CivPlan Pty Ltd ABN 49 620 926 114
CivPlan Consulting Pty Ltd ABN 79 157 731 912
Sydney Office: 152 Sailors Bay Rd, Northbridge, NSW, 2063
South Coast Office: 390 Princes Hwy, Bomaderry, NSW, 2541
T: 1800 318 052 E: info@civplan.com.au W: www.civplan.com.au

Water Sensitive Urban Design Report

515 Crookwell Road, Kingsdale, NSW

Lot 103 & 104 DP 1007433

Planning Proposal – Large Lot Residential Development

LGA: Goulburn Mulwaree Council

Report No: 21024CC-003
Revision: 1
Site Inspection / Field Work Date: 6th October 2021
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John Weil
Principal Civil Engineer
BEng(Hons) MIEAust CPEng NER
Ph: 0408 581 227

Author and Document Control:

Field / Design Work By:	Written By:	Reviewed / Approved By:
Josh Eves Civil Engineer	**John Weil** Principal Civil Engineer	**John Weil** Principal Civil Engineer

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References:

- Goulburn Mulwaree Council – Development Control Plan 2009
- Goulburn Mulwaree Council – Design Specification 2013
- Australian Rainfall & Runoff – A Guide to Flood Estimation – 2019
- Landcom Managing Urban Stormwater Soil and Construction Volume 1 (4th Edition 2004) known as the "blue book".
- WaterNSW - NorBE Assessment Guidelines 2015
- WaterNSW - NorBE User Guide for Consultants 2015
- WaterNSW - Using MUSIC in Sydney's Drinking Water Catchments 2012
- WaterNSW - Development in the Sydney Drinking Water Catchment – Water Quality Information Requirements June 2018
- AS/NZS 1547:2012 - On-site Domestic Wastewater Management
- WaterNSW (2019) Designing and Installing On-Site Wastewater Systems. A Sydney Catchment Authority Current Recommended Practice.
- Environment & Health Protection Guidelines: On-site Sewage Management for Single Households (1998)

Contents

Appendices:

- Appendix A: ALS Testing Results
- Appendix B: Borehole Logs
- Appendix C: Calculations
- Appendix D - Disposal System Standard Drawings

1. Purpose and Scope

1.1 Purpose and Scope

This report has been prepared for Precise Planning Pty Ltd on behalf of Alimaco Pty Ltd to assess the site constraints, limitations and opportunities for the implementation of Water Sensitive Urban Design (WSUD) measures to the planning proposal at 515 Crookwell Road, Kingsdale, NSW. This report will assess the following components that effect the overall WSUD strategy:

- Onsite wastewater management
- Stormwater quality management

The site is located inside of the WaterNSW Catchment Area and this assessment has been prepared in accordance with the standards and guidelines listed in the references on page 2 of this report.

Onsite wastewater management analysis will be undertaken in accordance with relevant local, state, and federal standards and guidelines (listed in the references), to achieve a nutrient and water balance to enable a neutral or beneficial (NorBE) water quality outcome.

Stormwater quality analysis will be undertaken in accordance with WaterNSW guidelines to achieve a NorBE water quality outcome using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) software.

A detailed site investigation was carried out on Tuesday the 6th October 2021 by John Weil, a suitably qualified and experience civil engineer.

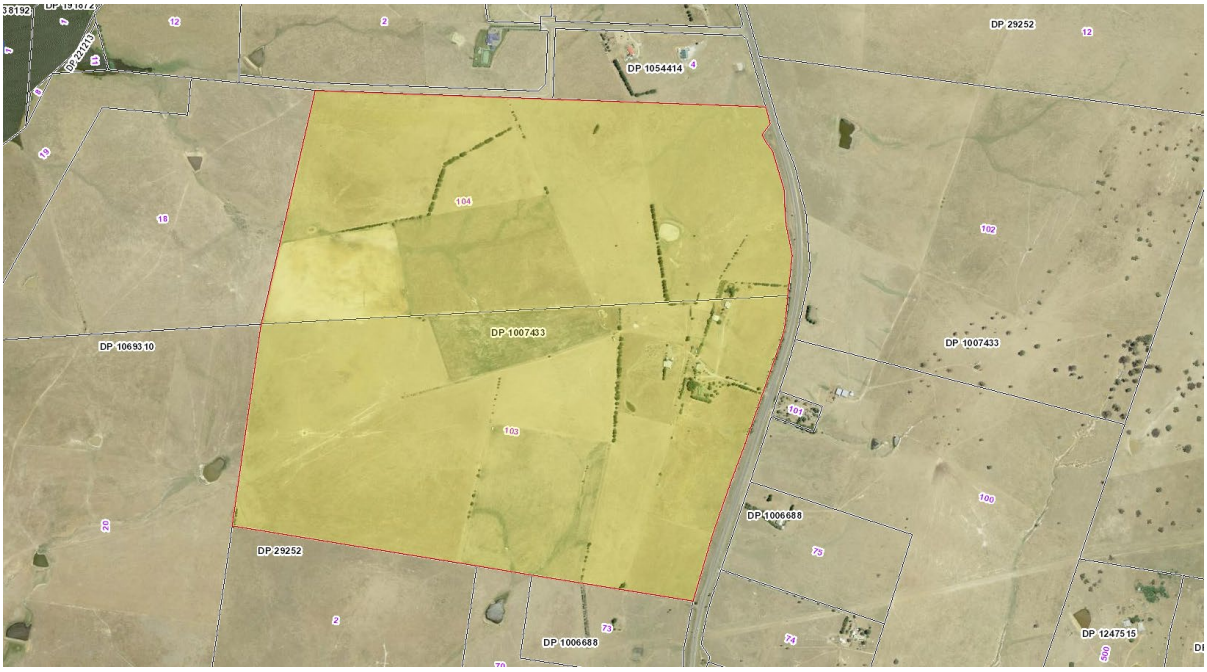

Figure 1: Site Location - NSW Imagery (SIX Maps)

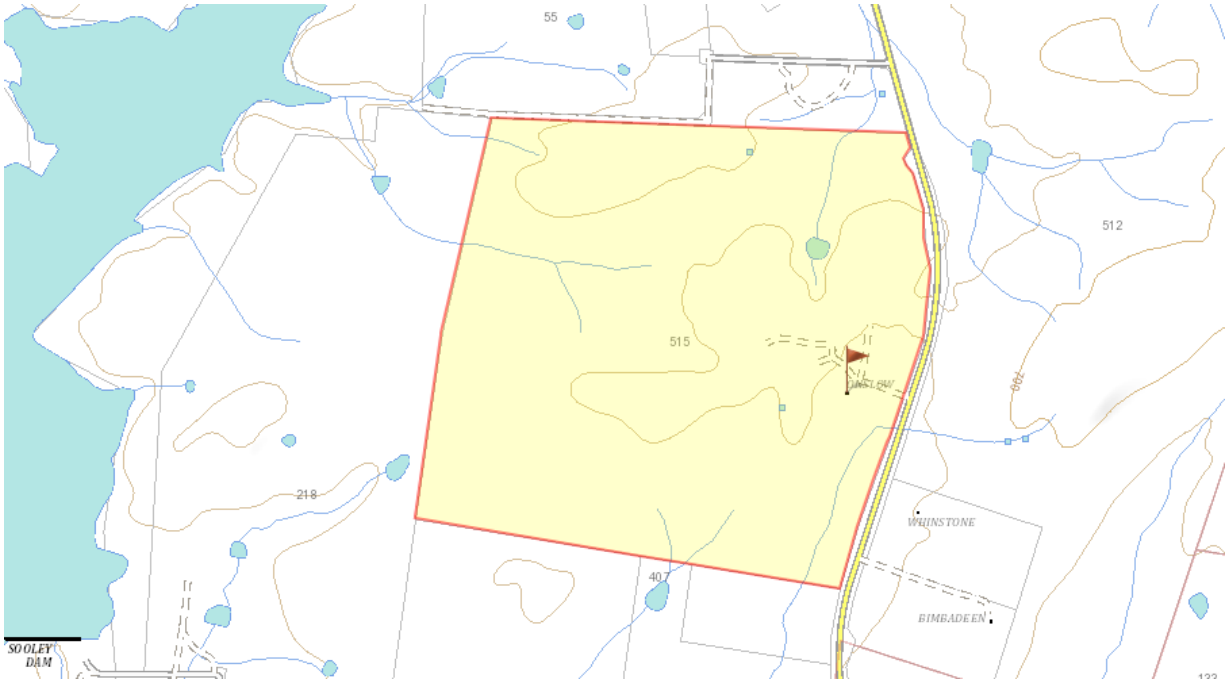

Figure 2: NSW Topography (SIX Maps)

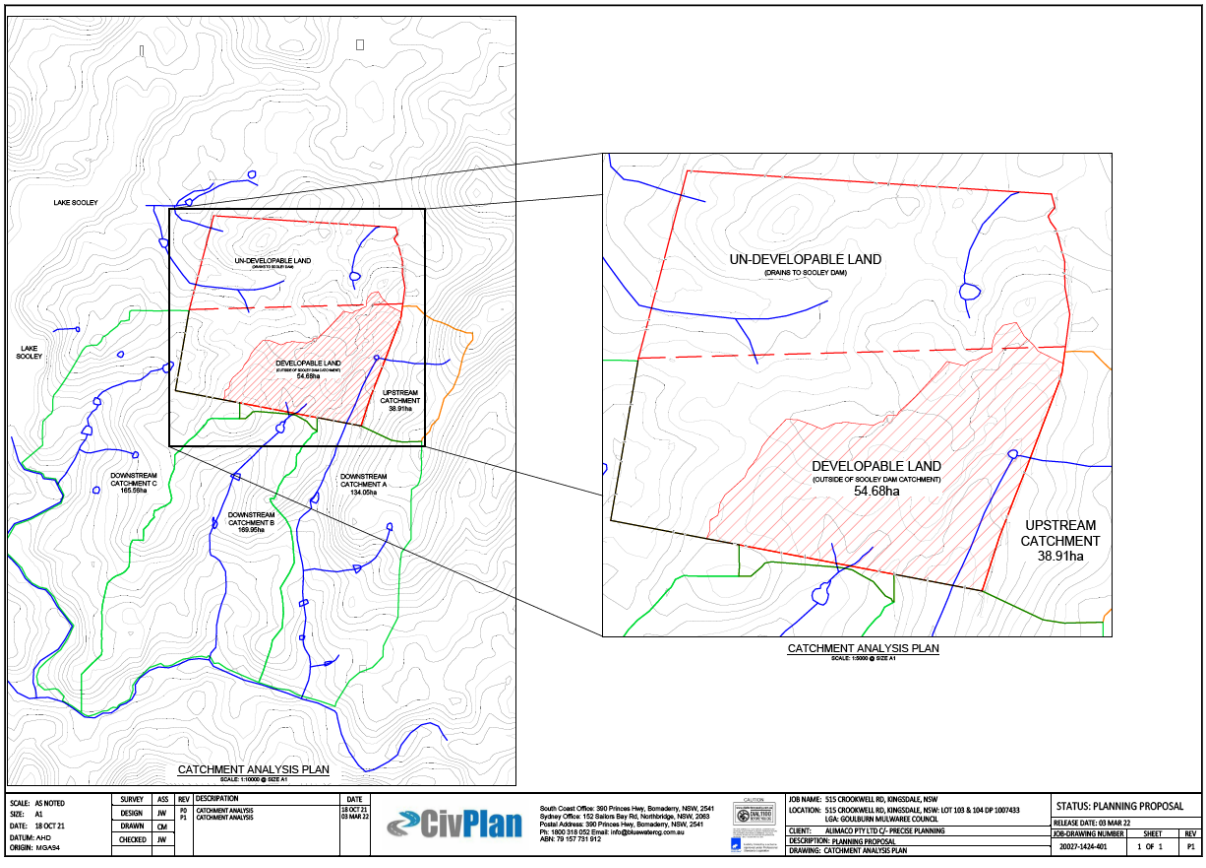

Figure 3: Developable Land & Catchment Analysis

2. Project Overview

2.1 The Site

The site is located on Lot 103 & 104 DP 1007433 at 515 Crookwell Road, Kingsdale, NSW and is within the Goulburn Mulwaree Council and the WaterNSW catchment area. Access to the site is via an unpaved driveway from Crookwell Road leading to a dwelling and associated sheds and grain storage silos in the centre along the eastern boundary.

Lot 103 DP 1007433 has an approximate area of 90.97ha and lot 104 74.19ha. The developable land area of the site only (figure 3) is being assessed for this report, which is 54.68ha. This area is being considered due to the catchment bypassing nearby Sooley Dam to the west and flowing directly towards the Wollondilly River, downstream of the dam. The area is generally undulating and dips at approximately 6-7% falling from the northern extent at approximately RL 685 to RL 670 approximately 760m to the south.

The property has a driveway leading from Crookwell Road on the eastern boundary to the main dwelling and extended driveways leading to multiple large rural storage sheds and silos west and north of the dwelling. Further north, a gravel road leads to additional rural sheds and fenced stock yards. The remainder of the property is divided and fenced paddocks for different purposes, including for sheep grazing and cropping. A paddock to the south of the dwelling contains a bore (ID: GW050231).

The remainder of the rural property is divided and fenced into paddocks used for multiple purposes including sheep grazing and cropping. The site is zoned as RU6 Transition C3 Environmental Management under the Goulburn Mulwaree Local Environmental Plan (2009).

Property Address	515 Crookwell Road, Kingsdale, NSW
Title Id	Lot 103 & 104 DP 1007433
Ownership	Alicamo Pty Ltd
Local Government Area	Goulburn Mulwaree
Current use	Rural
Land Zoning	C3 Environmental Management
Proposed use	Large Lot Rural Residential
Council	Goulburn Mulwaree Council

Surrounding land use is rural farmland (stock & cropping), with Goulburn residential township located to the southeast 5km. Sooley Dam is located west of the site 1.05km from the western boundary.

2.2 Proposed Development

The site at 515 Crookwell Road, Kingsdale is a planning proposal to change the zoning to enable the development of approximately 23 large rural residential allotments with a minimum lot size of 2ha. The conceptual layout for this planning proposal is shown in figure 4.

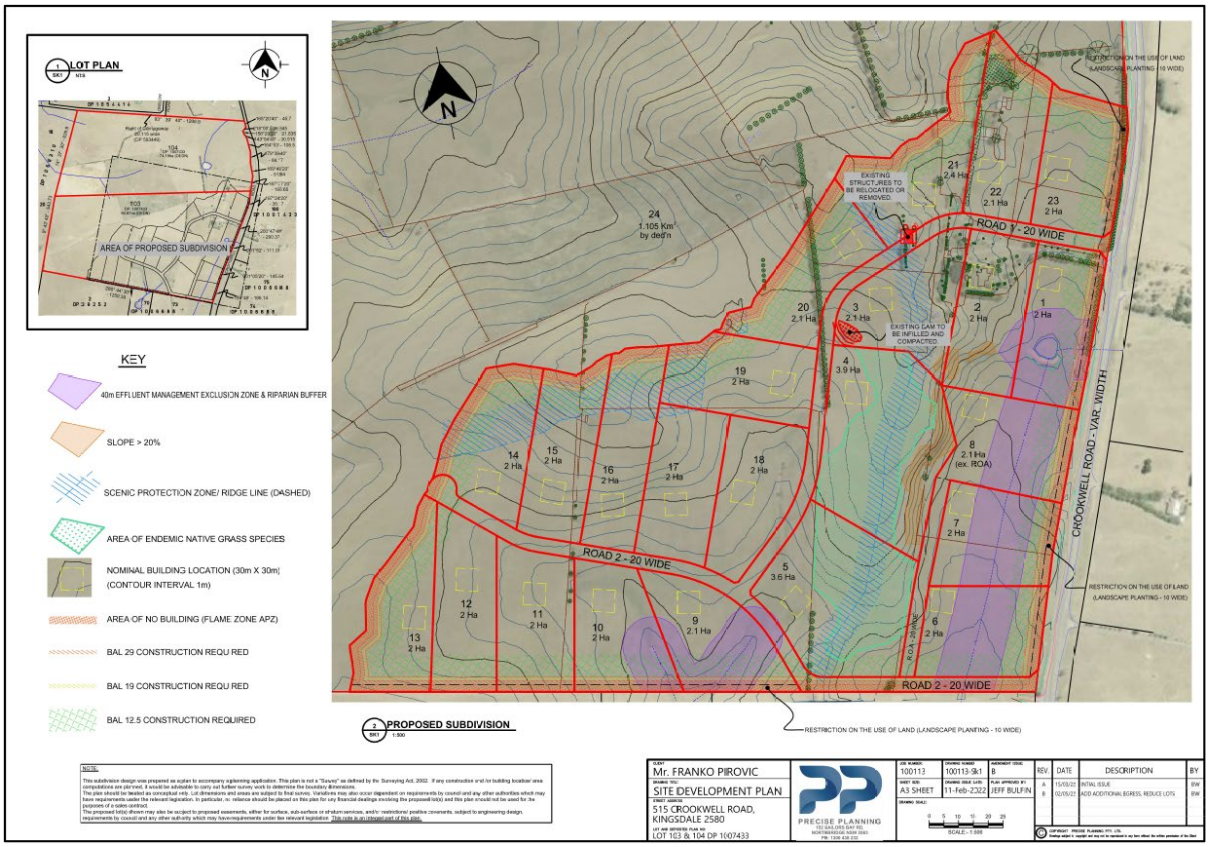

Figure 4: Conceptual Layout

2.3 General Geology

The 1:100,000 geology sheet for Goulburn indicates that the site is underlain by feldspar-lithic quartz sandstone with minor interbeded siltstone and mudstone of the Mount Fairy Group with Bishopthorpe suite dolerite formed in the Siluro-devonian.

2.4 Surface Topography

The area is generally undulating and dips at approximapagetely 6-7% falling from the northern extent at approximately RL 685 to RL 670 approximately 760m to the south.

2.4 Rainfall Data, Surface Hydrology & Sub-Surface Hydrogeology

Rainfall on the site area considered to be developed will naturally follow the slope of the site and drain to the south, towards the Wollondilly River.

As the site is within the WaterNSW Catchment area, data has been drawn from the WaterNSW catchment weather stations, with the site being located within Zone 3 for evaporation & Goulburn TAFE for rainfall, as shown in Table 1 below (reference figure 2.1 table 2.1 and 2.2 in the document *Designing and Installing On-Site Wastewater Systems v.2 by WaterNSW dated Nov 2019*).

Month	Mean Monthly Rainfall (mm)	Median Monthly Class A Pan Evaporation (mm)	Rainfall – Evaporation (mm)
January	61.9	187	-125.1
February	60.7	145	-84.3
March	55.6	124	-68.4

April	44	79	-35.0
May	40.7	51	-10.3
June	53.1	34	19.1
July	40.8	39	1.8
August	52.5	61	-8.5
September	48	88	-40.0
October	52.5	123	-70.5
November	62.6	146	-83.4
December	62.8	185	-122.5
Annual	**635.2**	**1262**	**-626.8**

Table 2: Rainfall Data: WaterNSW Weather Station Data: Goulburn TAFE / Zone 3

The rainfall data used to undertake the required modelling, analysis and design has been drawn from the ARR Data Hub and BoM using Australian Rainfall and Runoff 2019 (ARR19). The data drawn from the nearest point to the subject site was a Latitude 34.7479 South and Longitude 149.7375 East.

