

flow systems

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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
Prepared by	Zoe Rogers 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:	Land Capability Assessment for recycled water management scheme at proposed North Cooranbong Master Plan Development, Cooranbong, NSW
Author:	Zoe Rogers
Project Manager:	Mark Saunders
Date of Issue:	21/05/14
Job Reference:	Report_01242_LCA_002
Synopsis:	This preliminary report provides the results of our investigations regarding Land Capability Assessment for the proposed North Cooranbong Master Plan Development, Cooranbong.
Client Details	
Client:	RPS Australia
Primary Contact:	Mr Stuart Greville (RPS Australia)

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Version Number	**Date**	**Status**	**DISTRIBUTION – NUMBER OF COPIES** (p – print copy; e – electronic copy)		
			Client	Other	Other
01	16/05/14	Draft	1e	-	-
02	21/05/14	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 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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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 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 14th 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

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0 300 600 900 1200 m
(Approx Scale)

N

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	
0.1–0.5		TP 1/2	A	SC to SiC	weak pedality (SC)	grey	30% pink/red	nil	SM	
0.6–1.2		TP 1/3	B1	LC	weak pedality to massive	orange-brown	nil	nil	SM	includes remnant organic layer @ 550-750mm
1.3–1.7		TP 1/4	B2	MC	blocky, pedal	orange-pink	50% red	nil	SM	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
Environmental Consultants Pty Ltd

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

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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
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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
0.1–0.2		TP 10/1	A1	SL	weak pedality	dark grey brown	nil	nil	SM	
0.3–0.7		TP 10/2	B1	SiC	pedal, blocky	bright yellow-brown	gleying common	nil	SM	
0.8–1.4		TP 10/3	B2	SiC	pedal, blocky	grey	30% red	nil	SM	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
0.1–0.2		TP 15/1	A1	SL	weak pedality to massive	dark grey brown	nil	nil	D	
0.3–0.8		TP 15/2	B1	LS	weak pedality	light yellow-brown	20% gley	<10%	SM	gravel size varies
0.9–1.5		TP 15/3	B2	SC - SiC	weak pedality	grey	40% red/pink	<10%	SM	gravel size varies; 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
5.51	to	6.00	Moderately acid	preferred range
6.01	to	6.50	Slightly acid	preferred range
6.51	to	7.30	Neutral	preferred range
7.31	to	7.80	Mildly alkaline	preferred range
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
ASPAC
Proficiency tested by Aust. Soil & Plant Analysis Council Inc.

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

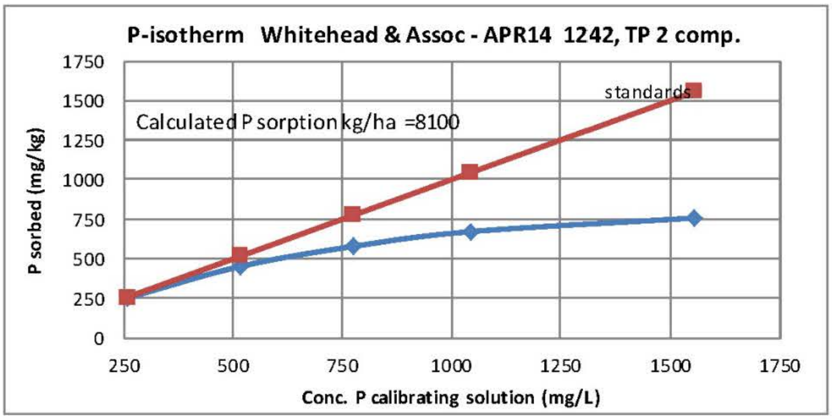
Whitehead & Assoc. Project 1242 APR14

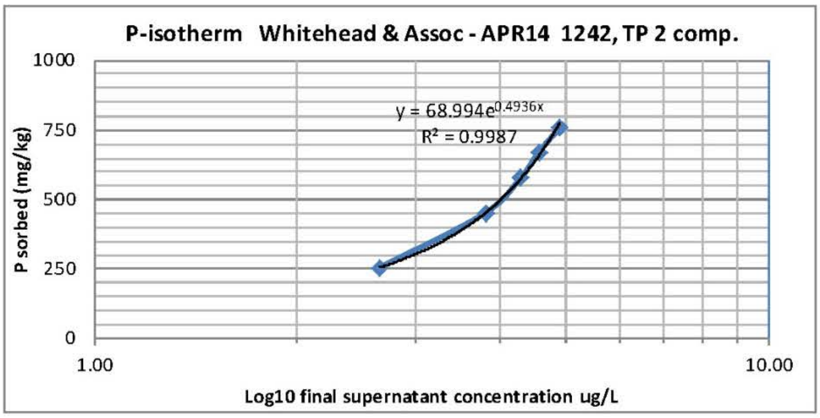
Exc.Al+ H	Ca		K		Mg		Na		Base Sat.	ESP	CEC	Ca/Mg	Site Location
cmol+/kg	mg/kg	cmol+/kg	mg/kg	cmol+/kg	mg/kg	cmol+/kg	mg/kg	cmol+/kg	%	%	cmol+/kg	ratio	Sample ID
4.72	9	0.04	23	0.06	285	2.35	34	0.15	35.5	2.0	7.3	0.0	1242, TP 2 comp.
1.12	173	0.86	30	0.08	233	1.92	87	0.38	74.3	8.7	4.4	0.4	1242, TP 3 comp.
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

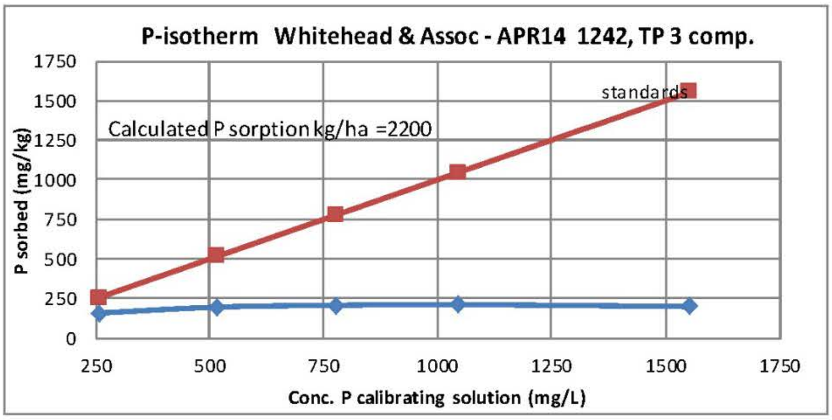
Commercial and research laboratory for soil, water and plant analysis.
Soil survey and analytical assessments, landscape analysis and plant nutrient relationships,
Wastewater and effluent reuse specialists - on-site and decentralised