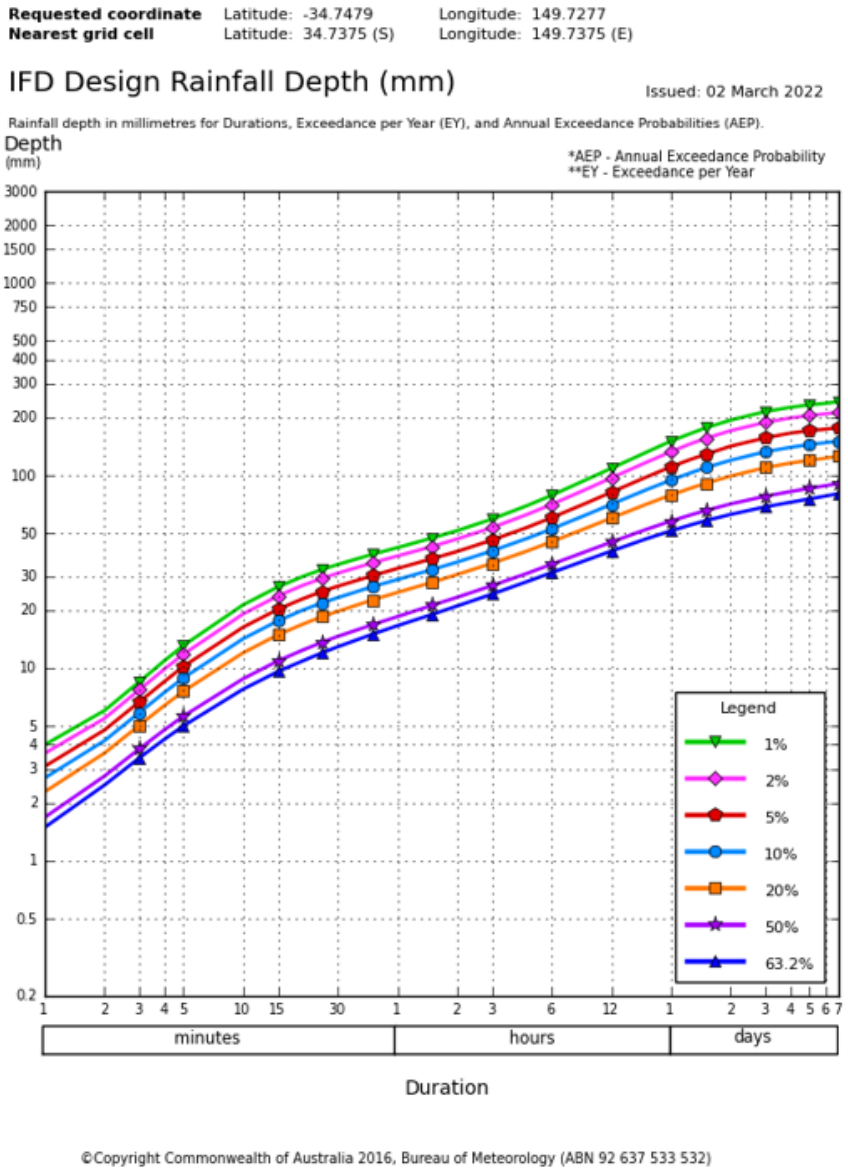

Figure 5: IFD Design Rainfall Intensity Data: Latitude 34.7375 South and Longitude 149.7375 East

Hydrogeology Map of Australia: Commonwealth of Australia (Geoscience Australia) describes aquifers on and around the site as porous with extensive aquifers of low to moderate productivity. It is expected that a seasonal perched groundwater table will exist on the site at the interface between the soil and the underlying bedrock. If present, the groundwater would typically follow the topography of the Site and drain towards the south as per the surface water runoff.

2.5 Groundwater

There are two bores located on the site. GW035919 in the north-western section of site and was drilled to 23.50m for domestic stock purposes. GW050231 is located near the eastern boundary of the site. This water-bore is for domestic stock purposes also and was drilled to 38m depth on 1st February 1980. There are four bores off site that are within a 500m vicinity. GW110284 to the north, GW049127 and, GW043667 to the east and GW049788 to the south (Figure 6).

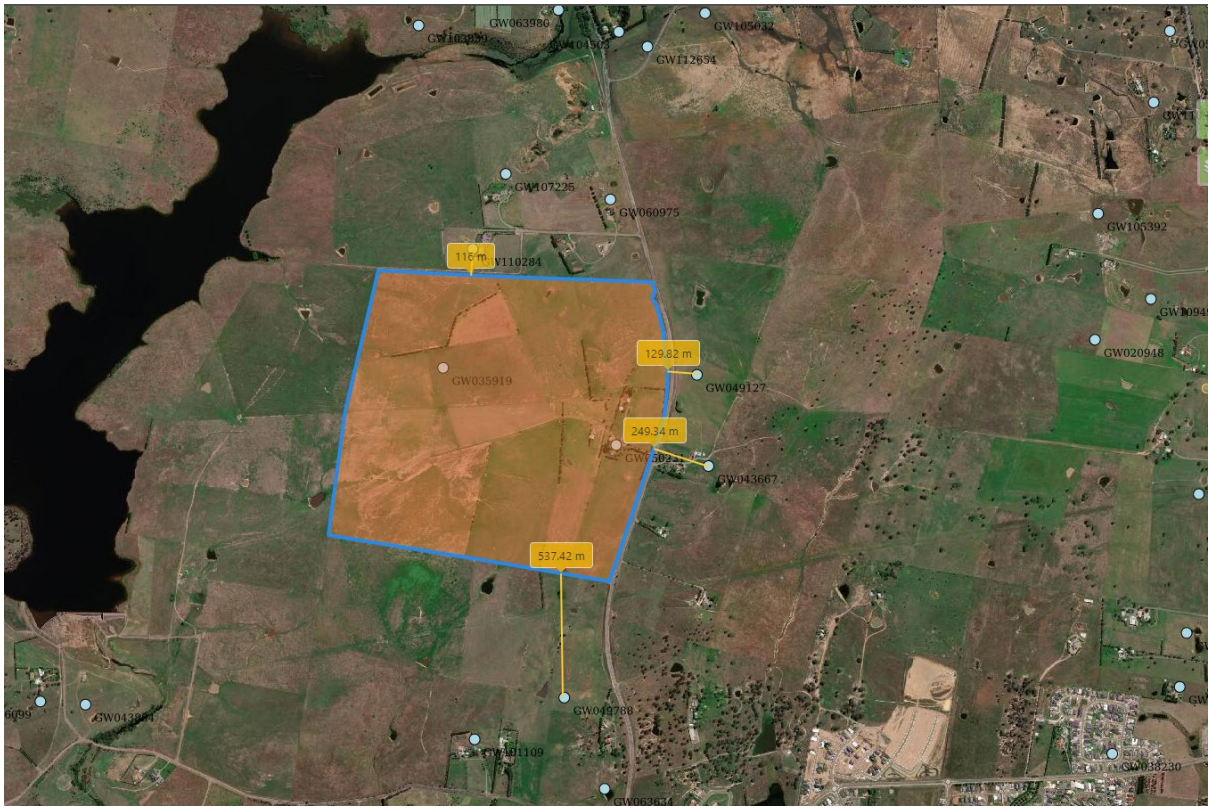

Figure 6: Groundwater Bore Locations (MinView).

2.6 Site Study Area Catchment Analysis

As part of the initial strategy for this planning proposal, Goulburn Mulwaree Council released an *Urban and Fringe Housing Strategy document dated 28th July 2020 and adopted on the 21st July 2020 (Resolution 2020/261)*. As part of Alimaco's submission to this document, a preliminary catchment analysis undertaken to determine the extent of the site that naturally drains away from the Lake Sooley catchment. The outcome of this analysis can be seen in figure 3, which is also consistent with the SIX Maps topographical output shown in figure 2.

Subsequent advice from WaterNSW dated 9th August 2021 (ref. no. DOC2021/0690662), expressed concerns that *"based on our drainage mapping and the SLWCA, part of the area identified by*

BlueWater Catchment Analysis Report as drainage away from Lake Sooley actually appears to drain northwards towards Bumana Creek and then into Lake Sooley".

The SLWCA referred to above is shown in figure 7 below. Based on detailed catchment analysis, undertaken using detailed site survey, LiDAR and satellite generated terrain models, as well as detailed site inspections, there is an error relating to this document's mapped watercourse flow analysis, which has been visually shown in figures 8 and 9.

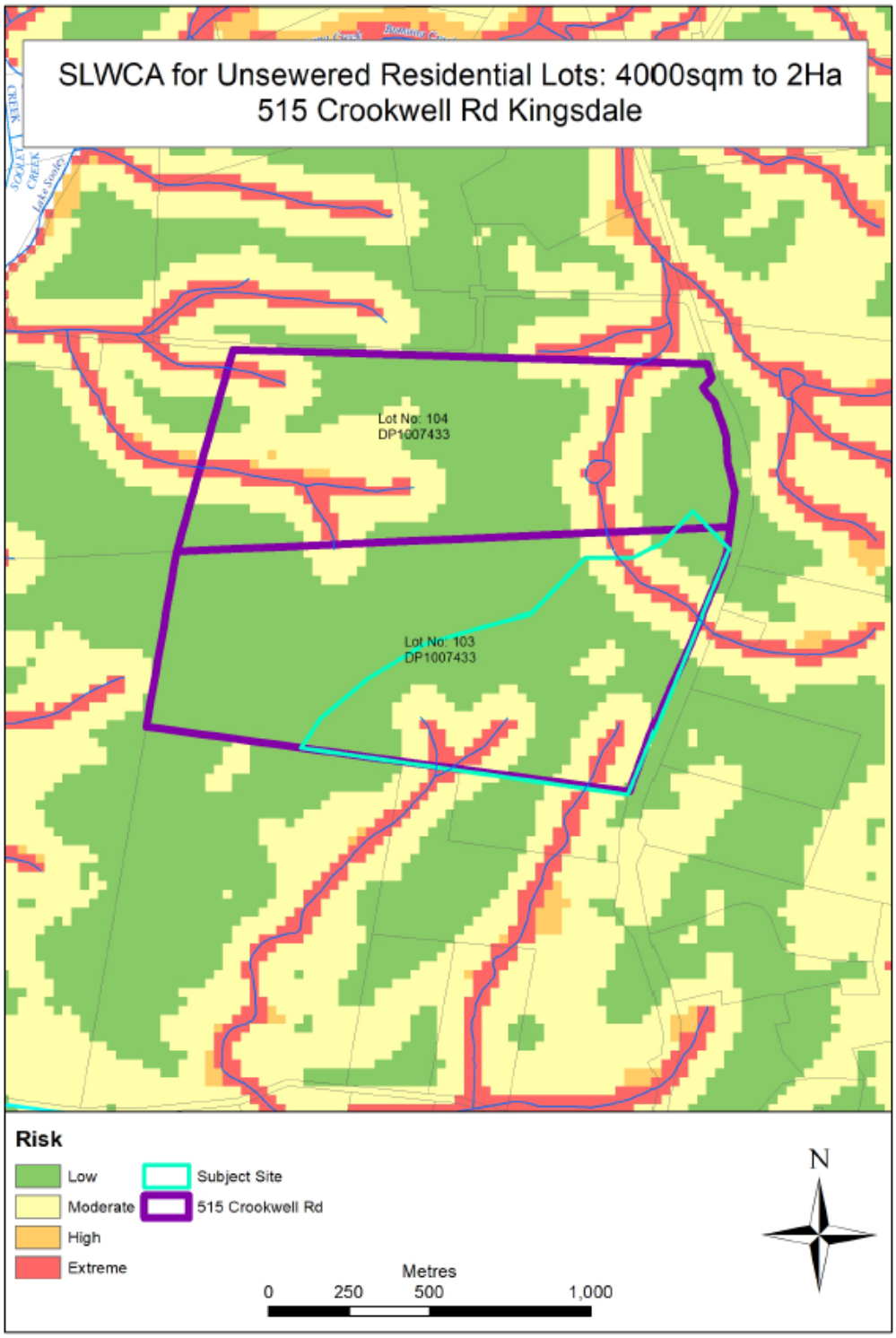

Figure 7: SLWCA Provided by WaterNSW

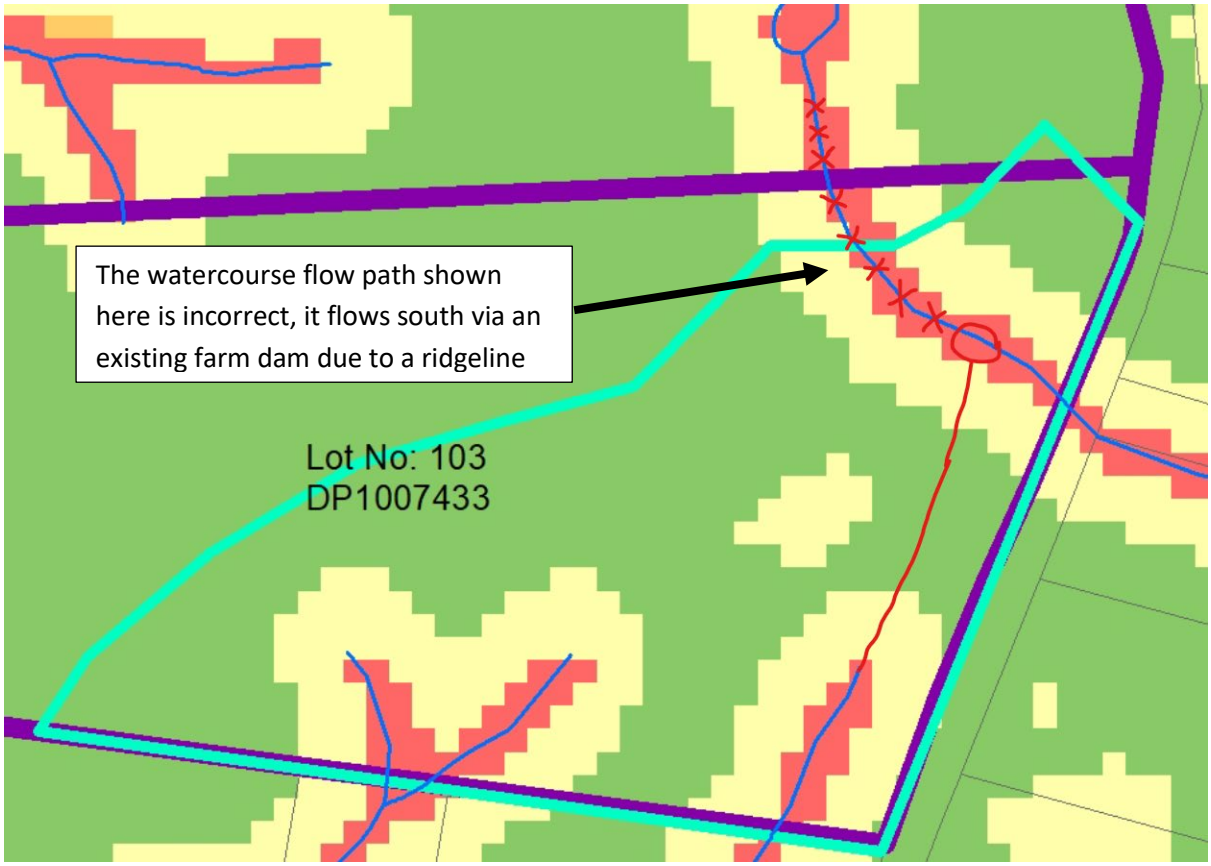

Figure 8: Watercourse Mapping Error

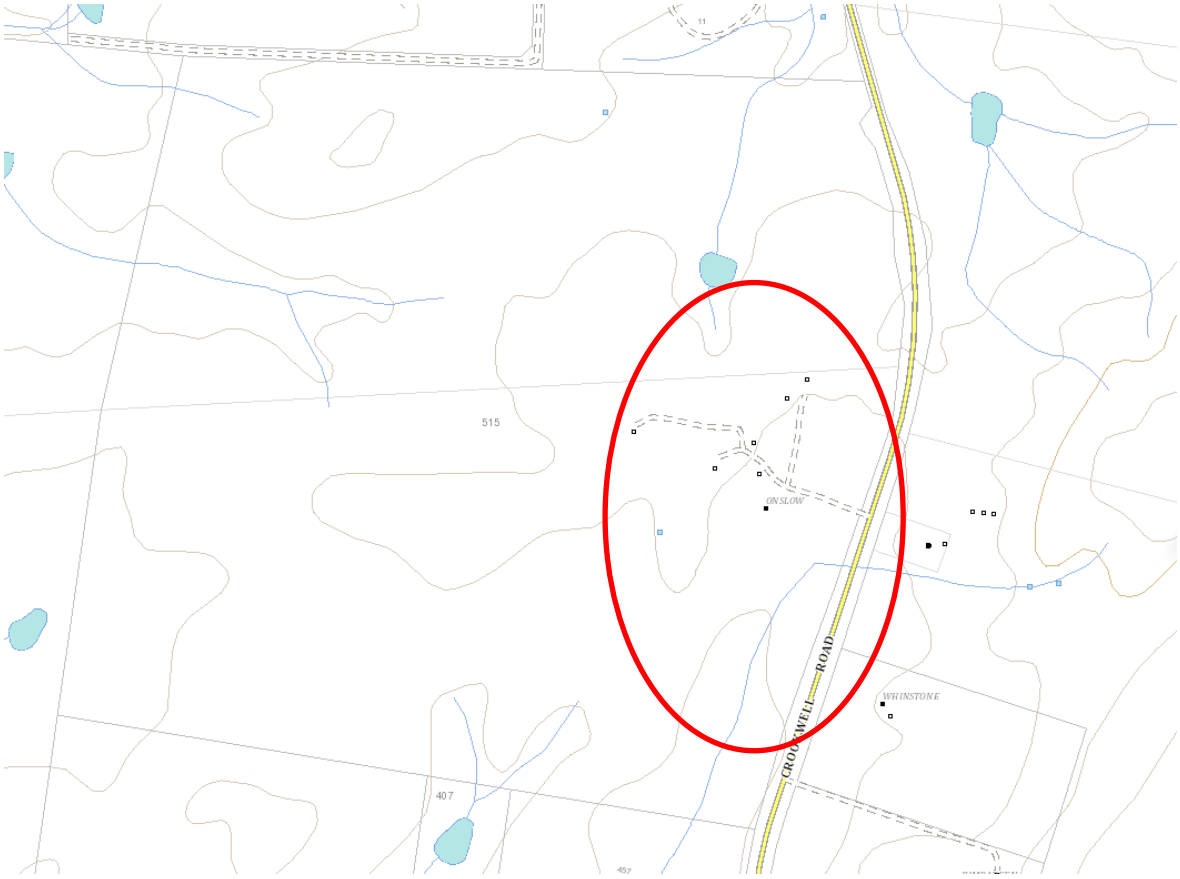

Figure 9: NSW Topography (SIX Maps) with Mapped Watercourses

3. Onsite Wastewater Management

3.1 Overview

The site is to be assessed for its suitability to implement onsite wastewater management treatment systems and disposal methods for the proposed large lot rezoning, noting that the site is within the WaterNSW catchment area. The specific standards and guidelines for this assessment are:

- AS/NZS 1547:2012 - On-site Domestic Wastewater Management
- WaterNSW (2019) Designing and Installing On-Site Wastewater Systems. A Sydney Catchment Authority Current Recommended Practice.
- Environment & Health Protection Guidelines: On-site Sewage Management for Single Households (1998)

3.2 Site Assessment

The table below, in accordance with *Environment & Health Protection Guidelines: On-site Sewage Management for Single Households (1998) table 4*, outlines the site assessment ratings for the suitability of this stie for onsite wastewater management:

Feature	Capable (minor limitation)	Marginal (moderate limitation)	Unsuitable (major limitation)	Site
Flood Potential				
EMA	Above 1 in 20 year flood level	-	-	Capable
Treatment System	Above 1 in 100 year flood level	-	-	Capable
Exposure	High sun and wind exposure	Moderate sun and wind exposure	Low sun and wind exposure	Capable
Slope (%)				
Surface irrigation	0-6	6-12	>12	Capable
Sub-surface irrigation	0-10	10-20	>20	Capable
Absorption system	0-10	10-20	>20	Capable
Landform	Hill crest, convex side slope, plains	Concave side slopes and footslopes	Drainage plains and incised channels	Capable
Run-on and upslope seepage	None – low	Moderate	High – diversion not practical	Capable
Erosion potential	No sign of erosion	-	Signs of erosion	Capable
Site drainage Groundwater	No sign of surface dampness	-	Signs of surface dampness	Capable
Fill	No fill	Fill present	-	Capable
Buffer distance	See relevant LGA & Authority tables	See relevant LGA & Authority tables	See relevant LGA & Authority tables	Capable
Land area	See relevant LGA & Authority tables	See relevant LGA & Authority tables	See relevant LGA & Authority tables	Capable

Rocks and rock outcrops (% of land surface)	<10%	10-20%	>20%	Capable
Geology / Regolith	-	-	Major geological discontinuities, fractured or highly porous regolith	Capable

Table 3: Site Assessment Criteria

Based on the above site assessment criteria in table 3, there are no significant limitation to the site conditions for application of an onsite wastewater management system. Noting the following specific comments in relation to the site:

- EMAs to each lot should be sighted in areas where the slope is between 0-10%, noting there is an isolated steep zone of >20% in the south-eastern corner of the site, parallel to Crookwell Rd, see the shaded area in figure 4
- Buffer distances for EMAs to each lot need to comply with the requirements set out in *WaterNSW (2019) Designing and Installing On-Site Wastewater Systems. A Sydney Catchment Authority Current Recommended Practice table 2.6 & Environment & Health Protection Guidelines: On-site Sewage Management for Single Households (1998) table 5*
    - 40m buffer from intermittent watercourses and dams as shown in figure 4.
    - It should be noted that the mapped watercourses shown in figure 2 and 4 of this report have been inspected and confirmed as intermittent with no defined bed or banks.
- The soil depth to the site is generally >1m to enable effective disposal of effluent via subsurface methods, with only very minor localised areas having less soil depth.
- No permanent or perched groundwater was encountered within 3m of the surface during site investigations.

3.3 Soil Assessment

Soil permeability is calculated in accordance with AS/NZS 1547:2012 Table 5.1 with indicative permeability rates aligned to the soil category, texture and structure. The design irrigation/loading rate (DIR/DLR) is determined from AS/NZS 1547:2012 Table 5.2 (figure 10 below).

TABLE 5.2
SOIL CATEGORIES AND RECOMMENDED DESIGN IRRIGATION/LOADING RATES (DIR/DLR) FOR LAND-APPLICATION SYSTEMS

Soil Category	Soil texture	Structure	Indicative permeability (K_{sat}) (m/d)	Design irrigation/loading rate (DIR/DLR) (mm/day)						
				Trenches and beds (see Table L1)			ETA/ETS beds and trenches (Table L1)	Drip and spray irrigation (Table M1)	LPED irrigation (Table M1)	Mounds (basal area) (Table N1)
				Primary treated effluent		Secondary treated effluent				
				Conservative rate	Maximum rate					
1	Gravels and sands	Structureless (massive)	> 3.0	(see Note 1 of Table L1 for DLR values)			(see Note 4 of Table L1)	5 (see Note 2 of Table M1)	(see Note 3 of Table M1)	32
2	Sandy loams	Weakly structured massive	> 3.0						4	24
			1.4 – 3.0	15	25	50				
3	Loams	High/ moderate structured	1.5 – 3.0	15	25	50		4 (see Note 1 of Table M1)	3.5	24
		Weakly structured or massive	0.5 – 1.5	10	15	30				16
4	Clay loams	High/ moderate structured	0.5 – 1.5	10	15	30	12	3.5 (see Note 1 of Table M1)	3	16
		Weakly structured	0.12 – 0.5	6	10	20	8			8
		Massive	0.06 – 0.12	4	5	10	5			(see Note to Table N1)
5	Light clays	Strongly structured	0.12 – 0.5	5	8	12	8	3 (see Note 1 of Table M1)	2.5 (see Note 4 of Table M1)	8
		Moderately structured	0.06 – 0.12	(see Notes 2 and 3 of Table L1)	5	10	5 (see Notes 2, 3, and 5 of Table L1)			(see Note to Table N1)
		Weakly structured or massive	< 0.06			8				
6	Medium to heavy clays	Strongly structured	0.06 – 0.5					2 (see Note 2 of Table M1)	(see Note 3 of Table M1)	
		Moderately structured	< 0.06							
		Weakly structured or massive	< 0.06							

Figure 10: Soil Categories

From the field work conducted, testing (see appendix A) and analysis of the borehole logs (see appendix B) the indicative permeability and design irrigation/loading rates (DIR/DLR) were determined as follows in Table 4 and 5.

Soil Zone	Soil Category	Soil Texture	Structure	Indicative Permeability (K_{sat}) (m/day)	Design Irrigation Rate (mm/day)
Topsoil (0-0.3m)	3b	Silty loams	Weak	0.5-1.5	4.0
Subsoil (0.3-1.0m)	5b	Light clays	Mod	0.05-0.12	3.0

Table 4: Design Irrigation Rate

Soil Zone	Soil Category	Soil Texture	Structure	Indicative Permeability (K_{sat}) (m/day)	Design Loading Rate (mm/day) (Secondary Effluent)
Topsoil (0-0.3m)	3b	Silty loams	Weak	0.5-1.5	30
Subsoil (0.3-1.0m)	5b	Light clays	Mod	0.05-0.12	10

Table 5: Design Loading Rate

From the samples taken from the test pits, alkalinity and electrical conductivity tests were undertaken to determine any chemical constraints to onsite wastewater disposal. The dispersivity of the site soils were determined by undertaking the Modified Emerson Aggregate Test in accordance with AS/NZS 1547:2012 Appendix E7. Summary of results can be found in table 6.

515 Crookwell Road, Kingsdale, NSW

Sample Number	Depth (m)	pH	EC (µS/cm)	Moisture Content (%)	Resistivity at 25 °C (ohm cm)	Exchangeable Cations (meq/100g)					Exchangeable Sodium Percent	Sulfate as SO4 (mg/kg)	Phosphate Sorption Capacity (mg/kg)
						Exchangeable Calcium	Exchangeable Magnesium	Exchangeable Potassium	Exchangeable Sodium	Cation Exchange Capacity			
LOR	-	0.1	1	1	250	0.1	0.1	0.1	0.1	0.1	0.1	10	250
Limits	-	-	4000	-	-	-	-	-	0-5	>15	-	-	>800
BH001/1	0.1	5.1	27.0	-	-	3.9	2.1	0.4	<0.1	6.6	1.1	-	-
BH001/2	0.5	6.8	41.0	-	-	7.2	14.9	0.3	0.6	23.0	2.4	-	-
BH001/3	1.0	7.9	87.0	-	-	-	-	-	-	-	-	-	-
BH002/1	0.1	6.1	30.0	-	-	5.5	3.6	0.6	<0.1	9.8	0.8	-	-
BH002/2	0.5	7.2	31.0	-	-	11.3	14.0	0.3	0.4	26.0	1.6	-	-
BH0B1/1	0.1	6.4	27.0	-	-	11.9	11.8	0.2	0.6	24.4	2.3	-	-
BH0B1/2	0.5	8.6	37.0	17	-	9.1	13.8	0.2	2.3	25.3	9.2	<10	1290
BH0B1/3	0.8	9.1	313.0	-	-	7.1	14.8	<0.2	2.9	25.0	11.6	-	-
BH0C1/1	0.1	6.9	27.0	-	-	1.8	0.8	0.5	<0.1	3.1	0.8	-	-
BH0C1/2	0.5	7.6	60.0	11.5	-	1.8	1.9	2.0	<0.2	5.7	<0.2	20.0	1710
BH0C1/3	0.8	7.5	102.0	-	-	-	-	-	-	-	-	-	-
BH0D1/1	0.1	6.2	22.0	-	-	9.0	4.2	0.1	0.2	13.6	1.3	-	-
BH0D1/2	0.5	7.6	45.0	19.3	-	7.1	12.3	0.2	0.7	20.4	3.5	10.0	1780
BH0E1/1	0.1	6.4	16.0	-	-	2.1	0.2	<0.1	<0.1	2.5	2.9	-	-
BH0E1/2	0.5	5.8	46.0	12.4	-	2.2	4.3	0.1	0.6	7.2	8.1	50.0	1370
BH0E1/3	0.8	6.8	111.0	-	-	-	-	-	-	-	-	-	-
BH0F1/1	0.1	6.2	16.0	-	-	3.1	0.4	<0.1	<0.1	3.6	1.3	-	-
BH0F1/2	0.5	6.5	48.0	16.1	-	5.3	5.8	0.2	0.3	11.7	2.8	40.0	-
BH0G1/1	0.1	5.5	18.0	-	-	2.2	0.3	<0.1	<0.1	2.7	2.1	-	-
BH0G1/2	0.5	6.4	20.0	9.4	-	3.2	1.6	0.1	<0.1	5.0	1.5	10.0	-

EC- Electrical Conductivity TSS- Total Soluble Salts

Table 6: Tabulated NATA Laboratory Results

The table below, in accordance with *Environment & Health Protection Guidelines: On-site Sewage Management for Single Households (1998) table 6*, outlines the soil assessment ratings for the suitability of this stie for onsite wastewater management:

Feature	Capable (minor limitation)	Marginal (moderate limitation)	Unsuitable (major limitation)	Subject Site
Depth to bedrock				
Surf/Sub-Surf Irrigation	>1.0	0.5-1.0	<0.5	>1.5 (Capable)
Absorption Systems	>1.5	1.0-1.5	<1.0	>1.5 (Capable)
Depth to water-table				
Surf/Sub-Surf Irrigation	>1.0	0.5-1.0	<0.5	>1.0m (Capable)
Absorption Systems	>1.5	1.0-1.5	<1.0	>1.5m (Capable)
Soil permeability category (AS/NZS1547)				
Surf/Sub-surf Irrigation	2b, 3 & 4	2a & 5	1 & 6	Cat 5b (Marginal)
Absorption Systems	3 & 4	-	1, 2, 5 & 6	Cat5b (Unsuitable)
Course fragments (%)	0-20	20-40	>40	0-20% (Capable)
Bulk density (g/cm^3)				
Sandy loam	<1.8	-	>1.8	
Loam & clay loam	<1.6	-	>1.6	Cat 5b (Capable)
Clay	<1.4	-	>1.4	
pH	>6.0	4.5-6.0	-	(Capable)
Electrical Conductivity (dS/m) *(1dS/m = 1000µS/cm)*	<4	4-8	>8	(Capable)
Sodicity (Exchangeable Sodium Percent)				
Surf/Sub-Surf Irrigation (0-0.4m)	0-5	5-10	>10	(Capable)
Absorption Systems (0-1.2m)	0-5	5-10	>10	(Unsuitable)
Cation Exchange capacity ($cmol^+/kg$) _ (meq/100g)				
Surf/Sub-Surf Irrigation (0-0.4m)	>15	5-15	<5	(Capable - Marginal)
Phosphorus sorption (kg/ha)				
Surf/Sub-Surf Irrigation 0-1m	>6000	2000-6000	<2000	>6000 kg/ha based on 0.5m @ $1500kg/m^3$ (Capable)
Modified Emerson Aggregate Test (dispersiveness)	Class 1	Class 2	Class 3 & 4	Class 1 (Capable)

Table 7: Soil Assessment Criteria

Based on the above soil assessment criteria in table 7, the most suitable onsite wastewater management system for each individual lot would be a Department of Health approved ***Aerated Wastewater Treatment System (AWTS) and to treat draining secondary effluent (using a pressure dosing system) to a drip irrigation subsurface disposal system*** with a good quality topsoil depth of 100-150mm***.***

3.4 Effluent Loading

The site currently has a 4-bedroom dwelling. The calculations are to be based on the *WaterNSW (2019) Designing and Installing On-Site Wastewater Systems. A Sydney Catchment Authority Current Recommended Practice table 2.3,* for 4 or more potential bedrooms of ***900L/d can be applied for a non-reticulated water supply source***, noting that this represents the peak loading.

Design wastewater loading for each potential bedroom	Reticulated / bore water	Tank water
1-2 potential bedrooms	600L/d	400L/d
3 potential bedrooms	900L/d	600L/d
4 potential bedrooms	1,200L/d	800L/d
More than 4 potential bedrooms	1,200L/d plus 150L for each additional bedroom	800L/d plus 100L/d for each additional bedroom
Source: WaterNSW, 2015. Note: WaterNSW adopts a conservative approach for wastewater design calculations. Water saving fixtures should be standard in all new dwellings.		

Figure 11: WaterNSW (2019) Designing and Installing On-Site Wastewater Systems. A Sydney Catchment Authority Current Recommended Practice table 2.3

It is recommended that standard water reduction fixtures and low flow devices such as dual six or three litre flush toilets, water saving shower heads and taps need to be adopted.

3.5 Treatment System

Through a series of treatment and disinfection processes, the wastewater is transformed into a non-potable secondary effluent that can be applied to a designated EMA with subsurface drip irrigation. The system will provide clarification, aeration, biological treatment, and disinfection (chlorination and/or UV treatment). The final wastewater nutrient levels for the AWTS are Total Nitrogen 20-50mg/L and Total Phosphorus of 12-18 mg/L.

The optimal location for the AWTS and if required wet weather storage tanks will need to be finalised to complement the reticulated sewer network, development site layout and EMA extents.

Of particular note:

- System must be installed in accordance with
    - AS/NZS 1547:2012
    - WaterNSW (2019) Designing and Installing On-Site Wastewater Systems. A Sydney Catchment Authority Current Recommended Practice.
    - Manufactures design and specifications

- The AWTS must be at least 3m from any building, 6m from in-ground pools and potable water tanks and 40m from intermittent watercourse.
- A power and communications supply will be required.
- The design of the AWTS must consider possible intermittent inflows and variable inflow quality based on the development use.

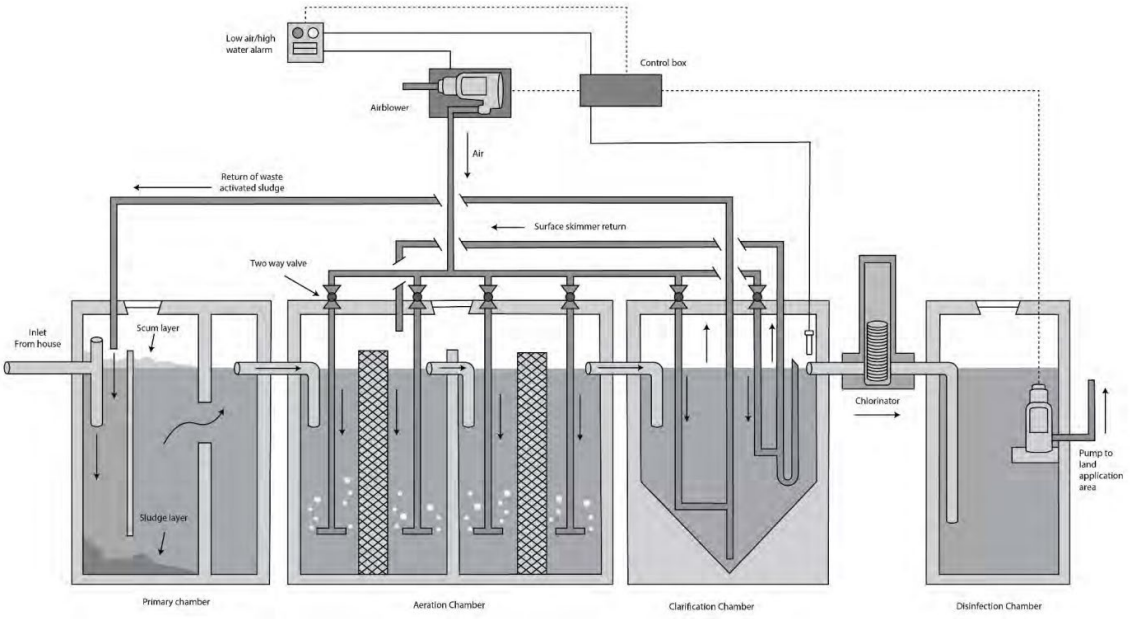

Figure 12: Typical Schematic of an AWTS

3.6 Disposal Method

The disposal method best suited to this site is an EMA of ***445m² sub-surface irrigation using drip lines.*** Alternatively, a smaller ***EMA of 411m²*** is possible although would require ***wet weather storage of 2kL*** to be installed.

The EMA is to be designed at the detailed design stage but must include:

- Shallow sub-surface irrigation via pressure compensating irrigation drip lines that evenly distribute effluent over the entire irrigation area, generally in up to a maximum of 400m^2 zones.
- Irrigation area to be designed, constructed and maintained in accordance with AS/NZS 1547:2012.
- Irrigation area to have a minimum topsoil thickness of 300mm.
- Distribution pipes should be minimum of 300mm underground (25mm uPVC or HDPE).
- Sub-surface drip lines (typically 16mm) at approximately 600mm spacing at 100-150mm deep.
- EMA and the treatment system (AWTS) must be outside of all the buffer areas indicated in section 3.2.
- EMA to be delineated by fencing or plant shrubs to prevent access via vehicles, livestock, domestic animals, and unauthorised humans.
- Signage in accordance with AS1319 indicating that the area is being irrigated with treated effluent are to be erected.

A typical example of a sub-surface irrigation system being installed can be seen in figure 13. See attached to this document Disposal System Standard Drawings at Appendix D

Figure 13: Typical Sub-Surface Irrigation System

3.7 Water & Nutrient Balance

The water and nutrient balance calculations can be found in Appendix C. The calculations are based on current best practice, literature and in accordance with the relevant guidelines listed in the references.

Of note the critical total nitrogen loading rate adopted is 65.7 mg/m^2/day as opposed to the nominal loading rate of 25 mg/m^2/day outlined in the Environmental Health Protection Guidelines 1998. This is derived from the paper written by Bob Patterson of Lanfax Laboratories in Armidale (Patterson, 2003) relating to critical nitrogen uptake.

The critical phosphorus loading rate adopted is 8.2 mg/m^2/day as opposed to the nominal loading rate of 3 mg/m^2/day outlined in the Environmental Health Protection Guidelines 1998. This is derived from the paper written by Bob Patterson of Lanfax Laboratories in Armidale (Patterson, 2001) relating to phosphorus uptake.