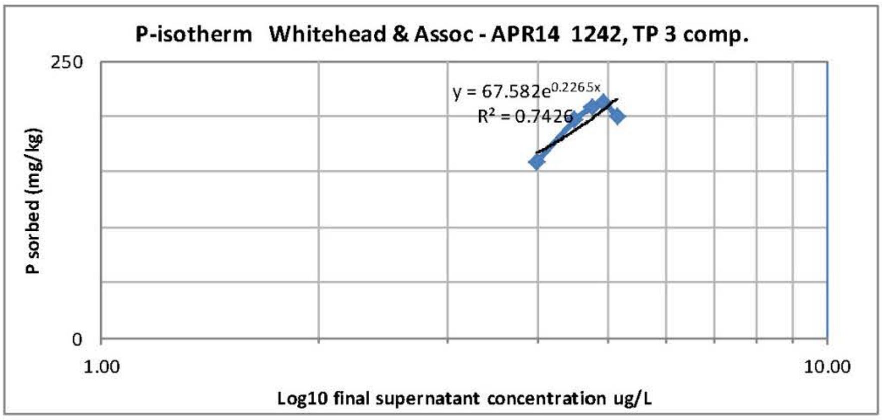




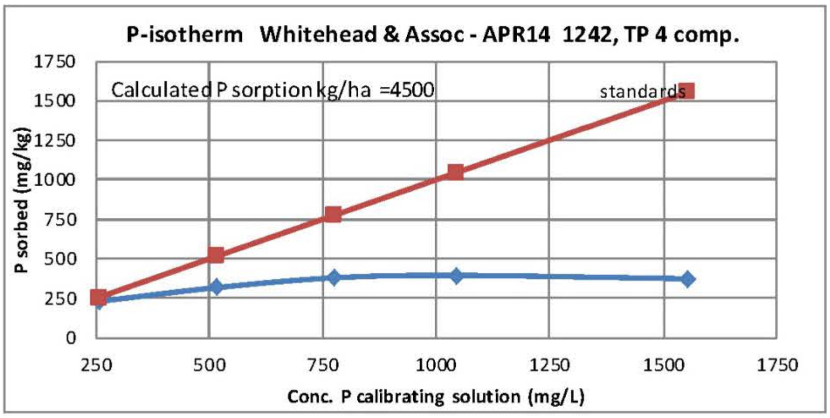
Percent sorbed is the proportion of the initial P sorbed during equilibration

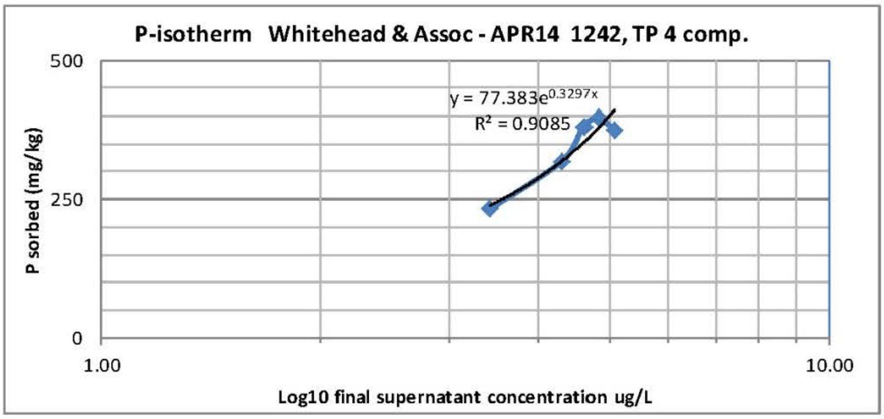
Initial P mgP/L	filtrate P mg/L	sorbed P mg/kg	Sample I.D.	Percent sorbed (%)		Std line	filtrate C ugP/L	Y axis Log C Y axis	X axis X axis
						P-isotherm Whitehead & Assoc - APR14 1:			
25.8	0.45	253.9	Whitehead & Assoc - APR14	98.3		258	447	2.65	253.9
51.6	6.41	452.0	1242, TP 2 comp.	87.6		516	6407	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						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	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
Calculated P sorption kg/ha =			2200						



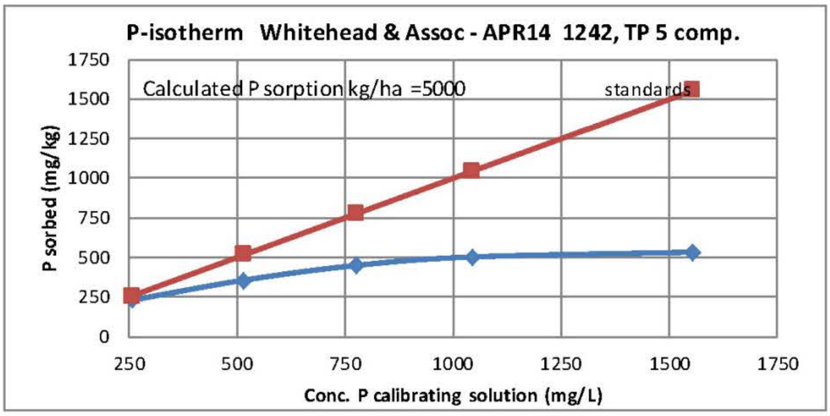


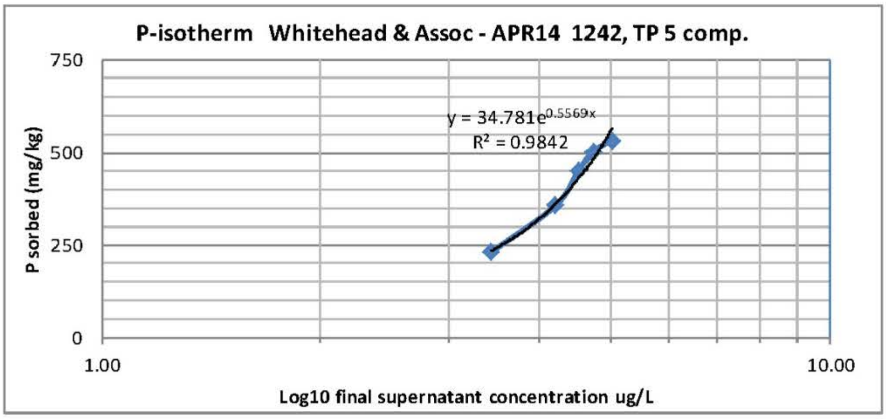
Percent sorbed is the proportion of the initial P sorbed during equilibration