A summary of the EMA areas required for nutrient calculations is in the Table 8:

Parameter	Calculation Result
Estimated total nitrogen concentration (AWTS)	20 mg/L
Estimated total phosphorus concentration (AWTS)	10 mg/L
Estimated bulk soil density	1500 kg/m^3
Phosphorus sorption depth	0.5m
Phosphorus sorption capacity	1290 mg P/kg (9675 kg/ha)
Design effluent loading	900 L/day/dwelling (assuming non-reticulated water supply)
Design EMA	445m^2 or 411m^2 with 2kL wet weather storage
Nitrogen limiting EMA required	411m^2
Phosphorus limiting EMA required	274m^2

Table 8: Water & Nutrient Balance Calculations Summary

In the unlikely event of an EMA failure, due to the minimum size of the lots and capability of the site and soils, there is sufficient available area within each individual lot for reserve application areas.

To prevent failure or broken pipes and connections, adequate stormwater and groundwater drainage needs to be installed. Ag pipes need to be installed around the entire base of the tank structure with the tank backfilled with free draining material. If this cannot be achieved due to inadequate fall on the site to drain the ag pipes, the tank may need to be anchored in accordance with AS/NZS 1546.1:2008.

For sloping site with surface flows an upslope stormwater diversion drain needs to be installed to prevent ponding and pooling around the top of the tank. Appendix D of this document has a standard detailed for such a drain.

3.8 Onsite Wastewater Capability Summary

Based on the onsite wastewater capability review the following summary can be provided:

- The geology, soil characteristics, landform, land availability and climate are suitable for onsite wastewater disposal using **sub-surface irrigation**.
- An approved **Aerated Wastewater Treatment System (AWTS)** producing secondary treated effluent is recommended for each lot.
- Sub-surface irrigation with an **EMA of 445m^2** with no wet weather storage is recommended to be employed to dispose of the secondary treated effluent to each lot. Alternatively, a smaller **EMA of 411m^2** is possible but requires a wet weather storage area of **2kL** to be installed.
- Sufficient land, including reserve application areas, is available to each of the proposal lots for secondary effluent to be disposed of and meet NorBE requirements.
- Buffer distances must be adhered to on the subject site, particularly for the mapped intermittent watercourses that present no defined beds or banks.
- It is recommended that standard water reduction fixtures and low flow devices such as dual six or three litre flush toilets, water saving shower heads and taps be adopted.
- The AWTS to each lot will require electrical and communications connections as well as quarterly inspection and maintenance.
- The AWTS and disposal system will need to be designed and installed in accordance with AS/NZS 1547:2012 by a suitably qualified and licensed manufacture and plumber respectively.
- The optimal location for the AWTS and storage tanks will need to be finalised to complement the reticulated sewer network, site layout and EMA extents.

4. Stormwater Quality Management

4.1 Objectives

The site is located within the Goulburn Mulwaree Council LGA and also WaterNSW Catchment Area and this assessment has been prepared in accordance with the standards and guidelines listed in the references on page 2 of this report.

Water quality modelling and analysis will be undertaken in accordance with WaterNSW guidelines to achieve a neutral or beneficial (NorBE) water quality outcome using MUSIC modelling software. The criteria to achieve NorBE are:

- Post-development **mean annual pollutant loads** for total phosphorus (TP), total nitrogen (TN) and total suspected solids (TSS) are to be a minimum of 10% less than the pre-developed conditions.
- Post-development **mean annual gross pollutant loads** are to be equal to or less than the pre-developed conditions.
- Post-development **pollutant concentrations** for total phosphorus (TP) and total nitrogen (TN) must be equal to or less than the pre-development concentrations between the 50th and 98th percentiles where runoff occurs.

4.2 Water Quality Modelling and Climate Data

The water quality modelling and analysis will be undertaken utilising Model for Urban Stormwater Improvement Conceptualisation (MUSIC) software using the WaterNSW guideline *"Using MUSIC in Sydney's Drinking Water Catchment"* and specific treatment node data provided by WaterNSW, specifically Zone 1. Figures 13, 14 and 15 show the rainfall, evapotranspiration, period and time-step details of the data used.

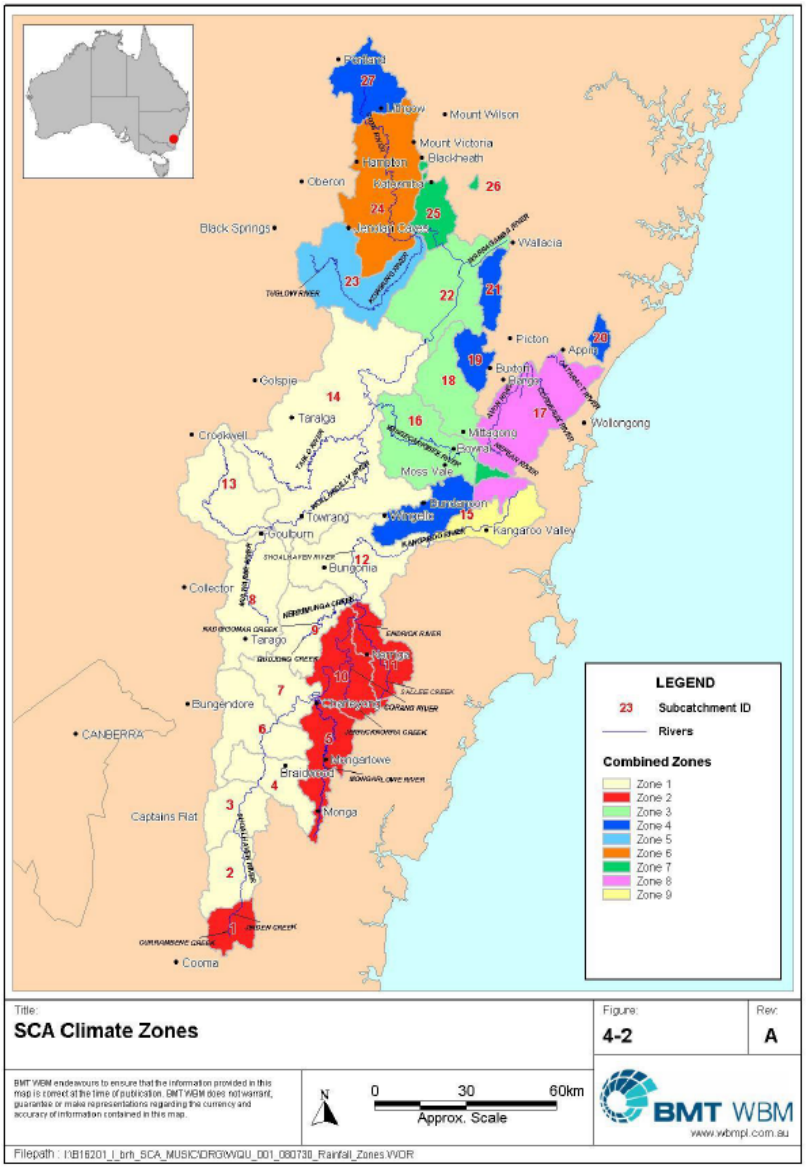

Figure 13: Climate Zones – Zone 1

	Rainfall/6 Minutes	Evapo-Transpiration
mean	0.010	3.210
median	0.000	2.700
maximum	12.500	5.290
minimum	0.000	1.300
10 percentile	0.000	1.320
90 percentile	0.000	5.000

	Rainfall	Evapo-Transpiration
mean annual	883	1172

Figure 14: Rainfall and Evapotranspiration Meteorological Data Statistics

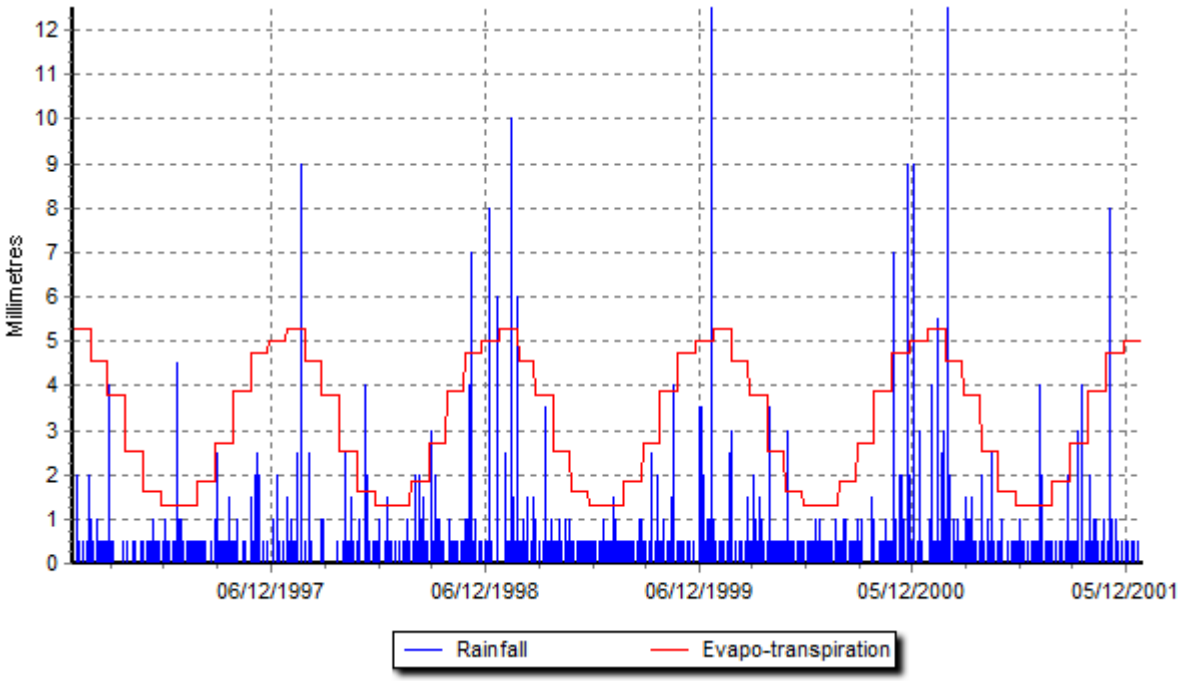

Figure 15: Time Step Graph with a 6-minute time step

4.3 Water Quality Approach & Catchment

The water quality approach consists of a rural setting with implementation of roadside bioretention swales to treat the new sealed road and grassed verge within the road reserve environment. It has been assumed that there will be no concrete footpaths due to the nature of the development, which is consistent with the Traffic Impact Assessment ref 300303400 dated 20th May 2022 by Stantec Pty Ltd. The road reserve width has been set at 20m wide with a sealed asphalt carriageway width of 9m, which is consistent with the Goulburn Mulwaree Council design standards and based on the lot yield, likely to be more than the minimum requirements.

For the new dwellings, an allotment yield of 23 individual allotments fronting the new proposed roads has been proposed, noting that lots 7-8 are via a right of way access handle. The roofs to each dwelling with allowance for sheds, garages etc has been assumed at 500m^2 per lot. The roof systems are to be connected via the gutter drainage network to a 10kL rainwater reuse tank (RWT) with an overflow to a bioretention raingarden, with an initial sizing of 16m^2. Furthermore, a residual 150m^2 of impervious area per lot for driveways has been allocated to bypass the plumbed RWT and have treatment via raingardens (12 lots being lots 1-4, 6-8, 9-13) or the bioswale (11 lots being lots 5, 14-23) depending on the natural topography of the development area.

Figure 16 below details the pre and post development land use, catchment sizing, effective impervious areas, assumptions, and applications.

Land Use	Surface Type	Effective* Impervious (%)	Area (ha)	Comments
Pre-Development				
Farming	Agriculture	0%	54.365	Developable Area
Dwelling/Shed	Roof	100%	0.116	Existing dwelling and sheds
Driveway	Unsealed road	50%	0.199	Existing unsealed driveways
Total	-	-	**54.68**	
Post-Development				
Sealed Road to bioswale	Asphalt	100%	1.53	9m wide sealed road
Road Reserve to bioswale	Verge - Grass	0%	2.0285	20m wide road reserve
Dwelling/Shed to RWT & Raingarden	Roof	100%	1.15	Allow 500m^2 per lot (23 lots)
Driveway to Raingarden	Unsealed road	28%	0.18	Allow 150m^2 per lot (12 lots)
Driveway to Bioswale	Unsealed road	28%	0.18	Allow 150m^2 per lot (11 lots)
Lot residual to bioswale (48%)	Rural Residential	0%	23.814	11 Lots
Lot residual bypass (52%)	Rural Residential	0%	25.798	12 Lots
Total	-	-	**54.68**	

** See WaterNSW MUSIC Guideline table 4.2*

Figure 16: Site MUSIC Catchments

Note that the default MUSIC stormflow concentration parameters have been used for the modelling of the quality measures and are in accordance with WaterNSW guidelines.

4.4 Treatment Measures

The water quality treatment measures for the proposed development are:

- Road Reserve
    - Roadside bioretention swales on each side of the crowned road pavement.
        - 2500m length in total with 0.6m wide and 0.4m deep filter media
        - Nutrient removal planting
        - Underdrain present with a 0.3m submerged zone
        - Lined system
- Lots / Dwellings
    - 10kL of RWT reuse/BASIX in addition to any other requirements, such as firefighting water storage capacity and or OSD requirements (PSD/SSR).
    - Reuse rates for external use are 55kL/year/dwelling and 0.845kL/day/dwelling for internal use. This is based on the WaterNSW guidelines and average dwelling size of 4 bedrooms.
    - Bioretention raingarden connected to the RWT overflow.
        - 16m2 and 0.4m deep filter media
        - Nutrient removal planting
        - Underdrain present with a 0.3m submerged zone
        - Lined system

4.5 Treatment Effectiveness

The treatment measures and subsequent results have been compared to the requirements of NorBE as outlined in section 4.1 of this report. The results from the MUSIC modelling in accordance with the approach, catchment and treatment measures outlined are shown in figure 17 to 21.

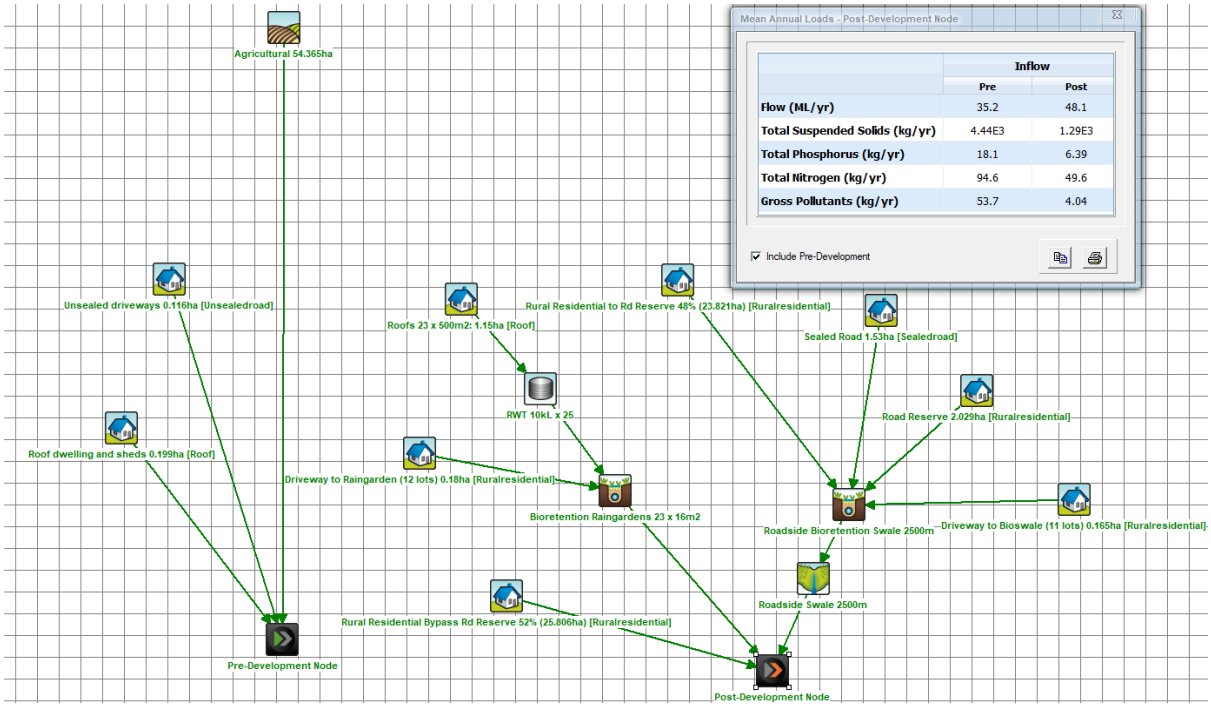

Figure 17: MUSIC Modelling – Treatment Measures & Mean Annual Loadings Reduction

Pollutant	Units	Pre	Post	Reduction
TSS	kg/yr	4440	1290	71%
TP	kg/yr	18.1	6.39	65%
TN	kg/yr	94.6	49.6	48%
GP	kg/yr	53.7	4.04	92%