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	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

P-isotherm Whitehead & Assoc - APR14 1

Calculated P sorption kg/ha = 4500





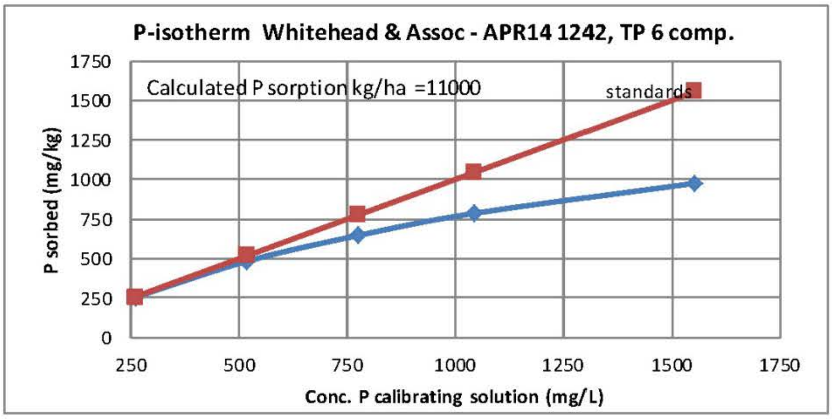
Percent sorbed is the proportion of the initial P sorbed during equilibration

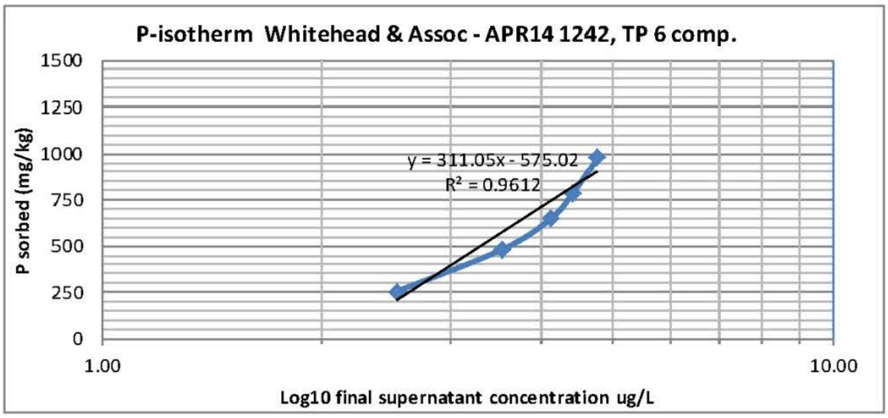
Initial P mgP/L	filtrate P mg/L	sorbed P mg/kg	Sample I.D.	Percent sorbed (%)
25.8	2.70	231.4	Whitehead & Assoc - APR14	89.6
51.6	15.92	356.9	1242, TP 5 comp.	69.2
77.7	32.63	450.3		58.0
104.5	54.13	503.7		48.2
155.3	101.90	534.0		34.4

Calculated P sorption kg/ha = 5000

P-isotherm Whitehead & Assoc - APR14 1

Std line	filtrate C ugP/L	Y axis Log C	X axis
258	2698	3.43	231.4
516	15920	4.20	356.9
777	32630	4.51	450.3
1045	54130	4.73	503.7
1553	101900	5.01	534.0





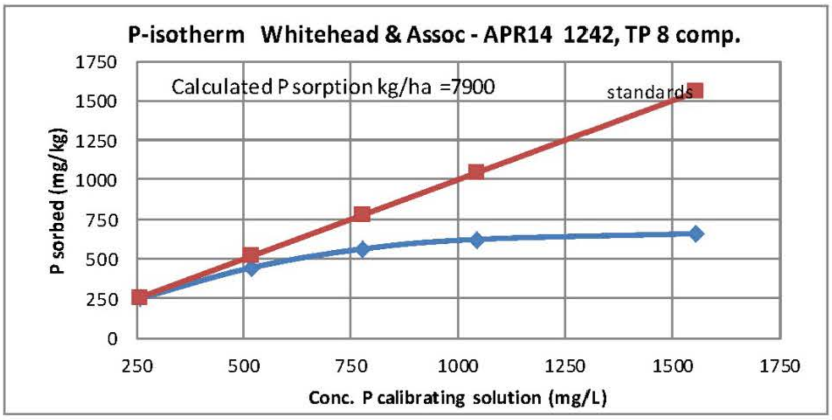
Percent sorbed is the proportion of the initial P sorbed during equilibration

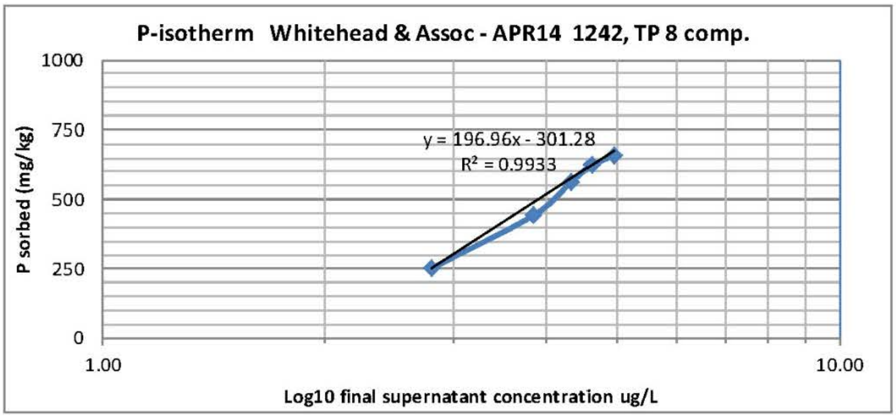
Initial P mgP/L	filtrate P mg/L	sorbed P mg/kg	Sample I.D.	Percent sorbed (%)
25.8	0.34	255.0	Whitehead & Assoc - APR14	98.7
51.6	3.41	482.0	1242, TP 6 comp.	93.4
77.7	13.00	646.6		83.3
104.5	25.90	786.0		75.2
155.3	57.71	975.9		62.8