Figure 18: MUSIC Modelling – Treatment Measures & Mean Annual Loadings Reduction

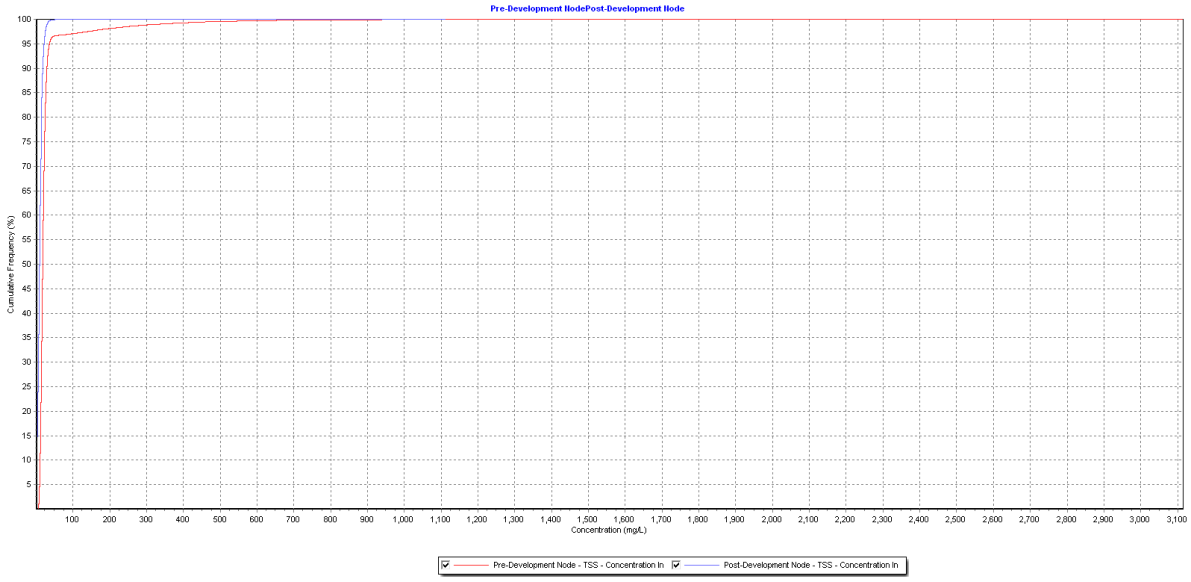

Figure 19: TSS Concentration

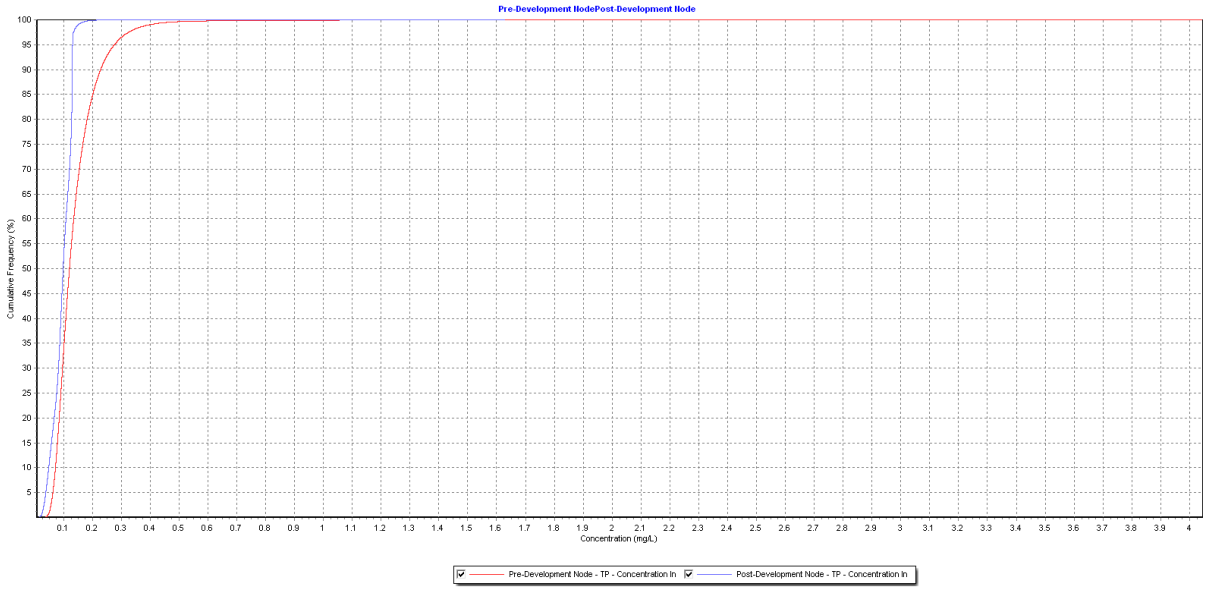

Figure 20: TP Concentration

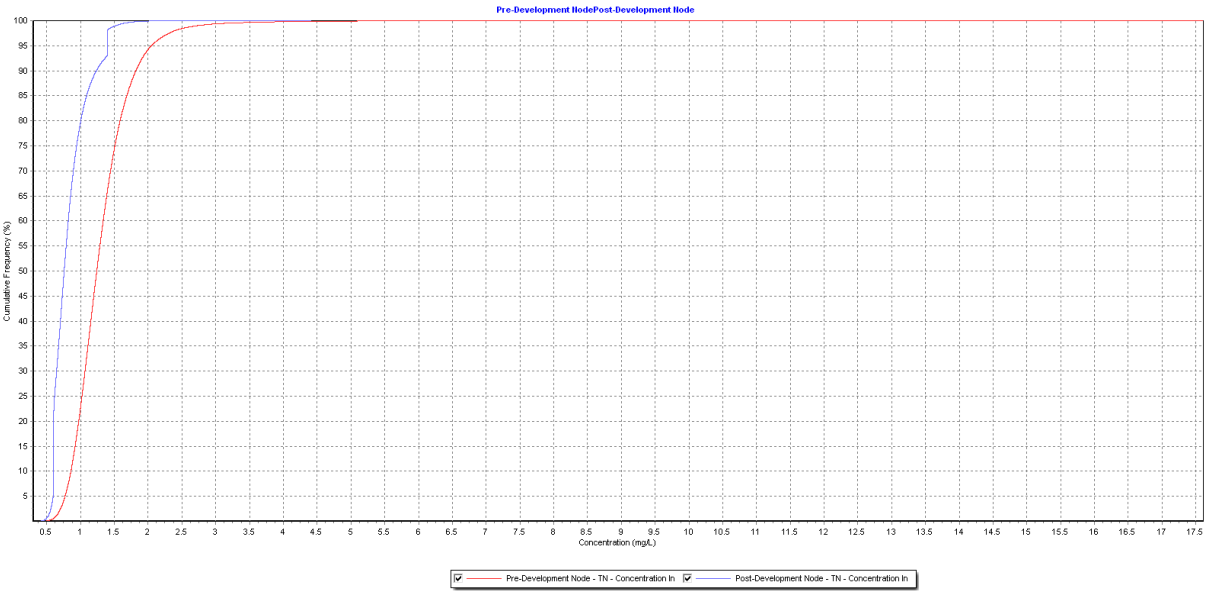

Figure 21: TN Concentration

4.6 Water Quality Capability Summary

In accordance with the WaterNSW guideline, NorBE Assessment Guidelines 2015, it has been demonstrated that the NorBE criteria for water quality can be achieved through the use of treatment measures that are sympathetic to the rural nature of the planning proposal.

The following NorBE criteria have been met, and in the case of the treatment measures modelled and analysed, exceeded:

- The post-development mean annual pollutant loads for total phosphorus (TP), total nitrogen (TN) and total suspected solids (TSS) are to be a minimum of 10% less than the pre-developed conditions.
- Post-development mean annual gross pollutant loads are to be equal to or less than the pre-developed conditions.

- Post-development pollutant concentrations for total phosphorus (TP) and total nitrogen (TN) must be equal to or less than the pre-development concentrations between the 50th and 98th percentiles where runoff occurs.

Appendix A – Laboratory Results

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES2139537**	Page	: 1 of 4
Client	: **CIVPLAN**	Laboratory	: Environmental Division Sydney
Contact	: Tanya Erofeev	Contact	: Customer Services ES
Address	: 390 Princes Hwy Bomaderry 2541	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: ----	Telephone	: +61-2-8784 8555
Project	: 515 Crookwell Road, Kingsdale	Date Samples Received	: 02-Nov-2021 10:48
Order number	: ----	Date Analysis Commenced	: 03-Nov-2021
C-O-C number	: ----	Issue Date	: 09-Nov-2021 12:01
Sampler	: ----		
Site	: ----		
Quote number	: EN/333		
No. of samples received	: 6		
No. of samples analysed	: 6		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Evie Sidarta	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	CR-BH0B/2	CR-BH0C/2	CR-BH0D/2	CR-BH0E/2	CR-BH0F/2
			Sampling date / time	06-Oct-2021 00:00	06-Oct-2021 00:00	06-Oct-2021 00:00	06-Oct-2021 00:00	06-Oct-2021 00:00
Compound	CAS Number	LOR	Unit	ES2139537-001	ES2139537-002	ES2139537-003	ES2139537-004	ES2139537-005
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**17.0**	**11.5**	**19.3**	**12.4**	**16.1**
ED040S: Soluble Major Anions								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	**20**	**10**	**50**	**40**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	CR-BH0G/2	----	----	----	----
				Sampling date / time	06-Oct-2021 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit		ES2139537-006	--------	--------	--------	--------
					Result	----	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	0.1	%		**9.4**	----	----	----	----
ED040S: Soluble Major Anions									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		**10**	----	----	----	----

QUALITY CONTROL REPORT

Work Order	: **ES2139537**	Page	: 1 of 3
Client	: **CIVPLAN**	Laboratory	: Environmental Division Sydney
Contact	: Tanya Erofeev	Contact	: Customer Services ES
Address	: 390 Princes Hwy Bomaderry 2541	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: ----	Telephone	: +61-2-8784 8555
Project	: 515 Crookwell Road, Kingsdale	Date Samples Received	: 02-Nov-2021
Order number	: ----	Date Analysis Commenced	: 03-Nov-2021
C-O-C number	: ----	Issue Date	: 09-Nov-2021
Sampler	: ----		
Site	: ----		
Quote number	: EN/333		
No. of samples received	: 6		
No. of samples analysed	: 6		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Evie Sidarta	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Acceptable RPD (%)*
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 3991825)									
ES2139537-003	CR-BH0D/2	EA055: Moisture Content	----	0.1	%	19.3	19.5	1.3	0% - 20%
ED040S: Soluble Major Anions (QC Lot: 3991824)									
ES2139537-004	CR-BH0E/2	ED040S: Sulfate as SO4 2-	14808-79-8	10	mg/kg	50	40	0.0	No Limit

Method Blank (MB) and Laboratory Control Sample (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Acceptable Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
ED040S: Soluble Major Anions (QCLot: 3991824)								
ED040S: Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	750 mg/kg	98.7	80.0	120

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

- **No Matrix Spike (MS) or Matrix Spike Duplicate (MSD) Results are required to be reported.**

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **ES2139537**	Page	: 1 of 4
Client	: **CIVPLAN**	Laboratory	: Environmental Division Sydney
Contact	: Tanya Erofeev	Telephone	: +61-2-8784 8555
Project	: 515 Crookwell Road, Kingsdale	Date Samples Received	: 02-Nov-2021
Site	: ----	Issue Date	: 09-Nov-2021
Sampler	: ----	No. of samples received	: 6
Order number	: ----	No. of samples analysed	: 6

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **NO Matrix Spike outliers occur.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **Analysis Holding Time Outliers exist - please see following pages for full details.**

Outliers : Frequency of Quality Control Samples

- **NO Quality Control Sample Frequency Outliers exist.**

Outliers : Analysis Holding Time Compliance

Matrix: **SOIL**

Method / Container / Client Sample ID(s)	Extraction / Preparation			Analysis		
	Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EA055: Moisture Content (Dried @ 105-110°C)						
Soil Glass Jar - Unpreserved						
CR-BH0B/2, CR-BH0C/2, CR-BH0D/2, CR-BH0E/2, CR-BH0F/2, CR-BH0G/2	----	----	----	03-Nov-2021	20-Oct-2021	**14**

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA055: Moisture Content (Dried @ 105-110°C)							
Soil Glass Jar - Unpreserved (EA055)							
CR-BH0B/2, CR-BH0C/2, CR-BH0D/2, CR-BH0E/2, CR-BH0F/2, CR-BH0G/2	**06-Oct-2021**	**----**	----	----	**03-Nov-2021**	20-Oct-2021	×
ED040S: Soluble Major Anions							
Soil Glass Jar - Unpreserved (ED040S)							
CR-BH0B/2, CR-BH0C/2, CR-BH0D/2, CR-BH0E/2, CR-BH0F/2, CR-BH0G/2	**06-Oct-2021**	**03-Nov-2021**	03-Nov-2021	✓	**03-Nov-2021**	01-Dec-2021	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Major Anions - Soluble	ED040S	1	6	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Moisture Content	EA055	1	6	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Major Anions - Soluble	ED040S	1	6	**16.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Major Anions - Soluble	ED040S	1	6	**16.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Moisture Content	EA055	SOIL	In house: A gravimetric procedure based on weight loss over a 12 hour drying period at 105-110 degrees C. This method is compliant with NEPM Schedule B(3).
Major Anions - Soluble	ED040S	SOIL	In house: Soluble Anions are determined off a 1:5 soil / water extract by ICPAES.

Preparation Methods	Method	Matrix	Method Descriptions
1:5 solid / water leach for soluble analytes	EN34	SOIL	10 g of soil is mixed with 50 mL of reagent grade water and tumbled end over end for 1 hour. Water soluble salts are leached from the soil by the continuous suspension. Samples are settled and the water filtered off for analysis.

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EW2104213**	Page	: 1 of 6
Client	: **CIVPLAN**	Laboratory	: Environmental Division NSW South Coast
Contact	: Tanya Erofeev	Contact	: Aneta Prosaroski
Address	: 390 Princes Hwy Bomaderry 2541	Address	: 1/19 Ralph Black Dr, North Wollongong 2500 NSW Australia
Telephone	: ----	Telephone	: 02 42253125
Project	: 515 Crookwell Road, Kingsdale	Date Samples Received	: 07-Oct-2021 15:12
Order number	: ----	Date Analysis Commenced	: 11-Oct-2021
C-O-C number	: ----	Issue Date	: 16-Oct-2021 08:12
Sampler	: Client, Tanya Erofeev		
Site	: ----		
Quote number	: EN/333		
No. of samples received	: 20		
No. of samples analysed	: 20		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Dian Dao	Senior Chemist - Inorganics	Sydney Inorganics, Smithfield, NSW

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- **Analytical work for this work order will be conducted at ALS Sydney.**
- ALS is not NATA accredited for the analysis of Exchangeable Cations on Alkaline Soils when performed under ALS Method ED006.
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	CR-BH001/1	CR-BH001/2	CR-BH001/3	CR-BH002/1	CR-BH002/2
			Sampling date / time	06-Oct-2021 00:00	06-Oct-2021 00:00	06-Oct-2021 00:00	06-Oct-2021 00:00	06-Oct-2021 00:00
Compound	CAS Number	LOR	Unit	EW2104213-001	EW2104213-002	EW2104213-003	EW2104213-004	EW2104213-005
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	**5.1**	**6.8**	**7.9**	**6.1**	**7.2**
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	**27**	**41**	**87**	**30**	**31**
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	**3.9**	**7.2**	**----**	**5.5**	**11.3**
Exchangeable Magnesium	----	0.1	meq/100g	**2.1**	**14.9**	**----**	**3.6**	**14.0**
Exchangeable Potassium	----	0.1	meq/100g	**0.4**	**0.3**	**----**	**0.6**	**0.3**
Exchangeable Sodium	----	0.1	meq/100g	<0.1	**0.6**	**----**	<0.1	**0.4**
Cation Exchange Capacity	----	0.1	meq/100g	**6.6**	**23.0**	**----**	**9.8**	**26.0**
Exchangeable Sodium Percent	----	0.1	%	**1.1**	**2.4**	**----**	**0.8**	**1.6**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	CR-BH0B/1	CR-BH0B/2	CR-BH0B/3	CR-BH0C/1	CR-BH0C/2
			Sampling date / time	06-Oct-2021 00:00	06-Oct-2021 00:00	06-Oct-2021 00:00	06-Oct-2021 00:00	06-Oct-2021 00:00
Compound	CAS Number	LOR	Unit	EW2104213-006	EW2104213-007	EW2104213-008	EW2104213-009	EW2104213-010
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	**6.4**	**8.6**	**9.1**	**6.9**	**7.6**
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	**27**	**77**	**313**	**27**	**60**
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	**----**	**9.1**	**7.1**	**----**	**1.8**
Exchangeable Magnesium	----	0.2	meq/100g	**----**	**13.8**	**14.8**	**----**	**1.9**
Exchangeable Potassium	----	0.2	meq/100g	**----**	**0.2**	<0.2	**----**	**2.0**
Exchangeable Sodium	----	0.2	meq/100g	**----**	**2.3**	**2.9**	**----**	<0.2
Cation Exchange Capacity	----	0.2	meq/100g	**----**	**25.3**	**25.0**	**----**	**5.7**
Exchangeable Sodium Percent	----	0.2	%	**----**	**9.2**	**11.6**	**----**	<0.2
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	**11.9**	**----**	**----**	**1.8**	**----**
Exchangeable Magnesium	----	0.1	meq/100g	**11.8**	**----**	**----**	**0.8**	**----**
Exchangeable Potassium	----	0.1	meq/100g	**0.2**	**----**	**----**	**0.5**	**----**
Exchangeable Sodium	----	0.1	meq/100g	**0.6**	**----**	**----**	<0.1	**----**
Cation Exchange Capacity	----	0.1	meq/100g	**24.4**	**----**	**----**	**3.1**	**----**
Exchangeable Sodium Percent	----	0.1	%	**2.3**	**----**	**----**	**0.8**	**----**
EK072: Phosphate Sorption Capacity								
Phosphate Sorption Capacity	----	250	mg P sorbed/kg	**----**	**1290**	**----**	**----**	**1710**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	CR-BH0C/3	CR-BH0D/1	CR-BH0D/2	CR-BH0E/1	CR-BH0E/2
			Sampling date / time	06-Oct-2021 00:00	06-Oct-2021 00:00	06-Oct-2021 00:00	06-Oct-2021 00:00	06-Oct-2021 00:00
Compound	CAS Number	LOR	Unit	EW2104213-011	EW2104213-012	EW2104213-013	EW2104213-014	EW2104213-015
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	**7.5**	**6.2**	**7.6**	**6.4**	**5.8**
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	**102**	**22**	**45**	**16**	**46**
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	**----**	**----**	**7.1**	**----**	**----**
Exchangeable Magnesium	----	0.2	meq/100g	**----**	**----**	**12.3**	**----**	**----**
Exchangeable Potassium	----	0.2	meq/100g	**----**	**----**	**0.2**	**----**	**----**
Exchangeable Sodium	----	0.2	meq/100g	**----**	**----**	**0.7**	**----**	**----**
Cation Exchange Capacity	----	0.2	meq/100g	**----**	**----**	**20.4**	**----**	**----**
Exchangeable Sodium Percent	----	0.2	%	**----**	**----**	**3.5**	**----**	**----**
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	**----**	**9.0**	**----**	**2.1**	**2.2**
Exchangeable Magnesium	----	0.1	meq/100g	**----**	**4.2**	**----**	**0.2**	**4.3**
Exchangeable Potassium	----	0.1	meq/100g	**----**	**0.1**	**----**	<0.1	**0.1**
Exchangeable Sodium	----	0.1	meq/100g	**----**	**0.2**	**----**	<0.1	**0.6**
Cation Exchange Capacity	----	0.1	meq/100g	**----**	**13.6**	**----**	**2.5**	**7.2**
Exchangeable Sodium Percent	----	0.1	%	**----**	**1.3**	**----**	**2.9**	**8.1**
EK072: Phosphate Sorption Capacity								
Phosphate Sorption Capacity	----	250	mg P sorbed/kg	**----**	**----**	**1780**	**----**	**1370**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	CR-BH0E/3	CR-BH0F/1	CR-BH0F/2	CR-BH0G/1	----
			Sampling date / time	06-Oct-2021 00:00	06-Oct-2021 00:00	06-Oct-2021 00:00	06-Oct-2021 00:00	06-Oct-2021 00:00
Compound	CAS Number	LOR	Unit	EW2104213-016	EW2104213-017	EW2104213-018	EW2104213-019	EW2104213-020
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	**6.8**	**6.2**	**6.5**	**5.5**	**6.4**
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	**111**	**16**	**48**	**18**	**20**
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	**----**	**3.1**	**5.3**	**2.2**	**3.2**
Exchangeable Magnesium	----	0.1	meq/100g	**----**	**0.4**	**5.8**	**0.3**	**1.6**
Exchangeable Potassium	----	0.1	meq/100g	**----**	<0.1	**0.2**	<0.1	**0.1**
Exchangeable Sodium	----	0.1	meq/100g	**----**	<0.1	**0.3**	<0.1	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	**----**	**3.6**	**11.7**	**2.7**	**5.0**
Exchangeable Sodium Percent	----	0.1	%	**----**	**1.3**	**2.8**	**2.1**	**1.5**

Inter-Laboratory Testing

Analysis conducted by ALS Sydney, NATA accreditation no. 825, site no. 10911 (Chemistry) 14913 (Biology).

(SOIL) EA002: pH 1:5 (Soils)

(SOIL) EA010: Conductivity (1:5)

(SOIL) ED007: Exchangeable Cations

(SOIL) EK072: Phosphate Sorption Capacity

(SOIL) ED006: Exchangeable Cations on Alkaline Soils

QUALITY CONTROL REPORT

Work Order	: **EW2104213**	Page	: 1 of 4
Client	: **CIVPLAN**	Laboratory	: Environmental Division NSW South Coast
Contact	: Tanya Erofeev	Contact	: Aneta Prosaroski
Address	: 390 Princes Hwy Bomaderry 2541	Address	: 1/19 Ralph Black Dr, North Wollongong 2500 NSW Australia
Telephone	: ----	Telephone	: 02 42253125
Project	: 515 Crookwell Road, Kingsdale	Date Samples Received	: 07-Oct-2021
Order number	: ----	Date Analysis Commenced	: 11-Oct-2021
C-O-C number	: ----	Issue Date	: 16-Oct-2021
Sampler	: Client, Tanya Erofeev		
Site	: ----		
Quote number	: EN/333		
No. of samples received	: 20		
No. of samples analysed	: 20		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Dian Dao	Senior Chemist - Inorganics	Sydney Inorganics, Smithfield, NSW

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Acceptable RPD (%)
EA002: pH 1:5 (Soils) (QC Lot: 3949224)									
EW2104213-009	CR-BH0C/1	EA002: pH Value	----	0.1	pH Unit	6.9	6.7	2.5	0% - 20%
EW2104213-001	CR-BH001/1	EA002: pH Value	----	0.1	pH Unit	5.1	5.2	0.0	0% - 20%
EA002: pH 1:5 (Soils) (QC Lot: 3949226)									
EW2104213-020		EA002: pH Value	----	0.1	pH Unit	6.4	6.5	1.9	0% - 20%
EA010: Conductivity (1:5) (QC Lot: 3949225)									
EW2104213-009	CR-BH0C/1	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	27	26	0.0	0% - 20%
EW2104213-001	CR-BH001/1	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	27	23	14.8	0% - 20%
EA010: Conductivity (1:5) (QC Lot: 3949227)									
EW2104213-020		EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	20	18	12.2	0% - 20%
ED006: Exchangeable Cations on Alkaline Soils (QC Lot: 3954682)									
EW2104213-007	CR-BH0B/2	ED006: Exchangeable Sodium Percent	----	0.2	%	9.2	9.4	2.2	0% - 20%
		ED006: Exchangeable Calcium	----	0.2	meq/100g	9.1	9.4	3.8	0% - 20%
		ED006: Exchangeable Magnesium	----	0.2	meq/100g	13.8	14.8	7.4	0% - 20%
		ED006: Exchangeable Potassium	----	0.2	meq/100g	0.2	0.2	0.0	No Limit
		ED006: Exchangeable Sodium	----	0.2	meq/100g	2.3	2.5	8.4	0% - 50%
		ED006: Cation Exchange Capacity	----	0.2	meq/100g	25.3	27.0	6.3	0% - 20%
ED007: Exchangeable Cations (QC Lot: 3954685)									
EW2104213-001	CR-BH001/1	ED007: Exchangeable Sodium Percent	----	0.1	%	1.1	1.1	0.0	0% - 50%
		ED007: Exchangeable Calcium	----	0.1	meq/100g	3.9	3.9	0.0	0% - 20%
		ED007: Exchangeable Magnesium	----	0.1	meq/100g	2.1	2.1	0.0	0% - 20%
		ED007: Exchangeable Potassium	----	0.1	meq/100g	0.4	0.4	0.0	No Limit
		ED007: Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	0.0	No Limit
		ED007: Cation Exchange Capacity	----	0.1	meq/100g	6.6	6.5	0.0	0% - 20%

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Acceptable RPD (%)*
ED007: Exchangeable Cations (QC Lot: 3954685) - continued									
EW2104213-017	CR-BH0F/1	ED007: Exchangeable Sodium Percent	----	0.1	%	1.3	1.2	0.0	0% - 50%
		ED007: Exchangeable Calcium	----	0.1	meq/100g	3.1	3.2	0.0	0% - 20%
		ED007: Exchangeable Magnesium	----	0.1	meq/100g	0.4	0.4	0.0	No Limit
		ED007: Exchangeable Potassium	----	0.1	meq/100g	<0.1	<0.1	0.0	No Limit
		ED007: Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	0.0	No Limit
		ED007: Cation Exchange Capacity	----	0.1	meq/100g	3.6	3.6	0.0	0% - 20%
EK072: Phosphate Sorption Capacity (QC Lot: 3947145)									
EB2127980-001	Anonymous	EK072: Phosphate Sorption Capacity	----	250	mg P sorbed/kg	4580	4580	0.1	0% - 50%
ES2136018-009	Anonymous	EK072: Phosphate Sorption Capacity	----	250	mg P sorbed/kg	2080	2060	1.4	No Limit

Method Blank (MB) and Laboratory Control Sample (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Acceptable Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA010: Conductivity (1:5) (QCLot: 3949225)								
EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	1412 µS/cm	105	92.0	108
EA010: Conductivity (1:5) (QCLot: 3949227)								
EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	1412 µS/cm	105	92.0	108
ED006: Exchangeable Cations on Alkaline Soils (QCLot: 3954682)								
ED006: Exchangeable Calcium	----	0.2	meq/100g	<0.2	2.5 meq/100g	98.0	80.0	110
ED006: Exchangeable Magnesium	----	0.2	meq/100g	<0.2	4.17 meq/100g	101	80.0	110
ED006: Exchangeable Potassium	----	0.2	meq/100g	<0.2	1.28 meq/100g	103	80.0	110
ED006: Exchangeable Sodium	----	0.2	meq/100g	<0.2	2.17 meq/100g	97.2	80.0	110
ED006: Cation Exchange Capacity	----	0.2	meq/100g	<0.2	----	----	----	----
ED006: Exchangeable Sodium Percent	----	0.2	%	<0.2	----	----	----	----
ED007: Exchangeable Cations (QCLot: 3954685)								
ED007: Exchangeable Calcium	----	0.1	meq/100g	<0.1	1 meq/100g	96.0	75.8	120
ED007: Exchangeable Magnesium	----	0.1	meq/100g	<0.1	1.67 meq/100g	95.2	74.9	115
ED007: Exchangeable Potassium	----	0.1	meq/100g	<0.1	0.51 meq/100g	110	80.0	120
ED007: Exchangeable Sodium	----	0.1	meq/100g	<0.1	0.87 meq/100g	98.8	80.0	120
ED007: Cation Exchange Capacity	----	0.1	meq/100g	<0.1	----	----	----	----
ED007: Exchangeable Sodium Percent	----	0.1	%	<0.1	----	----	----	----

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

- **No Matrix Spike (MS) or Matrix Spike Duplicate (MSD) Results are required to be reported.**

ALS Environmental

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EW2104213**	Page	: 1 of 5
Client	: **CIVPLAN**	Laboratory	: Environmental Division NSW South Coast
Contact	: Tanya Erofeev	Telephone	: 02 42253125
Project	: 515 Crookwell Road, Kingsdale	Date Samples Received	: 07-Oct-2021
Site	: ----	Issue Date	: 16-Oct-2021
Sampler	: Client, Tanya Erofeev	No. of samples received	: 20
Order number	: ----	No. of samples analysed	: 20

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **NO Matrix Spike outliers occur.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **Analysis Holding Time Outliers exist - please see following pages for full details.**

Outliers : Frequency of Quality Control Samples

- **NO Quality Control Sample Frequency Outliers exist.**

Outliers : Analysis Holding Time Compliance

Matrix: **SOIL**

Method / Container / Client Sample ID(s)	Extraction / Preparation			Analysis		
	Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EA002: pH 1:5 (Soils)						
Soil Glass Jar - Unpreserved						
CR-BH001/1, CR-BH001/2, CR-BH001/3, CR-BH002/1, CR-BH002/2, CR-BH0B/1, CR-BH0B/2, CR-BH0B/3, CR-BH0C/1, CR-BH0C/2, CR-BH0C/3, CR-BH0D/1, CR-BH0D/2, CR-BH0E/1, CR-BH0E/2, CR-BH0E/3, CR-BH0F/1, CR-BH0F/2, CR-BH0G/1	----	----	----	13-Oct-2021	12-Oct-2021	**1**

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA002: pH 1:5 (Soils)							
Soil Glass Jar - Unpreserved (EA002)							
CR-BH001/1, CR-BH001/2, CR-BH001/3, CR-BH002/1, CR-BH002/2, CR-BH0B/1, CR-BH0B/2, CR-BH0B/3, CR-BH0C/1, CR-BH0C/2, CR-BH0C/3, CR-BH0D/1, CR-BH0D/2, CR-BH0E/1, CR-BH0E/2, CR-BH0E/3, CR-BH0F/1, CR-BH0F/2, CR-BH0G/1	**06-Oct-2021**	**11-Oct-2021**	13-Oct-2021	✓	**13-Oct-2021**	12-Oct-2021	×

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA010: Conductivity (1:5)							
Soil Glass Jar - Unpreserved (EA010)							
CR-BH001/1, CR-BH001/2, CR-BH001/3, CR-BH002/1, CR-BH002/2, CR-BH0B/1, CR-BH0B/2, CR-BH0B/3, CR-BH0C/1, CR-BH0C/2, CR-BH0C/3, CR-BH0D/1, CR-BH0D/2, CR-BH0E/1, CR-BH0E/2, CR-BH0E/3, CR-BH0F/1, CR-BH0F/2, CR-BH0G/1	**06-Oct-2021**	**11-Oct-2021**	13-Oct-2021	✓	**13-Oct-2021**	08-Nov-2021	✓
ED006: Exchangeable Cations on Alkaline Soils							
Soil Glass Jar - Unpreserved (ED006)							
CR-BH0B/2, CR-BH0B/3, CR-BH0C/2, CR-BH0D/2	**06-Oct-2021**	**14-Oct-2021**	03-Nov-2021	✓	**14-Oct-2021**	03-Nov-2021	✓
ED007: Exchangeable Cations							
Soil Glass Jar - Unpreserved (ED007)							
CR-BH001/1, CR-BH001/2, CR-BH002/1, CR-BH002/2, CR-BH0B/1, CR-BH0C/1, CR-BH0D/1, CR-BH0E/1, CR-BH0E/2, CR-BH0F/1, CR-BH0F/2, CR-BH0G/1	**06-Oct-2021**	**14-Oct-2021**	03-Nov-2021	✓	**14-Oct-2021**	03-Nov-2021	✓
EK072: Phosphate Sorption Capacity							
Soil Glass Jar - Unpreserved (EK072)							
CR-BH0B/2, CR-BH0C/2, CR-BH0D/2, CR-BH0E/2	**06-Oct-2021**	**----**	----	----	**11-Oct-2021**	04-Apr-2022	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Electrical Conductivity (1:5)	EA010	3	21	**14.29**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations	ED007	2	13	**15.38**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	1	4	**25.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
P Sorption Index & P Sorption Capacity	EK072	2	17	**11.76**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH (1:5)	EA002	3	22	**13.64**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Electrical Conductivity (1:5)	EA010	2	21	**9.52**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations	ED007	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Electrical Conductivity (1:5)	EA010	2	21	**9.52**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations	ED007	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
pH (1:5)	EA002	SOIL	In house: Referenced to Rayment and Lyons 4A1 and APHA 4500H+. pH is determined on soil samples after a 1:5 soil/water leach. This method is compliant with NEPM Schedule B(3).
Electrical Conductivity (1:5)	EA010	SOIL	In house: Referenced to Rayment and Lyons 3A1 and APHA 2510. Conductivity is determined on soil samples using a 1:5 soil/water leach. This method is compliant with NEPM Schedule B(3).
Exchangeable Cations on Alkaline Soils	ED006	SOIL	In house: Referenced to Soil Survey Test Method C5. Soluble salts are removed from the sample prior to analysis. Cations are exchanged from the sample by contact with alcoholic ammonium chloride at pH 8.5. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil.
Exchangeable Cations	ED007	SOIL	In house: Referenced to Rayment & Lyons Method 15A1. Cations are exchanged from the sample by contact with Ammonium Chloride. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil. This method is compliant with NEPM Schedule B(3).
P Sorption Index & P Sorption Capacity	EK072	SOIL	In house: Referenced to Rayment & Lyons Method 9H1 & 9I1 Soil is bought to equilibrium with a solution of P at known concentration. P absorbed, released is determined by FIA analysis of the final solution.

Preparation Methods	Method	Matrix	Method Descriptions
Exchangeable Cations Preparation Method (Alkaline Soils)	ED006PR	SOIL	In house: Referenced to Rayment and Lyons method 15C1.
Exchangeable Cations Preparation Method	ED007PR	SOIL	In house: Referenced to Rayment & Lyons method 15A1. A 1M NH4Cl extraction by end over end tumbling at a ratio of 1:20. There is no pretreatment for soluble salts. Extracts can be run by ICP for cations.
1:5 solid / water leach for soluble analytes	EN34	SOIL	10 g of soil is mixed with 50 mL of reagent grade water and tumbled end over end for 1 hour. Water soluble salts are leached from the soil by the continuous suspension. Samples are settled and the water filtered off for analysis.

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ Brisbane: 32 Shand St, Stafford QLD 4053 Ph:07 3243 7222 E:samples.brisbane@alsenviro.com
☐ Townsville: 14-15 Desma Ct, Bohle QLD 4818 Ph:07 4796 0600 E: townsville.environmental@alsenviro.com
☐ Melbourne: 2-4 Westall Rd, Springvale VIC 3171 Ph:03 8549 9600 E: samples.melbourne@alsenviro.com
☐ Adelaide: 2-1 Burma Rd, Pooraka SA 5095 Ph: 08 8359 0890 E:adelaide@alsenviro.com
☐ Perth: 10 Hod Way, Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsenviro.com
☐ Launceston: 27 Wellington St, Launceston TAS 7250 Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT:	CivPlan	TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g., Ultra Trace Organics)	☐ Standard TAT (List due date): ☐ Non Standard or urgent TAT (List due date):
OFFICE:			
PROJECT:	515 Crookwell Road, Kingsdale	ALS QUOTE NO.:	COC SEQUENCE NUMBER (Circle) COC: 1 2 3 4 5 6 7 OF: 1 2 3 4 5 6 7
ORDER NUMBER:			
PROJECT MANAGER:	Tanya Erofeev	CONTACT PH: 0416777210	
SAMPLER:	Tanya Erofeev	SAMPLER MOBILE: 0416777210	
COC emailed to ALS? (YES / NO)		EDD FORMAT (or default):	
Email Reports to (will default to PM if no other addresses are listed): tanya.erofeev@civplan.com.au			
Email Invoice to (will default to PM if no other addresses are listed): info@civplan.com.au			

FOR LABORATORY USE ONLY (Circle)			
Custody Seal Intact?	Yes	No	N/A
Free ice / frozen ice bricks present upon receipt?	Yes	No	N/A
Random Sample Temperature on Receipt:		°C	
Other comment:	20.1		

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Tanya Erofeev			
DATE/TIME: 7.10.21	DATE/TIME: 07/10/21 1500	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	Soil pH	Conductivity EC	Exchangeable Cations	Phospate Sorption Capacity	Soluble Salts				Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	CR-BH001/1	6.10.21	S			1	1	1						
2	CR-BH001/2	6.10.21	S			1	1	1						
3	CR-BH001/3	6.10.21	S			1	1							
4	CR-BH002/1	6.10.21	S			1	1	1						
5	CR-BH002/2	6.10.21	S			1	1	1						
6	CR-BH06/1	6.10.21	S			1	1	1						
7	CR-BH06/2	6.10.21	S			1	1	1	1					
8	CR-BH06/3	6.10.21	S			1	1	1						
9	CR-BH10C/1	6.10.21	S			1	1	1						
10	CR-BH10C/2	6.10.21	S			1	1	1	1					
11	CR-BH10C/3	6.10.21	S			1	1							
12	CR-BH10D/1	6.10.21	S			1	1	1						
13	CR-BH10D/2	6.10.21	S			1	1	1	1					
14	CR-BH10E/1	6.10.21	S			1	1	1						
15	CR-BH10E/2	6.10.21	S			1	1	1	1					
				TOTAL		15	15	13	4					

Environmental Division
Wollongong
Work Order Reference
EW2104213

Telephone - 02 4225 3125

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

CHAIN OF CUSTODY

ALS Laboratory: please tick →

Unit 16, 33 Maddox St, Alexandria NSW 2015 Ph: 02 8784 8555 E: samples.sydney@alsenviro.com
Unit 1, 5 Rosedale Rd, Gladesville NSW 2111 Ph: 02 9815 7311 E: samples.newcastle@alsenviro.com
Brisbane: 32 Shand St, Stafford QLD 4053 Ph:07 3243 7222 E:samples.brisbane@alsenviro.com
Townsville: 14-15 Desma Ct, Bohle QLD 4818 Ph:07 4796 0600 E: townsville.environmental@alsenviro.com
Melbourne: 2-4 Westall Rd, Springvale VIC 3171 Ph:03 8549 9600 E: samples.melbourne@alsenviro.com
Adelaide: 2-1 Burma Rd, Pooraka SA 5095 Ph: 08 8359 0890 E:adelaide@alsenviro.com
Perth: 10 Hod Way, Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsenviro.com
Launceston: 27 Wellington St, Launceston TAS 7250 Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT:	TURNAROUND REQUIREMENTS: (Standard TAT may be longer for some tests e.g., Ultra Trace Organics)	☐ Standard TAT (List due date):	FOR LABORATORY USE ONLY (Circle)
OFFICE:		☐ Non Standard or urgent TAT (List due date):	Custody Seal Intact? Yes No N/A
PROJECT: 515 Crookwell Road, Kingsdale	ALS QUOTE NO.:	COC SEQUENCE NUMBER (Circle)	Free Ice / frozen Ice bricks present upon receipt? Yes No N/A
ORDER NUMBER:		COC: 1 2 3 4 5 6 7	Random Sample Temperature on Receipt: °C
PROJECT MANAGER: Tanya Erofeev	CONTACT PH: 0415777210	OF: 1 2 3 4 5 6 7	Other comment:

SAMPLER: Tanya Erofeev	SAMPLER MOBILE: 0415777210	RELINQUISHED BY: Tanya Erofeev	RECEIVED BY:	RELINQUISHED BY:
COC emailed to ALS? (YES / NO)	EDD FORMAT (or default):	DATE/TIME: 7·10·21	DATE/TIME:	DATE/TIME:
Email Reports to (will default to PM if no other addresses are listed): tanya.erofeev@civplan.com.au				
Email Invoice to (will default to PM if no other addresses are listed): info@civplan.com.au				

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED Including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	Soil pH	Conductivity EC	Exchangeable Cations	Phospate Sorption Capacity	Soluble Salts				Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
16	CR-BH0E/3	6·10·21	S			1	1							
17	CR-BH0F/1	6·10·21	S			1	1	1						
18	CR-BH0F/2	6·10·21	S			1	1	1	[redacted]					
19	CR-BH0G/1	6·10·21	S			1	1	1						
20	CR-BH0G/2	6·10·21	S			1	1	1	[redacted]					
			S											
			S											
			S											
			S											
			S											
			S											
			S											
			S											
			S											
			S											
TOTAL						5	5	4						

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

Appendix B – Borehole Logs

Client:	Alimaco Pty Ltd		Latitude -34.7063	Logged By: Tanya Erofeev	Borehole No: BH01
Project:	515 Crookwell Rd, Kingsdale, NSW		Longitude 149.703942	Geology: Report Section 2.1	Vegetation Grass
Logged By:	Tanya Erofeev	Date Started: 6/10/2021		Equipment: Hand Auger	Total Depth: 1.2m
Auger Operator:	CivPlan	Date Completed: 6/10/2021		Groundwater Depth: N/A	AHD RL Surface: -

Depth (feet)	Penetration Resistance (Blows/0.1m)	Sample Number	Groundwater	Graphic Log	**Lithological Description:** **Soil Group Name:** modifier, color, moisture, density/consistency, grain size, other descriptors **Rock Description:** modifierm color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.	Moisture Condition	Consistency Density
		BH001/1	Not Encountered		TOPSOIL: Silty CLAY, medium brown, low plasticity, grassland roots	Slightly moist	Soft
					CLAY LOAM: Reddish brown, light clay loam medium plasticity	Slightly moist	Soft
0.5		BH001/2			MEDIUM CLAY: Light brown, medium clay, high plasticity	Slightly moist	Firm
					MEDIUM CLAY: Light brown, medium clay, high plasticity weathered gravel inclusions	Slightly moist	Stiff
1.0		BH001/3			Borehole terminated at 1.2m depth.		