Calculated P sorption kg/ha = 11000

P-isotherm Whitehead & Assoc - APR14 12

Std line	filtrate C ugP/L	Y axis Log C	X axis
258	342	2.53	255.0
516	3414	3.53	482.0
777	13000	4.11	646.6
1045	25900	4.41	786.0
1553	57710	4.76	975.9



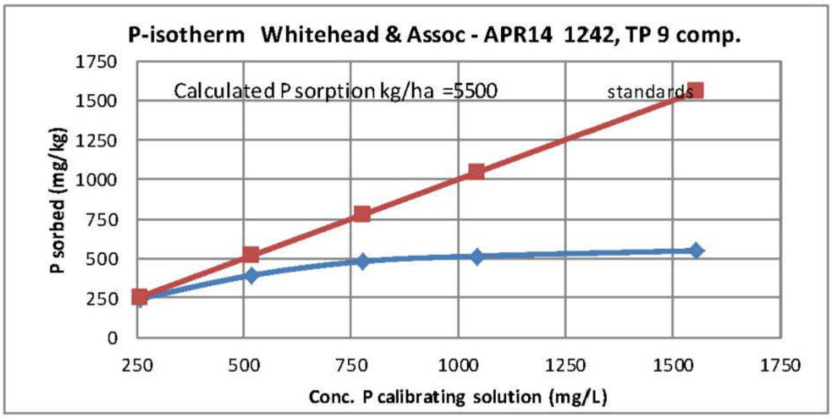


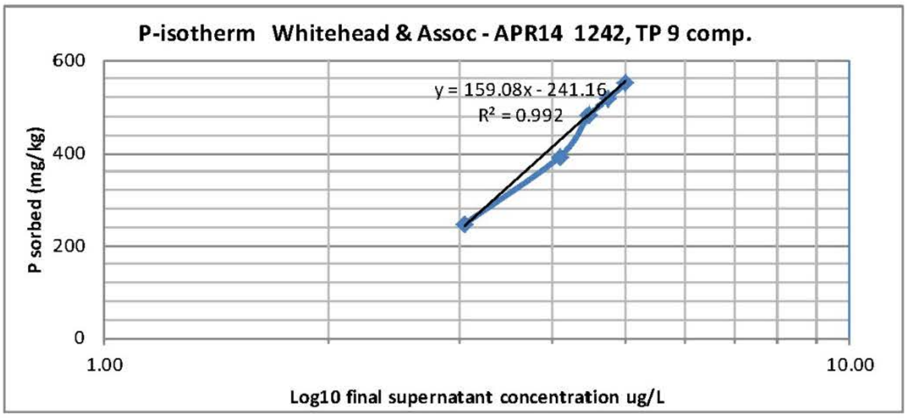
Percent sorbed is the proportion of the initial P sorbed during equilibration

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	0.63	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

P-isotherm Whitehead & Assoc - APR14 1

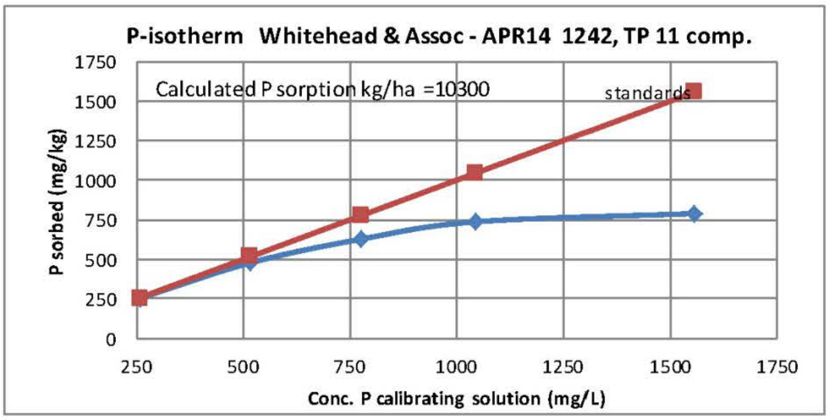
Calculated P sorption kg/ha = 7900

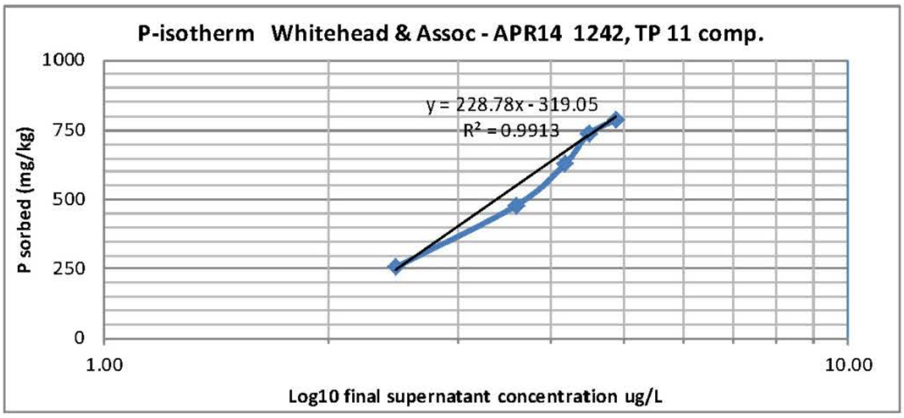




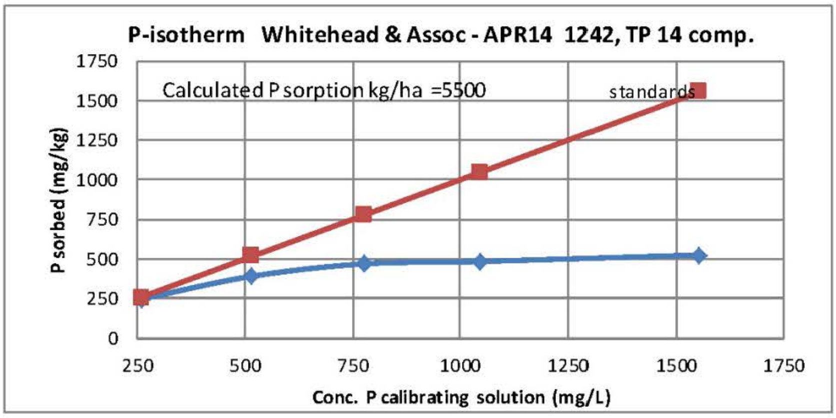
Percent sorbed is the proportion of the initial P sorbed during equilibration