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Borehole Log: Sheet 1 of 8

DPC - Dynamic Cone Penetrometer

CBR - California Bearing Ratio

Client:	Alimaco Pty Ltd		Latitude -34.7087	Logged By: Tanya Erofeev	Borehole No: BH02
Project:	515 Crookwell Rd, Kingsdale, NSW		Longitude 149.7041	Geology: Report Section 2.1	Vegetation Grass
Logged By:	Tanya Erofeev	Date Started: 6/10/2021		Equipment: Hand Auger	Total Depth: 1.2m
Auger Operator:	CivPlan	Date Completed: 6/10/2021		Groundwater Depth: N/A	AHD RL Surface: -

Depth (feet)	Penetration Resistance (Blows/0.1m)	Sample Number	Groundwater	Graphic Log	Lithological Description:	Moisture Condition	Consistency Density
		BH002/1	Not Encountered		TOPSOIL: Silty CLAY, medium brown, low plasticity, grassland roots	Slightly moist	Soft
					LIGHT CLAY: medium brown, light clay, medium plasticity	Slightly moist	Soft
0.5		BH002/2					
					MEDIUM CLAY: medium brown, light clay, high plasticity	Slightly moist	Firm
1.0							
					Borehole terminated at 1.2m depth.		

Soil Group Name: modifier, color, moisture, density/consistency, grain size, other descriptors

Rock Description: modifierm color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.

DPC - Dynamic Cone Penetrometer

CBR - California Bearing Ratio

Client:	Alimaco Pty Ltd		Latitude -34.7113	Logged By: Tanya Erofeev	Borehole No: BH0B
Project:	515 Crookwell Rd, Kingsdale, NSW		Longitude 149.7035	Geology: Report Section 2.1	Vegetation Grass
Logged By:	Tanya Erofeev	Date	Started: 6/10/2021	Equipment: Hand Auger	Total Depth: 1.2m
Auger Operator:	CivPlan		Completed: 6/10/2021	Groundwater Depth: N/A	AHD RL Surface: -

Depth (feet)	Penetration Resistance (Blows/0.1m)	Sample Number	Groundwater	Graphic Log	Lithological Description:	Moisture Condition	Consistency Density
		BH00B/1	Not Encountered		TOPSOIL: Silty CLAY, medium brown, low plasticity, grassland roots	Slightly moist	Soft
0.5		BH00B/2			LIGHT CLAY: dark brown, light clay, medium plasticity	Slightly moist	Firm
		BH00B/3			LIGHT CLAY: medium brown, light clay, medium plasticity	Slightly moist	Stiff
1.0					Borehole terminated at 1.2m depth.		

Soil Group Name: modifier, color, moisture, density/consistency, grain size, other descriptors

Rock Description: modifierm color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.

DPC - Dynamic Cone Penetrometer

CBR - California Bearing Ratio

Client:	Alimaco Pty Ltd		Latitude -34.7127	Logged By: Tanya Erofeev	Borehole No: BH0C
Project:	515 Crookwell Rd, Kingsdale, NSW		Longitude 149.7016	Geology: Report Section 2.1	Vegetation Grass
Logged By:	Tanya Erofeev	Date	Started: 6/10/2021	Equipment: Hand Auger	Total Depth: 1.2m
Auger Operator:	CivPlan		Completed: 6/10/2021	Groundwater Depth: N/A	AHD RL Surface: -

Depth (feet)	Penetration Resistance (Blows/0.1m)	Sample Number	Groundwater	Graphic Log	Lithological Description:	Moisture Condition	Consistency Density
		BH00C/1	Not Encountered		TOPSOIL: Silty CLAY, medium brown, low plasticity, grassland roots	Slightly moist	Soft
					CLAY LOAM: Light brown, light clay loam, medium plasticity weathered gravel inclusions	Slightly moist	Soft
0.5		BH00C/2			LIGHT CLAY: light brown, light clay, medium plasticity weathered gravel inclusions	Slightly moist	Firm
		BH00C/3			LIGHT CLAY: ligtht brown, light clay, high plasticity	Slightly moist	Stiff
1.0					Borehole terminated at 1.2m depth.		

Soil Group Name: modifier, color, moisture, density/consistency, grain size, other descriptors

Rock Description: modifierm color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.

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DPC - Dynamic Cone Penetrometer

CBR - California Bearing Ratio

Client:	Alimaco Pty Ltd		Latitude -34.716	Logged By: Tanya Erofeev	Borehole No: BH0D
Project:	515 Crookwell Rd, Kingsdale, NSW		Longitude 149.7015	Geology: Report Section 2.1	Vegetation Grass
Logged By:	Tanya Erofeev	Date	Started: 6/10/2021	Equipment: Hand Auger	Total Depth: 0.5m
Auger Operator:	CivPlan		Completed: 6/10/2021	Groundwater Depth: N/A	AHD RL Surface: -

Depth (feet)	Penetration Resistance (Blows/0.1m)	Sample Number	Groundwater	Graphic Log	Lithological Description:	Moisture Condition	Consistency Density
		BH00D/1	Not Encountered		TOPSOIL: Dark brown loam, low plasticity, grassland roots	Slightly moist	Soft
					HEAVY CLAY: dark brown/black, heavy clay, medium plasticity	Slightly moist	Stiff
0.5		BH00D/2			Borehole terminated at 0.5m depth.		
1.0							

Soil Group Name: modifier, color, moisture, density/consistency, grain size, other descriptors

Rock Description: modifierm color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.

DPC - Dynamic Cone Penetrometer

CBR - California Bearing Ratio

Client:	Alimaco Pty Ltd		Latitude -34.7145	Logged By: Tanya Erofeev	Borehole No: BH0E
Project:	515 Crookwell Rd, Kingsdale, NSW		Longitude 149.699	Geology: Report Section 2.1	Vegetation Grass
Logged By:	Tanya Erofeev	Date Started: 6/10/2021		Equipment: Hand Auger	Total Depth: 1.2m
Auger Operator:	CivPlan	Date Completed: 6/10/2021		Groundwater Depth: N/A	AHD RL Surface: -

Depth (feet)	Penetration Resistance (Blows/0.1m)	Sample Number	Groundwater	Graphic Log	Lithological Description:	Moisture Condition	Consistency Density
		BH00E/1	Not Encountered		TOPSOIL: Silty sand, light brown, low plasticity, grassland roots	Slightly moist	Soft
					CLAY LOAM: Light brown, light clay loam, medium plasticity weathered gravel inclusions	Slightly moist	Soft
0.5		BH00E/2			LIGHT CLAY: light brown, light clay, medium plasticity weathered gravel inclusions	Slightly moist	Firm
		BH00E/3			LIGHT CLAY: ligtht brown, light clay, high plasticity	Slightly moist	Stiff
1.0					Borehole terminated at 1.2m depth.		

Soil Group Name: modifier, color, moisture, density/consistency, grain size, other descriptors

Rock Description: modifierm color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.

CivPlan

DPC - Dynamic Cone Penetrometer

CBR - California Bearing Ratio

Client:	Alimaco Pty Ltd		Latitude -34.716	Logged By: Tanya Erofeev	Borehole No: BH0F
Project:	515 Crookwell Rd, Kingsdale, NSW		Longitude 149.7015	Geology: Report Section 2.1	Vegetation Grass
Logged By:	Tanya Erofeev	Date Started: 6/10/2021		Equipment: Hand Auger	Total Depth: 0.65m
Auger Operator:	CivPlan	Date Completed: 6/10/2021		Groundwater Depth: N/A	AHD RL Surface: -

Depth (feet)	Penetration Resistance (Blows/0.1m)	Sample Number	Groundwater	Graphic Log	Lithological Description:	Moisture Condition	Consistency Density
		BH00F/1	Not Encountered		**Soil Group Name:** modifier, color, moisture, density/consistency, grain size, other descriptors **Rock Description:** modifierm color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.		
					TOPSOIL: Silty sand, light brown, low plasticity, grassland roots	Slightly moist	Soft
					LIGHT CLAY: light brown, light clay, medium plasticity	Slightly moist	Soft
0.5		BH00F/2					
					Borehole terminated at 0.65m depth.		
1.0							

CivPlan

DPC - Dynamic Cone Penetrometer

CBR - California Bearing Ratio

Client:	Alimaco Pty Ltd	Latitude -34.716	Logged By: Tanya Erofeev	Borehole No: BH0G	
Project:	515 Crookwell Rd, Kingsdale, NSW	Longitude 149.6993	Geology: Report Section 2.1	Vegetation Grass	
Logged By: Tanya Erofeev	Date	Started: 6/10/2021	Equipment: Hand Auger	Total Depth: 1.2m	
Auger Operator: CivPlan		Completed: 6/10/2021	Groundwater Depth: N/A	AHD RL Surface: -	

Depth (feet)	Penetration Resistance (Blows/0.1m)	Sample Number	Groundwater	Graphic Log	Lithological Description:	Moisture Condition	Consistency Density
		BH00G/1	Not Encountered		TOPSOIL: Light brown loam, low plasticity, grassland roots and gravel inclusions	Slightly moist	Soft
					SILTY CLAY: Light brown clay, low plasticity	Slightly moist	Soft
0.5		BH00G/2			LIGHT CLAY: Light brown clay, low plasticity	Slightly moist	Firm
1.0					Borehole terminated at 1.2m depth.		

Soil Group Name: modifier, color, moisture, density/consistency, grain size, other descriptors

Rock Description: modifierm color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.

CivPlan

DPC - Dynamic Cone Penetrometer

CBR - California Bearing Ratio

Appendix C – Calculations

OWMP Calculator - Surface & Sub-Surface Irrigation

Client: Alimaco Pty Ltd
Project: 515 Crookwell Rd, Kingsdale, NSW
Project No: 20027CC
DA No: Planning Proposal
Date: 3-Mar-22

Design Irrigation Rate (DIR) for Irrigation Systems (AS/NZS1547:2012)

Soil Category	5b	
Soil Texture	Light Clay	
Structure	Moderate	
Indicative Permeability	0.05-0.12	m/day
Drip Irrigation DIR	3.00	mm/day

Nutrient and Organic Matter Balance

The formula used to determine area requirements based on organic matter and nutrient loads is as follows:

$$A = \frac{C \times Q}{L_x}$$

Where
- A = land area (m^2)
- C = concentration of nutrient or BOD (mg/L)
- Q = treated wastewater flow rate (L/d)
- L_x = critical loading rate of nutrient or BOD ($mg/m^2/d$)

Nitrogen Loading

C	20	mg/L	*Generally between 20 and 30*
Q	900	L/day	4 or more bedrooms / non-reticulated
N loss in soil	1	mg/day	*Could be up to 20%*
L_n			
Crop Uptake	240	kg/ha/yr	*Managed lawns*
Adjusted	65.71	$mg/m^2/day$	*Unit conversion*
Irrigation area	*274*	m^2	*Assuming no loss in soil (up to 20%)*

Phosphorus Loading

P Sorb capacity	1290	mg/kg	
Soil Depth	0.5	m	
Bulk Density	1500	kg/m^3	
Psorb	9675	kg/ha	

Amount of phosphorus that can be absorbed without leaching over 50 years

P Sorb Capacity	9675	kg/ha	
Predicted P Sorb	0.7		*Ranges between 33% to 70%*
$P_{absorbed}$	6772.5	kg/ha	
	0.67725	kg/m^2	

Amount of vegetation uptake over 50 years

L_p			
Crop Uptake	30	kg/ha/yr	*Managed lawns*
Adjusted	8.21	$mg/m^2/day$	*Unit conversion*
P_{uptake}	149900.532	mg/m^2	
	0.150	kg/m^2	

Amount of phosphorus generated over 50 years

C	10	mg/L	*Generally 10*
$P_{generated}$	164250000	mg	
	164.25	kg	

Irrigation Area Required

Irrigation area = $P_{generated} / (P_{adsorbed} + P_{uptake})$

Irrigation area *199* m^2

Limiting Nutrient	**Nitrogen**
Area Required	**411** m^2

Hydraulic Loading - Nominated Area Method

A water balance is based on the following equation calculated on a monthly basis:

Design Precipitation + Wastewater Applied = Evapotranspiration + Percolation

Or **P + W = E T + B**

Table 14: Expected Quality of Wastewater after Treatment in an AWTS

Parameter	Concentration *	Failure Indicator
Biochemical oxygen demand	<20 mg/L	>50 mg/L
Suspended solids	<30 mg/L	>50 mg/L
Total nitrogen	25 - 50 mg/L	not applicable
Total phosphorus	10 - 15 mg/L	not applicable
Faecal coliforms Non-disinfected effluent	up to 10^4 cfu/100 mL	not applicable
Faecal coliforms Disinfected effluent	<30 cfu/100 mL	>100 cfu/100 mL
Dissolved oxygen	>2 mg/L	<2 mg/L

*Design figures might not be indicative of long-term operational characteristics

Nutrient Uptake Rates

Vegetation Type	Total Nitrogen (kg/ha/year)	Total Phosphorus (kg/ha/year)
Good quality woodland	90	25
Poor quality woodland	65	20
Lawn – fully managed (clippings removed)	240	30
Lawn – unmanaged	120	12
Improved pasture	280	24
Perennial pasture	99	11
Shrubs and some trees – fully managed	150	16
Shrubs and some trees – unmanaged	75	8

For **bulk density (g/cm³)**, apply the following values:
Sandy soil – 1.8g/cm³
Intermediate – 1.5g/cm³
Clayey soil – 1.3g/cm³

- Phosphorus sorption data in milligrams per kilogram (mg/kg) is converted to kilograms per hectare (kg/ha) using the following equation (see Appendix 1 for indicative bulk density values):

Psorp (kg/ha) = Psorp (mg/kg) x soil depth (m) x bulk density (kg/m^2) x 0.01

Phosphorus Sorption Uptake Values

Soil Category	Texture	Structure	Acceptable P_{sorp}* (mg/kg)
1	Gravels and sands	Structureless	50
2a	Sandy loams	Weak	100
2b	Sandy loams	Massive	100
3a	Loams	High / moderate	200
3b	Loams	Weak / massive	200
4a	Clay loams	High / moderate	400
4b	Clay loams	Weak	400
4c	Clay loams	Massive	400
5a	Light clays	Strong	500
5b	Light clays	Moderate	500
5c	Light clays	Weak / massive	500
6a	Med-heavy clays	Strong	600
6b	Med-heavy clays	Moderate	600
6c	Med-heavy clays	Weak / massive	600

* If soil parent material is basalt then increase Psorp by 100mg/kg

TABLE M1
RECOMMENDED DESIGN IRRIGATION RATE (DIR) FOR IRRIGATION SYSTEMS

Soil Category (see Note 1)	Soil texture	Structure	Indicative permeability (K_{sat}) (m/d)	Design irrigation rate (DIR) (mm/day) Drip irrigation	Spray irrigation	LPED irrigation
1	Gravels and sands	Structureless (massive)	> 3.0	5 (see Note 2)	5	(see Note 3)
2	Sandy loams	Weakly structured massive	> 3.0			4
			1.4 – 3.0			
3	Loams	High/ moderate structured	1.5 – 3.0	4 (see Note 1)	4	3.5
		Weakly structured or massive	0.5 – 1.5			
4	Clay loams	High/ moderate structured	0.5 – 1.5	3.5 (see Note 1)	3.5	3
		Weakly structured	0.12 – 0.5			
		Massive	0.06 – 0.12			
5	Light clays	Strongly structured	0.12 – 0.5	3 (see Note 1)	3	2.5 (see Note 4)
		Moderately structured	0.06 – 0.12			
		Weakly structured or massive	< 0.06			
6	Medium to heavy clays	Strongly structured	0.06 – 0.5	2 (see Note 2)	2	(see Note 3)
		Moderately structured	< 0.06			
		Weakly structured or massive	< 0.06			

NOTES:
1 For Category 3 to 5 soils (loams to light clays), the drip irrigation system needs to be installed in an adequate depth of topsoil (in the order of 150 – 250 mm of *in situ* or imported good quality topsoil) to slow the soakage and assist with nutrient reduction.
2 For Category 1, 2, and 6 soils, the drip irrigation system has a depth of 100 – 150 mm in good quality topsoil (see CM1 and M3.1).
3 LPED irrigation is not advised for Category 1 or Category 6 soils – drip irrigation of secondary effluent is the preferred irrigation method.
4 LPED irrigation for Category 5 soils needs a minimum depth of 250 mm of good quality topsoil (see M5 and CM7.1).