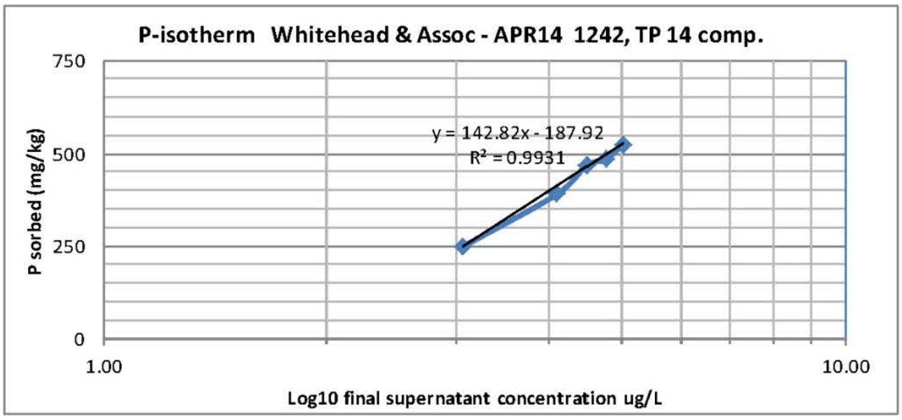
Initial P mgP/L	filtrate P mg/L	sorbed P mg/kg	Sample I.D.	Percent sorbed (%)	P-isotherm Whitehead & Assoc - APR14 1: Std line	filtrate C ugP/L	Y axis Log C	X axis
25.8	1.12	247.3	Whitehead & Assoc - APR14	95.7	258	1115	3.05	247.3
51.6	12.30	393.1	1242, TP 9 comp.	76.2	516	12300	4.09	393.1
77.7	29.49	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					





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	0.29	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						





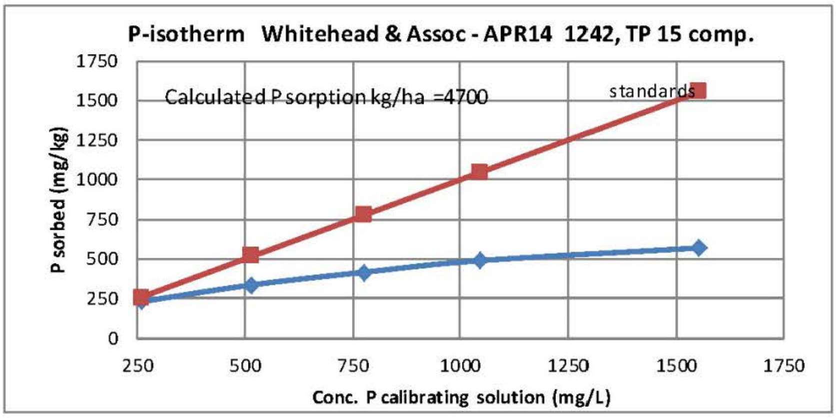
Percent sorbed is the proportion of the initial P sorbed during equilibration

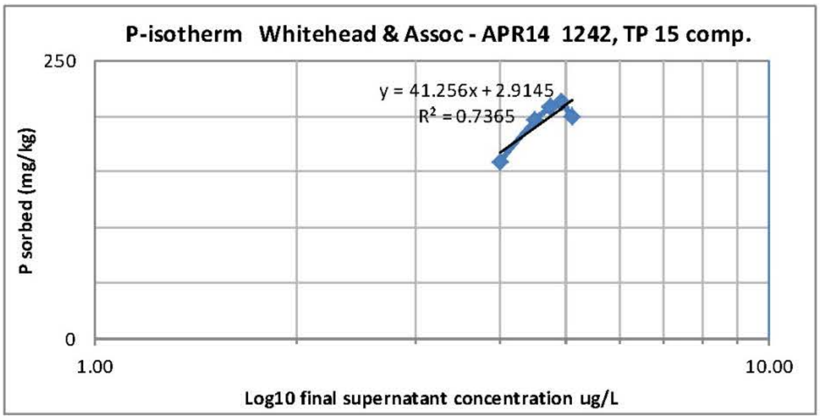
Initial P mgP/L	filtrate P mg/L	sorbed P mg/kg	Sample I.D.	Percent sorbed (%)
25.8	1.12	247.2	Whitehead & Assoc - APR14	95.7
51.6	12.53	390.8	1242, TP 14 comp.	75.7
77.7	30.78	468.8		60.4
104.5	56.07	484.3		46.3
155.3	102.80	525.0		33.8

Calculated P sorption kg/ha = 5500

P-isotherm Whitehead & Assoc - APR14 1:

Std line	filtrate C ugP/L	Y axis Log C	X axis
258	1120	3.05	247.2
516	12530	4.10	390.8
777	30780	4.49	468.8
1045	56070	4.75	484.3
1553	102800	5.01	525.0





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	2.79	230.5	Whitehead & Assoc - APR14	89.2		258	2791	3.45	230.5
51.6	17.97	336.4	1242, TP 15 comp.	65.2		516	17970	4.25	336.4
77.7	36.04	416.2		53.6		777	36040	4.56	416.2
104.5	55.58	489.2		46.8		1045	55580	4.74	489.2
155.3	98.34	569.6		36.7		1553	98340	4.99	569.6
Calculated P sorption kg/ha =			4700						

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

Prepared for	RPS Australia
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Document Control Sheet

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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
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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.

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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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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.

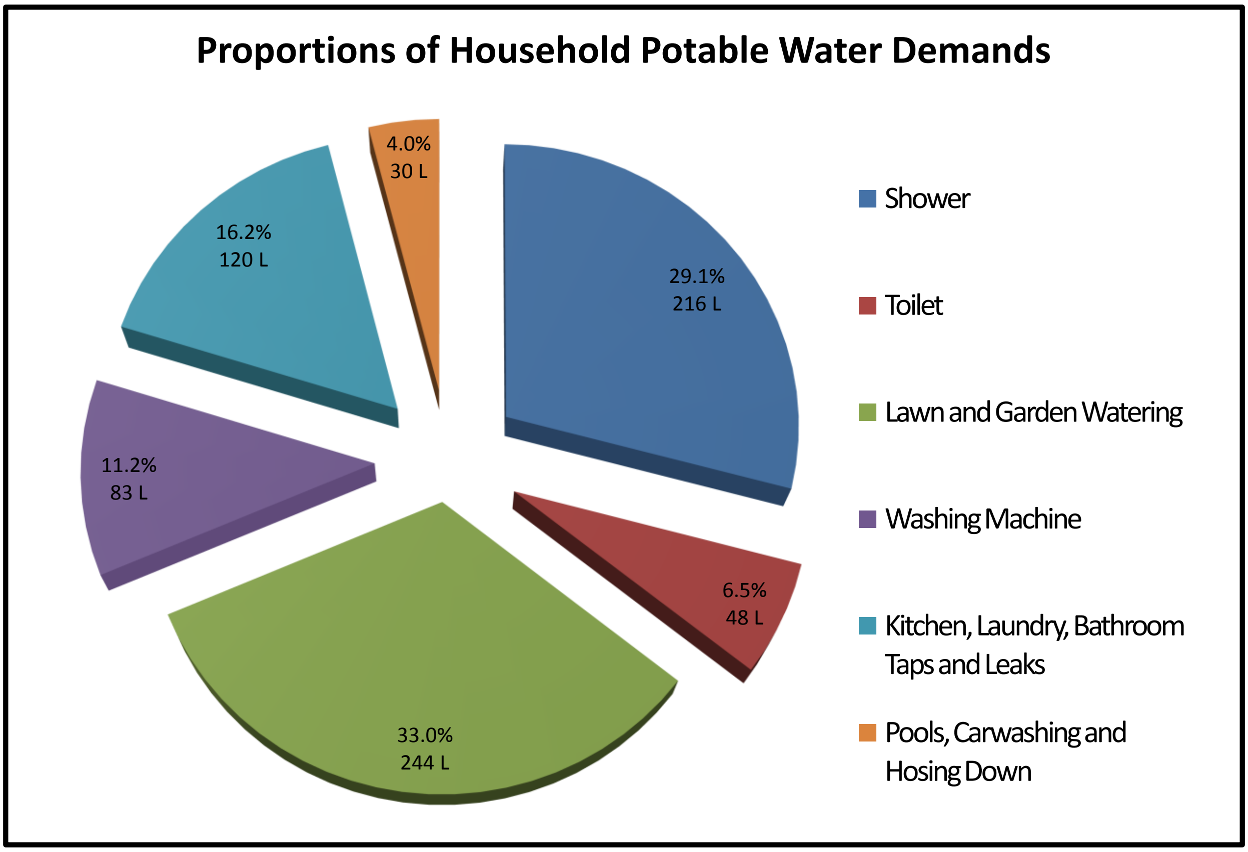

Figure 4 Proportional water usage within a residential household (internal and external water use)

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.