TABLE H1
TYPICAL DOMESTIC WASTEWATER DESIGN FLOW ALLOWANCES – AUSTRALIA

Source	Typical wastewater design flows (L/person/day)	
Residential premises	On-site roof water tank supply	Reticulated water supply
	120	150

Source: Australian Bureau of Statistics. Water Account 2004/2005. Chapter 7 Figure 7.3

Monthly Water Balance to Determine Wet Weather Storage - Nominated Area Method

Design Wastewater Flow	Q	L/day	900
Design Percolation Rate	R	mm/week	21
Land Area	L	m^2	411

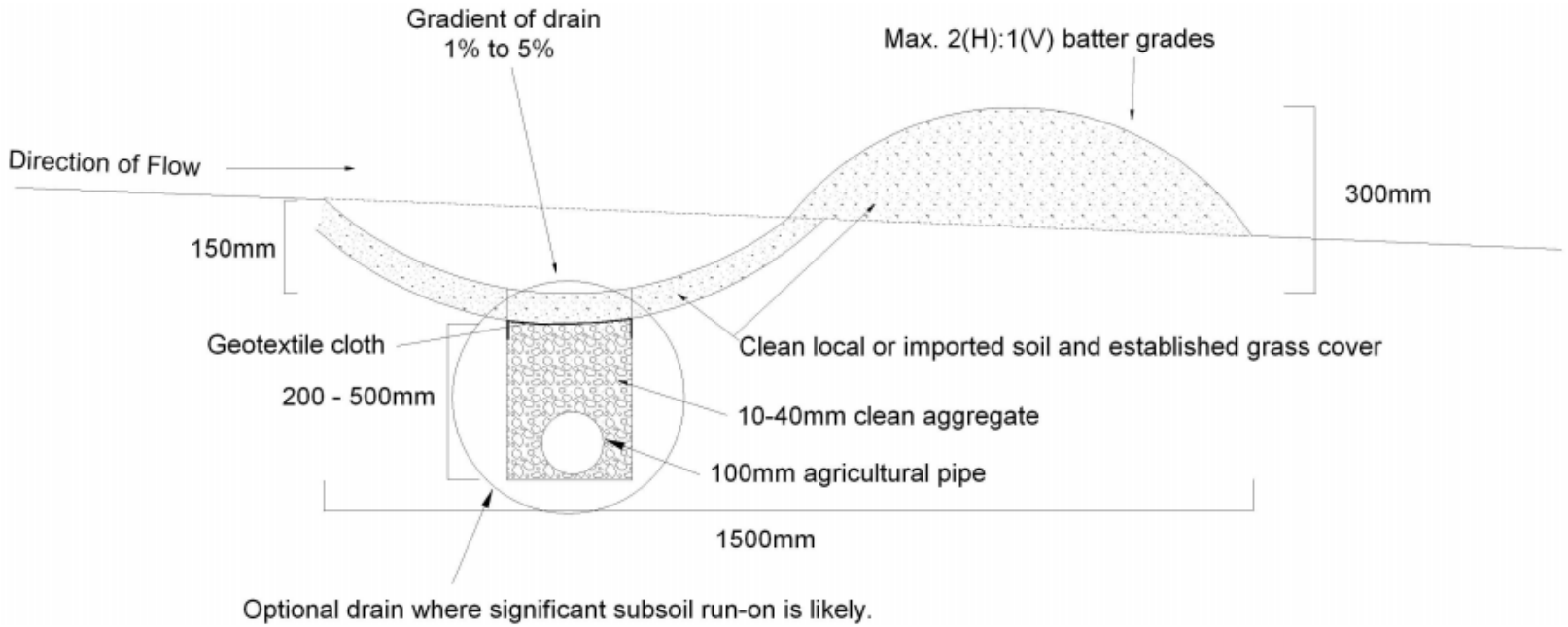
Parameter	Symbol	Formula	Units	January	February	March	April	May	June	July	August	September	October	November	December	Total
Days in month	D	-	days	31	28	31	30	31	30	31	31	30	31	30	31	365
Precipitation	P	-	mm/month	61.9	60.7	55.6	44	40.7	53.1	40.8	52.5	48	52.5	62.6	62.8	635.2
Evaportation	E	-	mm/month	187	145	124	79	51	34	39	61	88	123	146	185	1262
Crop factor	C	-	-	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	-
Inputs																
Precipitation	P	-	mm/month	61.9	60.7	55.6	44	40.7	53.1	40.8	52.5	48	52.5	62.6	62.8	635.2
Effluent Irrigation	W	(Q x D) / L	mm/month	67.9	61.3	67.9	65.7	67.9	65.7	67.9	67.9	65.7	67.9	65.7	67.9	799.3
Inputs		P + W	mm/month	129.8	122.0	123.5	109.7	108.6	118.8	108.7	120.4	113.7	120.4	128.3	130.7	1434.5
Outputs																
Evaportranspiration	ET	E x C	mm/month	149.6	116	86.8	55.3	35.7	23.8	27.3	42.7	61.6	98.4	116.8	148	962.0
Percolation	B	(R / 7) x D	mm/month	93.0	84.0	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	242.6	200.0	179.8	145.3	128.7	113.8	120.3	135.7	151.6	191.4	206.8	241.0	2057.0
Storage	S	(P + W) - (ET + B)	mm/month	-112.8	-78.0	-56.3	-35.6	-20.1	5.0	-11.6	-15.3	-37.9	-71.0	-78.5	-110.3	-
Cumulative Storage	M	-	mm	0.0	0.0	0.0	0.0	0.0	5.0	0.0	-15.3	-53.2	-124.2	-202.7	0.0	-
Storage	V	Largest M	mm	5												
		(V x L) / 1000	m^3	**2.06**												
Land Area Zero Storage				154	181	225	267	317	445	351	335	261	201	187	157	

Nominated Area	**411** m^2	**Wet Weather Storage**	**2 kL**

Minimum Area Requried for Zero Storage	**445**	m^2

Appendix D – Disposal System Standard Drawings

Cross Section: Upslope Diversion Drain



Standard Drawing 10A – Upslope Diversion Drain

(not to scale)

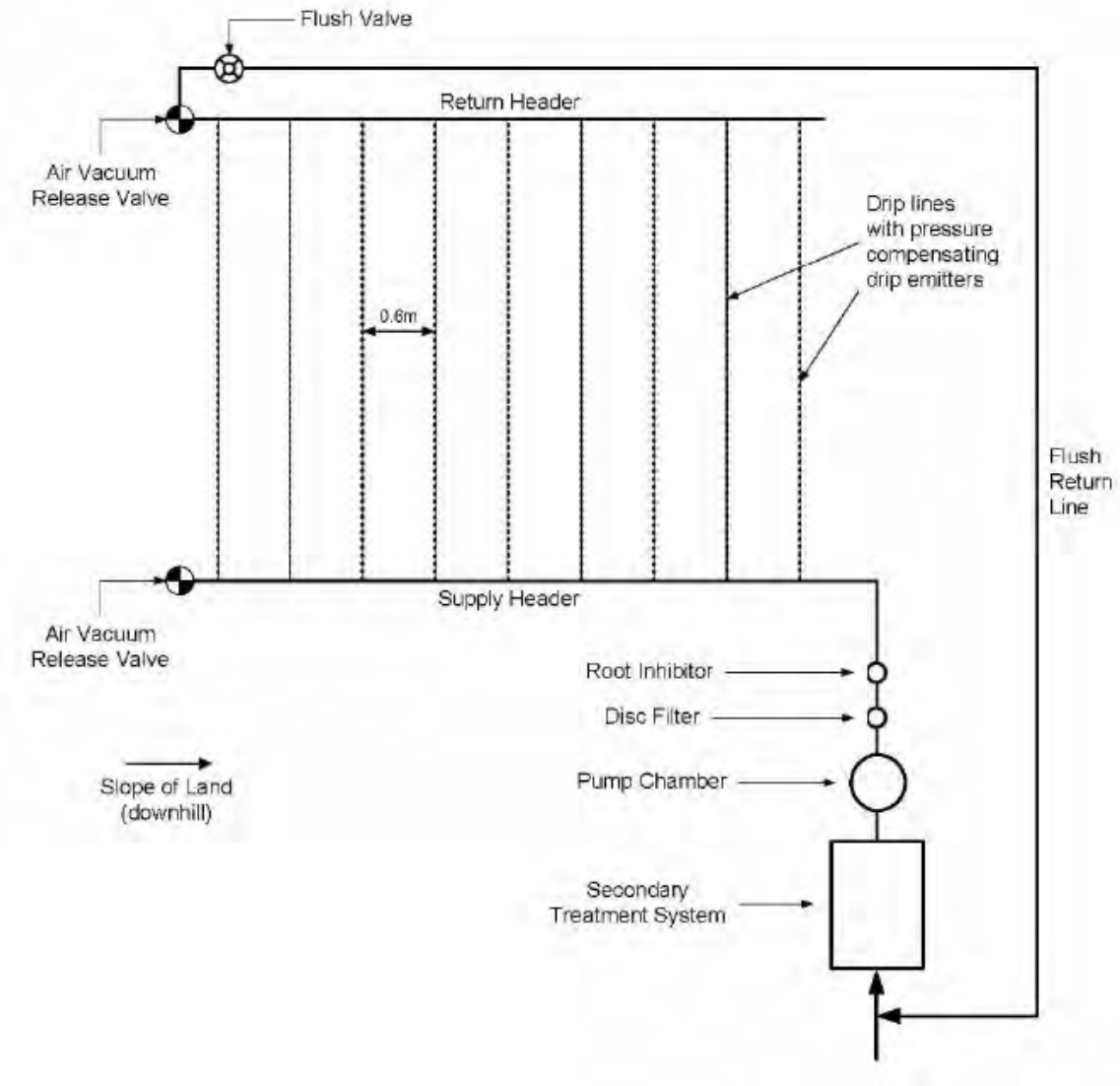
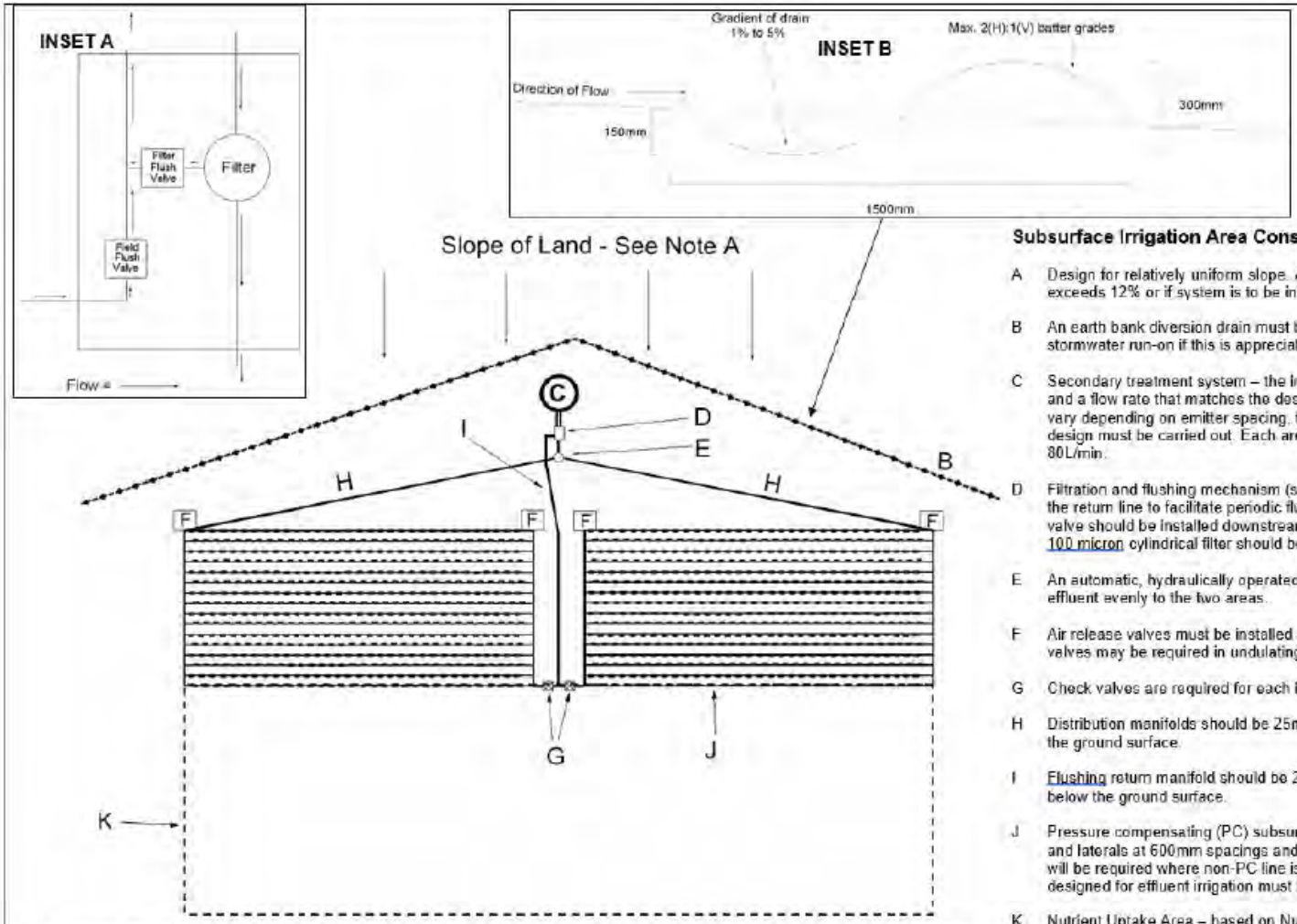


Figure 13.3 Subsurface irrigation schematic for effective distribution and flushing (Source: Centre for Environmental Training, 2019)



This standard design has been based on a generic area of irrigation based on typical conditions. It does not eliminate the need for a site and soil evaluation to be carried out or any additional consideration of site specific issues. It should be used as a generic guide only.

Subsurface Irrigation Area Construction

A Design for relatively uniform slope. Additional design work may be required where slope exceeds 12% or if system is to be installed over undulating ground.

B An earth bank diversion drain must be constructed upslope of the area to divert stormwater run-on if this is appreciable (see Inset B and Standard Drawing No.13A).

C Secondary treatment system – the irrigation pump must provide a *minimum* 20m head and a flow rate that matches the design output of the selected dripline. Flow rate will vary depending on emitter spacing, flow rate and lineal metres of line. A full hydraulic design must be carried out. Each area should be capable of discharging a minimum of 80L/min.

D Filtration and flushing mechanism (see Inset A) – a field flush valve must be installed on the return line to facilitate periodic flushing to the treatment tank. An additional filter flush valve should be installed downstream of the field flush valve. A (minimum) 150 mesh; 100 micron cylindrical filter should be installed and cleaned regularly.

E An automatic, hydraulically operated sequencing valve should be installed to deliver effluent evenly to the two areas.

F Air release valves must be installed at high points in each area. Additional air release valves may be required in undulating terrain.

G Check valves are required for each irrigation field to facilitate periodic flushing.

H Distribution manifolds should be 25mm uPVC or polyethylene pipe buried 300mm below the ground surface.

I Flushing return manifold should be 25mm uPVC or polyethylene pipe buried 100-150mm below the ground surface.

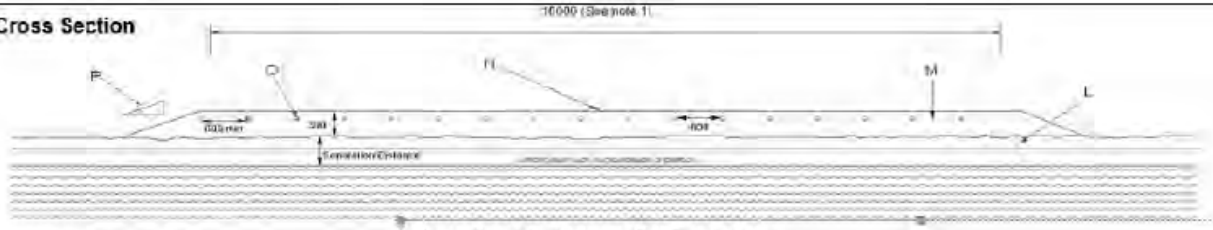
J Pressure compensating (PC) subsurface drip line laterals (typically 16mm) with emitters and laterals at 600mm spacings and buried to a depth 100-150mm. A pressure regulator will be required where non-PC line is used. Only subsurface dripline specifically designed for effluent irrigation must be used.

K Nutrient Uptake Area – based on Nutrient Balance of Total Phosphorus or Total Nitrogen, whoever requires the greater uptake area.

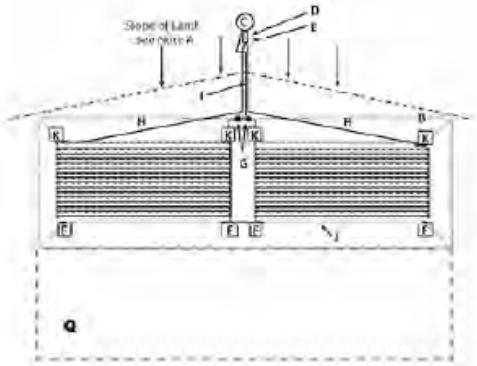
Standard Drawing 13B – Subsurface Effluent Irrigation

(not to scale)

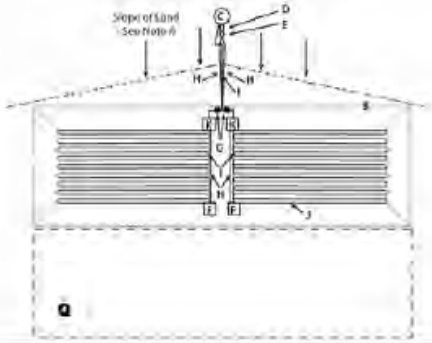
Cross Section



Plan View - 'End to End' Manifold Design



Plan View - 'Single Trench' Manifold Design



Raised Subsurface Irrigation Bed Construction

Note 1
The layout and dimensions used in this drawing is for demonstration purposes only. The location, configuration and layout of individual subsurface irrigation zones will need to be determined on a site-specific basis. The purpose of this Standard Drawing is to illustrate a typical configuration and specify minimum system components (e.g. flush lines, separate zones and dripline spacing). Minimum subsurface irrigation areas for different dwelling sizes should be determined by water balance and in accordance with AS/NZS 1547:2012 and this document.

A Design for relatively uniform slope. Additional design work may be required where slope exceeds 10% or if system is to be installed over undulating ground.

B An earth bank diversion drain must be constructed upslope of the effluent irrigation area to divert stormwater run-on if this is appreciable.

C Secondary or Advanced Secondary Treatment System – the irrigation pump must provide at least 20m head to the driplines (after static lift and friction loss) and a flow rate that matches the design output of the selected dripline. Flow rate will vary depending on emitter spacing, emitter flow rate and lineal metres of dripline. A full hydraulic design must be carried out.

D Filtration system – a suitable filter must be installed on the system. Minimum standard is a 150 mesh, 100 micron cylindrical filter however some systems will require a disc filter with finer filtration capacity. Some proprietary driplines require the installation of a 'tech-filter' that doses the system with a root and biofilm inhibitor.

E An automatic, hydraulically operated sequencing valve should be installed to deliver effluent evenly to a minimum of two separate zones.

F Automatic field flush valves must be installed to provide line flushing at each pump operation. One valve should be installed for every 100 lineal metres of line in the zone/system. The valves can be installed in-field in irrigation boxes (backfilled with aggregate) or back at the treatment system.

G Check valves are required on the return flush manifold of each zone to facilitate periodic manual flushing.

H Distribution (supply) manifolds should be 25mm uPVC or polyethylene pipe buried a minimum 300 mm below the ground surface. Where possible, the supply and flush manifolds should be located in the same trench.

I Return flush manifolds should be 25mm uPVC or polyethylene pipe buried 100-150mm below the ground surface.

J Subsurface drip lines with emitters at 300mm spacings and laterals at 600mm spacings and buried to a depth 100-150mm. Only subsurface dripline specifically designed for effluent irrigation must be used. Irrigation zones may be installed with manifolds at opposite ends or at the same end (with laterals coiling back) as shown in the Standard Drawing.

K Air release or vacuum breaker valves must be installed at high points in each zone. Additional air release valves may be required in undulating terrain.

L Prepare the site by clearing all shrubs, trees and boulders. Cut trees to ground level and then grind the stump out to a depth of 300mm and backfill with permeable material such as the natural topsoil or sand (not clay). Scarify the natural soils across the entire basal area to a minimum depth of 200mm taking care not to compact the basal area in the process. This should extend to at least 1m beyond the perimeter.

M Subsurface irrigation bed is to be raised to a total height of 300mm above the natural ground surface. Compaction should be minimised when installing the bed. The fill must be an organic loam to sandy loam with minimal clay content.

N Grass (turf) must be established over the raised bed immediately after completing construction.

O Dripline laterals must be buried 100-150mm below the surface.

P Batter slope 1(vertical):3 (horizontal) maximum.

Q Nutrient Uptake Area.

Standard Drawing 13C – Raised Subsurface Irrigation Bed

(not to scale)