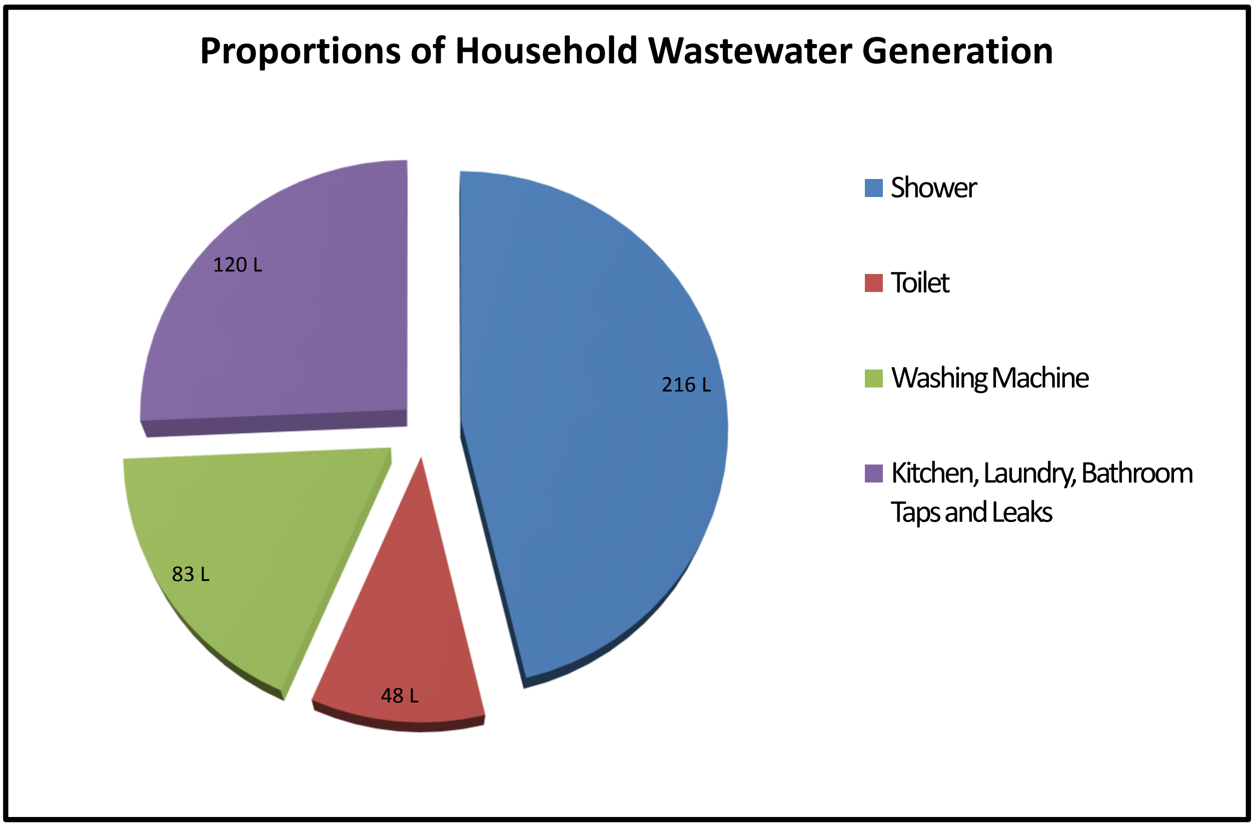

Figure 5 Proportional wastewater generation within a residential household

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

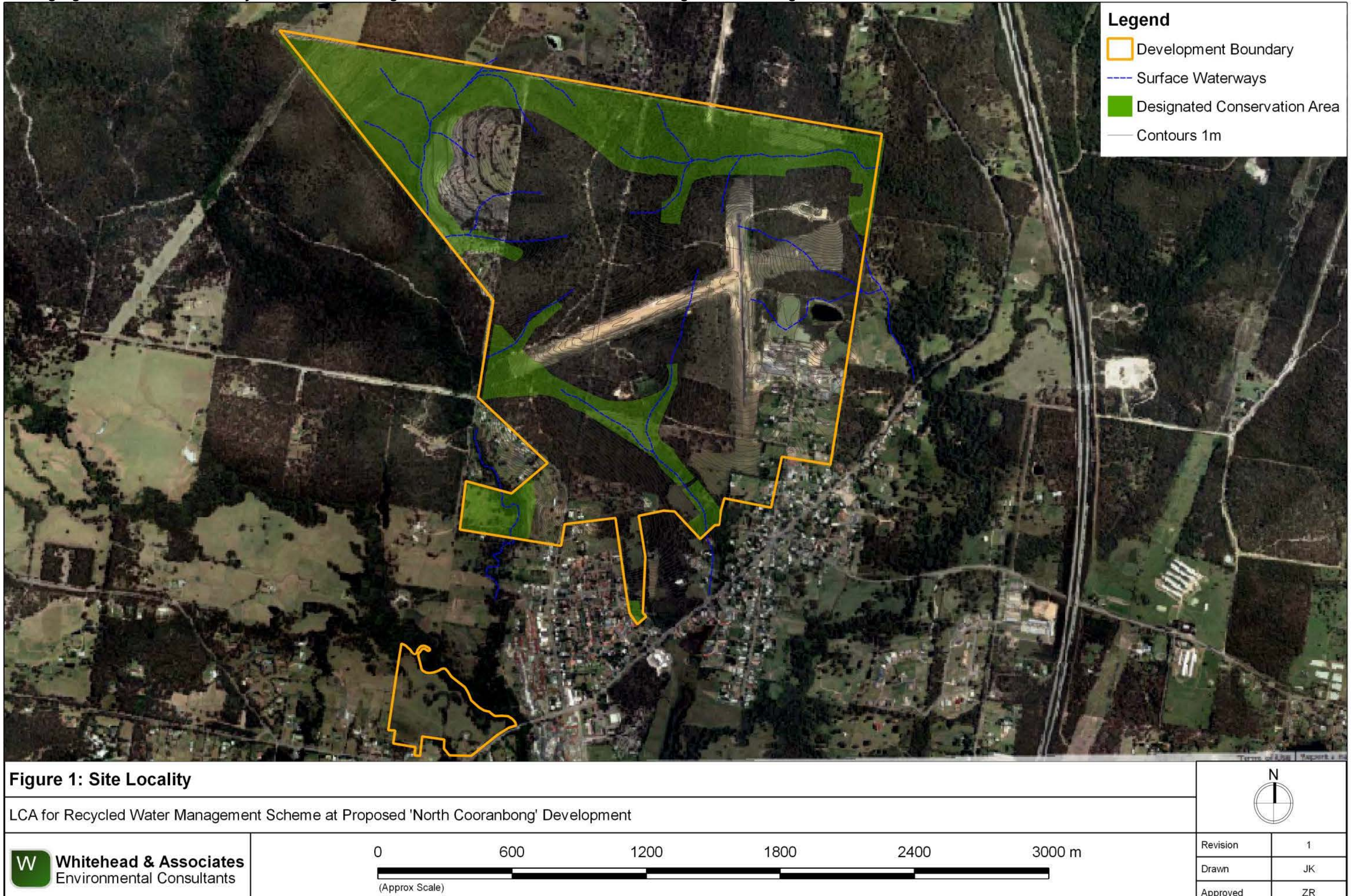

Figure 1: Site Locality

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

Whitehead & Associates
Environmental Consultants

Revision	1
Drawn	JK
Approved	ZR

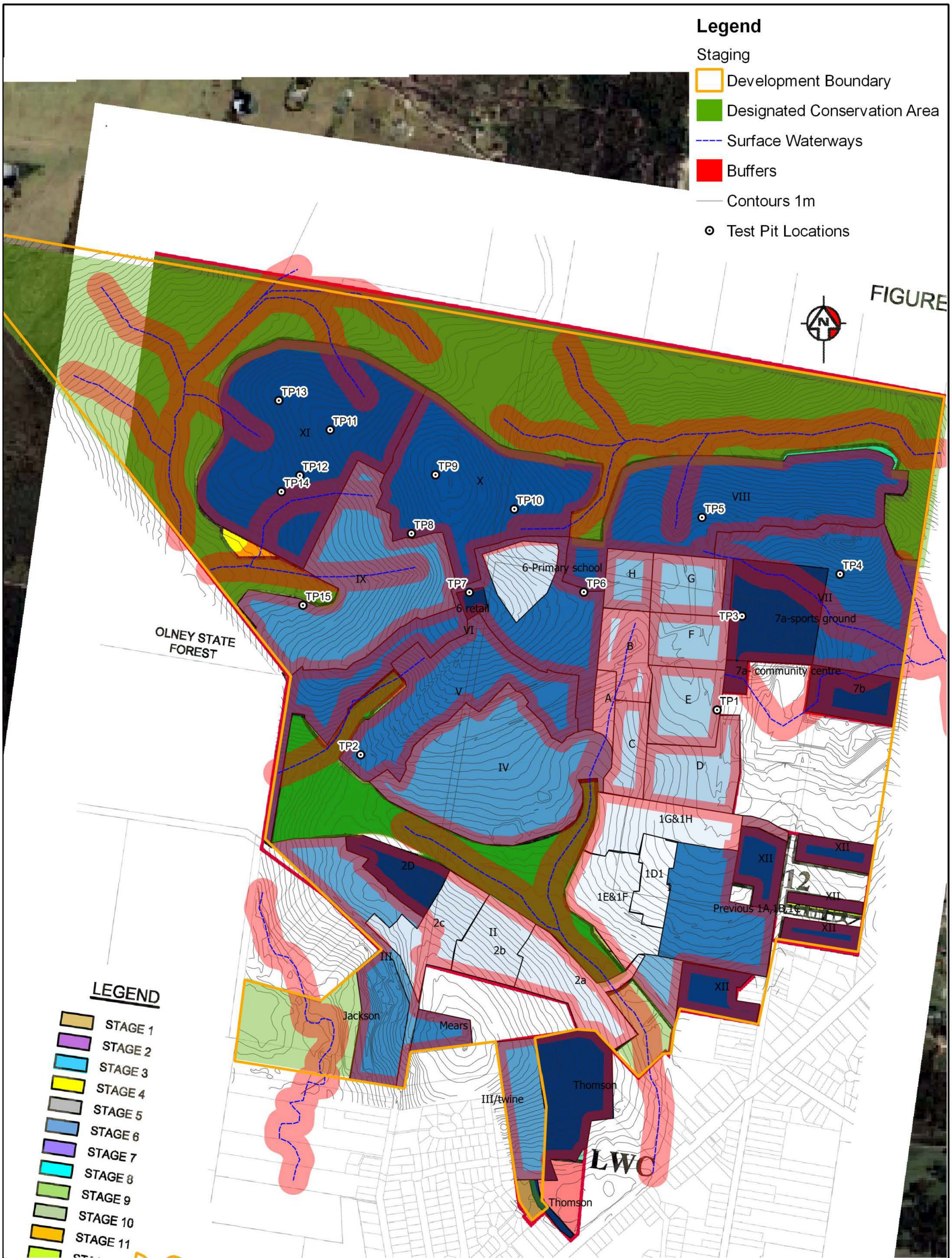

Figure 2: Site Plan

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

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

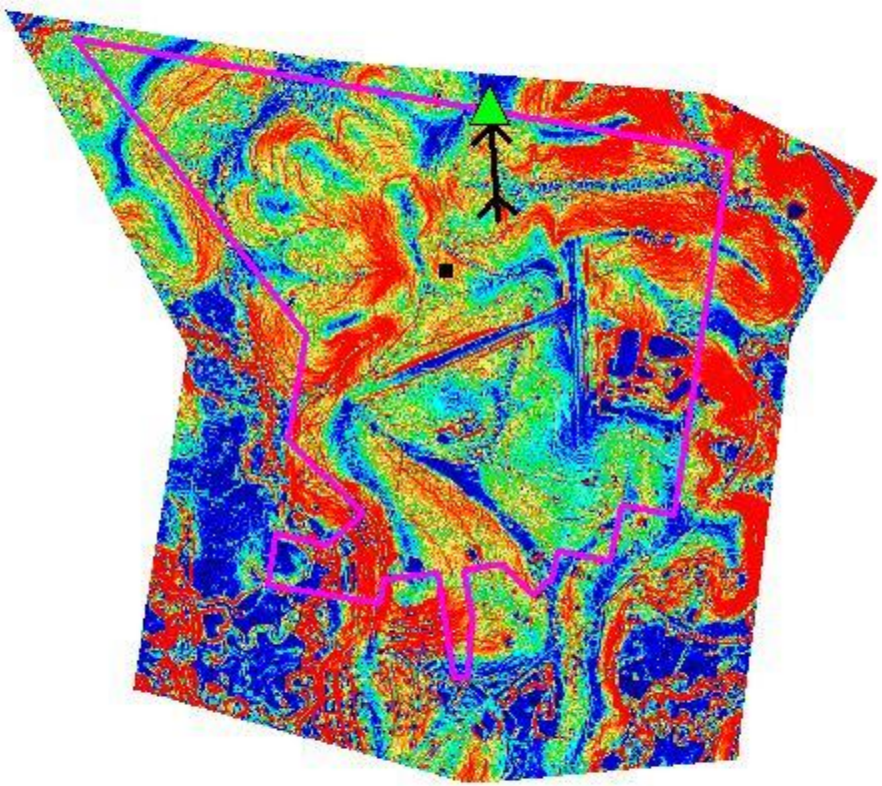

Figure: DSM Output screenshot

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**

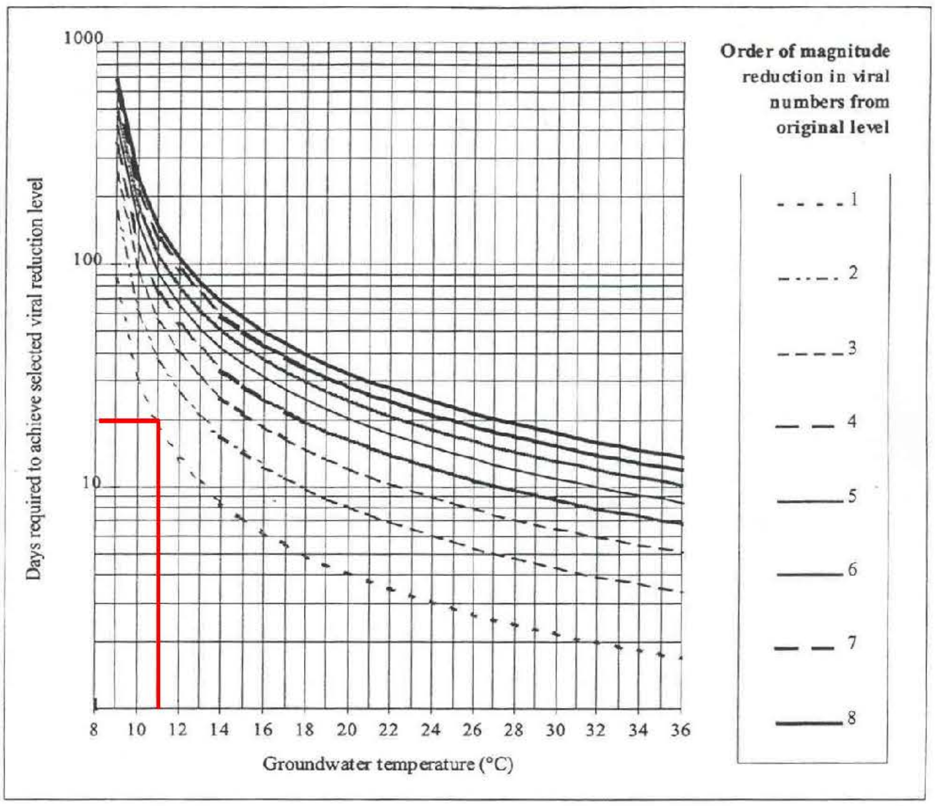

Figure 1. Relationship between Groundwater Temperature and Viral Die-Off Time for Various Order-of-Magnitude Reductions in Viral Numbers